

# *Holding Court With the Ghost of Gilman Terrace:*

Selected Writings of  
**RALPH MILTON WATERS, M.D.**

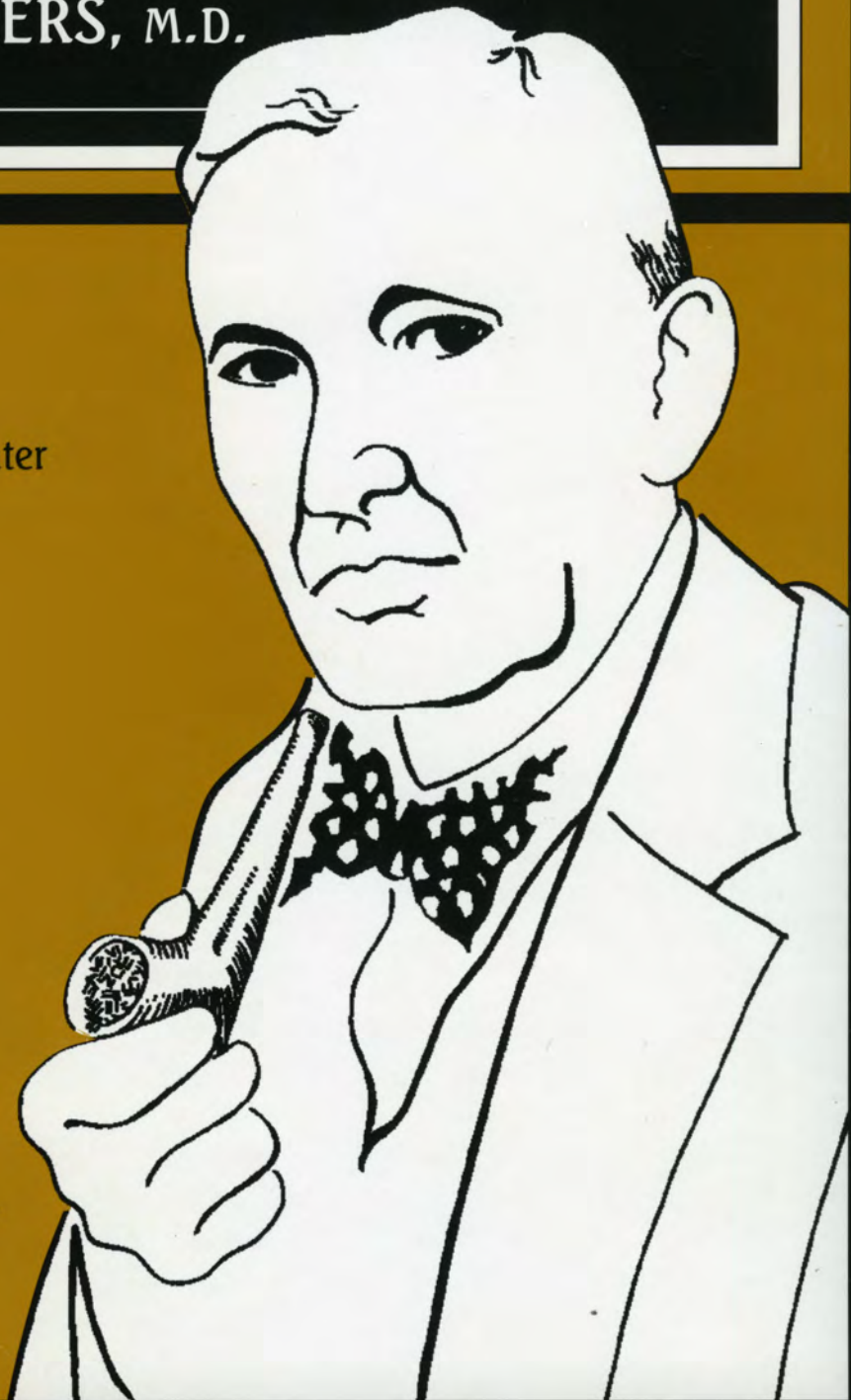
Edited by  
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Harvard Medical School  
Beth Israel Deaconess Medical Center

*Foreword by Donald Caton, M.D.*

**BIOGRAPHY  
AUTOBIOGRAPHY  
SAFETY  
RESUSCITATION  
N<sub>2</sub>O, CO<sub>2</sub> & TOO MUCH O<sub>2</sub>  
PROFESSIONALISM**

*In Commemoration of the  
75th anniversary of  
Academic Anesthesiology  
Madison, Wisconsin, USA*

**The Wood Library-Museum of Anesthesiology  
Park Ridge, Illinois, USA  
2002**





*HOLDING COURT WITH THE GHOST  
OF GILMAN TERRACE*

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**Edited by**

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*With a Foreword by*

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**Wood Library-Museum of Anesthesiology  
Park Ridge, IL**

**2002**

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And Professionalism in Anesthesiology  
A Celebration of 75 Years  
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## FOREWORD

No American deserves more praise than Ralph Milton Waters for transforming anesthesiology from a surgical technique to a medical profession. Waters himself describes the state of Anesthesiology in Sioux City, Iowa in 1913, when he first practiced it: "A few more or less full time surgeons ... employed nurses to administer ether in the mornings at hospitals and act as office nurses in the afternoons. A majority of us ... depended upon each other to act as anesthetist as occasions demanded." Waters' comments are apropos. When he began practice, most important innovations in anesthesia had come from dentists, surgeons or obstetricians. Only a handful of physicians had shown any interest in the biological or chemical principles underlying the anesthetic state. Most important, there were virtually no textbooks to disseminate information about anesthesia, journals to stimulate research, or societies to set standards for education and practice. Within fifty years, however, this situation changed. Not only had anesthesiology become a medical specialty, it had attained the hallmarks of a profession. In large part, Ralph Milton Waters served as a major stimulus for this transformation.

The papers assembled by Dr. Lai in this volume illustrate Waters' seminal role in the transformation of Anesthesiology. As shown in this book, Waters described the lowly state of anesthesia theory and practice in papers published as early as 1919. Later papers set out Waters' ideas about the education and training needed to prepare physicians for the practice. His requisites included a sound background in general medicine, because he knew that anesthesiologists must deal with all kinds of disease, as well as training in basic science and research. Waters stated clearly and repeatedly that the practice of anesthesia should not be consigned to individuals who serve simply as technicians, no matter how facile they may be with their hands.

Waters' papers provide considerable insight about the methods he used to achieve his goals. He was an articulate and persistent publicist for improvements in the teaching and practice of the specialty. He formed close personal and professional relationships with others who were also working for the same goals, McMechan, for example, who founded the first journal, McKesson, who improved equipment, Leake, who was a basic scientist, and Guedel and Rovenstine, known primarily as educators. The research papers included here illustrate another facet of Waters' efforts to improve anesthetic drugs, equipment and safety practices. The list of 'Waters Residents.' shows just how far his influence spread. A large number of current leaders in prestigious Anesthesia Departments owe their professional roots to Madison, Wisconsin and this remarkable man.

Characteristics that define a profession are dedication to the education of its members, to improvements in its practice through research, to the dissemination of information and to the development and enforcement of high ethical standards. The papers assembled here show that Ralph Waters saw in the crude practice of Anesthesiology in 1918 the potential for a profession that could benefit the public good. Waters articulated his vision, and showed others how to bring it into being. Such clarity of purpose should be honored now when our profession is under attack by so many outside forces. Dr. Lai's collection of these papers is a fitting tribute to the life and work of Ralph Milton Waters.

Donald Caton, M.D.  
Chair, Publications Committee  
Wood Library-Museum of Anesthesiology  
June 6, 2002

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A magical combination of wonderful teachers, colleagues, friends and family is responsible for the genesis of this book. At the University of Rochester Medical Center Department of Anesthesiology, Strong Memorial Hospital, Rochester, New York, where I trained, I was surrounded by the legacy of the three chairs: Alastair Gillies, Ronald Gabel, and Denham Ward. Dick Wissler told me to “Say Hi!” to Don Caton, which I’m glad I did. My advisor Mike Richardson told me that there are going to be history books, and someone has to write them. Doug Bacon whetted my interest in history while he was next door at Buffalo before moving to the “other” Rochester. Doris Cope introduced me to the Anesthesia History Association, through which I have met so many giants of our field: Lucien Morris, Carlos Parsloe, Ted Smith, C. R. Stephen, Leslie Rendell-Baker, Selma Calmes, Gerald Zeitlin, A.J. Wright and many others. International colleagues I am fortunate to have met include Jean Horton, Tony Bennett, Thomas Boulton, Michael Goerig and J.C. Diz.

I thank *my* “Chief”, Carol A. Warfield, for her support and encouragement as well as two other important commodities – time and money. Other generous supporters include the Wood Library- Museum of Anesthesiology, Mark Schroeder and Susan Goelzer from the University of Wisconsin Department of Anesthesiology, and Abbott Laboratories. The person most responsible for the publication of this book is Patrick Sim, Wood Library-Museum Librarian. An early supporter of the book when it was only an idea, he gave it direction, purpose, and nurturing. Once the book became a reality, he was invaluable in coordinating the whole project including working with our printer Roz Pape. I am deeply grateful to the WLM Publications Committee, the WLM Board of Trustees, and WLM President Kathryn McGoldrick for approving this project. Without Judy Robins’ bibliography of Ralph Waters, I never would have seen the whole picture; without Karen Bieterman’s help in obtaining copyright permissions, there would be no picture to see.

Finally, I thank my sister-in-law Christine Mihevc for drawing the delightful cover of the book, my wonderful wife Marianne for coming up with the noble title of the book, and Don Caton for writing the insightful Foreword to the book as well as inspiring me to research and study the history of anesthesiology.

David C. Lai, M.D.  
Boston, MA  
June 6, 2002

## PREFACE

The inspiration for this book of selected reprints of the writings of Ralph Milton Waters is “The History of Anesthesiology Reprint Series” published by the Wood Library-Museum of Anesthesiology. Of the thirty annual volumes published thus far from 1971 to 2000, twenty percent feature a work by Waters. These six articles are present in each of the first three decades of publication of the Reprint Series: *Clinical Scope and Utility of Carbon Dioxid Filtration in Inhalation Anesthesia* reprinted in Part V Carbon Dioxide Absorption (1975), *Pain Relief for Children* reprinted in Part IX Pediatric Anesthesia (1979), *Closed Endobronchial Anesthesia in Thoracic Surgery: Preliminary Report* reprinted in Part X Endotracheal Anesthesia (1980), *Pioneering in Anesthesiology* reprinted in Part XXI Views of Our Specialty (1991), *The Down-town Anesthesia Clinic* reprinted in Volume XXII Ambulatory Anesthesia (1992), and *A Study of Morphine, Scopolamine and Atropine and Their Relation to Preoperative Medication and Pain Relief* reprinted in Volume XXV Morphine: Part of the Anesthetic Regimen (1995). Volume XXVI Anesthesia Organizations (1996) features an article by C. R. Stephen on the Anaesthetist’s Travel Club, of which Waters was a founding member. Waters is described as “... fair at all times, personable, level-headed and a sound thinker, exemplified by his love of smoking a pipe. Teaching was a prime motivation in his life, and his residents idolized him for what he stood.” In his own words, Waters states, “The foundation of any specialty is dependent, I suppose, first upon men, second upon publications and third upon organizations through which men meet for mutual development by exchange of ideas.”

The purpose of this book is to provide a compilation of select writings of Ralph Milton Waters, as there is none currently available. I feel this is extremely important, especially in light of the recent ASA Newsletter September 2001, Volume 65, Number 9 – Ralph Milton Waters, M.D.: Roots, Branches and His Undying Legacy as well as this conference in Madison celebrating 75 Years of Ralph M. Waters and Professionalism in Anesthesiology. As the explosion of medical literature continues unabated at a frightening pace, older literature becomes harder to find, *if one knows what to look for*. I hope to highlight some of the lesser-known works of Ralph Milton Waters and make them readily available, so that one may spend more time appreciating what he has done for the field of anesthesiology. An example of this is the second section, “AUTOBIOGRAPHY”, with the complete references following the main article in sequential order.

I hope you, the reader, have as much enjoyment reading this book as I had creating it. I leave you with the mantra of one of my favorite teachers, P. J. Papadakos, from the Strong Memorial Hospital, University of Rochester Medical Center Department of Anesthesiology, Rochester, NY:

“The teaching lamp ... is lit.”



# ***BIOGRAPHY***

Abstracted by David C. Lai, M.D., from:

**Gillespie NA. Ralph Milton Waters: A brief biography. Br J Anaesth. 1949;21:197-214**

All quotations are from the cited article.

#### RALPH MILTON WATERS: A BRIEF BIOGRAPHY

By Noel A. Gillespie, D.M., F.F.A.R.C.S., D.A.

Associate Professor of Anaesthesia, University of Wisconsin

Ralph Milton Waters (RMW) was born into a family of pioneers. On his father's side, the Waters came from England to Salem, Massachusetts in 1604. They journeyed westward in 1810 to form present day Gustavus, Ohio. On his mother's side, the Scots emigrated from Ipswich, England to found Ipswich, Massachusetts. The Scots were also among the first inhabitants of Hartford, Connecticut. In 1789 Aaron Scott moved to "The Connecticut Western Reserve" where present day Scottsburg, Ohio is named in his honor.

RMW was born in North Bloomfield, Ohio. An early example of his inventiveness was using pet lambs to help deliver milk from the family farm. The Waters family moved to Austinburg, Ohio when RMW was eight where he attended the Grand River Institute.

From 1903-1907 RMW studied at Adelbert College of Western Reserve University, followed by medical school also at Western Reserve University. RMW worked as an orderly in various Cleveland hospitals as well as serving a formal internship at Cleveland German Hospital. After receiving his M.D. in 1912, RMW moved to Sioux City, Iowa, in the spring of 1913 to start a general practice. He returned to Cleveland that October to wed Louise Diehl. Back in Sioux City, RMW's transition from a general practitioner with an interest in obstetrics to an anaesthetist was accomplished "by gradual degrees". "Though it be a dereliction of a biographer's duty to allow his victim to speak for himself, Dr. Waters (1946) has described those early days in a manner which cannot be equaled by anyone else." <sup>1</sup>.

By 1915 the transition was almost complete. An early awareness of the work of Elmer Isaac McKesson blossomed into friendship, admiration and gratitude <sup>2</sup>. RMW's medical career was interrupted in 1916 by active duty in Texas as a member of the Iowa National Guard. His return to Sioux City at the end of the year marked two important milestones: his decision to specialize in anesthesia and the beginning of his interest in carbon dioxide absorption <sup>3</sup>. In 1917 RMW joined McMechan's Society, later known as the National Anaesthesia Research Society.

RMW's first paper<sup>4</sup> deals with the issue of non-physician anesthesia providers; his second with ambulatory anesthesia<sup>5</sup>. In 1924 RMW took over the practice of an anaesthetist in Kansas City, Missouri. The Waters family spent three years there before moving to Madison, Wisconsin. RMW's circle of friends expanded to include not only Frank McMechan and "Ira" McKesson, but also Albert Miller<sup>6</sup> and Arthur Guedel<sup>7,8</sup>.

RMW's familiarity with Madison predated his younger sister's marriage to Professor Hastings of the Department of Agricultural Bacteriology, University of Wisconsin. While still at Adelbert College, RMW helped to build one of the large office



buildings near Capitol Square as a summer job. RMW moved to Madison in February 1927 to be the professional man (in contrast to a technician) in charge of anesthesia at the new State Hospital. His family joined him in the fall. At Madison, RMW continued his practice of keeping anesthesia records<sup>9</sup> as well as his carbon dioxide absorption technique. The department gained support from the hospital due to the savings realized with this technique.

One of the most important educational forums was the weekly “Staff Meeting<sup>10</sup>”, a ‘Morbidity and Mortality’ or ‘Clinical Conference’ meeting. A unique aspect was: “. . . Because it is good experience it has become the custom for the residents in turn to assume the Chair at these meetings. In an effort to curb our increasingly slipshod use of the language it has been decreed that he who has been in the Chair the previous week shall act as “critic” or “censor” the next week. It is his duty to take note of all solecisms, colloquialisms, or unparliamentary terms observed in the discourses of the participants; then at the end of the meeting to call the offenders to account. Though this be done half in jest, yet it has proved an efficient corrective to the use of medical jargon.” “. . . At these meetings, whose atmosphere is one of good-fellowship, the Chief’s contribution is characteristic. Though often in the forefront of the argument, he never plays Sir Oracle. Rather it is his pleasure to let hot young bloods debate vigorously their theories of how a case should have been conducted, while he listens tolerantly. When the battle of words subsides he is wont to say: “Which all goes to show that there are many ways of skinning a cat.” As is well known, he feels strongly that particular agents and techniques matter much less than the skill with which they are used.”

RMW also had a teaching plan for medical students: lectures in the third year followed by full participation in the department including administration of anaesthetics under supervision in the fourth year.

RMW’s department is described as a “benevolent autocracy”. “The Chief” not only discusses which house to buy or apartment to rent with his residents, he then helps them move. His own house is always open to the department. So that others may spend the holiday at home, the Chief has taken New Year’s Eve call for many years. Although his main relaxation is reading, he also enjoys quiet walks in the country and is an accomplished ping-pong player.

RMW was a pioneer in the early use of several drugs. Among them were tribromethyl alcohol, avertin, cyclopropane<sup>11</sup>, and Pentothal.

His common interest with Guedel in the endotracheal technique resulted in several papers<sup>12,13,14,15</sup>.

In 1936 RMW was the invited guest speaker of the British Medical Association<sup>16</sup>. While in Europe, he made a pilgrimage to Paderborn to honor Serturmer; while in London he visited the neglected grave of John Snow in Old Brompton Cemetery. At Oxford RMW gave a perfect demonstration of cyclopropane anesthesia for a five-minute appendectomy by an Oxford surgeon. “In the few intervening moments the operating conditions had been all that the most exacting surgeon could demand.”

RMW held many important positions, including 2<sup>nd</sup> President of the American Board of Anesthesiology and 1<sup>st</sup> Chairman of the American Medical Association of Anesthesia. His role as Chairman of the Sub-Committee on Anesthesia of the National Research Council during WWII produced the monograph “Fundamentals” for the

instruction of 17 medical officers and students. For the 100<sup>th</sup> anniversary of chloroform<sup>17</sup>, RMW and his department investigated the drug with modern methods and practice as if it were a new drug.

Honors bestowed upon RMW include: the 4<sup>th</sup> Henry Hill Hickman Medal in 1944, the Irving S. Cutter Medal by his medical fraternity Phi Rho Sigma in 1946, and the Order of Vasa from Sweden in 1947. The Cutter Medal citation reads: ‘Not only has he contributed significantly to the art and science of anesthesia; he has been a leader in the development among physicians of a truer perspective concerning this important specialty. To-day he speaks for anaesthetists and for thoughtful physicians the world over, in his insistence upon this specialty as a branch of medicine rather than as a technical craft.’ Countries represented among RMW’s residents include Sweden<sup>18</sup>, India, Britain, China, Argentina, Finland, Mexico, Brazil<sup>19</sup>, Peru, and Uruguay.

Dr. Geoffrey Kaye’s impressions of the department are a fitting conclusion. The individuality of Madison reflects RMW’s personality, including his uncompromising scientific honesty and originality. Criticism such as “a bad article, and I am sorry you wrote it” may make one feel “naked and ashamed”, but is never hurtful as RMW is an equally severe self critic. The emphasis on failures rather than successes is for the common good, and inspires one to do better. His ever-present pipe may be withdrawn long enough to comment “However thin he slices it, it is still baloney.” RWM is well known for his work on carbon dioxide absorption and cyclopropane, but more valuable are his teachings of avoiding self-complacency, recording one’s work, and reviewing the record with an honest and fearless mind.

Dr. Kaye ends with:

“I should be a bad Moslem, I fear, for I demand not one but many Meccas. Of my Meccas of anaesthesia, however, Madison will ever remain amongst the most rewarding and the most revered. Let me end with a parable. There was once a dealer of Grimsby in England who used to store live cod in tanks, until they could be sold to advantage on the London market. Having plenty of food and no work to get it, the cod became so lethargic that the Billingsgate fishmongers complained that their flesh was quite insipid. So the dealer placed a live dogfish in each tank. The dogfish chased the cod around and gave them an interest in life, so they arrived in London in excellent condition. The lethargy which afflicted the cod is paralleled in our work by *laissez-faire* and self-satisfaction: the dogfish is the symbol of Ralph Waters.”

#### REFERNECES:

1. Waters RM. “The Development of Anesthesiology in the United States: Personal Observations 1913—1946.” *Journal of the History of Medicine and Allied Sciences*, Vol. 1, No. 4, pp. 595-606, October, 1946.
2. Waters RM. Foreword to *Some Papers on Nitrous Oxide-Oxygen Anesthesia by the late Elmer Isaac McKesson, M. D.*, edited by K. C. McCarthy. Toledo, Ohio. Privately printed. 1953.

3. Waters RM. Clinical scope and utility of carbon dioxide filtration in inhalation anesthesia. *Current Researches in Anesthesia and Analgesia* 1924; 3:20-22
4. Waters RM. "Why the Professional Anesthetist?" *Journal-Lancet*, Vol. 39, p. 32-34, January 15, 1919.
5. Waters RM. "The Down-Town Anesthesia Clinic." *American Journal of Surgery (Anesthesia Supplement)*, Vol. 33, No.7, pp. 71-73, July 1919.
6. Miller AH. Ascending Respiratory Paralysis Under General Anesthesia. *JAMA* 1925;84:201-202.
7. Guedel AE. Third Stage Ether Anesthesia: A Sub-classification Regarding the Significance of the Position and Movements of the Eyeball. *American Journal of Surgery (Anesthesia Supplement)*, 1920, Vol. 34, No. 4 pg. 53-57
8. Waters RM. "Ether Anesthesia: Relation of Plane of Anesthesia to (1) Circulatory Depression and (2) Surgical Technic." *The Journal of the Missouri State Medical Association*, Vol. 22, No. , pp. 401-402, October, 1925.  
[Read before the Jackson County Medical Society, April 28, 1925. (RMW Collection contains reprint.) Reprinted by permission in *Anesthesia and Analgesia*, Vol. 5, No. 1, pp. 41-43, February, 1926.]
9. Waters. "Teaching Value of Records." *Journal of the Indiana Medical Association*, Vol. 29, No. 3, pp. 110-112, March, 1936. [Presented before the Section on Anesthesia of the Indiana State Medical Association at the Gary session, October 9, 1935.]
10. Waters RM, Hathaway HR, Bennett JH, Cassels WH, Leigh MD, Slocum HC, Pfeiffer JC. "Anesthesia Staff Meeting, October 30, 1937: University of Wisconsin Medical School and State of Wisconsin General Hospital, Department of Anesthesia." *Anesthesia and Analgesia*, Vol. 17, No. 5, pp. 277-285, September-October, 1938.
11. Waters RM, Schmidt MR. Cyclopropane anesthesia. *JAMA* 1934;103:975-983.
12. Guedel, Arthur E., and Ralph M. Waters. "New Intratracheal Catheter." *Anesthesia and Analgesia*, Vol. 7, No. 4, pp. 238-239, July-August, 1928.
13. Guedel AE., Waters RM. "Endotracheal Anesthesia: A New Technic." *Annals of Otology, Rhinology and Laryngology*, Vol. 40, No. 4, pp. 1139-1145, December, 1931.
14. Waters RM., Rovenstine EA and Guedel AE. "Endotracheal Anesthesia and Its Historical Development." *Anesthesia and Analgesia*, Vol. 12, No. 5, pp. 196-203, September-October, 1933.

15. Waters RM. "Arthur E. Guedel." *British Journal of Anaesthesia*, Vol. 24, No. 4, pp. 292-299, October, 1952.
16. Waters RM. Present status of cyclopropane. *Brit Med J.* 1936;2:1013-1017.
17. Waters RM "Chloroform During 100 Years." *Ugeskrift for laeger*, Vol. 113, No. , pp. 511-513, April 26, 1951. Kloroform I 100 AR
18. Gordh T. Ralph M. Waters and Swedish Anesthesiology. *J. Clin. Anesth* 1994, Vol. 6,
19. Parsloe CP. Ralph Milton Waters: His Influence on the World and Me. *American Society of Anesthesiologists Newsletter* 2001;65(9):17-18.

## WHY THE PROFESSIONAL ANESTHETIST?\*

By R. M. WATERS, M. D.,  
SIOUX CITY, IOWA

I hear that some surgeon in this state is using a nurse or an office girl—I'm not sure which—to administer anesthetics to his patients. Do you know why? The only honorable reason he could give is because he believes that she can give an anesthetic better than any practitioner of medicine available in his community. Surgeons with this handicap can be found in many communities in the United States today.

To my knowledge there are three reasons why a surgeon should employ other than a medical graduate as an anesthetist: First, necessity or convenience; second, the cost; and, third, lack of proficient anesthetists among the physicians available.

I admit the convenience of employing a nurse as an anesthetist who is your individual helper and is at your beck and call every hour of the day or night. I admit the convenience, and sometimes the necessity, of allowing a nurse to administer an emergency anesthetic when no one else is available, just as I admit the necessity of the husband tying the umbilical cord in the absence of other human help at a precipitate labor; but that is no argument that we do not need to train doctors to be obstetricians. No more is the occasional necessity for a layman or a nurse to administer an anesthetic argument that we physicians should not fit ourselves to do the best work that can be done in that line and help to develop the science, to make it better.

\*Read at the 27th annual meeting of the South Dakota State Medical Association, at Mitchell, May 23 and 25, 1915.

Convenience is no excuse if better service can be secured for the patient in another way.

As to the dollars and cents argument I believe the public is glad to pay for the best service to be had for their sick. I make a living, and I do *nothing* but anesthesia, so I think it is true in the case in hand.

The third reason that a surgeon can advance for employing non-professional anesthetists is, as I said in the beginning, the only honorable one, namely, the lack of proficient anesthetists among the doctors available, and, I regret to admit, it is a valid one in the Midwest of the United States. Interest in the science of anesthesia has been lacking, but better times are in sight.

A decade or two ago this country woke up to the fact that the average doctor was no better obstetrician than the average midwife. What was the result? In larger towns men began to take up obstetrics as a specialty, and schools laid emphasis on obstetrical teaching for all physicians, and what a wonderful improvement we have seen!

Just so now is the country awaking, in the last few years, to the fact that the average doctor is a no better anesthetist than the average nurse, and what is to be the result? Shall we "lay down on the job," and say, "Oh, a woman is fitted by nature to give anesthetics; we will train the nurses." Did it seem wise to say that about obstetrics? And yet a woman is surely better fitted by sex to coax the budding human offspring into the light of day, if sex is an argument, then she is to guide a patient's way through the "valley of the shadow" of anesthesia. We have women physicians who are good obstetricians, and so do we have women physicians who are good anesthetists, but not because they are women simply. I do not want a midwife or a nurse to deliver my wife when my hoped-for son arrives; neither do

I wish a nurse or an office girl to anesthetize her when her appendix is removed.

"Well," I hear some surgeon say, "my nurse can administer an anesthetic better than any of my fellow practitioners whom I find available, and I shall continue to use her." If you, in your town, are sure that this statement is true I can not blame you. My paper today is a plea for better times.

I wish especially to appeal to the physicians (both women and men) in every town who occasionally give anesthetics, to wake up, get busy, and make anesthesia a part or all of your business. Do it the best you know how every time you officiate at the head of the table. Learn all there is to find out about it, and help the rest of us to do it better by adding to the developments already made. Keep records of your cases,—good results and bad,—and report them accurately. Keep abreast of the literature on the subject. You will be surprised at the amount of reading along this line that you can find. Anesthesia is a science worth while. It is not a nurse's job which you must be ashamed to have to perform—to feel concerning it as you would at being caught giving a soapsuds enema. It is a physician's job; an art, if you please, just as much as surgery is an art, and requires training, reading, and work to do it well.

A nurse's training is not sufficient foundation for becoming an anesthetist of value to both patient and surgeon. One must often use all the professional knowledge he possesses to judge the advisability of risking an anesthetic in a given case, and only the man who often gives anesthetics and watches the reaction of the patient to operation and anesthetic damage, can judge best what the prospective case will stand in time and rough procedure. Only one who makes it a study can best judge how the patient

is standing a procedure once begun. Shall the appendix be removed or left alone after a long, hard hysterectomy? Sometimes it is removed without damage, and sometimes it is a grave misjudgment to take the extra time. Can the surgeon tell? He sees a white sheet before him with a six-inch abdominal wound in the center. The anesthetist knows the pulse and respiration rates, and the pulse-pressure tendency from the beginning, and has seen the effect of the previous procedure. He can best say whether ten minutes more operating means shock for the patient or not. Is a nurse's training sufficient to fit her for such observations and judgment? But am I not right? Are there not times when every surgeon feels the need of advice as to when to quit and when to keep on? If the properly trained individual is the anesthetist, is he not the one to give that advice?

I presume that an occasional case of shock developing either during or after operation is the experience of some of my hearers. I shall therefore digress to the extent of calling your attention in a hurried way to two studies of the subject with which you are doubtless familiar, but which will bear a second consideration, I am sure. I mention them here as examples of one phase of the science of anesthesia which makes it more interesting than the giving of a soapsuds enema.

At the San Francisco meeting of the A. M. A. some years ago McKesson, of Toledo, reported five thousand anesthetics during which he had made five-minute records of the systolic and diastolic blood-pressure readings. In summing up, he stated that he believed that he could, positively, foretell the oncome of shock from his blood-pressure readings fifteen to thirty minutes before the pulse-palpation gave warning. He was right. Lately "acidosis" has almost eclipsed "shock" in interest in regard to patients who "go bad." Captain W. B. Cannon, late of Boston, and his

medical research committee of the R. A. M. C., have made the following interesting observations on wounded and exposed soldiers in France:

A man in whom are the clinical signs of "shock" as we commonly class them, has a lowered blood-pressure and a reduced alkalinity of the blood-plasma, the reduced pressure and reduced alkalinity or acidosis corresponding to a large extent in degree. Cannon's deductions as to the real relation of "acidosis" and shock,—or exemia, as he suggests calling it,—we have no time to consider here. Suffice it to say then that we have here some very interesting facts of practical value to the anesthetist and surgeon.

The time to treat shock, as we all know, is previous to its complete development. If, as would appear from these late reports from the front, blood-pressure readings can be used to foretell the onset of "acidosis," as well as shock, or the symptoms we know by that name, are not the blood-pressure readings worth while taking in every uncertain case in civil practice? Personally, I believe that if such readings were taken and interpreted in every bad-risk case, and sufficient team-work existed between anesthetist and surgeon, shock would be a very rare occurrence in civil surgery.

Will you pardon the digression? It was merely to suggest to you that there is more to anesthesia than the watching of the drops as they fall from a Squibb's  $\frac{1}{4}$ -lb. can onto a gauze mask. Anesthesia is a subject of intense interest. It is a very young science, and, I predict, it will advance very far in the next decade. Is it not worth while for one of you, in every group of physicians who work more or less in co-operation, to give it the special attention it demands? This does not mean, necessarily, an exclusive specialty. Every man must have a hobby. The art of administering anesthetics offers newness, interest, and good remuneration if it is done thoroughly

and well. The time is near when the public will demand the best that is to be had in this line. The non-professional person cannot properly give an anesthetic. Do you not think it is "up to" more of us to adopt this orphan hobby?

In conclusion: if by chance any doctor present can influence a medical-school curriculum one iota toward better instruction in the administration of anesthetic drugs, both general and local, I pray that he may exert all that influence. By that means only can the doctor of medicine of the future be saved the necessity, which must be yours and mine, of digging it out for himself.

### DISCUSSION

Dr. C. E. McCauley (Aberdeen): I was somewhat responsible for the presentation of the paper of Dr. Waters, and I feel like offering him an apology for the position in which he has been placed on the program (his paper coming after nearly everybody has gone home), because I believe it is a very vital subject.

The subject of anesthesia has been neglected in the medical schools; and up in this Northwestern country, particularly, we have gotten into pretty bad habits. I do not like to call names, but I think the Rochester Clinic has been responsible for this. They make the claim down there that a nurse makes a better anesthetist (I have heard Dr. W. J. Mayo say this) than the average doctor, because the average doctor is more interested in the operation, and is watching the operation and is not watching the anesthetic.

Possibly that is true from the standpoint of the general practitioner, or when one surgeon is giving the anesthetic and another surgeon is doing the operating, and the man who is giving the anesthetic is too much interested in the operation and is not watching his anesthetic. But that does not get away from the fact that we should have trained men to give anesthetics. It is a big science by itself. Dr. Farr has shown how hard it is to put anything new into this thing, and you will not be able to get anything new into anesthesia unless you get someone to study and work it out.

I know that in one town in this state there are several nurses giving anesthetics. Three or four of them were girls that were taken out of training schools and had never had any experience. I have had two cases where I was called on hurriedly, within six weeks, where one

of those nurses was giving the anesthetic. Both cases were diagnosed as acidosis. Fortunately, both patients recovered. I do not say it was the fault of the nurse, but I know that she knows nothing about anesthesia, and simply pours the ether on until the patient is anesthetized or asphyxiated, whichever word you want to use.

It seems to me that this is a thing that we ought to take up as medical men and use our influence to secure better educated anesthetists. Anesthesia does not necessarily mean ether anesthesia, but all lines of anesthesia. It would be absurd to say that anybody without any training can put a patient clean out of business in five minutes and hold him there, without knowing something about the fundamentals of physiology, anatomy, and the action of drugs. This thing is getting so big up in this country that, as the essayist said, if you get a nurse to give an anesthetic, there is really no inducement for a doctor to make a specialty of it, but all over the country there are experienced men who like to do that sort of work, and who are doing good work along that line and making good money out of it. If we can get a few men to follow this work, it will prove an interesting field and a remunerative field, as well.

I think the main reason that we are having nurses give anesthetics, at least up in this country, is the question of money. In most of the towns you will find some men who are good anesthetists. We have one or two in our city who are good anesthetists; but we have a fixed fee for a great deal of our work. You will find that the average fee for small work, such as tonsils, is \$25, \$35, or \$50. The average fee for major operations runs between \$100 and \$200. Suppose I do twenty-five operations a month. It would cost me \$10 for the majors and \$5 for the minors on an average where they are done under an anesthetic. I am going to pay out anywhere from one hundred to one hundred and fifty dollars a month for anesthesia, and if I can hire a girl who will keep my instruments clean, and who will do my office bookkeeping, work, etc., I can get her for about sixty-odd dollars a month, and I am making from one to two hundred dollars a month clear on that alone.

I really believe that is the reason. It is no reason at all, of course, for we should charge the cost of the anesthesia to the patient. I say, "My fee is so much," and then the other doctor's fee is ten dollars or twenty-five dollars, or whatever he charges. I try to pay him according to the fee that I get, in proportion, but never less than ten dollars. I do not know when I have paid less than ten dollars for the giving of an anesthetic.

I find that patients do not object, even in circumcisions and in opening abscesses in children where it is only a minute's work. I had a baby a few weeks ago with an abscess in the neck. The parents did not object to paying the anesthetist ten dollars, although it took not over two or three minutes. They even appreciated it. The mother came to me afterward, and said that she was glad I had had this man give an anesthetic because she knew that he was a safe man.

I think it is a simple matter to educate people as to the seriousness of anesthesia, and just as soon as you do that, and the anesthetists find that they are going to get enough of that work to pay them, they will become interested in it.

Another thing against the use of nurses in this work,—and possibly it can be said against all of us,—is the fact that the average nurse has absolutely no previous record of the patient, and if she had it would do her no good. The anesthetist should examine the patient the night before, and take the blood-pressure on the evening before and in the morning. He should know exactly what condition the patient is in. How many patients do we have that ever have a urinalysis before their operation? I am referring, of course, to small operations. How many have blood-pressure records taken, or anything of that kind? There should be a good anesthetist in every town the size of Mitchell, where we are holding this meeting, who could give properly any anesthetic, and check up on patients twenty-four hours, or as many days, before the operation as necessary, and get them in good shape.

I had a patient come into my office not long ago with a systolic pressure of 80, and a diastolic of 50, and it had been planned to have a serious operation the next day, with a nurse to give the anesthetic. No examination had been made; and the man had a frankly surgical condition, of which anybody could make a snap diagnosis; and they were going to operate. And what would have been the result if he had gone through a serious two-hour operation? I put him in the hospital for a few days, got the blood-pressure back to 100 systolic and 65 diastolic. This patient went through a rather stormy convalescence, but he got well.

It seems to me that we ought to bring this thing home to all the men who are doing surgery, and all of us are doing surgery to a certain extent. Of course, there are cases in country towns where the operator has to employ the husband or the wife or the hired man, or an office girl, to give the anesthetic, but that is not true

of the men in the towns where there are two or three doctors at least.

DR. D. W. CRAIG (Sioux Falls): This is a very important subject, and the paper we have just listened to is not going to revolutionize the question of the administration of anesthetics at once. It may work in gradually and change the methods later, to a large extent, but it is going to take time. The doctors in the different cities are going to continue to use ether. Possibly some other anesthetic will be invented or discovered which may supersede both of them.

But I am very much interested in the administration of ether. I have studied it a great deal, and a few years after I graduated at Northwestern I became a demonstrator in the use of ether at the Northwestern Dental School, and became very well acquainted with the use of it. I believe I can give a fairly good ether anesthesia; however, I am willing to at any time give it up when we find anything better.

But the point the doctor makes, that it should be given by a specialist, some man who is well acquainted with and knows how to handle it, is a very good one. I think the time will come, if we continue to use it extensively, when possibly we shall discover some method of giving it, besides the present method, the open method, and I think that warming it and giving the vapor from a cylinder, mixed with nitrous oxid and oxygen at pleasure,—I believe that is another field which will be developed much more than it is at present, and probably will come into wider use than now. But it is expensive, and requires some one who thoroughly understands the giving of it to administer it effectively and safely.

I am very much interested in the subject, and I am sure that the best method will prevail, and that is what we want.

DR. MORTIMER HERZBERG (Vermilion): There is a matter with reference to local anesthesia which has been brought out very nicely this afternoon. In my limited experience, there is one thing which has astonished me in seeing work in some of the clinics, and that is the crudeness and lack of consideration with which the patient is treated previous to the operation. My previous experience has been in the East. I have never seen, until I came here, them take a patient in almost any surgical condition, walk him into the clinic, pile him on a table in front of the nurses and every one else, and before he was under the anesthetic start to strap him down on the table. I think that is just abattoir work.

In the East the poorest and most humble patient, who pays nothing, who may stay in the hospital for a month, at the public charge, is taken into a private room where things are quiet. He is put in bed a day or so before the operation, if possible. He is carried out on a cot by the orderlies and the nurse. The patients are taken into a private room, and under pleasant circumstances are given their anesthetic, and then carried into the operating-room. How you are going to overcome the shock of taking a patient into the operating-room, as above described, is more than I can say. I think it is very crude, and I should like to see that changed in the Northwest.

DR. R. E. FARR (Minneapolis): I would like to say that if we had enough men like Dr. Waters, or had had such men twelve or fifteen years ago, in the country where I work, I probably never would have been doing very much local anesthesia work. My experience was just like the experience of everyone else. Years ago I started out with the internes giving the anesthetic. In those days I was young and husky, and I threw one interne clear across the room once, and he hit the door of the operating-room, and I do not think he came back. I caught him three times during the operation turning his back on the operation and talking to a nurse. The first time I did not speak to him, but the third time I started into him. If we had had that sort of thing such as Dr. Waters described in those days, we would not have gone into local anesthesia.

There is no question in my mind but that general anesthesia can be made very safe. The only trouble is, we are up against actual conditions as they exist, and you take it in the Northwest here, how are you going to get the doctors in Minneapolis to give anesthetics for you? At St. Mary's I tried to hire a physician to give my anesthetics, but they would not allow me to take the physician into that hospital or I would have to leave the hospital. I was not strong enough to put it over. They wanted their internes to have the experience. The internes were no good; they were not under my control or under the control of the superintendent of the hospital; they were under nobody's control. They knew more than any of us. And I myself knew twenty times as much as I do now, when I was an interne.

I went to another hospital, and I tried to do the same thing. I said I must have my own anesthetist. They said no, we have these nurses, and they must be trained, and they are going to give the anesthetic. Finally, after I had a long, long fight, they finally put in a couple of physicians. They happened in this case to be women who had made a failure of practice. Unfortunately,

the professional anesthetist who is a physician in this country is largely that type of individual. He is a man who cannot get business any other way, and he goes into anesthesia. He is willing to take the business of giving anesthetics because he can make a bare living at it.

The reason we have not better men or a larger number of good men giving general anesthetics, is that we do not see that they are properly paid. If I were going to do an operation under general anesthesia, and knew that it was to be or had to be general anesthesia, or was going to have it done on myself, I do not think twenty-five dollars is any too large a fee for such an individual, or fifty dollars or even one hundred dollars. In many instances the anesthesia is more important than the operation itself.

But we are up against this proposition. This war is going to have this influence. We are not going to have physicians enough to give anesthetics, and the nurses are being worked in to give anesthetics. And when the war is over they are coming back here, and they are going to continue to do it; and we are up against that sort of thing.

We are going to lack physicians for the next ten or fifteen years, if the war goes on here yet, and what are we going to do about it? My notion is that if we have men like Dr. Waters, enough of them, then the problem is pretty well solved.

It is desirable to know in what way the patient had been handled while you are away. Crile tells of his experience, what he knows now compared with what he knew before the war began; and you will get a different viewpoint, those of you who have heard him. He has stayed in the hospital for twenty-four hours at a time where he used to stay down simply in the forenoon only. He found out what went on in the afternoon and evening and in the middle of the night, and I believe that every surgeon would do well to do what I have done, to go back and live and stay at the hospital afternoons and evenings for a while and make a psychological study of this thing.

I went back and I staid there, and I had not started to do it, but I staid there to see what happened to those patients. You get a viewpoint such as the nurse gets, if she is interested, and you find out what the condition of the patient is in the afternoon and in the evening and at night. I will bet you, if you take 100 cases and let some unskilled anesthetist take care of them, and then let Dr. Waters take 100 cases of the same type, the same men operating, you will find an entirely different proposition.

The proposition of handling the tissues—the anesthetic will govern the way the tissues have to be handled, even with the same men doing the work. The individual who is not properly relaxed will have to be fought. The tissues will have to be fought. I have seen it over and over again, in just packing the abdomen, and pushing back those intestines that are trying to force their way out, which never occurs in any proper anesthesia. I mean, as a rule. That patient can be sent almost to death, just in packing the abdomen to get ready to take out a pair of pus tubes. I have seen it over and over again.

I would like to see professional anesthetists with "M. D." after their names, but it is going to be a proposition to educate the laity.

My people will pay out the money for these anesthetists if I impress them with the fact that it is necessary. You have got to handle the hospital people, and this nurse proposition, and you have the biggest clinic in the United States, and those that exert the most influence against this other thing.

I saw it at a large clinic in the West here within the last month,—and I saw at least half a dozen blue patients each day when I was there, blue all the way through the anesthesia and straining and fighting, and the surgeons fighting the abdominal viscera, and the nurse giving the anesthetic sitting there smiling and talking with other nurses at the side, and looking towards the visitors; I don't know what their idea was, but they were not looking at the patient.

I don't know how we are going to overcome this, but I believe that such cases as Dr. Waters has brought out here today,—and it is too bad that more of the society did not hear it,—will be a good thing.

DR. FRANK I. PUTNAM (Sioux Falls): This is a day of specialists.

When a patient comes to me for an operation I say, "Who do you want to put you to sleep?" "Whoever you say," they almost always say. "Well," I say, "it is always my custom to have your family doctor." You can say that when you have been in the place long enough to have seen all the men who are doing general practice and giving anesthetics. I have seen them give anesthetics. They are all good, but some are better than others. Personally, I have given one anesthetic, and that was about a week ago, on a little child about three weeks old with a case of strangulated hernia. That was an emergency case, and I gave the anesthetic. I believe that if a man would locate in Sioux Falls as a specialist for the giving of anesthetics, he would make

a good living. When a patient asks the question, "Who do you want to have put me to sleep?" you can say that there is a specialist in that particular line there, and they go for him.

Dr. WATERS (closing): In regard to the possible objections on account of the fee for the giving of an anesthetic: It occurs to me to tell you an experience which I had along that line. When I started out I used to depend on the surgeon for the collection of the fee, as it seemed to have been the custom in that town to have it done that way. I found it very unsatisfactory because sometimes I did not get my fee. For the last several years my custom has been to collect my own fee directly from the patient, usually at the time of operation. My business is almost all cash. The people do not object. They know to whom they are paying the fee, and when they come to pay the surgeon's bill they have forgotten about this, and it does not look as if it was tacked onto his bill, and it seems to get by, and they digest the idea of paying the anesthetist a little better.

In regard to the pre-operative examination, etc., which was spoken of. Of course, I realize that is part of the anesthetist's business, and although I did not mention it, I endeavor always to do it. I take care of my own hypodermics, too, and I consider it a part of my business to make this pre-operative examination of the patient before the anesthetic is given. I find that oftentimes a surgeon is too busy or forgets to think about that. The anesthetist often does not see the surgeon until he gets to the operating-room. If the surgeon tells them what to expect and how to go about it, they would do better. They are better satisfied in every way. I do not have any difficulty at all about the fee with the people. The biggest kick I have is sometimes from the surgeon, because there are surgeons who are a little suspicious of me if I get twenty-five dollars or fifty dollars for giving an anesthetic, and they think that is more than I ought to have, if they get three or four hundred dollars for the operation.

I believe it is worth that amount if the work is fairly well done. It is not the people who do the kicking. I have many cases come to me on account of the insistence of the patients, and in spite of the surgeon, sometimes. But I think the surgeons mostly appreciate good anesthetics, and are glad to have them, and I think it is well worth any man's time to take this work up, and at least to pay attention to it.

The subject of ether anesthesia has come up quite extensively. I would like to say an additional word in

regard to that. I do not believe that ether is our perfect anesthetic at all. I believe, as an adjuvant in combination with nitrous oxide and oxygen, ether is very useful in some cases, but I believe that we have in nitrous oxide and oxygen, with possibly sometimes the addition of ether, a very close approach to the ideal in general anesthetics, which Dr. Farr has shown in his pictures this afternoon on local anesthesia. I will admit that Dr. Farr's technic is hard to carry out successfully, as he carries it out. It is a thing which one must spend some three years on in order to perfect the technic in local anesthesia. I believe it is necessary also for a man to spend as much time and attention in the technic of nitrous oxide and oxygen anesthesia. It is necessary for him to be doing it every day. If he goes away for six months and comes back he finds that he is rusty, and it takes him some time to get back on the job. The technic is of such a fine nature that you have to keep at it every day and study it right along in order to keep up.

There is a development the world over in the administration of anesthetics and in nitrous oxide and oxygen, particularly because that is receiving more attention from men who have gone into the subject in detail, because it seems to be the nearest to the ideal. There are being developments made every day and every month that are well worth while to keep the men reading and to confine their reading almost exclusively to that which relates to anesthesia and anesthetics. Almost everything has some relation to it, as far as that goes, but I find a great plenty of literature to occupy all the spare time I can get.

It is an interesting subject that is well worth any man's time in taking it up, at least as a hobby, along with his general practice, if he is not exclusively specializing. And in any town of reasonable size, such as Sioux Falls, I feel very sure it would be without question but a very short time until a man would make an abundant success of it in a material way, in confining himself absolutely to anesthesia.

The surgeon comes to appreciate and depend upon you, for it takes a lot of worry off of his mind. I have in mind a man who used to have lots of worry. He was conscientious, and he worried lots about the anesthetic, but he has come to depend upon me exclusively now for that part of it. He happens to be a specialist of the head variety, and he is not up on chest-work, and I make it a habit to go over his cases very carefully.

Within the last week he called me to the hospital on a certain occasion to give an anesthetic at a certain time. I believe the time was eleven o'clock. I got there

about an hour and a half before he did. I was in for another case; and the patient was just arriving. This young man had had an acute cold with tonsillitis and had recovered. He was in the office of the doctor, and thought he was sufficiently over his cold—he seemed to be all right. The surgeon thought he would operate on him because the tonsils were evidently seriously damaged and apt to cause another attack of the kind which he had had.

In going over him I found that he had quite a quantity of albumin in his urine, at least noticeable, and the blood-pressure apparatus showed his blood-pressure very shallow. I suggested that the doctor wait a week; and he asked if this young man could appear in his office in a week. The week would be up Saturday, and I heard that this patient was sick in bed with a temperature of 103.° Had I given him the anesthetic and had his tonsils been taken out on the occasion suggested we would doubtless have been blamed for the fact that he was laid up now, and things would have been in rather an embarrassing situation.

It is the little things which surgeons do not take time to do themselves that are the things that help surgeons, which are appreciated by them. It is just an illustration of what use you can be, and to show you that it is worth while to take the thing up.

I think in every community, even in those which are very small, a man can still do general practice and pay special attention to anesthesia to such an extent that it will be worth while.

I thank you for your very kind reception of a subject which I had not expected would be of especial interest to you.

THE DOWN-TOWN ANESTHESIA  
CLINIC.\*R. M. WATERS, M.D.  
SIOUX CITY, IOWA.

The subject assigned to me is so foreign to the thoughts uppermost in the minds of us all that I feel almost a slacker in presenting it. However in due time the war will be over and it is possible that many of us may land, thereafter, in new locations. In case we do I feel sure that a short story of my experiences may be of some value.

In 1915 my practice consisted largely of anesthesia and I was using my home as telephone headquarters with no office whatever; doing largely anesthetics for major surgery in the various hospitals. An occasional call from a dentist however broke the routine and in many such cases the dentist and patient alike objected to going to the hospital both because of the time and expense involved. It was suggested to me that a down-town office equipped to care for dental and minor surgical cases would be useful, as we had no exclusive specialist in exodontia in our town, and some surgeons were also anxious to establish extra hospital clinical facilities.

After the Mexican border demobilization in 1916 I made bold to try such a plan, my practice from that time being confined exclusively to anesthesia. An office was equipped with a waiting room and a small operating room with an adjoining room containing a cot on which a patient could lie down after his anesthetic. In due time the place became popular and we moved. I say *we* for two reasons. First, it avoids a too egotistical repetition of the pronoun *I* and second, chiefly because my office assistant, a girl of twenty-one, has been more than half responsible for the success of the experiment. Her interest and faithfulness have made it possible to make definite dates and keep them properly, and see that no dentist or surgeon has felt himself slighted or inconvenienced. I bespeak for any of you, who may make a like venture, a careful selection of your assistant and I wish you good luck.

In February 1918 we found ourselves with three units of floor space in the newest and most central office building of our town. The popula-

tion is 65,000 and we have a hundred doctors and fifty dentists in peace times. In this building some fifty doctors and dentists have their offices. We are equipped with a large reception room with easy chairs and reading matter to divert the attention of fond relatives. Our operating room is of ample size with large south and west windows. In it we have a modified French chair-table such as you have seen Drs. McKesson and Denman use in Toledo for tonsillectomy and nose work. This we find very convenient for the dentist's use also, as it can be tilted into a half reclining position readily and quickly back to the head-forward position during recovery after bloody extractions. It also makes an excellent flat operating table. We have also a dental engine, a sink with foot pedals to turn on water and a sterilizer for instruments, gauze, towels, gowns, et cetera, and a sterile water tank. In short the usual equipment for a minor surgery room. The sterilizer, however, we plan to replace with a better one in an adjoining room which we also use for storage of supplies.

To each side of the operating room is a room containing two or three cot-beds; separate doors open into each room through which the operating chair will roll with ease. Thresholds for such a door we have found are a nuisance and should be removed. One of these rooms we use for female patients and the other for males. There is running water in each, a mirror, etc. One thing we miss very much is a toilet and one should not be forgotten when planning such a place in a new building.

In addition, off the men's retiring room, I have a private office with desk and chairs which serves also as a good loafing and smoking room and a place in which doctors can wait when they are early; it has a separate exit to the building corridor.

Our hospital work with major surgery still occupies half our times and makes up half our income but that is mostly accomplished in the earlier part of the day. The down-town work consists of noon-time and afternoon appointments and occupies time which would be otherwise idle.

Dentists bring all sorts of difficult extractions and painful cavity preparations. Surgeons bring circumcisions, abscesses, and fractures and are gradually bringing more minor operations as time goes on. The head specialists bring some work and they too are gradually bringing more.

\*Read during the Fourth Annual Meeting of the Interstate Association of Anesthetists with the Indiana State Medical Association, Claypool Hotel, Indianapolis, Ind., Sept. 25-27, 1918.



Some dentists who used to attempt their own anesthesia now bring it to us. Others still do their less difficult cases and bring the more difficult ones to us. We take all sorts of cases, always attempting to give satisfaction regardless of expense. I mean we don't save anesthetic agents and let the patient feel the operation. We make careful physical examination on all suspicious risks. Others are accepted as they come. A sphygmomanometer and stethoscope are constantly present and frequently used. Here again the well trained and alert assistant is useful. She often warns me that the next patient is short of breath or shows some other evidence of needing careful examination.

We attempt, as I said, to give satisfaction to operator and patient and charge a fee that will pay expenses and a good profit. We make no fees in advance and have no set prices. Sometimes one tooth extraction takes ten seconds and sometimes it takes an hour and a half. The cost of materials and the value of our time make it necessary to gauge the fee by the work. Our minimum fee, with present cost of materials is seven dollars, the maximum is usually not over fifteen dollars. In other words our fees are considerable less than for similar work in hospital because less time and trouble is involved.

As to anesthetic agents used we aim to use  $N_2O-O$  as a routine. In particularly nervous patients we use as preoperative sedatives morphin and scopolamin, sublingually, as a rule. Ether we add very rarely and of course no chloroform for we do not use that even in the hospital.

We keep a card record of every case with physical findings when made, approximate weight, sex, complexion, and other details and also the assistant's estimate, each time, as to the degree of satisfaction to patient, surgeon and dentist. Also a record of what work was done and the length of time.

As to the satisfaction of my patrons. I think I can say this: there are none who have fault to find with our work. We aim to keep an abundant supply of  $N_2O-O$  and use it freely. Many patients and some doctors object to the fees but they come back and their friends come back. Satisfactory anesthesia and too large fees work out better than bargain sale fees and unsatisfactory anesthesia; especially as in open mouth work one cannot wisely be over economical of gases when using  $N_2O-O$  anesthesia. People forget the fee but they never forget the hurt nor fail to tell their friends about it.

We have made no start with local anesthesia as yet but have plans regarding it for the future. I believe it a very useful addition in connection

with such an establishment as I am describing. I know that many dentists would appreciate such service greatly as they prefer not to bother with learning the technic of local nerve-blocking and would feel safer in employing one who devotes his time to such work.

As to the preoperative preparation of patients we worry little about it. We prefer, when possible, a light meal for the last before the operation. Liquids are allowed at all times. Much of our work is done just before or during the noon-hour because patients have then an empty stomach and at the same time we do not disturb the usual routine of the patient in regard to eating. Every patient takes off his or her outer garments above the waist and corsets are removed by the women. A sheet serves as drapery when coming to the operating room. Every case must go to the toilet before undressing.

As to the after-care the only difficulty is to be sure that patients with blood in mouth or nose, spit it up and do not swallow it. That we accomplish by using pharyngeal packs during the operation when necessary for dental work and by changing to head forward position before removing the pack. The patient is usually awake before the pack is removed in such cases. Then the lateral position in the cot with face turned down by the pillow makes it easy to expectorate without rising up in bed. In this way we have little swallowed blood and little vomiting. The time required for recovery varies from one minute to three hours. Occasionally a woman in poor health who has been nauseated requires help to get home but this occurs rarely.

As to the success of the venture I think I can say that the men who are familiar with the place are well pleased. The place has been running in its present location now for eight months and is paying my total expenses with a nice profit besides.

I hear objections both from doctors and patients as to prices, occasionally. That bothers me not at all. I attempt to pay expenses and a net fair fee for myself in each case. I don't care to work on any other basis. The one thing I do strive for is to satisfy patient and operator. If I fail in that I wish no fee and I collect none. In the long run I believe that plan wins out.

As for *business getting* activity it is all with the dentists and physicians. The place is for their use and their convenience and consideration for them comes first. If Mrs. Jones calls up in regard to an anesthetic, because her neighbor Mrs. Brown was pleased, I ask after Mrs. Brown's health and tell Mrs. Jones to make any arrangements she sees fit with her dentist or

doctor. His office calls mine and makes the appointment.

One point which we lay emphasis upon and which I think is a business getter is prompt collection direct from the patient. We never bother a physician or dentist about a patient's bill. A statement is rendered before the patient leaves the office and seventy-five per cent pay them. If there is to be a loss we assume it, preferring not to bother the doctor with finances. So we avoid making an enemy of the doctor and patient alike, for every patient who owes you is your enemy.

The future for such a venture, I believe, is

bright. I know ours is not yet half-grown. Several additions have been planned for the immediate future; one, a permanent graduate nurse assistant. So far we have only employed the extra assistant as occasions demanded.

We have considered seriously the manufacture of our own N<sub>2</sub>O also. Frequently other additions suggest themselves or are suggested by physicians and dentists. When the war is over I trust many of you may develop down-town minor surgery and dental clinics of much larger scope.

539 FRANCES BLDG.

*Some Papers On*  
**NITROUS OXIDE-OXYGEN**  
**ANESTHESIA**

*by the late*

ELMER ISAAC McKESSON, M.D.

Director of Anesthesia, Lucas County Hospital; Consulting Anesthetist to Flower Hospital and Toledo Hospital; Anesthetist to St. Vincent's Hospital, Toledo State Hospital and Toledo Dental Dispensary, Past President of the National Anesthesia Research Society, The Interstate Association of Anesthetists and of the Academy of Medicine of Toledo and Lucas County. Fellow of the International College of Anesthetists and of the American Medical Association, etc.

*With a foreword by*

RALPH M. WATERS, M.D.

EMERITUS PROFESSOR OF ANESTHESIA, UNIVERSITY OF WISCONSIN

*and a Biographical sketch by the late*

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*Edited by*

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TOLEDO, OHIO

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## FOREWORD

*Doctor E. I. McKesson* was given the unique privilege of helping to plant the germ of an entirely new conception of clinical anesthesia, of protecting and aiding it through its early growth and finally of witnessing its establishment in its present accomplished existence. McKesson possessed a comprehension of physiology and physics with a rare skill in mechanics, a combination unusual in the equipment of a physician. At the beginning of the present century, the production of surgical anesthesia had become a technical procedure of little interest to thoughtful members of the profession. McKesson was one of the few individuals whose efforts served to initiate that renewal of scientific interest in anesthesia, the fruition of which is being realized at the present time.

A review of his writings should serve two purposes. First, it will again remind practical anesthetists of the importance of careful record keeping. The popularizing of such a routine in surgical anesthesia was due largely to his efforts. Second, certain of these papers should stimulate investigators in fundamental science to bring experimental technic to bear upon problems of saturation and desaturation of body tissues with the anesthetic gases. Many points in this regard are but poorly understood and deserve the light which laboratory experimentation can shed upon them. McKesson's fertile mind left in these papers many hints and suggestions which, if followed up, may lead to added knowledge.

It is with pleasure that I commend a rereading of these papers to every anesthetist and to the personnel of every laboratory where search for anesthesiologic truth is of paramount interest.

RALPH M. WATERS, M.D.  
*Emeritus Professor of Anesthesia,*  
*University of Wisconsin.*

Anesthesia Staff Meeting, October 30, 1937:  
University of Wisconsin Medical School and State of Wisconsin  
General Hospital, Department of Anesthesia.\*

W. H. Cassels, M.D., Chairman,  
R. M. Waters, M.D., H. R. Hathaway, M.D., J. H. Bennett, M. D., W. H.  
Cassels, M.D., M. D. Leigh, M.D., H. C. Slocum, M. D. and  
C. C. Pfeiffer, M.D., Participants, Madison, Wis.



**EDITOR'S NOTE.**—The Anesthesia Staff Meeting presented by the Department of Anesthesia of the University of Wisconsin School of Medicine and the State of Wisconsin General Hospital as part of the program of the Sixteenth Annual Congress of Anesthetists, aroused such interest on the part of those in attendance that the publication of this Staff Meeting was thought to serve a most useful purpose as a splendid example of how such Staff Meetings may be conducted with profit to all concerned and the specialty.

**Premedication and Thyroidectomy**

**D**R. CASSELS, CHAIRMAN: It is one o'clock and we are all here, I think. Dr. Leigh has a death to report.

*Dr. Leigh:* This was a 66 year old woman who had an enlarged thyroid for 40 years with symptoms of increasing toxicity for the past year. Physical examination showed a large substernal thyroid, paralysis of the left vocal cord, high blood pressure and auricular fibrillation. She had a cough and precordial pain. Her basal metabolic rate was plus 51. She was treated with bed rest, Lugol's solution and luminal gr.  $\frac{1}{2}$  t.i.d. for two weeks and her basal metabolic rate came down to plus 44. Thyroidectomy was considered advisable, although she was admittedly a poor risk.

She was given  $\frac{1}{6}$  gr. of morphin and  $\frac{1}{150}$  gr. of scopolamin 2 hours before operation and this dose was repeated one hour before operation. When she arrived in the operating room, she was asleep and a pharyngeal airway was inserted before inhalation anesthesia was started. Nitrous oxid was then administered by the carbon dioxid absorption technique. Immediately after the induction there was a sharp fall in blood pressure, but it returned to its previous level after the surgical procedure was begun. Anesthesia was smooth throughout.

On the night of the operative day, the

\*Presented during the Sixteenth Annual Congress of Anesthetists, University of Wisconsin School of Medicine and State of Wisconsin General Hospital Program, October 29-30, 1937.

patient began developing much mucus. By the end of the day she had lost her ability to cough this out and endobronchial aspirations, without anesthesia, were carried out at 2 to 3 hour intervals during the next 48 hours. The other therapy she received was digalin, oxygen by oropharyngeal insufflation, 2 doses of morphin to control her restlessness and sodium iodid, 20 cc. of a 10 per cent solution intravenously for four doses at approximately 8 hour intervals. She died on the morning of the fourth postoperative day. Postmortem showed extensive purulent bronchopneumonia and substantiated the other clinical findings.

*Dr. Cassels:* Is there any discussion of this case?

*Dr. Leigh:* A cervical block was considered for this patient because of her extreme age and because of her cardiac disability. However, it was quite inadvisable from the surgical standpoint because of the large substernal extension of the gland.

*Dr. Waters:* Does anyone wish to criticize the administration of a half grain of luminal 3 times a day for 2 weeks? The thought is that it would be possible to accumulate a rather large quantity of luminal in a patient with that dosage.

*Dr. Pfeiffer:* It is certainly true that luminal accumulates.

*Dr. Waters:* She should have been getting marked depression at the time of operation. You were able after  $\frac{1}{6}$  gr. of morphin and  $\frac{1}{150}$  gr. of scopolamin

repeated, to place a pharyngeal airway before anesthesia was begun, without any pharyngeal reflex? No cocaine was used in any of the efforts at toilet of the tracheobronchial tree? Isn't your practice, as a rule, to need some cocaine-ization? That would be evidence of considerable depression, it seems to me.

In regard to the matter of sodium iodid, not long ago a paper was published in which a group of toxic thyroid cases was studied, half of them getting iodine therapy after operation and half of them not. In that paper the direct suggestion was not made that the excessive secretions postoperatively might be due to that therapy, but the conclusion was drawn that the group *not* given massive doses of sodium iodid postoperatively did better. I am sure that from an anesthetic standpoint, the iodides are becoming a nuisance in thyroid surgery. If it must be given at the operative hour, it seems to me that it might be delayed until the patient is asleep, and the postoperative use of it I should very much question in view of the fact that iodides are supposed to increase the secretion in the tracheobronchial tree and in the pharynx. I should question these two forms of therapy very decidedly.

Considerable circulatory depression appeared soon after anesthesia started, which I think is not a rare finding in certain types of cases, and there are times when I have actually pleaded with the surgeon to start an operation with the hope that it would improve the circulatory condition and sometimes the respiratory condition of the patient as well. I think this was an example of such an occurrence, was it not? I think we may say that the anesthesia itself had little to do with this woman's death; nevertheless, I am not at all sure that some of our therapeutic efforts did not.

*Dr. Cassels:* We will proceed with the interesting cases. Doctor Pfeiffer has a case to report.

*Dr. Pfeiffer:* This is a case of a 20 year old female who was scheduled for thyroidectomy, non-toxic type. As usual, she was given a potent sedative beforehand—in this case morphin 1/6 gr. and scopolamin 1/150 gr. at 7:30 in the morning. Operation was scheduled at 9.00. When she came to the operating room, she was fairly depressed, and it was thought that nitrous oxid anesthesia would be sufficient without another dose

of opiate. However, the induction was difficult, with her blood pressure rising from 130 to 160 mm. systolic and her pulse rate increasing from 100 to 120 and maintained that level. When the surgeon made the incision, the patient moved reflexly, and it was decided to give her another subcutaneous dose of morphin. Five minutes after the hypodermic was administered, the systolic blood pressure had dropped to 130 mm. of mercury and the pulse rate had started to decline toward a normal value of 80 which then obtained for 25 minutes. The nitrous oxid anesthesia was then satisfactory for the continuance of the thyroidectomy.

*Dr. Cassels:* Is there any discussion of this case? The question seems to arise as to whether the improvement in the anesthetic condition can be attributed to the subcutaneous injection of morphin when the anesthesia became smooth five minutes after the injection, or whether some other factors enter in.

*Dr. Waters:* I think there are two points of interest in the case. Any patient subjected to thyroidectomy is a definite risk judging from my past experience. Some cases that may have a normal oxygen consumption at their pre-operative studies, prove at the time of operation to be anything but non-toxic cases so that I am usually suspicious. I should hesitate to say that 1/6 gr. of morphin and 1/150 gr. of scopolamin 1½ hours before induction of anesthesia in any thyroid case was a heavy dose. I should say that it was a minimal pre-anesthetic dose, although this case may have been an exception. We see a few of them. In the second place, what is a heavy dose of morphin and scopolamin for cyclopropane anesthesia is oftentimes an extremely light dose for nitrous oxid, and in our thyroid work here we ordinarily try to use nitrous oxid.

The second point is that in a nitrous oxid anesthesia, a great many of the difficulties encountered, even with experienced anesthetists, are difficulties involved in the matter of impatience of the anesthetist. He does not wait long enough to get a nitrous oxid atmosphere thoroughly established. He wishes to consider that he has anesthesia long before the nitrogen is removed from the anesthetic atmosphere. If he has patience enough, or if he has forethought enough to get anesthesia started early, nitrous oxid will many times smooth

itself out. It is scarcely possible for me to believe that a hypodermic given on the table, resulted in smoothing out the anesthesia in 5 minutes. I should therefore believe that probably she was a non-toxic thyroid case and the dose was an adequate premedication, and that had there been a little more time and care devoted to the establishment of anesthesia, the second hypodermic might not have been necessary.

*Dr. Hathaway:* I would like to disagree with the point concerning the effect of morphin under anesthesia. I believe that I have seen it in a number of cases, and I think I can substantiate my observations by other men on the service seeing it. I believe that within 5 minutes of the subcutaneous administration of morphin and scopolamin, or morphin alone, one can get a morphin effect on the anesthesia. I have noticed it particularly in perineal repair cases.

*Dr. Waters:* I will back up Hathaway. I think you are right.

*Dr. Cassels:* Dr. Leigh has a case to report.

#### Respiratory and Obstruction and Blood Pressure

**D**R. LEIGH: White female aged 52 years, scheduled for a thyroidectomy. Premedication, morphin 1/6 gr. and scopolamin 1/150 gr. two hours and one hour before operation. The anesthesia was started with nitrous oxid by the absorption technique, and during the first 15 minutes, there was a laryngospasm and partial obstruction. The blood pressure was 160/80. No changes in pulse rate and no changes in respiration. Five minutes later, the patient was intubated. In the meantime the blood pressure had gone up to 190/100. Pulse rate had risen from 70 to 120. Blood pressure dropped down from 190/100 to 150/90. The pulse rate during the obstruction had risen to 120 and remained at that rate. Respirations were unchanged. During intubation it was noticed that the left cord appeared to be in the midline, accounting for the partial obstruction. The anesthetic agent for maintenance was cyclopropane by the absorption technique. Following the operation, respirations were satisfactory, and there was no obstruction after the tube was removed.

*Dr. Cassels:* During induction with nitrous oxid followed by a brief period of cyclopropane anesthesia, there was a

partial obstruction. In that period the blood pressure rose considerably. After intubation, it fell and leveled off at about normal. Dr. Slocum, how would you interpret these facts?

*Dr. Slocum:* It seems to me definitely that the blood pressure went up due to oxygen want, which would tend to make you believe that it was a case where something should be done in a hurry.

*Dr. Cassels:* Has anyone anything else to contribute in this case?

*Dr. Waters:* Dr. Slocum are there any reasons other than oxygen want which might accompany obstruction and which might also have an ultimate effect on the blood pressure control mechanism? What are the functions of respiration which, when interfered with, may cause a rise in blood pressure?

*Dr. Slocum:* One is for carrying the agent, one is to carry oxygen, and one is for elimination of carbon dioxide.

*Dr. Waters:* And one other. There is a rhythmic change in thoracic pressure during the respiratory cycle which, when interfered with by obstruction, may affect blood pressure. It is my impression that if there is a disturbance of the blood pressure control mechanism, be it from respiratory obstruction, cardiac or whatever, once the blood pressure mechanism is disturbed, it rarely completely reestablishes itself until the anesthesia is finished. You started, I believe, with a systolic pressure of 130, which went to extreme heights, and even after intubation and apparently complete reestablishment of normal physiology in so far as it was possible, still there was a systolic that was 150 or something of that sort well above the normal. Once you have disturbed the mechanism of blood pressure control, it tends to continue.

*Dr. Pfeiffer:* Do you find that that sort of a patient is more apt to have circulatory collapse.

*Dr. Waters:* Later on? That is a point on which it is difficult to be positive; nevertheless, I think that we have that sort of a hunch in our minds.

*Dr. Cassels:* I would like to ask Dr. Waters if he has any explanation for the rise in pulse rate?

*Dr. Waters:* Isn't it usual to have an accompanying rise in pulse rate when the blood pressure goes up?

*Dr. Cassels:* It occurred after the intubation.

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*Dr. Waters:* Well it may have occurred during the rise too because there are no readings taken during the rise. However, there is a very good explanation for the rise in that in oxygen want the pulse rate often rises after the condition is relieved.

*Dr. Cassels:* Dr. Hathaway has a case to report.

### Respiratory and Cardiac Arrest

**D**R. HATHAWAY: The other morning I had a 73 year old white male patient who came up for an exploratory laparotomy and possible gastric resection. He had an advanced carcinoma of the stomach, emphysema, arteriosclerotic cardiovascular disease with a functional capacity of II-A. There was moderate emaciation and moderate secondary anemia treated by transfusions preoperatively. He had received 1/8 gr. of morphin and 1/200 gr. of scopolamin at 6:30 a. m. At 7:45 anesthesia was started using nitrous oxid-ether sequence by the closed technique. It was found that the preoperative hypodermic was a little too large for this patient as he was too depressed. Seven minutes after induction began, a closed oral endotracheal tube was inserted. At that time the blood pressure had risen from preoperative readings of 110/70 to 140/70. The pulse remained at 60.

The patient resisted the tube when it was inserted and in order to obtain deeper anesthesia, manual ventilation was used. This was continued for the next seven minutes so that when the incision was made 14 minutes after the induction of anesthesia, the patient was making no respiratory effort. He was no doubt in rather deep anesthesia as I had, so to speak, pumped a large amount of ether into his alveoli. Very shortly after the incision was made, it was noted that the pulse rate could not be obtained and neither could the blood pressure.

Immediately upon noting that the cardiac action had apparently ceased, the setup was disconnected and mouth to tube respiration carried out. At the same time, the surgeon was urged to open the abdomen and massage the heart, which he did, thus initiating heart action as when he first palpated the heart, no movement was felt. Five minutes later, the pulse was obtained at a rate of 60 and very shortly thereafter the blood pressures returned to 130/80.

This obtained throughout the remainder of the procedure.

There was no further surgical manipulation since the case was found to be an inoperable carcinoma of the pylorus. The patient was discharged from the hospital, and received x-ray therapy. The reason I brought the case up was to show that no resuscitative measures were used other than mouth to tube inflation and direct cardiac massage.

*Dr. Cassels:* I think it would be a good idea if I reported a case that I have here as it might have a bearing on this very near tragedy. This was a woman of 36 years who had a dilatation and curettage, total hysterectomy and right salpingo-oophorectomy done under cyclopropane anesthesia. The anesthesia proceeded almost uneventfully except for a considerable rise in blood pressure, developing within the first fifteen minutes and being maintained for the next hour and twenty minutes.

About an hour after induction, there was laryngospasm caused by traction on the peritoneum. This persisted, and one-half hour later in an effort to relieve the laryngospasm, I applied pressure to the breathing bag during inspiration over a period of about ten minutes. Five minutes after it started, the pulse and blood pressure were about as before, but five minutes later, the blood pressures had fallen from 210/140 to 125/100 and the pulse rate had risen to 188. Pressure on the bag was immediately discontinued, the pulse rate fell promptly. Within 5 minutes, it was down to 70 again and stayed low, but the blood pressure continued at the lower level which it had reached.

I bring this case up in conjunction with Dr. Hathaway's because I would like to hear a discussion as to whether pressure on the breathing bag might bring trouble of this type. You will recall that there is a report of an experimental study of overdistension of the lungs showing that it dams back the blood into the right heart and decreases the systemic blood pressure. I am wondering if these cases might not be accounted for in this way.

*Dr. Pfeiffer:* Was there any evidence in either of these two cases of distension of the stomach due to your use of the bag as a means of artificial respiration?

*Dr. Hathaway:* In my case, a closed endotracheal tube was used.



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*Dr. Cassels:* There was no evidence of distension of the stomach in my case.

*Dr. Slocum:* Don't you find in most of these cases where there is partial obstruction due to laryngospasm that the original drop in blood pressure goes to a point somewhat below the average normal for a patient and then proceeds to climb regardless of type whether it is due to laryngospasm or due to a bad tube, or whatever it is?

*Dr. Waters:* In this case, the statement that 1/8 gr. of morphin and 1/150 gr. of scopolamin was found to be an overdose in this old gentleman would appear in some places to be a rather radical statement. I know many anesthesiologists who would say that 1/8 gr. of morphin would never be an overdose to anyone who could still breathe. Nevertheless, we here find that that is not true and I agree that it might certainly have been too much in this case.

The rise in blood pressure, which he describes at the time of or near the intubation, could have been due to several factors. In the first place, the fact that the patient reacted immediately after the intubation, gives one the opinion that anesthesia was not deep and therefore one would think that the light anesthesia at the time of the intubation was the cause of the rise in blood pressure. However, with his description of an overdose of premedication, it is very possible that the patient had considerable depression of respiration, and had had even previous to the induction of anesthesia. With some added depression during induction he might readily have had something like the other case; that is, a piling up of carbon dioxid. When one is conducting controlled respiration, he has assumed under those circumstances a physiologic function which is ordinarily carried on by the automaticity of the respiratory center. Seldom is man a perfect substitute for God in such matters. Any sort of change in the respiratory exchange may have been the result of controlled respiration. Dr. Hathaway did not mention the matter of a table lift. It is true that the surgeon at times asks for the table to be broken in an extreme way. Was the table level in this case?

*Dr. Hathaway:* Yes.

*Dr. Waters:* Then that could not explain a possible reflex through the celiac plexus, and a cardiac arrest resulting which we believe we have seen occur.

The case is rather a sort of hair raiser. I should like to ask if the surgeon's decision to explore only, was in any way influenced by his state of mind after he had been asked to massage the heart? I am quite sure that even rather bold surgeons are sometimes deprived of their nerve at times like this.

*Dr. Hathaway:* This surgeon was reassured by both Dr. Taylor and myself, and he reassured us back that there was nothing he could do for the patient.

*Dr. Waters:* It is well to put yourself as an anesthetist over into the shoes of the surgeon and try to picture what his thoughts and feelings may be when we are in trouble.

In the second case, reported by Dr. Cassels, I should question the just occasion for his wishing to discuss the two cases together. It is true that tachycardia is a serious matter. It is known to all of us, here at least, that an extreme bradycardia, arrhythmia or irregularity followed by tachycardia seems to be the course of events preceding a ventricular fibrillation. This belief is based upon certain experimental work in our laboratories. In view of this fact, I should, but for one reason, be tempted to think that the tachycardia in your case was a straight overdose of the anesthetic agent. However, you have also told us that there was a laryngospasm coincident with the handling of the peritoneum. Isn't it possible, then, that this was rather a light anesthesia? Too light? In fact, I think that in most cases when laryngospasm is noticed, the anesthesia has been allowed to drift too light.

*Dr. Cassels:* The anesthesia was mostly in the lower second plane, rising toward the upper second plane as the laryngospasm occurred, and was considerably deeper at the time of the tachycardia. I don't believe that cyclopropane had been added in excess at any time prior to this positive pressure being used.

*Dr. Waters:* There are times when we must modify our conception of the physical signs coincident to the anesthesia. We utilize ordinarily the progressive respiratory paralysis as a guide in the region in which a patient is carried for intra-abdominal surgery, but it is possible that we fail to recognize certain other signs that might well fit into the picture by which we judge the depth of anesthesia. If there is laryngospasm, it is possible that we should say that the anesthesia cannot be very deep for that

reason, regardless of other physical signs. That is to be thought of.

The man on the job at the time is the best judge of the relation between cause and effect. Then we will come to this matter of an increased pulmonary pressure as a cause of circulatory change. Dr. McKesson used to honestly believe that there were certain cases in which a gradual oncoming circulatory depression became evident which, when positive pressure was instituted in the respired atmosphere, showed a very definite improvement in this circulatory condition. That is in the literature, I think. It is known, of course, that the Hering-Breuer reflex can be overstimulated and affect respiration so as to prevent the next inspiration being taken.

The production of a tachycardia from overdistension of such a breathing bag as we use seems to me unlikely in that it would probably burst if pressure got to a point of danger; nevertheless, in a bad risk patient I think this might occur. There is another thought in regard to a distended breathing bag; *namely*, that you may simply be doing what you do when you throttle a patient—prevent his expiring the alveolar contents: Although a patient goes through respiratory movements, he doesn't cause any exchange to take place. Again, a reflex similar to the laryngospasm due to stimulation, which your patient had, could be conceived as a cause of your tachycardia. We will have to leave the thing up to you and you think that the distended bag was the cause of the tachycardia.

*Dr. Cassels:* Dr. Slocum has a case to report.

#### Acidotic Respiration

**D**R. SLOCUM: This was an orthopedic case, a fourteen year old boy, induced and maintained by the absorption technique with cyclopropane. Premedication and induction were both apparently quite satisfactory. In the course of the first fifteen minutes, the anesthesia ran quite smoothly, at which point there was a noticeable increase in blood pressure, with an accompanying increase in pulse rate. An airway was placed in the patient's throat, but did not relieve the situation. It was noticed that the respirations at the end of the first twenty minute period began an associated climb whereupon the canister used in the absorption technique

was checked up and found to be questionable.

Because of the fact that another canister was not immediately available, the patient was continued along for another 15 minutes. During the course of this time the blood pressures rose about 40 points, the pulse rose about 55 points. The respirations took a maximum rise of approximately 20 points, all of these being above the normal readings for this particular patient.

At the end of this 40 minute period, a new canister was substituted for the one which was believed to be defective. There was an immediate drop in systolic and diastolic blood pressure with a slow corresponding drop in pulse rate. Within 10 minutes, blood pressures had dropped slightly below the average readings of the patient, and the pulse began to level off gradually. The respirations within this 10 minute period dropped approximately to a point one-half the rise. The operation and anesthesia both continued from that point onward in an uncomplicated manner.

*Dr. Cassels:* Dr. Leigh, you have been very quiet. How would you comment on this case?

*Dr. Leigh:* This case from a physiological view takes in an excess of carbon dioxide and its effect on the respiratory system and circulatory system. The circulatory system usually shows a rise in the blood pressure and an increase in the pulse rate, and also in the respiratory system, there is an increase in the respiratory excursion and sometimes an increase in the rate. I should say that Dr. Slocum has learned the two cardinal signs by which to determine saturation of the alkali when he is using the carbon dioxide absorption technique.

*Dr. Pfeiffer:* We had a patient this morning who we thought was suffering from carbon dioxide excess. She had no change in heart rate or in blood pressure nor did she have any irregularities in respiration, but she did have an acidotic type of respiration, no respiratory pause at any time, which is typical of acidotic breathing. We let her go for a period of 5 minutes, and this kept up without any change. Then we changed canisters and she immediately dropped back to normal breathing, and the expansion was much diminished and all this time there was no change in any of the other systems.

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*Dr. Waters:* What do you consider an acidotic type of breathing?

*Dr. Pfeiffer:* The abolition of the rest period in breathing; maximal respirations and a sufficient expiration and inspiration which changed when we changed canisters.

*Dr. Cassels:* Didn't that patient have acetone in her urine?

*Dr. Pfeiffer:* That was the preceding patient.

*Dr. Waters:* May I ask Dr. Slocum whether he is sure that the blood pressure and pulse abnormalities did not drop back toward normal after he put his pharyngeal airway in place?

*Dr. Slocum:* There was a reading within 5 minutes.

*Dr. Waters:* That was still up where it was before?

*Dr. Slocum:* The airway was placed within the next 20 minute period, and that was following placement of the airway.

*Dr. Waters:* The reason I asked was that in raising the mask to insert the airway, one often loses the contents of the bag and has to add fresh gases. Oftentimes the test of whether a canister is inefficient or not can readily be made without removing it by putting a fresh supply of gases in your system and see the drop which will occur in the next 30 seconds, and then hyperpnea and rising blood pressures gradually return. Of course I was implying that you probably made a slow introduction of the pharyngeal airway and lost the gas that you had in the system. You have evidently learned to slip the mask upward quickly over the nose and forehead and after insertion, quickly back in place.

I should like to comment on Dr. Pfeiffer's statements. He has stated that there was no circulatory change and no change in the respiratory rate. He did not say much about the depth in his first statement. I thought he had said that there was no change in respiration. We have often made the statement that either the rise in blood pressure or an oncoming hyperpnea will warn the anesthetist if the soda-lime was inefficient. The hyperpnea would have saved you. Now, why didn't the blood pressure go up?

*Dr. Pfeiffer:* We allowed 5 or 10 minutes.

*Dr. Waters:* That brings us to the possibility of a patient with a disturbed acid base balance failing to react as a

normal individual would react and I think that is very possible, and I think that has led to a very great deal of trouble. It is quite possible to even fail to see any hyperpnea or any respiratory change with accumulating carbon dioxide in acidotic children.

*Dr. Pfeiffer:* Has it been your experience that soda-lime gives out 100 per cent all at once, or does it become inefficient in a gradual manner?

*Dr. Waters:* I think there is no question but that is possible. We have worked a great deal with the shape and size of containers for soda-lime in an attempt to try to see to it that there is a general use of the soda-lime throughout. If we have succeeded in perfecting the shape and arrangement of the canister, it should wear out suddenly.

*Dr. Cassels:* Is there any further discussion? Dr. Bennett has the next case.

*Dr. Bennett:* This is a case which occurred last July. As some of us were away at the time, its discussion at staff meeting was postponed. A girl of 12 years came up for tonsillectomy. Because of pyelitis, she had been receiving ammonium mandelate for about two weeks before operation. Fluids had been limited. Urine pH was 5.5 on the ward. Thirty hours before operation, the ammonium mandelate was stopped and fluids increased.

The induction of anesthesia was done with open drop ether without difficulty. In the third plane, intubation was done with a nasal endotracheal tube by direct vision. The nasal tube was connected to a small bag with an exhalation valve between the bag and the tube. Operation was begun. Twelve minutes later, a generalized convulsion of the clonic type occurred with preliminary twitchings. The color and pulse remained good. Since the patient did not breathe spontaneously, the bag was removed and the chest inflated by mouth to tube pressure. The operation was stopped. Hartman's solution was given intravenously, and Bourne's solution was given rectally. Respiration did not begin until after removal of the endotracheal tube and mouth to nose inflation.

The operation was concluded, and the patient sent back to the ward. She became conscious about one-half hour later. Her course after operation was uneventful. The important factors to be considered in this case were an induced acidosis in a girl of twelve years

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in hot weather, and an anesthetic technique which probably did not completely remove carbon dioxid from the respired atmosphere. It is probable that the acid base balance was not normal since the ammonium mandelate had been stopped only 30 hours before operation.

*Dr. Cassels:* The case is open for discussion.

*Dr. Slocum:* I might say that the use of ammonium mandelate to get the urine down to a pH of 5.5 which involves the more excessive use of a mandelate and this process takes longer than 30 hours to induce, therefore to re-establish definite acid-base balance, the patient should possibly have been removed from the ammonium mandelate routine and some other method than pushing fluids might have been tried.

*Dr. Waters:* In the first place, I believe that we had another case of a similar sort after ammonium mandelate therapy here. I think it is an important point to keep in mind. It may be that it takes a matter of days to re-establish normal pH conditions in the tissues and blood after a 2 weeks' therapy of this sort, and we might well bear it in mind in the future.

It is interesting that we all of us tend to take possible building up of excessive carbon dioxid as a probable factor in initiating convulsions during anesthesia. It has been our belief that convulsions appearing during anesthesia have been, in well over 90 per cent of the cases, connected with an excess of carbon dioxid in the respired atmosphere. Excess carbon dioxid is a frequent accompaniment of our technique. Convulsions only occur when the physiologic state of the patient is extremely abnormal. In this case it was true there was considerable rebreathing. It is also true that the tube itself might have been too small for that patient. Neither of these conditions were observed by the anesthetist. Nevertheless, it must be admitted that with considerable rebreathing, there must have been an excess of carbon dioxid in the alveoli of the patient.

Because of our interest in getting all the data that is possible on all cases that experience convulsions during anesthesia, we had agreed in the past that we would secure a blood sample for careful analysis of blood chemistry in every case in which it was at all possible, and that we would save the breathing bag for gas analysis. I was guilty of losing the bag

sample and of failing to get a blood sample before the intravenous alkali was started. It is an example of our proneness to get excited when sudden unexpected occurrences confront us in the operating room. It is rather a sad reflection on our scientific interest.

The fact that respirations did not start until the tube was removed, is perhaps apt to give a misconception of what actually occurred. Having been called to one other case while it was in a convulsion, in which the tube had been placed in the bronchus, I wished to remove the tube before I did anything else to be sure it was not in a bronchus. Respirations were not taking place at that time because the patient was in convulsions. Nevertheless, I removed the tube, used direct inflation without the tube, and respiration was resumed. My own conclusion in this case was that we had a disturbed chemical balance in the body of a somewhat unusual sort; nevertheless, it acted as many cases that I have seen have acted in going into a convulsion when the elimination of carbon dioxid was interfered with by anesthetic technique. The fact that no facial muscle twitching was observed but that the convulsion, full blown, was the first thing noted is not the usual sequence of events under similar circumstances. When a child on a hot day, perhaps with a fever, is acidotic, shows a reaction from carbon dioxid, it has been my experience that the first thing noted is a twitching of the facial muscles often about the eyes, followed shortly by the convulsive seizure. I suppose it is possible in this case that the anesthetist may have missed some facial twitching which occurred but was not seen in the presence of the operative procedure in the mouth. I should consider this a case of disturbed acid base balance before operation in which the so-called trigger effect of an excess carbon dioxid induced a convulsive seizure.

*Dr. Cassels:* Dr. Slocum has one consultation to report.

### Opiate Depression

**D**R. SLOCUM: I was asked by the medical service to see a 66 year old woman who had been admitted with pernicious anemia and severe cord changes. For extreme pain and restlessness, dilaudid 1/20 gr. had been administered every 4 hours for 4 doses. Examination revealed the patient to be comatose and respirations six per min-

ute. In spite of the depression, there was no evidence of respiratory obstruction or oxygen want. However, oxygen therapy and frequent changes of position were advised as a prophylactic measure. Scopolamin might have been used for respiratory stimulation, but I did not think it was necessary, and by omitting all forms of treatment other than oxygen therapy, I had the opportunity to impress on the intern the fact that the respiratory rate was not important as long as there was sufficient oxygenation.

*Dr. Cassels:* A 1/20 gr. of dilaudid is equivalent to about 1/3 of a grain of morphin. This dose was repeated every 4 hours. It would seem that this debilitated old woman was receiving more than a husky young adult would probably tolerate without marked effect.

*Dr. Pfeiffer:* The patient had 4 such doses.

*Dr. Slocum:* I might say that so far as the results were concerned, the oxygen was continued throughout the night and she made a perfectly uneventful recovery from this opiate depression.

*Dr. Cassels:* Since this case brings up the question of opiates and it was mentioned that scopolamin might have been used to treat it, I think that, unless there is any discussion pertinent to this particular case, it might be well for Dr. Bennett to give us a report he has prepared on our studies on morphin and scopolamin, so far as they have gone.

*Dr. Waters:* I would like to add a word. I should question Dr. Slocum on what seems to me to be a nochalant attitude toward a respiration of six per minute. I doubt whether a respiratory rate of six per minute is always adequate respiration. I think I should agree with him that certainly prophylactic oxygen should have been started. I might call your attention to the fact that so far we have not to my knowledge tried scopolamin as an antagonist in depressed respiration after dilaudid so that we will not be justified in transferring anything that Dr. Bennett may report as true in the case of morphin as applying to other morphin-like substances.

*Dr. Bennett's* report was presented and discussed.

*Dr. Cassels:* Before we adjourn, we will hear from the critic of the day.

#### Criticisms

**D**R. PFEIFFER: Dr. Leigh said, "the anesthetic was commenced," whereas he probably meant to say, "the anesthetic agent was administered."

Dr. Slocum said, "your oxygen want is best treated by," and Dr. Waters countered immediately with, "your increase in blood pressure." This familiarity with oxygen and blood pressure is probably justified except that in some cases it becomes ridiculous; as for instance the statement which might occur, "your bad breath in gangrene of the lung," or "your 4-plus Wasserman reaction in syphilis."

Dr. Hathaway said, "the patient had his preoperative findings of," whereas the preoperative findings belonged to the patient and it would have saved time to have said, "the patient's preoperative findings were." Dr. Hathaway also said, "cardiovascular action had ceased." This is probably his introduction of a portmanteau word to indicate that both the apex beat and the pulse at the wrist were no longer palpable. This may be, if he really means this, a valuable addition to our vocabulary.

Dr. Bennett must have smoke-sensitive eyes for he kept them closed for a full 10 or 15 minutes, to the point of muscular relaxation, when his charts fell on the floor and he awakened.

Dr. Slocum said, "an airway was placed in the patient's throat." This is suggestive of slipping an aspirin tablet into the patient's throat. If he had said, "a pharyngeal airway was inserted," he would have conveyed the idea much more concisely. He also used the expression, "the pulse rate increased 20 points, the blood pressure rose 20 points, and respiration increased 10 points." Whereas it is true that our charts have nothing but points on them, in discussion it would be better to use "millimeters of mercury" or "rate."

Dr. Waters said, "respirations did not start for some time." I doubt the need for the plural subject in this case.

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## A New Intratracheal Catheter \*

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Ralph M. Waters, M.D., Anesthetist, Madison, Wis.



HEREWITH IS A DESCRIPTION of an intratracheal catheter, designed for the closed intratracheal administration of any inhalation anesthetic agent, by the carbon dioxid absorption method of Ralph M. Waters. The catheter, fourteen inches in length, of rubber or other composition, as free as possible from tendency to kink or collapse, having a wall thickness of one-sixteenth of an inch, and an inside diameter of three-eighths of an inch. The position of openings in tracheal end are optional.

### Inflation and Deflation

**A**N INFLATION BAG of thin soft rubber is attached about the body of the catheter, so that the lower edge of the inflation bag is about one inch above the tracheal end of the catheter. This inflation bag may be of a single layer of rubber, cemented in place, or of a double layer of rubber, slipped tightly over the catheter body. The inflation bag is one and one-half inches in length, and is so made that when inflated to a diameter of five-eighths of an inch, the rubber is just beginning to be stretched, (Fig. 1.) When deflated, it lies in folds,

when the catheter is in place. Inflation is held by a clamp of some sort on the inflation tube.

The catheter is introduced through direct vision laryngoscope under anesthesia, so that the entire inflation bag lies within the trachea just beneath the larynx. It is then inflated with from seven to ten cubic centimeters of air, bringing the outer wall of the inflation bag into close contact with the inner wall of the trachea. Inflation is best accomplished with a graduated syringe. It is important to know the capacity of the bag, and to measure the quantity of air introduced, as under-inflation may

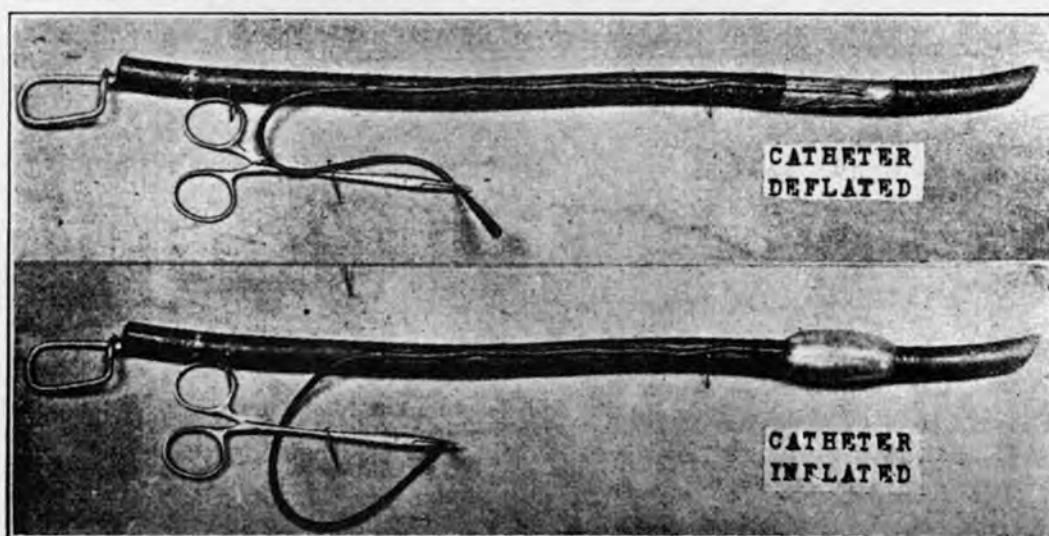


Fig. 1.

close to the catheter wall. Inflation is accomplished through a flexible rubber tube, not larger than a number eight French catheter, and long enough to extend conveniently well out of the mouth,

\*From the Department of Anesthesia of the Indiana University School of Medicine and the University of Wisconsin, School of Medicine.

permit leaks, and over-inflation may rupture the bag.

With the catheter in place and inflated, the anesthesia breathing bag and soda lime receptacle for absorption of carbon dioxid of expiration, are attached, and anesthesia conducted in the usual manner.

The catheter effectively prevents all air leaks and renders the respiratory system entirely closed, with a controllable to and fro respiratory exchange. Aspiration of foreign matter into the lungs is not possible with the catheter in place.

#### Illustrative Case Reports

**T**HE FOLLOWING case reports are examples of tests made.—  
*Case 1.*—Patient anesthetized with ether following nitrous oxid, for laparotomy. Trendlenberg position to such a degree that nostrils and lips of patient were on the same level. During the anesthesia, through the inflated catheter, the mouth and nose were filled with water which was allowed to remain in place for a period of about five minutes. It was then aspirated away and the test repeated. There were no air bubbles and neither anesthesia nor respiration were influenced in any way. The capacity of the respiratory passages above the larynx in this patient was about two and one-half ounces, with the teeth separated one-half an inch.

*Case 2.*—Patient anesthetized with ethylene following nitrous oxid. The test just described was repeated with the same result, except that the capacity of the upper respiratory passages here was but two ounces, with the teeth separated one-half inch.

In both cases the inspiratory recession of water from the lip line was about one-fourth inch or roughly between one-fourth and one-half ounces.

*Case 3.*—Dog of about twenty pounds weight was anesthetised with ethylene after preliminary morphin. The catheter was introduced and inflated. Then the apparatus was connected and the dog together with soda lime container, were

completely submerged in water and kept there for a period of one hour. During this time there was nothing unusual in the respiration, or pulse or the general conduct of the animal under anesthesia. There were no air bubbles, after the first displacement of air from the upper respiratory passages. At the end of the hour, the breathing bag, one of four liter capacity, was emptied and refilled with oxygen. After two minutes this was repeated, but the dog awakened and sat up in the tank before the bag could be completely filled. The catheter was removed and the dog placed on the floor, where he stood up, shook the water off, and lay down for a nap.

The following is a record of pulse and respiration during this experiment:—

	Pulse	Respiration
2:15 p. m.—Dog submerged		
2:20 .....	110	20
2:30 .....	120	26
2:35 .....	120	25
2:40 .....	140	32
2:45 .....	150	38
2:50 .....	150	36
2:55 .....	145	32
3:00 .....	150	34
3:05 .....	145	26
3:10 .....	150	34
3:15 .....	145	26

This dog at rest has a normal pulse of 140 and respiration of 20 per minute.

This experiment was conducted in the laboratory of the Indiana University School of Medicine. There were present, Dr. Waters of University of Wisconsin, Drs. Guedel, Trusler and Thomas of Indianapolis and Messers B. G. Meredith and N. C. Davidson, senior students, together with students in general from Indiana University School of Medicine.

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## ENDOTRACHEAL ANESTHESIA: A NEW TECHNIC.\*

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AND

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The method of anesthesia herein described is employed in operations about the head and neck. It is especially effective in surgery of the mouth and nose.

We have used this technic since 1928.<sup>1</sup> It involves closing the trachea just below the vocal cords with an inflatable cuff placed over an endotracheal catheter, and the application of Waters' carbon dioxide absorption technic of anesthesia.

The catheters employed are of sizes 26, 28 and 30 French. We have not used this technic in any patient under nine years of age.

The cuff consists of two pieces of Penrose rubber tubing, one of which is one-fourth inch and the other one-half inch in diameter, both two inches in length. These are placed one inside of the other and their ends cemented together. A No. 8 French soft rubber catheter is cemented into the end of the cuff and serves as the inflation tube. The cuff is slipped over the end of the catheter so that one-half inch of the catheter protrudes. (Fig. 1.)

We employ the following technic, although there are a number of variations possible. The patient is anesthetized with nitrous oxide or ethylene by an entirely closed method, the carbon dioxide of expiration being allowed to accumulate within the breathing bag. With gas anesthesia established, ether vapor is carried rap-

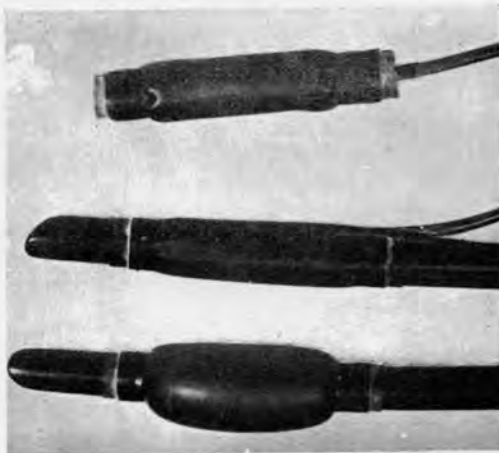


Fig. 1.

- A. Rubber cuff detached, uninflated.
- B. Cuff attached to catheter, uninflated.
- C. Cuff attached, inflated.
- D. Inflation tube.

idly into the mixture for a period of from six to ten minutes or until early ether anesthesia is well along. At this point carbon dioxide is added to the mixture in an amount approximating 10 per cent. Following the addition of carbon dioxide the character of respiration changes rapidly from hyperpnoea to a nearly complete respiratory arrest. Here the mask is removed, after which

\*Acknowledgment is expressed for aid in the development of the clinical application of this method, Waters to the surgical staff of the University of Wisconsin Medical School; Guedel to Howard L. Updegraff, M. D., of Hollywood, California.

the apnoea continues for a period of from twenty to forty seconds. During this apnoeic period the vocal cords are widely separated and do not exhibit their opening and closing movements with the slight respiratory excursions present. (Fig. 2.) With the return of normal respiration the cords assume their normal activity. During this apnoea the anesthesia lies in the upper half of the surgical stage. In this state, with the jaw and throat muscles relaxed and the vocal cords widely separated, the catheter

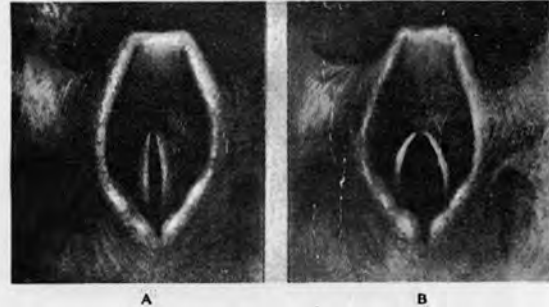


Fig. 2. Vocal Cords.

- A. During apnoea under ether anesthesia with blood carbon dioxide normal or below normal.
- B. During apnoea under ether anesthesia with blood carbon dioxide much above normal.

with cuff deflated is introduced through a direct vision laryngoscope, so that the upper border of the cuff lies just beneath the vocal cords. (Fig. 3.) The anesthesia apparatus, now with a soda-lime cannister for carbon dioxide absorption in place, is connected with the catheter. The cuff is then inflated.

Inflation of the cuff is accomplished by injecting air from a ten cubic centimeter ground glass syringe through the small inflation tube. The degree of inflation is determined by the sense of pressure within the syringe. Inflation is carried to a point at which the outside wall of the cuff lightly but firmly contacts the wall of the trachea. Under-inflation will permit leakage between the cuff and the tracheal wall. Over-inflation will produce tracheal soreness lasting from twelve to twenty-four hours. The quantity of air required is from four to ten cubic centimeters. It is interesting to note that with advancing age the required quantity of air increases proportionately, regardless of the physical type of the patient.

In acquiring the sense of proper inflation, we suggest practice with a cuffed catheter, first within a five-eighths inch glass test

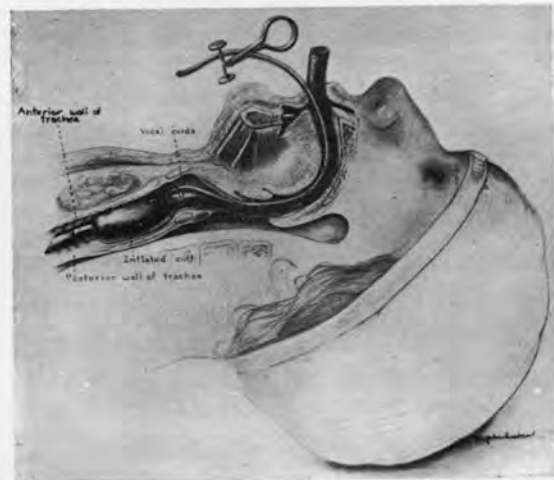


Fig. 3.

Endotracheal catheter in place with cuff inflated. Note position of cuff with relation to vocal cords and compression of esophagus against the vertebrae.



tube, where the degree of inflation can be seen, after which more practice with a freshly removed trachea of a lamb.

Maintenance of anesthesia after the catheter is in place rests upon the principles of carbon dioxide absorption anesthesia technic (Waters<sup>3</sup>). Briefly, this is as follows.

Anesthesia presupposes a proper saturation of the blood with the anesthetic agent. Neither nitrous oxide nor ethylene are destroyed within the body. They must be eliminated through the lungs. Therefore anesthesia, once established, is maintained without the addition of more gases, so long as the escape of those gases present in the body be prevented. The continuous administration of oxygen to satisfy body metabolism is necessary. This varies in amount between 200 and 800 cubic centimeters per



Fig. 4.

Wire gauge over breathing bag. Soda-lime cannister in position.

minute. The expired carbon dioxide is absorbed by soda-lime granules.

The gases inspired are warm and moist. The warmth is due to heating of the soda-lime by its absorption activity, and to the retention of body heat otherwise lost through expiration. After twenty minutes of anesthesia the gas temperature ranges between 100 and 104° F. The moisture is that of expiration retained within the breathing bag.

For the proper regulation of oxygen flow we employ a stationary gauge, placed over the breathing bag. (Fig. 4.) If more oxygen is admitted than the patient can utilize, the bag fills and approaches the gauge. If insufficient oxygen is admitted, the bag falls away from the gauge. These bag fluctuations are manifest before there is clinical evidence of incorrect oxygen flow. With the bag in constant relationship with the gauge, anesthesia is constant, provided there are no leaks in the apparatus.

The closing technic is important. After the operation is finished, the mouth and pharynx are cleansed of accumulated débris. This is accomplished by irrigation with water or saline solution.



Fig. 5.

Showing irrigation of mouth and pharynx. The irrigation solution in this case is milky for photographic purposes.

(Fig. 5.) With the pharynx clean, the anesthetic apparatus is disconnected from the catheter and the patient allowed to emerge to the point of return of the swallowing reflex, at which time the laryngeal reflex is active. The cuff is deflated and the catheter withdrawn at the crest of inspiration.

Although many patients have retched, with the inflated cuff in place, but two or three cases have succeeded in forcing vomitus into the pharynx, and in these the amount in each case was less than one ounce. On the other hand, with light anesthesia, such as sometimes occurs during the irrigation process, the patient may with effort swallow some of the irrigation fluid. The mechanical obstacle to both the swallowing and vomiting act seemingly lies in the compression of the esophagus against the bodies of the vertebræ by the cuff. (Fig. 3.)

The purposes of this technic are to prevent aspiration of operative débris into the lungs and to provide a clear field of work for the surgeon. We have found it nicely applicable in adult tonsillectomy when for any reason general anesthesia must be employed.

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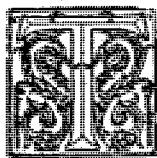
#### BIBLIOGRAPHY.

1. Guedel-Waters: A New Endotracheal Catheter. *Jour. Anesthesia and Analgesia*, July-August, 1928.
2. Waters, R. M.: Carbon Dioxide Filtration in Inhalation Anesthesia. *Jour. Anesthesia and Analgesia*, February, 1924.
3. Waters, R. M.: The Technique of Carbon Dioxide Filtration in Anesthesia. *Jour. Anesthesia and Analgesia*, June, 1926.

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## Endotracheal Anesthesia and Its Historical Development\*

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THE PLEASURE OF this research was surpassed only by the labor involved. The surprises were many and great. Difficulty was encountered, due to the fact that prior to twenty-five years ago very few anesthesia developments appeared under the classification of Anesthesia. They were meagerly published in surgical reports and it was necessary to peruse untold pages in securing material for this treatise. Like opening oysters for pearls. French, German and English literatures only were consulted and it is highly probable that many interesting facts, published in other languages, have been missed.

### Early Intubations

THE development of endotracheal anesthesia had three apparent causes for its initiation. These were, (1) the treatment of respiratory obstruction and resuscitation by artificial respiration; (2) protection of the tracheo-bronchial tree from contamination by debris in surgery of the mouth and nose; and (3) control of intra-pulmonary pressure in thoracic surgery.

The laryngeal tube of James Curry is said to have been well known in 1791, and Fine of Geneva, in 1800, devised a leather laryngeal tube which he introduced through the nares. Bichat tells of Dessault's attempt, in 1801, to pass a nasal feeding catheter, but when feeding was attempted it was found that the catheter was in the trachea. Later in the same year, Dessault, remembering the feeding experience, successfully introduced a catheter

through the nose into the trachea in a case of oedema of the glottis. The catheter was kept in place a day and a half and was followed by recovery of the patient.

Chaussier, in 1806, and his successor Depaul, in 1845, at the Maternite' de Paris, used a curved metal tube which was introduced by touch into the larynx for resuscitation of the new-born, *Fig. 1*. Matas states that Cap of Lyons, in 1828, described a laryngeal tube with a pump attached for artificial respiration.

Laryngeal intubation was sufficiently common in 1829 to provoke a critical discussion, led by LeRoy, before the French Academy of Sciences, whereupon Dumeril and Magendie were appointed a committee of investigation. They reported that the damage done by attempts at intubation far outweighed its advantages.

In 1854, Horace Green and D. M. Reese performed intubation of not only the trachea but of the bronchi, for direct medication to lung tissue. Three years later, Bouchut reported a method for the treatment of croup by intubation of the larynx. He described a tube 18 mm. to 24 mm. long and 6 mm. to 8 mm. in diameter, introduced on a hollow sound. A "silken bridle" was attached to facilitate removal.

\*Read during the Eleventh Annual Congress of Anesthetists, the International Anesthesia Research Society in Joint Meeting with the Associated Anesthetists of the United States and Canada, the Eastern Society of Anesthetists, the Mid-Western Association of Anesthetists, the Southern Association of Anesthetists and the New York Society of Anesthetists, Hotel McAlpin, New York City, October 17-21, 1932. From the Department of Anesthesia, University of Wisconsin, Madison, Wis.

This was evidently the forerunner of the O'Dwyer tubes so popular in the treatment of laryngeal diphtheria in the pre-antitoxin days.

Truehead of Galveston, Texas, in

1869, published an account in German, describing a two-phase artificial respiration device including an endo-laryngeal airway. Matas refers to Truehead's device as consisting of pyriform pieces

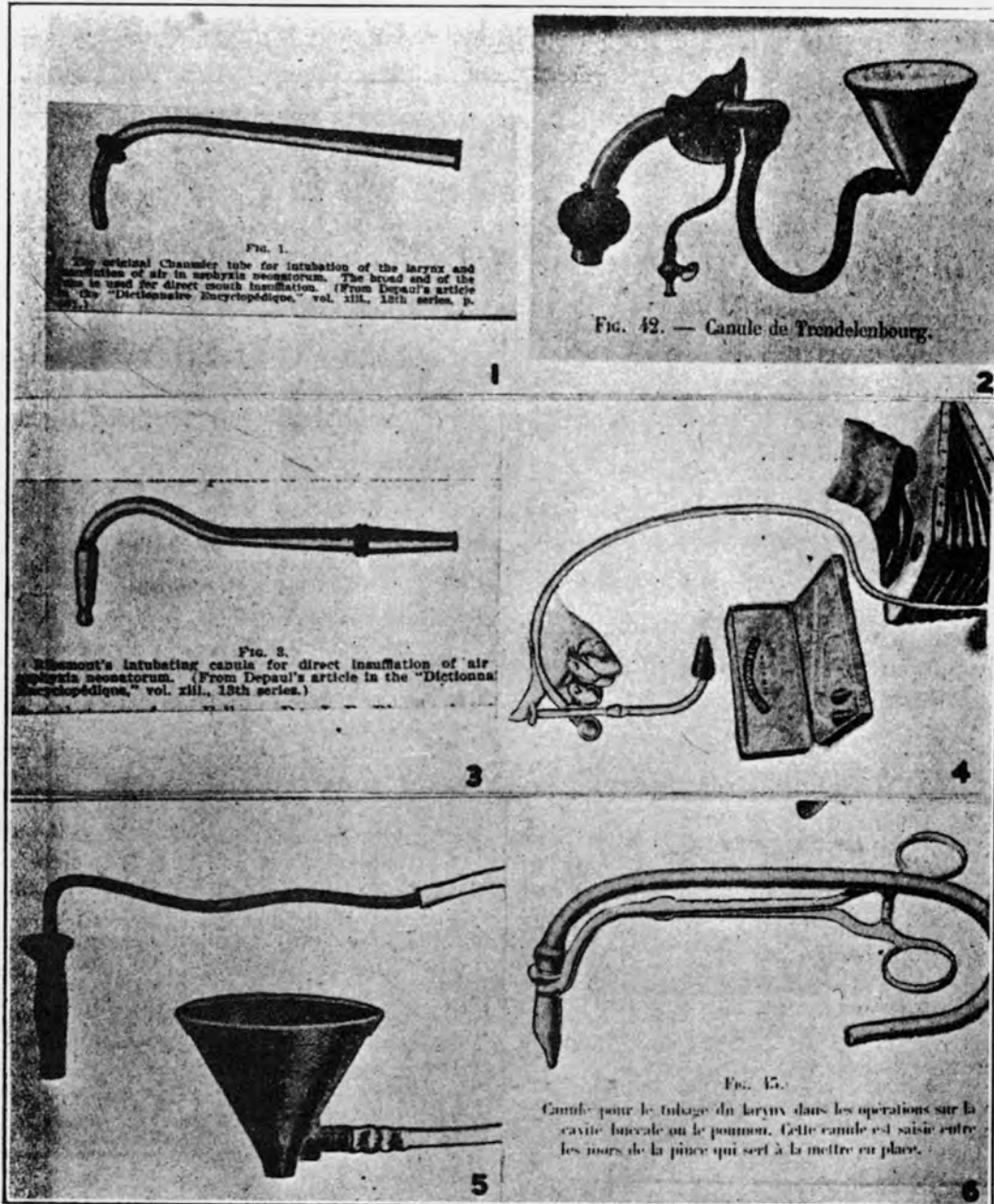


Fig. 1. Chaussier's tube for oral intubation of the larynx for mouth to trachea insufflation in asphyxia neonatorum. Used by Chaussier in 1806. Fig. 2. Trendelenburg tracheotomy canula with inflated cuff. Used by Trendelenburg in 1871. Fig. 3. Riehmont's canula for endotracheal insufflation of air in asphyxia neonatorum. 1877. Fig. 4. Fell-O'Dwyer apparatus for artificial respiration by laryngeal intubation. Prior to 1896. Fig. 5. Apparatus of Hubbard for excluding blood from the larynx, apparently the first attempt to intubate the larynx for anesthesia. Used prior to 1894. Fig. 6. Catheter of Doyen for excluding operative debris from the larynx. Reported in 1897.

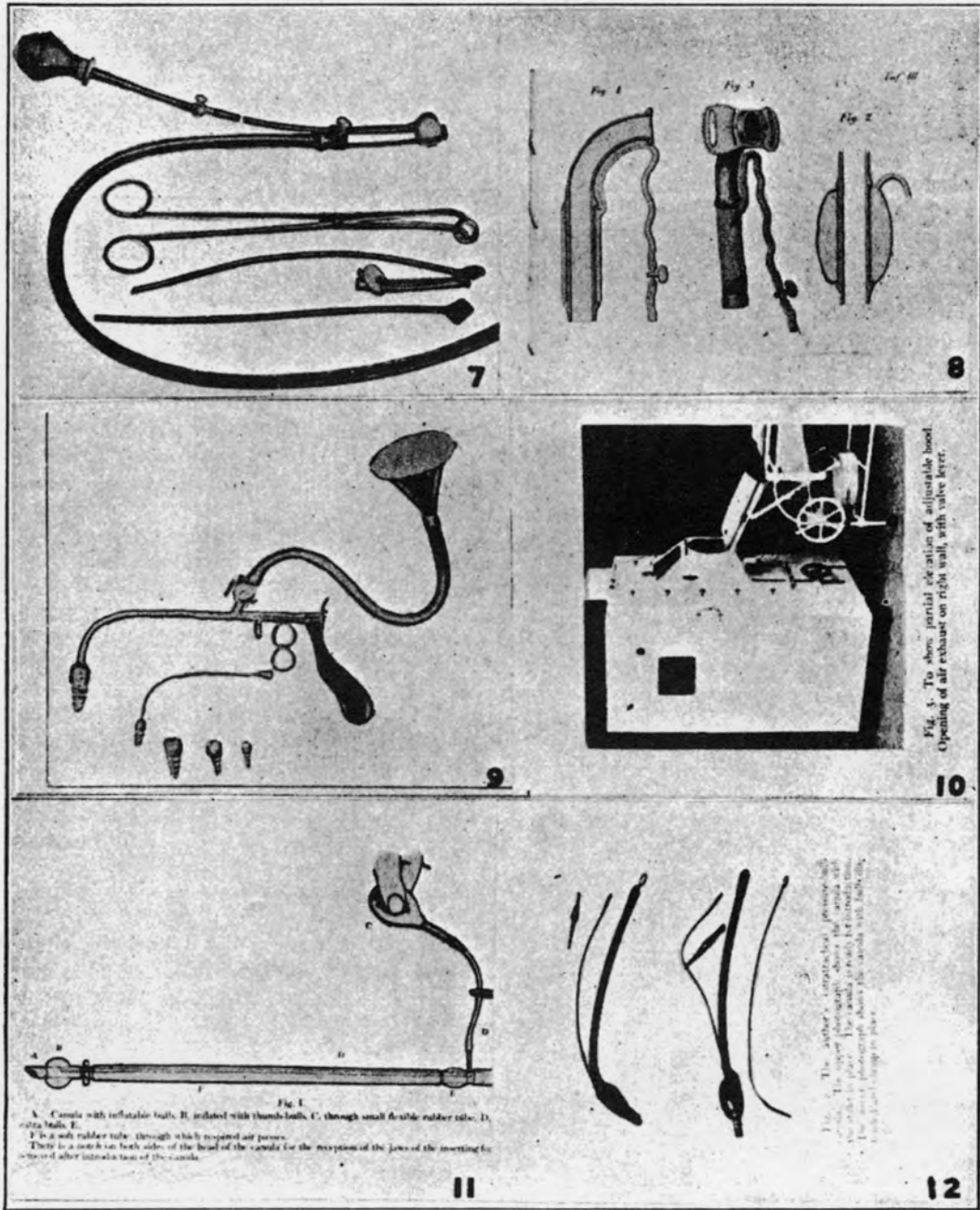


Fig. 7. Stockum's tracheal catheter with inflatable cuff. Used prior to 1898. Probably the first laryngeal tube with an inflatable cuff. Fig. 8. Trendelenburg's inflated cuff catheter showing mechanism. Employed through tracheotomy opening only. Fig. 9. Matas modification of Fell-O'Dwyer apparatus. Used in 1899 or 1900. Fig. 10. Robinson's Anesthesia Cabinet for thoracic surgery. Employed positive pressure about the patient's head. Used prior to 1910. Fig. 11. Green's catheter with inflatable cuff, for artificial respiration. Used in 1906. Fig. 12. Dorrance's cuffed catheter. Employed in treatment of traumatic injuries of lungs and pleura. Apparently for pressure control during thoracic surgery. Reported in August, 1910.

attached to a mouth tube shaped like a curved catheter. These were graded in size for various ages but were used chiefly in the newborn. "The device" Matas states "automatically injects and aspirates air in and out of the trachea in a rythmical fashion".

**Tracheal and Laryngeal Intubation**  
**H**RIEDRICH TRENDELENBURG, while an assistant in Langenbeck's clinic, in 1869, devised an apparatus (*Figs 2 and 8*) which, so far as we can learn, first made possible clinical endotracheal anesthesia. As described by Trendelenburg, in 1871, the principle and technique were physiologically and mechanically sound, except that the tube was inserted through a previously made tracheotomy opening. The larynx as a passage way was disregarded. This tube carried an inflatable cuff of thin rubber to make "wasserdicht" contact with the tracheal wall. In spite of the mutilation necessary for the use of Trendelenburg's apparatus, it was apparently widely used during the last three decades of the 19th century for we have found it described and illustrated in literature from various parts of the world. As we shall see, the funnel and tube as well as the inflatable cuff were later adapted to non-mutilating techniques.

In 1877, Riebmont described a tube (*Fig. 3*) for direct insufflation of air in asphyxia neonatorum. Two years later, Garail, using Riebmont's tube had added a rubber bulb for insufflation.

In 1880, Macewen employed endotracheal intubation by way of the mouth, for respiratory obstruction from any cause. Among other cases he reported two in which the catheters were left in place for thirty-six and thirty-nine hours. In one of these it was reported that there was no difficulty in swallowing liquids while the catheter was in place. In 1881, J. W. Paton, following Macewen's technique, reported a case of a child in which the catheter was left in place for forty-eight hours.

Following 1880, O'Dwyer perfected his intubation set for use in the treatment of laryngeal diphtheria. Between 1880 and 1886, by combining his tubes with the apparatus of Fell, he succeeded in popularizing the method of direct artificial respiration by laryngeal intubation, (*Fig. 4*). Matas and his co-

workers later applied this apparatus, modified, in anesthesia for thoracic surgery, (*Fig. 9*).

In November 1896, Tuffier and Hal-lion reported laboratory experiments with laryngeal intubation for the prevention of pneumothorax in chest surgery. Their tube apparently carried an enlargement at the end to prevent leakage between the vocal cords. Quenu and Longuet, about the same time, conducted similar experiments apparently independently, which they reported shortly after the report of Tuffier.

Doyen in his book "Technique Chirurgicale" in collaboration with Roussel and Millot, in 1897, condemns the Trendelenburg technique of preliminary tracheotomy, and describes his own tubes for laryngeal intubation anesthesia. Doyen illustrated four sizes of aluminum tubes, with the flannel covered funnel idea and to-and-fro respiration. He recommended introducing his canulas through the mouth either by touch or direct vision, using a specially curved tongue depressor for his direct vision exposure. Leakage about his catheter in pulmonary inflation, could be prevented by pinching shut the mouth and nose. He states, "The elastic rings of Trendelenburg seldom function perfectly".

W. J. van Stockum, a Dutch surgeon, in 1898, published a description of an apparatus for anesthesia, employing laryngeal intubation with a catheter carrying an inflatable cuff, (*Fig. 7*). He reported the removal of a carcinoma of the tonsil in which the bleeding was profuse but with no interference with tranquil respiration.

Matas, in 1900, published an article stressing the value of "Intralaryngeal" anesthesia in prevention of acute surgical pneumothorax. His apparatus, a modification of that of Fell and O'Dwyer (*Fig. 9*), he stated could be utilized "(1) as a respirator; (2) as a tampon canula; (3) as an anesthetizer; (4) as a tractor of the larynx and tongue; (5) as an insufflator; and (6) as an aspirator". Parham of New Orleans used this apparatus in a thoracic operation during 1898.

**Preventing Acute Pneumothorax**  
**I**T IS WELL here to mention the experimental efforts made from 1900 to 1910 in preventing acute pneumothorax in thoracic surgery, as it

was this problem which lent much to the advancement of endotracheal anesthesia. The three general lines of experimentation in this field were:

(1) The negative pressure cabinet large enough to contain the operating team and the body of the patient, the patient's head being outside of the cabinet, exposed to room atmosphere. The chief sponsors of this plan were Sauerbruch and Willy Meyer.

(2) The small positive pressure cabinets to include only the patient's head, (Fig. 10). Also tightly fitting helmets and gas masks were tried, the latter having held its place as gas anesthetic machines have progressed mechanically. Leading exponents of positive pressure in the respiratory passages were Saurebruch, Brauer, Robinson, Tiegel, Wilms, Kuhn and others.

(3) The application of positive pressure through endotracheal airways. Sponsoring this method were Tuffier,

Doyen, Stockum, Matas, Green, Dorrance and Kuhn.

The tubes of Stockum, and probably those of Doyen and Matas were used clinically before 1900. The tube used by Green, in 1906, was a metal canula carrying an inflatable cuff, (Fig. 11), and was used with an alternate positive and negative pressure to maintain artificial respiration. Numerous dogs were operated but we find no record of the use of this apparatus in clinical surgery.

In August 1910, Dorrance published a report of a series of animal experiments in which he used finally a modification of Green's tube, carrying an inflatable cuff. His description of this tube and its application fits well the cuffed catheters and their technique as it is employed today, (Figs. 12 and 13). Dorrance introduced his tube several times in anesthetized patients but had had no opportunity to use it clinically

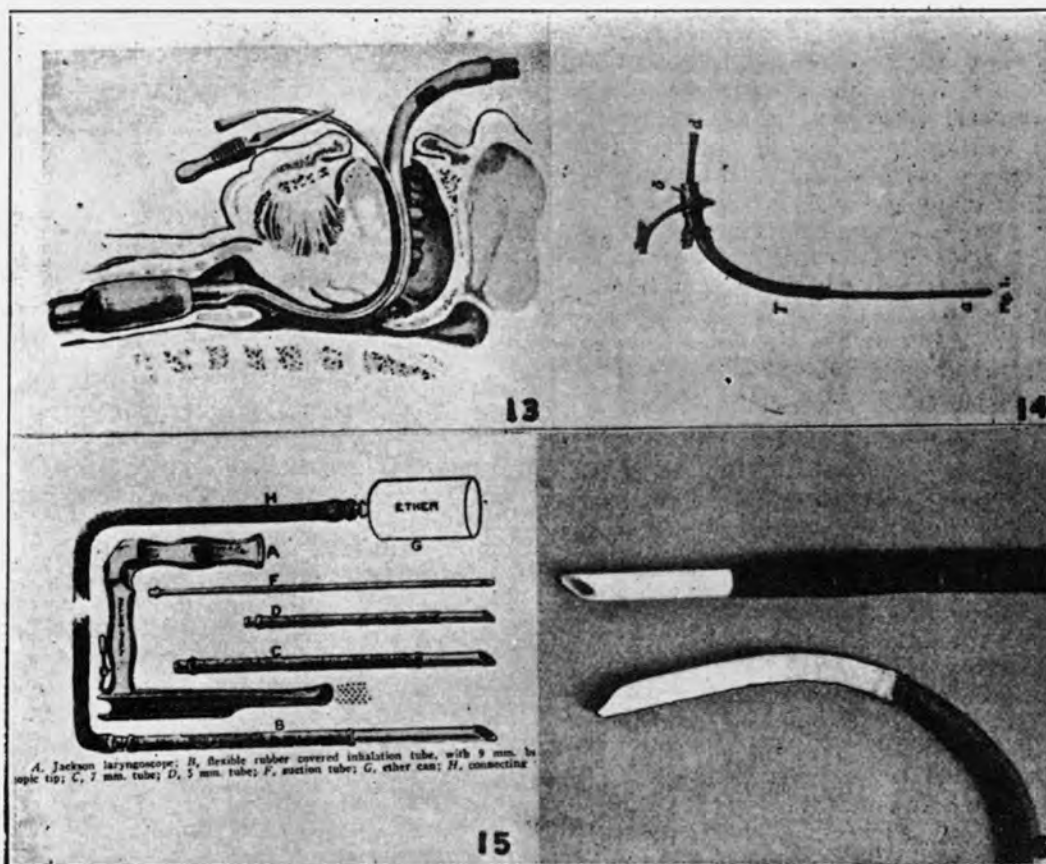


Fig. 13. Dorrance's cuffed catheter in place. Cuff inflated. August, 1910. Fig. 14. Endotracheal tube of Franz Kuhn. Reported in January, 1910. Apparently the first endotracheal tube with a smaller catheter passed through it. Fig. 15. Flagg's endotracheal outfit for ether administration. Fig. 16. Catheters of DeCaux. Spiral wire with rubber tip.

in thoracic surgery prior to the date of his report. He had however used the tube for direct mouth to trachea insufflation in three cases of respiratory failure, with satisfactory results.

It is interesting to note the great similarity between the anatomical drawing of Dorrance showing his tube in place (*Fig. 13*) and the drawing of Waters and Guedel (*Fig. 20*) published in 1932 without knowledge of Dorrance's work. At the 1911 International Surgical Conference, Garre reported the work of Dorrance under the title of "Der Pneumothorax".

Kuhn is outstanding among the German workers of the first decade of this century. With the problem of pneumothorax in mind he devised, among other things, an endotracheal tube made of metal strap, coiled to form a "flexible cylinder". It was of sufficient caliber to accommodate to-and-fro breathing, and to fit the glottis in a more or less air-tight manner. He stressed the importance of to-and-fro breathing and called attention to the danger of cord spasm interfering with free expiration with the small catheter insufflation technique. Kuhn's tube was sufficiently large to accommodate the passage of a smaller catheter and he was apparently the first to employ this technique which is common today in endotracheal anesthesia, for the aspiration of operative debris from the trachea during lung surgery, (*Fig. 14*).

During the second decade of this century we find endotracheal anesthesia in a stage of rapidly growing popularity, finding use most extensively in England, Canada and Australia. However there seemed to be some very definite deterrent to its progress. Today we look back and see this deterrent in the physiological unsoundness of the positive pressure insufflation technique.

#### Endotracheal Inhalation vs. Insufflation

**P**ROBABLY the greatest impetus toward popularity of endotracheal anesthesia was the work of Meltzer, Auer and Elsberg. In 1909, Meltzer and Auer published their paper "Continuous Respiration Without Respiratory Movement", the spectacular aspect of which attracted much attention. They accomplished their results by insufflating a high volume oxygen

and ether laden air current continuously through a small endotracheal catheter, allowing sufficient space between the outer wall of the catheter and the vocal cords for the escape of this insufflated air. The natural result of this continuous forced pulmonary ventilation with its removal of alveolar carbon dioxid, was the removal from the patient of the impetus to breathe.

Elsberg, in 1910, showed before the New York Academy of Medicine, his complicated but efficient apparatus for carrying out the anesthesia ideas of Meltzer and Auer. Elsberg, within a year after the publication of his report, had used this method in more than one hundred cases. However early in this series he abandoned the idea of holding respiratory movement in abeyance as being unnecessary. It was found that the cases which breathed for themselves stood up under the operation and left the table in better condition than those in which respiratory movement was abolished.

The work of Meltzer and Auer and of Elsberg marked the beginning of the end of endotracheal anesthesia by insufflation in favor of the method of endotracheal inhalation. Herewith follows a brief analysis of the reasons for the abandonment of insufflation.

(1) The continuous flow of air, which was all too frequently cold and dry, through the trachea and lungs depleted the tissues of heat and moisture and by the excess removal of carbon dioxid greatly disturbed the acid-base balance of the patient.

(2) There was the ever present danger of subcutaneous emphysema of the face and neck when the outlet about the catheter might become obstructed, by cord spasm or accumulated debris, with the pressure regulator awry at the same moment. Most of us who had used endotracheal insufflation to any extent knew well the embarrassment of explaining away these "wind tumors".

From 1912 until after the Great War, insufflation still enjoyed considerable popularity but the dissatisfaction with the method was manifest in the attempts to get rid of the above mentioned two deficiencies. For example, the double apertured catheter appeared about this time, having one opening for insufflation and the other for outflow.

It is noteworthy here that during and

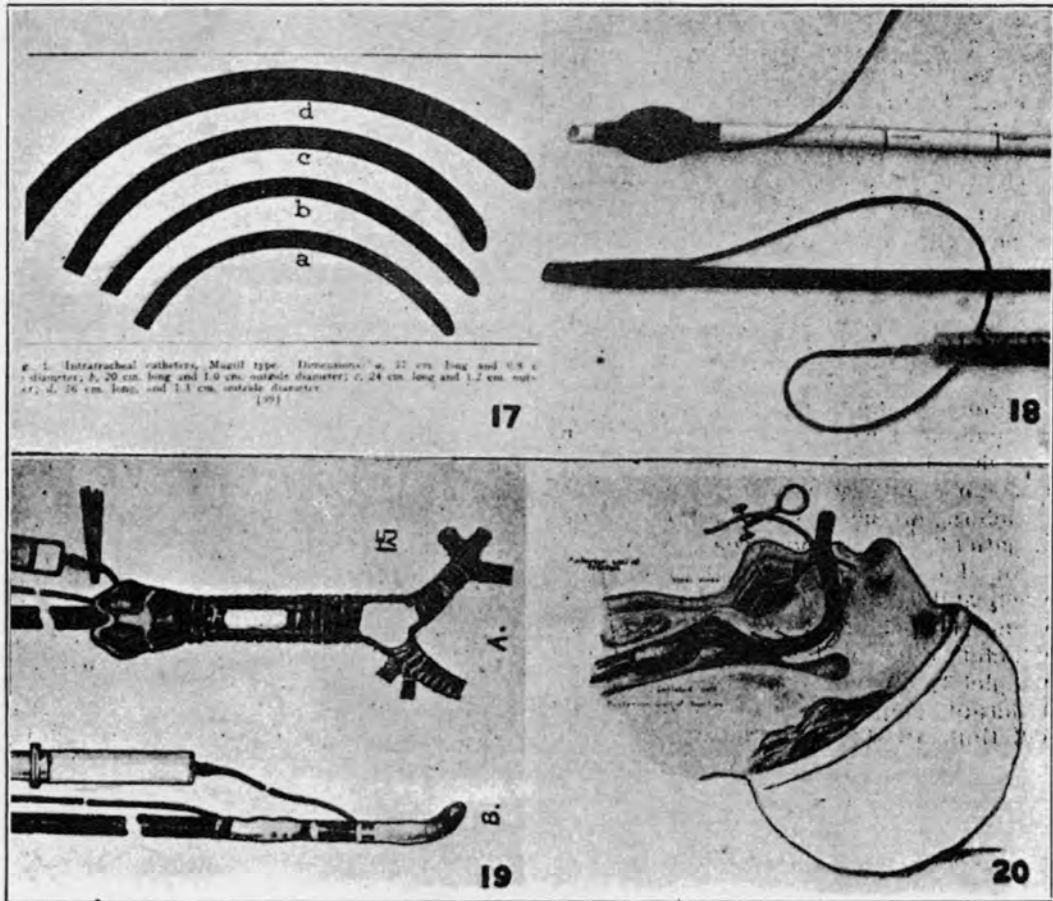


Fig. 17. Magill's soft rubber catheters. Fig. 18. Catheters with Guedel-Waters cuff. Inflated and uninflated. Fig. 19. The two balloon catheter of Waters for endobronchial intubation in lung surgery. Fig. 20. Guedel-Waters cuffed catheter in place.

after the Great War the field of application of endotracheal anesthesia widened greatly. Its value in thoracic surgery was not forgotten but the field of plastic reconstructive surgery of the face and neck, with its rapid development demanded this type of anesthesia to the extent that the thoracic surgery application became secondary. The necessity of exclusion of blood from the trachea and the maintenance of tranquil anesthesia for this work became paramount. With this increased demand for endotracheal anesthesia, greater effort was manifest in rendering it free from trouble.

In 1920, Rowbotham and Magill began to report their experiences in surgery of the head and neck under endotracheal anesthesia and it was they who shortly afterward put into use the method of to-and-fro breathing instead of insufflation. Insufflation died promptly.

Endotracheal inhalation with its freedom from pressure and the danger of emphysema, together with its conservation of body heat and moisture and the acid-base equilibrium, entirely supplanted insufflation.

Magill instituted the use of the soft rubber curved tube for nasal laryngeal intubation, which was also applied in oral intubation. He secured a more or less air-tight contact in the larynx by selecting a tube of sufficient size to fill the vocal slit, and reinforced this when necessary by packing the pharynx with gauze. These tubes and this technique are well known and in common use today, (Fig. 17).

In 1927, Flagg, with the aid of Chevalier Jackson, produced his spiral wire, metal tipped tube for oral laryngeal intubation by direct vision, (Fig. 15).

Hargrave soon followed with his sug-



gested woven wire, gum coated catheters which are used in the same manner.

DeCaux produced a spiral wire tube like that of Flagg except that it had a flexible rubber laryngeal tip, (Fig. 16). The tubes of Flagg, Hargrave and DeCaux were made in various sizes with the idea of filling the vocal slit to prevent leakage.

In 1928 Guedel and Waters, in an effort to more completely exclude blood and other operative debris from the trachea during mouth and nose surgery, and to make practicable the application of Waters' carbon dioxid absorption technique to pressure controlled endotracheal anesthesia, devised an inflatable rubber cuff for endotracheal catheters, (Figs. 18 and 20). This later proved to be a duplication of the work done by Dorrance, in 1910. Guedel and Waters demonstrated the leak-proof ability of their catheter cuff, by anesthetizing a dog and holding it submerged in water for an indefinite period. The authors have used this cuff on all types of endotracheal catheters, in nasal and oral intubation, in patients above seven years of age.

In 1931, Waters demonstrated the practicability in dogs, of intubation of either bronchus with a cuff tipped

catheter thus enabling him to isolate completely from respiration the lung undergoing operation. By inflation and deflation of the cuff he was able to maintain any degree of distension, even to complete collapse of the lung being operated, without respiratory movement in that lung, during any period and for as long as desired during the operation, (Fig. 19). His effort was prompted by the necessity of preventing the debris from the operated lung from gravitating into the trachea and the other bronchus. Respiration is carried on entirely by the good lung.

Corrylos, in 1931, perfected a technique in which, by passing a small aspirating tube through his to-and-fro respiratory catheter, he was able to keep the trachea and bronchi comparatively free from operative debris during lung surgery.

Thus has been carried to date the chronological development of a great advance in anesthesia, and we would predict that the present decade will witness the widespread application of this advance, endotracheal anesthesia.

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## VIDENSKAB OG PRAKSIS

### KLOROFORM I 100 ÅR

Af RALPH M. WATERS, M. D.  
Madison, Wis., U. S. A.

Om aftenen den 10. november 1847 præsenterede James Y. Simpson en erstatning for æter for the Medico Chirurgical Society of Edinburgh. Han sagde: »Jeg har forsøgsvis udvalgt og indåndet adskillige kemiske vædsker med en mere vellugtende og behagelig duft — — — Jeg har imidlertid fundet een langt mere virksom end nogen af de andre, nemlig kloroform, og jeg kan udtale mig med den største pålidelighed om dens overlegne anæstetiske egenskaber, idet jeg nu har prøvet den på mere end 30 personer«. Han nævnte derefter 7 fordele, som det nye stof havde fremfor svovlsurt æter. Disse var i korthed: Der krævedes mindre kvantum, virkningen var hurtig og fuldstændig, det var mere »behageligt og let at indånde«, mindre kostbart, det efterlod en behagelig lugt ved patientens ånde og den assisterendes klæder, det var lettere at transportere, og der krævedes ikke speciel inhalator eller specielt apparat for at administrere det. Den teknik, der blev foreslået i den originale meddelelse, var at samle lommestørklædet som en kop i den hule hånd og, når operationen begyndte at blive alvorlig, hælde »en eller to theskefulde kloroform i størklædets hulning« og hurtig holde det op mod patientens ansigt. En måned senere sagde Simpson til det samme auditorium: »Når den anvendes ved kirurgiske operationer, bør den gives hurtigt og i store doser« — — — og tilføjede: »Jeg tror, alle de gentagne mislykkede resultater og uheld kan tilskrives to årsager, nemlig 1. brugen af en uren og dårlig kloroform og 2. at den ikke er givet i tilstrækkelig store og hurtige doser«. Han tilføjede imidlertid ved denne lejlighed: »Det er utvivlsomt for virkningsfuldt et stof til at blive betroet til sygeplejersker og ikke uddannede personer«.

Mindre end 3 måneder senere, den 29. januar 1848, indtraf Hannah Greeners nu meget omtalte død som følge af anvendelse af een teske-

fuld kloroform efter den teknik, som Simpson havde foreslået.\*) Der havde tidligere i samme måned lydt advarsler. John Snow henledte opmærksomheden på faren ved at indånde koncentreret kloroformdamp fra et lommestørklæde for at fremkalde bevidstløshed efter 6—7 indåndinger, som Simpson havde anbefalet. (1). Han anbefalede 2 minutter som minimumstid for indånding og mente at »der kræves et apparat ved hjælp af hvilket dampen kan indåndes meget langsomt i begyndelsen«. Efter at have læst om Hannah Greeners død kommenterede Snow: (2) — »Jeg betragter resultatet som det eneste, der var at vente i betragtning af kloroformens overordentlig hurtige virkning, når den indåndes fra et lommestørklæde. Jeg har iagttaget at dampens virkninger kan akkumuleres i ca. 20 sekunder efter at inhalationen er afbrudt« Snow henviste også til bemærkninger af M. Sédillet i Academy of Sciences den 10. januar, i hvilket han sagde: »Blegheden, den svage puls, den lave respiration og hudens kølighed tiltager undertiden i alarmerende grad, efter at inhalatoren er blevet fjernet«. I sin kommentar til Hannah Greeners død skrev Snow: »Til at give kloroform ved operationer må man bruge et apparat, som ikke besværliggør respirationen, og ved hjælp af hvilket kloroformkoncentrationen i indåndingsluften kan reguleres« og »jeg dadler ingen; thi idet dr. Simpson præsenterer os kloroformens fordele, kan han ikke dadles for den omstændighed, at hans oplysninger ikke stiger frem, perfekte og fuldkomne, som Minerva fra Jupiters hoved«.

\*) Skønt dette var det første dødsfald under anæstesi som blev kendt af offentligheden, muligvis fordi den engelske lov påbyder, at ligsynsmanden foretager en undersøgelse i sådanne tilfælde, var dog lignende ulykker indtruffet under brugen af æter i 1847. En rapport i London Medical Gazette 41: 432, den 10. marts 1848, omhandler en 55-årig mands dødsfald i august 1847, indtruffet under en æter-anæstesi på hotel Dieu i Auxerre.

Fra »The Department of Anesthesia, Medical School, University of Wisconsin«.

I løbet af de 100 år man har brugt kloroformen er stoffet vekselvis blevet fordømt og lovprikt og synes nu i litteraturen at blive endelig forkastet. Når man læser litteraturen igennem, er den mærkelige ligegyldighed over for Snow's påstand om administrationsmådens betydningsfuldhed iøjnefaldende. Talrige rapporter, der er udsendt af komiteer og kommissioner i forskellige lande og til forskellige tider, har sjældent mere end nævnt de tekniske detaljer ved brugen. Kun få henviser til anvendelsen af ilt eller tungeholdere o. lign. Sjældent er der tale om en nøjagtig og kontrolleret koncentration af kloroformdampen.

Vi har nylig, i det mindste forsøgsvis, modtaget flere nye stoffer (Avertin, Cyclopropan, Barbitursyrederivater, Vinylæter og Triklorætylen for at nævne nogle stykker) som først blev prøvet af anæsthesispecialister, der var kendt med moderne metoder og instrumentarium. Som forsøgsobjekter blev brugt både dyr og mennesker, og disses diæt og vædskebalance blev nøje overvåget. Ilt, tungeholdere o. lign. stod til rådighed. Mens man sammenlignede nogle af disse stoffer med ældre, blev det åbenbart, at et videre studium af kloroform var nødvendigt. For eksempel fandt man, at Vine-then »frembragte focal nekrose af leveren og var giftigere i denne henseende end kloroform«. Vine-then's virkninger på urinstofclearance var alvorlige, hvorimod kloroform frembragte ringe eller ingen forandringer i nyrefunktion at dømme efter urinstofclearance, bestemt efter talrige forsøg med hunde. Efter en standardpræpareret dosis af adrenalin frembragte kloroform en mindre forøget stimulering af autonomt innerveret væv end Cyclopropan og »fibrillære trækninger udløstes ikke i vore kloroformforsøg«. (3) (4) (5) Disse resultater var i strid med mange angivelser i litteraturen.

I betragtning af de netop nævnte erfaringer syntes en specifik undersøgelse af kloroform på sin plads. Da klinisk materiale var nødvendigt hertil, begyndte vi i 1940 at bruge kloroform ved et specielt tilfælde i operationsstuerne. Ved slutningen af 1946 var 892 patienter blevet bedøvet med dette stof. Alle tilfældene blev underkastet den sædvanlige statistiske analyse. Nogle enkelte blev undersøgt i detaljer ved hjælp af adskillige til rådighed stående midler i laboratorium og klinik. På samme tid er der blevet udført forsøg på forskellige dyrearter, specielt hunde. De detaljerede resultater vil i korthed blive offentliggjort i en række skrifter. Det har været et kooperativt arbejde. Medlemmer fra »The Departments of Internal Medicine, Surgery, Physiology and Pharmacology« så vel som fra »The Department of Anesthesia« bidrog til arbejdet. Man har under brugen af kloroform omhyggeligt passet på, at åndedrættet ikke blev hæmmet. Den indåndede luft blev i mange tilfælde tilsat ilt i ubegrænset mængde både i laboratoriet og på operationsstuen. Der blev imidlertid intet specielt apparat taget i brug til kontrol af fordampningen eller til overføring af damp til forsøgspersonen. Teknikken varierede fra den såkaldte »open-drop« metode til »kuldioxyd ab-

sorption med alle de sædvanlige overgangsled. Vi begyndte imidlertid med sund hensyntagen til stoffets evne og »lunefulde« (6) natur, og vi ser ingen grund til at opgive denne indstilling.

*Leveren.* Forandringer i kefalin-kolesterolreaktionen, bromsulfaleinprøven, thymolreaktionen, protrombintiden og ikerusindex er blevet undersøgt for at bedømme virkningen på leveren. 65 kirurgiske tilfælde bedøvet med kloroform blev sammenlignet med 56 tilfælde bedøvet med andre mere almindeligt anvendte stoffer. Der blev fundet lidt større forandringer efter brugen af kloroform.

*Nyrerne.* Nyrefunktionen er blevet undersøgt på lignende måde som beskrevet for leverens vedkommende. Fenolsulfonptaleinekskretionen, urinstof-clearance, alkalireserven, blodsukkeret og restkvælstoffet blev undersøgt før og efter kloroformanæstesi i 40 tilfælde og ligeledes i 42 kontrolforsøg. Forskellen på de to grupper er ringe.

*Blodcirkulation.* Der er blevet optaget elektrokardiogrammer under mange kloroformanæstesi ved forskellige operationer. Adskillige typer på arytmi er set. Ventrikulær tachycardi har man mødt; men ventrikelflimren er ikke observeret under kloroformanæstesi hos hunde og mennesker, undtagen når de første fik adrenalin. Een patient fik hjertestandsning, efter at han havde holdt vejret og derefter gjort to dybe indåndinger af koncentreret kloroformdamp. Fyldning af lungerne i den hensigt at reducere kloroformkoncentrationen resulterede i en genoptagelse af den normale hjerterytme med et efterfølgende normalt postoperativt forløb. Det er mit indtryk, at alvorlige forstyrrelser i hjerterytmen er frembragt af en pludselig forøgelse af damptrykket eller af grov overdosering. Blodtrykket kan næsten vilkårligt reduceres ved at kloroformkoncentrationen forøges; men en tilstrækkelig dosis til at fremkalde anæstesi til kirurgisk brug kan opretholdes på ubestemt tid uden bemærkelsesværdigt forøget fald i blodtrykket.

I årene 1940—46 inclusive blev 32,828 patienter bedøvet på anæstesiafdelingen, Wisconsin General Hospital. Der blev brugt kloroform til 892 (2,7 %) af disse patienter. Hospitalets dødsprocent for de 31,936 bedøvet med andre stoffer var 2,6 %, medens den for kloroform var 6,7 %. To af disse dødsfald indtraf på operationsstuen, de ene ved slutningen af en stor hjerneoperation efter et blodtab og et efter en lignende operation efter at der var anlagt en klemme på arteria cerebri media. Af de 892 patienter led 303 (33,9 %) af en ondartet sygdom. Patienter, som man vidste led af lever-, nyre- eller hjertesygdomme, fik kloroform. Størstedelen af de udførte operationer var store og af betydelig varighed. I 702 tilfælde (78,7 %) blev resultatet af anæstesen betragtet som »tilfredsstillende«. I 44 tilfælde blev afslappelsen betegnet som »utilfredsstill-

lede, skønt kirurgen kun i 11 af disse udtrykte afgjort utilfredshed. Af størst betydning er gruppen på 12 patienter, hos hvem anæstesiologen observerede, at en yderst farlig situation indtraf. Uheldene var sædvanligvis resultatet af pludselig overdosering og bestod i standsning af åndedrættet, krampe i epiglottis og alvorlige cirkulationsforandringer, af hvilke de sidste var de farligste.

#### RESUME

Jeg må erkende, at andre i vid udstrækning har del i det arbejde, jeg netop har henvist til. Min eneste andel har været lejlighedsvis at anvende kloroform, når valget, i betragtning af hvad litteraturen havde ladet os vente, syntes uklogt. Der gøres rede for detaljer i artiklen, og flere vil blive offentliggjort med passende kommentarer af de personer, som har gjort arbejdet i virkeligheden. Mit personlige standpunkt som resultat af undersøgelsen er følgende:

John Snows opdagelser og slutninger (1848-58) synes langt mere korrekte end dem, andre har gjort efter hans tid. Hurtig forøgelse af koncentrationen af kloroform, som dermed pludselig når hjertet, kan føre til hjertestandsning på grund af direkte giftighed overfor myocardiet. Man må anvende en omhyggelig administration for at give patienten kloroform under et kontrolleret tryk. Rigt og ubesværet åndedræt er væsentligt; — i en atmosfære tilsat ilt, når det står til rådighed. Muligheden for pludselig hjertestandsning, ikke åndedrættet, er altid til stede under enhver administration. Stadig palpation af pulsen er nødvendig. Muligheden for øjeblikkelig forandring af koncentrationen og lejlighed til kunstigt åndedræt må altid være for hånden.

Skønt lever- og nyrefunktionen kan beskadiges af et hvilket som helst anæstesimiddel sker det ikke så konstant efter kloroform, som jeg ville have troet efter litteraturen. Muligvis skyldes dette forskelligheder i administrationsteknikken. Det er givet, at en fri respiration, rigelig ilt og omhyggelig kontrol af damptheden (koncentrationen) er af betydning.

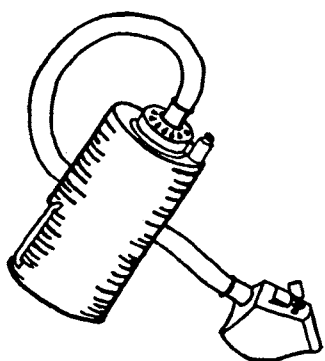
Kloroform er et betydeligt og »lunefuldt« stof med både ønskede og uønskede egenskaber. Hvorvidt et mere passende apparat til fordampning og kontrol af administrationen kan formilde de uønskede egenskaber og retfærdiggøre, at man drager fordel af de ønskede, får stå hen. Snow havde i sandhed ret, når han forudså, at instruktionen i brugen af et nyt anæstesimiddel, hvad enten det var nyt i 1847 eller 1947, ikke ville stige frem perfekt og fuldkomment, som Minerva fra Jupiters hoved.

#### Literatur:

- 1) Diskussionen i Westminster Medical Society, den 8. januar 1848, og gengivet i London Medical Gazette 41: 74, den 14. januar 1848.
- 2) London Medical Gazette 41: 277, den 18. februar 1848.
- 3) Orth, O. S., H. C. Slocum, I. W. Stutzmann og W.

I. Meek: Forsøg over Vinethen som anæstesimiddel. Anesthesiology 1: 246, 3. november 1940.

- 4) Orth, O. S. og I. W. Stutzman: Konstante værdier for urinstofclearance hos hunde efter kirurgisk anæstesi med Cyclopropan, Æter og Kloroform. Proc. Soc. for Exp. Biol. & Med. 39: 403, november 1938.
- 5) Meek, W. I., O. S. Orth og H. R. Hathaway: Æter, Kloroform og Cyclopropans virkninger på hjertets automati. In. of Pharm. & Exp. Therap. 61: 3. november 1937.
- 6) En vending, der blev brugt i »Glasgow Report« om anæstesimidlers virkning fremstillet for »The Scientific Grants Committee of the British Medical Association« og udgivet i »The British Medical Journal«, juni 1879.



# CHLOROFORM

## A Study after 100 Years

*Edited by*  
*Ralph M. Waters*

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## Preface

THE FOLLOWING pages record the observations and experiences during the past decade of a considerable number of persons. Included were my several immediate associates and residents in the Department of Anesthesia. But in addition, many friends and co-workers in the University, both within and outside the Medical School, have contributed valuable suggestions and assistance.

Personally, I feel much like the fly sitting on the axle of chariot wheel and exclaiming "what a dust do I raise," since my own contribution to this effort has been minimal in the extreme. I am most grateful to every one mentioned in the book and to many others for accomplishing work which I myself had long hoped, but neglected, to do.

For the past one hundred years chloroform has been the cause of a controversial storm of length and intensity rarely equaled in medical literature. Fear and distrust, based upon incomplete knowledge and misconceptions, have engendered a present disuse of this agent which seems out of all proportion to the facts. The confusion which followed the introduction at approximately the same time of such widely dissimilar agents as ether and chloroform could only be equaled if we imagine the turmoil and doubts which would have arisen had nitrous oxide and cyclopropane made their début together instead of nearly one hundred years apart. It is interesting to speculate how different might be the current view of chloroform had it been cautiously introduced

## PREFACE

as a new drug within the past decade. During our early studies of cyclopropane, one of us frequently remarked to an associate, "If chloroform as an unknown drug were the subject of our investigations, our enthusiasm might be quite as great." Doubtless the statement stemmed from its author's early personal experience, since he had used chloroform occasionally for special purposes over a period of many years. Modern methods of study of the potency, toxicity, and specific pharmacological effects of a drug upon the various functions of the body differ from those of the nineteenth century. The thought occurred to us at Wisconsin, "Why not study chloroform again by means of these more modern methods as we would a new agent." This we have done in the recent past.

This investigation was conducted in two different ways. In the laboratory the effects of the drug on experimental animals were examined. Methods for estimating concentrations of chloroform in blood and in vapor were evolved and applied. In the operating rooms the drug was administered to more than a thousand patients who were being subjected to all forms of surgical intervention, and meticulous records were kept. Each record covers not only the events which took place during the administration, but also the details of the condition of the patient before and after operation. Special investigations of renal, hepatic, and cardiac function were conducted in many of the clinical cases, both during and after the operation. If the consent of the relatives could be obtained, autopsy was performed in each fatal case.

It is our hope that extension of these studies may continue. Lucien Morris and LeRoy Sims have already begun investigations of the possible effects of disturbances of the content of oxygen and carbon dioxide upon the toxicity of chloroform. Simpson Burke, Lucien Morris, and others in the group are greatly interested in perfecting more accurate means for controlling the tension of chloroform vapor during administration. Perhaps this monograph may be the means of stimulating interest and investi-

## PREFACE

gation in this subject by those outside the Wisconsin group. If so, the effort will have served a useful purpose.

Dr. LeRoy Sims, of the Department of Internal Medicine, has pursued the studies of hepatic function begun by Dr. Frederick J. Pohle. In November, 1947, Dr. Pohle was taken from us by sudden illness and death. This has been to us a loss as grievous personally as professionally. For "Fred" was in his early forties, and on the threshold of a brilliant career in internal medicine. Moreover, he was a man of great personal charm and honesty, which had endeared him to all whose good fortune had brought them into contact with him. He played a leading part in the inception of this work, and the section devoted to studies of hepatic function in the human being remains unchanged as he wrote it. We, therefore, wish to dedicate this work to the memory of our friend and co-worker.

R. M. W.

*Madison, 1950*



# *AUTOBIOGRAPHY*



## Pioneering in Anesthesiology

RALPH M. WATERS\*

MADISON, WISCONSIN

ON A cold, windy day in the winter of 1912-13, a medical practitioner in a small city in our Missouri River Valley turned over to me his office, whatever I could retain of his practice, and his bull terrier. He was bound for Vienna, postgraduate study, and, I suspect, specialization in the future. The office was spacious and "well located" over a drug store. The practice which came to me, largely referred by the pharmacists downstairs, most often proved to be drug addicts seeking relief in those days before the Harrison antinarcotic law. The dog, a very unsatisfactory companion for a bachelor, would not eat in the presence of human observers and caused me much inconvenience. I collected \$144 in fees the first month without accepting the largest roll of bills I had ever seen up to that time; it was offered by an addict if I would inject a syringe of cocaine solution into his vein.

One of my duties in conducting the practice was occasionally to administer somnoform (a then popular mixture of ethyl and methyl chloride and ethyl bromide) to the patients of a neighboring dentist. I was permitted to join the informal and unorganized staff of my predecessor's hospital. A surgeon there possessed an apparatus for the administration of nitrous oxide, but no one, except the advertising "painless" dentists, knew how to use this agent. I

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volunteered, and thus the foundation for my career of specialization was laid.

In general, the line drawn between specialists and general practitioners was at that time neither very straight nor very distinct. For instance, I am sure that 75 per cent of the members of the county medical society attempted, at least occasionally, to perform major surgical operations. I was not without guilt myself in those days. In a then recognized hospital, I once anesthetized a woman while a man removed her uterus without benefit of ligature or suture. Clamps were applied to the vessels *after* the bleeding had become "less active" and the wound was closed about the clamps. Believe it or not, she lived long enough to regain consciousness. In the good old days a suction tip in the anesthetist's hand often supplemented the skill of the surgeon's dissection of numerous pairs of tonsils.

The requirements for specialization in many mid-western hospitals consisted of the possession of sufficient audacity to attempt a procedure and persuasive power adequate to gain the consent of the patient or his family.

With native intelligence and periodic visits to centers of medical learning in this country and abroad, a creditable specialist often eventually resulted. Technics were not so intricate nor was the breadth of knowledge so extensive as at present. Frequently a "half-baked" specialist designated him-

self as paying "special attention to" this or that. A practitioner especially interested in gynecology for instance, had printed on the door of his office and on his professional cards and stationery, "John Doe, M.D., Special Attention to Diseases of Women." The first formal recognition of limitation in my own practice was upon professional cards carrying the notation "Practice Limited to Obstetrics and Anesthesia." This was solely because I liked to do such work and had no thought of the impossible conflicts in appointment that were bound to occur.

After three years of mixed experience and a month's visit with an eastern anesthetist, my practice in the small midwestern city became "limited to anesthesia." I was a specialist. Many a fellow practitioner in the Mississippi Valley and its tributaries became a specialist in similar fashion in the years before the first World War. To be sure, residencies in some of the specialties were available in hospitals associated with the better medical schools. Occasionally a man studied a specialty for several years in European clinics. On their return these men usually settled in the large centers on the seaboard. Some became specialists by associating themselves with an older preceptor in the specialty. In the main, however, specialists as I saw them in the midwest originated as I have described.

Generally, incomes depended more upon the boldness of the man and his economic acumen than upon his professional proficiency. Then, even more than now, the color of a man's necktie, the length of his waistline, his glibness of tongue, or his cheery manner had much to do with his success. I once had the unpleasant duty of anesthetizing a woman for the removal of her kidney by a "surgeon" who had tied off the ureter at a previous simple hysterectomy. When I returned the patient to her room, the husband detained me for some time with a recitation of the virtues and skill of the operator.

FROM what I have said, it should be obvious that financial success and even professional recognition in a specialty could be gained without a great outlay of time and study. It was quite another matter regarding one's own self-respect and personal satisfaction. Within a few months of the beginning of my special interest it became evident to me that

(1) interest in anesthesia was superficial when it existed at all in this country; (2) opportunities for training were scarce; and (3) such contributions as were being made came largely from those whose primary interest was surgical or that of the laboratory. Real specialists in anesthesia were rare indeed.

In certain centers a very few physicians had interested themselves in the practical and technical aspects of the subject. I found that the source of this interest was Great Britain and that the first scientific specialist in anesthesia (I had almost said the only one) began his practice and his investigations almost with the first public demonstration of surgical anesthesia.

It was on October 16, 1846, that Morton first administered ether at Massachusetts General Hospital in Boston. A month later, John Snow began the study and the administration of ether.<sup>1</sup> Dating from January 28, 1847, he reported that "the ether produced the desired effect in every operation performed in St. George's Hospital." Snow's biographer says, "What had been a mere accidental discovery, I had almost said a lucky adventure, was turned by the touch of the master [Snow] into a veritable science." Although Snow died eleven years later, his influence remained. His scientific study and application explains much of our present knowledge and skill at the end of the first century in the use of anesthesia. The respect in which Snow was held by the profession in Great Britain influenced high-caliber men throughout the British Empire to follow in his footsteps. The few men such as Bennett, Gwathmey, and others who specialized in anesthesia in this country received their inspiration not from New England but from Snow and his followers in Great Britain. To this day, in the British Empire, the administration of anesthetic agents has never been entrusted to those who do not have a medical degree.

I have written elsewhere of the influence of publications and organizations upon the development of this specialty during the present century.<sup>2</sup> Others will record the influence of the recent war. My own effort has been along lines of undergraduate and graduate teaching and investigation; in other words the contribution of the medical school. After ten years of private practice "limited to anesthesia," two things seemed obvious to me. First, improve-

ments in our knowledge of the subject, the whys and hows of both the science and the art, depended upon close cooperation of those who administered drugs in the operating room with those who worked in the laboratories. Only in the medical school can such cooperation be established. Second, so long as the majority of physicians had little or no understanding of the dangers, the importance, and the possible contributions to the welfare of patients which anesthesiology can offer, no improvement or recognition could be expected. Again the medical school was the answer. Only when every medical college is teaching those whom it graduates the real foundations upon which sane administration of narcotic drugs must be based, can we expect the profession to appreciate and demand legitimate service for its patients.

In early days the deplorable belief was common, and still lingers in the minds of some of the profession, that the best in anesthesia lay in the "choice of agent," the selection of a particular drug with some occult fitness for administration in a given case. Little consideration was given to the all-important fact that all known anesthetic drugs and methods of using them often produce dangerous side effects. We were long in recognizing that it is the anticipation and recognition of these undesirable physiologic disturbances accompanying anesthesia and their management and control which constitute wise and safe anesthesia.

IN 1927, I was glad to accept a place on the medical faculty at Wisconsin. Objectives of that position from the beginning have been fourfold. In order of their importance they still remain: (1) to provide the best possible service to patients of the institution; (2) to teach what is known of the principles of anesthesiology to all candidates for the medical degree; (3) to help long-term graduate students not only to gain a fundamental knowledge of the subject and to master the art of administration, but also to learn as much as possible of effective methods of teaching; and (4) to accompany these efforts with the encouragement of as much cooperative investigation as is consistent with achieving the first three objectives.

Some of the details of our attempts to carry out

these objectives have been published in previous papers.<sup>3, 4, 5, 6</sup> It will be sufficient to say here that we believe our undergraduates have acquired only what is essential by a didactic period once a week during the second half of their third year (junior) and a service of two weeks in the operating room during their senior year. This we feel gives only the minimum of information and experience in anesthesiology necessary for any well-informed physician. If anesthesiology as a specialty is contemplated, a residency of at least three years' duration seems to be advisable. To review our experiences and personal conclusions regarding these residencies at Wisconsin after twenty years may be of interest to others. Some of the conclusions apply to the specialty of anesthesiology only. Others seem to me of general application to graduate instruction in all the specialties.

Possibly by accident, and certainly for selfish reasons at first, resident graduate students in the specialty were chosen who had had some experience in anesthesia as a special interest during a period of general practice. Compared with individuals who come right to specialization from a rotating internship, such residents seemed to have definite advantages. It has been my practice, almost without exception, to urge, if not require, that every applicant for an appointment on our service finish a period of two or three years in general practice before he makes a final decision as to what specialty he desires to enter.

After observing individuals for twenty years, both during their training period and following it, I feel quite sure that an interval in general practice before specialization is highly desirable. I believe that the younger doctor who follows the plan of internship, general practice, final decision as to his specialty, and then a long-term residency will be more successful and more satisfied ten years after graduation than would the same individual if he went into a specialty directly following his internship. This statement, I realize, demands some defense.

From the young man's standpoint it may be argued that a period of general practice before specialization delays the beginning of one's real life work until the individual is too old for real enthusiasm. Economic security may be delayed, and the early establishment of a family and a permanent

home of one's own may be impossible. However, as I look back upon those who have been associated with me in the study of anesthesiology in the long past, these two objections seem to be overbalanced by numerous advantages. At least some of these men who became specialists married, had families, and yet were economically stable and happy.

THE hospital staff and management may argue that the resident with previous experience in general practice is intractable, less cooperative, less studious, and more demanding. Some of these objections depend upon the point of view. If, as a primary function, the hospital expects its residents in the specialties to care for its patients, and to do the work of the hospital and the visiting staff, then the younger and less experienced in life they are, the better. For instance, I know of hospitals that have "modernized" their service in my own specialty by replacing former technicians in anesthesia—the so-called "anesthetic nurses" who got a salary of \$150 or more a month—with "residents" in anesthesia, young doctors at 25 dollars a month. These "residents" have been allowed to anesthetize patients, private and others, without proper supervision or instruction while the hospital budget is balanced by the fees which it collects for their services.

If, as I believe, residencies or fellowships in the specialties are maintained primarily for the purpose of creating capable specialists who will contribute the maximum in efficient service to the public in the future, it is the responsibility of the hospital to provide time, opportunity, and instructors necessary to prepare them. An immature youngster just finishing his internship may be happy with the opportunity to care for patients independently, to operate upon them, or to anesthetize them, and to permit such experience to be called "training for a specialty." The man with experience in general practice does not accept such conditions as "graduate training for a specialty." We, as staff members and hospital administrators, must guard against having opinions or supporting practices which contribute to the convenience of the visiting staff and the economic security of the hospital at the expense of the quality of special training offered. I am suggesting that the maturity of the man who begins to special-

ize after a brief experience in general practice will prevent us—teachers, visiting staff, and hospital administrators—from exploiting, however unconsciously, the graduate student.

But, you say, common honesty and understanding on our part will prevent exploitation of the graduate student. Agreed. What then are the real advantages of the plan I am proposing? They extend in two directions—to the community and to the young doctor. One of our unsolved problems in recent years has been the deficiency of available family practitioners to serve our smaller communities. If every medical graduate, on finishing his internship, were to undertake a short period of general practice, this shortage would not exist. A few months or years of such experience gives the young doctor an opportunity to learn how to collect and spend money, how to conduct himself in his relations with the community in which he lives, with patients and their families, and with other physicians. It is so easy to acquire a critical and unsympathetic attitude in a specialty. It is less easy when one has lived "on the other side of the fence." But more especially the young doctor during general experience will see all sides of the practice of medicine; he will refer cases to specialists; he will learn that no patient is the problem of a single specialty. While making these observations, he will be in a position to decide just what specialty he will really enjoy and where his inclinations and skills will fit.

What about the community when he leaves to begin his special residency or his fellowship? Once the custom becomes established, will not a heritage develop much as it operates now regarding internships? Certain schools establish the custom of sending a man to this hospital, another to that, each year. As long as the hospital is satisfied, the habit continues. Sometimes it is a fraternity or some other small group which determines what hospital a particular senior will choose for his internship. Would not the same habit develop in determining where he would enter general practice the next year? The office, equipment, even the motor car and living quarters, might be handed down in a similar manner. If, as I am sure would happen, an occasional young doctor decided that he likes general practice and did not return for training in a specialty, I believe both the community and the pro-

fession would benefit by the doctor's decision.

To implement such a plan as I am advocating, a slight change is necessary in customs among administrators. Interns have said to me, "I like the idea of having experience in general practice before I decide what specialty I shall enter. But I get the impression that it will be next to impossible for me to secure a desirable appointment in a first-class department unless I arrange for it while I am an intern." Obviously, if the intern waits to avail himself of experience and maturity before choosing his life work, he must not be penalized for it. If more mature individuals are appointed, it is my firm conviction that the hospital superintendent and the director of training in any specialty will observe benefit not only to the graduate student but also to the service.

Even when a person has the advantage of a period of general practice during which he decides upon a specialty, he may be mistaken regarding his preference. Actual experience may prove that his aptitudes lie elsewhere. Both the candidate and our department always look upon the first six months of a resident's service as a trial period. If either side decides that a mistake has been made, we try to rectify it as soon as possible. Although these methods of deliberation in planning one's future may seem like waste of time, they make for satisfaction and success in later life. Everyone is not intrinsically equipped to be a surgeon, an obstetrician, an internist, or an anesthetist. May it not be advantageous to spend a reasonable time in deliberation and experimentation? Certainly there should be no disgrace attached to changing one's mind about the choice of his future life work. If the choice has been right, life is a joy forever after. Uncongenial work is drudgery.

What does the evidence show in the later experience of our own men who have gone out as specialists in anesthesiology? I am quite willing to admit that the number has been altogether too small to have the slightest statistical significance. We have had with us residents of three categories: (1) those who came to the specialty from their internships; (2) those who have had an interval of two or three years in general practice; and (3) a few who have come to us late in life, sometimes after part-time specialization for some years. What can we say of

their comparative accomplishments?

Those in the first group acquire knowledge and technical facility as readily as the others. On the other hand, as a group while in residency they show less good judgment, less independence of thought, and less self-reliance. They are more, rather than less, likely to give evidence of brashness or foolhardy conduct. After leaving us, when "out on their own," the first group have had more difficulty in building a place for themselves in the world. Their relations with hospital staff or medical school faculty, with hospital administrators, and with the community at large, have been more difficult at first and satisfactory adjustments have been made much more slowly.

THE second group, who have returned after an experience of two or three years in general practice, have, in our experience, shown little or no tendency to resist the necessary routine of a department, record-keeping, cooperation, and the like. They have adjusted to institutional life without difficulty. As a group, they offer more original ideas, good and bad, which not only prove a healthy stimulus to discussion in the department and to investigative effort, but also at times result in change of conviction in the department. The advantage to us and to our institution deriving from this second group over the first, though noticeable, may not have been great. The advantages to the resident himself, however, both during his training and in later life, seem to us considerable. He comes to us after a mature choice of what he wants to do. He works harder and grasps his opportunities with more vigor. Possibly the fact that he is older and more mature when he begins to practice "on his own" explains some of his advantage. However, I do not believe that age and maturity are the only factors. The broad viewpoint acquired as a general practitioner remains with him as a specialist. Experience in economic and social relations does not have to be acquired at a time when he is trying to establish himself as a specialist.

Finally, what of those in the third category who have been out in the world for a good many years either as part-time specialists or as general practitioners? Some of these are merely men who,

through failing health, deficient professional background, or desire for change, wish to specialize. These must be discouraged at once. An old dog doesn't learn new tricks very easily. As a rule, those in the third class do not fit into a residency program nor do they benefit themselves thereby. We have met a few exceptions to the rule, but these are rare indeed.

Personal acquaintance with candidates through long correspondence and at least one protracted personal interview is necessary if the director of a training program is to fulfill all his obligations. These extend not only to the applicant but to the applicant's prospective fellow students, to the specialty and last, but most important of all, to the medical profession as a whole and the service it will render to the public. If we cannot help young physicians to become specialists who will be a credit to our profession, if we do not put them in a position to perform a useful service in years to come, our efforts had better not be devoted to the "training of specialists."

## SUMMARY

Specialization in medical practice has developed as knowledge and skills have extended with the years. Methods of preparation of specialists have varied widely. I have recited some personal experiences and observations both as student and as teacher. The very informal customs I have described as being characteristic of some parts of our mid-west at the time I began practice in 1913 had certain advantages. Independence, self-reliance, and originality were developed; or at least these qualities, when naturally present, were not diminished. Sometimes, however, the freedom allowed led to boldness, rashness, and foolhardy practice, resulting, in certain cases, in disaster and death, if not murder.

Certainly it was not the ideal manner of preparation. We have speculated as to how the advantages of the informal, individualistic method of learning to be a specialist can be combined with the advantages of the formal training that is customary at the present time.

I think we may conclude that familiarity with physiologic functions and the manner in which these are affected by therapeutic procedure is the essential background of specialization. Added to such familiarity, technical skills in diagnosis and treatment are not enough to produce a real specialist. He must also have a rational, well-rounded attitude toward the general problems involved in the practice of medicine and the care of the sick. If our training of specialists sacrifices one of these three factors, either scientific background, special skills, or a rational, well-rounded attitude, it is not very successful.

Having tried to select those candidates for special training in anesthesiology who have conducted a general practice after internship and having watched a fairly large number of these later as specialists, in comparison with others who began to specialize directly after internship, I cannot avoid certain definite impressions.

1. The former general practitioners are happier and are better satisfied with their specialty.

2. They are more successful and more convincing professionally as specialists.

3. They more easily and completely command the respect and the economic recognition of fellow physicians, hospital administrators, and the public.

It is my belief that a young person will act for his own and the communities' best interest if he delays decision as to specialization and his choice of a specialty until he has passed through at least a short period in the general practice of medicine or its equivalent.

## REFERENCES

1. WATERS, R. M.: John Snow, first anesthetist. *Bios.* 7:25, March, 1936.
2. ———: The development of anesthesiology in the United States, in *Journal of the History of Medicine and Allied Sciences*, Vol. I, No. 4, 1946.
3. ———: The teaching value of records. *J. Indiana M. A.* 29:110, March, 1936.
4. WATERS, R. M., HATHAWAY, H. R., and CASSELS, W. H.: The relation of anesthesiology to medical education. *J.A.M.A.* 112:1667, April 29, 1939.
5. WATERS, R. M.: The evolution of anesthesia. *Proc. Staff Meet., Mayo Clin.* 17:428, No. 27, July 15, 1942.
6. ———: Anesthesiology in the hospital and in the medical school. *J.A.M.A.* 130:909, April 6, 1946.

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## John Snow, First Anesthetist

by RALPH M. WATERS, M. D.  
Madison, Wisconsin

Bastard children seldom get fed with a silver spoon. The first months in the life of the babe, surgical anesthesia, proved no exception to the rule. In December, 1846 Doctor Bigelow "took a chance" and risked his social reputation by carrying a basket containing the two-months old infant across the ocean to London, but he offered the young child little nourishment on the journey. Holmes, a liberal man for the times, had, it is true, contributed a name the very week of the birth, but the veriest prude of an old maid was always glad to take vicarious pleasure in visiting the foundling asylum for this same purpose. Taking care to sidestep all inquiries as to parenthood, Bigelow abandoned the fatherless infant on the steps of the hospitals of London. Being a wise physician, he probably foresaw that the prospect of a long and useful life in relieving the pains of the human race would not be enhanced by over-frankness about the squabble between dentists and chemists as to parenthood. One can hope that he omitted to mention to his British medical brethren the patented name "letheon." They, too, were blessed with olfactory organs no less keen than the physicians of Boston.

What was to become of the abandoned child In each British hospital some kind-hearted doctor took it up and proved to himself and the rest of the staff that it was real. Abolition of surgical pain could be accomplished by inhaling the vapor of sulphuric ether. What were the dangers? How long could it be safely given? What was the best method of vaporizing it? How much should be inhaled?

From the Department of Anesthesia, University of Wisconsin Medical School.

No one knew. The careful British physician therefore began to do as his American cousins were doing—relegate the administration of ether to the pharmacist, the janitor, or whoever might realize too little of the seriousness of the undertaking to be afraid of it. But fortunately one physician of London possessed the courage as well as the training which fitted him to serve as the foster father of the new child of such lowly birth, already christened "surgical anesthesia." As one of his friends (Richardson) expressed it, "What had been a mere accidental discovery, I had almost said a lucky adventure, was turned by the touch of the master (John Snow) into a veritable science."

John Snow was a farmer's son, born near York in 1813. Being the oldest boy, he had early farm training in responsibility. This, coupled with a natural sense of mechanics was advantageous

to one who was to father a science which involved interference with the physiology of surgical patients to the extent of furnishing them with a return trip ticket good for more than half way to the great beyond. When he was fourteen years old, he was apprenticed to Surgeon Hardcastle of Newcastle on Tyne. He was known as an exceptionally strong swimmer, either in spite of, or because of the fact that from the age of seventeen to twenty-five he was a strict vegetarian. He was a temperance fanatic at this time and for many years after he went to London. During the seasons of 1831 and 1832, there was an extensive cholera epidemic in and around Newcastle and the young apprentice, then eighteen years old, was sent to Killingworth Colliery to look after the poor cholera sufferers. As we shall see later, the observations made at this time were remembered and put to good use. The apprenticeship terminating when he was twenty, he spent the years 1833 and 1834 at Burnop Field. There followed a period at home in York and then eighteen months assistantship to Mr. Warburton at Pately Bridge in Yorkshire. Warburton must have been a man of character and ability for Snow later mentions him with a great deal of gratitude. Before going up to London in 1836, he evidently made a visit home (York) for he was noted, not too cordially, as having been responsible for the organization of temperance societies thereabouts.

In October, 1836 Snow went to London and entered the Hunterian School of Medicine on Windmill Street. The school had long since gone out of existence by 1858, but it gave Snow a much needed opportunity to dissect the human body and to prepare himself for the examinations necessary for recognition as a fellow in the Royal Medical and Chirurgical Society. After two years at the Hunterian School, he opened an office at 54 Frith Street, Soho Square and became a regular attendant at the Out Patient Clinic of Charing Cross Hospital. He early formed the habit of regular attendance at the Westminster Medical Society. Richardson describes Snow, at this time, as a very modest rather backward but extremely seriousminded young medical enthusiast. Like some of the moderns who have become interested in anesthesia, he was possessed of distinct individual peculiarities. He ate no meat and drank no liquor. His first few attempts at discussion of papers read at the Westminster Society were rather completely ignored and he described to his friend Richardson the inward elation which he experienced when, after several attempts, his discussion was finally referred to one night by one of the old wheel horses of the society, as "the comment of the previous speaker." He seems to have quite overflowed with pride when, still later, one of them actually referred to him by name and actually agreed with his discussion. After three years of schooling in the Manchester Medical Society, John Snow had built up sufficient self-confidence, at the age of twenty-eight, to read a paper of his own before that body of wise men.

His first paper was entitled "Asphyxia and on the Resuscitation of Newborn Children." The paper was read October 16th, 1841 and published less than a month later in the London Medical Gazette of November 5th, 1841, rather more prompt medical editorial service than that afforded even the medical wisacres of the present day. It expressed the view that the cause for initiation of the first respiratory effort of the newborn was exactly similar to that causing the second, the third and the last breath, namely, want of oxygen. In Richardson's short comment on the paper, he makes no mention of its having contained reference to carbon dioxide. Unfortunately, the London Medical Gazette relapsed into innocuous desuetude about 1850 and I have so far been unable to find a copy of the volume for 1841. The paper ended with the presentation of a Mr. Read's double air pump for artificial respiration. It is interesting to recall in this connection that twelve years earlier (1829) the French Academy of Sciences had appointed a committee to investigate the usefulness or lack of value in resuscitation of mechanical respirators and laryngeal intubation and after a heated discussion the society had con-



cluded that more harm than good resulted from such efforts. Snow, himself, must have come later to a similar conclusion for during his experience in anesthesia in 1847 and following, both in the laboratory and the operating room, he usually spoke of only two methods of artificial respiration—first and chiefly, direct mouth to mouth chest inflation, and second, a method which he called Marshall Hall's, somewhat like that which has come to be known with us as the Schäfer method. The prone pressure was applied as in the Schäfer method, but between the periods of pressure, inspiration was aided by rolling the subject up to and beyond a complete lateral position.

It is scarcely possible to follow Snow's life or thoughts from 1841 to 1847 and the introduction of ether, without having access to the files of the London Medical Gazette. Such access I have so far failed to attain. There was a more or less constant stream of papers from his pen published in that magazine during the ten years following his initial attempt and before the demise of the Gazette. The variety of his interest during this period is shown by some of the titles of his publications: "Presentation of an Instrument for Performing Paracentesis of the Thorax," published in 1842; "Method of Securing Removal of the Placenta in Cases of Retention with Hemorrhage," published in 1842; and "Circulation in the Capillary Vessels," published March 3, 1843. Those following 1846 were almost all concerned with anesthesia and were republished in substance in the Monograph on Ether and in his text. Previous to 1847, however, several papers appeared on various subjects. It was probably in this period when he wrote most of the first edition of his Monograph "On the Mode of Communication of Cholera." His interest in this disease, first initiated during his service at Killingworth Colliery in 1831-32, was not dropped. In fact, the first edition was revised and greatly enlarged after the cholera epidemic of London in 1854. Although admitting that John Snow was a great anesthetist because he anesthetized the Queen while she brought forth the Princess Beatrice, J. J. Little of the Department of Pathology and Bacteriology of the University of Toronto, wrongly I think, says of him, "His chief title to fame, however, is the work he did in unravelling the mystery of the transmission of cholera poison. As early as 1848, thirty-five years prior to the epochal discovery of the cholera vibrio by Koch, and before micro-organisms were discovered to be among the causative agents of disease, Dr. John Snow had solved the problem of control of this dread scourge. His observations had forced him to conclude that cholera virus was taken directly into the gastro-intestinal tract from poison excreted by those already suffering from the disease. It is to Snow alone that we must credit the conception that cholera is a disease communicated by contaminated drinking water." The University of London granted Snow the degree of Doctor of Medicine in 1844 and in 1845 he was appointed Lecturer on Forensic Medicine at the Aldergate School of Medicine which position he held until the passing of the school in 1849.

His interest in and understanding of the physiology of respiration was excellent preparation for the foster father of the founding which was to lead him to his life work. In September 1847, approximately ten months after Bigelow's visit to London, John Snow published a monograph on ether. Included in this book is a careful classification of physical signs accompanying its administration by inhalation. Experiments are described employing nearly all commonly used laboratory animals of the present day and birds as well. Studies on the effect of different doses of ether on the respiratory mechanism, on the circulatory mechanism as well as the central nervous system are described in detail with very discerning comment and conclusions. The book also contains a description of a carefully constructed apparatus for vaporization and administration of ether and a description in detail of nearly eighty cases in which he had administered the agent. Soon afterwards, Simpson introduced chloroform and he began the study and administration of that agent as well as continuing a search for a better agent which he thoroughly believed could be found. His friend Richardson says: "The first inhalations of ether in this country (England) were not so successful as to astonish all the surgeons, or to recommend etherization as a common practice. The distrust arose from the manner in which the agent was administered. Dr. Snow at once detected this circumstance . . . and remedied the mistake by making an improved inhaler. . . . He next carried out many experiments on animals and on himself and brought the administration to great perfection. The book was readily appreciated by the profession and was just beginning to sell when the discovery of chloroform threw ether into the shade and the book with it."

The Medical Gazette continued to contain many contributions by Snow, describing his experiments with anesthetics which he reported to the Westminster Medical Society. In 1851, unfortunately,

the magazine went out of existence after the Society had become a part of the London Medical Society. For one of such a retiring and modest make-up, the loss of his old vehicles of expression was an embarrassment, but not for long. The new associates in the London Society appreciated the worth of John Snow and he was made orator in 1852. He spent a year preparing the oration. It was entitled "Continuous Molecular Changes, more particularly in Relation to Epidemic Diseases." Little describes it as "a veritable compendium of epidemiological forecasts." In 1855 Snow was made President of the London Medical Society, probably showing in what high esteem his contemporaries held his ideas on disease transmission. The revision and publication of the second edition of his Cholera Monograph after the epidemic of 1854 is said by Richardson to have cost him two hundred pounds of his own money with scarcely a cent of income. He spent a great deal of time gratuitously during the epidemic in studying transmission as well as in trying to promote protective measures for the public health. The story is told of a visit, during the epidemic, to the meeting of the Vestrymen at St. James in whose district was included Broad Street. The population of the district was rapidly being depleted, by death from cholera on the one hand, and by abandonment of homes in panic, on the other. Several wise men of the medical profession having been invited to the meeting to advise the vestrymen, Snow attended as an uninvited but interested spectator. Being unable to keep quiet longer, he asked permission to speak and when asked what remedy he would suggest, he replied, "remove the handle from the Broad Street pump." Amid the jeers of the experts, his suggestion was finally adopted followed by a subsidence of the epidemic in the neighborhood. Richardson in commenting on the story, says, "Men with great thoughts in their head, think of little things which little men cover with their widespread feet."

The remaining story of what is known of the life of John Snow can best be told in the form of a review of his final literary effort, the last sentence of which together with the index and a biographical introduction was written by his dear friend Benjamin W. Richardson, later Sir Benjamin Richardson. I have found no mention that Snow ever had a love affair. He lived an unvarying bachelor life of hard work with the exception of one or two attempts at vacation on account of his health and as a concession to his medical advisors. Such trips were dismal failures and he returned to the old grind and was happy. Again as a concession to medical advice, he modified his gastronomic habits, even indulging in a little wine for his health's sake. Little satisfaction rewarded his physician friends who attempted to treat him. He died at forty-five while writing the last paragraph of his book "On Chloroform and Other Anesthetics; Their Action and Administration." His good friend Richardson had entered into a rather jovial mutual agreement with him not so long previously, that whichever should survive the other, would be bound to straighten up the affairs of his deceased friend. This promise, Richardson fortunately took quite literally. He apparently appreciated the monumental as well as practical value of the scarcely completed manuscript. He added a very efficient index and by way of preface a most delightful, though brief, biography of Snow. He must have worked very diligently in settling his friend's affairs for although Snow died on June 16th, 1858, the book containing Richardson's index and his biographical introduction was in print in August, 1858, seven weeks later. Seldom has a man been blest with a more faithful or capable friend and biographer. The settlement of his financial affairs probably occupied little time. Richardson speaks of his frugal bachelor habits and states that his practice had consisted, for the last ten years of his life, of about four hundred and fifty administrations of anesthesia a year, bringing him an income never exceeding a thousand pounds.

Although the title of Snow's book might lead one to suspect that the text dealt largely with chloroform, it is rather a complete dissertation on all the work done on anesthesia between its announcement in 1846 and the time of Snow's death in 1858. Largely, it covered work done by Snow himself because little of a really scientific nature had been accomplished up to that time. Because of unfamiliarity with Snow's work, many of us have believed that Hewitt's textbook of anesthesia, the first edition of which was published in 1893, was the earliest scientific treatment of the subject. A book published by Flagg in Philadelphia in 1851 is representative of several earlier texts. It details a great deal of clinical experience with ether, but shows no effort on the author's part to apply scientific methods of observation and experimentation to a study of the underlying principles involved in the pharmacology of pain relief. Snow's book, on the contrary, shows a remarkably keen mind at work in an attempt first, to determine the best methods of administering the agents which were known at that time; second, to determine wherein lay dangers from

their administration and means of avoiding these dangers; and third, to find other drugs and other methods of administration that might prove less harmful and more advantageous than those suggested by Morton and Simpson. Although Snow was a farmer boy, his studious habits throughout life resulted in the acquisition of a cultural background as well as a scientific attitude of mind. Whether he read foreign languages fluently or not, I have not found evidence other than his apparent familiarity with what was going on in France, Italy, Germany and Russia during his own time. He must have read Latin with ease because his translations of some of the old prescriptions for pain relief are more detailed and his comment on them more rational



than any I have read. His description of the often mentioned spongy sponge is an excellent illustration.

As intimated by Richardson, Snow recognized almost at once the importance of the manner of vaporizing and inhaling ether and the art of technique. His first effort, therefore, was in the direction of perfecting a vaporizer and inhaler to replace the haphazard dropping or pouring of the liquid agent on a handkerchief or sponge, which had at once replaced the first and unscientific mask-inhaler used by Morton. His realization of the importance of the matter is shown in his own words: "The method of obliging a person to get all the air he breathes through tubes and valves is perfectly new, and in such a process, greater facilities for respiration are required than would generally have been supposed. On this account, many of the apparatuses at first invented did not allow of easy respiration, but offered obstructions to it,—by sponges, by the ether itself, by valves of insufficient size, but more particularly by tubes of insufficient calibre: and there is reason to believe that, in many instances, this was the cause of failure, and that in others the insensibility, when produced, was partly due to asphyxia, a circumstance especially to be avoided:—for as I stated at the Westminster Medical Society, February 13th, 1847, I found that when an animal was gradually asphyxiated by mixing carbonic gas with air—or by compelling it to breathe in a limited quantity of air, insensibility to injuries was induced: but that it was a painful process to induce insensibility in this way and also dangerous to the life of the animal." It is interesting to note how Snow went about constructing a vaporizer and inhaler, for the administration of ether vapor. He first anesthetized small animals in closed containers of known cubic capacity and sufficiently large to avoid accumulation of carbon dioxide or oxygen want. By many repetitions he determined the amount of the agent which when vaporized would produce given degrees of anesthesia. From these figures, he calculated how heavily laden with ether vapor the inspired air of a patient must be. Recognizing the factor of cooling, as vaporization took place, he stabilized temperature by means of a large water jacket, this to contain water at room temperature and useful only to prevent a drop in temperature of the liquid ether, not to warm it. The point of his water jacket around the vaporizing chamber to stabilize temperature only, was missed by his contemporaries and is still missed by



"Drawing of ether chamber, with the bottom removed to show the interior. The valve, of the same metal as the chamber, is soldered to the top, and reaches to one-sixteenth of an inch from the bottom."



SNOW'S MASK AND ETHER CHAMBER.

many of his disciples. In the accompanying illustration taken from the text is shown the ether inhaler used by Snow in his clinical work. The five or six trips around the vaporizer over the ether surface, served to give maximal time for the inspired air to pick up an optimal ether vapor pressure. The point of safety of the vaporizer was that all air drawn over the ether through the tube would come through with the same vapor tension. You will note that the inlet tube to the vaporizer is five-eighths of an inch in diameter and the outlet tube to the mask is three-fourths of an inch in diameter. This is because in picking up ether vapor the volume of air which passes the inlet tube is increased (100 to 165 at 70°). A one-way valve on the mask end of the delivery tube acted to prevent breathing back into the tube and the valve on top of the mask served as a one-way exit valve, but could also be partially or completely pushed to one side to allow a great deal or a little admixture of pure air in each inhalation as the anesthetist saw fit.

We have already quoted Richardson as saying that Snow's book on ether was no sooner out (September, 1847) than Simpson announced chloroform (November, 1847).



SNOW'S CHLOROFORM INHALER.

Snow had only given one hundred and fifty-two ether administrations before he changed to chloroform. He administered ether twelve times thereafter. Here Snow showed his weakness, for he allowed himself to be made an opportunist by public demand as has many an anesthetist of later days. Chloroform accomplished a beautiful induction for the surgeon to see and it was pleasanter for the patient to take. Against his better knowledge he did that which was easier to do than to argue. Very early, however, Snow said, "An impression became very prevalent that chloroform was safer than ether. This impression arose rather from the general tenor of Dr. Simpson's essay than from any direct statement, for he had not treated on this

point." He knew and states that ether was given for eleven months in Europe and sixteen months in America before chloroform was introduced, and that only one death was reported during that time and that, from want of air, while chloroform deaths were occurring at the rate of two or three per month. However, one can excuse Snow on the ground that he kept careful records and honestly set down his findings both experimental and clinical. Had his book of 1858 been taken more seriously by his confreres, or had he lived to lend his personal influence to its introduction, the history of anesthesia might have been different. In the book, are reports of many deaths accompanying or following chloroform anesthesia which he carefully analyzed, selecting fifty in which he felt sure chloroform was the main factor. Thirty-five of these are accompanied by autopsy reports. Not a bad record for a modern clinician to emulate.

Preceded by experiments similar to those on which the construction of the ether inhaler was based, he devised a chloroform apparatus (Figure 3). He intended the maximum vapor concentration of air drawn through it by inhalation to be limited to five per cent. Experiments with animals had proved to him that a vapor per cent of eight to ten or over caused sudden cardiac arrest due to direct cardiac muscle effect. He thought, therefore, that by limiting the maximum concentration to five per cent, he would never risk cardiac damage. Again the water jacket at room temperature was important. A contemporary disgusted him by removing the water and holding the bottle in his pocket thus raising the vapor tension and killing a patient.

In discussing chloroform deaths, he recognized two kinds of syncope, anemic and cardiac. Chloroform always caused cardiac syncope and at autopsy the right heart was dilated and full of blood in both patients and experimental animals. By way of treatment when the patient "went bad" with chloroform, he recommended in addition to artificial respiration by mouth to mouth insufflation or Marshall Hall's method, as with ether, that it might be of value to open the jugular vein. He had also tried (unsuccessfully) both with animals and with patients an electric current applied with a needle inserted into the heart muscle through an intercostal space. In concluding the discussion of ether and chloroform, Snow says, "I believe that ether is altogether incapable of causing the sudden death by paralysis of the

heart. I have not been able to kill an animal in that manner with ether." In view of the influential recommendations of a committee of the Royal Medical and Chirurgical Society made six years after Snow's publication, that an alcohol-chloroform-ether (A. C. E.) mixture was a contribution to safety, it is interesting to note that Snow speaks of chloroform-ether mixtures as undesirable, combining the undesirable qualities of each without compensating advantages. Ether being six times as volatile, he says, one vaporizes nearly all ether at the beginning of an administration and at the end possibly all chloroform.

At the present time there is great confusion as to the meaning of various terms used in the discussion of pain relief. For instance, narcotism, anesthesia, analgesia, planes of anesthesia, basal narcosis, and preliminary medication have different meanings in the minds of various authors. Snow, on the other hand, had very clear cut notions of terms and their meaning. He says, "The term anesthesia has been frequently employed to designate the insensibility and suspension of consciousness caused by chloroform and ether; but in describing the effect of these agents, I shall confine this term to its original meaning, privation of feeling, and I shall employ the term narcotism to designate the entire effects of these agents on the nervous system." He preferred to divide the effects into "degrees" and not into "stages" because slighter degrees of narcotism occur in late stages of the process, during recovery as well as at the beginning. Snow's degrees of narcotism and their characteristics were in his own abbreviated expressions as follows: The **FIRST DEGREE** covers all effects experienced while consciousness persists. This includes diminished sensibility to pain if the degree is maintained for some time. In the **SECOND DEGREE** is the appearance of sleep with no correct consciousness. If the eyelid is raised, the eyeball moves in a voluntary (?) manner. There may be movement of the limbs, laughing or talking, and dreams occur while going into or coming out of the second degree. Suggestion is often possible. Hearing is usually retained. There is a considerable amount of anesthesia sufficient for obstetric pain relief but it is not sufficient to stop uterine contractions for turning. After a short period of third degree, the second may sometimes suffice for maintenance in surgical operations. In the **THIRD DEGREE** there are no voluntary (?) motions of the eyes or limbs. Pupils are generally contracted and inclined upwards. Rigidity and spasm may occur. Loss of sensibility of the conjunctiva is present. Absence of winking when the edges of the lids are touched is the best criterion that the patient is in the third degree and will bear the knife. In the **FOURTH DEGREE** breathing is stertorous, the pupils are dilated and the muscles completely relaxed. (This degree, he says, is seldom needed in surgery but one must remember that in Snow's day, surgery consisted of superficial operations to a large extent. He administered anesthesia ten times for ovarian cystectomy, all ten patients dying of peritonitis on the fifth or sixth day.) Of the **FIFTH DEGREE** Snow says, "If inhalation is further continued in animals, breathing becomes difficult, feeble and irregular and sometimes performed only by the diaphragm whilst the intercostal muscles are paralyzed." (Here he antedated Miller's description of intercostal paralysis by sixty years and in describing the third degree, came close to Guedel's description of extraocular muscle paralysis though he confused the description by using the word "voluntary"—obviously not what he meant.) If the inhalation is carried still further, he says, respirations cease but the heart continues to beat very distinctly until its action becomes arrested by absence of respiration as in asphyxia. A footnote adds that although with chloroform, respiration may be suspended with an amount that has very little effect on the motion of the heart, it is quite possible to stop the heart's action by the immediate effect of this agent because when warm blooded animals are made to breathe eight or ten per cent of chloroform vapor the blood becomes so charged as to stop heart action when the high concentration reaches the coronary arteries.

Having definite ideas of these five degrees of narcotism, put Snow in a position to study various agents in comparison with ether and chloroform. He had calculated the concentration of both of these agents, that was required to be vaporized to bring animals in closed containers to the various degrees. He believed that his own body held twenty-six pounds and five ounces of blood serum and lymph, measuring four hundred and ten fluid ounces. The factor in animals for chloroform second degree was 0.0000614 so that four hundred fluid ounces reduced to minima multiplied by this factor gave twelve minima of chloroform necessary to bring him to second degree narcotism and eighteen minima for third degree. Vaporizing this amount in a closed bladder into which he breathed back and forth, he satisfied himself of the approximate correctness of his calculations. The amount calculated for ether was a little over four drams. Thus more than ten times as much ether was needed as chloroform.

Handicapped by lack of methods of gas and blood analyses, it is surprising how accurate were Snow's figures regarding concentrations. Richardson says, "he experimented with carbonic acid, carbonic oxide, cyanogen, hydrocyanic acid, Dutch liquid, ammonia, nitrogen, amylovinic ether, puff ball smoke, allyle, cyanide of ethyle, chloride of amylo, a carbo-hydrogen from Rangoon tar and a carbo-hydrogen coming over with amylene, and various combinations" in searching for a drug with the practicability of chloroform and no tendency to cause cardiac paralysis. In studying a new agent he "first ascertained the boiling point of the specimen, then the point of saturation of air with its vapor at different temperatures; then the effect of inhalation of the vapor by inferior animals, and the quantity required to be inspired with the air breathed to produce insensibility." This done he pushed it in one or two experiments to death both by a rapid large dose and a long continued small dose to determine whether respiration or circulation was first damaged.

*Mono chlorurretted chloride of ethyle:*—This he prepared by exposing to the sun's rays a mixture of the vapor of chloride of ethyle and chlorine gas. The substance was similar to Dutch liquid (made by the combination of olefiant gas and chlorine gas). It smelled and tasted the same but had a different boiling point and was not decomposed by alcoholic potash. He was only able to make one or two drams but found a supply of ethyl chloride in Paris where it was used as a local application for rheumatism. He secured a pint bottle from this source from which he distilled enough of the mono-chlorurretted product to administer it to twenty-two patients. He concluded that the difficulty of procuring it in pure form was a bar to its usefulness.

*Amylene:* This agent was extensively studied by Snow and administered to two hundred and thirty-eight clinical cases. It was first made, according to Snow, by Professor Balard of Paris in 1844 by distilling amylic alcohol with chloride of zinc and bears the same relation to amylic alcohol that olefiant gas or ethylene bears to common alcohol. Snow's chemistry is either at fault or a misprint occurs for he says that it contains ten atoms of carbon and ten of hydrogen. Recognizing that there are several sorts of amylene, he found that which boils at 95° F. the most desirable for anesthesia. After many animal experiments, he determined that ten per cent produced unconsciousness, twenty per cent deep insensibility, and twenty-five per cent could be used with perfect safety. He proved it to be inhaled and exhaled as such without destruction in the body and "that like chloroform it was capable of causing sudden death by over narcotism of the heart and paralysis of that organ but with greater difficulty." The lack of sickness, pleasant induction without salivary secretion, extreme potency, and the fact that anesthesia was present in the lighter degrees of narcotism appealed very much to Snow. He says, "the greater number of operations under amylene were performed while the patient was in second degree narcotism, being apparently awake, although not really conscious of surrounding objects." This fact made an exception to his rule for testing operability by means of the eyelid reflex. On carrying the dosage higher, however, he found the various degrees of narcotism present as with ether and chloroform, the difference being in the earlier appearance of anesthesia or lack of sensibility to pain. There was usually pain relief after two or three breaths and he had administered it in several obstetrical cases, some with consciousness retained while suffering no pain. In summing up his findings of the two hundred and thirty-eight cases, there was postoperative hysteria in a few cases, vomiting during or at the end in two cases, while there was later sickness in eight or ten more. Many cases did not have empty stomachs. The recovery was extremely rapid. Pulse increased in frequency and force. Respiration was accelerated, resembling ether rather than chloroform. Pupils dilated during a fast induction only. Color was heightened. Sweating was present in a few cases only. There was less struggling and rigidity than with chloroform. He comments, "amylene differs widely from chloroform and still more from sulphuric ether in the promptitude with which patients generally recover from its effects. This is a character of amylene which might have been predicted from its physical properties. I have many times observed how quickly and indeed almost instantaneously, small animals recover from stupor

NOTE: Doctor Witzemann comments that the organic chemists of Snow's day considered the atomic weight of carbon to be six instead of twelve. This fact would make Snow's statement as to the formula for "amylene" correct.

occasioned by certain permanent gases which are sparingly soluble in watery fluids, as olefiant gas, carbonic oxide and carbonic acid gases, nitrous oxide, and the gaseous oxides of methyle. Ether is as volatile as amylene but much more soluble in watery fluids. Consequently a large quantity of ether is absorbed during inhalation and the blood

has to pass many times through the lungs to be freed of all the ether. The quantity of amylene absorbed is small and because of its volatility it is quickly eliminated." Realizing that Snow probably did not have on his desk a handbook containing Tables of Solubility, one can excuse minor discrepancies in his impression of the solubility of carbon dioxide for instance, in "watery fluids" as well as his omission to take advantage of the solubility of ether in fats in support of his argument.

With such a pleasing experience with amylene, why did Snow give it up? He administered it to many more patients than he did ether. Beginning in November, 1856, his results were excellent for six months, then came a death on the table. Mr. Ferguson was operating with the patient in the prone position. He had closed the valve of the inhaler completely for a few seconds and believed that a toxic concentration reached the coronaries. Respiration persisted after the pulse was lost. He worked at methods of resuscitation for one and one-half hours, including the electromagnetic battery attached, first to wet sponges outside the chest, and then to a needle inserted at the left of the sternum at the level of the nipple. Apparently efficient artificial respiration was kept up throughout the hour and a half. At autopsy, there was a large heart with considerable fat about it, a little clear fluid in the pericardium, and the lungs were emphysematous. In July, another sudden death occurred at St. George's and he was through. In discussing these deaths he dismissed oxygen want as a factor because the inhaler tube was twice the size of the trachea. He believed the trouble began in the heart in each case and was due to the variable boiling point of amylene, implying that he had a more volatile product than usual on these two occasions, thus delivering to the patient over thirty per cent amylene vapor. He concluded that the unreliability of the product precluded its further employment.

In 1854 Snow reported to the London Medical Society, experiments on the use of solid carbon dioxide topically applied for producing local anesthesia. His broad outlook upon and extensive experience with the subject of pain relief offered the brightest possible prospect for further momentous contributions from him. The tragedy of his early death probably deprived medicine of advances in the

relief of suffering for which it had to wait many years. He hoped, says Richardson, "for an anesthetic agent which might be inhaled with absolute safety and which would destroy common sensation without destroying consciousness." We are still hoping for just that. Few men who excel in one line of endeavor have been endowed with a broader interest in scientific medicine. He expressed himself in the sanest fashion upon a great variety of subjects. Even malignancy stimulated him to speculation. He "believed all such morbid growths to be of local origin and that they arose from some perversion of metabolism," and this in spite of his appreciation of the very different etiology of many other diseases regarding which he expressed himself quite definitely as believing in their transmissibility. He once mentioned the possibility of an intermediate host as a possible necessity in the transmission of some diseases. With such an active and fertile mind, it is too much to hope that Snow could have maintained an interest in anesthesia for twelve years without speculating as to the manner in which drugs produce narcotism. Richardson says, "he thought he had explanation and proof that the action of volatile narcotics is by arresting or limiting those combinations between oxygen of the arterial blood and the tissues of the body, which are essential to sensation, volition, and all the animal functions."

If one will but consider the prodigious amount of fertile thought and labor applied by this man to the subject of anesthesia during the twelve years the world was privileged to benefit by his efforts, one may appreciate the tremendous loss it suffered in being deprived of the other twenty-five years of his services had he lived a normal life of three score years and ten. As the matter stands, we need not hesitate to say that John Snow was and remains today the greatest anesthetist as well as the first. May I close with another quotation from his dear personal friend, Sir Benjamin Richardson, the last sentence of whose short biography is this, "The old changes of the world live after him, women mourning for their children; youths exulting on the marriage day; the inanimate returning to the elements; the animate returning to the infinite, but in the gaping time shall it chance rarely for another science-man to come and go, who, taking him all in all, may call him 'brother.'"

# The Development of Anesthesiology in the United States

PERSONAL OBSERVATIONS 1913-1946

RALPH M. WATERS\*

THE foundation of any specialty is dependent, I suppose, first upon men, second upon publications, and third upon organizations through which men meet for mutual development by exchange of ideas. Perhaps my own personal observations covering the past thirty-three years may shed some light upon the development of the specialty of anesthesiology in this country.

In January, 1913 I began the general practice of medicine in Sioux City, Iowa. There were roughly 65,000 people in the town and 100 physicians, of whom some 95 performed surgical operations, at least occasionally. The temptation to become one of the 95 was too great for me to resist. Previous training and ability had nothing to do with qualifications. Whether one practiced surgery or not seemed rather to depend upon having the nerve to attempt it and gaining the consent of the patient. A few more or less full-time surgeons, who were looked upon as specialists, employed nurses to administer ether in the mornings at hospitals and act as office nurses in the afternoons. A majority of us, occasional "surgeons," depended upon each other to act as anesthetist as occasions demanded, or sometimes we "borrowed" the nurse technician of one of our more glamorous surgical colleagues. Under these conditions, probably three reasons contributed to my early interest in, and special attention to anesthesia. First, the results of anesthesia which I observed were variable and offered something of a challenge. Second, extra-curricular experience in the administration of anesthetics while a student in Cleveland, together with occasional opportunities to observe the use of nitrous oxide by the extremely skillful dentist, Charles K. Teter, had developed in me an unusual interest in the subject. And lastly, one of the more "surgical" surgeons returned from an eastern trip in 1913 with a nitrous oxide apparatus (the first in Sioux City) the use of which he offered to me in other cases if I would anesthetize his patients.

Thus, following 1913, began a period of special interest in anesthesia. A desire to study was the natural outcome of this enforced special interest, but I did not know of Hewitt's or any other textbook nor had I seen a special journal dealing with the subject.<sup>1</sup> It was with considerable joy, therefore, that I discovered the introductory number of the *Quarterly Supplement of Anesthesia and Analgesia* appended to the October 1914 issue of the *American Journal of Surgery* (Fig. 1). The editorial page stated that it was the official organ of the American Association of Anesthetists and that the editor was F. Hoeffler McMechan. Needless to

\* Department of Anesthesia, State of Wisconsin General Hospital. This paper was read before the William Snow Miller Seminar of

Medical History, Madison, Wisconsin, March 1946.

say, this supplement to the *American Journal of Surgery* was favorite reading matter until it was discontinued in 1926. Almost simultaneously with the appearance of the quarterly supplement, the textbook of Gwathmey and Baskerville became available (Fig. 2). Gwathmey with McMechan's help had begun the organization of an American Association of Anesthetists in 1912 after a request for a section in the American Medical Association was denied. This organization held scientific meetings yearly from 1913 to 1926, under the secretaryship first of Gwathmey and then of McMechan. My name appears among those elected to membership in 1917.

Papers by Ira McKesson had earlier attracted my attention. In the fall of 1915, correspondence with him resulted in my visiting Toledo. The nitrous oxide apparatus purchased for our use by the surgeon in 1913 had seemed to me unsatisfactory. It had been replaced by one devised by Coburn of New York, and that by modifications of my own. My curiosity regarding the McKesson technique was satisfied during this visit and several pieces of apparatus from the Toledo Technical Appliance Company were used thereafter. The professional hospitality shown me by McKesson is remembered with gratitude. The apparatus used was a piece of mechanical perfection. The physiological principles underlying anesthesia which he taught at that time are in the main acceptable today. Ira McKesson *was* the Toledo Technical Appliance Company. He led the life of a multiple personality. Rarely has a physician developed a serious interest outside the practice of medicine without sacrificing much of his professional standing. McKesson was first of all a capable physician. His fellow members of the Toledo Academy of Medicine without exception respected him as such. He was also an expert mechanic and designed in detail all the apparatus sold. He directed the business of his appliance company with fairness to his employees and with financial success. Among business men he was highly respected. He was a civic minded, useful citizen of Toledo—a popular member of the Chamber of Commerce. And with it all, he found time to teach neophytes such as I was in 1915, not only the technical principles of the administration of nitrous oxide, but much of physiology and the diagnosis and treatment of acute physical disorders whether or not they were the result of the administration of anesthetic drugs. Many of the ideas now current regarding the use of oxygen as a therapeutic agent were discussed in Toledo at that time. McKesson was a physician, a teacher, a mechanic, a business man, and an outstanding citizen, respected by his confreres in each field. Rarely does one man lead, with success, a life so versatile.

<sup>1</sup> In the British Empire the early impetus given to the scientific study of anesthesia by John Snow had borne fruit. I later learned that an excellent textbook on anesthesia had been published in 1893 by Sir Frederic Hewitt. The second edition of this work (1901) is a scholarly treatise on the subject with due consideration given to the significance of current knowledge of physiology and pharmacology as applied to the subject. The *Proceedings*

of the Royal Society of Medicine began to publish papers read in its Section on Anaesthetics in 1908. In Canada and other parts of the Empire, specialization in anesthesia was common at the beginning of this century. Howell, Bourne, Johnston, and many other Canadian anesthetists were potent influences in initiating recognition and interest in the subject in the United States.

It was through informal visits of McKesson and W. Hamilton Long of Louisville to McMechan's home, then in Cincinnati, that the Interstate Association of Anesthetists was organized. The first meeting was held in Cincinnati in 1915. McMechan was made secretary. Although I had previously exchanged letters with him, it was with considerable surprise to me that he greeted me at this meeting, as I approached his wheelchair, with "Ralph Waters from Sioux City, Iowa. We are delighted to see you." I do not yet know who had tipped him off as to my identity. He was like that—friendly toward everyone and he never forgot a name or face.

Some knowledge of the early life of the McMechans (Fig. 3) is necessary to account for their unusual accomplishments.<sup>2</sup> Frank's father and his grandfather were respected physicians in Cincinnati, Ohio. He graduated from St. Xavier College with both a Bachelor's and Master's degree when he was 17. In school, he is said to have excelled in oratory, elocution, debating, dramatics, and music. His father realized that he was too young to enter medical school and approved of the three years which he spent as reporter on the *Cincinnati Post*, an early paper directed by E. W. Scripps. He entered the Medical School of the University of Cincinnati in 1900, graduating in 1903. During his newspaper and medical student days, his interest in dramatics continued. Anesthetists have been accused of having stolen one of the most promising young dramatists in the early years of this century. Amateur dramatics was the means of bringing the McMechans together. Laurette Van Varsevold was a student at a Cincinnati School of Acting and they met in the relation of director and pupil-actress. They were married after he had practiced general medicine in Cincinnati for six years, during which time his major interest was devoted to anesthesia. Eighteen months later (1911) he became badly crippled with arthritis. He attended the meeting of the American Medical Association in Minneapolis in 1912 on crutches and shortly thereafter became confined to a wheel chair or bed for the rest of his life.

At the first meeting of the Interstate Association in 1915, I remember watching his movements with considerable interest. All his joints seemed to be involved in arthritic changes. He could turn his head slightly from side to side and he was able to move his hands slightly by limited flexion at the wrists and by limited pronation and supination. Movements of the mandible separated his teeth only slightly. Pain was a constant early accompaniment of his affliction as each new joint became involved. At this meeting and for several years following he was able to manipulate a pencil, once it was placed in his hand. By very skillful use of a small, very long-handled fork and a similar spoon, he was able to bring bits of food to his lips. However as the disease progressed, all joints became completely ankylosed. Later I remember striving among other of his friends for the privilege of relieving Mrs. McMechan of the task of helping him dine when he could no longer use the long-handled utensils.

<sup>2</sup> For certain facts regarding the McMechan family the author wishes to acknowledge his indebtedness to a pamphlet entitled *Francis Hoeffler McMechan, A.B., A.M., M.D., F.I.C.A., A Brief Sketch of His Life and Work*

by Omar Ranney (Lakewood, Ohio). It was incorporated in the journal *Current Researches in Anesthesia and Analgesia* (September-October 1939).

The early dramatic experience together with his natural and cultivated excellence in written expression and oratorical ability were all useful aids in promoting and organizing a new speciality. Of dramatics he once said: "This experience gave me the capacity to dramatize meetings, dinners and international congresses. One must stage them to have them a success. You have to pick the papers for one of these meetings like you do characters for a play. The same is true of speakers. You must have unity of purpose to get the message across." Certainly no one who attended a meeting planned by the McMechans between 1915 and 1930 could fail to appreciate the dramatic quality. The physical handicap of the secretary only added to the dramatic setting. At a dinner of anesthetists and their wives, with visitors from all parts of the world, the voice of the helpless toastmaster penetrated most pleasingly to the occupant of every chair. Delight-

## American Journal of Surgery

### QUARTERLY SUPPLEMENT of ANESTHESIA and ANALGESIA

[American Journal of Anesthesia and Analgesia]

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OFFICIAL ORGAN  
of the American Association of Anesthetists and Scottish Society of Anesthetists

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OCTOBER INTRODUCTORY NUMBER A. D. 1914

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Fig. 1. Introductory number of the *Quarterly Supplement of Anesthesia and Analgesia*.



# ANESTHESIA

BY

JAMES TAYLOE GWATHMEY, M.D.

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WITH TWO HUNDRED AND EIGHTY-THREE  
ILLUSTRATIONS IN THE TEXT

NEW YORK AND LONDON  
D. APPLETON AND COMPANY

1914

Fig. 2. Title-page of Gwathmey and Baskerville's textbook on *Anesthesia*.

ful favors and honors were presented in words that brought tears to the eyes of both the recipient and his enemies. Again at scientific meetings the summary by the secretary of a morning's symposium of papers was a work of art. In ten minutes he could present the major points made by each of six previous speakers and the discussions all wrapped in an intelligible package ready to take home.

Various experiments both in publications and organization were tried by McMechan. In 1916, the Surgery Publishing Company copyrighted the first of a series of American Yearbooks of Anesthesia and Analgesia (Fig. 4) to be edited by McMechan. The foreword states:

While the Quarterly Supplement of Anesthesia and Analgesia of the American Journal of Surgery has provided a journalistic medium for the publication of the Transactions of various associations of anesthetists it does not lend itself to the collation of the world's ultra-scientific researches in these subjects. [Consequently this series is begun. Volume one, the foreword continues] has been compiled exclusively of exhaustive articles by prominent authorities . . . to bring a given number of subjects in anesthesia and analgesia strictly up to date. In succeeding volumes of the Yearbook, Collective Abstracts will continue the revision of these subjects as necessity arises and other subjects of equal importance and interest will be introduced and as comprehensively and exhaustively handled. The Yearbook will thus assume the form of a continuously broadened and revised encyclopedia for authoritative reference.

Judging from these expressions in the foreword the editor's plans for these yearbooks were truly ambitious. A large volume of nearly 500 pages was issued for 1915-16 and a similar second volume for 1917-18. Both are a credit to the editor and the selected authors as well. War-time editing and publishing doubtless were difficult endeavors during the first as well as the second world war. The second volume did not appear until 1920 and no further volumes exist. In the foreword to volume two dated Thanksgiving Day, 1920 appears the following:

So far no Anesthesia Foundation has eventuated although recently some forward-looking manufacturers of anesthetics and apparatus have united to finance a National Anesthesia Research Society which, it is hoped, if it can serve its expectations, will sooner or later become a foundation.

The name "National" was soon changed to "International." A monthly "Bulletin" in Pamphlet form was issued for a time, and a monograph of 97 pages on *Nitrous Oxide-Oxygen Analgesia and Anaesthesia in Normal Labor and Operative Obstetrics* was published in 1920. For a short time the International Anesthesia Research Society employed a lay Executive Secretary, T. T. Frankenberg, who maintained a headquarters office in Columbus, Ohio, but the arrangement proved unsatisfactory and the secretarial as well as editorial work continued to be accomplished by the McMechans. The Research Society held a first Congress of Anesthetists in 1922 and the early Bulletin was replaced by a journal. The first number of *Current Researches in Anesthesia and Analgesia* appeared in August, 1922. It continued under the editorship of McMechan until his death in 1939 and is still published by Mrs. McMechan under the editorship of Howard Dittrick.

In addition to the organization of the Interstate Association of Anesthetists (1915) McMechan's stimulus was instrumental in the initiation of other regional societies in many parts of the United States and one in Canada. The year 1926 was a memorable one both for the McMechans and for anesthesia in general. In that year the old American Association of Anesthetists became the Associated Anesthetists of the United States and

Canada with the purpose of serving as a parent organization to the Interstate (its name now changed to Midwestern), the Canadian, the Pacific Coast, the Southern and the Eastern Associations. *The Quarterly Supplement* appearing with the *American Journal of Surgery* was discontinued in that year.

In the last number of the *Supplement* appeared an announcement of a proposed trip of American anesthetists to attend a meeting of the Section on Anaesthetics of the British Medical Association to be held in Nottingham, England in July. The over-all cost of the trip was expected to be \$1195. Seventeen American anesthetists and their wives made this trip visiting anesthetists throughout the British Isles and some continental centers. The McMechans accompanied and directed the party. Another journey to Europe was made by the amazing couple in 1928 and one to Australia and New Zealand in 1929. The latter trip was almost too much for the physical shadow that was McMechan's body at that time. Neither his physical nor his mental vigor was regained thereafter. In contrast to former days when his charming voice held audiences spellbound, he had scarcely the strength to be heard in ordinary conversation. In spite of the added handicaps McMechan carried on until his death in 1939. Although he could not attend his Sixteenth Annual Congress of Anesthetists held in Chicago two years before his death, he knew that an honor was to be conferred upon him. The following is the letter of acceptance which he sent to be read after the presentation:

Only such a token as one of your congress loving cups could possibly symbolize your appreciation and recognition. However, this gift of gifts is far more yours than ours, because in everything we have tried to do for you and anesthesia, you have taken the greater part.

Your memberships are in reality Organized Anesthesia itself, and your loyalty in maintaining your memberships is what has finally created international anesthesia. The present financial stability and the promising economic future of the specialty is the result of your support in good times and bad.

Your liaison with basic science, which may be one of your proudest boasts, is the friendliness of that large group of research workers who have come to our meetings for years to find out our problems, and who have then opened the doors of their laboratories to show us the solution of our problems. May this liaison prosper for years to come in our mutual cooperation.

Clinical anesthesia is what through years of pioneering each and every one of you have made it. Now it remains for all of us to bestow the heritage we have won for ourselves, to others, knowing that they will carry on splendidly. In doing this the best interest of surgery, the patient, and the hospital will be served. Added to this there are those who must shoulder the burden of teaching and instructing each new generation of anesthetists so that the specialty may never lag in carrying out its greatest obligation.

Your journal publishes the very best of your own and others' research and clinical advances as reported at your meetings and Congresses, and stands as an assurance that you are doing more than your share to realize the world conquest of human pain.

Our part in this marvelous labor of love has been the tie that binds your efforts together for effective achievement through a cooperation that has become one of the most astounding fellowships in the allied professions and basic sciences.

Needless to say this gift of gifts will be cherished for all the years to come as the most precious souvenir of our lives and work; but never forget that in

treasuring it we will also keep all of you in our heart of hearts, because it is you who have made our lives, work and friendships the greatest compensation that a kindly Providence could possibly bestow.

Emotional and brilliant, true-blue, and steadfast with a moral determination to stand for what he believed right, McMechan was utterly incapable of shilly-shallying or compromise. The recognition and advancement of anesthesia were very dear to his heart. Opposition was frequently encountered. At times he vented his wrath upon surgeons and representatives of our national medical organizations, and many of these returned the compliment, with interest. Such conflicts were unfortunate and valueless. By some they were thought to have obstructed the advancement of the cause which he sought to promote. To illustrate some of the principles held by McMechan which were once thought to be controversial, I quote from an address which he made in 1935 before a joint session of the Council on Medical Education and Hospitals of the American Medical Association with the Federation of State Medical Licensing Boards. The subject of the discussion was, "Should The Radiologist, The Pathologist and The Anesthetist be Licensed to Practice Medicine?" McMechan was asked to give the viewpoint of anesthesia. He said in part:

Anesthesia was the gift of pioneer doctors and dentists to suffering humanity, and every significant advance in its science and practice has been contributed by doctors, dentists and research workers of similar standing. In contrast, technicians have added nothing of any consequence. Anesthetics are among the most potent and dangerous drugs used in the practice of medicine; they penetrate to every cell and organ of the body and may cause almost instant or delayed death by their toxic effects. The dosage of general inhalation anesthetics cannot be prescribed in advance but must be determined from moment to moment during administration. The dosage of local and other anesthetics must be determined by the risk of the patient, the nature and duration of the operation to be done—certainly a challenge to the knowledge and experience of the keenest doctor. No patient should ever be given an anesthetic whose condition and risk has not been diagnosed in advance of the operation, so that every resource of medical science can be used to lessen the risk and make the recovery more assuring. Certainly in this preoperative evaluation and the selection of the safest anesthetic and best method of administration, the medical anesthetist is more in a position to act as a consultant than a technician. . . .

The safety of the patient demands that the anesthetist be able to treat every complication that may arise from the anesthetic itself by the use of methods of treatment that may be indicated. The medical anesthetist can do this, the technician cannot. More recent developments have extended the field of medical anesthesia to include resuscitation, oxygen therapy and therapeutic nerve block for intractable pain, and treatment of various conditions of disease and the rehabilitation of the disabled—all fields of practice quite beyond the capacity of the technician.

The thoughts which he has so well expressed are probably held at present in theory by the medical profession throughout the world. In practice in the United States we are still far from complete acceptance of them. Whether the compromises considered expedient by many will, in the long future, prove the wiser course remains to be determined.

Last year I was asked for suggestions as to a fitting subject for a portrait which might be added to the Dean Cornwell Series, dealing with anes-

thetia. The following notes record my thoughts at that time, stimulated no doubt by proximity since I was traveling past the towns where the McMechans lived after 1914 and where their productive work was accomplished. As made at the time, the notes read as follows:

Today I lolled through Northern Ohio in a comfortable roomette on the New York Central's Commodore Vanderbilt. Oral examinations of the American Board of Anesthesiology lay ahead at the Waldorf-Astoria in New York. As we sped through Avon Lake and Rocky River, the skeleton-like figure of Frank McMechan in his folding wheel chair with Laurette at his back, appeared before my thoughts. Idleness led to speculation and I found myself wondering if any other physician during the century of anesthesia gave so much—of himself, his time and his wife,—to the cause of relieving pain.

I thought of Priestley and Davy, of Vesalius and Lavoisier, of Theodor and Sertürner and the host of others who made scattered single contributions in an unconscious effort to lay the foundation stones of a science of anesthesia. I thought of Mesmer and Braid, of Hickman and Colton, of Long and Wells and of Jackson and Morton. I thought of Simpson. And then I thought of the fertile decade contributed by John Snow. And the failure of his associate Ben Richardson to carry on in the Snow tradition of brilliant investigation and hard work although he did do his friend and us the priceless service of seeing that Snow's invaluable book was finished and printed after his death. To it he added the only biography we have of its author and at the same time one of the most beautiful and perfect tributes of one physician to another; but he lacked the originality, energy and enthusiasm to finish the work that his friend had begun. And then I thought of Boyle and Clover, of Andrews and Paul Bert, of Ombredanne and Bennet, of Trendelenburg and Stockum, of Prince and Meltzer and Auer, of Teter and Guedel and McKesson, Heidbrink, Draeger and Foregger and the many others who contributed solutions to mechanical and physiological problems of anesthesia, and then I thought of Koller and Bier, of Labat and Howard-Jones. Great as is our debt to all these and many others—I said to myself—do we not owe even more to the two who gave us our first real textbooks of anesthesia—Hewitt in Europe and Gwathmey in America.

Just then I had a glimpse of the Westlake Hotel in Rocky River where Frank McMechan spent his last days and I asked myself: What sort of a contribution is the most important to a specialty? In my dreaming, I saw Frank, a young doctor stricken eight years after graduation with an arthritic condition which placed him first on crutches, then in a bed or a wheel chair for the rest of his life. Never again could he hold an anesthetist's mask in his hand or stand on his feet. And yet I saw him propped up in bed dictating by the hour—letters to anesthetists all over the world—articles for journals all over the world on all the various aspects of drug administration, of the importance of teaching medical students all that was known about anesthesia, of the advantages to be gained by interstate, national and world-wide journals, meetings and discussions. I saw McMechan in my dreaming, sitting almost motionless in his chair pleading the

importance of a thorough knowledge of anesthesia to a thousand physicians in a hall in Kansas City in which one could hear a pin drop and his every word in the remotest corner of the room. I saw his wife directing two strange porters how to lift him as painlessly as possible from his wheel chair to a berth in a pullman car on the Missouri Pacific for the trip from Kansas City to Chicago. I saw not only strange porters but those who spoke no English, carrying him to and from the decks of ships in the ports of Europe and Australia, always under the watchful eye and careful direction of his wife Laurette. In these countries I have been told he, again from his wheel chair, held the attention of medical audiences while addressing them in French or German when the occasion demanded.

Every slightest detail in the arrangements for anesthetists' meetings was perfect during the years while McMechan was "Secretary-General" of both American and International societies of anesthesia. Frenchmen, Germans, Spaniards, East Indians, Chinese, visitors from all over the world came to anesthetists' meetings in this country because they knew Frank McMechan. If he did not know their language, his fluency with the language of friendship filled all the gaps.

Of the anesthetists who were living between 1912 and 1939, it is doubtful if there was a single one who did not know him personally and count the McMechans his friends. The McMechans made the get-together spirit that lives after him among the anesthetists of the world.

And so I thought—yes, textbooks are necessary, great discoveries are necessary, hard work is necessary for the development and perfection of a specialty in medicine. The author of a textbook who gathers together all that has been done makes a wonderful contribution. Without it, teaching is difficult. And yet is not the man who can bring together the knowledge of a specialty that is scattered throughout the world, promote its discussion, inspire further investigation and cement all the interested individuals together with the common bond of friendship—is not such a man the greatest benefactor to his specialty?

And so I decided to suggest to the artist, a portrait of McMechan in his wheelchair, his wife a little back and to the side. Pictures seen dimly on the wall behind (or shadowy figures) representing Davy, Wells, Morton, Long, and Snow. Grouped at either side of the chair there might be room for figures representing a contemporary anesthetist of this and other countries, and a physiologist and pharmacologist. I wondered if such a concept, translated from my crude expression to artistic terminology might appeal to Mr. Cornwell as fitting subject matter to constitute "a portrait of Anesthesia"?

Be that as it may, there is little doubt in my own mind that the contributions toward the abolition of pain in the world made by the McMechans from 1912 to 1930 were unequalled. Until 1930 we who are now considered "older anesthetists" were content to delegate all the labor of organization and the conduct of organized effort to one man. The need for a Section of Anesthesia in the American Medical Association, for a National Board of Certification, for a modernized journal of anesthesiology and other ad-

vances was evident to those within and outside the specialty. Effort was required which could not be met by older methods. The original Long Island Society of Anesthetists (1905) had been renamed the New York Society in 1911 but it had been largely a local organization. In casting about for a vehicle through which to apply newer methods, this old New York Society was expanded to become The American Society of Anesthesiologists, Inc. Some fears were felt during the decade before 1940 that this organization too might make the mistake of laziness among its individual members—of saddling one man with all the work. Through the tremendous interest, enthusiasm and energy of Dr. Paul Wood, the re-organization and expansion was launched with a minimum of difficulties. Through his unusual farsightedness and unselfishness, the constitution and by-laws provide the machinery whereby every member may do his part and help to carry the load. A Section on Anesthesiology is now included in the scientific sessions of the American Medical Association. A National Board of Anesthesiology, Inc. stands ready to certify as competent those anesthetists who pass its examinations. A creditable journal, *Anesthesiology*, is published six times a year by the American Society of Anesthesiologists, Inc. All the society's affairs are initiated through the action of a representative Board of Directors—it is a democratic organization.

There is argument throughout the world in these days as to whether a completely democratic organization can properly govern a state. Experience in societies of anesthetists testifies to certain advantages and certain disadvantages of one man direction. Initiation of the organized movement for better anesthesia certainly benefited immeasurably by the unusual personality of McMechan, by his capacity for friendship, by his untiring labor, and by his ability to dramatize the need. Paul Wood has made a similar and no less valuable contribution to anesthesia in America.

At present a world-wide interest in the subject seems to stem from teaching organizations and publications largely in the British Empire and the United States. The responsibility upon those within the specialty is great. In years to come the application of current scientific knowledge and technical skills can carry forward the ideas, ideals, and efforts of Snow and Hewitt, of Gwathmey and McMechan. The rational control of pain can become safe and available to all the human race. To accomplish this, the specialty needs the understanding cooperation of the medical profession, of scientists, of philanthropists, of sociologists, of hospital management, and of the public.



FIG. 3. Dr. and Mrs. F. Hoeffler McMechan. (Courtesy of Mrs. McMechan.)



*Journal of the History of Medicine: OCTOBER 1946*

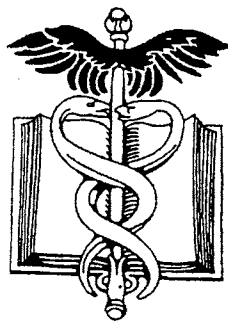
# *The* AMERICAN YEAR-BOOK *of* ANESTHESIA & ANALGESIA

F. H. McMECHAN, A.M., M.D.

1915

*Editor*

1915



SURGERY PUBLISHING COMPANY

92 WILLIAM STREET ☒ ☒ ☒ ☒ ☒ ☒ ☒ ☒ ☒ NEW YORK CITY.

FIG. 4. Title-page of the first volume of *The American Year-Book of Anesthesia and Analgesia*.

# THE TEACHING VALUE OF RECORDS

RALPH M. WATERS, M.D.  
MADISON, WISCONSIN

## WAYS AND MEANS

Early in my professional life I chanced to fall into an argument with a surgeon as to the relative merits of ether and nitrous oxide as related to safety. He assured me that he had never lost a patient on the table during his twenty years of experience and that it was because he had always used ether. Since it was important for my own satisfaction either to verify or disprove this statement, my spare moments during the next year were spent in either written or spoken interviews with this surgeon's former assistants and available members of his surgical team during the twenty years in question. The result was the establishment of positive evidence of five such deaths. Since the surgeon was a personal friend of mine, known to me to be absolutely honest, the experience strongly impressed upon me a very important circumstance; namely, that one's memory is a very poor vehicle on which to rely as a source of facts. I resolved to attempt, at least throughout my professional life, to avoid making statements based on memory. Among scientific people, statements and even opinions seldom carry much weight

<sup>1</sup> From the Department of Anesthesia, University of Wisconsin Medical School.

<sup>2</sup> Presented before the Section on Anesthesia of the Indiana State Medical Association at the Gary session, October 9, 1934.

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when they are not backed by carefully recorded, controlled experimentation. Although clinical effort can perhaps not always be accompanied by controlled experimentation in every case, clinical experience can always be recorded.

Anesthesia in America at the present time is to an extent "in the spotlight." A need for better service in anesthesia is felt by the surgeon, the remaining members of the hospital staff, the patient and the hospital management. Are they getting better service this year than last? Without records, no one can say. A discussion of the advantages derived from records by the various individuals concerned should begin with the anesthetist.

### THE ANESTHETIST

Although I have heard a surgeon object to the record keeping of his anesthetist because the effort detracted his attention from his patient, I feel certain that intelligent observation of any experienced anesthetist while record keeping at the operating table will convince the most critical surgeon that keeping a careful record of occurrences as they appear serves definitely to concentrate the anesthetist's attention on his patient. Only by means of records of preoperative condition, effects of anesthesia and operation while the patient is subject to them, and a careful follow-up of postoperative morbidity can the anesthetist determine whether his effort of this year is an improvement over last year or not. No greater aid is available to the anesthetist than a review of these records to determine what is the best choice of agent or method in a given case. Impressions based on memory are apt to be erroneous. In the operating room, one may choose the method or drug which is most convenient or the easiest to use, whereas records may prove that a more cumbersome method or a more expensive drug gives, in his hands, better results. The figures as published by another anesthetist are not a reliable criterion. We have found that the skill and dexterity of different individuals, on the same hospital service and undergoing the same course of instruction, vary markedly with different drugs and methods. Statistics covering a small number of cases of one's own, therefore, are more useful by far than those covering thousands of cases in the experience of another.

The basic principles of physiology, pharmacology, and biochemistry are the foundation stones of anesthetic teaching, it is true, but one's statements in the classroom and clinic to undergraduate and graduate students alike are greatly emphasized by accounts of results as gleaned from careful records. A beginner in the art of anesthesia can be supervised, guided, and corrected only if he is recording from minute to minute his technical maneuvers and the changing results. Unless the student is required to record constantly what he sees in changing physical condition and results, he will seldom have fixed in his mind the many facts of which he may have been told in the lecture room.

### THE SURGEON

The most futile argument in the world is carried on between two doctors in regard to the effect of a therapeutic procedure during and following which neither has ever kept records. A surgeon is too often apt to judge of the therapeutic excellence of anesthesia by, for instance, the flaccidity of muscles. The anesthetist is too often apt to use, as the criterion, ease of administration. If the records show that a given anesthetist can use a drug to produce absolute flaccidity of the muscles of every patient to the complete convenience of the surgeon without increase in postoperative morbidity, that should settle the argument until the figures tell another story. On the other hand, if the records show that in a given group of cases in which maximum flaccidity has been maintained throughout operation as compared with a similar group where the surgeon has been slightly embarrassed or delayed because of insufficient relaxation, show less postoperative morbidity in the latter group, it may be that the surgeon will feel that the better postoperative results warrant toleration of the inconvenience. Memory, however, supplies too undependable evidence upon which to base such a decision. There can be no final settlement of such arguments. Reconsideration of statistical analyses each year must be made to settle arguments and determine the future action of all members of the surgical team. Once the surgeon appreciates that the anesthetist bases his use of agents and methods on definitely recorded previous experience, many arguments and misunderstandings will be avoided.

### THE REMAINDER OF THE STAFF

The general practitioner or internist and the admitting officer or hospital superintendent are interested in the compilation of records for their prognostic value. In deciding upon what to recommend to a given patient, the average experiences of previous patients to whom similar operative procedures have been recommended in the past is useful. If a woman who contemplates a hysterectomy asks, "Will I be nauseated afterward?" and they can reply, "Last year, Madam, twenty-five out of every hundred women undergoing such an operation in this hospital were nauseated during the first day, eight of whom vomited not more than twice, and two were both nauseated and vomited for more than three days severely," the woman has been rendered a real service.

### THE HOSPITAL

The business office is interested in the length of time the various drugs are administered as compared with the cost of these agents. If a change in method can be shown to result in marked reduction in cost, without increase in morbidity or inconvenience to patients, surgeons, or the members of the staff, then the management may willingly advance money for providing such equipment.

First may I say that any system of record keeping will require effort. Records will not keep themselves. Carelessly kept or inaccurate records are scarcely better than none. To be of value, negative as well as positive findings must always be recorded. A simple system, well and accurately carried out, is more useful than an elaborate one incompletely or carelessly conducted. A record system must be chosen that is fitted to the personnel available. Some of the most efficient anesthesia records are probably kept in the anesthetist's hip pocket.

At the Wisconsin General Hospital, we have used record sheets from which information is transferred to Hollerith punched cards. This has

<sup>3</sup> Rowenshine, E. A.: *A Method of Combining Anesthetic and Surgical Records for Statistical Purposes*, *Anesth & Analg.*, XXX:122-128 (May-June), 1934.

the advantage of greatly simplifying the sorting and compilation of information. Manifestly one's private cases or the work in a small hospital could be compiled easily by hand.

The figures compiled from the records of a large hospital are not thought to have any particular value as a general yardstick by which to judge the usefulness, safety or applicability of any agent or method under other conditions than those obtaining where the records were made. At the Wisconsin General Hospital, such figures are most valuable in teaching our own students, anesthetists and surgeons. The old statement is quite true, "One can prove anything by statistics." If one elects to give ether to all his "bad risk" cases who are to undergo prolonged and severe operations, reserving other agents for "good risk" patients presenting for minor operations, his statistical evaluation will be very unfavorable to ether. The greatest care is necessary in evaluating figures after they are obtained.

The great value of clinical records, in my estimation, does not lie in the publication of the resulting statistics with a hope of benefiting others, but rather in direct benefit to those who keep such records. If the anesthetist must answer the question "Yes" or "No" in regard to each minor factor concerning preoperative condition, occurrences during operation, and during the postoperative hospitalization of every patient, he will of necessity have to observe more carefully and to correlate more accurately, cause with effect. Without accurate recording, the teacher loses a valuable aid in checking his own personal impressions as well as the ability and progress of his students.

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# THE RELATION OF ANESTHESIOLOGY TO MEDICAL EDUCATION

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This paper has been written to emphasize the need for undergraduate and graduate instruction in anesthesiology and to describe ways and means of its accomplishment.

Recent advances in medicine have widened the scope of anesthesiology to include problems which were only dreamed of twenty-five years ago. The insistence of patients on complete abolition of pain has made more prevalent the use of depressant drugs and the administration of such drugs in larger doses. There results a necessity for clinicians especially trained in the administration of pain-relieving drugs and the management of depressed states. For reasons too numerous to discuss fully here, the medical profession finds itself in the anomalous position of having an obvious lack of clinicians trained in anesthesiology and having scant provision for such training in our medical schools and hospitals.

## OBJECTIONS

The following six arguments against clinical instruction are so frequently advanced as to warrant reference to them in some detail: 1. A sufficient number of physicians will not be interested. 2. Present day excellent instruction in the basic science departments makes clinical instruction in anesthesia superfluous. 3. "A little knowledge is a dangerous thing." 4. The medical school curriculum is already overcrowded. 5. The economic adjustments necessary for instruction and the employment of physicians specializing in anesthesia are impossible. 6. The administration of anesthetics is an art, not a science, and as such may be done quite as well by one without scientific training. Each of these six opinions is probably honestly held by some persons and should be honestly answered.

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1. The impression that a sufficient number of physicians will not be available is erroneous. Young doctors will show interest in proportion to the inspiration which is imparted to them. The practice, so common at present in many of our medical schools, of delegating not only the technical administration of anesthetics but also the clinical teaching to persons without professional qualifications does not stimulate the interest or respect of the medical student and hospital intern. Conversely, it is noticeable that applications for residencies in anesthesia in hospitals come in higher proportion from Canada and from districts in this country where the administration of anesthetics is limited to graduates in medicine. In centers where professional training has become recognized, there is ample demand for positions. Furthermore, the professional and financial success of others in the specialty adds to its appeal. Recognition of the anesthesiologist as a specialist in certain phases of medicine and therefore as a valuable consultant to other departments adds to the attractiveness of the specialty. Such recognition has been withheld only because of improper teaching and lack of example.

2. The contention that all necessary instruction in anesthesia is provided by good courses in physiology, biochemistry and pharmacology can be based only on an entirely inadequate conception of the clinical importance and relationships of anesthesiology. Careful consideration will show that clinical interpretation and application of basic science knowledge is admittedly necessary in every other branch of medical education. Anesthesiology deserves no less clinical interpretation. It deals with the management of patients acutely depressed by drugs, with artificial respiration, resuscitation, the maintenance of free air passages, the administration of oxygen and other gases, and with the recognition of evidences of oxygen want and carbon dioxide excess, to mention but a few of its ramifications. Many circumstances of depression due to accident or illness bring about changes in the body similar to those accompanying anesthesia. In the medical or surgical wards, however, such disturbances take place over a period of hours or often days, whereas in the operating room they develop often in a matter of minutes and can be followed through cause, development and treatment in a single teaching period. Here then is the ideal place to teach these fundamentals to the student. In later practice, whether he becomes a specialist or a general practitioner, he will have daily use for this knowledge.

3. The dean of a great school has offered as an excuse for complete absence of clinical instruction in

anesthesia from his curriculum the quotation "A little knowledge is a dangerous thing." This argument is quite as applicable to the clinical teaching of surgery or any other portion of medical practice. The argument has two obvious fallacies: 1. Lack of clinical teaching will not prevent graduates in medicine from considering themselves competent to deal with matters of anesthesia. Thus by its own standards the argument fails. The minimum of knowledge is already assumed by the medical graduate; therefore he is dangerous; therefore the school should amplify his knowledge as much as possible, at least to the extent of showing him his limitations. 2. The fundamentals of anesthesia are matters of everyday application in every branch of medical practice and therefore cannot be omitted. Training in anesthesiology will amplify a little knowledge gained in other departments and make the young graduate a safer rather than a more dangerous practitioner. Whether students are to administer anesthetics or not, they should go out from medical school prepared at least to care for patients while they are subject to drug depression, sometimes induced by an overdose. Physicians must in all justice be possessed of sufficient knowledge of the clinical use of anesthesia to recognize the good from the bad. They should be able to save a life by reestablishing a patent airway or performing efficient and safe artificial respiration when necessary. That some recent graduates are dependent on the fire or police department or on their boy scout manuals for artificial respiration is a serious reflection on present day medical education.

4. That the curriculum is too crowded to include clinical anesthesiology is more apparent than real. Even without formal lecture periods the student, patient and anesthetist can constitute a teaching unit in ward or operating room. When the department was established at the University of Wisconsin twelve years ago there appeared to be no time available for lectures. However, the first year one hour was assigned, the next three hours and the year following six hours. With the present arrangement, to be described later, the curriculum seems no more crowded than twelve years ago. It is apparent therefore that, once the need is appreciated, available time will be found.

5. That no money is available for the establishment of a department of anesthesia on a professional basis may temporarily be true in some institutions. Medical progress modifies budgeting and may involve an added outlay for equipment, replacements and other changes.

A well qualified director of anesthesia, who is capable of filling with credit the chair in the faculty of the medical school, should command an income comparable to that of other members of the staff. In the light of the increased scope of the service rendered, necessary budgetary adjustments are insignificant. In some institutions ill advised purchases, lack of attention to home construction of apparatus, and waste of materials have increased costs. With proper reorganization certain economies may result. The change has actually been made in some institutions with a definite financial saving within the first three year period.

6. There can be no question that the administration of anesthetic drugs is an art just as is the skilful handwork of the clever surgeon, but it is an art in the application of fundamental principles of basic science. The minute to minute necessity for the utilization of knowledge of physiology, of pharmacology, of biochemistry, of anatomy and even of physics is appreciated by every keen anesthetist. The rapidity with which changes may occur and the need for accurate thinking and prompt judgment are not exceeded elsewhere in medical practice. The trained anesthesiologist is a scientist applying scientific knowledge of respiration and circulation both in the operating room and in the wards. Art in anesthesia, to be safe for the patient, must be based on a scientific foundation quite as broad and fundamental as is the foundation for the art of surgery.

#### CONTRIBUTIONS TO GENERAL MEDICAL EDUCATION

Whatever type of practice they expect to pursue, young physicians must go out with sufficient knowledge of clinical anesthesia to recognize its limitations and its possibilities. Somewhere in the medical curriculum, students must be provided the opportunity to correlate the basic pharmacologic facts regarding depressant drugs with their clinical application. They must be taught the proper management in the wards of patients under the influence of such drugs. They must recognize the physiologic and biochemical disturbances which accompany the depression of respiration and circulation as well as have a knowledge of the measures and technics available to correct such disturbances. Such matters can be taught more effectively and more easily during the study and care of the surgical patient before, during and after anesthesia than at any other time.

A series of combined didactic lectures and clinical demonstrations on narcotized patients can be utilized

for undergraduate teaching. A laboratory course in surgical technic can be utilized to emphasize the more fundamental principles and to permit experience in open drop technic. During a short period of the fourth year and of the internship the student may serve with the anesthesia department, gaining knowledge through discussion as well as practical experience.

Emphasis is laid on the side effects both of the drugs and of the technic. The principles on which depend the choice of sedative and narcotic drugs and their dosage are discussed, and their administration is demonstrated. Methods of maintaining patent air passages and the treatment of depression are practiced. Indications for and methods of administering pneumotherapy are demonstrated and discussed. Various supportive treatments of depression by rectal, subcutaneous and intravenous routes are discussed and technics of administration demonstrated. The causes and treatment of acute respiratory derangement accompanying and following anesthesia are discussed and demonstrated when possible. The physiologic principles of technic for obstetric pain relief and the physiologic and biochemical balance in the mother as an influence on the condition of the child at birth are stressed. During the administration of pain-relieving drugs to women in labor, the anesthetist has an ideal opportunity to impress on students the fundamental physiologic inter-relationship between mother and fetus and the influence which he may exercise on the condition of the fetus by the judicious or injudicious administration of gases or other drugs to the mother. The physical state of patients before operation and their postoperative course in the light of the effects of drugs is studied and recorded by both the senior student and the intern. Such a course of supervised instruction and experience we believe essential in the general medical education of every young physician.

In anesthesiology, as in almost all phases of teaching, service and instruction go hand in hand. Consciously or unconsciously, the student imitates the instructor's service to others and emulates his success. Seeing the anesthetist approach patients with judicious recognition of the problems in medicine and psychology which they present, the student will realize the seriousness of assuming responsibility for the patient's life while administering drugs the therapeutic doses of which range from 65 to 90 per cent of the lethal doses. The student observes that the patient's welfare is the constant concern of the anesthetist and that by means of

frequent observations and accurate detailed records the anesthetist can note minute to minute changes, can interpret and assess their significance, can adjust his own course accordingly and can consult with the surgeon should circumstances require a change in the planned procedure. If the student should become a surgeon, he will benefit by knowing to what extent he may rely on the cooperation and advice of the anesthetist and to what extent he may feel free to attend to the operative procedure without being concerned about the anesthesia. If the anesthetist is qualified to assume complete responsibility for the general condition of the patient, the surgeon's attention may be devoted entirely to teaching and carrying out the surgical procedure, more time may be spent allowing the surgical neophyte to obtain some practice and the young surgeon may be permitted more safely to take the full responsibility for many surgical procedures.

#### SPECIALISTS

One can hardly start a discussion of the training now required to qualify as an anesthesiologist without first commenting on the debt the profession owes to the many self-taught specialists who have pioneered in this neglected field. Starting with the object of providing patient and surgeon with the best available conditions during operations, many physicians have, through years of service, coupled their extensive experience with a scientific attitude of observation and inquiry to build the practice of anesthesiology into the science it is today. They have contributed the numerous developments which now make intensive training almost obligatory before a younger man can call himself their equal. That these self-taught anesthesiologists still constitute the backbone of the specialty is evident from the fact that only three of the nine members appointed to the American Board of Anesthesiology have qualified by way of formal postgraduate training.

With the larger conception of anesthesia service coming to recognition at this time, it would seem that within a few years any hospital of 100 beds or more with an average proportion of surgical work will need the full time of at least one specialist in anesthesia to perform the various duties connected with a complete service. The qualifications of such a specialist should equal those necessary for certification by the American Board of Anesthesiology, an affiliate of the American Board of Surgery. To qualify for the examination of this board at present, a physician must be of good moral character, of ethical standing, a member of the Amer-



ican Medical Association, licensed by law to practice medicine, a graduate of a grade A medical school, a former hospital intern and a specialist of at least four years' standing, two years of which should have been spent in intensive graduate study. After 1941, in the opinion of the board, the special preparation should consist of six years' specialization, three of which should be spent in thorough training "in the clinical phases of anesthesiology and in anatomy, physiology, pharmacology, biochemistry and other basic sciences which are necessary to proper understanding of the problems involved in the specialty of anesthesiology." Such instruction must have been received in institutions approved by the Council on Medical Education and Hospitals.

The recent rapid increase in the number of institutions offering adequate training and the number and qualifications of the applicants are most encouraging. It may be asked what is to become of these physicians after they finish their training. Placing young specialists in the United States has so far not proved difficult. The demand on the part of medical schools and large teaching hospitals has exceeded the supply. Eventually a saturation point of teaching positions will of course be reached. However, several obvious circumstances will bring about satisfactory adjustments. Established departments tend to expand in scope, requiring an increasing number of associates and assistants. Many men are intensely interested in anesthesiology but not in teaching as a major interest or in research activities. Although they are quite as capable as the teachers, their preference is for private practice in hospitals without university affiliations. The minimum amount of instruction to the house staff necessary in such hospitals is given willingly by these men just as it is by attending staff members in other specialties. The fact that hundreds of physicians who had little or no formal training in anesthesiology, either graduate or undergraduate, have succeeded in such practice in the past proves that there will be abundant need for well trained practitioners in the future.

#### RESEARCH

It should be emphatically stressed that research is merely a by-product of a department of anesthesiology. First and foremost should come good service to patients, then teaching and finally, when these are assured, research.

The physical signs induced by, the character of the response to, and the effective dose of anesthetic and depressant drugs are not the same with animals as with man, yet the laboratory is the logical starting point for any physiologic or pharmacologic investigation which may ultimately receive clinical study and final evaluation. Several recent advances in anesthesiology serve to emphasize that cooperative effort between the laboratory worker and the clinician is essential. In addition to purely clinical research, the anesthetist is capable of contributing much toward the satisfactory amalgamation of laboratory and clinical data through discussion of the planning of experiments involving anesthesia and cooperative assistance in the laboratory, aid in checking the results of animal experiments with human beings, offering to the basic science departments the opportunity for clinical observation of their problems, carrying clinical problems to the basic science experts for their consideration and investigation, and independent investigations. The control of the patient essential to proper anesthesia provides admirable circumstances for the study of changing bodily function incident to the anesthetized state.

#### TECHNICIANS

Surgeons have depended and still depend, to a constantly decreasing extent, on technicians for the administration of anesthetics. A reference to this situation is therefore necessary. The aid of the nursing profession has been priceless. The neglect by the medical profession of so important a function has thus been compensated to some extent. It is obvious, however, to one who has spent many years in training others in the technical as well as in the scientific aspects of pain relief that a more appropriate field for the nurse-technician in medicine is to be found in obstetrics and minor surgery, if indeed such technician assistance is necessary. True, one not possessed of a medical background can be taught to do many things in medical practice. However, the minute by minute need for knowledge and judgment in matters pharmacologic as well as physiologic is rarely so great in normal obstetrics and during certain surgical procedures as it is during the administration of a majority of anesthetics. Decisions during delivery of a parturient woman or during the removal of an appendix are seldom so likely to affect directly the later incidence of morbidity or even mortality as are the decisions which must be made and acted on during the management of the anesthetized patient. If

a technician must be used—and the present need in some localities is admitted—a physician well versed in anesthesiology should be constantly close at hand. The practice, current in some medical schools, of training nurses as anesthetic technicians and sending them out to administer anesthetics without supervision is perpetuating an unjustifiable hazard.

Our experience has taught us two important facts. 1. The employment of anesthesia technicians in a hospital seriously embarrasses the satisfactory training of medical students and doctors. 2. The average intern, after good training in the basic sciences and a half year of reliable undergraduate instruction in the clinical use of anesthesia, can, at the end of a month of carefully supervised practical experience in the operating room, be trusted with the welfare of an anesthetized patient more safely than can the average technician after years of experience. This statement is made advisedly and after long observation of persons working in both categories.

#### ESTABLISHMENT OF A DEPARTMENT

In what does a department of anesthesiology in a medical school consist? First and without doubt there must be a director, a physician who is the best possible clinical anesthetist as well as teacher. Progress will be more satisfactory if the director's time is devoted solely to one institution. His income should be adequate to maintain him on a par with the heads of other departments. Immediate need for assistants will depend on local circumstances and the size of the hospital. Once such a director is a part of the faculty and hospital staff, gradual development of a department in the hospital and in the school should take place. The basis of both teaching and research is good clinical anesthesia. The director's time during the first year therefore should be concerned mainly with learning the ways of the surgical staff and the staffs of other departments and fitting himself to supply their individual needs. During the director's second year, a short course of lectures and demonstrations to undergraduates can advantageously begin. If the curriculum is hopelessly crowded, possibly an hour can be offered here and there from some branch of surgery or from obstetrics. Gradually the need will become more apparent and the time will become available. As soon as possible, one or two fourth year students at a time should be assigned in rotation to clinical anesthesia. A student will learn more during one week full time than during three weeks part time. The same is true of interns. The longer the period of contact, the better will be the result. During the director's second year, residencies in anes-

thetia may be thought of, the number depending on the size of the hospital. Only after the clinical work is running smoothly, with the full confidence of the surgical staff, can undergraduate teaching, then graduate teaching and finally research be undertaken.

#### A SAMPLE DEPARTMENT

The department at the University of Wisconsin as constituted at present will be described, not because it approaches the ideal but because we are familiar with it. Organizations in existence for a shorter time are already more nearly ideal. Some of these have been initiated in hospitals connected with medical schools,<sup>1</sup> while others are in hospitals without teaching affiliations.<sup>2</sup>

This department may be outlined as follows:

##### A. Personnel

1. Professor of anesthesia in medical school and director of anesthesia, university hospitals; full time; salary from medical school and fee privileges for private patients
2. Instructor in anesthesia: former resident; salary from medical school
3. Research fellow: former resident; salary jointly from research fund and hospital. It is hoped to make two or three permanent associates in the future
4. From five to seven residents: duration of appointment three years; prerequisites M.D., rotating internship and preferably one year residency in internal medicine or two in general practice; stipend and maintenance similar to those of other departments

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##### 1. References include:

- Gatch, W. D.: Anesthesia in Curriculum and Clinic, *J. A. M. A.* **69**: 367 (Aug. 4) 1917.  
Herb, Isabella: Anesthesia in Relation to Medical Schools and Hospitals, *Am. J. Surg.* **35**: 50 (April) 1921.  
Bourne, W.: On the Teaching of Anesthesia to Medical Students, *Brit. J. of Anaesth.* **1**: 74 (No. 2) 1923.  
Waters, R. M.: The Requirements of an Anesthesia Service, *Anesth. & Analg.* **9**: 219 (Sept.-Oct.) 1932.  
Wright, A. M.: Teaching and Anesthesia Service from the Viewpoint of Surgery, *ibid.* **14**: 246 (Nov.-Dec.) 1935.  
Rovenstine, E. A.: Anesthesia at Bellevue Hospital, *Hospitals* **10**: 84 (June) 1936.  
Dollar, D. M.: The Teaching of Anesthesia, *Anesth. & Analg.* **15**: 225 (Sept.) 1936.

##### 2. References include:

- Salzer, M.: Anesthesia as a Part Time Specialty, *Tr. Sect. Surg., Gen. & Abd., A. M. A.*, 1922, pp. 45-52.  
Palmer, C. B.: Organization of a Hospital Anesthesia Department, *Anesth. & Analg.* **11**: 50 (April) 1923.  
Miller, A. H.: Organization of the Anesthesia Service of the General Hospital, *J. A. M. A.* **101**: 1119 (Oct. 7) 1933.  
Leech, B. C.: Organization and Management of a Department of Anesthesia in a 200 to 400 Bed Hospital, *Anesth. & Analg.* **13**: 192 (Sept.-Oct.) 1934.  
Ruth, H. S.: Anesthesia Service, *ibid.* **14**: 243 (Nov.-Dec.) 1935.  
Schwartz, A. L.: Professional Anesthesia: A Hospital Plan in Operation Eighteen Years, *J. Indiana M. A.* **29**: 165 (April) 1936.  
Tovell, R. M.: The Department of Anesthesia, Hartford Hospital: A Report for 1937, *Anesth. & Analg.* **17**: 268 (Sept.-Oct.) 1938.

5. Interns; spend one month in the anesthesia service
6. Fourth year medical students; one week full time; fifty students in each class

## B. Teaching

### 1. Undergraduate

- (a) One lecture, second year (courtesy of the pharmacology department)
- (b) Course in surgical technic and anesthesia (given to one half of the third year class each semester)  
Instructor and two residents supervise anesthesia and teach fundamentals of open drop ether and chloroform anesthesia with dogs  
Twenty three-hour laboratory periods a year
- (c) Sixteen lectures second semester of third year, one hour periods  
Demonstration-lecture usually with anesthetized patient; quiz
  - (1) History, terminology and scope of anesthesiology  
*Review of Fundamentals of Physiology*
  - (2) Circulation
  - (3) Prophylaxis and treatment of circulatory disturbances
  - (4) Respiration
  - (5) Prophylaxis and treatment of respiratory disturbances
  - (6) The autonomic nervous system  
*Review of Fundamentals of Pharmacology*
  - (7) Nonvolatile agents and correctives
  - (8) Gases and vapors (including fire hazard)  
*Fundamentals of Technic*
  - (9) Oral, rectal, subcutaneous and intravenous technics
  - (10) Open drop technic; signs of anesthesia
  - (11) Carbon dioxide absorption technic
  - (12) Other inhalation technics (partial rebreathing, etc.)
  - (13) Physiology, pharmacology and technic of obstetric pain relief  
*Fundamentals of Local and Block Anesthesia*
  - (14) Pharmacology, principles, toxicity (prophylaxis and treatment)
  - (15) Block technics: emphasizing simple field blocks and spinal blocks
  - (16) ~~Therapeutic and diagnostic procedures with anesthetic drugs~~
- (d) Each fourth year student for one week full time with department; preoperative check of patients scheduled for operation; operating room work; postoperative check of patients; record keeping

### 2. Postgraduate

- (a) Intern, twelve of house staff, one month each full time
- (b) From five to seven residents, three year periods  
First and third years, clinical anesthesia with some teaching experience and research

Second year, research major interest (anesthesia problems) with courtesy contact in laboratories of pharmacology or physiology, or clinical research  
Trial being made of a limited number of six month appointments of graduates already practicing anesthesiology who wish a postgraduate course; not yet established; if adopted, tuition will have to be charged

- (c) The department is open to visiting physicians at all times, though no clinical experience is offered such visitors

#### C. Departmental meetings

- (a) Current literature review and discussion, two hour session, Monday 7 p. m.  
One member reports each week on journals assigned to him; 106 journals covered, with occasional articles from others  
A small departmental library maintained; medical school library near at hand
- (b) Clinical work: Review of past week's cases, including deaths of surgical patients; two hour session, Wednesday, 1 p. m.  
Meetings attended by whole anesthesia staff, including intern, student and visitors; chairmanship, in rotation, by residents
- (c) First year residents required to attend all undergraduate lectures
- (d) All members of the department expected to attend hospital staff meetings, including clinical-pathologic conferences and university medical meetings

Preoperative rounds are made each evening, when the clinical records of patients are reviewed and transferred to departmental record sheets; after the patients are seen, orders are written for premedication. Odd hours are utilized by residents and interns to examine records and patients after operation and to complete the anesthetic record. The record sheet is then coded to a Hollerith punch card for permanent filing. All records are sorted yearly and a statistical survey of the work of the department compiled. An effort is made to have each resident write at least one paper and gain experience in lecturing to medical students.

The review of basic science for the resident, aside from his attendance at undergraduate lectures, is accomplished in an entirely informal way. Frequent contact with a skeleton, models and charts in the department aids him in coordinating his knowledge of anatomy with the technic of injection anesthesia. Experimental blocks and dissection of the cadaver are made possible through the courtesy of the anatomy department. Joint research efforts are constantly in progress with the departments of physiology and pharmacology and other

basic science groups as well as with the various departments of clinical practice. Constant reference to the literature is stimulated as a result of discussions in the operating room and at departmental meetings. This has seemed sufficient for all practical purposes.

A department of anesthesia must conform to the needs of the institution served. In the plan outlined, two permanent associates with an eventual rank of associate professor are essential for future development. The instructor should be retained on a semi-permanent basis. Such a personnel is an essential if the short term (six months) instruction to graduates is instituted.

#### SUMMARY

By anesthesiology is meant not only the science of the administration of drugs for the comfort of patients during operation but also the management of patients in depression from other causes. Pneumotherapy, intravenous therapy, therapeutic and diagnostic procedures involving the use of anesthetic drugs, and other efforts based on similar scientific knowledge, logically fall within the scope of anesthesiology. Clinical instruction in this subject is sound educational policy in the broad training of every physician. The outline given of the establishment and conduct of such a department in a teaching hospital and medical school is not ideal but may afford a groundwork on which better organizations may be constructed in other medical schools and in the various hospitals. The patient under the influence of pain-relieving drugs, together with the department of anesthesia, constitutes a natural decussation of many of the pathways between basic science and clinical teaching. Appreciation of this relation is, we believe, a contribution to our educational program.

NOTE.—The references cover only the published accounts of established departments of anesthesia. There are many departments, especially of recent origin, which have not been described in the literature.

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## THE EVOLUTION OF ANESTHESIA. I.\*

Ralph M. Waters, M. D., Madison, Wisconsin: The fruits of research may be long in reaching their market. Propriety, precedent and prevailing practice have often been in conflict with progress, performance and the attainment of perfection.

The medical profession is only recently beginning to learn that the practitioner must be conversant with the contributions of the experimenter if he is to render the best to his patients. Such an attitude is placing a grave responsibility upon those concerned with medical education, a responsibility appreciated by teacher and pupil alike. The present day student of medicine must become sufficiently familiar with research, its language and its methods, that he may separate the wheat from the chaff—recognize the experimental contribution that may form the basis for sound clinical practice from that which is of academic interest only or the one that is the result of unsound or dishonest investigation.

Until recent times, the education of physicians made no pretense of including any familiarity with the methods and products of science. The usual result was a lag, of a quarter century, a half century—even of centuries of time—between the demonstration of a scientific fact and its correlation with other demonstrated facts and finally the incorporation of a new departure into medical practice. The evolution of anesthesia well illustrates what I am trying to say.

Painless surgery did not await the discovery of a drug. Theodoric wrote of his father's "somniferous sponge" in 1298. To be sure, his description of its use has been misinterpreted by moderns. But if patients were asked to suck the moistened sponge, not inhale from it, adequate quantities of drugs could be ingested to produce surgical anesthesia, such as Theodoric described. Modern anesthetists have produced anesthesia, satisfactory to surgeons and safe for patients, with only two of its ingredients.

Valerius Cordus described a method for the preparation of ethyl ether in 1545. His contemporaries knew that the inhalation of its fumes would relieve headache.

Humphry Davy in 1800, published a description of adequate methods for the preparation and purification of nitrous oxide together with beautifully described studies of its pharmacologic actions—chiefly upon himself. He inhaled it mixed with oxygen to relieve extreme pain in his chest which he had rashly produced by the previous inhalation of a very irritant gas mixture which he called "hydro-carbonate." In the conclusions to his experiments, he made the oft quoted suggestion that nitrous oxide could be used to relieve the pain of surgery. In 1800, too, a young pharmacist's assistant in Paderborn noticed the complaints of physicians concerning the variability in effect of prescriptions of opium which were compounded. After experiments, first pharmacologic or chemical and later pharmacologic, with animals, his friends and himself as subjects, he solved the problem of the production of alkaloids and the isolation of the active principle of herbs. The soluble salts of the alkaloids of morphine and other drugs permitted an accuracy of dosage previously impossible.

\* Mayo Foundation lecture presented January 28, 1942.

Editor's note: This is the first of two papers on this subject. The second will appear in a subsequent issue.]



If not for lack of a drug, why then was the wait so long for comfort to accompany the cuttings of the surgeon? One important reason, certainly, was the failure of the medical profession to recognize the importance of, and become familiar with, the contributions to scientific knowledge. It would be impossible for the modern anesthetist to produce anesthesia safely with the two ingredients of the "somaiferous sponge" in the manner illustrated if he were unaware of the functions of circulation and respiration, of means of supporting them when depressed or even of restoring them when interrupted. The writings of Vesalius were available in the sixteenth century, those of Harvey and the early members of the Royal Society in the seventeenth and those of Priestley, Lavoisier and Davy in the eighteenth and yet it was nearly the middle of the nineteenth century before the first surgical operation was performed upon a patient insensible because of drug action.

Even so, what may be referred to as the chance discoveries of the anesthetic qualities of nitrous oxide and ether in New England in the 1840's was not based upon familiarity of physicians with scientific discoveries of the past. Since, however, the functions of respiration and of circulation were understood, even by laymen, in the fourth decade of the nineteenth century, the demonstration of "insensibility during surgical operations produced by inhalation" appealed to the well read man of the period as based upon sound knowledge and it was accepted in spite of the unsavory manner of the introduction. Without a general appreciation of the why and how of breathing, and of why and how the blood circulates, the secrecy regarding the identity of the drug, the squabble regarding priority in discovery and the almost quackish nature of the introduction might have caused another long delay in acceptance. With such general understanding of breathing and circulation, physicians were possessed of a means of observing the effects of the inhalation of strange vapors and of judging the safety of the resulting condition.

During the first decade following the public demonstration of surgical anesthesia, progress was fortunate in enlisting the interest and enthusiasm of an individual familiar with the scientific literature, clever in laboratory experimentation, accomplished as a practical anesthetist and withal possessed of sufficient imagination to apply with discretion what he found in the literature, in the solution of the problems presented by the new procedure. It was disastrous that the early death of John Snow cut short the productive career of the first professional anesthetist. The prophecy of his biographer, Sir Benjamin Richardson, was fulfilled. Richardson's biography ends with these words: "But in the gaping time shall it chance rarely, for another science-man to come and go, who, taking him all in all, may call him 'brother'."

Snow died in 1858. A study of progress in anesthesia since that time convinces one that we still await the rare chance, prophesied by Richardson, when another "science-man shall come and go who may call John Snow 'brother'." By this remark I do not mean that significant contributions to the science and art of anesthesia have not been made. On the contrary, brilliant researches have come from the hand and head of physiologists, pharmacologists, surgeons and anesthetists. What I do imply is that full measure of benefit to patients has been delayed, and even lost, because correlation and application of demonstrated facts have been slow or absent of accomplishment. We anesthetists have too often allowed ourselves to become technicians, unaware of the scientific and medical literature and its possible application to our endeavors. Regnault and Reiset

demonstrated the physiologic soundness of continuous respiration of an atmosphere from which carbon dioxide is chemically removed and to which oxygen is added. Snow utilized this principle in experiments, but died before he had opportunity to apply the principle to clinical anesthesia. We anesthetists neither read Regnault and Reiset nor Snow and waited until Frank Mann and Dennis Jackson forced carbon dioxide absorption technic upon us a half century later. The surgeon, Trendelenburg, devised a method of closed endotracheal anesthesia before 1870, that he might remove malignant growths from the region of the pharynx without embarrassment to respiration from obstruction and from contamination of the tract with blood. We anesthetists waited until the third decade of this century to bring the method to sufficient perfection to make it an acceptable aid to modern anesthesia and surgery. These two examples from many will serve our present purpose. Regnault and Reiset and Trendelenburg were not anesthetists. Their interests were primarily in other fields. If their imaginations were sufficiently fertile to visualize the possible broader implications of their work to clinical anesthesia, they had neither the time nor the opportunity to correlate their experiences with the problems of narcosis.

I believe I need go no further in citing instances to prove that clinical practice in anesthesia has been and still is handicapped, by failure to correlate and utilize existing knowledge. I have already called attention to the changing attitude in medical education. How far must we go in making laboratory scientists of our future practitioners of medicine? What I propose to add to this point will seem very much like "carrying coals to Newcastle" since I realize that the Mayo Clinic has been a pioneer in promoting co-operative effort between the laboratory and the clinic. The question is a very live one in such a department as that with which I am associated at the University of Wisconsin. Obviously a period of years spent in the laboratory by every anesthetist will make of him only another laboratory scientist, a result highly desirable but not likely to increase the supply of good clinical anesthetists. Primarily, an anesthetist, to serve his proper function, must be a sound clinician and an artful one. A large percentage of his training period then must be based upon experience in the hospital with patients. It is felt, however, that a small portion of his time should be spent with the basic science departments of the medical school—not with the primary hope that he will make a startling discovery but that he will become acquainted with those who are capable in so-called pure research, acquainted with their language and with their methods. We hope, and believe it is proving so, that benefits will accrue on both sides. First that the man in training will establish friendly relations and a common language with those who are capable of critical and exhaustive investigation. On such a foundation, he ought to develop the ability to judge, personally, of the reliability and value of scientific literature. Secondly we hope, and again believe it is proving so, that laboratory investigators may to a certain extent be lured away from their laboratories and induced to spend at least some of their time in the operating rooms and wards of the hospital, seeing for themselves what the outcome of their conclusions may be when brought to the ultimate test—clinical trial. We even hope that some of their observations may be made upon anesthetized patients instead of upon animals, to the benefit of patients as well as to the accuracy of their conclusions. There seems to have been in the past too much—what shall I say—perhaps veneration, in the mutual relation of clinicians and laboratory experts. Whatever term describes this relation, it is based on unfamiliarity each with the other's methods, problems and language. To preserve his own self-esteem, each has

tended to assume toward the other one of two opposite attitudes. The pose adopted is either that of timidity and obsequiousness on the one hand or of self-reliance and arrogance on the other, both equally detrimental to co-operative accomplishment. There seems to be no better common meeting ground than the operating rooms and wards of the hospital in which are patients depressed by narcotic drugs. Once the "bull in the china shop" approach of the clinician to the laboratory, and of the anatomist, pharmacologist, physiologist and biochemist to the hospital has been abolished, the two groups can work in harmony and mutual respect to the benefit of both their accomplishments.

If we can establish a teaching personnel in an atmosphere blended of basic science and clinical experience, whom, how and what shall we try to teach in order to supply the rapidly increasing demand for competent anesthesiologists?

## THE EVOLUTION OF ANESTHESIA. II.\*

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### WHOM SHALL WE TEACH?

It probably goes without saying that a prerequisite for special training in anesthesia must be the usual work required for the M. D. degree followed by a general hospital internship or its equivalent.

If a need exists for technicians as aids to the anesthetists, it can best be met, I believe, through the training of hospital corps men, orderlies or nurses at the time when the need arises, and under circumstances permitting the teacher to continue supervision of and responsibility for the work of the pupil. I am convinced that attempts to combine two types of training, one for the physician with his medical background and one for the prospective technician, cannot help but lower the standard of training which can be given the former. This should not be interpreted to mean that the experienced technicians may not render excellent service to the patient. From personal experience and observation, however, I do feel certain that the difficulty of training physicians in anesthesiology is greatly increased if the two types of instruction must be combined. In a university hospital, of course, the question scarcely needs to arise since undergraduate students and interns are more than grateful for the experience in observation and management of acute respiratory and circulatory crises as well as in the administration of drugs.

From our experience at Wisconsin, we are convinced that candidates for special training in anesthesia are (other things being equal) much better prospects if they have followed their internship with three years' experience in general practice, preferably in a small town. Several advantages result. During the three years of general practice, the young physician learns to deal successfully with people and with other doctors. In his contacts with the latter, he has an opportunity to be sure that he has chosen his specialty wisely. He may put aside sufficient funds to tide over the lean years of special training. From the standpoint of the university, we find that candidates after three years of general practice are more mature, more serious minded and determined in their work. They are not so much inclined to be critical of other specialties and other specialists. They have a sympathetic attitude toward other physicians in and outside the hospital staff. They know how to deal with patients. Possibly some, during the three years, find that they enjoy or are especially fitted for general practice and are saved entry into a specialty as misfits. Personally, I am convinced of the desirability of experience in general practice as a prerequisite to specialization in anesthesia.

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[Editor's note: This is the second of two papers on this subject. The first appeared in the issue of July 15, 1942.]

I have already confessed to a personal prejudice for more clinical atmosphere in basic science teaching as well as for more scientific attitude in the teaching of clinical medicine. Such a blended atmosphere is highly desirable but not too common at present. Safety in drug administration for the relief of pain is dependent not only upon a thorough familiarity with the pharmacologic action of drugs but also upon an understanding of the physiologic mechanisms which tend to be deranged by effective doses of all sedative, narcotic or anesthetic agents. It has proved necessary, therefore, for teachers of anesthesiology to review and to apply pharmacologic, physiologic and biochemical knowledge, specifically to the problems of pain relief. The task will become less and less arduous of course as the basic science teacher is more and more exposed to the hospital atmosphere. At the University of Wisconsin we still find it advantageous to conduct more or less formal lectures, discussions and demonstrations with our own undergraduates. To these the residents are exposed. Little or no formal or classroom work is offered primarily to the resident in anesthesia. Two semiformal department meetings per week we have thought adequate. At these, cases, problems and current literature are discussed. With the informal questions and discussions which take place daily in operating rooms and wards, we have thought that continuous clinical practice should adequately complete the training. The constant necessity for mature residents to teach the younger residents and undergraduates adds materially to benefit derived.

In the present emergency, when six months' or even six weeks' courses of instruction are being tried, older methods will surely be found inadequate. Only experience can determine how extensively lectures, demonstrations, quizzes and discussion can be made to take the place of practical experience. Results will depend to a great extent upon the interest and industry of the pupils.

#### FINALLY, WHAT MUST BE TAUGHT?

Not infrequently in the past I have encountered medical educators, deans and directors of departments of surgery, whose conception of the scope of anesthesiology was so circumscribed as to make futile the initiation of a department of anesthesia in their schools. Illustrating the probable result of the abortive establishment of departments of anesthesia based upon inadequate concepts of the possibilities, one university began with the addition of a well trained anesthetist but with the expectation that this individual would devote all his time, as a sort of supertechnician, to the anesthetization of the private cases of the visiting surgical staff. No budget was provided for assistants, and no time for teaching. The attempt was a failure and abandoned. However, it did perhaps serve a useful purpose in convincing the faculty of the potentialities of a properly organized department. The same institution is now organizing, with an adequate budget for personnel to deal with all clinical anesthesia in the institution, teaching and research, including the direction of efforts in inhalation therapy, resuscitation, the care of acute respiratory and circulatory crises and diagnostic and therapeutic procedures involving the use of anesthetic drugs and methods.

The anesthetist should, of course, first of all be held responsible for the provision of safe and satisfactory surgical anesthesia in the operating room. With the demand of the surgeon what it is and what it is becoming, this is no small undertaking. Some may believe that the anesthetist ought therefore to restrict his interests to the operating room. On the other hand, his opportunity to observe patients with acute derangement of the function of respiration and circulation is

more frequent than any other member of the hospital staff. The necessity for the proper introduction of needles is constant in his work in the operating room. Daily he manipulates apparatus for the control of inhaled atmospheres. By just such knowledge and skills as are necessary to the anesthetist in the operating room, morbidity and mortality of patients in the wards of the hospital, in the shops, in the streets and on the field of battle can be decreased. Rarely are other staff members so advantageously situated for the teaching of the prophylaxis and management of the disorders just enumerated. It appears to me obvious that the field for the endeavors of the anesthetist is not unduly restricted, nor are his prospective pupils solely candidates for specialization in anesthesia. Should not every physician be familiar with the fact that all drugs which relieve pain tend to disturb the function of respiration? Should he not have been exposed to the best possible instruction in the establishment of an artificial air passage to the lungs when the natural one is obstructed? Should he not be expert with means of producing adequate exchange of air when injury, illness or drug depression endanger that function? Is it not, therefore, probable that the person who is preparing for the general practice of medicine, or any of its specialties should be permitted to gain as much knowledge as possible from at least a brief acquaintance with the department of anesthesia?

You may wonder why there has been so much palaver concerning teaching when I intended to discuss "the evolution of anesthesia." This is why—because at the present stage of development of anesthesia I have the feeling that good teaching can more successfully promote progress than can research. Investigation, it seems to me, is at present in advance of clinical application. By this I do not mean that anesthetists may abandon research. If in the past there had existed a closer relationship between investigators and anesthetists, application of known facts need not be trailing behind the discoveries. In the process of trying to teach, however, we anesthetists come to realize how grievously we have failed fully to utilize, to the best advantage of our patients, some of the older scientific contributions which we have already incorporated into clinical practice. When a scientific contribution has been found applicable to our problems, we anesthetists have been prone to utilize it in the easiest manner possible, without thought or imagination, provided only that it gives a better result than we were accustomed to see with the older method. Let me try to illustrate. The oldest example is the problem of controlling artificial atmosphere for inhalation. In 1847 John Snow copied the mask designed at the request of Humphry Davy by James Watt. Throughout the years, each generation of anesthetists has copied the Watt mask. At present we have different materials with which to manufacture gadgets through which atmospheres might be led into the respiratory tract, plastics and new methods of preparing rubber and glass. Dr. Bulbulian and those associated with him have shown us some originality in this matter. More efforts are needed along the same line. Another example: the local anesthetic effect of certain drugs was demonstrated a half century ago. We still inject them with a syringe and needles similar to the ones used by Braun in 1905. We no longer believe with the English translator of Braun's book, that "local anesthesia is a method which has no mortality," but I think Dr. Lundy will agree with me that we have added but few really new technics of injection since Braun's publications. And another example: in the years before 1923, I became interested in the clinical application of the principle of the chemical absorption of carbon dioxide from anesthetic atmosphere. A mechanical arrangement was assembled which would hold soda lime and the respired atmosphere in a leakless manner. The

resulting anesthesia was more satisfactory than open administration, with which I had previously been familiar. I presume I had some hope at the time that manufacturers might develop mechanical changes and improvements. They did make changes but seldom were they either developments or improvements. Only now after twenty years use of this technic am I becoming sufficiently concerned with the resulting physiologic and biochemical disturbances to realize that the needed investigations are challenges to the best research effort that laboratory experts have to offer. If carbon dioxide absorption technic is to be perfected as it might and ought to be, it is a problem for the co-operative labor of the anesthetist, the physiologist and the chemical and the mechanical engineer.

These are three examples, chosen from many illustrations of the defects and neglects for which we present day anesthetists must answer. Honest confession, they say, is good for the soul.

Last, but by no means least, I must emphasize the keeping of records. In 1915, McKesson, following the pioneer work of Cushing, emphasized the feasibility of recording at short intervals the pulse and respiratory rates, blood pressure and coincident observations throughout every operation. He presented a graphic chart for the purpose and commented upon 5,000 cases in which such observations had been recorded. This I believe to have been one of the few classical contributions to the evolution of anesthesia. Since 1915, we anesthetists have learned to record in all cases, minor as well as major, not only observations made during anesthesia and operation but those made before and after operation. These we may subject to statistical analysis, thus affording more accurate estimates of the results of our work. Much more important than their statistical value, however, such records are indispensable for the following reasons: (1) they focus our attention upon the patient and how he is affected by what we do to him; (2) they serve as a basis for later leisurely discussion of our procedures and the results; that is, they are the basis for all teaching and all improvements in practice. Without well kept records, we are deprived of a basis for discussion, comparison and conclusion and are left dependent upon memory and personal opinion as a foundation for instruction and for progress.

I have omitted any specific references to drugs and methods. This I have done intentionally because I believe that the contribution of a new drug here or of a new method there has had, and will have, little lasting influence upon the evolution of anesthesia. Permanent improvement will develop in the future, as it has come in the past, mainly through consideration of scientific facts—laborious learning, imaginative insight and accumulative application. Introduction of new drugs and new methods will be as it has been, incidental to such consideration.

#### SUMMARY

In attempting to outline the evolution of anesthesia, I began by bewailing the lack of utilization by our predecessors of the scientific contributions which were available to them. In emphasizing the importance of teaching in the developmental process, I raised your hopes, perhaps falsely, that we present day anesthetists might be better than our predecessors. I implied that, since we are concerned with depressed patients, sometimes unconscious, we are in a more advantageous position to enlist the interest and help of the laboratory scientist than are other clinicians. Finally, I have come to admit that many of our methods are faulty and in great need of further imaginative and constructive investigation. Having clinical competence and an established habit of routine recording of the physiologic

changes accompanying drug action and surgical manipulation, we ought to be in a position, not only to improve our practice but also to profit by the help which others are willing to offer. I hope we may prove capable of worth-while co-operation with surgeons in solving their problems which, of necessity, are always modified by the drug effects necessarily present. I also hope that, when it is necessary, we may serve in a way to "sponsor" the laboratory expert, to introduce him into the atmosphere of the operating room and the hospital.

In such a co-operative environment of study of our joint problems as I have tried to outline, perhaps we can teach ourselves and our pupils safe and sane methods for the present relief of pain without promoting an attitude of confidence that present solutions of our problems are conclusive. If such an outlook can be maintained, continuous progress may result—truly the evolution of anesthesia.

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## ANESTHESIOLOGY IN THE HOSPITAL AND IN THE MEDICAL SCHOOL

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Two circumstances have been blamed for the delay or reluctance in accepting to the fullest the service which modern anesthesia might render. One is the lack of a sufficient number and quality of physicians prepared to accept the responsibility. The other, sometimes suggested as a cause for the first, is the existence of widespread abuses, exploitation and all round lack of appreciation of those who are devoting their energies to the specialty. The present would seem to be an auspicious time to reconsider the subject and to discuss how anesthesiology can best serve the needs of the medical student, the surgical profession, the hospital and, most important of all, our patients. During the war many surgeons for the first time observed the advantages of medical training as the foundation for an anesthetist. At the same time the number of physicians who realize the importance and attractiveness of anesthesiology as a major interest has been increased by several hundred per cent. We are now at a crossroad. Either we must take advantage of this new realization of the importance of anesthesia and of the interest and enthusiasm of returning "military anesthetists" or we shall continue the former abuses, neglect and exploitation of anesthesia and anesthetists. In the first instance patients will receive in the long future the best service in anesthesiology which current knowledge makes it possible to give them. In the second, that service will regress to a new low of neglect.

In order to establish a reasonable view of the problem we must disabuse ourselves of a generally held belief that the importance of anesthesiology lies in the "choice of agents" or in the particular "technic" employed. All drugs and the methods by which they are admin-



istered are subject to abuse. Through fundamental knowledge and diagnostic skill the abuses are avoided or neutralized, quite as much as by artful technical manipulations. The unimportance of the chosen drug is shown by the accompanying illustrations. An outline of experiments comparing some effects of vinyl ether, trichlorethylene and chloroform appears in table 1. It is evident that chloroform, an old but now almost discarded drug, does not come off second best when compared with two new agents which have been accepted with considerable enthusiasm. A statistical evaluation of results following the administration of common agents at Wisconsin General Hospital is presented in tables 2

TABLE 1.—*Effects of Anesthetic Agents on Dogs\**

	Hepatic	Renal	Cardiac
Divinyl ether (vinethene)	Central zonal necrosis to acute yellow atrophy	Definite impair- ment; urea clearances 10% to anuria	None
Trichlorethylene (trilene)	Minimal hy- dropic to fatty degeneration	No definite impairment	Severe (ventricular tachycardia)
Chloroform	None to mini- mal hydropic degeneration	No alteration of function	Moderate (ventric- ular tachycardia rare)

\* The three agents were administered to dogs by the carbon dioxide absorption to and fro technic, particular attention being paid to adequate oxygen tension in the respired atmosphere and to adequate ventilation of the lungs. Administrations, one hour in duration once a week, were repeated to produce structural as well as functional hepatic and renal damage if possible. The general picture rather favors chloroform in the comparison.

and 3, the former showing the incidence of major pulmonary complications and the latter of "hospital" deaths occurring in the daily work of the institution. It will be noted that the variation in results is not wide following the use of the several agents. If time for discussion permitted, it could be shown that such variations as do exist are better explained by the preoperative condition of patients, the nature of operations and the lack of training and the inexperience of anesthetists rather than by correlation with the drug chosen or the method of its administration. For instance, both death rate and pulmonary morbidity were high among patients credited to nitrous oxide and "other" inhalation agents. However, nitrous oxide, combined with high percentages of oxygen, was often used in cases in which the physical condition was desperate or the need for oxygen administration acute. Likewise the addition of "other" agents was often in the presence of incurable disease in order to study the effects of drugs with which we were less familiar.

TABLE 2.—Major Respiratory Complications\*

Agent	Number of Cases	Incidence	
		Cases	Per Cent
Cyclopropane.....	10,607	229	2.16
Ether.....	5,203	143	2.74
Nitrous oxide.....	2,114	76	3.59
Other inhalation.....	624	31	4.96
Intravenous barbiturate.....	1,398	16	1.14
Regional agents.....	3,017	79	2.61
Others.....	263	4	1.52
Total.....	23,226	621	2.67

\* This table indicates that the percentage of major respiratory complications does not vary widely. The physical state of the patients receiving nitrous oxide and "other agents" is believed to explain the higher percentage with these agents rather than effects of the drugs.

TABLE 3.—Deaths in the Operative and Postoperative Periods\*

Agent	Number of Cases	Deaths	
		Cases	Per Cent
Cyclopropane.....	10,607	225	2.12
Ether.....	5,203	123	2.36
Nitrous oxide.....	2,114	102	4.8
Other inhalation.....	624	27	4.33
Intravenous barbiturate.....	1,398	24	1.7
Regional agents.....	3,017	108	3.57
Others.....	263	12	4.56
Total.....	23,226	621	2.67

\* Comparable to table 2, the higher death rate following nitrous oxide and "other agents" is believed to be due to the preoperative condition of the patients.

It's not the tools but the way the tools are used. The future of anesthesiology, as I see it, is not dependent on the discovery of new drugs but may be boiled down to two efforts: (1) elimination of certain abuses which are common and accepted practices in our country and (2) the establishment of an understanding by schools, the profession and the public of what anesthesiology really implies in the hospital and in the medical school.

#### ABUSES

To enter into a detailed and comprehensive discussion of the abuses of anesthesia, of the anesthetist and by the anesthetist is not the present purpose. Doubtless a complete survey of the whole country ought to be made in order to call to our attention the various and sundry sins of omission and commission which we are permitting to continue, largely without realizing their harmful effects on the service which our patients receive.

A brief enumeration of a few of these abuses will illustrate what is meant. The following quotations extracted from resolutions adopted by the Board of Trustees of the American Medical Association, after they had been accepted by the American Hospital Association and other national bodies, state the ideals of organized medicine: <sup>1</sup>

A qualified medical specialist in anesthesia is entitled to recognition as a professional member of the medical staff and as head of a hospital department.

Neither the hospital nor the anesthetist should exploit the patient or each other.

and yet widespread disregard of these precepts is common. A well organized and adequately staffed department of anesthesia is the exception rather than the rule in our hospitals. The administration of such departments as do exist is too often dominated by hospital executives or others whose vision of the ideal is blurred by a desire to avoid entries on the debit side of the ledger. The employer of a physician well trained in anesthesiology, on a restricted salary and with an inadequate number and quality of assistants, exploits that physician. If the employer collects as anesthetic fees from patients more than is spent to provide service in anesthesia, the public is exploited. No less blameworthy is the physician who, although a competent anesthesiologist, hires inexperienced, untrained physicians or technicians at inadequate salaries so that he may appear to serve more private patients—and collect more fees.

The patient's "fear of an anesthetic" is proverbial. Perhaps the contempt bred of familiarity which dominates the attitude of those of us who work in operating rooms is more illogical than the patient's fear. The needs of many modern surgical operations demand that the patient be carried much nearer to a fatal dose of drugs than does any other branch of therapeutics. Cases are not rare when diagnostic acumen and swift change in the plan of management are matters of "life and death." But care of the patient during operation is only one of many services to patients, surgeons and hospitals which may be considered a part of anesthesiology. The public wants the best service obtainable and for that it has always been willing to pay. If present abuses and injustices can be eliminated, even now patients pay enough to secure much pleasanter and safer service than they are getting. The best would be willingly purchased. What we need for the future is to determine how best to organize the service of anesthesiology in the hospital and in the medical school.

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1. Anesthesia Service in Hospitals, J. A. M. A. **114**:1260 (March 30) 1940.

## COSTS

In line with practice common in the other surgical specialties, the professional anesthetist has, in the long past, collected his income directly from his patients. Since the fees of the surgeon were very large in comparison with those of the anesthetist, the latter found it necessary to administer many more anesthetics than the surgeon had to perform operations in order to acquire a satisfactory income. Under these circumstances every minute of his working hours has to be arranged very carefully if his many small fees are to equal one or two of those received by the surgeon. The burden of "free" cases and extremely long operations may fall with considerable injustice on the anesthesiologist. With increasing duties outside the operating room which the practice of anesthesiology now implies, various plans are being tried for equitable distribution of the funds collected. Full time and part time salaries, percentages based on the work done and skill required, or these combined with private fees are some of the methods in use. Probably no one plan will be found best for all institutions. The important thing is to avoid "exploitation," to be sure that sufficient funds are set aside or collected to pay adequately for good service in anesthesiology and then to guarantee that such funds be used to provide such service and for no other purpose.

## ORGANIZATION

The accompanying diagram is an outline of service in anesthesiology which may be split apart to apply to various types of institutions. The word "salaries" in the figure had better be read "remuneration" since, where private cases predominate, the fees collected directly may constitute the whole or a part of the source of income. In any case the organization of a real "department of anesthesiology" is desirable in order to provide unity of effort and efficient twenty-four hour service in whatever meaning the word is taken to imply in a given hospital. Whether intravenous therapy, inhalation therapy, block anesthesia for diagnosis and therapeutic purposes, the care of acute pulmonary difficulties or other services are included is a matter for decision by each hospital staff. Responsibilities will be assumed as individual skills and interests develop.

The diagram includes both hospital and medical school relations because organizations in a majority of our medical schools are as yet in the gestation period. Certain mistakes have been made in starting new departments. The most common, in hospitals as well as in the university hospital-medical school setup, is the

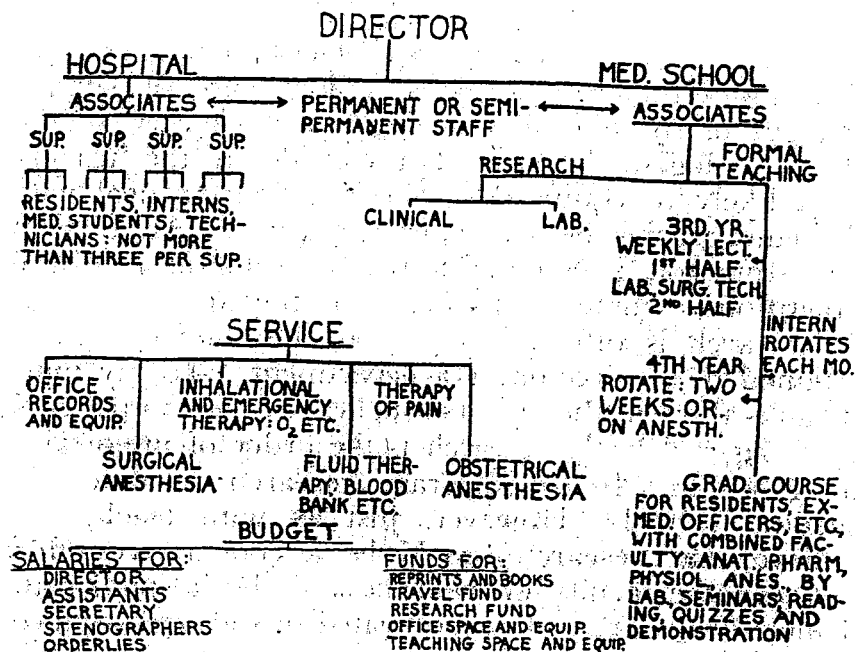
misconception that a single experienced and capable individual can constitute a department of anesthesiology and can care for the multifarious duties in even a small hospital. The diagram at the upper left emphasizes the fact that service, even in the operating room, requires at least one competent supervisor for each three operating teams if safe practice is to be maintained.

In institutions where the geographic spread of operating rooms is wide or where the incidence of serious operations is great, maximum safety may demand an experienced and competent anesthetist for each operating team. A single person may of necessity be asked to initiate the organization of a department. However, unless sufficiently competent associates can be added shortly, the individual's health will suffer and the service will fail. One individual cannot be in several places at one time. A "department" implies sufficient personnel, not a single individual trying to teach a large group of neophytes or to supervise a similar number of technicians.

#### TEACHING

Modern hospitals are medical teaching centers, good or bad, whether they wish it or not. If we in medical schools who have contact with undergraduate medical students did our full duty, interns and residents would come to the hospital well founded in the basic knowledge necessary for clinical teaching of anesthesiology. Since we still fall short of that goal, a brief intensive course to cover the basic need is contemplated in some schools, as is indicated at the lower right of the diagram. Such courses, given in medical schools, may be combined with residencies in hospitals where clinical material, clinical teaching and capable supervision are available but a faculty team in a medical school is not possible. Experience has taught that, however excellent the instruction in anatomy, physiology, pharmacology and biochemistry in the regular curriculum, these matters need to be reconsidered and emphasized in the light of clinical experience in anesthesiology. Results of such short graduate courses for medical officers during the war support the belief that they may prove very valuable if suitable curriculum and teachers can be arranged.

No less important than graduate teaching is that to which the medical student is exposed. Both must be conducted from the point of view of the hospital, not the laboratory. The sixteen lecture-demonstration-discussion periods shown in the diagram as required of third year students prove to be a minimum of time in which to reinterpret and apply the undergraduate's



Composite diagram of departmental organization. The scope of the effort and the size of the institution will determine the number of individuals needed. Under "Budget," salaries should be understood to mean "remuneration," since private fees may constitute all or a part of the financial support.

previous knowledge of basic science to the problems which he must solve in the hospital. On graduation he ought to have sufficient knowledge of anesthesia to distinguish the good from the bad, and in addition every physician must have a clear concept of the physical as well as the physiologic factors of the respiratory and circulatory systems. Since care of sudden changes in these factors is the hourly concern of the anesthesiologist, he has been considered the teacher most likely to equip the medical student to deal with the emergencies he will later encounter. All this, in my estimation, is essential to the education of a medical practitioner whatever his plans for the future may be.

Research is often looked on as the chief end to be attained by a director or a department. To my mind it ranks third in the objects sought. Service to patients, teaching and lastly research is the order of importance as I see it. In the diagram, research is under the medical school. However, just as with teaching, I believe that research should be a cooperative effort between the faculty of medicine and the hospital staff. If new drugs are to be investigated or old ones studied, the laboratory first, then the operating room should be the order of attack. It is important for the anesthesiologist to be familiar with laboratory customs, language and literature. It is no less important for certain workers in the laboratory to become familiar with the problems of the operating room and the ward. Much wasted effort in unnecessary experimentation

can be avoided by interdepartmental friendship and understanding throughout the medical school and hospital.

#### RELATIONS WITH THE SURGICAL DEPARTMENT

The primary duty of anesthesiology is service in the operating room to the surgeon and to his patients. At the same time every department of the hospital can benefit by the help of the anesthesiologist on certain occasions. Should the department be a subdivision of the department of surgery or should it be a separate entity? In the diagram it is shown in the latter relation because experience has demonstrated that this is the more satisfactory to all concerned. Such independence, however, implies an exceptionally sympathetic attitude toward surgery. Those who take part in a surgical operation should form a "team" in the best sense of the word. The attitude of the anesthesiologist in that team must be one of the utmost cooperation—cooperation even to the point of subservience when subservience is necessary for the best accomplishment of the team. But never subservience beyond that point. The anesthesiologist is the colleague of the surgeon. The patient is best served by their mutual friendship and joint discussion of the problems involved in his care. Young anesthetists and surgeons must be warned against acquiring a critical attitude toward each other. There is ample opportunity for the display of the talents of the anesthetist in anesthesiology and of the surgeon in surgery. The attitude of each toward the other can benefit by previous experience in the general practice of medicine. The precepts exemplified in the golden rule should govern their personal relations. In too many of our hospitals anesthesiology suffers, because of domination by the department of surgery or by the administrative office of the hospital. Patients will receive the best service in a hospital where the personnel deserves and receives the respect of the whole institution.

#### TECHNICAL ASSISTANTS IN ANESTHESIOLOGY

Habit determines the routine of our daily lives. Once we are accustomed to doing a thing in a certain way, that becomes and remains the right way unless we devote some real thought to the matter in reconsideration. Some assistance for the woman in labor was found necessary in very early times. Women and the medical profession accepted the midwife as the usual assistant at parturition. The physician was called in only after the customary practice had failed. It was but little

over a century ago that Dr. Gregory was fined a hundred pounds sterling in the courts of Edinburgh, Scotland, because of a public caning which he had administered to Dr. Hamilton. Gregory was then professor of physic, or what we call internal medicine, at the University of Edinburgh, and Hamilton was the predecessor of Sir J. Y. Simpson in the chair of midwifery. After paying the fine, Gregory is said to have remarked that he would gladly repeat the experience since he could not abide the pretensions of the nonentity who represented on their faculty the despised art of midwifery. The midwife custom prevailed at that time. Anesthesia came to us one hundred years ago. Compared with obstetrics it is in its infancy. Perhaps it is not strange that in many communities it has become a custom in our country to hold nurses responsible as technicians in anesthesia. Is this right or is it wrong? If we employ nurses or other nonmedical persons as technicians only, as assistants in the care and preparation of equipment, in supervising depressed patients, and in various other ways where diagnostic and therapeutic decisions are not involved, their services can be valuable. On the other hand it is unfortunate, and I believe definitely wrong, when doctors—whether surgeons or anesthesiologists—find it necessary to serve as a figurehead in assuming responsibility for the acts of technicians which involve decisions of a medical nature, decisions in which they take no part. A modern surgeon's duties require all of his attention during operations. Few anesthesiologists can be expected to maintain intelligent contact with more than 2 or 3 cases at one time. If we saddle nurses with the responsibility of anesthesiology and collect from our patients what amounts to professional fees for their services, pocketing the surplus or allowing them to do so, it constitutes exploitation of the public. If we attempt to teach nurses the science and art of anesthesia, that is also wrong because it exploits the medical students who wish to learn anesthesiology while in school and may wish to practice it after graduation. The student will not take kindly to the sort of instruction which can be superimposed on the preliminary training of a nurse, nor will he look with favor on a specialty which is in competition with those who are not medically trained. The argument is offered that an experienced technician often administers anesthetic drugs better than a physician. Individual comparisons may support such a contention. But similar individual comparisons may be made regarding the performance of minor surgical operations. A demonstration was made in earlier times regard-



ing obstetrics. And yet we now approve of 20 to 30 per cent of the medical student's time, in his last two years, being devoted to instruction in obstetrics and gynecology. Midwives are rare. Rightly, nurses are given a course in obstetric nursing just as they ought to be in anesthetic nursing, but attempts to make anesthesiologists of people without a medical background will delay or prevent the future service which ought to be expected from anesthesiology. New drugs, new technics, the study of older ones, teaching and organization, all must depend on the competence of interested and enthusiastic physicians. Unless they are to be allowed to put in practice their discoveries, unless their specialty receives recognition and respect when it deserves it, interest and enthusiasm will fail. Capable brains will look elsewhere for employment.

#### SUMMARY

The public as a whole is not receiving the best service that anesthesiology is capable of supplying. A reason often cited is that anesthesiologists are not available in sufficient quality or number. This deficiency is due to a variety of abuses which have become common practice in the hospitals of this country. A custom, once established, is accepted indefinitely unless its effects are analyzed periodically. The present seems an auspicious time for us to devote some intensive consideration to existing abuses of and by anesthesiology with a view to improving the care of patients. Proper education of undergraduate and graduate students in our medical schools and hospitals is one method leading to improvement. Another is through the organization of departments of anesthesiology in medical schools and hospitals.

There is danger of the "vicious circle" type of influence on progress. To force nurses to assume the practice of anesthesiology interferes with proper teaching of medical students and young doctors. These in turn begin practice with inadequate knowledge of anesthesiology. As "authorities" in the profession, they later will accept inadequate service as satisfactory and withhold economic and professional recognition of anesthesiologists. Young doctors will hesitate to come to an unrecognized specialty. With fewer physicians, more anesthetic nurses will be required. The ultimate

result might become a technical nonscientific service in anesthesia with no one in the medical profession competent to criticize it.

Abuses and undesirable customs of practice have crept upon us. In many instances this has occurred without those who are responsible being aware of the far reaching effects. The imminent return of many hundred medical officers whose interest in anesthesiology has been stimulated by the exigencies of military service creates an auspicious time to correct our mistakes.

# ***SAFETY***

## ACCIDENTS DURING ANESTHESIA.\*

R. M. WATERS, M.D.,

SIoux CITY, Iowa.

Unfortunately, instruction in the art of anesthesia has been so neglected in the past that most persons who attempt it as a specialty have been under the necessity of acting, to a large extent, as their own teachers. Portions of the literature of anesthesia that have been found most instructive to me have been the *very* occasional case reports of accidents occurring during administration. It is my purpose then today to report to you five fatal accidents, during a practice of the specialty covering eight years, with their lessons. At some future date I shall beg the privilege of reporting a series of non-fatal accidents of a serious nature occurring during the same period. If in so doing, a repetition of my errors, by some one else, may be prevented I shall deem myself well repaid.

### LACK OF PROPER MORTALITY STATISTICS.

I had hoped to present you with really scientific statistics as an introduction but such data I find more than difficult to obtain. A scattering few reports of 35,000 and 50,000 administrations without a death, and mention in some text books that the death rate from chloroform is 1 in 3,000, ether 1 in 10,000 and nitrous oxid-oxygen 1 in 100,000 is the best obtainable. The Military Medical reports for the past three years are not yet available, I am sorry to say.

Several years ago Dr. M. Salzer, of Cincinnati, collected Coroner's and hospital statistics on anesthetic mortality within a radius of 200 miles. From those that would supply data it was found that deaths under anesthesia averaged between one in four to six hundred administrations. More recently Dr. Stewart, of the same city, has compiled statistics of 10,700 operations, for removal of tonsils and adenoids, in the same territory, and found that 20 deaths had occurred in the series, or one death in less than six hundred administrations.

Sir A. L. Fleming, speaking to the Section on Anesthetics of the Royal Society of Medicine in London, reports 700 deaths occurring during or immediately following anesthesia, in three years, but his data again was gleaned from Coroner's reports in the daily papers, for want of better material. I quote from his report a paragraph with which I most heartily agree.

*"It seems a great pity that we cannot devise some method by means of which we might obtain full and accurate account of all instances where an anesthetic kills, helps to kill, or threatens to kill.*

\*Read before the American Association of Anesthetists, during the Eighth Annual Meeting, Hotel Grunewald, New Orleans, April 26-27, 1920.

*One naturally wonders whether this Section could not do something in the direction of inducing anesthetists to report their difficult cases so that we might have the advantage of their experience. As an illustration of the incompleteness of many of the reports, we find that in only 542 of the 700 cases included in the review is mention made of the nature of the anesthetic employed. The first point which attracts our attention is the number of fatalities occurring, with melancholy regularity in different parts of the country (England)."*

### THE EXPERT AND THE GREATER PERCENTAGE OF HAZARDOUS RISKS.

The routine administration of anesthesia over a goodly portion of the United States today is done by internes, nurses and office assistants which forces, to a large extent, the occasional doubtful case to the door of the specialist in this line. His percentage of poor results may therefore be great. But is that an excuse for his not reporting his misfortunes if for no other purpose than that of their instructive value?

During the eight years of my experience, administrations have totaled approximately 7,200. This includes some eight or nine hundred administrations during hospital internships. *The 5,000 administrations during the last five years have included a goodly number of cases referred to me because doubt was probably present as to the advisability of using the routine anesthetist ordinarily employed. Nearly all during the last five years included the use of oxygen with nitrous oxid or ether or both.*

### CASE REPORTS.

CASE I. (March, 1914). A boy eight years old under osteopathic treatment for general peritonitis during the previous three weeks. Abdomen tense with pus and patient in extremis. Nitrous oxid was administered with a small percentage of oxygen and incision made. The pus shot into the air and he was dead. The whole procedure was over too quickly to make observations. *The case is almost devoid of teaching value except that the possibility of saturating this child with oxygen first and gradually introducing small percentages of either nitrous oxid or ether might have bettered the result.*

CASE 2. (May, 1916). Mrs. C. Age 61, weight 250 lbs, deeply jaundiced and septic. Diagnosis, stone in the common duct of the bile tract. Delay and administration of sedative drugs before administering nitrous oxid and oxygen was advised against by the internist consultant as also was suggestion of ether as a possible choice. Nitrous oxid and oxygen induction was then attempted, using a small percentage of oxygen. At the beginning of the operation the pupils dilated, then the respira-

tion ceased and lastly the pulse. Pure oxygen was not available immediately and under pressure enough to inflate the lungs due to the type of apparatus then in use.

**DEDUCTIONS—First:** An anesthetist must use his own judgment as to drugs and method of administration. He alone should know what drug or drugs he can the most wisely use in a given case.

**Second:** His judgment should include an ability and equipment to recognize a toxic myocarditis when present and a knowledge as an anesthetist that very high percentages of oxygen are required with either nitrous oxid or ether in a case of toxic myocarditis. A sphygmomanometer is essential in his equipment.

**Third:** He should at no time administer nitrous oxid-oxygen when pure oxygen direct to the patient's lungs is not available instantly.

**Fourth:** Until he is familiar with all the physical signs by which an anesthetized patient's condition is judged, namely pupil reactions, signs of the extrinsic muscles of the eyeball (Guedel) together with respiration, pulse and systolic and diastolic blood pressure observations, as well as color he will do much better to select ether rather than nitrous oxid as the agent of choice in deeply jaundiced persons and those of the dark skinned races.

**CASE 3.** (December, 1916). Mrs. H. D. Age 31, weight, 125 lbs., sick five days, pulse over 150 and arhythmic three days previous. Diagnosis, pus tube ruptured or ruptured ectopic pregnancy. Patient suffering moderate air hunger for six to eight hours. Slight cardiac dilatation to right. Pulse 150, arhythmic and irregular. Systolic blood pressure 118, diastolic 80. Pain in left chest radiating to center for past six to eight hours. It was later learned that a diagnosis of myocarditis had been made and ice bags ordered for chest three days previously by another physician and refused, as was operation at that time. Morphine sulphate gr. 1/8 and scopolamine gr. 1/150 were administered hypodermically and one-half hour later nitrous oxid-oxygen induction was begun, again with a small percentage of oxygen. Pupils dilated during first few breaths. Respiration stopped almost with dilatation and pulse last. Pure oxygen under pressure was not immediately available.

**DEDUCTION—First:** Weight was here placed on a nearly normal blood pressure reading without due concern for the other factors involved. A normal pulse pressure with a very rapid heart rate leaves no reserve of a possible increased rate when needed.

**Second:** As in Case 2 scant oxygen was administered in a case of toxic myocarditis when a large excess of oxygen was needed by the patient. Ether instead of nitrous oxid might have been wisely added to the oxygen.

**Third:** Again pure oxygen was not instantly available with which to inflate the lungs when normal respiration ceased.

**CASE 4.** (November, 1917). Baby, one year and ten months of age. Blue baby at birth, otherwise normal. No heart lesion demonstrable. Diagnosis, Naevus of the scalp. Anesthesia induced with nitrous oxid and oxygen and continued with ether and pure oxygen, using an adult mask and slightly negative pressure, requiring slight inspiratory effort to maintain flow of oxygen through ether. During fifteen minutes consumed by the operation, the pupils were normal but pulse gradually decreased in rate. At this time ether was shut off and pure oxygen continued, pulse rate still decreasing. Voluntary respiration stopped twenty-five minutes after anesthesia began and was continued artificially with pure oxygen under pressure. Heart stopped thirty-five minutes after anesthesia began.

**DEDUCTIONS—First:** The most likely explanation of anesthetic death in a child, over-dose of the drug, would seem to be ruled out by the contracted pupils. However, we know that a child's pupils often fail to contract after the second stage of anesthesia and remain dilated while in apparent perfect surgical anesthesia. Conversely, they possibly may fail to dilate when entering the fourth stage.

**Second:** Probably this baby was asked to make some effort at inspiration in order to keep up the flow of oxygen. Could this have been a factor? My present habit is to use some excess pressure, that the inhalation may be free, when anesthetizing children with an apparatus of this sort.

**Third:** An adult mask with outlet valve in the top was used which may have been too large for the tidal air of the child patient, thus causing it to accumulate an extreme excess of carbon dioxide and not getting the fresh mixture at all. This case comes nearer convincing me that death can occur from the administration of an anesthetic *per se*, without the added factor of poor technic, than any other with which I am familiar. I am at a loss to explain the accident satisfactorily.

**CASE 5.** (November, 1918). J. R. Age 37, weight 145 lbs. Healthy male. Operation preparation of dental cavities. Patient extremely apprehensive and worried because of cavity preparations extending over previous days and refused to continue work without anesthesia.

Nitrous oxid and oxygen anesthesia was induced with ease; pulse, reflexes and color remaining excellent during fifteen minutes. More than ten per cent. oxygen was mixed with the nitrous oxid. The position used was a semi-reclining one in the chair. With the advent of signs of vomiting nitrous

oxid was increased but vomiting occurred. Position of the chair was quickly changed to one in which the trunk is past a right angle with the thighs, and head forward, the color becoming increasingly cyanotic during this time and the pupils dilated. Respiratory efforts using accessory muscles of respiration were noticeable at this time. Semi-solid vomitus presented from the mouth. A finger in the mouth removed more stomach contents; the throat felt clear. However, attempt at inflation of lungs with pure oxygen through a face mask failed; another exploration of throat with curved forceps and finger removed a particle of meat from the glottis of a size to perfectly fit that cavity. Further inflation of lungs with pure oxygen was easy. The pulse at this time was rapid and weak. Artificial respiration with oxygen was continued over an hour without effect except that the cyanosis was replaced by pallor. This patient had eaten his noon-day lunch three and a half hours previous to the induction of anesthesia.

Autopsy showed a normal heart and other organs but lungs more or less completely contaminated by semi-liquid vomitus both in the bronchi and smaller divisions to the alveoli.

DEDUCTIONS—*First*: An individual, when under mental stress may have his digestive processes slowed to a considerable extent. I have since seen a patient with normal digestion who retained food eaten twenty-four hours previous to operation.

*Second*: The semi-reclining position, ordinarily desired for dental work, is a dangerous one in which to administer anesthesia. The possibility of inhaled vomitus and respiratory obstruction is a real danger. Safe positions during anesthesia are necessary even at the inconvenience of the operator.

#### CONCLUSIONS.

A. F. Stotts of Galesburg, Ill., speaking before the American Association of Railway Surgeons, October, 1911, said: "*The three most important factors concerned in anesthetic mortality rate, in their order of importance, would seem to be the anesthetist, the patient and the anesthetic agent; and we might also say that these same three factors in their order of enumeration are the most properly concerned in the safety of any anesthetic administration. By far the most important essential in the safety of the anesthetic is that it be administered by an expert.*" I think he is right.

I believe that the witnessing of these accidents has helped me to avoid similar ones since; and I hope by that much have I gained in my struggle to become an expert in the art of anesthesia. If, by reporting them in such detail as was possible, any-

one can be helped along the road which I am traveling I shall be very happy. The time is approaching when more adequate instruction may be had in the science of anesthesia. In the meantime reports of our failures and accidents I believe worth while.

In conclusion an anesthetist must *first* be able to estimate himself, the strong and the weak points of his ability. He must not attempt the impossible. He must have the initiative to use his own judgment in preference to that of a specialist in another field.

*Second*, he must be able to estimate his patient, to recognize myocarditis and a weakened circulatory system and treat it as it deserves.

*Third*, he must have at his command a series or combination of drugs with which he is thoroughly familiar together with proper apparatus for getting them to his patient at the right time. This will include (a) a knowledge of the value of oxygen when added to all inhalation anesthetic agents and the mechanical means to properly administer it in proper dose at the proper time; (b) a knowledge that it is poor judgment to hurry nitrous oxid-oxygen induction at any time and especially so in a case of weakened circulatory muscle. Let him remember that such a patient has a tendency to dyspnoea in bed and will be comforted by pure oxygen and anesthetized while still taking high percentages of that gas; (3) a knowledge of the folly of attempting muscular relaxation with nitrous oxid and oxygen alone without preoperative administrations of sedative and relaxing drugs or the addition of ether to his mixture; (d) and lastly, it will include a careful attention to preoperative preparation and position of his patient during operation if these factors are to add or subtract from the patient's risk.

525 FRANCES BUILDING.

RALPH M. WATERS, M.D.,  
SIOUX CITY, IOWA.

Not coveting the reputation of *official crape hanger* among the anesthetists of North America I regret presenting sheets of sorry results for your consideration; but nevertheless as we read the program of this meeting there appears so much of good cheer and happy reports from the other anesthetists that perhaps the gloom cast by my efforts will be quickly dispelled by the whirlwind of success and sunshine which is to follow.

*Every case which we are asked to anesthetize should, without fail, on every occasion be subjected to the following inquiry:*

1. The last intake of food and its nature if recent.
2. The condition of the lungs and the heart, especially as to history and inspection.
3. Condition of the nose, of the mouth and of the throat (teeth, tonsils and respiratory obstructions).
4. The mental attitude and the stability of the central nervous system.
5. The general physical resistance as related to operation to be undergone, including, in all doubtful cases, careful observations of circulatory system reserve before and during anesthesia.

Failure to make such an inquiry or to judicially consider its results has made necessary the relating of the following seven case histories as well as five other more serious accidents previously reported, (*American Journal of Surgery, Anesthesia Supplement*, July, 1920, Vol. xxxiv, No. 7, p. 76.)

CASE REPORTS—POSTOPERATIVE PNEUMONIA.

CASE 1.—Male, aged 38; clinical diagnosis ruptured duodenal ulcer five hours previous. After the operation a history of pulmonary tuberculosis, only recently arrested, was obtained. He died three days later from pneumonia. He was given a late preoperative sedative and that containing atropin. Extreme rebreathing, respiratory stimulation and ether anesthesia were used when he needed quiet, shallow respiration with no lung irritation. A history or a physical examination would have warned us.

PERITONSILAR ABSCESS.

CASE 2.—Female, aged 27; obese and thick necked; operation left mastoidectomy. A swelling of the left neck was explained by the surgeon as a Bezold's abscess. A metal airway was inserted to relieve respiratory obstruction so commonly encountered in short neck individuals. Some force was required to slip the airway over the tongue. When it was removed the pharyngeal portion was covered with pus. Inspection of the throat showed a rather neat incision in a peritonsillar abscess on the left side. Her pneumonia was of only thirty-six hours duration. A hurried mouth inspection would have saved this woman's life.

\*Presidential Address presented before the Organization Meeting of the Mid-Western Association of Anesthetists in Joint Session with the National Anesthesia Research Society, Hotel Muehlebach, Kansas City, Mo., October 24-26, 1921.

HYSTERICAL BLINDNESS.

CASE 3.—Female, aged 30; operation removal of an impacted third molar tooth. She was thoroughly frightened. The operation required forty-five minutes. When the patient was partially recovered from anesthesia the dentist allowed a sponge coated with blood and mucous to slip back into the glottis, causing temporary respiratory obstruction with deep cyanosis until I removed it by a blow on the patient's back. The husband was present. Fifteen minutes were required before consciousness was completely regained.

After four days of apparently normal convalescence this woman awakened in the night with an attack of vomiting and found difficulty in moving her right arm. The next morning she said she could only distinguish light but that the arm was recovered and it remained so. The partial blindness persists after three years. The diagnosis by a neurologist whom I asked to see her was *hysterical blindness*. An ophthalmologist gives the opinion that "she may have definite pathology along the optic tract somewhere." This result is one of partial blindness after anesthesia which might have been prevented by appreciating the mental disturbance of the patient, sending her to a hospital beforehand and using a sedative drug previous to the anesthesia. Needless to say I have not, since that day allowed a dentist to use a small sponge of the kind then used.

VAGUS TRAUMA.

CASE 4.—Female, aged 15; mental grade 7 to 8. Operation tonsillectomy and adenectomy. Nitrous oxid-oxygen induction followed by ether-air maintenance. At no time were the pupils dilated and a roving eye-ball was present during the latter half of the operation. Ether discontinued one and a half minutes before end of operation. Patient was charged to prone from lateral position in which the operation was done, and moved to the hospital cart. In transferring her to the cart my wrist was under her neck and as the transfer was made her head rolled so that my wrist undoubtedly met the soft parts of the side of her neck rather forcibly. After the transfer she failed to make further respiratory efforts. Peripheral pulse was not palpable. Schaefer manipulations were continued over a period of five minutes before voluntary respiration was resumed. The color had been very bad, a greyish cyanosis. Pure oxygen was given for three or four minutes after recovery during which time the respirations were slow but efficient. No further difficulty presented.

This case was later gone over carefully with the fluoroscope and plates of the chest to check the previous negative physical examination and no abnormalities were found. Your opinions are solicited as to the cause of respiratory and circulatory arrest in this instance, mine being that trauma to the vagus occurred in transferring her from table to cart. We should be extremely cautious and gentle in moving anesthetized persons even when the actual relative position is not to be changed.

CEREBRAL HEMORRHAGE.

CASE 5.—Male, aged 56, operation cystoscopy. Cachectic and anemic. Nitrous oxid-oxygen used without preoperative medication. Withdrawal of the instrument at the end of operation caused strug-

gling, followed immediately by collapse. Pulse disappeared, then pupils dilated and lastly respiration ceased. Immediate heart massage and lung inflation with oxygen under low pressure brought recovery in order of disappearance. The pulse became palpable after two or three minutes; the pupils contracted next and normal respiration was resumed after ten minutes. Oxygen was inhaled for one-half hour with some rebreathing. Six hours later he recovered consciousness. His speech was thick and difficult, face muscles twitching and head turned to right. Lower limbs later proved to be partially paralyzed. This was very likely a cerebral hemorrhage occurring during anesthesia. Whatever occurred I committed several errors in my efforts. *First*, preanesthetic blood pressure observations were not taken. These readings would have been interesting and without doubt useful in showing the wisdom of postponing anesthesia. *Second*, no sedative was ordered, making struggling during induction and recovery more likely. *Third*, the patient was forced out of bed to walk to the operating room instead of being transferred on a cart.

VALUE OF M'KESSON'S RULE FOR SHOCK.

The next two cases illustrate the value of the McKesson rule:—"With a pulse rate of 120 or more, a pulse pressure of 20 millimeters of mercury or less and a systolic pressure of 80 m.m. or less, in a patient, who, at the beginning of operation, had presented normal pressures, frank shock has occurred. If these low pressures are continued without improvement for more than one-half hour, a vicious circle is generally established which, without treatment, will cause the death of the patient within three days."

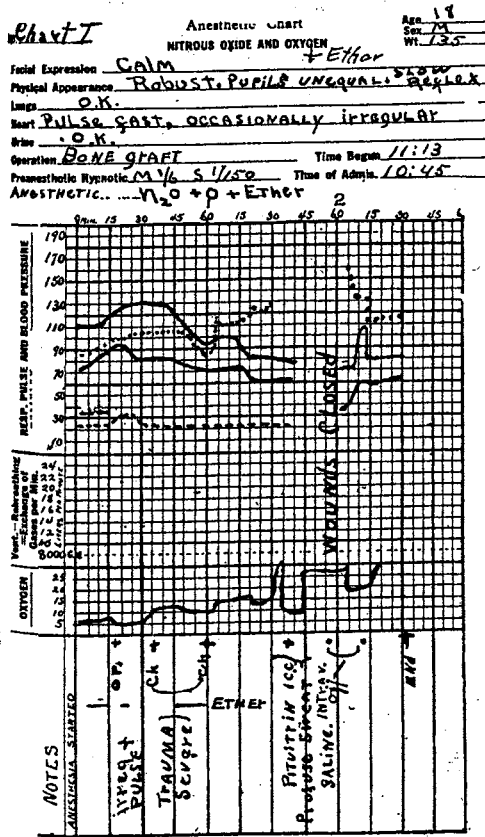
CASE 6.—Male, aged 18; operation bone graft from left tibia to right femur on Hawley fracture table, with extreme extension. The boy was robust

except for an old fractured femur and accompanying suffering. Physical examination was negative except for unequal pupils with sluggish light reflex and a fast pulse, occasionally irregular. Nitrous oxid-oxygen anesthesia was used, supplemented with rather large quantities of ether, thought necessary for relaxation. *Note the development of frank shock allowed to continue over one-half hour without treatment.* No response to 1 cc. of pituitrin (surgical) within fifteen minutes. One quart of normal saline intravenously improved the pressures and pulse rate somewhat. Recovery very stormy demanding extreme treatment for shock repeatedly during ensuing twenty-four hours. Eventual recovery good.

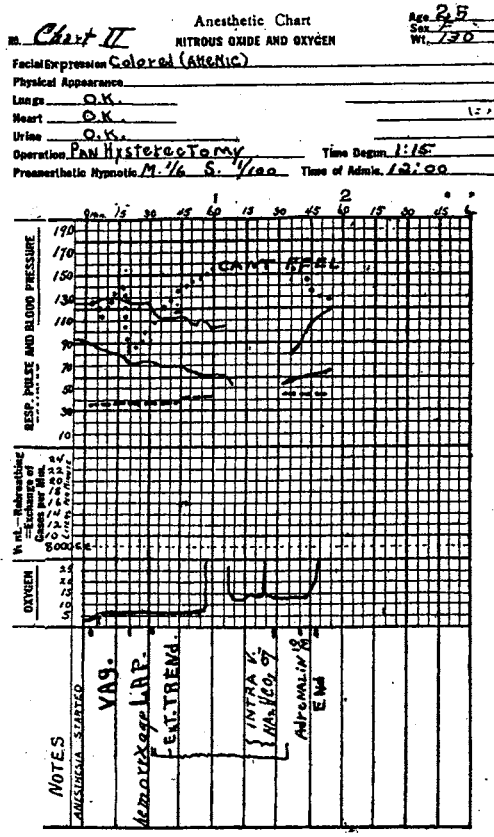
CASE 7.—Female, aged 25. Operation pan-hysterectomy for carcinoma of fundus. Previous severe bleeding with secondary anemia. *Note frank shock not allowed to continue one-half hour without treatment.* Off table without shock and recovery satisfactory without further treatment.

The first chart (Case 6) is that of a healthy boy, handicapped only by previous suffering, who was almost lost through our transgression of McKesson's Rule; while the second chart (Case 7) that of a woman, handicapped by previous long continued hemorrhage and consequent anemia, shows the patient in no danger because of a strict interpretation of the rule.

In conclusion then let us practice using a seeing eye and a hearing ear and digest the facts they bring us with a judicial mind. Proper interpretation of a careful physical examination and data secured during anesthesia is the anesthetist's best insurance against casualties. 107 GILMAN TERRACE.



Ventilation = Tidal Resp. x Rate Resp. Per Minute. Normal = 7-9-liters.



Ventilation = Tidal Resp. x Rate Resp. Per Minute. Normal = 7-9-liters.



# THE MODERN HOSPITAL



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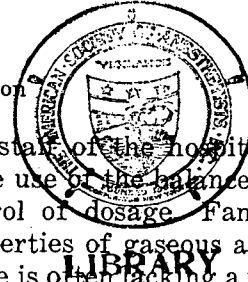
NUMBER 5

## Dangers in the Use of Compressed Gas and How to Avoid Them

By R. C. BUERKI, M.D. **Property of**  
and

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Wisconsin General Hospital, Madison



WE wish to call attention to certain dangers present when gases are used in the conduct of anesthesia and when they are employed for therapeutic purposes. This discussion will omit entirely, however, any consideration of the hazards incurred from fires and explosions when compressed gases are in use. These hazards are believed to be too little understood at present to permit an authoritative consensus that might serve as a satisfactory guide for hospital management. For the present it is suggested that the member of the hospital staff who, according to the requirements of approved hospitals, is held responsible for the conduct of anesthesia in the hospital, also be made responsible for the elimination of danger from fire and explosion. On the other hand, dangers of another sort are present whenever compressed gases are used, and it is these dangers that we shall discuss.

Hazards in the use of compressed gases are not essentially different from the dangers constantly present in the administration of other toxic drugs. The training of doctors and nurses, however, has emphasized a knowledge of potent drugs that exist in the physical form of liquids and solids. The

professional staff of the hospital is usually well trained in the use of the balance and the graduate for the control of dosage. Familiarity with the physical properties of gaseous agents is less common and there is often lacking a proper conception of the control of the dosage of substances administered by inhalation. The fact that the administration of gaseous agents by inhalation for therapeutic purposes is under second to second control should on first thought result in less frequent errors of a serious nature in the choice of drug and dosage. On the other hand, the extreme potency of the few gases in therapeutic use and their rapidity of effect when inhaled make it possible for them to be the cause of many hospital tragedies, unless the professional personnel can be brought to an appreciation of their physical and therapeutic properties and the proper means for their control. Two examples of the result of lack of such knowledge on the part of doctors and nurses may serve to emphasize the point.

A newborn child did not breath spontaneously. The doctor asked for "a carbon dioxide-oxygen mixture." The attendant nurse did not find a cylinder of carbon dioxide-oxygen mixture in the

usual place and ran into the corridor to look for one. She found there a cylinder of pure carbon dioxide, designed for quite another purpose, but noting the carbon dioxide label, she brought the cylinder to the doctor who inflated the lungs of the newborn child, with a fatal result. The doctor was in error as well as the nurse because he carelessly asked for "a carbon dioxide-oxygen mixture." Such mixtures are marketed in proportions varying from 3 per cent carbon dioxide and 97 per cent oxygen to 30 per cent carbon dioxide and 70 per cent oxygen, and one of the mixtures of a higher percentage might also have been fatal. Had the doctor been using a potent solid or liquid drug he would doubtless have checked the label by reading it himself, but because of his lack of familiarity with the gaseous preparation, he did not use ordinary care. A mere whiff of the gas into his own nostrils would have revealed the error.

#### *A Fatal Error*

In another case a gas-oxygen anesthesia was begun with an apparatus carrying one control valve for oxygen delivery but with two yokes, so that a reserve tank of oxygen might be always available. The previous day, a tank of pure carbon dioxide had been placed in one of these oxygen yokes and had not been removed. Since the tops of the two tanks looked exactly alike, they were both supposed by the anesthetist to contain oxygen. Being familiar with the properties of compressed gases, he realized that by opening the cylinder valves wide while the control valve was closed he could cause a flow of oxygen from the full tank of oxygen to the one partially full. Such a procedure would result in an equal division of the total supply of oxygen in the apparatus. Then by closing one cylinder and using the other, he would have early warning of need for a fresh supply. The maneuver was therefore performed.

Since the unrecognized cylinder of carbon dioxide was nearly full and under high pressure whereas the supply of the oxygen cylinder was nearly exhausted, the resulting mixture in both tanks was one of high carbon dioxide content. After one cylinder valve was closed, the oxygen control valve and the nitrous oxide were turned on and anesthesia was induced. The extreme hyperpnea which developed was treated with more "oxygen." Sufficient concentration of carbon dioxide to produce respiratory depression was then reached, and no further clinical evidence of physiologic carbon dioxide effect was manifest. After the undertaker's visit, the pure carbon dioxide cylinder was discovered on a yoke designed to carry a reserve oxygen cylinder.

Mistakes similar to these and others are occur-

ring regularly in our hospitals. Examples could be cited indefinitely of mistakes in identity and unintentional mixing of all the compressed gases in common use. Such errors are exactly comparable to the administration of morphine sulphate when atropine sulphate is intended, or to the administration of morphine sulphate, grams 0.650, when grams 0.065 is intended. The factor of human fallibility or temporary mental lapses in the professional staff of the hospital will probably continue to cause accidents and fatalities from the use of gaseous drugs. Until the training of nurses and physicians includes a complete familiarity with the physical and pharmacologic qualities of compressed gases, accidents are more apt to occur with the less familiar agents. How can the hospital help to safeguard its staff from such tragedies?

The causes of accidents with compressed gases may be divided into five general classes: (1) carelessness in manufacture and in testing at the factory; (2) inconspicuous or confusing labels and painting of cylinders; (3) mechanical connections that permit unappreciated flow from sources of higher pressure to points of lower pressure, resulting later in the use of unidentified and dangerous mixtures; (4) hurried assembly of cylinders and apparatus in emergency cases and their use in dark rooms; (5) ignorance or heedlessness on the part of the hospital personnel allowed to handle and administer compressed gases.

Difficulties of the first class have been almost completely overcome by the manufacturers themselves. Toxic impurities are now almost unheard of in therapeutic gases manufactured by reputable firms. Some factories claim to make tests of each cylinder before shipment. Nevertheless, the frequent examination of samples of therapeutic gases taken from jobbers and hospital supplies is highly desirable. The Government now renders such a service covering liquid anesthetic agents. Such service should cover compressed gases used medicinally.

#### *Labeling and Painting the Cylinders*

The lack of uniformity in labeling and painting the cylinders is still a possible source of error in identifying compressed gases. There are still present in some hospitals in North America cylinders of oxygen painted red, while in others only ethylene cylinders are painted red. It is to be hoped that mixed supplies from the two sources do not come together in one hospital. Some manufacturers, in the interest of neat appearance, have painted all their medicinal gas cylinders a uniform neutral color with only a small portion colored to signify the identity of the contents. Labels likewise are in many cases uniform for different gases, the

identity of the contents of cylinders being indicated on the label only by writing in the name on a blank space on the label. This is particularly true of oxygen and carbon dioxide mixtures. Carbon dioxide is an extremely potent drug, capable of causing death in some patients by a few inhalations. It is probable that more care shown by the manufacturers in providing uniform and conspicuous labeling might help to prevent accidents.

#### *A Dangerous Type of Apparatus*

Mechanical connections that permit flow from sources of higher pressure to points of lower pressure, resulting in the use of unidentified and dangerous mixtures, often are not considered dangerous. If a bottle of tincture of digitalis and a bottle of laudanum stand side by side on the drug room shelf, they are safe from mixing even if the stopper of each bottle is removed. With gases under pressure, however, the conditions are entirely different. The accompanying diagram is a rough representation of a compressed gas control valve with two yokes, one conducting from compressed gas cylinder A and one from cylinder A'. Such an arrangement is designed by the apparatus manufacturer to permit a reserve cylinder A' of a given gas to be always connected and available when cylinder A is exhausted.

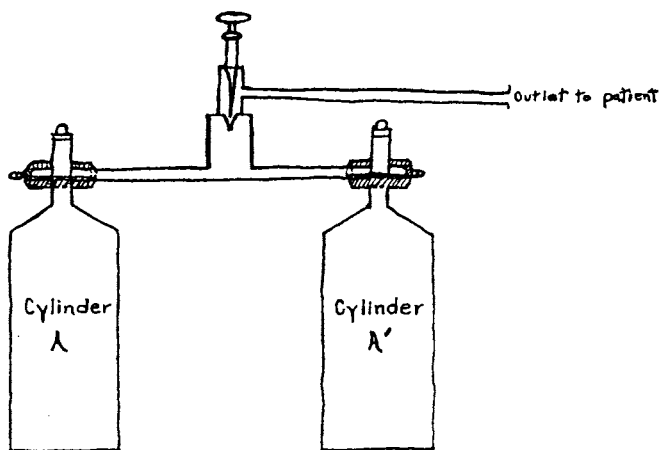
When only two gases were used in medicine, nitrous oxide and oxygen, apparatus manufacturers provided one delivery control for each gas and there was no likelihood of a doctor or a nurse wishing to attach gases of different identity in the positions of A and A'. As more gases have come into use the temptation to continue the use of the old apparatus, which connects a cylinder in the yoke provided for A' (a reserve stock identical with A), has persisted and a gas of a new identity B often has been placed in the position of A'. With cylinders of compressed gases A and B so connected, a mere failure to close tightly the cylinder valves (comparable to the cork being loose in adjacent bottles of laudanum and tincture of digitalis) will permit a flow of gas B into cylinder A, or vice versa, depending on which gas is under the greater pressure. If cylinder B is full and cylinder A nearly empty, the result of opening both cylinders will be that cylinder A will then contain a high percentage of gas B. This is what happened in the incident cited earlier in the article when oxygen was gas A and carbon dioxide was gas B. Carbon dioxide was then given to the patient under the mistaken impression of the anesthetist that it was oxygen.

Manufacturers of compressed gas apparatus have kept abreast of developments in the use of newer gases. They have also sent out warnings to

hospitals concerning the dangers in using apparatus of old design. Unfortunately, not all hospitals have seen fit to modify or to replace their old equipment.

The hurried assembly of cylinders and apparatus in emergency cases and under conditions of poor lighting may bring about undesirable results. During the excitement of caring for an emergency case, either for operation or during attempts at resuscitation, cylinders are connected to the apparatus in the wrong position. Inexperienced orderlies, nurses, anesthetists and other members of the staff contribute to such accidents. Hurry and excitement are frequent causes of mistakes. Poor lighting facilities, such as are present in the fluoroscopic room and the room for work in the head specialties, may contribute to accidents.

The mental capacity and attitude of the hospital personnel permitted to handle and administer compressed gases is worthy of serious consideration.



*In this gas control valve with two yokes, though it is designed to permit a reserve supply, the temptation is great to place gas of a new identity in A'. Then a mere failure to close the valves tightly will permit a flow of the new gas into A or vice versa, depending on which gas is under the greater pressure, and the patient may receive the wrong gas.*

The cylinders in which gases are compressed are of necessity very heavy. Pressures in full cylinders range upward to 2,000 pounds per square inch. A strong man is often needed to move these containers. On the other hand, the content of the cylinders is often capable of producing death much more rapidly than any of the drugs in liquid or powder form to be found on the pharmacy shelves. The old saying, "A strong back and a weak mind," is not always true, but certainly the person chosen from the hospital staff to supervise the administration of compressed gases should not be singled out for this duty solely because he can lift the tanks. Some persons of a high degree of intelligence have a defective conception of the elementary principles of physics, and high pressure and low pressure of gases are alike to them. A valve means nothing to them because they cannot see the sub-

stance the valve prevents from flowing. Both professional and lay attendants of such a mental make-up are responsible for many accidents with compressed gases.

There is a growing tendency on the part of both the medical profession and the hospital management to appreciate that anesthetic drugs are extremely toxic and that they demand careful handling and administration. The present recognition of the necessity for one member of the professional staff being held responsible for the anesthetic department is evidence of this tendency. Such a person will solve most of the problems in connection with the use of compressed gases.

#### *Why Careful Inspection Is Necessary*

There is a tendency, however, toward carelessness in the supervision of the use of carbon dioxide as a therapeutic agent. The fact that carbon dioxide is a normal constituent of expired air has tended to mask an appreciation of the possible dangers connected with its use as a therapeutic agent. The opportunities for dangerous or fatal error in the use of carbon dioxide alone or in mixtures with oxygen are quite as great as with the use of other compressed gases. Although manufacturers have been extremely meticulous in the preparation and marketing of compressed gases for medicinal use, we believe an added check in the form of more careful inspection of such gases, including carbon dioxide, would be beneficial.

One of the bureaus of the Government has for some time made a practice of analyzing samples of ether from the open market. Whether an attempt has been made to check in a similar manner the supplies of compressed gases for medicinal use, we do not know. In any case we believe this could be done to advantage and that such an analysis might include inspection of carbon dioxide for medicinal use. Such an inspection could be made to serve as a check on the labeling and the painting of cylinders, which are so important as a prevention of mistakes in the identity of compressed gases.

In the commercial use of compressed gases, mistakes in identity have been avoided to some extent by the use of different thread connections for explosive gases so that it is impossible to connect an explosive gas cylinder to a nonexplosive

gas inlet. A manufacturer of anesthetic and therapeutic gas apparatus makes the following suggestion for the prevention of mistakes in the identity of compressed gases. "Every manufacturer of compressed gases to be used for therapeutic purposes should be required to market his products in cylinders, the valves of which are individual for each gas. The apparatus manufacturer should likewise be required to supply individual yokes or threads. As a result, an attempt to attach a carbon dioxide cylinder to an oxygen inlet or an ethylene cylinder to a nitrous oxide inlet would be physically impossible." This suggestion, if carried out, would undoubtedly eliminate many of the dangers to which our patients are now exposed.

The organization of anesthetists has tried for several years to induce manufacturers to agree to a uniform labeling and painting of medicinal gas cylinders but without success. It is evident, therefore, that before any uniformity of effort can be expected, some Federal agency must be set up, with absolute authority to enforce uniform regulations.

In the meantime, hospitals can best safeguard their patients from the dangers here discussed by making sure that the administration of compressed gases is placed in the hands of intelligent persons. Orderlies entrusted with handling cylinders and apparatus should be chosen for their intelligence and reliability and not for their strength. At least one physician of the professional staff should be held responsible for the instruction and direction of nurses and orderlies who may be required to assemble, clean or otherwise come in contact with compressed gas equipment.

Actual administration of compressed gases, either for the alleviation of pain or for other therapeutic purposes, should be the direct responsibility of a physician just as is the administration of other toxic drugs. The fact that compressed gases require more elaborate apparatus for their control in administration only adds to the seriousness of the responsibility of the person charged with their use. It is unfair for a nurse or an orderly to be held responsible for the handling and administration of compressed gases when the physician devotes his individual attention to the administration of solid and liquid agents.

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### "Explosion Jitters"

THERE was a time when the surgeon was haunted by the fear of wound infection. The novice assistant, the careless nursing staff, or the unreliable catgut manufacturer were thought to harbor the ghost. Today the fear of explosion furnishes a more dramatic substitute. Whereas wound infection stole upon surgeon and patient insidiously, in the still small hours of the night, fire comes upon the operating room scene in the full glare of the "Klieg lights." It has even been known to announce its arrival with the fearful detonation of a bomb. There can be little doubt that the ghost of fire hides among the accoutrements of the anesthetist.

We are accustomed to the use of illuminating gas in our basements and kitchens and of gasoline in our automobiles. We rarely think of the danger involved, and yet the chemical nature of ether, ethylene, or cyclopropane does not create a greatly different hazard. Why should there be extreme apprehension in the operating room and little or none in the kitchen and garage? Three possible reasons may be suggested.

1. Oxygen is mixed with ignitable substances in the operating room and not at home: Apparatus may, therefore, contain or deliver ignitable mixtures.

2. Anesthetic apparatus is moved about, assembled or dismantled either in accommodating itself to the respiratory movements of the patient, or at the convenience of the operator: Hence static electricity of differing potentials may accumulate.

3. Electrically operated instruments or the actual cautery used in the operating room may, especially if defective, constitute a source of ignition.

An ignitable gas or liquid escaping from its container in the pure state must be mixed with adequate oxygen, and vaporized if a liquid, before it will take fire. Extremely dilute mixtures are, in many instances, violently explosive; whereas, higher concentrations may fail to explode or even to burn when exposed to spark or flame. Knowledge of the exact concentrations of a particular substance, which will ignite or explode when mixed with air or artificial atmospheres of higher oxygen tension is of no practical value since, in the process of making and dispersing any gaseous mixture, there may exist, at one time or another, all concentrations of any component. Unless oxygen is needed for physiologic reasons (those recognized as indications for oxygen therapy outside the operating room) anesthetic atmospheres containing the same tension of oxygen as atmospheric air or slightly higher are more suitable for the patient's welfare and are apt not to produce violently explosive mixtures with any agent.

Atmospheres contaminated by ignitable substances, and containing oxygen or nitrous oxide, should be kept in closed containers without leaks (anesthetic apparatus with carbon-dioxide absorption technique) during the period when electrical apparatus must be used in the vicinity. If open techniques of administration of ignitable anesthetic agents are used, or if leaking containers or pipe lines are suspected, the use of electric equipment had better be prohibited.

Electrostatic charges are prone to accumulate on surfaces subject to movement and friction. If contamination of the contained or surrounding atmosphere is suspected, it is important to bring into intimate contact, by handling, all the component parts of apparatus and these with patient and anesthetist before fresh contact or separation of the component units takes place.

The "housing and grounding" elements in moveable equipment may easily become defective. For this reason, electric equipment in hospitals should be frequently and intelligently inspected and kept in perfect repair.

The surgeon or hospital superintendent should insist upon intelligent supervision of anesthetic administration in his institution. No rules for "safe practice" can replace the minute-to-minute supervision of a responsible anesthetist in the operating room. A "jittery" attitude on the part of others only adds to the hazard.

The danger of explosion may be compared to that from hemorrhage. The operating room mortality rate from blood loss is far in excess of that from explosion. Yet the surgeon, the hospital superintendent, the public press, and the patient do not expect the mortality from hemorrhage to be reduced by sets of rules prepared by committees and posted in the operating room corridors. Deaths from hemorrhage are less frequent as knowledge of anatomy, physiology, and surgical technique is disseminated among surgeons. Likewise fires and explosions in operating rooms will become less frequent as knowledge of physics, chemistry, and technical skill is disseminated among anesthetists.

In the meantime it is well to remember that fire or explosion accidents which injure patients or operating room attendants are rare indeed. When such accidents occur, there would seem to be no more reason for hysterical outbursts in the press and for "jitters forever after" on the part of those concerned, than in the case of a death in the operating room from hemorrhage. By all means, increase our knowledge of the physical and chemical factors involved in the ignition of anesthetic agents. In the meantime let us put the responsibility where it belongs—on the anesthetist. Let us see that his knowledge and skill is the best obtainable, and if he has an accident, let us look upon it as we would upon any slip in technique or diagnosis by surgeon or consultant and stop the development of this new disease "explosion jitters."

—Ralph M. Waters, M.D.  
Madison, Wis.

## CURRENT COMMENT AND CASE REPORTS

CURRENT COMMENT is a new department in ANESTHESIOLOGY. In it will appear invited professional and scientific correspondence, abbreviated reports of interesting cases, material of interest to anesthesiologists reprinted from varied sources, brief descriptions of apparatus and appliances, technical suggestions, and short citations of experiences with drugs and methods in anesthesiology. Contributions are urgently solicited. Editorial discretion is reserved in selecting and preparing those published. The author's name or initials will appear with all items included.

### CASE OF EXPLOSION IN THE OPERATING ROOM

In the hope of avoiding the ignition of anesthetic atmospheres containing ether, ethylene and cyclopropane, certain precautions have been in practice at Wisconsin General Hospital for many years. Although omissions of one or more of these precautions have doubtless occurred many times in the long past, an explosion in the operating rooms had not occurred until this winter.

The precautions which we have depended upon have been:

1. The use of the carbon dioxide absorption technic for all inhalation anesthesia when possible. Limitation of oxygen as a diluent in the closed system, at least during induction, to a tension only sufficient to satisfy physiologic demand.
2. In hazardous circumstances, substitution of nitrous oxide, with or without chloroform added, when the absorption technic cannot be used.
3. The keeping of electric equipment in good repair.
4. Cooperation between the rest of the operating room personnel and the anesthetist so that the latter is always warned before cautery, electric knife, etc., are placed in service.
5. Precautions against ignition by static electricity:
  - a. Deliberate movements and gradual changes.
  - b. Contact with patient and apparatus by the anesthetist before induction; usually accomplished during preliminary survey of pulse and blood pressure and check of apparatus.
  - c. In the assembly and adjustment of parts of apparatus, and their connection with the patient, making sure that the anesthetist holds both of two parts in his own hands before making or breaking contact.
  - d. Avoidance by the anesthetist and attendants of clothing and conduct known to promote static accumulation.

Occasionally the physical condition of a patient or the demands of a particular

operation offer temptation to violate certain of these principles. This case illustrates the possible result of such violations.

#### CASE REPORT

A tuberculous patient was subjected to thoracoplasty. The temperature in Madison that morning was 19 below zero Fahrenheit. The operating room temperature was 77 Fahrenheit, and the relative humidity of the atmosphere was 33 per cent. The resident anesthetist had been asked to wear a face mask, gown and rubber gloves in self-protection against infection. Induction of anesthesia was made with cyclopropane. Pure oxygen, instead of oxygen and air, was employed as a diluent because it was felt that the extent of the pulmonary tuberculosis would not otherwise permit an adequate supply of oxygen. When the need of an artificial pharyngeal airway was evident, the mask, connected to a to-and-fro canister and bag, was slipped up over the nose and forehead. The slip joint between mask and canister was loosely connected and the canister and breathing bag fell to the floor as the mask was being replaced over the airway. As the canister and bag struck the floor, a violent explosion of the remaining cyclopropane and oxygen in the bag took place at floor level. A shredded rubber bag and a frightened operating room personnel were the only unfortunate results, and the anesthetic and operation were completed without further incident.

#### COMMENT

Possibly our extreme fear of infection of anesthetists while handling tuberculous patients is not justifiable. Possibly we were over-conscious of the danger of hypoxia in this patient. Certainly we were using apparatus either in defective condition or too hastily and carelessly assembled before induction (loose slip joint). Certainly we believe that had all the precautions enumerated above been followed, this accident would not have occurred.

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## DEATHS IN THE OPERATING ROOM

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*Madison, Wis.*

IN the ten years from 1933 to 1942 inclusive, fifty-one patients have died in the operating rooms of the Wisconsin General Hospital. During this time the Department of Anesthesia has anesthetized 44,891 patients, and has kept accurate records of each administration and of the postoperative course of the case. This series does not, however, include cases anesthetized by the surgeons for minor surgical procedures, nor those cases in which anesthesia has been induced by other members of the staff for diagnostic or therapeutic purposes. Several deaths have occurred, for instance, after the topical application of a drug to the pharynx or urethra. Since no member of the Department of Anesthesia was present no records of these exist. The purpose of this paper is to analyze the details of the deaths occurring during the administration by anesthetists, and from this point of view, in order to see what lessons may be learned from them.

It is the function of this hospital to act as a center for surgical consultation for the State. Only rarely are emergency operations performed. On the other hand, a large number of major abdominal, thoracic, or cerebral interventions are undertaken in persons debilitated by chronic diseases and old age. If it is felt that, whatever the risk, operation provides the only hope of recovery we do not hesitate to undertake it. The personnel of the Departments of Surgery and Anesthesia includes men of mature experience and judgment as well as younger residents and interns under instruction and students in their clinical years. An effort is made to ensure that patients are treated by persons of a skill appropriate to the technical difficulties of their case.

In some localities the law makes a death on the table the subject of a coroner's inquest. In times past there have therefore been occasions on which, when the patient appeared to be in a state of circulatory collapse, the operation has been completed in haste and the patient has been removed from the operating room before all signs of life were extinct. Not always did this artifice succeed in its object. It seems plain that a patient in such dire straits should be kept quiet and free from any superfluous trauma, while the recognized measures for the support of a failing circulation are applied. This has been our invariable rule: indeed a number of the patients to be discussed have died in the operating room some hours after the completion of the operation. This series therefore includes all the patients who, after operation, did not at least recover either consciousness or the condition in which they were before operation. This definition is necessary because some were in

\* From the Department of Anesthesia, Medical School, University of Wisconsin.

coma, before operation, from circulatory depression, infection, or an increase in intracranial pressure.

In table 1 are condensed the salient facts of these fifty-one cases. In two of them no anesthesia was necessary (Cases 46 and 49), the patients being already unconscious, and a member of the Department of Anesthesia merely administered oxygen, supervised supportive treatment and maintained a clear airway by intubation of the trachea in order to remove secretions. In Case 9 the death occurred during the removal of a cerebral tumor from a patient already in coma; local infiltration was performed by the surgeon. In Case 12 cocaine had been instilled into the urethra by the technician to the Urological Service, and the patient died of a cocaine reaction. We do not propose further to discuss these four cases because the patients were not under the care of our department.

When a patient dies during an operation several factors must be carefully considered in assigning the cause of death. These are: the condition of the patient, the nature of the operation and the skill with which it was performed, the agent and technic of anesthesia, the wisdom and skill with which they were used, and the degree of clinical acumen displayed by surgeon and anesthetist in treating the condition when it was recognized that an emergency had arisen. In the majority of cases a combination of these factors has been responsible for the fatal outcome, and it is impossible to assign the responsibility exactly. In a few cases in this series we feel that death was mainly due to one cause. In the interests of brevity these cases will be considered first.

#### 1. SURGICAL DEATHS

In eight cases (Nos. 4, 27, 28, 29, 32, 38, 43, and 49) death was due to the operation alone, and in our opinion anesthesia played no part in it. Seven were due to massive hemorrhage; one took place at a second operation (suprapubic cystostomy) in a patient already in coma after the bladder had been ruptured during endoscopic resection of the prostate. As anesthetists we feel that we are not entitled to an opinion as to whether or not these deaths could have been avoided, and we do not propose to discuss these cases further.

#### 2. DEATHS DUE TO THE PATIENT'S CONDITION

In our opinion death during operation was due solely to the condition of the patient in Cases 7 and 45.

*Case 7.*—An otherwise healthy youth of 19 was moribund from an increase in intracranial pressure caused by a cerebellar abscess. He was in coma from which he would occasionally rouse to fits of violent excitement. Respiration was depressed and irregular, and no preliminary medication had been given. Induction with cyclopropane and intubation with a cuffed tube were uneventful. Respiration failed some minutes later when the patient was placed in the prone position. The color was poor at that time but a pulse could still be felt. An incision was rapidly made and ventricular puncture performed, but circulation failed as the incision was made. Autopsy showed a large circumscribed abscess of the left cerebellar hemisphere. There was no "pressure collar" in the vicinity of the fourth ventricle.

*Case 45.*—A healthy man of 38 had suffered for years from a chronic gastric ulcer. It had long since been agreed that exploration and probably partial gastrectomy were desirable. The patient, however, was not anxious to undergo an operation. Two months before his admission he suddenly had an attack of pain in the right iliac fossa. A diagnosis of appendicitis was made and the



symptoms subsided on conservative treatment. When eventually exploration was undertaken he seemed in excellent physical condition, save for some hypertension (blood pressure 168 mm. systolic and 102 mm. diastolic). Induction was with cyclopropane and maintenance with ether, both being administered by the "absorption in circuit" technic, a tracheal tube being in place. Deep anesthesia (third plane of third stage) was maintained throughout an operation which lasted for three hours. It was noticed that the pupils appeared more dilated than seemed consistent with the plane of anesthesia and the preliminary medication (morphine, grain  $\frac{1}{6}$ , scopolamine, grain  $\frac{1}{150}$ ). A retroperitoneal appendix was found and removed with some difficulty. Partial gastrectomy was then performed with even greater difficulty since an ulcer on the posterior aspect of the stomach had become firmly fixed to the pancreas. His condition after operation was excellent for 42 hours. Then he was suddenly found to be cold and sweating, his blood pressure could not be obtained and his pulse was rapid and thready. The abdomen was not unduly tender or rigid. Although his color was good, a transfusion of whole blood was given and oxygen therapy was instituted. A divergence of opinion as to the diagnosis prevailed among those in charge of the case. Some felt that his condition was due to hemorrhage; others that it was the result of a peripheral circulatory collapse. Fifty hours after the original operation, the former opinion prevailed and it was decided to reopen the abdomen and search for the source of hemorrhage.

The condition of the patient had altered but little in the previous eight hours. He received no specific preliminary medication, but had had some morphine in the course of the day. When placed on the operating table signs of pulmonary edema were present and his color was bad. Because of a delirious response to painful stimuli as the result of being moved to the operating table, a hurried induction was performed with a mixture of nitrous oxide and cyclopropane and resulted in almost instantaneous death, respiration failing one minute before circulation. At necropsy two large myocardial infarcts were found. One was recent and the other older. It seemed as though the older one might well have been the cause of what at the time was diagnosed as appendicitis. There was also edema of the lungs and an infarct in the right kidney. Although this case is of great clinical interest, it is sufficient to submit here that death was imminent even had the patient not been anesthetized.

TABLE 1

No.	Patient	Age years	Cause*	Operation	Physical status	Anesthesia	Determining complications
1	L. H.	49	4	Mastectomy	3	N <sub>2</sub> O	Hypoxia
2	E. C.	8/12	3	Bronchoscopy; bean at bifurcation	6	Ether	Hypoxia
3	L. N.	12	3	Occipital exploration	3	C <sub>3</sub> H <sub>6</sub> -Ether	Circulatory depression
4	E. R.	38	1	Cervical laminectomy	3	C <sub>3</sub> H <sub>6</sub>	Hemorrhage
5	G. S.	53	4	Dental extraction (not done)	3	C <sub>3</sub> H <sub>6</sub>	Sudden overdose
6	L. F.	46	4	Rhinoplasty (not done)	3	C <sub>3</sub> H <sub>6</sub>	? Fibrillation
7	F. G.	19	2	Drainage of cerebellar abscess (not done)	7	C <sub>3</sub> H <sub>6</sub>	Central failure
8	R. B.	13	3	Removal of cerebellar tumor	4	C <sub>3</sub> H <sub>6</sub>	Hemorrhage
9	H. P.	3	3	Cerebral decompression for subdural hemorrhage	7	Procaine	Central circulatory depression
10	A. H.	50	4	Excision of lip (cautery)	3	Pentothal-N <sub>2</sub> O	Hypoxia
11	J. A.	62	7	Gastric exploration	7	N <sub>2</sub> O-Ether-Procaine	Cardiac failure
12	H. T.	60	4	None (cystoscopy)	2	Cocaine	Cocaine reaction
13	J. C.	36	6	Suture of perforated duodenal ulcer	6	C <sub>3</sub> H <sub>6</sub>	Cardiac failure
14	J. R.	8/12	3	Repair of meningocele	6	Ether	Circulatory failure
15	R. B.	16	4	Lobectomy, second stage	3	C <sub>3</sub> H <sub>6</sub>	Hypoxia
16	S. F.	48	4	Attempted esophageal dilatation	2	C <sub>3</sub> H <sub>6</sub>	Fibrillation
17	P. G.	22	6	Attempted thyroidectomy, tracheotomy	7	C <sub>3</sub> H <sub>6</sub>	Obstruction

TABLE 1 (Continued)

No.	Patient	Age years	Cause*	Operation	Physi- cal status	Anesthesia	Determining complications
18	E. W.	44	4	Dilatation and curettage	2	C <sub>2</sub> H <sub>6</sub>	Overdose
19	A. H.	78	7	Transurethral prostatec- tomy	7	Procaine (spinal)	Circulatory failure (pulmonary throm- bosis)
20	A. M.	42	7	Laminectomy (tumor)	3	N <sub>2</sub> O-Ether	Relative overdose (obstruction)
21	R. H.	24	3	Removal of cerebral tumor	3	C <sub>2</sub> H <sub>6</sub> -Ether	Trauma, hemorrhage
22	M. D.	66	3	Nephrectomy for hyper- nephroma	3	C <sub>2</sub> H <sub>6</sub>	Pulmonary embolism
23	S. P.	26	6	Repair of vaginal walls	2	C <sub>2</sub> H <sub>6</sub>	Cardiac failure
24	E. H.	21	7	Pneumonectomy	3	N <sub>2</sub> O-Ether	Hypoxia
25	N. B.	34	7	Thoracotomy, closure of bronchopleural fistula	4	C <sub>2</sub> H <sub>6</sub>	Hemorrhage into sound lung.
26	C. S.	68	4	Diagnostic spinal	3	Procaine (spinal)	Circulatory failure
27	E. G.	46	1	Pneumonectomy	3	C <sub>2</sub> H <sub>6</sub>	Hemorrhage
28	E. A.	54	1	Removal meningioma	2	Avertin- N <sub>2</sub> O	Hemorrhage
29	R. C.	49	1	Pneumonectomy; vena cava cut	2	C <sub>2</sub> H <sub>6</sub>	Hemorrhage
30	N. M.	5	4	Attempted pneumonectomy —inoperable	3	C <sub>2</sub> H <sub>6</sub> -N <sub>2</sub> O	Obstruction
31	L. L.	74	6	Endoscopic resection of prostate	5	Pentothal	Circulatory failure
32	L. T.	71	1	Thyroidectomy. Inferior thyroid artery cut	3	Procaine (Cerv. block)	Hemorrhage
33	M. B.	35	5	Open reduction of fractured femur	1	C <sub>2</sub> H <sub>6</sub>	Circulatory failure
34	S. A.	5/12	3	Suboccipital exploration (hydrocephalus)	4	Ether	Central respiratory failure
35	C. L.	54	4	Pneumonectomy	3	C <sub>2</sub> H <sub>6</sub>	Circulatory failure
36	R. M.	5/12	3	Drainage of cerebral abscess	3	Ether	Central respiratory failure
37	G. H.	2/12	3	Cerebellar exploration	2	CHCl <sub>3</sub> -N <sub>2</sub> O	Hemorrhage
38	T. C.	59	1	Cerebellar exploration	2	Avertin Procaine	Hemorrhage
39	A. D.	73	6	Cholecystojejunostomy	4	C <sub>2</sub> H <sub>6</sub> -Ether	Circulatory failure
40	W. G.	26	6	Thyroidectomy	3	N <sub>2</sub> O-C <sub>2</sub> H <sub>6</sub>	Circulatory failure
41	E. S.	64	4	Drainage pulmonary abscess	3	Pentothal- N <sub>2</sub> O	Obstruction by cuff
42	S. B.	73	6	Endoscopic resection of prostate	3	Procaine (spinal)	Circulatory failure
43	O. L.	67	1	Esophagectomy; perforation of atrium of heart	3	C <sub>2</sub> H <sub>6</sub>	Hemorrhage
44	A. P.	63	6	For repair of vaginal walls. Died after preliminary medication	3	Nil	Obstruction
45	E. C.	38	2	Exploration of abdomen	7	C <sub>2</sub> H <sub>6</sub> -N <sub>2</sub> O	Myocardial infarction
46	J. S.	8	3	Removal of cerebellar tumor	4	Nil	Central failure
47	E. C.	48	7	Gastrectomy	3	N <sub>2</sub> O-Ether	Relative overdose
48	L. N.	29	6	Colostomy	3	N <sub>2</sub> O-Ether	Relative overdose
49	M. B.	74	1	Suprapubic cystostomy after ruptured bladder	7	Nil	Circulatory failure
50	A. K.	50	6	Dilatation and curettage	4	C <sub>2</sub> H <sub>6</sub>	Coronary occlusion
51	C. O.	41	4	Thoracoplasty	3	Pentothal Nuper- caine (spinal)	Circulatory failure

\* Cause: 1—Death due to operation.

2—Death due to patient's condition

3—Death due to patient's condition and operation.

4—Death due to anesthesia.

5—Death due to anesthesia and operation.

6—Death due to anesthesia and the patient's condition.

7—Death due to anesthesia, the patient's condition and operation.

### 3. DEATHS DUE TO THE EFFECTS OF THE PATIENT'S CONDITION AND THE OPERATION

In our opinion nine deaths during operation were due to these causes, and anesthesia was not responsible. For the sake of brevity, the facts are shown in table 2, and the cases will not be further discussed.

TABLE 2  
DEATHS DUE TO THE PATIENT'S CONDITION AND THE OPERATION

No.	Sex	Age	Operation	Physi- cal status	Anesthesia	Remarks
2	F	8 mo.	Bronchoscopy; attempt to remove bean at bifurcation	6	Open ether	Foreign body became impacted at bifurcation and complete obstruction resulted; left lung atelectatic before operation
3	M	12 yrs.	Occipital exploration for cerebellar tumor	3	C <sub>2</sub> H <sub>6</sub> -Ether-N <sub>2</sub> O. Closed Endotr., abs.	Death from circulatory failure following hemorrhage and trauma
8	M	13 yrs.	Third attempt to remove cerebellar tumor; marked increase in intracranial pressure	4	C <sub>2</sub> H <sub>6</sub> . Closed Endotr., abs.	Uncontrollable hemorrhage; Circulatory failure
14	F	8 mo.	Removal of cervical meningocele	3	Ether	Died suddenly when dressings were being applied
21	M	24 yrs.	Removal of tumor at base of brain	3	C <sub>2</sub> H <sub>6</sub> -Ether. Closed Endotr., abs.	Severe hemorrhage; circulatory failure
22	F	66 yrs.	Nephrectomy for hypernephroma	3	C <sub>2</sub> H <sub>6</sub>	Pulmonary emboli when renal vein was divided; immediate respiratory failure
34	F	5 mo.	Exploration for tumor of fourth ventricle	4	Ether. Endotr.	Central respiratory failure while dressings being applied
36	M	5 mo.	Drainage of multiple abscesses of brain	3	Ether	Central respiratory failure at end of operation
37	M	2 mo.	Suboccipital exploration	3	N <sub>2</sub> O-CHCl <sub>3</sub>	Central respiratory failure

### 4. DEATHS DUE TO ANESTHESIA

In a further twelve cases (Nos. 1, 5, 6, 10, 15, 16, 18, 26, 30, 35, 41, and 51) anesthesia was the cause of death. Although most of the patients were classified as having a physical state of 3 (1) by reason of the disease from which they suffered, there was no reason to anticipate a fatal accident in any of these cases.

Two of the deaths (Nos. 1 and 10) were caused by hypoxia during anesthesia with nitrous oxide. In one case radical mastectomy was to be performed for carcinoma in a bronchitic woman of 49 who weighed 168 pounds. In the other, excision of a carcinoma of the lip was performed in a man of 50 who had some arteriosclerosis and old rheumatic carditis. He received basal narcosis with pentothal and an endotracheal tube was passed. Death occurred when the dressings were being applied. Both patients were anesthetized by anesthetists of comparatively little experience. There seems little doubt that both accidents could have been avoided by a person of greater experience.

Two deaths were due to the injudicious exhibition of spinal analgesia.

*Case 26.*—A patient of 68, with advanced arteriosclerosis and impending gangrene of the feet, died when given spinal analgesia for a diagnostic investigation of changes in temperature of the skin. He also had chronic bronchitis, and was recorded as having a "functional capacity" of III according to the definitions of the American Heart Association. The analgesic consisted of 150 mg. of procaine dissolved in 2 cm. of spinal fluid and injected moderately fast into the third lumbar interspace, with the patient in the lateral position. The patient was turned into the supine position and analgesia was found to be at the level of the tenth dorsal segment. It ascended to the seventh dorsal when the table had been placed in slight Trendelenburg position for a minute, and the table was again leveled. Five minutes had elapsed since the injection when, just as the temperature of the skin was being recorded, the patient complained of "feeling bad" and became slightly restless. The pulse and blood pressure could not be obtained, the level of analgesia had apparently not altered, and since the patient was still breathing spontaneously he was given oxygen. A few moments later respiration became periodic and then ceased. Attempts at resuscitation were unsuccessful. This accident definitely resulted from poor judgment and execution on the part of the anesthetist.

*Case 51.*—A woman of 41 had advanced bilateral phthisis and a vital capacity of less than 60 per cent of normal. She had previously undergone three stages of thoracoplasty, anesthesia being uneventfully conducted with cyclopropane and nitrous oxide. On this occasion it was decided to produce high spinal analgesia with nupercaine for the fourth stage of thoracoplasty. The patient, however, declined to remain conscious and for this reason she was given .25 Gm. of pentothal intravenously in 2.5 per cent solution. Ten cubic centimeters of nupercaine in  $\frac{1}{1500}$  solution was then injected, the patient being in the left lateral position and the table horizontal. This caused a severe fall in blood pressure, for it could not be determined thereafter, although a feeble pulse was counted at a rate of 100. When the uppermost towel-clip was applied to the skin, the patient moved. The junior anesthetist in charge interpreted this as meaning that analgesia was not sufficiently high, and he therefore raised the head of the table ten degrees. Within five minutes pulse and spontaneous respiration ceased simultaneously, and the usual resuscitative measures were of no avail. In all, .4 Gm. of pentothal had been given. This death was due to the misuse of a method unsuitable to the condition of the patient by an anesthetist of insufficient experience. The blame rests with the senior men instructing him, for allowing him to attempt such a method in such a patient.

One patient died as the result of an accident in the course of endotracheal anesthesia using an inflatable cuff.

*Case 41.*—A man of 64 suffered from an abscess of the left lung. It had been drained once before and he now had a bronchocutaneous fistula. He showed slight secondary anemia (hemoglobin 12.1 Gm., erythrocytes 4,030,000), marked leukocytosis (55,000 cu. mm.) and generalized arteriosclerosis. Since the actual cautery was to be used, induction was by means of 1 Gm. of pentothal in 5 per cent solution. An orotracheal tube, carrying an inflatable cuff, was passed, and anesthesia was maintained with nitrous oxide-oxygen by the to and fro absorption technic. When the patient was turned on his side respiration became somewhat shallower. As the operation began, thirty minutes after the induction of anesthesia, it was noticed that respiration was taking place entirely through the fistulous opening. The surgeon therefore packed the opening, and thereafter no ventilation took place in spite of respiratory effort. Nor could the lung be inflated manually from the bag. The patient's color was poor, the pulse was becoming thready, and he was therefore turned into the supine position. The inflatable cuff was then deflated and as soon as this had been done it again became possible to inflate the lungs manually. The circulation, however, failed within fifteen minutes. Necropsy showed "pulmonary effusion, bronchopneumonia and bronchiectasis of the left lung, and purulent bronchiectasis and atelectasis in the right lung." In this case death was probably due to respiratory obstruction caused by a bulging of the inflatable cuff over the end of the endotracheal tube (2).

Seven patients died during anesthesia with cyclopropane (Cases 5, 6, 15, 16, 18, 30 and 35), in our opinion primarily because of anesthesia. In Cases 15 and 30, however, the technic of administration was at fault and not the agent. This may well be true of some of the earlier cases also.

*Case 15.*—A youth of 16 was to have the second stage of a left lower pulmonary lobectomy for bronchiectasis. The first stage had been uneventfully accomplished fourteen days earlier with cyclopropane anesthesia; and the patient was in comparatively good condition before the second operation. His hemoglobin was, however, but 65 per cent of normal and 4,340,000 erythrocytes per cubic millimeter were counted. Induction was performed with cyclopropane and was slow and difficult, a circumstance characteristic of reduced absorptive alveolar surface. Intubation was achieved orally with a catheter of the Hargrave type whose end was molded into a short curve and which carried two inflatable cuffs. It was passed with ease into the right bronchus past the 10½ inch mark. Severe hemorrhage was encountered ten minutes after the operation began and the blood pressure fell abruptly to 70 mm. systolic and 40 mm. diastolic. There was little respiratory exchange and the anesthetist had difficulty in “controlling” respiration. This presently led him to withdraw the endobronchial tube an inch. It was soon evident, from the improvement in respiratory exchange, that the tube had been too deeply placed so that its cuff occluded the eparterial bronchus and caused atelectasis of the right upper lobe. By this time, however, the circulatory depression had already reached a point at which it did not respond to treatment. Death was therefore due to a technical error in the use of the endobronchial technic.

*Case 30.*—A girl of 5 was to have a right pneumonectomy for congenital cystic lung and bronchiectasis. She had slight anemia (hemoglobin 70 per cent, erythrocytes 4,200,000 per cubic millimeter) and the heart was displaced to the right. Partial pneumothorax had been established on the right ten days before the operation. Preliminary medication consisted of morphine grain ¼<sub>12</sub> and scopolamine grain ⅓<sub>300</sub>, given ninety minutes before induction. Smooth, uneventful induction with cyclopropane was followed by intubation with a short, semistiff tube passed by direct vision. Much pus was aspirated through the tube, and some respiratory obstruction occurred during which the pulse rate fell to 40. The left main bronchus was then intubated with a number 4 Magill tube carrying an inflatable cuff. When this was in place, however, respiration became inefficient and the patient's color poor. The tube was then withdrawn into the trachea. For a time ventilation seemed adequate and maintenance was achieved by the semiclosed technic. When the operation began the patient coughed and expelled the tube from her larynx. A number 3 Magill tube without a cuff was then passed into the trachea. At intervals it became obstructed by pus, and it kinked sufficiently to prevent the effective use of suction. As the pleura was opened, circulation suddenly failed and did not recover when artificial ventilation was instituted. Postmortem examination confirmed the diagnosis and showed a small patch of atelectasis and very little pus in the left lung.

This death was due to the effect of the recurrent bouts of hypoxia during anesthesia. The attempt at bronchial intubation was probably ill-advised or poorly executed in this case. It is often difficult to remove viscid secretions adequately through the small tubes appropriate in children. An experienced anesthetist conducted the case, and it is doubtful whether the death could have been avoided.

Five patients died in a manner suggestive of abrupt cardiac failure during anesthesia with cyclopropane.

*Case 18.*—A woman of 44 was to undergo the completion of an inevitable abortion. She had 62 per cent hemoglobin and 4,600,000 erythrocytes per cubic millimeter and her blood pressure was normal. Some physical signs suggestive of early phthisis were found in the left upper lobe and she showed slight enlargement of the thyroid gland. Anesthesia by the to and fro absorption technic

was conducted by a student under the constant supervision of a senior resident, and induction was begun with flows of 5 liters of oxygen and 320 cc. of cyclopropane per minute. When the bag had filled with oxygen the flow was reduced to 300 cc. per minute. Induction was very slow: five minutes elapsed before the third stage was entered. The evidence of a bystander, proffered later, suggests that the color was poor at this time, but the signs were those of the upper half of the first plane. The flow of oxygen was increased to 400 cc. per minute, and the cyclopropane was left running at 320 cc. per minute. Ten minutes after anesthesia was begun, and just as the operation was starting, the blood pressure was normal, the pulse rate was 60 and the respiratory rate was 28. The eyeballs were still moving and the flow of cyclopropane was stopped. Two minutes later respiratory movement suddenly ceased as the cervix was being dilated. The pulse vanished at the same time. Treatment was of no avail. This was a clear case of primary cardiac failure. It seems almost incredible that a relative overdose of the agent could have been administered, but it is possible that some technical error was committed.

*Case 16.*—Cyclopropane anesthesia was administered to a woman of 48 for dilatation of an esophageal stricture. She suffered from postmenopausal psychosis and had attempted to commit suicide by swallowing lye. She had successfully undergone the same treatment for the stricture in each of the previous three weeks; the preliminary medication, agent, technic, and personnel being identical on each occasion. Apart from her mental condition and some secondary anemia (hemoglobin 65 per cent; erythrocytes 3,733,000 per cubic millimeter), she seemed a normal subject. Induction was begun with an excess of oxygen and a flow of 500 cc. per minute of cyclopropane. After one minute the flow of oxygen was reduced to 300 cc. per minute. In three minutes the third stage was entered, and after seven minutes, when the patient showed signs of being in the second plane, the flow of cyclopropane was stopped. Nine minutes from the start of anesthesia the systolic pressure had risen 20 mm. from the preoperative level, the pulse rate was 84 and the patient's condition seemed good. The instruments were not as yet ready and the surgeon, seated next to him, was discussing the patient's condition with the anesthetist. Suddenly the latter felt the pulse vanish beneath his finger, and respiration ceased at the same moment. Efforts to resuscitate were of no avail. The anesthetist was a senior resident of considerable experience. This also seems a clear case of primary cardiac failure.

*Case 35.*—Pneumonectomy was to be performed in a man of 54 for carcinoma of the right upper lobe. The patient was in good general condition, although he had lost fifty-one pounds in four months. He showed slight secondary anemia (hemoglobin 10.8 Gm. per cent; erythrocytes 3,650,000 per cubic millimeter) and was coughing up some mucoid sputum. Induction with cyclopropane-oxygen was uneventful, the only evidence of the second stage being some talking by the patient. After four minutes of anesthesia the blood pressure had risen from 130 mm. to 180 mm. systolic and from 80 mm. to 90 mm. diastolic. The patient appeared to be in the second plane of the third stage, and was exhibiting mild signs of pharyngeal obstruction. The ampul of cyclopropane had run out at this point. A pharyngeal airway was then inserted, the mandible being fully relaxed. As the anesthetist replaced the mask on the face and refilled the bag with oxygen he noticed that pulse and respiration were both absent. All efforts to resuscitate proved vain. At autopsy the heart was found moderately hypertrophied, there was congestion of the liver and spleen, and evidence was found of disseminated sporotrichosis.

*Case 5.*—An extremely fat woman of 55 was to have all her remaining teeth extracted. She had a history of rheumatic carditis and suffered from hypertension, arteriosclerosis and enlargement of the heart. The thyroid gland was also enlarged, but there were no signs of toxicity; and there was marked pulmonary emphysema. She weighed 203 pounds and measured five feet one inch. Eight days earlier she had been successfully anesthetized with ethylene and nitrous oxide, after preliminary medication with morphine, grain  $\frac{1}{4}$ , and scopolamine, grain  $\frac{1}{100}$ , for dilatation and curettage. At that time her blood pressure had been 150 mm. systolic and 100 mm. diastolic. Immediately before

induction for the second operation it was 210 mm. systolic and 100 mm. diastolic; morphine, grain  $\frac{1}{6}$  and scopolamine, grain  $\frac{1}{150}$  had been given ninety minutes before. Induction was begun by allowing 2500 cc. per minute of oxygen and 600 cc. per minute of cyclopropane to flow into a closed system, no canister being in place. Early in induction the flow of cyclopropane was increased to 1200 cc. per minute for fifteen seconds. There was some hyperpnea because of the accumulation of carbon dioxide, and this was succeeded by respiratory depression from the agent. After one and a half minutes, respiration being almost arrested, and with the eyeballs still moving, nasotracheal intubation was performed by direct vision. The cords were seen to be well abducted. The patient did not breathe after intubation and a pulse could not be palpated. Artificial ventilation, by blowing air into the tube, was at once begun, but the color became grey. Saline and glucose solutions were administered intravenously, and coramine and adrenalin were injected into the heart. She was then placed in a mechanical respirator, oxygen being administered through the endotracheal tube, and the intravenous saline being continued. Neither circulation nor respiration recovered. Autopsy revealed a fibrotic and arteriosclerotic heart, chronic passive congestion of liver, spleen, and kidneys, and atelectasis of both lower lobes. In the opinion of the pathologist the latter condition may have been present before anesthesia.

In cases 35 and 5 death was undoubtedly the result of primary cardiac failure. It is interesting to speculate as to whether the stimulus of the airway touching the pharyngeal wall in the first case, and a tube being inserted into the trachea in the second case (3) may have caused a reflex vagal inhibition of the heart.

*Case 6.*—A woman of 46 was to have a fourth plastic operation for the correction of a cicatricial deformity of the face resulting from the previous excision of a carcinoma. She had tertiary syphilis and some aortitis. The first operation was performed with local infiltration with procaine, and consisted of a partial excision of the growth. Five months later a further excision was performed with nitrous oxide-ethylene-ether. In the ensuing year she was given three uneventful narcoses with cyclopropane by the closed endotracheal absorption technic. On the last occasion she was very much afraid of anesthesia. She received morphine, grain  $\frac{1}{8}$ , and scopolamine, grain  $\frac{1}{200}$ , at 6:30 a.m. and induction with cyclopropane was begun at 7:55 a.m. At 8:05 a.m. circulation ceased abruptly and artificial ventilation with oxygen for forty minutes had no effect. The anesthetist, whose experience is wide, remarked at the time that this case resembled death due to ventricular fibrillation more closely than any other he had seen. It occurred in fairly deep anesthesia. At autopsy, myocardial fibrosis and coronary sclerosis were found, and there was some scarring and thickening of the aortic intima. Both lungs showed emphysema and atelectasis.

## 5. DEATH DUE TO THE EFFECTS OF ANESTHESIA AND OPERATION

*Case 33.*—An open reduction of a fracture of the neck of the left femur was undertaken in a woman of 35. Except for the fact that she was unduly fat, her physical condition was good. Anesthesia was uneventfully induced with cyclopropane-oxygen and caused the blood pressure to rise from 160 mm. to 180 mm. systolic and from 100 mm. to 110 mm. diastolic, and the pulse rate to fall from 120 to 86. Some arrhythmia was noticed twenty-three minutes after the start of induction, and twelve minutes after the operation had begun, anesthesia being then of the second plane. Oxygen was added to the contents of the bag and the arrhythmia disappeared. Ten minutes later the pulse suddenly became impalpable and the blood pressure could not be obtained although some oscillations of the mercury were seen at about 60 mm. Spontaneous respiration, however, continued normally for eighteen minutes more. At the time of the circulatory collapse oxygen was substituted for the anesthetic mixture, and when respiration failed, the trachea was intubated and manual ventilation with oxygen

was instituted. Necropsy revealed some atelectasis of the dependent portions of both lower lobes. When histologic sections of the lungs were examined, however, globules of fat were found in the vessels lining the alveoli. It was the pathologist's opinion that the quantity of fat present was, of itself, not sufficient to cause death. He thought it probable that it had nevertheless given rise to sufficient hypoxia to render the myocardium liable to a sudden failure.

#### 6. DEATHS DUE TO THE COMBINED EFFECTS OF ANESTHESIA AND THE PATIENT'S CONDITION

In the interests of brevity these ten cases are shown in tabular form in table 3. Some explanatory notes are, however, necessary.

TABLE 3  
DEATHS DUE TO A COMBINATION OF ANESTHESIA AND THE PATIENT'S CONDITION  
(For operation and determining complications—see Table 1)

Case	Age	Phys. state	Preoperative complications	Anesthesia	Contribution of anesthesia to death
13	36	6	Syphilitic carditis; chronic nephritis; malignant hypertension; signs of cardiac failure 5 hrs. after perforation of duodenal ulcer	C <sub>2</sub> H <sub>6</sub>	Attempt to administer nitrous oxide-ether failed because patient "would not tolerate ether." There may have been some technical ineptitude about the administration.
17	22	7	Carcinoma of thyroid—compression of trachea; almost complete respiratory obstruction	C <sub>2</sub> H <sub>6</sub>	Anesthetist unable to intubate when obstruction became complete after induction. Tracheotomy performed, but too late. Tube also eventually passed too late.
23	26	2	Mild diabetic; extremely obese	C <sub>2</sub> H <sub>6</sub>	Sudden respiratory arrest. Air-oxygen used as diluent by inexperienced anesthetist. Possibly hypoxia or overdose.
31	74	4	Arteriosclerosis; incipient cardiac failure; auricular fibrillation; sarcoma clavicle	Pentothal	There may have been a relative overdose of the agent. Died during operation, twenty minutes after induction.
39	73	4	Carcinoma of head of pancreas; arteriosclerotic cardiac disease; fibrillation; incipient failure; gross debility	C <sub>2</sub> H <sub>6</sub>	Deficient relaxation. High concentration of cyclopropane given; then high concentration of ether added. Probable relative overdose in an attempt to secure relaxation.
40	26	3	Extreme hyperthyroidism from toxic adenoma, otherwise healthy	C <sub>2</sub> H <sub>6</sub>	Attempt to anesthetize with N <sub>2</sub> O for 30 minutes, then cyclopropane used. Death from abrupt circulatory failure after 1½ hrs. There may have been hypoxia in first half hour, or the cyclopropane may have caused circulatory failure.
42	73	3	Advanced arteriosclerosis; functional capacity III; asthma; pleurisy	Procaine (Spinal)	Circulatory failure 5 minutes after spinal given. Poor judgment in choice of method for this patient.
44	63	3	Arteriosclerosis, functional capacity III; diabetes mellitus; asthma	None	Given 2 doses of morphine, grain 1/12 and scopolamine, grain 1/300 one hour apart. Became irrational, acute decompensation developed and patient died.
48	29	3	Rapidly growing carcinoma of colon; previous ileo-transversostomy; now has fungation of growth and profuse secondary deposits	N <sub>2</sub> O-Ether	Induction by closed technic. Rapid addition of ether. Circulatory failure early during operation, probably due to relative overdose.
50	50	4	Gross hypertension; signs of cardiac failure; former cerebral hemorrhage	C <sub>2</sub> H <sub>6</sub>	Recent coronary occlusion found at autopsy. Probably there was a relative overdose of cyclopropane during induction.



*Case 39.*—This patient suffered from advanced carcinoma of the head of the pancreas and was grossly jaundiced. He was also in a state of impending circulatory collapse and showed auricular fibrillation. Anesthesia was attempted with cyclopropane, and at the beginning of operation relaxation of the abdomen was deficient. The gallbladder rest was raised soon after the operation began, and from then on no readings of blood pressure could be obtained. Intubation was performed by the oral route, and ventilation was manually augmented through the tube, a high concentration of cyclopropane being used. The pulse was by now almost imperceptible and the abdomen was still rigid. In an effort to secure relaxation, ether was added to the cyclopropane and manual ventilation was continued. It is difficult to say exactly when circulation ceased, but the patient was probably dead seventeen minutes after the ether was added.

*Case 40.*—This young man was in excellent condition except for the extreme toxicity resulting from an adenoma of the thyroid. He had marked exophthalmos and his metabolic rate had been 172 per cent of normal a few days earlier, but had fallen to 124 per cent before operation. Twenty-two minutes were expended in induction with nitrous oxide, and the operation then lasted eighty minutes. The patient had received morphine, grain  $\frac{1}{4}$ , and scopolamine, grain  $\frac{1}{100}$ , as preliminary medication, and this proved inadequate for maintenance with nitrous oxide. During induction some hypoxia was present. Cyclopropane with an excess of oxygen was used during the remainder of anesthesia, and death occurred as the operation was being completed. The patient suddenly became pale and the pulse disappeared. The blood pressure had shown the rise which is characteristic of thyroidectomies, but in the thirty minutes before death the pulse rate had slowed from 140 to 84. Three reasons may be invoked to explain this case. Patients with marked thyrotoxicosis occasionally exhibit cardiac failure during operation irrespective of the anesthetic. It may be that the hypoxia to which he was subjected during induction gave rise to damage which proved fatal; or the cyclopropane may have precipitated the cardiac failure.

*Case 44.*—The patient was a woman of 63, weighing 148 pounds, and suffering from asthma, arteriosclerosis, hypertension, and diabetes mellitus. She received two doses of morphine, grain  $\frac{1}{12}$ , and scopolamine, grain  $\frac{1}{300}$ : one, two hours and the other, one hour before operation. When brought to the operating room she was irrational and very restless and was restrained by the orderly. At this time her color and pulse were good. Twenty minutes later she suddenly became dusky, her respirations were inaudible and the pulse was faint and irregular. Artificial respiration with oxygen was of no avail. Although autopsy was not performed, it seems clear that this patient died of acute decompensation while waiting for operation. She had been treated with digitalis up to the time of operation. It is possible that a pulmonary or coronary embolus was the cause of death. The preliminary medication, however, was excessive for a patient in her condition.

#### 7. DEATHS DUE TO THE COMBINED EFFECTS OF ANESTHESIA, OPERATION, AND THE CONDITION OF THE PATIENT

The details of these six cases are shown in table 4. We feel that all three factors conspired to provoke the fatal outcome in them. In Case 19 the strain of operation and anesthesia would probably have resulted fatally, irrespective of what method or technic was used. In Cases 24 and 25, although surgical accidents provoked the cause of death, the patients could probably have been saved had appropriate measures been instituted in time by the anesthetist.

#### DISCUSSION

One of us (4) has recently called attention to the fact that death during operation and anesthesia has occurred about once in every 1000 cases in a series of almost 250,000 cases in five teaching hospitals on

TABLE 4  
DEATHS DUE TO A COMBINATION OF ANESTHESIA, THE PATIENT'S CONDITION,  
AND THE OPERATION  
(For operation and determining complications—see Table 1)

No.	Age	Physical state	Preoperative complications	Anesthesia	Remarks
11	62	7	Bleeding from gastrointestinal tract; extreme anemia; mitral stenosis; functional capacity III; hydrothorax	N <sub>2</sub> O-Ether-Procaine	Relative overdose of ether. Procaine superfluous.
19	78	7	Hypertrophy of prostate; arteriosclerosis; emphysema	Procaine (spinal)	Collapsed at end of operation. Pulmonary thrombosis and a fresh thrombus in left ventricle found at necropsy.
20	42	3	Tumor of spinal cord; spastic paralysis	N <sub>2</sub> O-Ether	Patient died towards end of operation. At one point an excessive dose of ether was given and there had been obstruction during induction.
24	21	3	Tumor of right lower bronchus; atelectasis right lower lobe	N <sub>2</sub> O-Ether	Fragment of tumor broke off, was blown into trachea and then aspirated into bronchus of sound side. Death from respiratory obstruction. Endobronchial anesthesia might have saved this patient.
25	34	4	Pulmonary abscess and bronchocutaneous fistula	C <sub>2</sub> H <sub>6</sub>	Hemorrhage into sound lung while attempting to close fistula. Intubation and drainage by suction should have saved the patient.
47	48	3	Bleeding from carcinoma of stomach; secondary anemia; arteriosclerosis	N <sub>2</sub> O-Ether	Relative overdose of ether at the close of operation. Circulatory failure.

three different continents. The present series of 47 deaths in 44,894 administrations means a mean immediate mortality of .104 per cent, whereas the mean mortality of the 227,546 cases quoted in that paper is .12 per cent. In that paper the attitude of an anesthetist towards death on the table is outlined. Stress is laid on the fact that the particular anesthetic agent in use is of less importance than its judicious application. We wish to reaffirm and emphasize this belief here. As a matter of interest, the incidence of deaths during the use of the various agents is shown in table 5. It will be noticed that the incidence of deaths is higher with ether than with cyclopropane, and that the figure for pento-

TABLE 5  
INCIDENCE OF DEATHS DURING OPERATION BY AGENTS

Main agent	Total deaths	Total cases anesthetized	Incidence %
N <sub>2</sub> O.....	3	4,679	0.064
CHCl <sub>3</sub> .....	1	163	.61
C <sub>2</sub> H <sub>6</sub> .....	22	22,063	.0997
Ether.....	12	9,741	.123
Procaine.....	5	4,772	.1047
Nupercaine.....	1	63	1.59
Pentothal.....	2	1,568	.1275

Total cases considered: 43,049.  
Remaining 1,845 with other agents: No deaths.  
Forty-six cases are considered here; one patient received no anesthetic agent.

thal is almost identical to that for ether. Both the latter are higher than the mean of .104 per cent. The figures for nupercaine and chloroform are not significant since too few patients have been anesthetized

with these agents to make the figures comparable. The figure for nitrous oxide deserves the note that this agent is used for almost all cerebral operations and the majority of interventions in desperately ill patients.

The decade under consideration covers the "lifetime" of cyclopropane as an anesthetic agent. It is not our purpose to discuss its safety or utility here. We merely submit that, in our hands, it has proved no more dangerous than other agents.

TABLE 6  
INCIDENCE OF DEATHS DURING OPERATION BY TECHNIC

Technic	Total deaths	Total cases anesthetized	Incidence %
Open.....	2	2,308	0.087
Insufflation.....	3	2,815	.107
Semiclosed.....	2	2,125	.094
Absorption.....	31	30,572	.101
All Inhalation.....	38	37,820	.10
Intravenous.....	2	1,577	.127
Spinal.....	4	2,878	.139
Regional and Infiltration.....	2	1,882	.106

Total cases: 44,157.  
Other technics: 737; no deaths.

Table 6 shows the incidence of deaths during anesthesia according to technics. The figures support our view that the inhalation methods are less conducive to fatal accidents than others; for, with the exception of regional analgesia, the death rate is higher with intravenous and spinal methods.

It should also be mentioned that, in addition to the cases under consideration, three patients have died in the postoperative period for reasons for which the anesthetic was directly to blame. These will be discussed in a separate communication.

#### SUMMARY

Fifty-one patients have died in the operating rooms of the Wisconsin General Hospital during the decade 1933 to 1942 inclusive. During this time the Department of Anesthesia has anesthetized 44,894 patients, of whom 47 died during anesthesia. The causes of death are summarized as follows:

1. Deaths due to operation: 8 cases.
2. Deaths due to the patient's condition: 3 cases.
3. Deaths due to the patient's condition and operation: 10 cases.
4. Deaths due to anesthesia: 13 cases.
5. Death due to anesthesia and operation: 1 case.
6. Deaths due to anesthesia and the patient's condition: 10 cases.
7. Deaths due to all three factors: 6 cases.

The details of these cases are presented and discussed. The incidence of deaths during anesthesia according to agent and technic is given in tabular form.

The majority of these fatalities could have been avoided by the exercise of greater skill or judgment. We believe that these attributes will become more readily available as the number of well-trained and experienced professional anesthetists increases.

#### REFERENCES

1. As defined by the Committee on Records and Statistics of the American Society of Anesthetists. See Saklad, M.: Grading of Patients for Surgical Procedures, *Anesthesiology* 2: 281-284 (May) 1941.
2. Gillespie, N. A.: Endotracheal Anaesthesia, U. of Wisconsin Press, 1941, pp. 78-81.
3. Brace, D. E., and Reid, L. C.: Irritation of the Respiratory Tract and its Reflex Effect upon the Heart, *Surg., Gynec. & Obst.* 70: 157-162 (Feb.) 1940.
4. Gillespie, N. A.: Death during Anaesthesia. In Press. *Brit. J. Anaesth.*, Jan., 1944.

# *RESUSCITATION*

## Artificial Respiration: Comparison of Manual Maneuvers.\*

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THE YEAR is 1774. Imagine yourself an ancestor, struggling back to intelligence, your last memory a nose full of water. As you feel more like yourself, you observe a benign old gentleman. He is responsible for the twinge in your side. He likes a barrel for draping a victim. Gravity and pomeling force water out and air in. You should be thankful that barbed wire fences are not yet invented.

### Then and Now

YOUR HAND WANDERS to your face. The forceps just disappearing into a checked vest pocket has taken two of your best grinders. Cheerfully you would trade two little toes; the stimulation should be as good. As you sit up, you know that future meals off the mantel will emphasize gratitude for rectal stimulation with tobacco smoke. Some advertiser of the day should claim "A lift with old Yardley's plug cut." Finally you discover the shrill noise in the background to be a waspish old lady, a nuisance to all but you. She bedevilled them till they put hot blankets around you and blew in your nose to inflate your chest. How could that which enlivens a blue new born revive an adult?

In one hundred and sixty odd years since the discovery of oxygen and beginning of the Royal Humane Society, we have had much study, some added knowledge, but little real progress. Fads for resuscitation have come and gone. Each sure-fire aid, just the thing, has failed, giving way to another certainly the best of all time.

It didn't take long to discourage rectal insufflation of tobacco smoke, after Brodie (1811) found he could kill animals with rectal infusions.

The bellows and pumps have recurred in a number of forms since Hunter and Goodwyn (1788) found them useful experimentally. Goodwyn's careful work permitted him to experiment on human subjects without danger of injury, but

in practice the victim of asphyxia had to be lucky. Either an unskilled and zealous operator would injure the lungs or an obstructed airway would balloon the stomach. Leroy (1829) discouraged the use of bellows for a time. Only recently we have discarded the Lungmotor and Pulmotor, both a bellows in principle, and as dangerous.

Therapeutic oxygen has had periodic rises and falls. Beddoes (1790) so pushed it for curing everything, that others would not use it at all. Erichsen (1845) gave it a fresh start. Today some prefer to use air, even with oxygen at hand.

Respirators of one type or another now have a vogue, for long-continued cases. Hospitals either have or want a respirator for a possible case of paralysis from poliomyelitis. All the machines are expensive. Some are more elaborate than others, having room for patient, doctor and nurse. The more common and simpler type has ports through which one may tickle the patient with the latest in stimulants.

Recent ideas include Eve's seesaw. The weight of the abdominal viscera produces inspiration and expiration as the head is raised and lowered. Results are good, as compared with manual methods. Equipment is simple and cheap.

Our friends in the Pacific are better able to absorb punishment. If a Japanese is knocked out during jiu-jitsu, his friends continue the performance by applying the heel of the hand smartly to tender portions of his anatomy—the pit of the stomach, nape of the neck, or middle of the clavicle. We prefer the barrel.

At times all methods of inflation have been frowned upon. For a number of years after Leroy, stimulation alone was used. The swing back brought a period

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## Anesthesia and Analgesia—May-June, 1936

of laying on of the hands. Many gentlemen worked and squabbled: Should one trundle the patient from prone to lateral (Hall)? Or look him in the eye and wave his arms (Silvester)? Or punch him rhythmically in the back (Schäfer)?

For about thirty years, Schäfer's prone pressure method for resuscitation has occupied the foreground of public attention. Red Cross and public service workers, life guards, and others are familiar with the technique.

Another prone pressure method is that of Nielsen, a Dane. He works

from the head of the patient, making pressure on the upper chest to produce expiration. As he releases pressure, he lifts the upper arms to increase the amount of air inspired. He believes his method to be one-third more efficient than Schäfer's.

Recently an article in a well known syndicated health column called attention to risks of the Schäfer method and to better results with the Silvester method, where the patient lies on his back and respiration is carried out by abducting the arms horizontally.

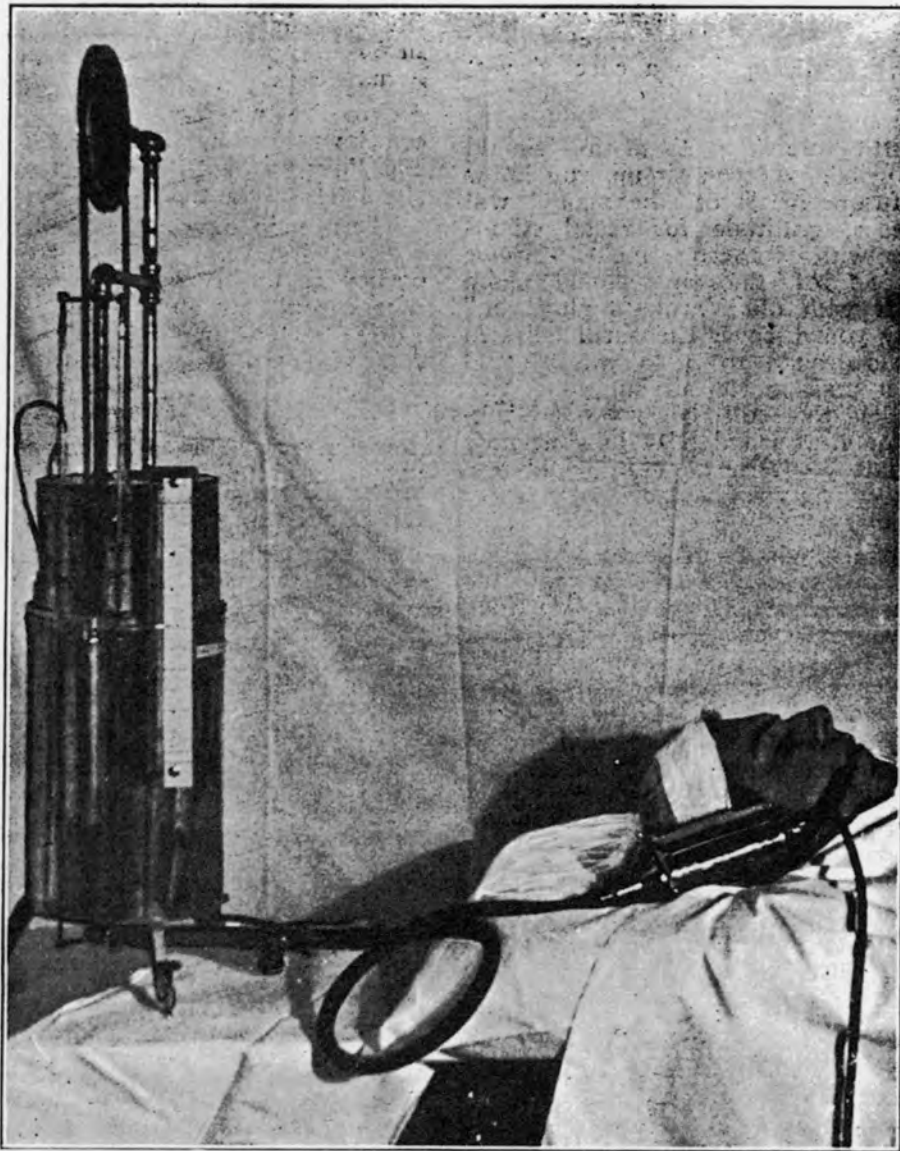


Fig. 1. Subject intubated with a closed endotracheal airway. The airway is connected through a canister of soda lime granules to a spirometer graduated in cubic centimeters.

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In an attempt to check the literature, we found little in regard to injuries from the use of artificial respiration. Theoretical considerations are well based but no conclusive proof is found that fracture of the ribs or rupture of viscera have resulted from manipulation.

Previous figures in the literature in regard to respiratory exchange during manipulation are of doubtful value. Dogs and other animals differ from man. Conscious human subjects have some degree of muscular control. Even in the fresh cadaver, some rigor is probably present.

### Experimental Data

**T**O MEASURE respiratory exchange, we have used as subjects patients brought into apnoea by artificially exaggerated minute-volume respiratory exchange while in moder-

ately deep anesthesia. The low carbon dioxide content resulting from such a procedure suffices to prevent voluntary respiratory movements while the skeletal muscles are completely relaxed. An endotracheal catheter with an inflated cuff assured a free airway without any leaks. The endotracheal tube was connected to a spirometer to determine exchange produced by various methods, (Fig. 1).

Four patients, two women and two men were used as subjects, (Table 1). The women were heavy, of the gall-bladder type. The men were in better physical condition, thinner and more active.

The difference in actual vital capacity is reflected in the results shown by the various types of manipulation, (Table 2). The smallest exchange was produced

TABLE I

Subject	Age	Sex	Wt. in Lbs.	Ht.	Vital Capacity		% A/T
					Theoretical in cc.	Actual in cc.	
D	47	F	183	5'2"	3800	1200	35.
H	47	F	188	5'2"	3800	2200	58.
O	19	M	152	5'7"	4500	4000	89.
L	48	M	154	5'6"	4500	4400	98.

Table 1.—Subjects used for manipulation, with their vital capacities.

TABLE 2

Subject	Exchange in CC. Obtained by Various Methods:							
	1	2	3	4	5	6	7	8
D					200	287	258	1.4
H	100	150	50		160	140	150	.87
O			380		680	1067	590	1.6
L				565	645	800		1.2

Table 2.—Exchange in cubic centimeters produced in four subjects.

- Col. 1. Eve Rocking Method, through 60°.
- Col. 2. Eve Rocking Method, through 90°.
- Col. 3. Pressure on anterior chest wall.
- Col. 4. Nielsen prone pressure method.
- Col. 5. Schäfer prone pressure method.
- Col. 6. Silvester, with pressure on anterior chest.
- Col. 7. Silvester, without pressure on anterior chest.
- Col. 8. Ratio of Col. 6 to Col. 5 (Silvester: Schäfer).

TABLE 3

Subject	Exchange Obtained by Various Methods; % of Actual Vital Capacity							
	1	2	3	4	5	6	7	8
D					17	24	21	1.4
H	4.5	6.8	2.3		7.3	6.4	6.8	
O			9.5		17	27	15	1.6
L				13	15	18		1.2

Table 3.—Exchange produced in terms of per cent of vital capacity. Columns are the same as in Table 2.



by manual compression of the anterior chest. The greatest exchange was produced by manipulation according to Silvester's method. Results with other methods were intermediate. It is interesting to note the increase in exchange when the chest is compressed by the arms in Silvester's method.

Our results may also be expressed in terms of the percentage ratio to the actual vital capacity, the results in Table 3 are in the same order as in Table 2.

#### Comment

**W**E BELIEVE a definite contribution has been made of a technique by means of which reliable information is gained as to the comparative effectiveness of various methods of artificial respiration. An apnoeic patient under deep inhalation anesthesia we believe exactly simulates the candidate for resuscitation by artificial respiration.

A study of the tables makes it obvious that the Silvester maneuver augmented by moderate pressure on the lower ribs accomplished by far the largest pulmonary ventilation. It is obvious that this is the only manual maneuver which actually simulates a positive inspiratory effort. This fact, however, should not induce us to lose sight of the fact that no effort at artificial respiration is of any value in the presence of an obstruction of the airway. In the dorsal position, gastric contents or other fluids as in drowning, may be present in the pharynx or air passages. Flaccid muscles may permit complete glottic occlusion. The prone position, therefore will continue to hold a definite advantage as an all around useful technique of resuscitation. The Schäfer prone pressure technique may hold a further advantage in that some benefit to circulation may be secondarily involved. Further information is desirable, however, as to the possibility of causing injuries with the method such as fracture of the ribs and visceral rupture. Although slightly less efficient in exchange it seems possible that the Nielsen modification of the prone pressure maneuver may be less likely to do harm.

In cases where the airway can be easily kept free of fluids and obstruction (conditions obtaining in every well manned operating room), we believe that the Silvester type of maneuver for artificial respiration, when properly applied, stands second only to direct mouth to mouth or mouth to nose in-

flation as an efficient means of causing respiratory exchange without the aid of apparatus.

#### Conclusions

**F**IRST. The Schäfer prone pressure method gives sufficient exchange for resuscitation but is probably most likely to cause visceral injury. In the obstructed or non-intubated patient it is preferable to place him face down to insure a better airway. Drainage, as in a drowned person, is provided.

2. The Nielsen method has the advantages of the Schäfer method and is probably less likely to result in injury.

3. Heavy, obese patients are difficult to respire by any method.

4. The best exchange was given by the Silvester method.

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#### References

1. Hall, Marshall: New Mode of Effecting Artificial Respiration. *The Lancet*, 1:229 (March 1) 1856.
2. Hall, Marshall: Asphyxia, Its Rationale and its Remedy. *The Lancet*, 1:393 (April 12) 1856.
3. Silvester, H. R.: The Natural Method of Treating Asphyxia. *Medical Times and Gazette*, 2:485 (Nov. 7) 1857.
4. Silvester, H. R.: A New Method of Resuscitating Stillborn and of Restoring Persons Apparently Drowned or Dead. *Brit. Med. J.*, No. 53, 576 (July 17) 1858.
5. Schäfer, E. A.: Artificial Respiration in Man. Harvey Lectures, 223, 1907-08.
6. Drinker, C. K.: New Apparatus for Artificial Respiration. The Barorespirator of Professor T. Thunberg. *J. of Indust. Hyg.*, 10:7 No. 1 (Jan.) 1928.
7. Drinker, C. K. et al: Recent Experiences of the Public Utilities of the United States and Canada in the use of the Schäfer Prone Pressure Method of Resuscitation in Cases of Electric Shock. *J. of Indust. Hyg.*, 10:117 No. 4 (April) 1928.
8. Eve, F. C.: Actuation of the Inert Diaphragm by a Gravity Method. *The Lancet*, 110 (ii):995 (Nov. 5) 1932.
9. Killick, E. M. and Eve, F. C.: Physiological Investigation of the Rocking Method of Artificial Respiration. *The Lancet*, 111 (ii) 740 (Sept. 30) 1933.
10. Kerridge, P. M. T.: Artificial Respiration for two years. *The Lancet*, 112 (i): 786 (April 14) 1934.
11. Cutter, I. S.: Artificial Respiration, Chicago Daily Tribune ("How To Keep Well"), (March 30) 1935.
12. Mijnlieff, C. J.: The Best Method of Manual Artificial Respiration And How to Employ It. *The Lancet*, 229:149, 5838 (July 20) 1935.
13. Cornwall, J. W.: Letter to the Editor. *Brit. Med. J.*, 3893:318 (Aug. 17) 1935.
14. Fisher, H. E.: The Evolution of Resuscitation. Nat'l Safety Council, Twentieth Annual Safety Congress (Pamphlet).
15. Guedel, A. E. and Waters, R. M.: Endotracheal Anesthesia: A New Technique. *Annals of Otol., Rhinol. and Laryngol.*, xl:1139, (Dec.) 1931.

## METHODS OF RESUSCITATION\*

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IF IT exists, the opportunity to bring the dead to life is rare. The sudden acute failure of the function of respiration or of circulation, or both, may result in a condition resembling death from which recovery is possible if proper measures are promptly instituted. It is to such "proper measures" for the restoration of respiration or circulation that the term "resuscitation" is, rightly or wrongly, often applied. The abundant margin of safety maintained by nature in the case of almost every other physiologic function is lacking in the matter of the transport of oxygen from environmental atmosphere to the tissues. Continuous adequate breathing, together with adequate blood flow, constitutes this transport mechanism. The total failure of either respiration or circulation must be extremely brief if the individual is to survive.

The length of time during which interruption of oxygen transport may be compatible with complete recovery has been the subject of much speculation. It depends upon the condition of the cells at the instant of complete interruption of transport and varies from a few seconds to nine or ten minutes. The individual suffering from severe cardiac decompensation may die within fifteen seconds of the initiation of complete respiratory obstruction or after three breaths of pure nitrous oxide. At the other extreme, a healthy athlete, after a period during which he breathes pure oxygen, may safely stay under water for nine or ten minutes. Recovery of the vegetative functions has been reported following periods of arrested oxygen transport of considerable duration.<sup>1, 2</sup> The more specialized centers of the central nervous system tolerate oxygen deprivation poorly. Failure of recovery may be preferable to recovery accompanied by blindness, amnesia, idiocy, or other defects of the higher centers. Methods of resuscitation to be effective must be instituted promptly and must transport oxygen efficiently until normal activity is restored.

Fisher<sup>3</sup> traced the evolution of methods of resuscitation. He described, in more or less detail, almost a hundred methods, 77 of which were attempts to perform artificial respiration, and 18 were designed to re-establish respiration by sensory stimulation of one sort or another. With the exception of cardiac or vascular massage, which is performed purposely or incidentally in many methods of artificial respiration, Fisher mentioned only four procedures involving direct attack upon the circulatory system.

Other than by the replacement of deficient blood volume by intravascular fluid injection, it is probable that less than 4 per cent of candidates for resuscitation can be benefited by direct attempts to replace, restore, or stimulate the circulatory mechanism. The surgical nature of direct attack upon the heart or blood vessels makes for delay and may interfere with efficient artificial respiration. The intravascular, intracardiac, or other administration of so-called analeptics, when the tissue cells already suffer oxygen want, may add insult to injury. The application of the electric current to re-establish heart action, suggested by Snow<sup>4</sup> and others<sup>5</sup>; the desensitization of the fibrillating heart by topical application or vascular injection of procaine, as suggested by Beck<sup>6</sup>;

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the intracardiac injection of adrenalin, and other specialized procedures demand knowledge and equipment not likely to be available under the usual circumstances when methods of resuscitation are needed.

Prompt restoration of oxygen, then, to the cells of the central nervous system is our primary object. Except in very unusual circumstances, the introduction of oxygen into the circulation other than through the alveolocapillary membrane<sup>7, 8</sup> has not proved satisfactory. Prompt, efficient, and yet not traumatic or overvigorous, artificial respiration is, therefore, the sheet anchor of resuscitation.

#### ARTIFICIAL RESPIRATION

If there are 77 different methods of performing a technical procedure (and Fisher did not exhaust the literature by any means), it indicates one of two things. Either no known method is satisfactory, or the method is of little importance compared with the understanding with which the method is applied. The latter may be presumed to be the case with methods of artificial respiration. Success was reported by the originator of each of the 77 methods. Why? Undoubtedly some of the individuals "resuscitated" would have re-established adequate oxygen transport without treatment. However, the originator of a method in every case had devoted time and thought to the problem involved. His effort to maintain a substitute for normal respiration was performed intelligently, and the result was satisfactory. However vigorously the chest be "squeezed" or the upper air passages "blown into"—be it by hand or machine—unless oxygen is replenished in the alveoli, the result will be valueless. Not infrequently has an efficient method of artificial respiration been applied in the presence of an obstructed glottis and with negative results. All too frequently do we waste valuable seconds or even minutes in procuring a piece of mechanical apparatus or a cylinder of oxygen to treat respiratory failure, when our own hands or our own respiratory muscles could have been used instantly to coax or force air containing oxygen into the victim's lungs.

It is possible, as demonstrated by Robert Hooke in the seventeenth century, and popularized by Meltzer and Auer in 1909,<sup>9</sup> to perform "respiration without respiratory movement." This means that if the deeper air spaces are flushed with a continuous stream of air or oxygen, an adequate tension of oxygen can be maintained in the alveoli, and the carbon dioxide tension can be kept below normal, so that there is insufficient acid stimulus at the respiratory centers to initiate movement. Only under unusual circumstances is such a technique of replacing normal respiration thought advisable in present-day practice. If sudden respiratory arrest is encountered in a viable patient, good practice dictates that we should initiate rhythmic exchange of alveolar atmosphere at once by the most available method at our immediate command.

#### TECHNICAL CONSIDERATIONS

Normal breathing while at rest is accomplished by intermittent exaggeration of the subatmospheric intrapleural pressure. It is brought about chiefly by synchronous contraction of the intercostal muscles and the diaphragm. Under stress normal breathing is probably a combination of active alternate increase and decrease of pleural pressures. When respiratory muscles cease activity, the lungs are held partly filled at atmospheric pressure by the negative pressure in the pleural cavities, in spite of the elasticity of lung tissue which is tending to collapse the lungs and force the contained atmosphere out. To maintain rhythmic exchange of the atmosphere in the alveoli, three physical changes and combinations of these are available:

- I. Intermittent exaggeration of negative intrapleural pressure.
- II. Intermittent increase of pressure in alveolar spaces.
- III. Intermittent decrease of negative intrapleural pressure.

I. *Intermittent Exaggeration of Subatmospheric Pressure.*—Silvester in 1858<sup>10</sup> described a manual maneuver which accomplished artificial intermittent exaggeration of the negative intrapleural pressure in a manner simulating the normal. With a pad under the shoulders and the patient in the supine position, the arms are raised over the head elevating the ribs, the pleural negative pressure is increased, and air rushes into the lungs. When the arms are returned to the sides, the ribs fall, the pleural pressure becomes less negative, and air rushes out of the lungs. He recommended that the arms be pressed against the ribs as they are returned to the sides to aid in expiration.

Woillez previous to 1881,<sup>11</sup> and more recently Drinker<sup>12</sup> and others, have popularized mechanical respirators, surrounding the trunk or the whole body below the neck with an airtight box in which the pressure can be intermittently reduced, thus raising the ribs and the abdominal wall and imitating the combined effect of intercostal and diaphragmatic action on the intrapleural pressure (see under III).

II. *Intermittent Increase of Pressure in Alveolar Spaces.*—The intermittent transmission of positive pressure to the alveoli through the air passages was probably the first method of artificial respiration described. Several passages in the Bible have been so interpreted.<sup>13, 14</sup> Vesalius maintained respiration by this means while he demonstrated the movements of the heart when the anterior thoracic wall of animals had been removed. Intermittent direct inflation of the lungs by hand pressure on a rubber breathing bag attached to a face mask or artificial airway is the common method used by the anesthetist when respiration ceases. He finds it possible to maintain adequate ventilation in this manner.<sup>15, 16</sup>

Numerous mechanical devices have been constructed to inflate the lungs intermittently. The fireside bellows is said to have been used by Vesalius. Goodwyn in 1786 described an especially made syringe,<sup>17</sup> and every generation since that time has had its favorite for the purpose.

III. *Intermittent Decrease of Negative Intrapleural Pressure.*—To decrease the negative or subnormal pressure in the pleural cavities and thereby cause atmosphere to rush out of the alveoli through the air passages (followed by passive inspiration), the thoracic cage must be made smaller by depressing the ribs or pushing the diaphragm upward, or both. The Schafer prone pressure manual method of artificial respiration<sup>18</sup> typifies the application of this principle. Simple intermittent pressure on the ribs or abdominal wall does the same. Mechanical devices by which the trunk or part of it is inclosed in an airtight rigid container can be used to decrease the negative intrapleural pressure if positive pressure is intermittently applied inside the container.

The combinations of these three principles of maintaining atmospheric exchange are many and varied. Synchronous application of I and II, alternation of II and III, and alternation of I and III have been advocated. Accomplishment is suggested by alternating changes of position of the whole body, by manual manipulation of various parts, and by cumbersome<sup>19</sup> or beautifully intricate<sup>20</sup> machines. Hand power, foot power, electric motors, and compressed gas, all have been and are being used to motivate such equipment.

In general, it may be said that manual maneuvers or direct inflation of the lungs from the operator's own respiratory tract have the advantage of instant availability and intimate personal relation to the effort, resulting in the likelihood that the rescuer will more readily appreciate defects in the methods, such

as an obstructed airway and inadequate or excessive exchange. The actual method of performing artificial respiration is relatively immaterial. In circumstances where the respiratory tract is free of contaminating material, direct inflation of the lungs by blowing intermittently through the patient's mouth or nose is probably the most readily available. The oxygen cylinder, breathing bag, and mask ought to be available in hospitals and emergency kits. The Silvester method is as efficient as other manual methods.<sup>21</sup> If the tract is contaminated by foreign material, as after vomiting or drowning, and suction apparatus is not available, the Schafer prone pressure maneuver is safer. The instant application of some method of intermittent exchange, when natural effort ceases, is all important.

Mechanical apparatus is constructed partially of rubber which deteriorates, of intricate machinery which gets out of order, of weighty substances which are difficult to transport. Delay in the application of apparatus is the rule, not the exception. If resuscitation is attempted with apparatus as promptly and as intelligently as with manual maneuvers or direct inflation, the result may be as good, but not better. The enrichment of the atmosphere with oxygen is valuable in either circumstance, and trauma or overventilation,<sup>22</sup> as well as inadequate atmospheric exchange, may result from our efforts. A mechanical respirator is as safe and as efficient as the physiologic intelligence and technical skill of the person who operates it and no more so. Comprehension of the physiologic factors involved and intelligent direction of the effort by an experienced physician are essential whatever the method employed.

Whether the rhythmic change in intrathoracic pressure experienced in normal breathing has an important influence upon blood flow has never been satisfactorily determined. In desperate circumstances intermittent high pressure (40 to 60 mm. of mercury) chest inflation in performing artificial respiration with oxygen has been observed to propel blood through the vessels.<sup>23</sup> Whether the usual rational efforts at performing artificial respiration may aid in maintaining an adequate blood flow has not been determined. Clinical experience leads me to believe that pulmonary circulation, at least, is influenced by rhythmic filling and emptying of the lungs. Attempts to substitute "respiration without respiratory movement" during open chest operations have been associated, after a period of fifteen or twenty minutes, with circulatory depression that appeared to be dependent upon the absence of the movement of the lungs, since circulation seemed to improve when intermittent inflation was resumed.

#### RESUSCITATION AND THE PHYSICIAN

It is obvious that there are many maneuvers capable of maintaining satisfactory exchange of the alveolar atmosphere when normal respiration ceases. Two factors more important than the method by which exchange is brought about are (a) the promptness with which the artificial method is initiated after normal activity has ceased; (b) the intelligence and physiologic understanding with which the method is applied. Because of a realization of the necessity for promptness, lay rescue squads were instituted and trained to function in the absence of a physician until one could reach the patient. They have served a useful purpose, but, as a result, the medical profession and the public have come to look upon "resuscitation" as a nonmedical effort. Medical schools neglect to teach the clinical application of physiologic principles to the care of acute respiratory morbidity. Many young physicians come to their internships dependent solely upon such knowledge and skill as they have gained from their Boy Scout training. Practitioners of medicine rush to the telephone to call rescue squads from the police and fire departments while patients die who could

be rescued. To the disgrace of present-day medical education, sudden failure of respiration is not a rare cause of death in the wards and operating rooms of the modern hospital.

Medical training must include knowledge and skill in the rapid re-establishment of a free and open airway. Specific instruction in the anatomy of the air passages, as it applies to the transfer of atmosphere to and from the alveoli, the use of a simple laryngoscope—its advantages and dangers—the nontraumatic insertion of an artificial airway, the use of suction or gravity to remove contaminating foreign substances, and the physiologic principles of oxygen and carbon dioxide transport, all these as well as methods of artificial respiration, must be included in the training of a physician. Equipped with such knowledge and skill, the physician will instinctively do the right thing in a moment of emergency. Clearing the airways and accomplishment of exchange will be prompt because they are instinctive. Facility in the care of respiratory failure can be taught by the department of anesthesiology. Anesthetized patients can be used as demonstration material to the advantage of patients as well as students. If experience is acquired when no serious emergency exists, the loss of time and waste motion characteristic of excited persons in an emergency may be avoided.

#### SUMMARY

“Resuscitation” is not the resurrection of the dead, but the re-establishment of oxygen transport from atmosphere to body tissues when either factor in that transport has been suddenly interrupted.

The restoration of circulation, once it ceases, is rarely possible. Treatment directed at the heart and blood vessels other than the injection of blood and other fluids is indicated only in unusual circumstances.

The most logical procedure in emergencies demanding resuscitation is the provision of (a) a free and unobstructed airway; and (b) intermittent exchange of alveolar atmosphere containing excess oxygen.

Mechanical devices will rarely be needed if instant intelligent aid is at hand. They do not produce more adequate exchange than direct inflation from the operator's own lungs or manual maneuvers, nor higher concentration of oxygen than a simple oxygen cylinder, breathing bag and mask, and they may over-ventilate or traumatize the lungs. Their sole advantage is seen in cases requiring long periods of artificial respiration, such as drug poisoning, paralyses, and the like, when the operator might become exhausted. Rarely will such cases come under the classification of “resuscitation”.

Finally, the re-establishment of the physiologic functions which transport oxygen is within the physician's province. The fact that some doctors even in hospital practice are dependent on lay rescue squads is a reflection on medical education.

#### REFERENCES

1. Courville, Cyril B.: Asphyxia as a Consequence of Nitrous Oxide Anesthesia, *Medicine* 15: 129, 1936.
2. Schreiber, Frederic: Cerebral Anoxia and Anesthesia, *J. Michigan M. Soc.* 38: 1050, 1939. Ibid: Mental Deficiency From Paranatal Asphyxia, *Proc. Am. A. Ment. Deficiency* 44: 95, 1939.
3. Fisher, Hart Ellis: The Evolution of Resuscitation, *Trans. 20th Annual Safety Congress Nat. Safety Council*, 1932.
4. Snow, John: On Chloroform and Other Anesthetics, London, 1858, J. Churchill, pages 261-262.
5. Hyman, A. S.: Resuscitation of Stopped Heart by Intracardiac Therapy. II. Experimental Use of Artificial Pacemaker, *Arch. Int. Med.* 50: 283, 1932.
6. Beck, C. S., and Mautz, F. R.: The Control of the Heart Beat by the Surgeon, With Special Reference to Ventricular Fibrillation Occurring During Operation, *Ann. Surg.* 106: 525, 1937.

7. Singh, Indeyit: Absorption of Oxygen From the Subcutaneous Tissues, *Quart. J. Exper. Physiol.* 22: 193, 1932.
8. Tunnicliffe, F. W., and Stebbing, G. F.: The Intravenous Injection of Oxygen Gas as a Therapeutic Measure, *Lancet* 2: 321, 1916.
9. Meltzer, S. J., and Auer, J.: Continuous Respiration Without Respiratory Movements, *J. Exper. Med.* 11: 622, 1909.
10. Silvester, Henry R.: A New Method of Resuscitating Still-Born Children, and of Restoring Persons Apparently Drowned or Dead, *Brit. M. J.* July 17, 1858, p. 576.
11. Woillez, E.: Nouveau Spirophore (Original presented in 1876), *Bull. Acad. de méd. Paris* 10: 847, 1881.
12. Drinker, P., and Shaw, L. A.: An Apparatus for Prolonged Administration of Artificial Respiration, *J. Clin. Investigation* 7: 229, 1929.
13. Genesis 2: 7.
14. II Kings 4: 32-38.
15. Guedel, A. E., and Treweek, D. N.: Ether Apnoeas, *Anesth. & Analg.* 13: 263, 1934.
16. Waters, R. M.: Carbon Dioxide Absorption From Anaesthetic Atmospheres, *Proc. Roy. Soc. Med.* 30: 1, 1936.
17. Goodwyn, Edmund: *The Connexion of Life With Respiration*, London, 1788.
18. Schafer, E. D.: The Relative Efficiency of Certain Methods of Performing Artificial Respiration in Man, *Proc. Roy. Soc. Edinburgh*, Part I, 25: 39, 1903-05.
19. Thunberg, T.: Der Barospirator. Ein Apparat für Künstliche Atmung nach einem neuen Prinzip, *Abderholden's Handbuch der biologischen Arbeitsmethoden*, 1927, Abt. 5, Teil 1, 561.
20. Craaford, C.: On the Technique of Pneumonectomy in Man, Stockholm, 1938, p. 53.
21. Waters, R. M., and Bennett, J. H.: Comparison of Manual Maneuvers, *Anesth. & Analg.* 15: 151, 1936.
22. Seevers, M. H., Stormont, R. T., Hathaway, H. R., and Waters, R. M.: Respiratory Alkalosis During Anesthesia, *J. A. M. A.* 113: 2131, 1939.
23. Waters, R. M.: Resuscitation: Artificial Circulation by Means of Intermittent High Pressure Chest Inflation With Oxygen. A Preliminary Report, *Anesth. & Analg. Bull.* 15 (Oct.), 1921.

## COUNCIL ON PHYSICAL THERAPY

THE COUNCIL ON PHYSICAL THERAPY HAS AUTHORIZED PUBLICATION  
OF THE FOLLOWING REPORT. HOWARD A. CARTER, Secretary.

### SIMPLE METHODS FOR PERFORMING ARTIFICIAL RESPIRATION

RALPH M. WATERS, M.D.  
MADISON, WIS.

Artificial means to replace the act of breathing need not be complicated or difficult.<sup>1</sup> Any intelligent person, even a child, may be taught to perform artificial respiration which is adequate and safe.

In his teaching at Padua four hundred years ago Vesalius<sup>2</sup> emphasized the importance of proper respect for the thoughts of the ancients—an excellent attitude of mind for modern people. He demonstrated the adequacy of simple intermittent inflation of the lungs with air as a substitute for normal breathing. Goodwyn<sup>3</sup> was the first physician to apply the knowledge of the exchange of oxygen and carbon dioxide during respiration. He called attention to the advantage of adding oxygen to the atmosphere used during artificial respiration. In the intelligent employment of these two contributions is embraced the beginning and the end of "artificial respiration." There is no more to it than that. And yet in the century and a half since Goodwyn's

book was published much paper has been used in describing how and with what mixtures of gases ventilation of the lungs ought to be accomplished.

Children are thought to like mechanical gadgets; nevertheless, how frequently do we find father playing with the electric train weeks after Junior has found other interests. Enthusiasm for the clever construction and intricacy of a mechanical respirator is more likely to determine its purchase and use, even by a physician, than is thoughtful reasoning or experiment as to its physiologic effects, its simplicity, reparability and all round availability. It is not my present purpose to discuss the relative merits of the numerous manual maneuvers suggested for the performance of artificial respiration, nor do I intend to compare the advantages of the many mechanical gadgets manufactured for the purpose. It is desired only to emphasize four facts: (1) that, as Vesalius demonstrated, gentle intermittent inflation of the lungs with air can serve as an adequate substitute for normal breathing; (2) that, if oxygen is available, it is desirable, as Goodwyn suggested, to add this gas to the atmosphere used; (3) that, regardless of the method employed, atmosphere cannot enter and leave the lungs if the air passages are obstructed, and (4) that elaborate equipment is not

1. It is well recognized that the various manual maneuvers (Schafer, Silvester and their modifications) to accomplish artificial respiration are capable of accomplishing adequate ventilation of the lungs when the air passages are not obstructed. The impression is gaining prevalence that, when apparatus is used, it must be costly and elaborate. This paper emphasizes the long recognized fact that very simple mechanical devices are satisfactory. No originality is claimed for the method described nor is it claimed to accomplish more efficient or safer pulmonary ventilation than the manual maneuvers.

2. Vesalius, Andreas: *De humani corporis fabrica*, Basel, J. Oporini, 1543.

3. Goodwyn, Edmund: *The Connection of Life with Respiration*, London, J. Johnson, 1788.

essential. If these four points are properly appreciated, any one can perform artificial respiration. It ought to be begun as soon as natural breathing stops by whoever is present at the time. Blowing into the subject's nose or mouth is the method which is always available. Manual maneuvers (Silvester, Schafer) can also be quickly applied. If apparatus is used, the simpler it is the better.

Anesthetists find it essential to be prepared to do artificial respiration at a second's notice. Overdose of an anesthetic or depressant drug, as well as various other accidents, sometimes stops normal breathing of the patient during an operation. The equipment described here is constituted of materials similar to those constantly used by many anesthetists to contain the anesthetic atmospheres breathed by their patients. They are therefore always in the hand of the anesthetist when an accident happens. In fact, when the anesthetist is alert, cessation of breathing is rarely dangerous. The method of artificial respiration described

in the following paragraphs has been used to "breathe" efficiently for the patient over long periods of time. It is even employed during some surgical operations to hold in abeyance for hours the normal movements of the respiratory muscles when such movements may interfere with delicate surgical procedures. Such experience constitutes evidence that serious harm from such artificial respiration need not result. Simple apparatus,

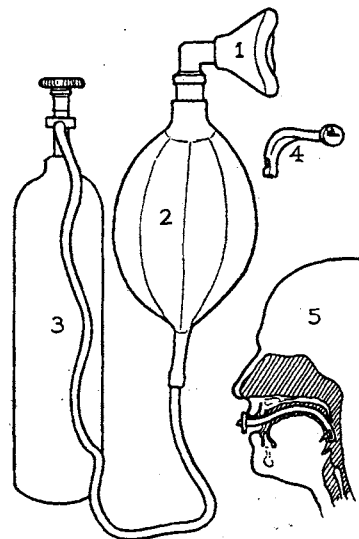


Fig. 1.—A mask (1) to cover the mouth and nose, and a sturdy rubber bag (2) connected to an oxygen cylinder (3) constitutes adequate equipment. A properly shaped pharyngeal airway (4) of metal or hard rubber when placed over the tongue into the throat (5) sometimes helps to maintain a free passage to the windpipe.

similar to that used by the anesthetists, costs little, is light and easily transported and can be employed by any intelligent person to perform artificial respiration. No elaborate and expensive machine will do a better job of artificial respiration.

#### EQUIPMENT AND PROCEDURE

Any manufacturer of an anesthetist's equipment can furnish a face mask with a 5 or 6 liter breathing bag of strong rubber connected to a rubber tube several feet long. A yoke to fit a small oxygen cylinder and a wrench with which to open the cylinder complete the assembly (fig. 1). The operator holds the mask tightly over the nose and mouth and fills the bag with oxygen (fig. 2 A). If oxygen is not available, the operator may hold the rubber tube in his mouth and keep the bag partly filled by blowing into it. Compression of the bag with the hand (fig. 2 B) forces atmosphere into



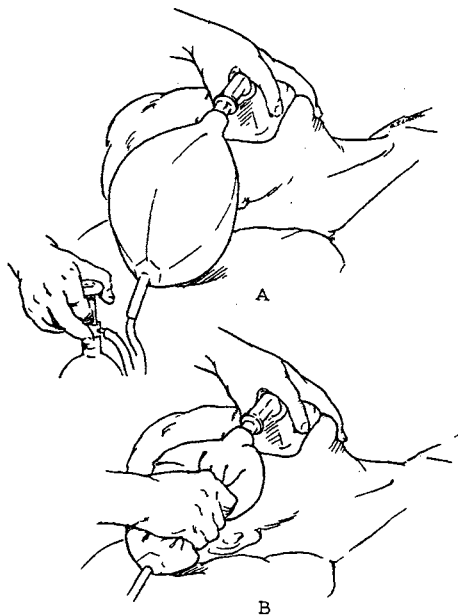


Fig. 2.—The bag is filled with oxygen (A) and squeezed by the hand (B) to force atmosphere through the upper air passages and windpipe into the lungs. As soon as movement of the chest is seen, indicating that the lungs are filling, the operator's hand releases the bag completely to allow the lungs to empty. Normal rates of breathing are 12 to 20 per minute. Try to imitate nature in both rate and depth.

the lungs (provided the mask is in approximately airtight contact with the face and the upper air passages are not obstructed). Release of pressure allows the atmosphere to return from the lungs. Such intermittent inflation of the lungs alternating with pauses to allow for deflation accomplishes adequate ventilation. The

bag will need to be refilled frequently enough to replace the atmosphere which unavoidably leaks from under the mask during inflation. The frequency of inflation is relatively unimportant provided a pause after each compression of the bag is sufficient to allow the chest wall to sink back to its passive condition and the lungs to collapse partially and force the inflated atmosphere out.\*

Artificial respiration should resemble normal breathing. The operator ought to estimate how frequently and how vigorously this subject, save for the accident, would breathe for himself. Such activity should be imitated as exactly as possible both in depth and in

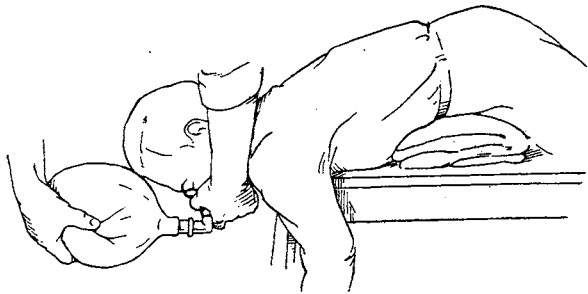


Fig. 3.—When intermittent inflation of the lungs is done with the subject's face down, the head low and a pad under the "stomach," water and other fluids may drain from the lungs and throat.

4. If the mask is held in really airtight contact with the face for several minutes, too much carbon dioxide—produced by the patient—may accumulate in the bag. Usually the necessary addition of oxygen or air to replace that which leaks between the mask and the skin of the face during the pressure of each inflation serves to remove carbon dioxide. Even if leakless contact is maintained, artificial respiration for less than five minutes will not permit a harmful accumulation of carbon dioxide. If long periods of artificial respiration are maintained with this equipment, frequent emptying and refilling of the bag is necessary. This is particularly important if breathing has stopped as the result of poisoning with volatile or gaseous substances such as ether or carbon monoxide.

rate. As pressure is made on the bag, the thorax of the subject must be watched to see when it begins to expand. If beginning movement of the chest can be seen or felt, enough pressure has been exerted and the bag should be released. The operator must be sure that the outflow of atmosphere from the lungs is not impeded by the weight of the hand against the bag.

*Free Exchange Essential.*—If for some reason passage to the windpipe is not open, atmosphere may fail to reach the lungs or it may be forced down the gullet into the stomach. To assure a free passage to the trachea and avoid blowing up the stomach or forcing vomited fluids, food or other foreign substances into the windpipe, three procedures may be useful:

1. Empty the mouth, nose and throat of any liquid (water in drowning; vomitus) or solid substance (food, tobacco, chewing gum, loose teeth). This can be done with the fingers, with a cloth sponge or, better, by gravity. Place the patient on his stomach, face down and head lowered if possible (fig. 3). A child can be

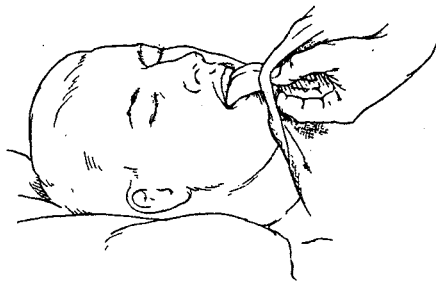


Fig. 4.—With your handkerchief the tongue may be pulled forward before gently passing an artificial airway over it (see 5, fig. 1).

“stood on his head.” Hospitals are equipped with devices for sucking material from the throat.

2. The relaxed and swollen tongue may fall backward to sit on the opening to the windpipe. In the face down position, gravity tends to keep the tongue away from the opening. In addition, the operator may pull the tongue forward: (a) By pushing the jaw forward with pressure behind the angles of the jaw. (b) By grasping the tongue with a cloth (fig. 4). (To hold the tongue forward while a mask covers the face, a large safety pin may be passed through the midline of the tongue, a half inch from the tip. Persons needing prolonged artificial respiration are unconscious and the slight injury to the tongue caused by the pin results in little soreness afterward.) (c) By placing a rubber or metal artificial airway if available (5, fig. 1).

3. To prevent inflation of the stomach, the hand or a moderate weight may be placed over the upper part of the abdomen if the victim lies on his back, or a soft roll of cloth may be under his stomach when his face is down (fig. 3).

#### ALTERNATIVE PROCEDURE

*Intermittent Direct Inflation of Lungs by the Operator.*—If the apparatus just described is not immediately available, valuable time must not be lost. Lives are sacrificed by neglecting the first thirty seconds after breathing stops. Direct inflation of the lungs is

always at hand (fig. 5). Either the nose or the mouth may be blown into while one hand of the rescuer holds the other portal closed. The other hand, resting on the subject's chest, perceives the point at which the chest moves; in other words, when the lungs are sufficiently inflated. If no movement takes place, obstruction is present and the air passages must be cleared by the various maneuvers described.

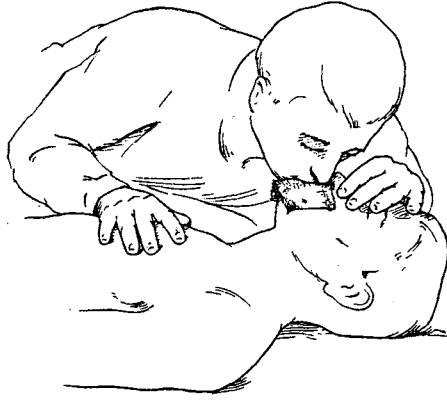


Fig. 5.—With his left hand the operator holds the subject's nose closed while he blows into the mouth intermittently. A handkerchief or other light material prevents contamination. The operator's right hand rests lightly on the chest in order that he may appreciate when air is entering the lungs.

#### COMMENT

Natural breathing is a very delicately adjusted mechanism for causing the atmosphere to enter and leave the lungs. The frequency of exchange and the depth of each breath are attuned to the needs of the blood and tissues for oxygen. The amount of air which enters and leaves the lungs each minute therefore varies widely for each individual and for the same individual at different times. Artificial respiration will therefore rarely exactly simulate normal breathing. The life processes of the individual who has ceased to breathe are at a low ebb and hence his demand for oxygen is comparatively little. When the air passages to the lungs are not obstructed, efforts at artificial breathing are apt to be overdone rather than underdone. If obstruction is present the opposite is true. Thoughtful and deliberate attention to the movements of the chest resulting from one's efforts will succeed while hasty and thoughtless activity may fail. Remember the object of normal breathing—to ventilate the lungs with air or oxygen which flows gently and slowly back and forth through the windpipe to and from the air sacs. Try to imitate normal breathing for each particular subject.

#### SUMMARY

If a reasonably robust person ceases to breathe, adequate artificial respiration may sustain life until breathing is reestablished. Only disappointment can result from performing artificial respiration on persons who cease to breathe as a terminal event in the course of disease. Methods are most useful which are instantly available and simple.

1. When breathing has stopped, do not concern yourself with calling for help, moving the patient, wrapping him in blankets or any maneuver other than keeping up intermittent rhythmic exchange of the atmosphere in his lungs.
2. Utilize inflation of the victim's lungs from the lungs of the operator, or exchange by manual maneuver, if apparatus is not at hand.
3. If and when a mask, rubber bag and a cylinder of compressed oxygen are available, fill the bag with oxygen and inflate the lungs by pressing on the bag.
4. In either case (2 or 3) use only sufficient pressure to expand the chest slightly. If one can see or feel the chest begin to expand as one blows or presses on the

bag, enough pressure is being used. The amount of pressure necessary may be great if the air passages are partially obstructed. Try to relieve such obstruction as soon as possible.

5. Allow adequate time for the lungs to empty before inflating them again.

6. Persist until the subject breathes for himself or until a physician has pronounced him dead.

7. If water or other substances are thought to be in the mouth, throat, and air passages, work with the patient in the face-down position with the head low if possible.

*N<sub>2</sub>O, CO<sub>2</sub> & TOO MUCH O<sub>2</sub>*

## NITROUS OXIDE CENTENNIAL \*

RALPH M. WATERS, M.D.

*Madison, Wisconsin*

ON December 11, 1844, Horace Wells was anesthetized with nitrous oxide in his dental office in Hartford, Connecticut during the extraction of a tooth. This event has constituted one side of a controversial triangle for the past hundred years. Should the credit for the introduction of surgical anesthesia be given to Crawford W. Long, a physician who administered ether in his office in Georgia on March 30, 1842; to Wells; or to William T. G. Morton, a dentist of Boston who administered ether in Massachusetts General Hospital on October 16, 1846? The old controversy is being revived this year because of resolutions which are being adopted and celebrations planned by medical and dental associations in honor of "The Horace Wells Centenary." At such a time it seems fitting to consider the history of nitrous oxide and to reacquaint ourselves with some of the less well known men who have contributed to our knowledge of this gas and its use as an anesthetic agent.

### PRIESTLEY

Nitrous oxide was first prepared and studied by Joseph Priestley some one hundred and seventy years ago. He began investigation of what he called "The Doctrine of Air" in 1767. Little was known of gaseous substances at that time and all were generally referred to as "air." The six volumes later published by Priestley were entitled "Experiments on Air" although they contain descriptions of experiments with nearly all the commoner gases known today. He believed in the current Phlogiston theory and referred to oxygen as Dephlogisticated Air. Nitrous oxide he called "Dephlogisticated Nitrous Air." A quotation from section 20 of volume V of the Experiments, published in 1783, will emphasize his great interest in nitrous oxide:

"in each of the four preceding volumes . . . I have treated of a species of nitrous air in which a candle burns with an enlarged flame. . . . In every successive volume will be found several advances in the investigation of . . . this species of air, in consequence of my having given to it perhaps more attention than it will be found to deserve. But our attention is by no means always bestowed according to the real, or even the seeming importance of the objects of it, but to something in them that excites our curiosity. Now there is something so exceedingly remarkable in this species of air, especially its property of admitting a candle to burn in it, when it is still as fatal to animal life as any species of air whatsoever, that I have not been able to refrain from attending to it."

\* From the Department of Anesthesia, Medical School, University of Wisconsin, Madison.

EXPERIMENTS  
AND  
OBSERVATIONS  
ON DIFFERENT KINDS OF  
AIR.

VOL. III.

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By JOSEPH PRIESTLEY, LL.D. F.R.S.

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*Facta est immensi copia mundi.*

OVID.

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L O N D O N :

Printed for J. JOHNSON, No. 72, St. Paul's  
Church-Yard.

MDCCLXXVII.

FIGURE 1.

In view of the frequent unscientific attitudes assumed by some later workers with nitrous oxide, it is regrettable that they did not read the Preface to volume I of "Experiments on Air." For instance, Priestley wrote:

"When, for the sake of a little more reputation, men can keep brooding over a new fact, in the discovery of which they might possibly have very little real merit, till they think they can astonish the world with a system as complete as it is new, and give mankind a prodigious idea of their judgment and penetration, they are justly punished for their ingratitude to the fountain of all knowledge, and for the want of a genuine love of science and of mankind in finding their boasted discoveries anticipated and the field of honest fame pre-occupied by men who, from a natural ardor of mind, engage in philosophical pursuits, and with an ingenuous simplicity immediately communicate to others whatever occurs to them in their inquiries. . . . In completing one discovery we never fail to get an imperfect knowledge of others of which we could have no idea before, so that we cannot solve one doubt without creating several new ones. . . . Among a multiplicity of new objects and new relations some will necessarily pass without sufficient attention; but if a man be not mistaken in the principal objects of his pursuits he has no occasion to distress himself about lesser things. . . . In the progress of his inquiries he will generally be able to rectify his own mistakes; or if little and envious souls should take a malignant pleasure in detecting them for him and endeavouring to expose him, he is not worthy of the name of a philosopher if he has not strength of mind sufficient to enable him not to be disturbed at it. He who does not foolishly affect to be above the failings of humanity will not be mortified when it is proved that he is but a man."

Before his death in 1804 in Northumberland, Pennsylvania, Priestley expressed in a letter to Humphry Davy in these words his high hopes that his work would go on:

"It gives me peculiar satisfaction that, as I am far advanced in life and cannot expect to do much more, I shall leave so able a fellow-labourer of my own country in the great fields of experimental philosophy. . . . I rejoice that you are so young a man; and perceiving the ardour with which you begin your career I have no doubts of your success."

Davy's work on nitrous oxide was published in 1800 after two years' experience as laboratory assistant in The Pneumatic Institute of Dr. Thomas Beddoes at Clifton near Bristol. This work won for Davy the appointment as Lecturer in Chemistry in the Royal Institution in London. As a model for the study of a new drug, it has scarcely been excelled to the present day. Although Humphry Davy was knighted because he was a great chemist, this pharmacologic masterpiece, done before he reached his majority, laid the foundation of his career. In it he checked and extended the chemical studies of Priestley. He then investigated extensively the pharmacologic effects upon animals and upon himself when nitrous oxide is inhaled. Some of his observations are described as follows:

"On April 11th (1799) I made the first inspiration of pure nitrous oxide; it passed into the bronchia without stimulating the glottis, and produced no uneasy feeling in the lungs. . . . In one instance, when I had head-ache from indigestion, it was immediately removed by the effects of a large dose of gas; though it afterwards returned, but with much less violence. . . . In cutting one of the unlucky teeth called dentes sapientiae, I experienced an extensive inflammation of the gum, accompanied with great pain, which equally destroyed the power of repose and of consistent action. . . . On the day when the inflammation was most troublesome, I breathed three large doses of nitrous oxide. The pain always diminished after the first four or five inspirations; the thrilling came on as usual, and uneasiness was for a few minutes swallowed up in pleasure. . . ."

Among his conclusions are the following:

"Modification of the powers of nitrous oxide by mixture of the gas with oxygen or common air, will probably enable the most delicately sensible to respire it without danger, and even with pleasurable effects. . . . As nitrous oxide in its extensive operation appears capable of destroying physical pain, it may probably be used with advantage during surgical operations. . . . Pneumatic chem-

## RESEARCHES,

### CHEMICAL AND PHILOSOPHICAL;

CHIEFLY CONCERNING

### NITROUS OXIDE,

OR

DEPHLOGISTICATED NITROUS AIR,

AND ITS

### RESPIRATION.

By HUMPHRY DAVY,

SUPERINTENDENT OF THE MEDICAL PNEUMATIC  
INSTITUTION.

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LONDON:

PRINTED FOR J. JOHNSON, ST. PAUL'S CHURCH-YARD.

BY BIGGS AND COTTLE, BRISTOL.

1800.

FIGURE 2.

istry in its application to medicine, is an art in infancy, weak, almost useless, but apparently possessed of capabilities of improvement. To be rendered strong and mature, she must be nourished by facts, strengthened by exercise, and cautiously directed in the application of her powers by rational scepticism."

#### HICKMAN

The statement has been made that Henry Hill Hickman used nitrous oxide in his attempts to produce surgical anesthesia.\* The evidence is wanting. The chief exhibit in support of Hickman's claims to being the first anesthetist is the Letter, the first page of which is shown in figure 3. This was privately printed and consists of a letter and the description of six experiments. Animals were sealed in glass containers to produce "suspended animation." The atmospheres used were atmospheric air; exhaled air; and carbon dioxide produced by the reaction of sulphuric acid with carbonate of lime. In these experiments, then, Hickman "suspended animation" in the first case with anoxia, in the second with anoxia plus carbon dioxide and in the third largely with carbon dioxide. Further evidence of Hickman's claims as the originator of the idea of surgical anesthesia is a letter

A

## LETTER ON SUSPENDED ANIMATION,

CONTAINING

### EXPERIMENTS

*Showing that it may be safely employed during*

### OPERATIONS ON ANIMALS,

*With the View of Establishing*

ITS PROBABLE UTILITY IN SURGICAL OPERATIONS ON THE

## Human Subject,

*Addressed to*

T. A. KNIGHT, ESQ. OF DOWNTON CASTLE,  
Herefordshire,

ONE OF THE PRESIDENTS OF THE ROYAL SOCIETY,

~~WHICH WAS READ AT THE ANNUAL MEETING~~

BY DR. H. HICKMAN,  
OF SHIFFNAL;

Member of the Royal Medical Societies of Edinburgh, and of  
the Royal College of Surgeons, London.

IRONBRIDGE: Printed at the Office of W. Smith.  
1824.

FIGURE 3.

sent to Charles the Tenth of France and recorded by the French Director of Public Establishments on August 7, 1828. This was referred to the Academie Royal de Medecine on September 28, 1828. The letter to the King of France refers to his experiments in causing "suspended animation" in animals and he says, "Hence it is to be

\* The author has been guilty in the past of repeating this error. Careful search, however, has failed to substantiate a relation of nitrous oxide to Hickman's experiments.

strongly inferred that the same salutary effects may be produced on the human frame, when rendered insensible by means of introducing certain gases into the lungs." No details are given and no mention by name of nitrous oxide or other "certain gases" is made. Hickman's claim received no further notice in Paris or elsewhere until 1847. It appears possible that at this time he gained undeserved credit for having used nitrous oxide. A letter from Horace Wells, setting forth his claims, was presented to the French Academy on February 23, 1847. During the discussion of Wells' letter by the Academy, Gerardin said:

"Seventeen or eighteen years ago the minister of the Royal Palace sent to the Academy a letter from an English doctor which set forth the different means of deadening sensibility during surgical operations. Among other means, nitrous oxide was mentioned. According to custom, the Section elected a committee of which I had the honor of being reporter. I need not say that this proposition met with much incredulity. One member only, Baron Larrey, said that it deserved the attention of surgeons."

It seems probable that Gerardin's memory played him false in recollecting specific mention of nitrous oxide in Hickman's Letter.

Without question, Hickman did suggest the abolition of pain during surgical operations and performed experiments upon animals to prove that it could be done with carbon dioxide. I have found no proof that he used or even mentioned nitrous oxide. Evidence is lacking at present that either Hickman or Wells or any other of the "discoverers" of surgical anesthesia were familiar with the book published in 1800 by Humphry Davy. Perhaps the unhappy title, an obscure publisher and the youth of the author deprived it of the audience which it so richly deserved.

#### COLTON

In the northwestern corner of Vermont near the shore of Lake Champlain lies the town of St. Albans. Here in the late 1830's a boy with eyesight too poor to justify his continuing in school was apprenticed to a chairmaker at five dollars a year. Gardner Quincy Colton went to New York City as a journeyman maker of cane-seated chairs about 1840. With some financial assistance from a brother, he was able to enter the College of Physicians and Surgeons in 1842 and became apprenticed to the famous Dr. Willard Parker. Financial difficulties in 1844 forced the young medical student to do something drastic. Chemistry at this time was a rapidly expanding field of knowledge and students at the College of Physicians and Surgeons were learning of the recent scientific discoveries. With borrowed money the former bottomer of chairs rented a hall and advertised a popular lecture on chemistry. The exhilarating effects following the inhalation of various volatile and gaseous agents were a means often used at the time to demonstrate the startling new facts of chemistry. In rehearsing his lecture, Colton chose the administration of nitrous oxide to members of the audience as one means of enlivening the dryer portions of a dissertation on pure science. The lecture was satisfactory in every respect. The net proceeds are said to have amounted to five hundred and thirty-five dollars. With such success behind him, a road tour was arranged. By the administration of nitrous oxide, several times a week, considerable experience and presumably skill were acquired by the medical student-lecturer and demonstrator. Colton's itinerary reached Hartford, Connecticut, on



the evening of December 10, 1844. The story is a familiar one of how Horace Wells, the dentist, attended this lecture, volunteered to inhale



FIG. 4. Gardner Quincy Colton.

nitrous oxide and noticed a fellow volunteer bump his shin sufficiently to draw blood while affected by the gas although he had no realization of the injury or pain connected with it.

It ought to be noted that American dentistry was making rapid strides at about this time. Technical skill in the preparation of false teeth had advanced to such a point that the removal of useless teeth in preparation for artificial replacements was frequently desirable and always painful. Being under the necessity of inflicting such suffering in his daily practice and realizing that if the useless teeth could be removed without pain, many more patients would become candidates for the prosthetic replacements, Wells was in a position to appreciate the practical value of this effect of nitrous oxide which he had observed at Colton's demonstration. An appointment was made for the lecturer to bring his nitrous oxide and inhaler to Wells' office the next morning. One of Wells' teeth was extracted without pain. Thus the first administration of nitrous oxide for the painless extraction of a tooth took place in Hartford, Connecticut, on December 11, 1844. Wells made the mistake that remains a common one to this day. He overemphasized the importance of the drug rather than of a thorough knowledge of its effects and of skill in its administration. Colton, who had had experience and therefore possessed considerable knowledge of nitrous oxide and skill in giving it, went on with his lecture tour, never suggesting by word or deed that he ought to share in the

credit for the first administration of surgical anesthesia. He was emphatic in later years that the idea belonged entirely to Wells. The more familiar one becomes with the men who claimed a share in the honor of being the discoverer of anesthesia (Collyer, Long, Wells, Jackson, Morton and others), the more certain one is that Gardner Q. Colton was as deserving as any. His attitude was always gentlemanly, modest and truthful.\* The chemical lecture tours were expanded to

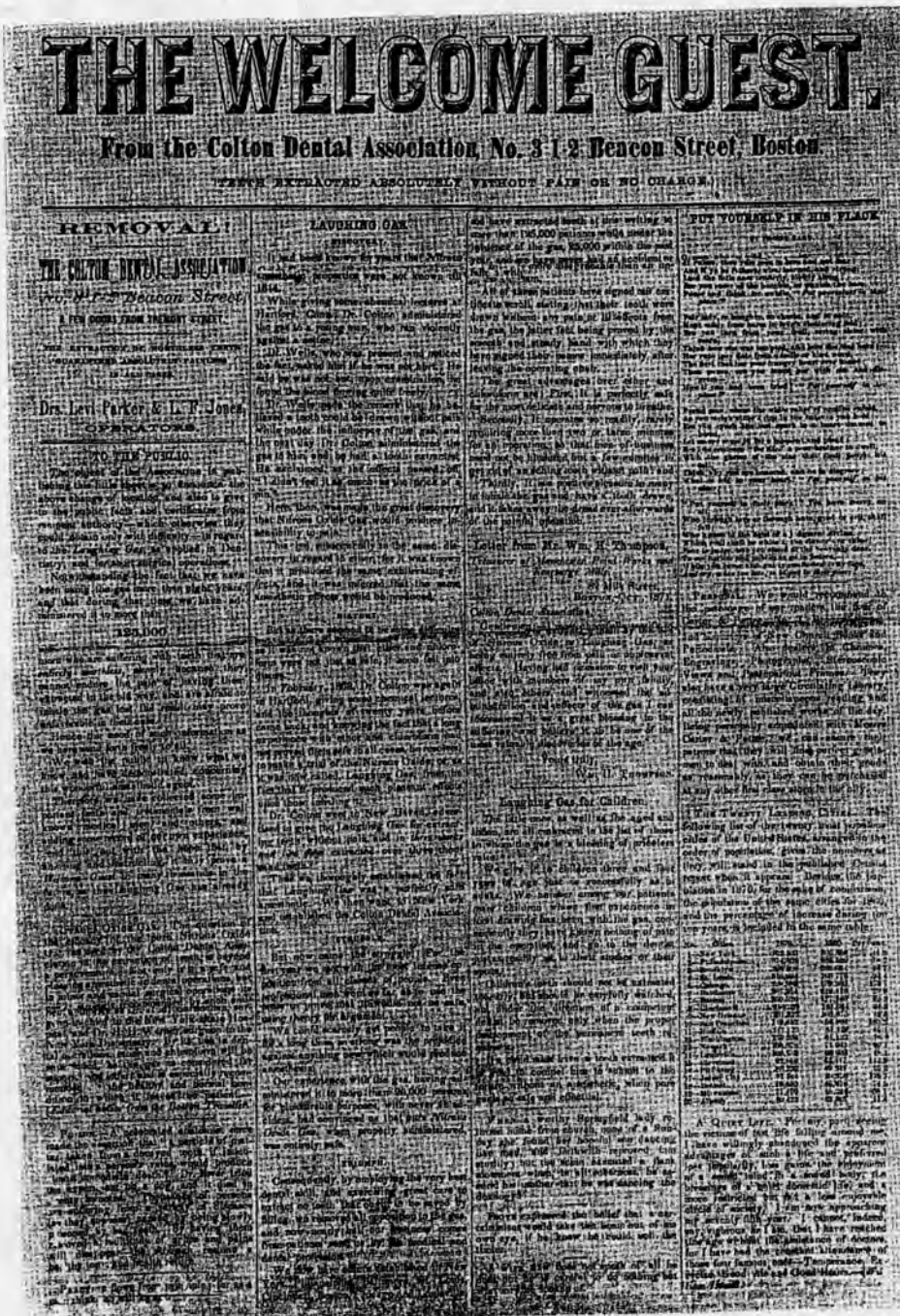


Fig. 5a. Reproduction of a page from "The Welcome Guest" is through the courtesy of the Library and Museum, The American Society of Anesthetists, Inc.

\* During the discussions on nitrous oxide in Great Britain in the year 1868, Charles J. Fox, a member of the Royal College of Surgeons, had Colton as a guest in his home for a week. He intimated that the visit was arranged more or less as a test of Colton. Fox's opinion was emphatic that Colton was capable, a gentleman, modest, unassuming and thoroughly honest.

include electricity and Samuel F. B. Morse is said to have given Colton some financial support for his help in popularizing the telegraph. An electric motor designed by Colton in 1847 is preserved in the Smithsonian Institute as one of the earliest models produced in this country. It was never patented. In 1849 he joined the "Gold Rush" and practiced medicine on the West Coast. He was appointed the first Justice of the Peace of the new state of California by Governor Riley.

Bigelow, who published a paper in the Boston Medical and Surgical Journal for November 18, 1846 reporting Morton's demonstration of "letheon," used nitrous oxide once for the amputation of a breast. At the first meeting of the American Medical Association in Baltimore in 1848, he described the case and the technic by which he administered nitrous oxide on April 26, 1848. The operation, amputation of a breast, lasted six minutes, and fifteen gallons of gas were used. He believed that the anesthetic qualities were destroyed in the body and hence, by a pair of valves, prevented reinhalation or rebreathing. However, with the exception of the few cases anesthetized by Wells, ether and chloroform chiefly occupied the attention of both physicians and dentists in this country and abroad for the first two decades following the introduction of anesthesia.

Colton lost the considerable savings of his California experience through unfortunate investments in the east and again became financially embarrassed. In 1863, he began a new tour of popular lectures. Before the lecture in New Haven, Connecticut, a discussion took place between Dr. Joseph H. Smith and Colton with the resulting announcement at the lecture that patients who wished to have their teeth pulled under nitrous oxide anesthesia would be accepted at Dr. Smith's office in the days following. They came in great numbers. Colton administered the gas and Smith pulled the teeth. In a brief period, 1,785 teeth were removed. In July, 1863, Colton hired John Allen "the best dental extractionist he could find" and opened an office in the Cooper Institute, New York City. This was the beginning of the Colton Dental Association. During the next few years, branches were maintained in many cities. Colton did no extractions himself but hired

## **COLTON DENTAL ASSOCIATION.**

3 1-2 BEACON STREET,  
BOSTON.

NEW YORK.

911 WALNUT STREET,  
PHILADELPHIA.

81 WEST FAYETTE ST.,  
BALTIMORE.

161 ELM STREET,  
CINCINNATI.

87 OLIVE STREET,  
ST. LOUIS.

90 WASHINGTON ST.,  
CHICAGO.

FIG. 5b. List of addresses of Association offices appearing in "The Welcome Guest."

competent dentists as associates. He was, so far as can be learned, well recognized for his skill, honesty and ability. The association offices all kept a register of patients' signatures. Each patient signed *after* his teeth were pulled and before leaving the office; in other words, within a few minutes of having been anesthetized with nitrous oxide. Cox, after his visit with Colton in England in 1868, stated that the register then included 40,000 names, and Andrews in Chicago in the same year quoted the figure of 60,000.

#### NITROUS OXIDE IN GREAT BRITAIN

The introduction of nitrous oxide into the British Isles and the presence of Colton there in 1868 came about in the following manner. A World's Fair was held in Paris in 1867. The Emperor's personal dentist was the American, Thomas W. Evans. Being a man of exceptional ability and personality, he arranged an exhibit from the United States as a contribution to the Exposition. It consisted largely in a display of the medical and sanitary advances made by our army medical corps during the war between the States. During a trip home to gather material, Evans was told of the work of Colton. He in-



*Thomas W. Evans*

FIG. 6. Thomas W. Evans. Dentist to Emperor Napoleon III.

investigated and decided that nitrous oxide ought to be a part of his exhibit with the result that Colton took his generators, inhalers, etc.,

to Paris. After the Exposition closed (in the fall of 1867) Colton was invited to remain in Evans' Dental Office during the winter. Nitrous oxide was administered to over a thousand patients. After these experiences, Evans was convinced that the gas deserved wider popularity. He went to London and during the week preceding April 6, 1868, demonstrated the administration of nitrous oxide for the painless extraction of teeth in several places before many physicians and dentists. The modesty of Colton is again evident in that Evans gave the demonstrations although Colton's apparatus and methods were used. Evans was a master showman, Colton was not. The medical and dental journals of Great Britain for the remainder of 1868 contain

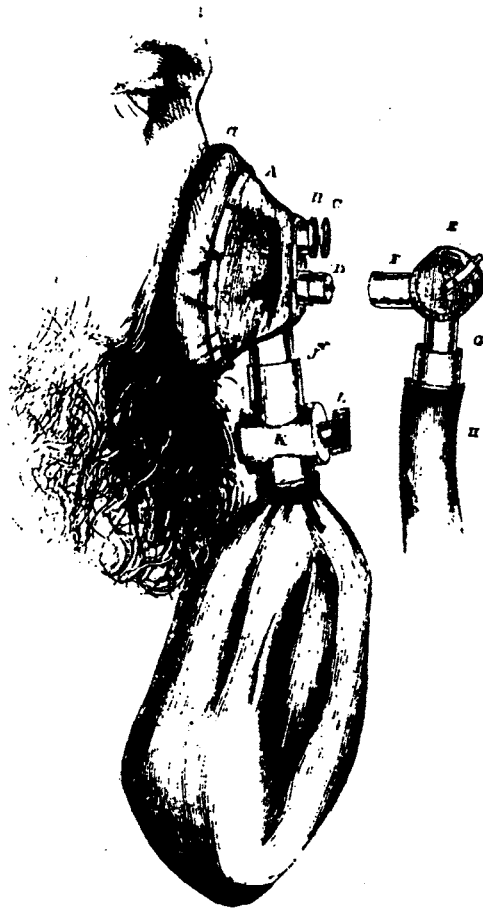


FIG. 7. An illustration from Clover's paper published in the British Journal of Dental Sciences for September, 1868.

innumerable articles, comment and discussion of nitrous oxide \* as an anesthetic agent both for surgical and dental operations. Among the physician anesthetists, Clover was the chief proponent and Richardson the chief opponent. Some of Sir Benjamin's remarks as president of the Medical Society of London in 1868 illustrate the reactionary viewpoint. He had not witnessed Evans' demonstrations nor had he made recent investigations of his own.

"It is painful to see," he said, "the childish excitement with which nitrous oxide and its effects have been recently dwelt upon. The gas has been treated as an unknown, wonderful and perfectly harmless agent; whereas in simple fact, it is one of the best known, least wonderful, and most dangerous of all the substances

\* The first announcement of the availability of nitrous oxide compressed in metal cylinders was made by Barth during this year.

that have been applied for the production of general anesthesia. . . . Nitrous oxide is not in the true sense the agent that causes the insensibility . . . it acts indirectly and the immediate stupefier is carbonic acid. . . . There are two explanations of this . . . it may be that nitrous oxide quickens the oxidation of the blood; and so causes accumulations of carbonic acid or . . . more probably, it acts by checking the outward diffusion of carbonic acid. . . . To make an animal breathe nitrous oxide is virtually equivalent to making it breathe carbonic acid itself." \*

Clover, on the other hand, was present at the demonstrations, recording carefully what he observed. He did many animal experiments and administered the gas to patients in preference to ether or chloroform on many occasions. Clover devised new inhalers and was a pioneer in the use of nitrous oxide as an induction agent before the inhalation of ether vapor. His influence was undoubtedly a major one in the continuous popularity of this gas for short surgical and dental operations in Great Britain from 1868 to the present day.

#### OXYGEN AND NITROUS OXIDE MIXTURES

With our present views regarding hypoxia and anoxia, it is difficult to believe that literally hundreds of thousands of patients were anesthetized by the use of nitrous oxide, with no admixture of oxygen and with few if any serious accidents. The reason lay in the recognition of its limitations. Nitrous oxide was not given to patients suffering from serious physical abnormality or disease, the degree of hypoxia was watchfully limited, the duration of administration was brief, and no attempt to produce muscular relaxation was ever made. Only the relief of pain was sought. The speed of induction, however, was attractive to the surgeon and the immediate and complete recovery from its effects was attractive to the patient. Compared with the tranquil anesthesia of ether and chloroform during operation, the results left much to be desired. The necessary brevity of administration was a handicap.

The November 1868 number of the Chicago Medical Examiner (Vol. IX, p. 456) contains an article entitled "The Oxygen Mixture—A New Anesthetic Combination" by E. Andrews, M.D., Professor of Principles and Practice of Surgery at the Chicago Medical College. In a glass jar, kept free of carbon dioxide by means of lime water, Andrews compared the effect of nitrous oxide on rats with the effect of a mixture of one quarter oxygen and three quarters nitrous oxide. A rat in nitrous oxide fell over in two minutes, showed labored breathing with decreasing rate until it died at the end of ten minutes. Another rat, exposed in a similar experiment to a mixture of 25 parts of oxygen and 75 parts of nitrous oxide, was completely anesthetized in two and one-half minutes, evidenced no panting or labored breathing and remained anesthetized for one-half hour at the end of which time it was removed from the chamber and recovered completely within ten minutes. A few brief administrations of the mixture to his own patients were cited and Doctors Rogers and Reber, dentists, were mentioned, the former having used the mixture for several years. The following is quoted from Andrews' paper:

"Some months ago such a mixture was proposed in England but was overthrown, I think, by the influence of Dr. Richardson, who argued, on theoretical ground merely, that it would not be successful or safe. I cannot learn that it was ever actually tried in Europe."

\* Seventeen years later (1885) Richardson said of nitrous oxide, "It is an admirable anesthetic for short operations, and although not absolutely free from danger, death having occurred under its influence, is unquestionably by far the safest of all known general anesthetics. Deaths probably not more than one in 100,000 administrations."

His final conclusion was that the best proportion for the mixture was likely to prove one-fifth oxygen and four-fifths nitrous oxide.

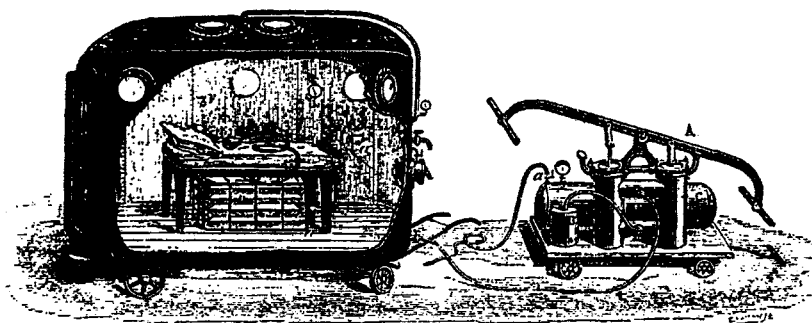


FIG. 8. A portable operating room for the application of Bert's technic as illustrated in Buxton's Text (1888). Buxton's legend is in serious error regarding the pressure used. Possibly it is also evidence of his lack of familiarity with this method which he credits to Fontaine.

Just ten years following Andrews' publication, Paul Bert read a paper before the Academy of Sciences in Paris (November 11, 1878) in which he made the statement that pure nitrous oxide was necessary to produce surgical anesthesia and that one-sixth of the respired atmosphere must be oxygen to maintain physiologic demands. He proposed therefore to use for anesthesia an atmosphere of one-sixth oxygen and five-sixths nitrous oxide administered under positive pressure of one-fifth of an atmosphere. Thus Bert believed that profound anesthesia and at the same time adequate oxygen in the tissues could be maintained. A large chamber was constructed in which pressure could be controlled. The first patient was anesthetized for an operation in such a chamber by M. Leon Labbé on February 13, 1879.

It soon became evident that the addition of oxygen to nitrous oxide was a distinct advantage. It was also obvious that neither the suggestion made by Andrews of using a predetermined and prepared mixture nor that of Bert of operating in a pressure chamber was entirely practical. The adage "what is one man's meat is another man's poison" applies very aptly to the dosage of all anesthetic drugs. To make every surgical operating room a controlled pressure chamber would be very expensive and the use of it inconvenient. The practical solution of the problem of administering mixtures of oxygen and nitrous oxide has been a gradual and still imperfect development from the time of Andrews and Bert to the present. Many dentists, physicians and manufacturers have contributed to it. The story of the interesting characters concerned with nitrous oxide since 1880 must be told at another time.

Improvements in the administration of nitrous oxide will doubtless continue to be made in the years to come. There is a tendency just now to abandon the use of this gas in some quarters for two reasons. The first because of the technical danger (or the professional temptation) of depriving the patient of enough oxygen. The second because nitrous oxide does not produce the pharmacologic effect which results in flaccid relaxation of skeletal muscles. Certain desirable qualities, however, will permit this agent to retain a deserved popularity in future years. Abolition of the sense of pain without the loss of consciousness (analgesia) can be more easily and more satisfactorily produced with nitrous oxide than with any other drug. Comfort and speed of induc-

tion of anesthesia are only equalled by the effect of cyclopropane and certain drugs when injected into the blood. No other drug leaves the body so rapidly. Hence a patient is restored to normal, following anesthesia with nitrous oxide, more quickly and completely than after the administration of any other agent. Further improvements in the technic of administration and a wiser choice of adjuvant drugs can, I believe, bring nitrous oxide to a position of usefulness which it has not yet enjoyed.

Dear Fred,  
Thanks for air surgeon.  
Hope things are going well & you.  
Birds are beginning to sing  
here which makes me wonder,  
Spring? End of War?  
Anyway I hope  
meantime best wishes  
for everything  
Ralph.





## ABSORPTION OF CARBON DIOXIDE FROM ANESTHETIC ATMOSPHERES: HISTORICAL ASPECTS \*

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SCIENTIFIC achievement may be said to consist in the establishment of facts of nature plus their combination into relationships which accomplish a useful purpose. Today we celebrate the centennial of the first public demonstration of a very important scientific achievement, surgical anesthesia. The volatility of ether, its passage through the alveolo-capillary membrane into the blood, and the retention of its identity while in the body were all important facts which had to be combined with knowledge of its pharmacologic effects before the usefulness of inhalational anesthesia was established. During the past century innumerable scientific facts have been gathered from centuries past, combined with current contributions and put to useful purposes. Thus, we hope that anesthesia is becoming a science as well as an art. We venture, still with some trepidation, occasionally to use the word "anesthesiology." On the other hand, in our struggle to become scientific we must guard against the real danger of losing our art.

Among the gleanings from the long past, the simple grosser facts of respiration remain the most important and useful to us as anesthetists. We ought to remember that the century previous to the one we celebrate (1746-1846) witnessed the first knowledge of why we breathe; the identification of oxygen, its absorption by the blood and the fact that carbon dioxide is produced and cannot be re-inhaled for long if unconsciousness and convulsions are to be avoided. It is with this latter fact, that is the elimination of carbon dioxide, that my remarks are to be concerned.

During the period when our ancestors were concerned hereabouts with Tea Parties in the harbor and arguments expressed with lead on a nearby hill, a protestant minister's avocation was the study of "the doctrine of air." By fortunate accident, Joseph Priestley lived next door to the "public brew house of Jakes and Nell" in Leeds, England. A free and unlimited supply of that kind of air which we call carbon dioxide lay like a thick heavy blanket over the surface of the fermenting wort in the beer vats. Jan van Helmont had called it "gas," Scheele

\* Read at the Ether Centennial, Boston, Massachusetts, October 16, 1946.

in Stockholm was calling it "aerial acid" and Black, a Scottish contemporary, "fixed air" because he could release it from crushed minerals like chalk and marble by the action of acids. Priestley used Black's term "fixed air" for carbon dioxide and "dephlogisticated air" for oxygen while Scheele called oxygen "fire air."

The science of chemistry was in its swaddling clothes. Knowledge of the physiology of respiration included only the fact that, like a candle flame, an animal could live but a limited time in a completely closed space. It was recognized that blood going *to* the lungs was dark and that returning *from* the lungs bright red. The reason for the change, however, was difficult to determine because of false "knowledge." Priestley, and Scheele, his contemporary in Stockholm and co-discoverer of oxygen, were constantly bedeviled in explaining their experiments by the necessity of accounting for "phlogiston," a fictitious product of fire and animal life which their predecessors believed they had proved to exist.

Both Scheele and Priestley used alkali to absorb carbon dioxide. That the identity of the alkaline absorbent varied seems probable from the results of their experiments. Scheele refers to the use of "milk" of lime and Priestley to "lime water." Scheele's famous bees lived in the atmosphere of "fire-air" which he provided for them when the "aerial acid" was absorbed. Priestley, on the other hand, was unsuccessful in similar experiments. Perhaps you will bear with me if I quote the matter in his own words. In Volume V, Page 158 of "Experiments and Observations on Different Kinds of Air," he wrote:

"My friend Dr. Ingenhousz has announced,\* what he thought to be a very valuable discovery, of the Abbe Fontana's with respect to the breathing of dephlogisticated air; and had there been no mistake in the business, it would have been a discovery of the very first magnitude. It is a method of making dephlogisticated air serve thirty times longer for respiration than when it is breathed in the common way, so that a pound of nitre would yield dephlogisticated air sufficient for the respiration of a man a whole day.

"The Abbe Fontana,' he says, p. 46, 'found that an animal breathing in either common or dephlogisticated air, renders it unfit for respiration by communicating to it a considerable proportion of fixed air, which is generated in our body, and thrown out by the lungs as excrementitious. This fixed air is easily absorbed by shaking it in common water, but infinitely more readily by the contact with quick lime water.'

"Then, after describing a method of breathing this air, which is by introducing a syphon through the water into the vessel containing air, he says, that the discovery consists in using lime water instead of common water. 'The Abbe,' he says, p. 48, 'found that the dephlogisticated air being, after each respiration, purified again by the lime water, still remains good about thirty times as long as it would when breathed in the ordinary way, and that thus the quantity of dephlogisticated air necessary for one minute will now serve for breathing during half an hour, and thus the expense will be thirty times less.'

"This language supposes that the Abbe had not only *reasoned* upon the case, but that he had also *verified* his reasoning by actual experiment; because it is said that he *found it to be so*. On the contrary, I can neither find any such thing in fact, nor the least colour for the expectation of it in reasoning; there being no advantage whatever in breathing dephlogisticated air in the manner that Dr. Ingenhousz describes. And his hypothesis concerning the nature of the injury that is done to air by respiration is manifestly erroneous. For the precipitation that is made of fixed air is nothing more than a *circumstance* attending the respiration of common or dephlogisticated air, the proper effect of that animal process

\* Added to the Preface of "Experiments Upon Vegetables" by John Ingen-Housz. See figure 2.

being, as I think I have fully demonstrated, the *phlogistication* of the air; and therefore, though the precipitated fixed air be absorbed ever so readily, the remaining air will be but very little the better for it. For if we were to mix much more than that proportion of fixed air with the air that we breathe, we should not perceive it to be at all inconvenient to us.

“It was but reasonable, however, that the assertion of so eminent a philosopher, and the assertion of a fact, should be tried by fact.”

Therefore, he tried the experiment but it did not succeed for Priestley; a mouse in “dephlogisticated air” (oxygen) over common water and another over lime water lived the same length of time. It seems fair to conclude that Priestley used a clear solution of “lime water” which he had used as a qualitative test for carbon dioxide as we do today whereas what has been translated from Scheele’s German as “milk of lime” and the alkali used by Fontana were different substances. Priestley was an honest and accurate experimenter. Does it not seem probable that, had he used a more adequate absorbent for carbon dioxide than the very inadequate “lime water,” even his strong loyalty to traditional authority would have been shaken? How much more productive his work might have been and how greatly might his fame have been enhanced if the experiment of Fontana had succeeded in his hands and “phlogiston” thus early had been banished from his reasoning. He returned to the experiment later (Vol. V, p. 368) and described a mouse which died in pure dephlogisticated air but he concluded that it died of cold.

That Priestley’s interest in means of absorbing carbon dioxide was not confined to lime water is evident from the following description of experiments made in 1771–1772 (Vol. I, p. 53).

“These experiments abundantly confirmed my conclusion concerning the restoration of air in which candles had burned out by plants growing in it. This restoration of air, I found, depended upon the *vegetating state* of the plant; for though I kept a great number of the fresh leaves in a small quantity of air in which candles had burned out and changed them frequently, for a long time, I could perceive no melioration in the state of the air.”

Finally, in view of the centennial we celebrate today, perhaps I may be permitted to quote one more passage from Priestley (Vol. I, p. 35).

“The manner in which I made several experiments to ascertain the absorption of fixed air by different fluid substances, was to put the liquid into a dish, and holding it within the body of the fixed air at the brewery, to set a glass vessel into it with its mouth inverted. This glass being necessarily filled with the fixed air, the liquor would rise into it when they were both taken into common air if the fixed air was absorbed at all.

“Making use of *ether* in this manner, there was a constant bubbling from under the glass, occasioned by this fluid easily rising in vapour, so that I could not, in this method, determine whether it imbibed the air or not. I concluded, however, that they did incorporate, from a very disagreeable circumstance, which made me desist from making any more experiments of the kind. For all the beer, over which this experiment was made, contracted a peculiar taste; the fixed air impregnated with the ether being, I suppose, again absorbed by the beer.”

Because of the rather general neglect by practicing physicians of the new scientific facts being discovered by Priestley, Lavoisier and their contemporaries, it should bring us some satisfaction to note the work of Edmund Goodwyn, a physician who published a masterly experimental study of drowning in 1786. Although he gave no details, his methods

appear to have been those of Lavoisier. The accuracy of his analyses of expired air testify to the adequacy of the absorption of "fixed air."

Separation of carbon dioxide from atmospheres containing nitrous oxide is described by Humphry Davy in "Researches, Chemical and Philosophical chiefly Concerning Nitrous Oxide or Dephlogisticated Nitrous Air and its Respiration" [1800]. On page 393, he records experiments in which he breathed a measured quantity of nitrous oxide to and from a spirometer as long as he could. Then, after the gas was transferred through mercury into a graduated cylinder, a small quantity of "concentrated solution of caustic potash was introduced into it and suffered to remain in contact with it for some hours." From such experiments he determined "that nitrous oxide is rapidly absorbed by the venous blood."

Apparently Davy was not yet entirely convinced of the source of carbon dioxide. To establish the fact that it came from the blood and not by combination of carbon and oxygen in the lungs he breathed a measured amount of hydrogen (p. 401) as in the above experiment because this gas was not absorbed by the blood as were nitrous oxide and oxygen. After the experiment "the carbonic acid was separated from it by means of solution of potash or strontian."

The systematic concepts of Antoine Lavoisier eliminated the conflicts and misunderstandings so that at the beginning of the Nineteenth Century it was established that respired air became irrespirable through the loss of oxygen and the addition of carbon dioxide. Several means



FIG. 1. Title page of the first publication of Scheele's work. It was translated into English in 1780. (Kindness of T. Gordh from the Library of the Karolinska Institute, Stockholm.)

of removing carbon dioxide from respired atmospheres had been employed. Fontana used "quick lime water," Scheele "milk of lime" and Davy "concentrated solution of caustic potash" and possibly of strontium (strontian). Unfortunately, Priestley failed to verify Fontana's experiments. He sought other means of "purifying" respired air. His use of growing plants is interesting and of ether, under the circumstances, amusing.

It is not surprising therefore, that the first scientific anesthetist should have availed himself of the simple chemical reactions already demonstrated to remove carbon dioxide from anesthetic atmospheres. Whether John Snow was aware of the work done in the Eighteenth Century is uncertain because the studies of respired atmospheres by Regnault and Reiset were published in 1849. These appear to have been the immediate stimulus of Snow's experiments. In the fifteenth of his series of articles "On Narcotism by the Inhalation of Vapours," he said:

"About 750 cu. in. of oxygen gas in a balloon was attached to one of the apertures of the spiral box which forms part of the ether inhaler I employ. Four ounces of solution of potassa were put into the inhaler and to its other opening was attached a tube connected with a facepiece without valves."

In a separate dish within the box he placed 15 minims of chloroform or  $2\frac{1}{2}$  drams of ether and inhaled the same oxygen and vaporized agent for periods of twenty minutes. Narcotic effects upon himself short of unconsciousness developed rapidly (three minutes in the case of ether) and were maintained until the mask was removed after twenty minutes. In a footnote, Snow said:

"I used the same arrangement in giving oxygen gas last year at the request of Dr. Wilson, to a cholera patient in St. George's Hospital. The patient who was in a state of collapse, was not saved or relieved by it."

In the often mentioned paper entitled "The Oxygen Mixture" E. Andrews, in 1868, described experiments with small animals in mixtures of nitrous oxide and oxygen. A glass jar was used with a "false floor" under which was placed a layer of lime water. To enhance the efficiency with which carbon dioxide was absorbed, lime water was also sprayed into the jar at frequent intervals.

A major portion of the British Journal of Dental Sciences, in this same year of 1868, Volume XI, is occupied with reports of the revival of interest in nitrous oxide.\* On page 442 is a communication from Alfred Coleman calling attention to his suggestion on April 25 that carbon dioxide could be absorbed from nitrous oxide so that it could be re-inspired. The letter stated that he had used such a technic in over 100 cases. He said, "The agent I employ for removing carbonic acid and aqueous vapour is quick lime recently and only partially slacked." The apparatus used is not well described nor is the reduction in the necessary quantity of nitrous oxide stated. I have searched, so far without success, for a more complete description of Coleman's work.

We have seen, therefore, that in the Eighteenth Century the fact was established that atmosphere when it is breathed becomes irrespirable through the removal from it of oxygen and the addition to it of

\* Thomas W. Evans, an American Dentist practicing in Paris, visited London in April 1868 and demonstrated the methods of manufacture and administration of nitrous oxide originated by Gardner Q. Colton.

carbon dioxide. Davy's experiments proved that nitrous oxide was soluble in the blood, that it was not destroyed in the body and that oxygen could be added to it with advantage and carbon dioxide removed from a mixture of nitrous oxide and air or oxygen without destroying either the oxygen or the nitrous oxide.

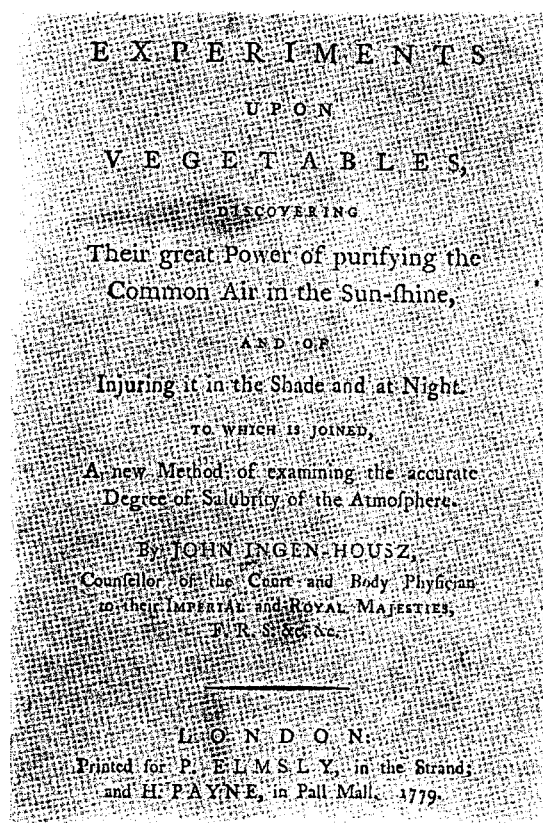


Fig. 2. At the end of the preface of this book, Ingen-Housz wrote, "When this book was entirely printed, and nothing but the latter end of the preface unfinished, I was informed by my friend the Abbe Fontana, that he discovered a few days ago a new method of procuring to a sick person the benefit of breathing any quantity of dephlogisticated air at a cheap rate." This was followed by a description of the absorption of carbon dioxide from an atmosphere of oxygen respired for long periods. These facts were later published by Fontana himself and probably constitute the first description of the absorption of carbon dioxide from atmospheres respired by human beings. (Courtesy of Library of the University of Wisconsin.)

In the Nineteenth Century, along with the public demonstrations and acceptance of surgical anesthesia, it was proved that chemical removal of carbon dioxide from mixtures of oxygen or air and anesthetic vapors could be accomplished without destruction of the anesthetic vapors just as it could without destruction of nitrous oxide. In other words, the necessary facts were established to permit the employment of a method in surgical anesthesia which we now call absorption technic. The combination of these facts into relationships which accomplish a useful purpose remained to be completed in the present century.

Early efforts after 1900 tried to apply "absorption" technic in clinical anesthesia by placing the "absorber" far from the patient without means of assuring contact of the expired atmosphere with the alkali. Such a mistake is illustrated in a paper by Franz Kuhn. The late Ira McKesson, after 1915, manufactured some experimental canisters to insert between the ether-vaporizer-rebreathing unit and the long breathing tube which connected the face mask to his apparatus. This was similar to Kuhn's plan. One of my own early efforts was an attempt

to reverse the position of McKesson's canister by placing it between the mask and the long tube and enlarging the rebreathing cylinder and bag.

The use of fused sodium peroxide, to absorb the carbon dioxide and water vapor of expired air while liberating oxygen as a result of the reaction, has received little or no attention by anesthetists. The paper by Brindley and Foregger, in 1906, is, so far as I know, the only one in the American literature and the "useful purpose" sought by them was the purification of the atmosphere of ships that sail under the seas.

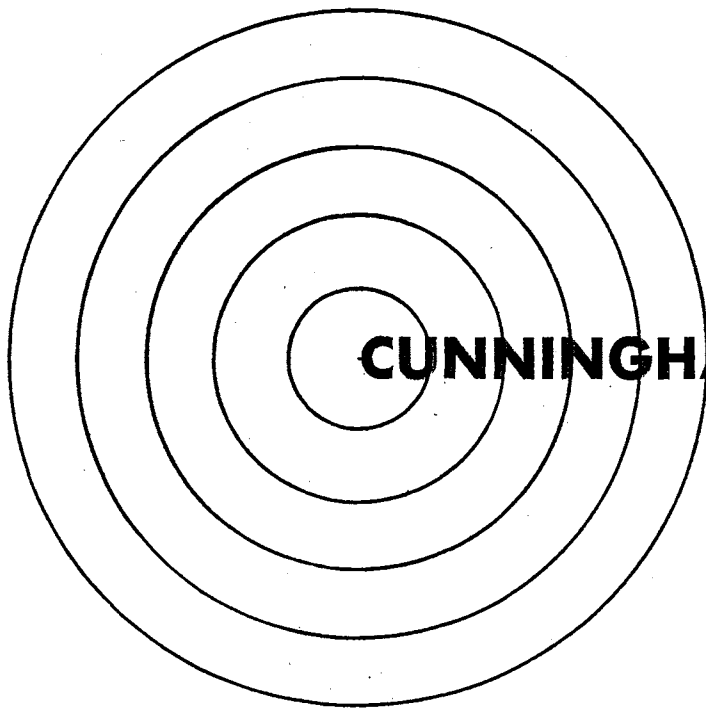
All anesthetists are familiar with the various ways in which facts established in the long past have been combined by the epoch-making work of Dennis Jackson and others who have followed him. The absorption of carbon dioxide from anesthetic atmospheres is a common technic in almost every modern operating room throughout the world. It is universally abused as well as used. Many physiologic sins are committed in its name. Its advantages sometimes mask these abuses.

If modern chemists and engineers can construct a warship which can safely and comfortably carry a large number of men for days and weeks at or near the bottom of the ocean, they *should* be able to help us construct an anesthetic apparatus of small bulk and cost which can "keep pure" indefinitely, the atmosphere respired by a single patient.

One of these days, the wizardry of modern chemistry which "improves upon nature" every week may devise for us a "super-vegetating plant" so much more efficient than those observed by Ingen-Housz and Priestley that it can eliminate carbon dioxide and produce oxygen at controlled rates while it adjusts the temperature, humidity and pressure of the anesthetic atmosphere. For the future, our concern must be to find how many established scientific facts we have failed to consider and how many new facts may be discovered, and combined with the old ones, in order to eliminate the abuses as well as increase the usefulness and safety of absorption technic.

#### REFERENCES

- Andrews, E.: The Oxygen Mixture, a New Anaesthetic Combination, Chicago Med. Exam. 9: 656-661 (Nov.) 1868.
- Brindley, George, and Foregger, Richard: Report on Experiments with Fused Sodium Peroxide on the Regeneration of Air for Submarines, Trans. Am. Electrochem. Soc. 9: 291-301 1906.
- Davy, Humphry: Researches, Chemical and Philosophical chiefly Concerning Nitrous Oxide or Dephlogisticated Nitrous Air and its Respiration, London, 1800.
- Fontana, Abbé Felix: Recherches Physiques sur la Nature de L'Air Nitrous et de L'Air Dephlogistiqué, Paris, 1776.
- Goodwyn, Edmund: The Connexion of Life with Respiration, London, 1788.
- Ingen-Housz, John: Experiments Upon Vegetables, London, 1779.
- Jackson, D. E.: A New Method for the Production of General Analgesia and Anaesthesia with a Description of the Apparatus Used, Journal of Lab. & Clin. Med. 1: 1-12 (Oct.) 1915.
- Kuhn, Franz: Perorale Tubagen mit und ohne Druck. III Teil, Deut. Zeit. f. Chirurg. 81: 63-81 (Jan.) 1906.
- Priestley, Joseph: Experiments and Observations on Different Kinds of Air, Vols. I and V, 1781.
- Regnault, V., and Reiset, J.: Recherches Chimiques sur la Respiration des Animaux des Diverses Classes, Ann. de Chim. et de Physique 26: 299-519, 1849.
- Scheele, C. W.: Chemische Abhandlung von der Luft und dem Feuer, Upsala, 1777.
- Snow, John: On Narcotism by the Inhalation of Vapours, London Medical Gazette N.S. 11: 749 (Oct.) 1850.



## CUNNINGHAM THEORY

## REVISITED

*The January-February 1965 Editor's Choice, entitled "The Fallibility of the Forrestian Principle," by Lyle M. Sellers, M.D., has created considerable interest among our readers.*

*Dr. Ralph M. Waters' recent letter to the Editor is self-explanatory.*

*Because of the many comments, the Editorial Board has decided to reprint the original article by Orval J. Cunningham, M.D., entitled "Oxygen Therapy by Means of Compressed Air," which appeared in the April 1927 issue of Current Researches in Anesthesia and Analgesia.*

— Editor

February 10, 1965

To the Editor:

This is a long-delayed letter to you.

I really must tell you how much I appreciate your having republished Dr. Sellers' defense of Orval Cunningham. I have only the regret that the defense was left to a laryngologist when it was the duty of an anesthetist to do it. Such defense was very long overdue.

I should explain that, in 1923, I moved from Sioux City, Iowa, to Kansas City, where I bought the office of Morris Clark, an anesthetist of that city for some time. He had physical disability which he attributed to the constant inhalation of ether vapor. I had heard of Cunningham and one of the first things I asked for in my introduction to the town was to meet him. During the next three years I had many visits with C. and often visited his place. The enclosed picture is one taken inside the large "tank" illustrated in Sellers' article. The dignified lady

first on the right of the picture is the Mother of Mrs. Waters, who had at that time a very annoying arthritis of the sort sometimes spoken of at that time as "post-menopausal." It was the one thing which C. was sure he could arrest, relieve the pain and stop further progress. The routine was to advance the pressure rather slowly, hold it at three atmospheres for roughly three weeks and then a gradual reduction to normal pressure. His explanation, given very modestly and tentatively, was that anaerobic organisms might be concerned in the etiology of the disease. He told me that the whole thing started in his mind as a cheaper way of administering oxygen therapy. (In Sioux City I had done considerable work in a minor way with the administration of oxygen by insufflation into the pharynx through a catheter via a nostril. So his work interested me from the start.) I liked and respected the man. He was a gentleman and honest as could be in my estimation. I left Kansas City for Madison, Wisconsin, in February 1927.



When the row started about the big globular structure which Timkin built in Cleveland and the American Medical Association criticism, I should have protested.

Now Dr. Sellers has made such a defense but it should have come from an anesthetist and long since. We should, however, be most grateful to Dr. Sellers for correcting a fault which rests squarely on the specialty of anesthesia.

I might add a few thoughts about Kansas City at that time. Cunningham had had what was probably the nearest to a real department of anesthesia at the University of Kansas, and for some time before 1920. I cannot remember the name of the surgeon who was the dominant factor in that region at that time, but he was an outstanding figure and believed thoroughly in professional anesthesia. The town was the finest in which to work of any of which I had knowledge in those days. The profession worked together in a way I had not experienced before that—or after that either. Logan Clendening was the outstanding internist and an excellent practitioner as well as historian and author. Dr. Orr, a younger man, had recently

taken over the Chair of Surgery at the University and was anxious to restore the good work of the days of Cunningham. It was the rule, not the exception, for anesthetics to be administered by physicians throughout the town. I first found Sir Fredric Hewitt's textbook in general use there. I must confess I was not familiar with that first text of anesthesia before that time.

Would you be kind enough to thank Dr. Sellers for me for doing what we ought to have done years ago.

With much gratitude and especial thanks for reproducing the article by Dr. Lyle M. Sellers in the January-February 1965 number, I am

Most sincerely yours,

/s/

RALPH M. WATERS, M.D.  
Orlando, Florida

P.S. I might add that Grandma Katie swore by Cunningham's therapy ever after. When "twinges" returned, I had to set up an O<sub>2</sub> cylinder in her room as a substitute. The "tank" she was in was like a Pullman car and comfy.



Grossmutter Katie (right foreground) in Cunningham's pressure chamber for her arthritis. Kansas City. 1925.

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## Oxygen Therapy by Means of Compressed Air.\*

Orval J. Cunningham, M.D., Kansas City, Mo.



THE METHODS OF THE ADMINISTRATION of oxygen or oxygen enriched air have been by means of face masks, breathing tubes, or various kinds of inclosures. The objections to these methods are such as to render their practicability questionable. A face mask permits of considerable (usually about 50 per cent) rebreathing. A patient usually tires of holding a breathing tube in the mouth longer than about thirty minutes. Where the exhalation is not separated from the inhalation as in the use of inclosures (tents, cabinets, chambers, etc.) about 30 cubic feet per minute of the respirable gas is required for each patient in order to prevent an undesirable accumulation of carbon dioxide. The expense of the manufacture of oxygen in such quantities is almost prohibitive except for use experimentally. To remove the carbon dioxide by means of soda lime over a considerable period of time, say several days, is not altogether satisfactory as it does not remove the other impurities.

### General Considerations

THE USE OF compressed air furnishes oxygen to the patient at any tension and for any length of time within physiological limits and in any amounts desired.

A pressure of thirty pounds above atmospheric pressure (forty-five pounds absolute) is equivalent to an air enriched by oxygen to an extent of approximately 60 per cent. The cost of the equipment is about \$10,000 per patient and the cost of operation and the furnishing of thirty cubic feet of air per minute per individual at thirty pounds positive pressure is within the reach of the average patient.

The equipment consists of three steel inclosures or tanks—a small experimental tank and two tanks eleven feet in diameter and about 100 feet long. As these patients are under the treatment several days continuously, means are provided for their comfort and entertainment such as radios, phonographs, pianos, telephones, attractive furnishings, bath rooms, etc. The longer treatments are taken only at intervals and the time between the treatments is spent in the sanitarium. The dosage is varied from 10 to 50 pounds per square inch above atmospheric pressure and in duration from 3 hours to 31 days. Most of the treatments are for 3 hours, 9 hours, and seven

days, with pressures at 20, 15 and 30 pounds above atmospheric pressure respectively. In the seven days treatment the last 48 hours is used for decompression. We use what we call a uniform step decompression.

The compressed air is purified by water scrubbing and conditioned by freezing out the excessive moisture to the extent that when the temperature is raised to 72 degrees Fahrenheit the relative humidity is about 65.

### High and Low Altitudes

I BELIEVE our eight years of use of compressed air indicates its mechanical practicability. Therefore, the next consideration would be, is compressed air a means of oxygen therapy—do we get more oxygen into the tissues and is it of therapeutic value? If compressed air is proved to be a means of oxygen therapy then the voluminous literature on oxygen therapy is at once applicable to our work. Many tests have shown the physiological effects of high altitudes and the use of low barometric chambers which, of course, is the reverse of our work. We know empirically the effects of high altitudes in pneumonia, certain heart conditions, hypertension and some of the "rheumatisms", and that it has been the general custom for many years in many parts of the world to send the more severe of these cases to lower altitudes. These conditions quickly respond to a greater or less extent to the compressed air treatment.

The fact that under compressed air

\*Read during the Sixth Annual Meeting of the Mid-Western Association of Anesthetists in Conjunction with the Kansas City Fall Clinical Conference, Baltimore Hotel, Kansas City, October 12-16, 1926.

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an excessive amount of gases is absorbed to the extent that if the pressure is too rapidly released, bubbles of nitrogen and oxygen (mostly nitrogen) which has gone out of solution can be found all through the tissues, is suggestive. If the tissues did not absorb excessive amounts of gases there could be no Caisson disease.

Paul Bert, after extensive animal experimentation with compressed air and determining the oxygen content of the various tissues reached the following conclusions—that with one additional atmosphere of air pressure, at the end of five hours, all the tissues of the body contain ninety per cent more oxygen in solution than under normal atmospheric pressure. He also showed that the normal oxygen tension of the various tissues differed greatly and that some of the tissues, such as nerve, bone and connective tissues, have a low oxygen tension.

### Anerobic Infections

**I**T IS IN accordance with the trend of modern thought that this is a factor in determining the site of infection of many germs. This, I believe is especially true with the fixed anerobes. We would expect to find them principally in nerve tissues, lymph, ends of the bones, indurated areas, etc.—in fact in places where the blood supply is poor.

We are using the treatment principally for anerobic infections or diseases which because of their response to the treatment and the tissues which they invade we believe to be due to anerobic infections. It is well known that the spirochete of syphilis is an anerobe. Our results with syphilis would indicate that the proper use of compressed air has a destructive effect on the spirochete pallida. The general physical condition of most of these patients greatly improves and their Wassermann tests become and remain negative. Also tabetic pains when present are quickly relieved.

The response to the treatment of diabetes mellitus, hypertrophic arthritis, and pernicious anemia has been such as to indicate that the cause of these diseases are also anerobic infections and that many of these cases are apparently cured by the use of compressed air. Disregarding the possibility of relapse after long intervals of time I believe it is safe to say that many of these cases are cured. You will recall that all of these diseases may invade the nervous system. A point of special interest is a disap-

pearance of the nerve complications of pernicious anemia in those cases that have responded to the treatment.

The beneficial effects of compressed air in the treatment of asthma has long been known. We have also been using it for hay fever. Many of these patients with these diseases have had no return of their disorders. We have found that the anaphylactic shock produced by the injection of sheep cells into the veins of sensitized rabbits is quickly relieved by replacing the animal under compressed air.

We have had encouraging results with five of twenty-seven cases of hopeless carcinoma. There have been recurrences in two cases where the tumors had apparently disappeared. The following facts are reasons for believing that carcinoma is due to an anerobic germ.

1. It usually occurs past middle life when the oxidative processes have diminished.

2. It attacks epithelial tissue which does not have a rich blood supply and therefore less oxygen.

3. Its metastasis is by way of the lymphatic system. Lymph has a low oxygen tension.

As negative evidence the converse is true of sarcoma which are reasons for believing that sarcoma is due to an erobic germ.

1. It usually occurs early in life.

2. It attacks mesodermic tissue which, for the most part, has a rich blood supply.

3. Its metastasis is by way of the blood stream which is rich in oxygen.

### Relations to Anesthesia and Acidoses

**T**HE ABOVE has been stated briefly because this paper is being read before an association of anesthetists and has but an indirect bearing on anesthesia. The anesthetist is interested principally in the physiological effect of the treatment and its possible application to anesthesia. Can it be used advantageously in certain conditions for some hours or days preceding the anesthetic in the way of preparation? Or used by administering the anesthetic and performing the operation under compressed air to secure a better or safer anesthesia, or using the compressed air treatment following the operation for the purpose of treating and preventing anesthetic or surgical shock, or perhaps some combination of the above? How will it influence the use of anesthetic agents? Will it help to answer the question if

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anesthesia is due to a lowered oxidation. As no conclusive work has been done on this phase of the subject we can at this time approach it only theoretically.

For the most part, the troubles of the anesthetist have to do with acidosis. The treatment has a beneficial effect with edemas in general. The acute edema of rheumatism is usually relieved within a few hours. Coincident with this, is a decrease in the red cell count—sometimes as much as twenty-five per cent. It is also observed at this time that the veins are more prominent. Also in cases where no visible edemas exist we often get a lowered red cell count. It would seem that the blood volume has been increased and that the increased fluid has come from the tissues in general. As edemas and at least some of the acidoses are directly associated with, or are different manifestations of the same process, it would seem that at least some of the acidoses have as a cause or a result a lowered oxidation and that the condition can be benefitted by the use of compressed air. Also there are

subjective symptoms to substantiate these conclusions, such as a feeling of exhilaration, well-being, better endurance, promotion of sleep, etc.

C. F. Nelson, in his recent article, "The Relief of Experimental Arterial Anoxemia by Compressed Air," shows that rabbits under twenty-one pounds positive air pressure show an average increase in the arterial oxygen saturation of 4.2 per cent. He also shows that the anoxemia produced by the pleurocentesis and the collapse of one lung was quickly eliminated when the animal was placed under compressed air. He also injected into the lungs of rabbits a 20 per cent solution of gum arabic until the arterial oxygen saturation was lowered from 30 to 40 per cent. The use of twenty-one pounds of air pressure for thirty to sixty minutes completely relieved the anoxemia and the original oxygen saturation was re-established.

The value to the anesthetist of a remedy that will remove or relieve an anoxemia is obvious.

3310 HARRISON AVE.

# ***PROFESSIONALISM***

## THE ANESTHETIST AND HIS "POWER OF ATTORNEY"\*

RALPH M. WATERS, M.D., Sioux City

Member American Association of Anesthetists; Member Interstate Association of Anesthetists

The anesthetist, the world over, recognizes that the doctor is the hardest patient he is asked to put to sleep. A doctor's fear of the ordeal is oftentimes beyond all reason when one realizes that he knows the chances of an accident in figures better than anyone else. He will travel farther and make more fuss to get into the hands of an anesthetist in whom he has confidence than he will to get to his favorite surgeon.

In wondering why this is true I have come to the conclusion that it is not so much because he fears the lack of skill in administering the agent used as it is hesitancy to surrender his "power of attorney," (I cannot find another word which expresses my meaning) to one in whom he has not absolute confidence that the judgment used for him, in his absence while he is asleep, will be at least as faithfully made as he would make it were he conducting his own affairs. What I mean is that a doctor looks for an anesthetist who will endeavor, as nearly as may be, to take his place mentally while he is unconscious.

A doctor should be an excellent criterion by which to be governed in such a matter, so that I wish then, in this paper, to make a plea that the anesthetist appreciate more fully the responsibility in assuming "power of attorney" for the patient while he is unconscious. During most of the great events of our lives, times of storm and stress, we are able to be, or at least try to be, at our very highest pitch of mental alertness. The one great exception to this rule is during a major surgical operation; and what greater day of physical storm and stress is an individual required to experience than the twenty-four hours covering the time, previous to, during and after a major operation. And yet the stress is so great in this case that one must be unconscious to bear it at all. Is not the reason for the doctor's greater timidity simply that he realizes more clearly than the layman what an extensive physical ordeal he is facing and is extremely reluctant to relinquish his mental supervision during that time?

Modern surgery has become so complicated and exacting that the surgeon can no longer be asked to look after the condition and welfare of the patient before and during operation. The anesthetist must do it. Oftentimes the consulting internist is of the greatest assistance but he is not always available and his relation to the patient during the operation, when he is present, does not permit him as good an opportunity to observe data available as does that of the anesthetist.

Therefore, I maintain, the anesthetist must assume the power of judgment in the patient's behalf, which the patient surrenders with the advent of unconsciousness. In other words the anesthetist must take up, along with the duty of properly administering the drug used, the administration of the patient's usual mental activities in so far as such action is necessary for the best welfare of the patient. A lawyer calls the power to act in his client's stead "power of attorney" and, as before stated, I know of no other term which aptly expresses the meaning: I want for this relation of anesthetist to patient.

In order properly to administer full duty to the patient the anesthetist need but vividly imagine himself in the patient's exact position sixty times each minute during the period of the ordeal. For instance, if at the pre-anesthetic visit the night before the operation he finds the patient frightened beyond reason at the prospect of the ordeal tomorrow at least an attempt should be made to get some rest for that patient during the night and see that a fitting pre-operative hypodermic be administered sufficiently long before the operation in the morning. If a pulse pressure is found exceeding in millimeters of mercury the whole diastolic pressure or a pulse pressure of less than 20 millimeters the surgeon can doubtlessly be persuaded to postpone the operation until the circulatory system can pick up to a safe point.

Last summer during the hot weather I was asked to anesthetize a gentleman of seventy-six years for prostatectomy. At the pre-operative visit his systolic blood-pressure was seventy with diastolic about ten millimeters less. A delay of several days of rest and abundant liquids gave us a diastolic pressure of 70 millimeters and systolic 110, when nitrous-oxid-oxygen was administered for one-half hour with little change in pressures. I think the result might have been different had we anesthetized him when first asked.

These pre-operative observations are made, to be sure, while the patient is conscious, but are made with "eyes" which the patient has not and therefore our judgment should rule instead of the patient's, under our "power of attorney." Next morning it may be advisable that the patient ride to the operating room instead of walk. It uses energy to walk through a long corridor and up-stairs to an operating room, and at such a time every calorie of energy saved may be worth while when we are playing with a narrow margin.

On the operating table the patient is scared and likely to think that remarks are not in order. If the table is hard, poorly padded and cold the patient will not mention it. The anesthetist should see that the table is warm and comfortable.

Oftentimes the surgeon and nurses get over warm in a room at 80 degrees Fahrenheit and believe it 110 degrees, and order a window up. Discomfort for surgeon and nurses is less harmful to a patient than a draught on an exposed perspiring body.

Who can best judge whether further operative procedure is wise on a person driven physically

\*Read before the Seventh District Medical Society, Sioux Falls, South Dakota, December 3, 1918.

into the "last ditch" by rough abdominal surgery, retractors and extensive gauze packs? And who is the better judge as to when enough of such procedure has been dealt, and that the patient had better be hurried to bed; the surgeon who can see a few coils of intestines and some iodine painted skin of the abdominal wall, perhaps, or the anesthetist with finger on pulse and charted readings of systolic and diastolic pressure and respiratory rate, color, sweating, et cetera? Often is it wise to leave that appendectomy after a hysterectomy and do it a few weeks later and if indications are that the wise procedure is to wait and get out, the anesthetist must use "power of attorney" and call quits.

Three weeks ago I was asked to anesthetize a woman for a trachelorrhaphy and cystocele operation. She was a strong, well looking woman of forty-five. An exploratory laparotomy first revealed a large gall-bladder packed full of stones. This bladder was removed without opening, the procedure requiring considerable rough retraction and pulling on deep structures. Though at no time was her pulse over a hundred the pulse pressure came within ten millimeters of the value of the diastolic indicating the wisdom of a secondary operation for the vaginal work. Later this was done with a beautiful recovery from both anesthetics without shock either time. Had all the work been done at once I am satisfied that a very stormy three days would have followed the procedure with even a possible unhappy result.

On the other hand a record sheet lies before me of the following case: "A man aged fifty-one, weight one hundred pounds. Abdomen opened for diagnosis. Jackson's membrane found and relieved, a thick gall-bladder with stones, and a hard ulcer of the pylorus present. When a gastroenterostomy was finished, at the end of forty-five minutes, the surgeon inquired as to the condition of the patient. Pulse-pressure and pulse-rate were little changed and further operation was advised. After resection of the pylorus pulse rate was under eighty and systolic 158, diastolic 90. Recommended removal of gall-bladder. Total time, two hours. Without a careful chart of the five minute readings of pressures with other data available, operation would doubtless have been discontinued without removing the pathological tissue. The recovery justified in every way the extended operation."

When the operation is finished and the patient is started for his room, unconscious, reflexes not returned, shall we cover him up with quantities of blankets on a warm cart that has had hot water bags on it or, just because he is unconscious and won't complain, shall we half cover him with feet and shoulders sticking out while passing through cold, draughty halls? And who but the anesthetist with "power of attorney" will see that such care is taken? Unless he goes to the room and watches, it will not be done in many hospitals, I am sorry to say.

And now if the reflexes are still absent and vomiting possible, the anesthetist cannot still "keep himself in the other fellow's shoes" and go away and run the risk of inhaled vomitus unless the patient is in a safe position and a nurse reliable and properly instructed is available to whom to hand over the "power of attorney."

Speaking of a safe position for the patient leads me to say a word in regard to position during and after tonsillectomy. I consider anesthesia for tonsillectomy one of the most hazardous risks we are asked to take. I will tolerate only two positions during operation. One the lateral with mouth turned down, the other sitting upright with body and head inclined forward. While returning to bed and after, until reflexes are under control, the prone position with one shoulder propped on a pillow and face to the side is routine. Tolerant of other positions than these, I believe courts an accident sooner or later.

Is it not reasonable to believe that many, if not all cases of "anesthetic pneumonia" could be avoided if the anesthetist were thorough in the preanesthetic examination and used the "power of attorney" boldly in every case throughout the period of unconsciousness? Beginning pneumonias operated for abdominal lesions are responsible for many cases of "post anesthetic pneumonia," and are not others traceable to exposure, dampness, and careless handling during and after operation? If the average healthy person stood for the bodily exposure and sudden changes of temperature imposed upon many a desperate risk, a good chance of acute respiratory infection as a sequel would be had.

Is not many a case of severe post operative shock brought on by extending operative procedure to fields which could be invaded with better judgment at a later time?

There are cases where extended procedure is wiser than a secondary operation but without the careful judgment of one who has the data in hand it is hard to pick the right case for the prolonged procedure. The anesthetist should have the data and should make the judgment.

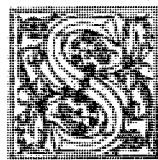
Is not the dorsal position after a tonsillectomy before reflexes are regained, with inhalation of secretions, blood and vomitus a possible source of danger? Why should we take the risk? Why not always use the prone position and let gravity keep the airways free?

Let us close then with a plea that when you administer an anesthetic you do so with a realization of the importance of the undertaking; appreciate your "power of attorney" and do not be afraid to use it. That is what you are employed for by the surgeon and what you are paid for by the patient.

826 Frances Building

## The Requirements of an Anesthesia Service.\*

Ralph M. Waters, M.D., Anesthetist, Madison, Wisconsin



SINCE I DO NOT KNOW of a completely adequate anesthesia service in any hospital in our country, I shall have to idealize to some extent in presenting to you what I personally consider the desirable requirements of such a service. My remarks can be placed under six headings: (1) Personnel; (2) Interdepartmental Relations; (3) Material Equipment; (4) Records and Filing Systems; (5) Undergraduate Teaching; and (6) Research Activities.

### Personnel

THE PERSONNEL of an anesthesia service in a modern hospital should, in my estimation, be headed by a fictitious individual with the following qualifications. He should first of all be an excellent practitioner of medicine, preferably with previous experience in general practice of the art, because he will come in contact with, and handle the patients of all of the various specialties in medicine as well as the patients of the general practitioner. He must have sympathy and forbearance with each one of these fellow practitioners whose patients come under his care. He must have respect for their help and advice. In addition, he must have many of the qualifications of a physiologist, pharmacologist, physicist, chemist, engineer, and anatomist. The drugs and methods used in pain relief constantly interfere with the processes of respiration both external and internal, with cardiac output, and with oxygen delivery to the cells of the body. The biochemical state of the body is prone to be deranged previous to the need for surgery. Pain-relief drugs are well known to still further upset the biochemical balance. Without a knowledge of physiology, at least in these particular respects, the head of an anesthesia department is handicapped.

The effect of drugs which are used for relief of pain, and a knowledge as to whether new drugs have been sufficiently studied is essential. Only

\*Read during the Tenth Annual Congress of Anesthetists, the International Anesthesia Research Society in Joint Meeting with the Associated Anesthetists of the United States and Canada, the Eastern Society of Anesthetists, Clinical Congress of Surgeons Week, Hotel McAlpin, New York City, October 12-16, 1931. From the Division of Surgery, University of Wisconsin Medical School and State of Wisconsin General Hospital, Madison, Wis.

by close contact with current pharmacologic literature can this knowledge be assured. Only by a background of training in pharmacology can one judge of the reliability of recently published reports on the usefulness of drugs suggested for pain relief.

Compressed gases and volatile liquids are among the agents necessarily used in anesthesia. The laws of physics govern the behavior of these gases and vapors. The action of partial pressures of mixtures of gases, solubilities, specific gravities, and countless other physical problems come up for solution in the everyday life of the anesthetist.

The apparatus necessary for the control of compressed gases, for the vaporization of liquids, and the maintenance of proper conditions for their absorption by the various membranes of the body make necessary a knowledge of engineering as well as of physics. Some of the agents commonly used, and which will be used in the future, are highly explosive. The electrical phenomena found in the operating room, flash points of various mixtures, electrical equipment in the operating room, and so forth must all be familiar to the anesthetist if he is to foresee and prevent danger.

The proper placing of locally acting drugs to block sensory and motor nerve activity requires an intimate knowledge of anatomy. Complete familiarity with the superficial bony landmarks, either when covered by a millimeter or a hundred millimeters of subcutaneous tissue, is desirable. I am picturing an ideal chief of an anesthetic service. I know of no head of any anesthesia department, or any physician anywhere who has all of the requirements. I know, for instance, of the head of one anesthesia department



who has the most beautiful anatomical laboratory that I have ever seen, not excepting those of the true teacher of anatomy. I know of an anesthetist who is an excellent mechanical engineer. I know of anesthetists who are good physiologists and good pharmacologists. I know of many whose knowledge of physics is adequate, but I know of no one who combines all of these qualities to the extent that I would consider him to be the ideal head of an anesthesia department.

The chief should be chosen with a view to fulfilling as many of the requirements which I have cited above as possible. He may be a part-time or full-time servant of the hospital. If the hospital is large, he will of necessity be a full-time worker. In the smaller institutions, a part-time worker may readily do other types of practice in addition. There should at least be a definite head of the department. There should be some one individual in every hospital, a graduate in medicine, thoroughly grounded in the fundamentals of his subject and responsible to the hospital management for the conduct of pain relief in that hospital.

If the hospital is large, or if teaching of graduates or undergraduates is undertaken, there must be one or two assistants to the chief who are well trained and permanent members of the staff; especially is this true if research work is to be accomplished. An individual who spends too many hours each day in technical conduct of anesthesia is apt to be physically and mentally exhausted. New ideas and thoughtful solutions of problems are not likely to be products of an overworked staff.

One assistant or forty may be required. Need for further help will depend on the number of operating rooms provided, it is true, but it will also depend upon the amount of cooperation which the staff is willing to offer in arranging schedules so that ten rooms are not working at ten and one at one o'clock. The whole staff working at one time adds to the cost of operation. The assistants may be provided by one of three plans: (1) They may be full or part-time well trained medical graduates; (2) They may be graduates in process of train-

ing for anesthesia; (3) A part or all of them may be technicians. Whether the technicians are nurses or lay people matters little in my estimation. My experience has been that a nurse's training as such is of little or no value as groundwork for training in anesthesia. I know, for instance, of two orderlies in a hospital, either one of whom is, as an anesthetic technician, decidedly better than any nurse technician which I have seen. They are adaptable, teachable, and have had long experience. Some nurses make excellent anesthetic technicians, others make poor ones.

A knowledge of physics, physiology, pharmacology, engineering and anatomy is lacking in the technician as a rule and therefore in general I should say that the service will be found more satisfactory where medical graduates continue to be used both as assistants and head of the department.

Certainly developments and improvements in anesthesia will come from professionally manned services. Emergencies will be better met by anesthetists trained in medicine. The unusual case will be handled with more perfect satisfaction to the surgeon. I realize that there is at present an extreme shortage of good professional anesthetists in the United States. This is as one would expect where little attention has been paid to the training of medical graduates as anesthetists. Only by establishing departments of anesthesia in our hospitals and providing training for medical students and graduates, can we expect to supply the ever increasing demand.

#### Interdepartmental Relations

THE ANESTHESIA service must to a man appreciate that his function in the hospital is always that of a fellow worker. He is a helper of the surgeon in all types of surgery; an aid to the internist, neuropsychiatrist, and the other specialists. He does not come in contact, as a rule, with patients as his own patients. The first contacts with the public are usually made by other members of the staff. Every member of the anesthetic personnel must therefore be of the adaptable type who is willing to cooperate, who is willing to take suggestions, and

who is willing to make suggestions in a friendly manner. Only by general consultation with the various men who have come in contact with the patient previous to operation can the anesthetist learn what the situation is which presents and decide best how to handle it. No two cases coming to operation are alike in their condition or in their demands for pain relief.

The anesthesia department should have close contact with the other departments in a manner quite aside from that of pain relief during surgery. Block anesthesia can many times be of the greatest aid in a diagnosis. Eliminating a known anatomical area of pain by the use of this method will often give information as to the site of pathology. Hopeless, intractable pain, not amenable to surgical treatment, may often be relieved for long periods, or permanently, by the use of nerve block. Only by intimate association with the other departments of the hospital can the anesthetist know of these cases and offer his help in their solution. Oxygen therapy, requiring as it does the use of compressed oxygen, can often be greatly facilitated and put upon a more rational basis by the help of the anesthetist. Few doctors other than the anesthetist are familiar with compressed gases and machinery for their handling. None has a better conception of the physical signs of oxygen want. His advice and oftentimes his supervision is very helpful in the accomplishment of effectual use of oxygen as a therapeutic agent. The use of block anesthesia as a diagnostic aid and as a means of permanent pain relief, as well as the use of oxygen as a therapeutic agent, are coming to be realized by the profession as worthwhile procedures. As time goes on, further and further demand will be made for the help of the anesthesia department in solving the problems of the internist, the neuropsychiatrist and others.

#### Material Equipment

**T**HE AMOUNT of money that may be spent upon material equipment for anesthesia in the hospital is appalling. The manufacturers have kept decidedly ahead of the profession in the manufacture of various paraphernalia which the hos-

pital can be asked to buy, always for good round sums. A piece of machinery or apparatus in the possession of a hospital where no member of the staff has a working knowledge of this apparatus, is wasted money.

An anesthesia service is an economical part of the hospital organization if for no other reason than to prevent a waste of money in buying material equipment which is not efficiently used. It is probably not essential that any one gas or gases and apparatus for their employment be included in any anesthesia service. Perhaps vapors and non-volatile agents could be quite as efficiently used. The important thing is to provide a personnel that is capable of using the drugs and equipment provided in a masterly fashion, always with a background of physiology, pharmacology, and physics that will insure a minimum disturbance of the physiologic functions of the patients of that hospital and with a maximum contribution to their treatment and safety. I should consider, then, that the material equipment necessary to establish a good anesthesia service need not be altered until the personnel has been properly established, allowing the personnel to determine what developments or changes might be advantageous in the future.

#### Records and Filing System

**N**EITHER THE SURGICAL RECORD nor the record of the internist is made from the viewpoint of anesthesia. Many post-operative complications and many complications on the operating table are laid at the door of other causes than anesthesia, when anesthesia should be blamed. If the personnel is provided with a working knowledge of physiology many of these past mistakes will be brought out. Only by properly recording the observations of changes in physical signs and symptoms occurring in the operating room and following, will future improvement result.

As to what constitutes an ideal anesthetic record, there is no accord. The items routinely recorded by one anesthetist may serve his purpose ideally, and be quite insufficient for the use of another. Generally we may say that records must be made of the physical and mental condition

of the patient previous to anesthesia, during anesthesia, and after anesthesia. If these records are carefully made, including a follow-up system of the signs and symptoms that may possibly be laid to the door of anesthetic drugs or anesthetic procedures, information will be accumulated which will serve in the future to improve the methods used in that hospital.

Records, however, are valueless unless properly filed. To file anesthesia case records in a manner which will permit of learning what one wishes to know as to his results at the end of the year, requires a rather extensive cross index system. My personal efforts to solve the difficulty have not met with the happiest success. We are constantly trying to modify our system in such a way as to be able to learn what we wish to know of the particular things we have done during the year when the year's work is finished. We have improved, but we are far from perfection. Only by realizing the need for careful records and careful filing with adequate cross indices, will records be of value in determining what not to do and what we may do for the best good of our patients.

#### Teaching

THE PRESENT chaotic state of knowledge of anesthesia in the profession is largely due to the almost complete failure of the present medical curriculum to recognize knowledge of anesthesia as a qualification to practice medicine. The profession receives its instruction in clinical anesthesia from the detail men of the drug manufacturers and from the salesmen of anesthetic apparatus. Instruction in many schools is confined to the Basic Science Departments. Such instruction is good so far as it goes, just as teaching of these courses is essential as a background for the study of medical and surgical diagnosis.

The instructors in Basic Science Courses, however, are seldom individuals with clinical experience in anesthesia. Laboratory animals are not as a rule comparable to sick surgical patients. They do not come to operation with disturbed body chemistry. Their reactions to a given drug may be different than human reaction

to the same drug. The technical procedures permissible in the laboratory are often quite impossible in the operating room. Clinical instruction in the application of knowledge gained in the Basic Science Departments is essential to the development of skill in diagnosis and therapy. Rational pain relief is no less dependent on accurate diagnosis and wisely chosen therapy than is the alleviation or cure of a disease by the internist or surgeon. If anesthesia is to improve in the future, it must be through better instruction of the undergraduate and interne in the clinical application of the knowledge gained in his freshman and sophomore years spent with the Basic Sciences.

Our own efforts at the University of Wisconsin have met with improvement in the curriculum which is still far from ideal. Juniors now receive sixteen hours of combined lectures, demonstrations, and quizzes in clinical anesthesia. Each Junior acts once as anesthetist in the surgical technique course in the laboratory. Seniors have one week each in the operating room. This time is occupied with giving supervised anesthesia and charting of physical changes in blood pressure, pulse, and respiration. Pre-anesthetic examinations and post-operative follow-up visits are made each day. The time is insufficient, but gives each student some knowledge of the problems of anesthesia and their solution. In the crowded condition of the medical curriculum this has so far seemed to be the maximum of time possible for each student to devote to anesthesia. Internes serve one month each in anesthesia. Two residents in anesthesia serve two years each. The chief and one assistant complete the hospital and teaching staff.

#### Research Facilities

CERTAINLY every hospital which is connected in any way with a university or is in any sense a teaching institution, should be interested in the development of new methods and new drugs. The anesthesia department is in a particularly happy situation for the accomplishment of many investigative activities. If there are available laboratories of physiology and pharmacology, so much the better. The spirit of fellowship existing between

the clinical branches in the hospital and the anesthesia service should exist quite freely between the anesthesia service and the Basic Science Departments. The physiologists will find no more fertile field for observation of the changes in respiratory and circulatory physiology than by observing anesthetized individuals and those subject to the fear and strain of surgical treatment.

New drugs and methods are being constantly presented in the literature for the relief of pain. Some of them are dangerous, some of them are distinct contributions to our present armamentarium. The great teaching hospitals of the country must maintain research facilities in connection with their anesthesia services if they are to fulfill their duty to the profession. At the present time, numerous drugs are being marketed either as anesthetic agents or anesthetic adjuvants, some of which in the long run will be proved not only useless but harmful. Few are the available places in the United States where a new drug can be thoroughly investigated in the Pharmacology Department, turned over to skilled professional workers in practical anesthesia, and finally on having undergone all experimental tests successfully, receive a thoroughly checked clinical trial. Evaluation of new agents and methods requires the judgment of a physician who can bring to bear the combined viewpoint of physiology,

medicine, and technical knowledge of anesthesia in reaching conclusions.

#### Summary

**A**N ADEQUATE ANESTHESIA service must depend on six factors: (1) Sufficient personnel in quality and number to supply the staff demand. The essential feature of an anesthesia staff is a director who is a graduate physician with real interest and ability. Given these qualities, he will develop knowledge of anesthesia and staff and equipment to render good service.

(2.) Friendly relations with other departments of the hospital will offer maximum opportunity for usefulness.

(3.) Material equipment is a fertile source of waste. The anesthetist is the best judge of what drugs and equipment he needs to render the best service.

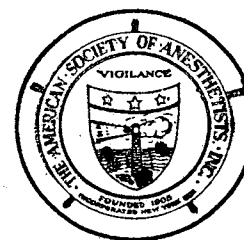
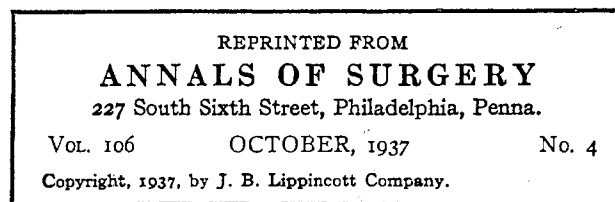
(4.) Records of preanesthetic and postanesthetic findings correlated with technique and late results are essential. If records are properly filed with cross references completed, much information would doubtless be available that is now lost to the profession.

(5.) Adequate clinical teaching of anesthesia for the undergraduate and graduate is essential if anesthesia service is to improve.

(6.) Research activities in anesthesia must be correlated with the clinical service in the specialty. Only so can reliable results be obtained.

STATE OF WISCONSIN  
GENERAL HOSPITAL.

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## ANESTHESIA AND SURGERY

RALPH M. WATERS, M.D., AND ERWIN R. SCHMIDT, M.D.

LIBRARY

MADISON, WIS.

FROM THE DEPARTMENTS OF ANESTHESIA AND SURGERY, UNIVERSITY OF WISCONSIN MEDICAL SCHOOL, MADISON, WIS.

ANTISEPSIS and later asepsis, together with anesthesia, made possible the development of modern surgery. Accepted by surgery, of the two it is only asepsis that was taken up whole-heartedly and developed. Anesthesia was gladly welcomed, but received little aid or stimulation either as an art or a science, by the surgical profession. Snow supplied a beginning scientific background for anesthesia; and, because the agents were potent enough to satisfy the demands of the surgeons, attempts to improve the status of anesthesia by medical men were frowned on by the surgical profession, and often deliberately hindered. This attitude placed anesthesia in the hands of young assistants who looked upon it as a necessary evil, a step, or a stage on their way to become a surgeon, or into the hands of the technician. This attitude has resulted in a distinct delay in the development of anesthesia as an art and a science.

The basis of this paper is derived from an association with medical men interested in the science and art of anesthesia, and is an attempt to correlate anesthesiology and surgery in a clinical way.

Anesthesia is produced by reducing the reflex activity of the nervous system. The reflex activity of the nervous system is directly proportional to the metabolic rate (Chart 1). Metabolic rate is variable, depending on sex, age, pain, emotion, fever, degree of muscular relaxation, and thyroid activity. The metabolic rate of a patient may be decreased by eliminating the factors of pain, nervous and muscular tension, thyroid activity, and fever. Pain and emotion are reduced by preoperative use of morphine, barbiturates, scopolamine, and nonvolatile drugs by mouth, hypodermic, *etc.* Thyroid activity, as in hyperthyroidism, is reduced by rest, food, sedation, and iodine. For each degree of fever, the metabolic rate is increased 7 to 8 per cent. If possible, the patient should wait for surgery until free from fever (Chart 2). These factors explain the reason for the varying amounts of agent necessary in the 100 per cent potent, and with the less potent agent demonstrate the impossibility of reaching a satisfactory stage of anesthesia (Chart 4).

The third stage of anesthesia has been divided into four planes (Chart 3). This has been made possible by observing certain physical signs as the anesthesia progresses up or down. Among these signs are the respiratory rate, the type of breathing, the abolition of the action of the intercostal muscles, the movement of the eyeball, the pupillary reaction with and without preoperative medication, the eyelid reflex, and the swallowing and vomiting reflex. The importance of making these finer divisions of the third stage becomes apparent (Chart 2). Many operations do not need third or fourth plane anesthesia, and many operations need a third or fourth plane anesthesia only for a short period and for a certain stage of the operation. Twenty minutes of third plane anesthesia may be as hard on a patient as two hours of second plane

anesthesia. Fourth plane anesthesia paralyzes the smooth muscle fibers of the blood vessels allowing the active circulating blood volume to be reduced and thus produces shock.

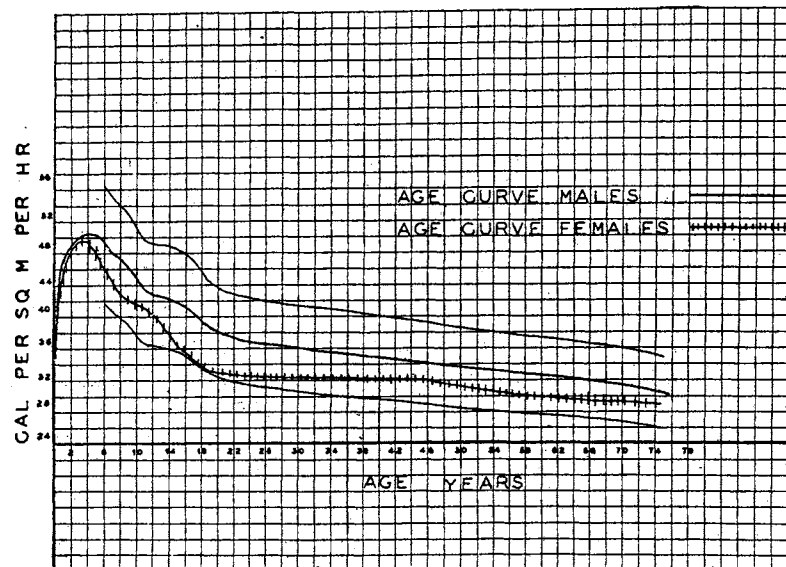


CHART 1.—The curves indicate the metabolic rate for male and female from birth to the seventh decade. The curve for males shows the limits of plus or minus variations of 15 per cent, which roughly delineates the range of "normal" variability. The curve for females is lower than that for the males. These curves, from ages six to 75, reproduce the latest Mayo Clinic predictions<sup>1</sup> with the single difference that their absolute values have been lowered by constant percentage amounts necessary to fit them to the measurements on normal subjects made over a period of years at the University of Wisconsin and State of Wisconsin General Hospital.<sup>2</sup> The curves below six years are idealized continuations that follow the general trend of the classic smoothed curve of Aub and DuBois.<sup>3, 4</sup>

The value of this finer distinction becomes more apparent in clinical surgery when we appreciate at what levels the various reflexes are abolished. It means a close cooperation between surgeon and anesthetist. As the operation progresses, the anesthetist can vary the depth of the anesthesia so as to eliminate the necessary reflexes to permit the performance of the operation, keeping the patient in the planes of anesthesia that are least harmful.

The various reflexes necessary to produce the clinical signs which are used in placing the level of anesthesia have been presented. A few other reflexes and the level at which they are abolished will be presented to show how these facts may be used to the advantage of the patient and the surgeon.

All reflexes as a result of skin trauma are abolished by anesthesia in the upper half of the first plane. Therefore for skin incisions this is sufficient. The reflex contraction of skeletal muscle is in proportion to the size of the muscle, the amount of traction stimulus, and the suddenness with which the stimulus is applied. Gradual stretching produces little or no response, and long continued stretching will produce a temporary paralysis of the muscle. Lower second plane anesthesia will abolish skeletal muscle contraction. Traction reflexes arise as a result of tugging or pulling on visceral structures. These are proportional to suddenness and the strength of the stimulus. The excitation of these reflexes results in: (1) Contraction of the abdominal wall with expulsion of the viscera; (2) stimulation of the respirations; and (3) adduction of the vocal cords. Even lower third plane anesthesia may not abolish these reflexes, but skeletal muscle response is abolished at the lower part of the second plane. By making traction gently, slowly, and continuously, the reflexes may not be irritated, and the necessity for the lower third stage anesthesia with the attendant paralysis of smooth muscle never arises. This

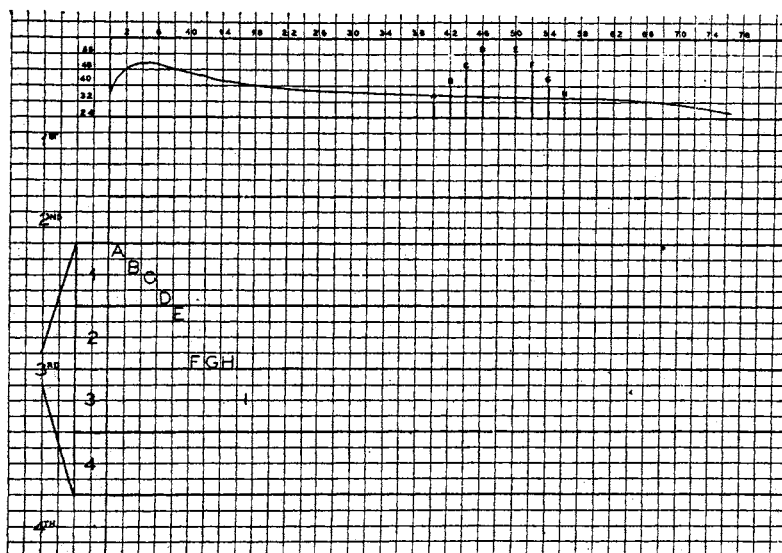


CHART 2.—With a metabolic rate of 24 calories per sq. Mm. of body surface, add the factor of fear and the rate is elevated as indicated by line A; pain will raise it as represented by line B; fever will give line C; and thyroid activity will result in line D. To depress this rate, barbiturates the night before will eliminate fear and give line F; the emotions are allayed and line G results; and preoperative medication with morphine and scopolamine will result in a lower rate—a much easier patient to handle. *Levels of Anesthesia at Which Reflexes Are Abolished:* (A) First part of first plane, third stage. Brain, bone, thyroid, breast, stomach, kidney, and other glandular tissues, except for traction reflexes from their coverings or attachments, are abolished. (B) Upper half of first plane, third stage. Skin reflexes are usually abolished at this level. (C) Below middle of first plane, third stage. Pharyngeal reflex is abolished. (D) Lower border of first plane, third stage, abolishes or renders negligible reflexes caused by injury to or cutting great sciatic nerve. (E) Junction of first and second planes, third stage, abolishes cough reflex. (F, G, and H) Lower level of second plane, third stage, abolishes or renders negligible muscle reflexes. The anal sphincter reflex may not be abolished by the fourth stage. The traction reflexes met with so frequently in abdominal surgery may be abolished but readily instituted by rough handling of the viscera. The subdiaphragmatic reflex, an adduction of the vocal cords usually upon expiration with a contraction of the abdominal muscles, may be present in the third plane; then intubation is preferable to deeper anesthesia. (I) Third plane, third stage, abolishes tone of smooth muscle when it reaches the middle of the plane (Guedel<sup>4</sup>).

is particularly true of the peritoneum. In closing an abdomen, application of forceps to the peritoneal edge and then pulling quickly on them stimulates these traction reflexes and changes the depth of anesthesia necessary from a second plane to a third plane or even deeper.

The upper plane of the first stage is sufficient to abolish the pain in surgical traumatism to bone, brain, thyroid, breast, kidney, spleen, liver, stomach, intestines and omentum. Their ligamentous attachments may be cut, burned, or crushed. Traction will cause some pain. Yet to perform an operation that may require an hour, only five or ten minutes need a third plane anesthesia; the usual procedure is to use the deepest stage of anesthesia necessary for any part of the operation and use it for the whole period. With a knowledge of the levels of anesthesia at which reflexes are abolished a competent anesthetist can gauge the depth so as to spare the patient and permit the surgeon to perform the operation. A competent anesthetist working with a surgeon not appreciative of these facts means that the type of anesthesia here described is impossible.

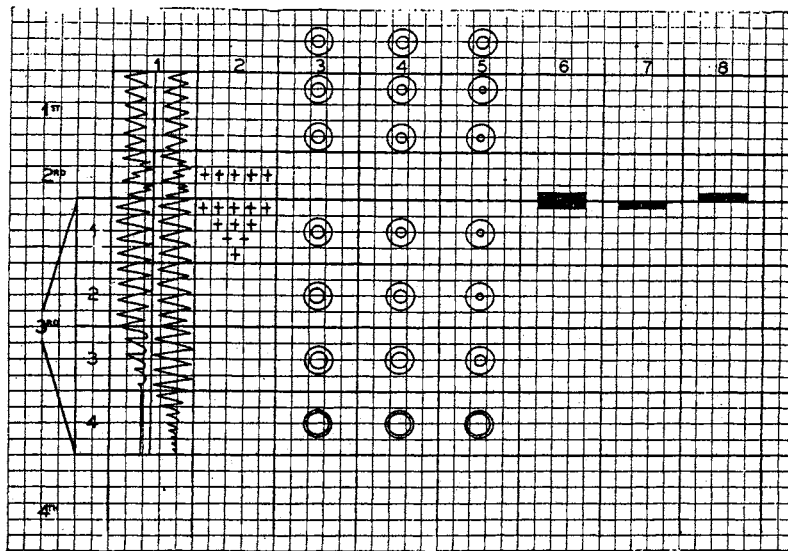


CHART 3.—Column 1 shows the respiratory motion. During the first stage it is fairly regular. There may be variations as a result of fear or emotions. The second stage has irregular breathing and when it becomes smooth indicates that the second stage is being entered. This smoothness persists until the lower part of the second plane when there is a beginning paralysis of the intercostal muscles. This paralysis becomes complete at the end of the third plane. The respiratory movement continues to decrease and the volume is less until the fourth stage is reached when respiration completely ceases. Column 2 represents eyeball activity. During the second stage there is marked eyeball activity. This continues into the third stage and becomes less the farther the anesthesia descends into the first plane, ceasing as the second plane is encountered. Columns 3, 4 and 5 show the reaction of the pupil in the different stages to no preoperative medication, to morphine and scopolamine, and to morphine, respectively. Column 6 shows the eyelid reflex which disappears as the third stage is entered. Column 7: In ascending anesthesia, as the patient reaches the upper part of the first plane of the second stage, the swallowing reflex returns, and as the second stage is reached the vomiting reflex becomes active (column 7). In descending anesthesia neither the swallowing nor vomiting reflexes are definitely placed (Guedel<sup>4</sup>).

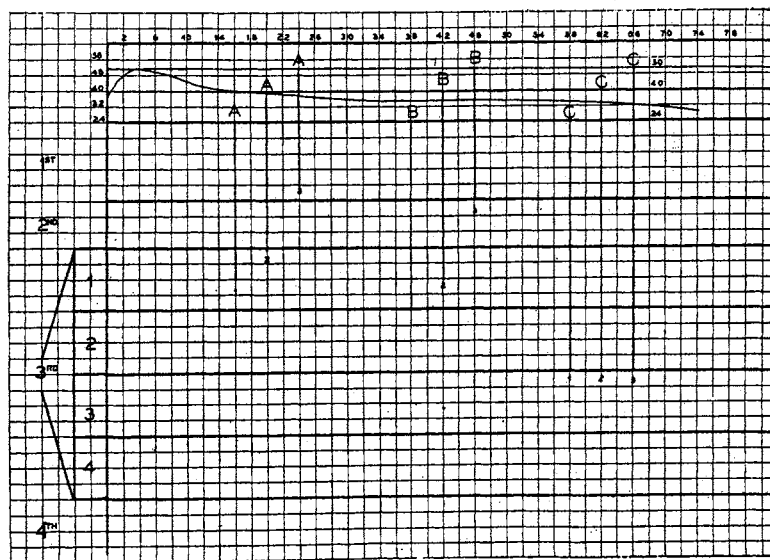


CHART 4.—Nitrous oxide: A-1—Starting at a metabolic rate of 24 calories per sq. Mm. of body surface will carry the anesthesia to the middle of the first plane of the third stage. A-2—Metabolic rate at 40 calories per sq. Mm. surface will reach only to upper margin of the first plane. A-3—Metabolic rate at 48 calories per sq. Mm. surface will reach the lower portion of the first stage. Ethylene: B-1—Metabolic rate of 24 calories per sq. Mm. surface reaches the lower edge of first plane, third stage. B-2—Metabolic rate of 40 calories per sq. Mm. surface reaches middle of first plane, third stage. B-3—Metabolic rate of 48 calories per sq. Mm. surface reaches lower portion of first stage. One hundred per cent potent anesthetic agents as chloroform, ether, vinyl ether, cyclopropane, and ethyl chloride can reach any depth of anesthesia; the amount of agent necessary will vary as shown by lines C<sub>1</sub>, C<sub>2</sub>, and C<sub>3</sub>, depending on metabolic rate (Guedel<sup>4</sup>).

#### REFERENCES

- <sup>1</sup> Boothby, Walter M., Berkson, Joseph, and Dunn, Halbert L.: *Am. Jour. Physiol.*, 116, No. 2, 468-484, July, 1936.
- <sup>2</sup> Stark, Marian E.: Unpublished compilations.
- <sup>3</sup> DuBois, E. F.: *Basal Metabolism in Health and Disease*. Lea and Febiger, 1936, p. 150.
- <sup>4</sup> Guedel, Arthur E.: *Inhalation Anesthesia—A Fundamental Guide*. The Macmillan Company, New York, 1937.



DISCUSSION.—DR. ARTHUR W. ELTING (Albany, N. Y.): I think we can safely say that today we are witnessing the birth of the science of anesthesiology. It is rather striking that over a large number of years there have been comparatively few papers presented to this Association on the general subject or the more intimate problems of anesthesia. I think in large measure that represents about the relative interest that the profession at large has taken in the subject of anesthesia.

As I remarked a few years ago on an occasion in New York, the reason why a large part of the anesthesia in this country is being administered by the trained nurse anesthetist was because the medical profession had failed in their job. The institutions of learning in medicine had not developed the proper teaching facilities. The profession, particularly we surgeons, had not demanded in our institutions properly organized, properly developed and controlled departments of anesthesia. Even today in very few institutions in this country are there such departments, but in some there are, and the heads of these departments are the forward looking men in the problem of anesthesia, its development for its practical avail to the patients and the surgeon, and for its usefulness in the training of doctors to give anesthetics.

I think we will all welcome the day when anesthesia in general is administered by the medical profession. That day, I believe, is not so far distant, not that I expect nurse technicians to disappear perhaps for a long time, because they have certainly been most effective and most efficient, but under the direction of a properly trained physician at the head of a department of anesthesia, their activities will become increasingly more useful.

It may be of interest to you to realize, as members of the American Surgical Association, that the first affiliated board to be recognized by the American Board of Surgery is the Board of Anesthesiology. Anesthesiology, therefore, becomes essentially the godchild of the American Surgical Association, and it seems to me that it is our duty as members of the American Surgical Association to further in every possible way the efforts of this small group, at present, but soon to be a larger group, of men who have devoted their interests, their time and their lives to the development of the science of anesthesiology.

Many of us have been more or less afraid of the possibilities of legislation in relation to anesthesia. Over the length and breadth of the country legislatures have been considering, and in one way or another threatening to limit us in the control of our anesthetic problems. I can assure you that this group who today represent the science of anesthesiology, who have been recognized by your Board, are a group of men from whom we shall expect to secure not legislation, but increasing education to the benefit of the patient and the surgeon.

DR. RALPH WATERS (Madison, Wis.) closing: Doctor Schmidt and I simply wish to make a plea for a little more coöperation between surgeons and the subject of anesthesia. Chronologically, the scope of the duty of the surgeon, like that of the whole medical profession, has progressed along a gradually widening road. In the long past the surgeon was concerned with the elimination of diseased tissue. Such removal implied first to cut it open, then to cut it off, and now, I take it, to cut it out. Both patient and surgeon were then satisfied if there was no pain and if death did not result.

The present day surgeon is, and the future surgeon will be, concerned with much in addition to the old duties of removing pathologic tissue. He will remodel the body and rewire the physiologic currents of life, not so much to prevent death, as to make living more abundant.

With such an aim, surgery can no longer depend for pain relief upon the anesthetic practices of former years. Pain relief must develop into a science, anesthesiology, if you will, a sister effort which will keep pace with the rapidly developing knowledge of the physiologic mechanisms of life so that it may speak a common language, with the modern surgeon on the one hand, and with the diagnostician and the laboratory on the other. In the light of developing physiologic discovery, new methods of pain relief must be devised and more logical use of old ones must be provided to serve as a foundation for the ever widening pathway of the surgery of the future. But that is not all. The anesthetist should and can have much help to offer the

surgeon in addition to pain relief: Comprehensive care of patients during operation, rational supervision of therapy with gases and vapors, the blocking of certain anatomic regions, the intravenous administration of various substances:—all may at times be advantageously entrusted to the anesthetist. The liaison between pharmacology on the one hand and surgery on the other can to a large extent come through anesthesiology.

Anesthesia and anesthetists, to date, can claim only a little progress other than a nucleus of enthusiastic pioneers who are willing and anxious to devote their lives to the development of a science of anesthesia. The helping hand of such a group as this, of which I am a guest, may mean a great deal. Most of you are teachers of surgery. Our schools have drifted toward a neglect of the teaching of anesthesia at a period in scientific progress when such teaching is paramount. Some of you have tried utilizing young surgeons, young internists, and others as instructors in anesthesia and as directors of departments of anesthesia. Such plans have not worked, I fear, because the subject is too broad and too deep. The pharmacology and physiology of anesthesia must be interpreted clinically by individuals with at least a modicum of clinical knowledge and clinical experience.

Doctor Schmidt and I wish to leave with you not the idea that we, at Wisconsin, have solved the problem of anesthesia—far from it—but rather that the problem exists and that it must be met in every medical school and in every medical center. The sooner all of you tackle this problem, the less lonesome those of us who have made a beginning will feel.

## ANESTHESIA, ANESTHETIC AGENTS, AND SURGEONS\*

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**T**HIS subject concerns itself with the anesthetist, his science and art, in relation to surgery. Cooperation is the essence of such an effort. As the field of knowledge grows, the need for joint endeavor increases.

In the history of anesthesia it will be found that the need for it was recognized long before the agent was discovered. The use of a drug sometimes had to await the discovery of the scientific facts of physiology and pharmacology before the anesthetic agent could be used. Sometimes the physiology and pharmacology at hand presaged the discovery of the agent. Science and anesthesia were necessary for the development of each other, and the art of anesthesia played only a secondary role. The discovery of the circulation of the blood by Harvey was fundamental in developing a knowledge of the function of circulation and respiration. The gaseous exchange between the air and the circulating blood of the lung, with the tissue cells, formed the basis for the use of volatile or gaseous agents in anesthesia. Priestley discovered nitrous oxide in 1772, and Humphrey Davy noted its anesthetic properties in 1799. Henry Hickman and John Snow determined from clinical and experimental evidence the basic knowledge of physiology and pharmacology, and the clinical application had to wait until 1868 when Edmund Andrews used nitrous oxide mixed with oxygen for clinical anesthesia.

As in the historical development of anesthesia, today the same fundamental principles apply. The facts of physiology and pharmacology must be understood and the pertinent scientific knowledge used in the giving of an anesthetic. The action of the drug upon the cell disturbs the normal physiology. A certain concentration tends to reduce reflex irritability and allow surgery. Changes in respiration and circulation, due to the technique of administration and the pharmacology of the drug, will markedly alter the normal physiology of the cells. Varying the dose of the drug, as well as special idiosyncrasies, affects the cell vitally. The volatile or gaseous agent when it gains entrance to the respiratory system brings up the whole subject of physiology, physiologic chemistry, and pharmacology. In order to reduce reflex activity, the cells in different parts of the body must be reached. There is an individual variation, a variation with respect to different tissue, and a general variation. Ordinarily the peritoneal reflexes are abolished in the lower half of the third plane of the third stage. Yet, even in the fourth stage with cessation of respiration, those reflexes may be present so as to make it impossible to close the peritoneum. The use of 0.5 per cent novocain solution injected into the periphery of the rectus sheath has abolished the reflex. With the peritoneum sutured and the anesthesia lightened, a relaxation takes place. This type of reaction does not occur often, but often enough to demonstrate that there is a variation beyond that which can be expected from a tissue or individual variation.

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The variations which are controlled by the anesthetist are based on an intimate knowledge of physiology and pharmacology, and the results are determined by the ability to recognize the clinical situation. Chloroform given over a long period of time, or to certain individuals, may result in direct cell damage with a resultant damage to liver function. Carbon dioxide excess causes a change in the biochemistry of the cell. Especially is this true in the red blood cell, for with a high concentration of carbon dioxide there is produced a definite biochemical shift producing an acidosis. To appreciate the biochemical shift, the mechanism of the blood buffers must be known, and the early recognition is necessary for early treatment. While the plasma sodium is around 330 mg. per cent and the plasma potassium 16 to 19 mg. per cent, there is a higher percentage of potassium inside the red blood cell. If carbon dioxide is piled up in the blood, this produces a shift of the chlorine from the plasma to the red blood cell. Since potassium does not diffuse from the cell, the chloride is also retained. This is known as the chloride shift. The biochemistry of the cell is changed. The change in the physical status of the patient modifies the physiology of that patient and the pharmacology of the drug action. Oxygen want has played a small role in the appreciation of anesthesia, and yet it plays an important part in morbidity, causing tissue changes that are hard to evaluate by present means of examination. The physiologists give us a critical level for blood pressure. This is around 50 mm. Hg. If this level is kept for a period of time, cells will suffer from lack of oxygen. This varies with different tissues. Brain cells are damaged more readily than other tissue cells. What the limits are no one knows. That there is a variation in individuals is known, but at present there is no way to determine which patients are susceptible to oxygen want, in the case of ordinary surgical risk.

The technique of anesthesia administration is best safeguarded by a knowledge of pharmacology of the drugs used and by an understanding of the physiologic shifts that may occur in the acid-base balance set up by the body. In surgery, the surgeon learns the fundamentals of the basic sciences, with their clinical applications before the technical side is attempted. Minus this background of basic science and clinical experience, the term used to indicate such an individual would be "operator." The art and mechanics of anesthesia follow the basic science and clinical application as naturally as in surgery.

An anesthesia service is of use outside the operating room. The evaluation of the anesthetic risk involved in the patient, the use of depressant drugs for the nonsurgical relief of pain, the employment of anesthesia block to aid in diagnosis as well as in therapy, and the supervision of oxygen therapy all fall within the province of a department of anesthesia. Following the operation, an anesthesia service is of great aid in applying physiology to the problems presented, such as the recognition and proper treatment of shock, whether it is due to trauma, loss of blood, adrenal insufficiency, or sympathetic nerve involvement as is met with in operations on the upper thoracic vertebrae. The early recognition is essential and can be detected by the anesthetist who has important knowledge at hand of the physiologic status of the patient during the operation. Respiratory emergencies which may develop are often suspected during operations. Atelectasis, increased bronchial secretion, and obstructions are met by recognizing the possibilities, and

when the emergency arises are taken care of by clearing the airway or using artificial airways or respirators. When the bronchi contain excess of mucus and become clogged, the tracheobronchial tree can be cleared by aspiration. The anesthetist should make postoperative rounds. The type of recovery, the nausea and vomiting, the stabilization of the patient, and the frequency of difficulty in voiding are factors that are important in evaluating the result of an anesthesia. From a critical review of 21,000 cases made by the anesthesia department at the University of Wisconsin, we can see how this applies. In Fig. 1 the percentage of major respiratory morbidity following various anesthetic agents is calculated. In Fig. 2 the same group of cases is analyzed to show respiratory morbidity following various types of operations. It is obvious that the intelligent supervision resulting from a cooperative effort in the care of these patients both during and after operation is more important than the choice of agent. Prevention and correction of the physiologic disturbance are the vital factors.

To assure a cooperative spirit in the surgical team, the surgeon must be in a position to appreciate problems from the anesthetic viewpoint. There must be a harmonious association, with a meeting of the minds and an understanding based on the problems on both sides. Most important is it for the anesthetist to be able to see the patient and study the complete record used in making the diagnosis the day before the operation. The difficulties in the case should be discussed and the plan made for the anesthesia and the operation. The surgeon should appreciate that all the drugs given in the course of the operation are a part of the anesthetic and affect it. Especially is this true regarding opium derivatives. There is a logical basis for this determination. Pain, fever, endocrine imbalance, and the emotions influence the patient so that more

of the anesthetic agent is required. The opium derivatives depress metabolism directly because they allay pain, inhibit mucous secretion, and aid the actions of the soporific drugs when given in combination with them. Barbiturates are not analgesic. In heavy doses they depress respiration specifically. However, in moderate doses they depress metabolism due to decreased emotional excitability. The dose of opium derivatives may be increased per pound of body weight in direct proportion to the increased metabolic rate of the patient when due to fever,

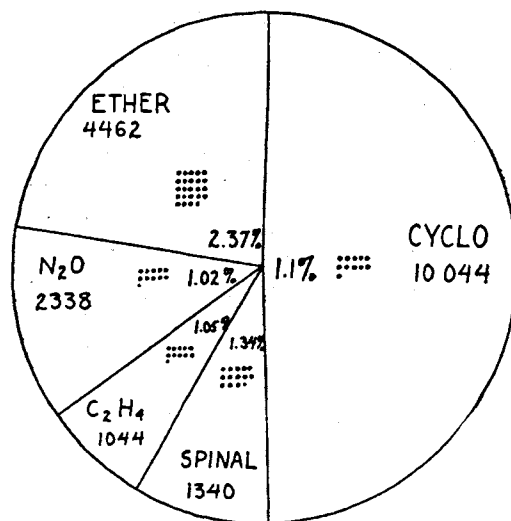


Fig. 1.—Major postoperative respiratory complications, by anesthetic agents.

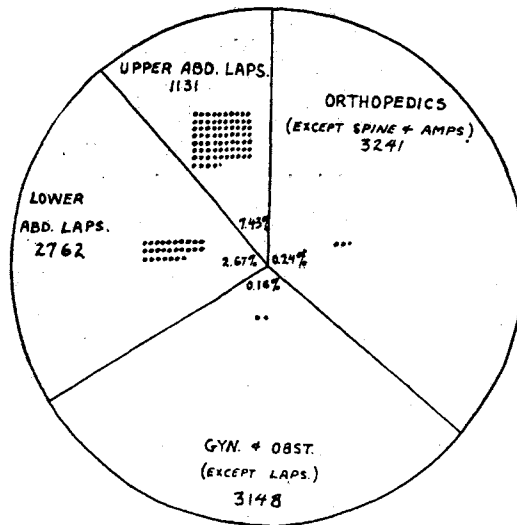


Fig. 2.—Major postoperative respiratory complications after certain types of operations.

fear, pain, and emotional instability. With a metabolic rate of 25 per cent above normal,  $\frac{3}{8}$  gr. of morphine will produce no more effect than  $\frac{1}{4}$  gr. in a normal person. In an aged person  $\frac{1}{6}$  gr. of morphine may be too much. The normal child at 6 to 12 years of age will tolerate more morphine per pound of body weight than at any period of life. A normal infant will tolerate about the same per pound of body weight as a person of 20 years. The surgeon should have enough knowledge

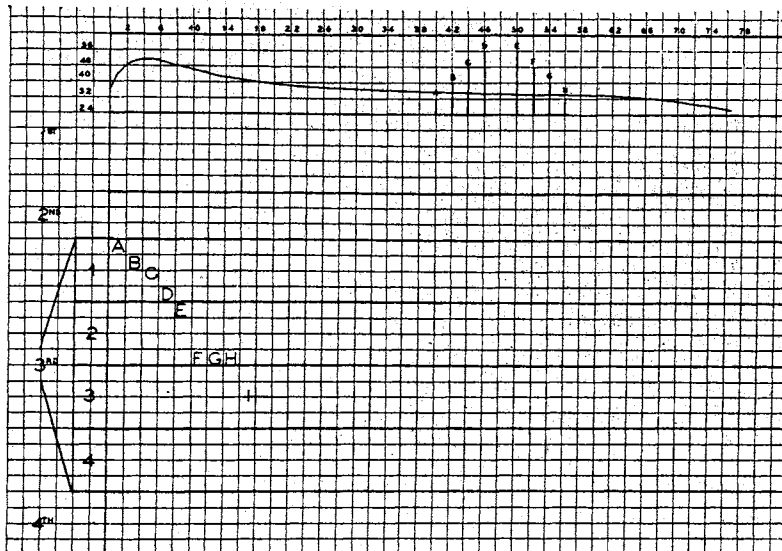


Fig. 3.—With a metabolic rate of 24 calories per sq. mm. of body surface, add the factor of fear and the rate is elevated as indicated by line A; pain will raise it as represented by line B; fever will give line C; and thyroid activity will result in line D. To depress this rate, barbiturates the night before will eliminate fear and give line F; the emotions are allayed and line G results; and preoperative medication with morphine and scopolamine will result in a lower rate—a much easier patient to handle. Levels of anesthesia at which reflexes are abolished: A, First part of first plane, third stage. Brain, bone, thyroid, breast, stomach, kidney, and other glandular tissues, except for traction reflexes from their coverings or attachments, are abolished. B, Upper half of first plane, third stage. Skin reflexes are usually abolished at this level. C, Below middle of first plane, third stage. Pharyngeal reflex is abolished. D, Lower border of first plane, third stage, abolishes or renders negligible reflexes caused by injury to or cutting great sciatic nerve. E, Junction of first and second planes, third stage, abolishes cough reflex. F, G, and H, Lower level of second plane, third stage, abolishes or renders negligible muscle reflexes. The anal sphincter reflex may not be abolished by the fourth stage. The traction reflexes met with so frequently in abdominal surgery may be abolished but readily instituted by rough handling of the viscera. The subdiaphragmatic reflex, an adduction of the vocal cords usually upon expiration with a contraction of the abdominal muscles, may be present in the third plane; then intubation is preferable to deeper anesthesia. I, Third plane, third stage, abolishes tone of smooth muscle when it reaches the middle of the plane (Guedel). (From Waters and Schmidt: Anesthesia and Surgery, Ann. Surg. 106: 790, 1937.)

of anesthesia to appreciate the applicability of different drugs and different dosages to particular operative requirements as they appear. If the reflex irritability is not reduced enough to carry out a certain procedure, he should wait until the proper depth of anesthesia has been reached. (Fig. 3.)

Preoperative hypodermic medication with some sedative drugs usually takes one to two hours to act. Properly timed, it will greatly aid the anesthetist; but, if the schedule is upset and only fifteen minutes is

permitted for action of preoperative medication, the whole plan of anesthesia has to be altered. Even when using what the anesthetists call a 100 per cent agent is this true.

To reach a proper concentration of the anesthetic agent in the blood stream needs a certain amount of time which will vary with individual cases and agents, depending on a number of factors, such as a non-obstructed airway, circulatory activity, the amount of pain the patient's pathology gives him, the amount of fever present, the emotional disturbance present, and possible endocrine imbalance.

Sudden changes in the operation may jeopardize the anesthetist's success. When doing a laparotomy and working inside the abdomen with packs all placed, the depth of anesthesia may be in the second plane of the third stage. A sudden quick pull on a retractor, by an assistant who has just awakened, immediately irritates the deep muscle reflexes, the abdomen becomes tight, the packs are displaced, and the entire operative field is disturbed. The depth of anesthesia has to be deepened. This takes time, prolongs the operation, and helps in producing shock. Why carry the patient so light? Because twenty minutes in the lower half of the third plane in the third stage is equivalent to two hours in the second plane of the third stage. Third plane (lower half) tends to paralyze smooth muscle and produces shock.

The surgeon should never force the decision as to the type of anesthetic agent used or how it is given. This should be left entirely to the anesthetist. The problem should be discussed and the surgeon should let the anesthetist know what is necessary in order to perform the operation. The anesthetist knows his ability and his limitations. He knows best how to give the surgeon the anesthesia the surgeon desires and what the patient can safely stand. The surgeon would resent being told he had to do an operation in a certain way if he knew that in some other way his knowledge and skill could be applied to give the patient a better result with less risk.

Anesthesia and surgery are bedfellows. Anesthesia has advanced remarkably in the last twenty years. Surgeons are still using anesthesia on the old empirical basis. In order to get the best anesthesia has to offer, there must be a realization on the part of the surgeon of the advances made and the possibilities that it offers. This field of surgery has become broad, just as other fields in medicine. It is not limited to the art alone, nor to the operating room. Therefore the utilization of this new field, as in other fields, means the cooperation of the internist, the anesthetist, and the surgeon.

## EDITORIAL

### PRESIDENTIAL ADDRESS \*

RALPH M. WATERS, M.D.

*Madison, Wis.*

A CAREFUL rereading of our constitution informs me that our President has a multiplicity of duties. For the faithful performance of them he is accountable to the membership, to the legal authorities of the State of New York in which we are incorporated, and primarily to the Board of Directors of our Society. This is as it should be. It is a healthy sign that a much more active functioning of our Board of Directors has been developing. Dr. Peterson's suggestions regarding the conduct of the Board's business have, I believe, been a distinct contribution. Since detailed reports of the business of the Board are mimeographed and sent to all members of the Board, it is easy for each one to know all the details of the Board's business and to take part by mail when distance prevents his attendance at Board meetings. Thus we are justified in the action just taken of increasing the number and the geographical distribution of members of the Board of Directors.

The addition of a president-elect to our list of officers has opened the way to a continuity of policy impossible previously. This arrangement together with my resignation of the post a year ago has permitted me to worry about my coming duties for twenty-four instead of twelve months. Dr. Lundy and I will confer regarding a dovetailing of Society plans for 1945 and 1946. I wish him a pleasant year of worrying and I am sure he will produce a profitable one of planning for 1946.

The development of the American Society has been in a sense a gradual expansion of the old New York Society of Anesthetists. This was natural since a majority of anesthetists in North America used to live in or near New York. As years go by, this has become less and less true. Perhaps we have tended to cling too long to some of the habits of a local Society. However that may be, our Board of Directors has decided to try a broadening policy. They have approved two meetings of the Society far from New York during the past year. These were conducted as "regional meetings" of the Society and publicized as such. It is hoped by the Board that this policy may be continued and extended in 1945. The suggestion has been made that these "regional" meetings had better be emphasized and publicized as meetings of The American Society of Anesthetists held in several regions during the year rather than as regional meetings. Thus, if members in Wisconsin find it more convenient to be away (or perhaps more attractive to travel) at the time of a meeting in New Orleans or Seattle than at the time of one in Chicago or New York we may plan to do so. In line with such a policy, it may be possible to determine and publish early in the year the dates and places for the several meetings of the Society throughout the year. As to the programs of these meetings, the following suggestion has come from several sources which ought perhaps to be recorded for consideration by committees on arrangements. Certain younger members complain of difficulty in gaining the ear of older anesthetists in these meetings; for example, with officers of the Society, teachers, and others. They find the task of running them down in hotel lobbies both arduous and unsuccessful.

\* Part of the address of the incoming President, before The American Society of Anesthetists, Inc., Dec. 14, 1944, New York, N. Y.



They imply that the geriatric discussions of the oldsters among themselves make them inaccessible. Their suggestion is that there might be arranged one informal session at each meeting when the whole society enjoyed perhaps a bottle of beer at smallish tables but in a large room where all were together. The usefulness of such a gathering (perhaps following an evening session) would depend upon a studied avoidance of reunions of old friends and acquaintances, leaving the opportunity for the development of new associations. Such an evening need not interfere with reunions of old friends at other times during the meeting. I pass the suggestion on for the consideration of program committees.

For a long time, members of the Society of my own age-group have discussed in private the need that the Society has for its direction to be taken over by new blood. Younger members have remarked about the desirability of such a change. Recognition of this need is easier than the graceful accomplishment of it. One of our younger members reminded me not long ago of a remark of W. J. Mayo before his death. It went something like this. "Young men going up the ladder are too often hindered rather than helped by the older men coming down." There is, I believe, truth in the statement but I have a feeling that the circumstance is due rather to lack of mutual understanding than to intent on the part of the older men. I am confident that I speak for all the older members of the A.S.A. when I say that it is our earnest desire that within the next three or four years the affairs of the Society may be directed entirely by a younger generation than ours.

This means that many of you will be asked to assume duties as officers and members of committees, even as committee chairmen, the nature of which will be unknown to you. Until our colleagues in military service are returned to us, those of you who are in civil life may have to double up in your work for the organization, as you have had to work longer hours and harder in the practice of medicine. You may have to undertake these new jobs before you feel confident. By doing, you will learn. As our members change their uniforms for clothing without brass buttons and gold braid, they will relieve us of this extra load. We must realize our obligation to see that they have restored to them their rightful place in the conduct of the affairs of the Society as well as that they be helped professionally in every way possible to regain the place in civil practice which they would have occupied had they not made the sacrifice of military service. In suggesting individuals to serve on the various committees during 1945, I have tried not to impose on those in military service. Doubtless I have failed thus to utilize the services of some medical officers who are not likely to go overseas. I have no means of knowing who is likely to be kept at home.

The greatest handicap of the president of such an organization as this, it seems to me, is the impossibility of his knowing personally so many of the members who probably have ability and willingness to serve the Society. I think I speak again for all the officers and future officers when I urge all of you, new members as well as old, not to hide your light under a bushel. The Board of Directors and the officers will be only too happy to have communications either direct, or through the columns of our journal, *ANESTHESIOLOGY*, or through the News Letter, which may contribute to the welfare of our Society and its members, present and future. I speak to all our younger members when I say this is your Society for the future. By the personal interest and effort of each one of you, and in this way only, will it succeed in its aims. If we who are coming down the ladder in Society activities get in your way, we hope you will not hesitate to make us realize that fact. We freely admit that three score years of activity are enough. Your help may be needed to show us how to come down the ladder gracefully, graciously and usefully.

## EDITORIAL

### ORGANIZATION AND ANESTHESIOLOGY \*

RALPH M. WATERS, M.D.

*Madison, Wis.*

Interest, enthusiasm and energy are precious qualities. In a given person they go far to determine individual accomplishment. A combined effort of individuals with similar interest and enthusiasm constitutes an "organization." By pooling their resources of natural and acquired ability, the members of an organization can conserve the total energy of the group and apply it at the time and place where it will do the most good for each individual in the group. A realization of these facts is always slow of appreciation. Anesthesia is celebrating its one hundredth anniversary.

Organizations of anesthetists were lacking, however, during the first sixty years. Like the strategic retreat of the Father of our Country which ended in triumph on the banks of the Delaware River on Christmas morning, 1776, organized anesthesia in America began in Brooklyn.

It may have been forty years ago this very hour when three anesthetists, who I hope are with us tonight—Erdmann, Schirmer and Tong—met in Brooklyn with others who have long since left us, to organize the Long Island Society. The name was changed in 1911 to the New York Society of Anesthetists. Possibly other local organizations were started in the early part of the century but the first national association was initiated in 1912.

It was at the meeting of the American Medical Association in Minneapolis in 1912 that James Gwathmey requested the establishment of a Section on Anesthesia. Since the request was not granted he, with the help of Frank McMechan and others, organized the American Association of Anesthetists. It held its first scientific meeting in 1913. Dr. Gwathmey was the first president and served as secretary until the spring of 1918 when he resigned because of an overseas assignment in the Army and McMechan assumed the duties of secretary of the American Association in his place.

The need for a special journal was appreciated by these early organizers and McMechan became editor of the Anesthesia Quarterly Supplement of the American Journal of Surgery. Its first number was published in October, 1914. It was continued until 1926 in which year the Supplement was discontinued and the name American Association of Anesthetists was changed to The Associated Anesthetists of the United States and Canada.

The reason for the discontinuance of the Quarterly Supplement in the American Journal of Surgery was because McMechan, the Editor and Secretary, had been busy organizing other societies and publications. Among these was the International Anesthesia Research Society which held its first "Congress" in 1922 and began publication of Current Researches in Anesthesia and Analgesia in 1923.

This journal is still published, under the Editorship of Howard Ditrück. Other publications edited by McMechan were two Yearbooks

\* Address of the retiring President, before The American Society of Anesthesiologists, Inc., Dec. 13, 1945, New York, N. Y.

of Anesthesia and Analgesia 1915-16 and 1917-18, a Monograph on Obstetrical Analgesia and a certain "Bulletin." The interest, enthusiasm and energy devoted to the cause of anesthesia before 1930 was largely that of one exceptionally capable anesthetist, Frank McMechan. He was truly an apostle of anesthesia throughout the world.

Until 1930 we who are now considered "older anesthetists" were content to delegate all the labor of organization and the conduct of organized effort to one man. The need for a Section on Anesthesia in the American Medical Association, for a National Board of Certification, for a modernized Journal of Anesthesiology and other advances was evident to those within and outside the specialty.

Obviously, effort was required which could not be met by older methods. In casting about for a vehicle, the old New York Society of Anesthetists was utilized and expanded to become national in scope. The result to date is the organization sitting in its tenth official annual session here tonight on the 40th anniversary of organized anesthesia in America. Certain of the original objects sought have been accomplished. The American Society of Anesthesiologists, Inc., is national in scope. It has many members in Canada and other countries also and they are most welcome.

There is a Section on Anesthesiology in the American Medical Association. There is a Journal, ANESTHESIOLOGY, which is the property of the Society. And there is an American Board of Anesthesiology, Inc. To brag of the society's accomplishments is not my present object.

I began by saying that an organization is a group of persons with similar interests and enthusiasm who combine their individual resources to conserve the total energy of the group and apply it when and where it is most effective. As an older anesthetist who had helped to make the mistakes of our earlier organizations, I confess to some fears during the early days of the decade of this organization that the mistake of laziness—of saddling one man with all the work—might be repeated by the members of the new society.

Through the tremendous interest and enthusiasm and energy of Dr. Paul Wood the Society was launched upon its career with a minimum of difficulties. Through his unusual foresightedness and unselfishness, our constitution and by-laws provide the machinery whereby every member may do his part and help to carry the load.

Through his altruistic and warmhearted friendship for the Society and for every member of it, he has helped us to become a true Organization. Doubtless there were times, and still are, when it would have been easier and more satisfying to do the thing himself than to advise one of us how to do it. But for the long future, I believe the Society will benefit in standing on its own feet.

As it is, no member can sit back and say, "Oh, let the secretary do it," or the president or the chairman of this or that committee. The Society's business is our business. We elect a Board of Directors to direct it. We elect officers to carry out the policies determined by the Board of Directors. All these servants of ours are changed at frequent intervals unless we see fit to reelect them.

Some of you may say, "What have I to do with it? A letter from me to the Board will accomplish nothing." If the Directors could meet in a room where all members could listen to their deliberations, as I

have done, I am sure every one would agree with me that they are a serious group of people earnestly trying to decide what is best for our Society. If you have suggestions which seem wise to you, it is your duty to submit them to the Board through the President or Secretary.

Your communications will be courteously received and thoughtfully considered. Their decisions will be made with a hope of bringing the greatest good to the greatest number. The execution of the intent of the Board will depend upon the availability of money and of members willing to function in an executive capacity.

Our Society needs more funds to function in this world of turmoil. Suggestions have already been made which will, I hope, permit us to furnish them. Directors and officers who give their time and effort ought at least be reimbursed for their monetary expenses. Capable full-time servants of the Society must be employed to accomplish routine business and special efforts. But let no member feel that his financial contribution, the mere payment of dues, however large, fulfills his obligation to the Society.

Because of travel restrictions, in recent times national meetings have been prohibited. In lieu of these, regional meetings of members of the organization have been held. I believe these were originally thought of as a substitute for national meetings. It has been my privilege to attend several of them in addition to the one being held here this week.

I am convinced that they should be continued in the future as a supplement to the national gathering. A temporary local chairman has gathered together a committee and organized a meeting of those in a region roundabout covering an area convenient regarding travel accommodations.

These local meetings have been planned under the general supervision of a coordinator of meetings in order that dates and regions might not overlap. The brief trial of this plan seems to me to have been so beneficial that I hope it may be continued when travel restrictions are abolished.

Whether such regional groups should complete formal organization or remain informal temporary gatherings of the National Society membership is probably immaterial. The important point seems to me to be that no local or regional effort should be allowed to detract one iota of the loyalty and effort of each member from the national society.

In unity there is strength. If anesthesiology is to meet the challenge of the time, the abilities and the energies of every member of our Society must be welded into a combined will to bring to all the American public the best of service in anesthesiology with maximum justice to the individual anesthesiologists who render that service.

With that statement I terminate my service to you as president of this Society.

It gives me pleasure at this time to turn over the gavel of the Society to the new president, Dr. John Lundy, who, I am sure, will do a lot better job than I have done. I wish him well.

State Medical Meeting  
of  
Georgia  
May, 1949

On this Centennial of the Medical Association of Georgia I deeply appreciate the honor of making a few remarks as an anesthetist.

At your Third Meeting, in 1852, one of your members presented a very honest and modest report of a decade of experimentation with ethyl-ether as an agent to produce surgical anesthesia. It is a recognized fact that Dr. Long actually used ether clinically for the purpose several years before anyone else. That he waited for 10 years before presenting his experiences publicly to this Association at its Third Meeting is evidence of that admirable conservatism which is, or used to be, a tradition of our profession. Some of my remarks this afternoon may suggest that there is still a place for the deliberation displayed by Crawford Long in our present-day attitudes toward medical progress.

I have been away from the influence of a laboratory and the operating room for the past six months. There are advantages as well as disadvantages to that circumstance. Among the advantages of removing one's nose from the grindstone is the acquisition of leisure to read and perhaps to think a little.

This may explain the title and what I shall try to say about New Wine and Old Bottles. For a text, let's take the last 4 verses of the 5th Chapter of St. Luke. They read as follows:

"And He spake also a parable unto them, no man putteth a piece of new garment upon an old, if otherwise then both the new maketh a rent and the piece that was taken out of the new agreeth not with the old. And no man putteth new wine into old bottles, else the new wine will burst the bottles and be spilled and the bottles shall perish. But new wine must be put into new bottles and both are preserved. No man also having drunk old wine straight-way desireth new for He saith the old is better."

And while I am about it, could I add two or three quotations from more modern literature; chiefly anesthetic, it is true, but some of the quotations may have some interest for those of you who are not anesthetists. One from Dr. Bloomfield in his introduction to "Modern Anesthetic Practice". He says:

"The anesthetist today must have as good a working knowledge of pressure gauges, flow meters, valves, stop-cocks and manometers of all kinds as he must have of the respiratory and circulatory system of his patient. Indeed, the latter are more often kept under observation by the use of dials and scales and bags than by directly noticing the color, pulse and breathing of the patient. Very often none of these are visible or palpable during operation. The machine has to be more observed than the patient and it is on the first rather than on the second that the administrator relies for guidance. He notices more what his machine is doing than what effect it is having. Yet machines are not infallible and do not always do what they say they are doing. The advantages which accrue from complicated apparatus are not obtained without their price."

And here is another little sentence from a fly-leaf of the book "A Synopsis of Anaesthesia" by J. Alfred Lee. It says:

"Relief from pain is purchased always at a price. The price in both morbidity and mortality does not greatly differ whatever the agent or agents used."

And another. This is taken from an article on "Neurological Complications after Spinal Anaesthesia and the Results from 2493 Cases followed up carefully by Gunnar Thorsen, a Swede. Thorsen makes this general remark in his introduction. He says:

"When a medical method, whether diagnostic or therapeutic, has been generally recognized it easily becomes a matter of routine, being deprived of unceasing critical observation. Indications and contra-indications become blurred. Results are misjudged. Limitations and risks are forgotten. . . . "It therefore becomes imperative to analyze now and again the results arrived at, as well as the risks and indications of the methods employed."

And I can't leave the literature without a reference to an article in the April Harper's Magazine entitled "Why Medicine is Not a Science" by Ian Stevenson. I can only quote you one remark, I should like to read the whole article to you. The quotation is this:

"No discipline can display a greater array of equipment by which its research is carried on, i. e. in medicine, yet none is inferior to medicine in organizing its knowledge into coherent principles."

One might get the idea from Dr. Stevenson's article that we place new wine, i. e., the new wine of isolated and unrelated facts, into old bottles of gases as to the laws governing the over-all picture and that the bottles burst in our hands strewing the floor with a jumble with still more unrelated facts. He concludes with this statement:

"Despite the great technical advances of our day, the future of medicine may well depend upon the training of physicians who were once more as the doctors of Ancient Greece, humanists and biologists as well as chemists and physicists."

The kind of thought stimulated in me by reading samples of which I have just given, and by the contemplation which goes with leisure, can perhaps with profit be followed a little way in the time at our disposal this afternoon.

Suppose we confine our present consideration to three categories. One will have to do with teaching, one with research and one with our daily practice.

In Anesthesia, at least, it seems to me that we are guilty of a certain neglect or incompleteness in teaching. At least, in our graduate teaching of anesthesia, we emphasize the modern, with a tendency to elide the basic and fundamental. In some places in our country we almost totally neglect undergraduate teaching of anesthesia at all, whereas I believe that every M. D. should graduate with a fundamental concept of breathing and circulation of the blood as seen by the anesthetist and that he should have enough technic to anesthetize safely and acceptably for usual operations. Thus, he can become the answer to the shortage of the anesthetists in the small hospitals in communities at the present time, and he need not be paralyzed in an emergency.

Why is it that the young doctor and even the old doctor these days is afraid to give even the occasional anesthetic when the occasion demands? It seems to me that we have taught him the complicated things if we have taught him anything about anesthesia and we have failed in emphasizing the simple, fundamental facts of Anesthesia, both technically and in the way of foundation of physiology, pharmacology, and so forth. One great teacher of Anesthesia once said to me: "You must put glamour into your teaching of the undergraduate or he won't be interested". I don't think that's true. I think that the solid facts of the foundation on which Anesthesia is based are interesting to the student and he is glad to have them if they are put to him in the right way. He certainly can use them when he gets out into practice. There isn't time this afternoon for me to go into my ideas of how we ought to go about the teaching of the undergraduate in Medicine. I can only say that in Anesthesia, I believe the undergraduate deserves emphasis on anesthetic matters or matters related to Anesthesia that deal with respiration, artificial respiration, the care of the respiratory emergencies such as obstruction and so forth. These, I think, are being neglected. And I am quite sure what we do teach them is more apt to be the complicated things that they cannot use and are only taught as a basis for glamour.

In one of the English journals recently a woman died during delivery and the comment made in the journal was this: "If this woman had been fortunate enough to have been delivered in a ditch on the way to the hospital by a farmer's wife she might be living today, whereas with all the multiple medications given her in the hospital and all the multiple obstetrical procedures applied to her she lost her life." We can then, at least, if we can't do good, aim to do no harm and we can teach our students that simple methods are a duty in the knowledge of every physician. We need to emphasize the transport of oxygen and carbon dioxide to and from the cells in the body and we need to emphasize the simple, circulatory facts that ought to be known to every doctor and not worry him about the way the electrocardiograph looks in every unusual case. We need, I think, to teach the medical student and every young doctor how to use two or three simple drugs to produce anesthesia. And I think that goes for surgical procedures, too. We have many graduates who are fairly good at gastric resections and they know a good deal about it. But to repair a simple hernia or open an abscess on an extremity seems to be one of their greatest difficulties. If we send out young doctors who as undergraduates and interns have seen nothing of simple methods and understood nothing of the complicated anesthetic methods we create a profession which has no recourse for self-protection and is helpless in the hands of technicians and unscrupulous specialists.

Now a word about research. Humphry Davy's most beautiful study of nitrous oxide which was published in 1800 was not applied to clinical medicine for another 50 years thereafter. That attitude is no longer present in the medical profession. Not so many years ago there was a paper published on the intravenous use of procaine to produce general anesthesia in obstetrics. After he had read that article, an intern talked to me and asked for my suggestions and approval of a research project which he was outlining that he himself would conduct, studying the intravenous use of 1% procaine to produce general anesthesia. I was horrified at the suggestion of the paper in the first place and I was more horrified at the idea of an intern who had never seen a procaine convulsion having the temerity to inject some intravenously. That type of research is bad, I think. The enthusiasm for the new and the lack of thought and the serious consideration of what is being done. Now there are a lot of basic science facts that are in the literature and ripe for clinical application or attempts at clinical application. Many of them are neglected, so there are two sides to the question. I would suggest for instance the relation of vitamins and diet and simple chemistry to the welfare of the surgical patient. There are many simpler, more practical and worthwhile subjects for one's efforts of research than the intravenous use of procaine by an intern certainly. For instance, we have a habit at the present time in a good many institutions of not giving a patient any water after 12 o'clock at night, before his operation no food, and after operation no food, no water, and all intravenous administration. There are such things as those that are habits, I suppose, they are not anything that are a blot on medical practice, but things that deserve some thought and some investigation and research, and they are legitimate types of research for any institution to undertake. I am reminded sometimes of the old 48-hour purge period before operation when a patient came in 48 hours before operation not to be studied and have a careful physical check-up, but rather that he begin his course of Epsom salts and castor oil before he was to be operated upon. Now that is no more ridiculous than the "no water, no food, and all intravenous" regime that the average surgical patient is subjected to at the present time. There was a gentleman at The General Hospital several years ago who was subjected to a prostatectomy early in the morning after having had nothing to eat or drink since the night before and he had intravenous saline, intravenous glucose administered to him in two separate tubes and needles after the operation. When we went in to ask the old man how he was in the afternoon, he said: "Well, I would be doing very well if I could get some decent stuff to drink, but one of these pitchers is too sweet and the other is too salty". No provision had been made for the old man to drink the fluid that he needed but it had to go in through the needles in his veins. Such ridiculous things are common in many hospitals and they are subject to study. There are certainly other chemical things that we need to study, for instance, Bowen and Staley years ago and others in the old days, found that certain alkali, dysodium phosphate and potassium carbonate, were very good drugs to administer to certain patients and yet they have gone out of style completely now, so a study of these would make a good research proposition for the present time. Certain institutions are equipped in personnel and in interdepartmental contacts to conduct good clinical research of either old or new drugs or methods. It must be kept in mind that well kept records are essential and well kept records require a lot of work and a lot of help. The majority perhaps might better limit their research to comparisons of established styles and making conservative reports upon their study. Unthorough reports, with unjustified conclusions lead others to adopt methods as acceptable before they are ripe. Judgment, thought, and common sense are necessary to institute a piece of research, to carry it through and particularly to report upon it safely. Research is good, but with fair and controlled trials--not the new because it is new or easy, but because it is good and proven good. The spectacular, the easy and the new are not always to the advantage of our patients.

What I shall have to say about our everyday procedures will of necessity be from the standpoint of an anesthetist. I think that the criticism of anesthesia in its everyday procedures may be interpolated into the practice of other specialists. I hope at least that it may have some interest for all of you. My criticism is largely that of over-complication of our everyday procedures and neglect of skill in simplicity. I think I ought to tell you a story of a good anesthetist I know who went out to a very well organized veterans bureau hospital recently to anesthetize a patient at their request. He unfortunately had to return to his own institution rather early and he knew that he couldn't finish the anesthetic himself but he thought that if he could get it well started and well set up that one of the residents or interns, of whom there were many in the institution, could carry on. And he thought that an open drop ether administration would be suitable for the patient under the circumstances. He found that in this group of some 18 interns and residents who eventually gathered about the operating room to see the sights the strange and expert anesthetist was showing them, he found that in that group not a one of the 18 had seen, let alone administered, an open drop ether administration before. That goes back to our bad teaching to which I referred previously.

Now in the 1900s, in the early 1900s, when I first came in contact with medicine, there was a terrific uproar in the profession about polypharmacy. And there were later on when polypharmacy was pretty well abolished, accusations of therapeutic nihilism and now I think the profession in

general has drifted to a happy medium. But I am wondering whether polypharmacy combined with intricate mechanical gadgets which were emphasized in the quotation from Dr. Bloomfield earlier, may have not come to anesthesia much later than polypharmacy came to the rest of the profession.

Another possible explanation that occurred to me is that our complication of the simple in anesthesia may be a defense mechanism in order for us as a young specialty to command the respect of the rest of the profession and of patients or even to get higher fees. Many years ago when I first started in the practice of anesthesia I remember that my secretary was very much amused one day to tell me that the City Gas Company had just called up to say that Mrs. Jones was in their office wishing to pay our bill. Our bill had been sent to her "for gas anesthesia". After that our bills were sent "for professional services rendered". Now I have a great deal of personal guilt in this matter. I have been responsible for promoting many new and complicated means of producing anesthesia. One of them, for instance, is the polypharmacy of a great deal of premedication with non-volatile drugs and basal narcosis and then added inhalational anesthesia and perhaps a combination of block anesthesia. And I used to give a lecture on "The Parallelism between Reflex Irritability and Metabolic Rate" from which I shudder at times now. I had a good deal to do with the introduction of what is called the carbon dioxide absorption technic in anesthesia and the introduction of cyclopropane and of the inflatable cuffs around an endotracheal tube to be used in place of drainage by position which is much more logical; gravity is an older procedure than inflatable cuffs and I had a good deal to do with the advocacy of artificial atmospheres instead of air as a vehicle for anesthetic agents. Now, much of this was honest effort on the part of modern anesthetists I quite agree, but how much of it was, and still is, a striving for glamour, a striving for justification for being a specialist in anesthesia? It seems to me that we have come to the time when we need to reconsider now and then as Thorsen has already been quoted as saying. To reconsider and to adopt a rational attitude and a re-evaluation of our ways of doing and by means of modern record keeping systems and the analysis thereof. We have reached the time when we should analyze now and again as Thorsen says and pick out what is good and what is superfluous. The simple is certainly better if it is efficient. We have found, for instance, that the omission of premedication of opiates and barbiturates before inhalational anesthesia is quite as satisfactory, the results are quite as good. We have found that the simple administration of one drug throughout an anesthetic, for instance ether, nitrous oxide, cyclopropane, chloroform, procaine, gives us a better control and knowledge of what we're doing to an extent that was impossible with the polypharmacy that we formerly employed. If our residents become experienced in simple methods and a sensible attitude they go out and teach to other younger fellows in the profession, interns and so forth, methods that are applicable to the small hospital in the small community, the general practitioner. Simplicity then, with understanding of fundamentals, should not and does not imply inadequate or unsafe procedures in our experience. We used to worry a good deal about utilizing the patients in the hospital to teach senior students to give open drop ether anesthesia. Yet, with fogging the patient during induction with nitrous oxide, we were able to do that and we found that the records justified the procedure, that the overall final result to the patient was not jeopardized by such procedures. We found that inhalational anesthesia without any barbiturates or opiates or tribomethanol or curare are quite feasible and quite useful and probably much safer for the patient, certainly safer in the hands of the less experienced. We have found that even chloroform in the hands of those who are somewhat experienced and with apparatus which can control the dose, that chloroform, ether and nitrous oxide certainly are very useable drugs as simple, anesthetic agents, single anesthetic agents. They require more patience and skill, it is true, but they are satisfactory to the patient. Now all doctors need to know as a foundation for all anesthesia the physiologic aspects back of it and they need to know certain simple technical safeguards and those can be acquired rather easily. They are easy to teach except that they require much patience and they get us into much less trouble than with fooling around with a multiplicity of new drugs and new methods. The morbidity and mortality have been found at least in our experience not to differ very greatly regardless of the drugs used or the methods used. Now would we have that John Snow had not, might be interesting. We do have today, as you know John Snow was a practitioner of anesthesia before 1860, we have better controlled dosage of many agents, especially the ones that we can inject. We still need better controlled dosage of nitrous oxide, chloroform, ether and so forth and that is being worked on at the present time. We need to know the modern concepts of free breathing, the use of airways, and we need to know that these can be used to cover up lack of care in the dosage of the agents. And we need to know the usefulness of oxygen which Snow did not appreciate in anesthesia. But we also need to know that it can be a disadvantage as well as an advantage in anesthesia if it is used where it should not be or to too great an extent. I think we can say, finally, in our daily practice that with nitrous oxide, ether and procaine and simple methods of administration for them reasonably simple but with careful attention in the apparatus paid to actual dosage. I think with those agents, and possibly with the occasional use of cocaine and chloroform, we would have five agents then, nitrous oxide, ether, pro-



caine, chloroform and cocaine. And with those, I believe, we could accomplish most that is necessary in anesthesia for everyday use. We certainly would need, however, to have patience in teaching, we would have to have expert skill just as great as with the newer agents and methods in the use of these older ones. We can learn the new agents and the new methods certainly after we have learned these older ones perfectly.

Now, in conclusion, I should like to leave with you certain questions. Is the idea of a slight dose of many drugs in comparison with an adequate dose of one drug, a good idea? Is balanced anesthesia important, as important as we have thought it was? And is polypharmacy in anesthesia always good?

Secondly, I should like to leave with you this thought. Are we wise to assume responsibility for performing vital functions of patients because our technical skill and development permits it? I don't deny the usefulness of artificial respiration and other fancy technical procedures by the expert anesthetist provided they need it, provided they are indicated, but if we keep on at the present rate, we shall shortly be asked to maintain circulation as well as respiration during operations. Unless that is essential, and it may become essential I'll admit, but unless it is essential for everyday use, I rather decry their employment.

And then I ask you, is the new always good because it is new? And again, is the combination administration of depressant agents and stimulant agents in order to correct the effect of each other, that is, depressants such as opiates, barbiturates, inhalational agents and so forth, counteracted by coramine, metrazol, oxygen, atropine group, picrotoxin and so forth, justifiable; and is curare an anesthetic agent at all and should it be added in order to correct the technical inability of an inexperienced anesthetist? And again, I warn against the feeling that the old is outmoded because it is old. We are finding as we study some of the older agents, particularly ether and chloroform, maybe if we would find the same thing in regard to cocaine, that they have their technical difficulties, it is true, but administered well, possibly they still have their uses in the armamentarium of modern surgical practice. And I would warn particularly against injection being a way of relieving everyone in the operating room of responsibility for the transport of oxygen and carbon dioxide by the respiratory and circulatory systems. Many people seem to have the feeling that as long as they inject the drug they need not worry about the condition of the patient. And I should again suggest that drugs, neither new or old, nor technics new or old, can take the place of fundamental understanding, experience and skill.

In other words, may I ask this? Are we matching our wines and bottles injudiciously? Are we patching old garments with pieces of new garments to the detriment of both the new and the old? Are we bursting good old bottles by putting new and still fermenting wine into them and are we failing to construct new bottles in time for them to receive the new crop of wine after each year's harvest? Are we neglecting to taste some of the old wines to learn for ourselves with modern gustatory sense whether the old may not be better. I'd like to leave the thing open for your discussion.

Editorial Comment: Doctor Waters delivered this address in the name state of the historic first anesthetic at the invitation of his former resident and as a graduate of Western Reserve University School of Medicine: Perry P. Volpitto, Present Professor of Anesthesia at University of Georgia.

RALPH M. WATERS

Compliments of  
Ralph Waters

**PROGRESS IN ANESTHESIA IN THE  
WESTERN HEMISPHERE**

Separata da  
REVISTA BRASILEIRA DE ANESTESIOLOGIA  
Abril de 1951

## PROGRESS IN ANESTHESIA IN THE WESTERN HEMISPHERE

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The development of a new speciality in the practice of medicine is profoundly influenced by, although not necessarily wholly dependent upon, discussions of problems of mutual concern and publication of the thoughts of individual specialists. The frequency and quality of meetings of interested individuals, therefore, together with journals in which their thoughts can be printed, constitute a means of measuring progress. The announcement of "Revista Argentina de Anestesia and Analgesia" in 1939 was received with pleasure in North America. A second journal, "Revista Brasileira de Anestesiologia" constitutes a new milestone indicative of the rapid progress of Latin American anesthesia during the past decade. A short review of activity along similar lines in North America may interest Latin American anesthetists at this time.

So far as I am aware the first attempt to hold a meeting of anesthetists on a national scale in the U. S. A. was in 1912. An effort to establish an anesthetic section of the American Medical Association failed at that time. In lieu there of an American Association of Anesthetists was formed and, in 1914 an official organ of publication was begun as "The Quarterly Supplement of Anesthesia and Analgesia" of the American Journal of Surgery. In the fall of the same year appeared the first edition of the book published by Gwathmey and Baskerville. This was the first comprehensive textbook on the subject produced in North America. One might assume therefore, that judged by the time of the first appearance of special publications on the subject, the specialty of anesthesia in North America can be considered to be a quarter of a

century older than in Latin America. Both were handicapped because initiation of our specialty was followed by a world war in each case. It is hoped that you in Latin America, who are younger by twenty-five years may profit by a discussion of possible errors of omission and commission which were made by your elder brothers to the North.

Pioneers in human endeavor tend to follow the pendulum of progress to extremes rather than to travel a middle course which common sense should dictate. The history of our specialty gives many illustrations of this fact. As time goes on the pioneer tends to become experienced, a mature anesthetic specialist in our case, with a more stable and rational approach to the problems involved. Although conditions differ in our two continents, a knowledge of mistakes made and of lessons learned during our thirty-five years as a specialty may to some extent be found valuable to you in your effort to establish a Specialty of Anesthesia which will promote safety for Brazilian patients and satisfaction for Brazilian surgeons.

1. ANESTHESIOLOGY A PART OF GENERAL MEDICINE — Administration of anesthetics in the U. S. A. until the end of the 19th century was largely entrusted to the temporarily idle medical student, intern, general practitioner, nurse or other individual who chanced to be available and not busy at the moment. It is probable that many of these persons developed considerable technical skill. Such employment, however, rarely commanded more than nominal recompense either in fees or other evidence of appreciation. This heedless attitude toward anesthesia had only one result to commend it; namely, medical students, interns and young doctors in general did acquire a limited amount of experience and familiarity with methods of administering anesthetic drugs. The results, however, were variable and unpredictable. Those who served as anesthetist more frequently were likely to acquire greater skill. Since a doctor received a very inadequate fee or none at all, he had only one incentive; namely, the opportunity it gave him "to watch the operation". As one noted surgeon of the 1890 expressed it "A nurse makes a better anesthetist than a physician because her attention is concentrated upon the anesthesia whereas a doctor is interested chiefly in watching the operation". Through the influence of this man and other prominent surgeons of that day, certain nurses in larger clinics in the mid-western United States came to be assigned to anes-

thetia as a major portion of their work. The habit spread. It was a short step from this practice to the "specialist" anesthetic nurse. This seemed a harmless plan at the time and the vogue persists even to the present in some hospitals in the U. S. A. Glaring faults of the system became evident later which were not appreciated at first. Only two need be mentioned here. The first was a tendency toward total lack of interest in, or knowledge of anesthesia by the medical profession itself. Realization of this defect was delayed because a lapse of many years intervened before those physicians whose early intimate personal experience with anesthesia were no longer in active practice. As a result, during a considerable period little instruction or experience in anesthesia was available to the medical student or young doctor. The second unfortunate effect of these early practices regarding anesthesia, which has been a handicap of far-reaching significance in delaying the establishment of anesthesia on a professional basis, was the custom of permitting the hospital to charge the public a fee for anesthesia — while using only a fraction of the amount so collected in rendering the service. Hospital management came to look upon anesthesia as a source of revenue.

Meanwhile, those two basic disciplines, physiology and pharmacology, had been making rapid strides in our knowledge of respiration and circulation and of the mechanism of drug action. Their application as the very foundations of anesthesia was neglected. Hence, those of us who constituted the membership of early anesthetic societies in the U. S. A. were, with few exceptions, really technicians; serving, with our limited basic knowledge, merely to replace the specialist nurse, albeit in a glorified sort of way. I need not labor the point here that we are, in recent years, struggling with all our power to found our art of administering drugs upon a firm scientific foundation of fundamental knowledge; — to make of ourselves masters of a science as well as an art of relieving pain. In this struggle we are finding, as I shall emphasize later, the necessity of thorough instruction by way of reinterpretation and application for the undergraduate medical student, of the physiological and pharmacological principles which must protect patients from the dangers of depression.

In short, every specialist in Anesthesia ought to be a competent physician. Conversely, every physician, whatever his specialty, ought to possess knowledge and skill enough to administer an anes-

thetic when he must, to recognize competence in an anesthetist and to care for a depressed patient intelligently, regardless of the cause of the depression.

2. WE OUGHT NOT DEPEND FOR OUR PRESTIGE UPON THE NEW, THE GLAMOROUS AND THE SPECTACULAR. — We are sometimes tempted to court popularity in strange ways. During my own very early experience in anesthesia when I first came to realize the advantages of nitrous oxide I made a distinction as to the agent used in collecting fees for my services. One day the cashier of the local illuminating-gas company called my office to say that one of our patients was in his office prepared to pay our bill ! It had been rendered as a charge for “gas anesthesia”. Thereafter, our charges were made for “professional services” regardless of the agents or technics employed. Perhaps the glamorous and spectacular in drugs and technics did tend to impress surgeons and patients with the fact that a specialist in anesthesia was different. Perhaps demand for our services was thus promoted. I have even heard teachers state that the new, glamorous and spectacular were necessary to attract the interest and enthusiasm of students. Such superficial and showy approaches, however, form a precarious foundation upon which to build a sound specialty. Real and permanent success will more likely be based upon fundamental knowledge of the principles of respiration and circulation, technical skill in administering tried and proven agents and sympathetic personal relations with both patients and surgeons. The programs of our meetings and our publications directly following their initiation thirty-five years ago furnish ample evidence that neophilism was rife among us. We grasped each new drug possessing possible anesthetic qualities as a substitute for all the older agents. We tried intensively to make each new technic replace older customs. Enthusiasm for the new is, of course, desirable because it is the pathway of progress. Modern medicine has, to a certain extent, reached its present high state of perfection along that path. Nevertheless, discretion ought to be mixed with the valor of enthusiasm for the new. To be sure once a new drug or technic has been thoroughly evaluated in fair comparison with the old — and proven better — it ought to be included in our armamentarium. But to be “proven better” a great deal of work and time must be directed to observing disadvantages as well as advantages of unfamiliar practices. “Thorough evaluation” and “fair comparison”

demand study not only of the new factor in the comparison but of the old as well. Present day methods of investigation are more refined and reliable than formerly. It is not surprising therefore, that results of restudy of older practices in these comparisons may vary from the conclusions arrived at and placed in the literature at a much earlier date.

Even when we have finally accepted a method, new or old, I would commend to you the following quotation from Gunnar Thorsen which appears in his recent thorough analysis of the spinal anesthetics which have been administered in his institution.

“When a medical method, whether diagnostic or therapeutic, has been generally recognized it easily becomes a matter of routine, being deprived of unceasing critical observation. Indications and contraindications become blurred. Results are misjudged. Limitations and risks are forgotten. It therefore becomes imperative to analyze now and again the results arrived at, as well as, the risks and indications of the methods employed.” (Acta Chirurgica Scandinavica, Vol. XCV, Suppl. 121.)

3. OUR OBLIGATIONS — What are the obligations of our specialty and to whom do we owe them? Of the many I shall refer to only four; allegiance, service, teaching and research.

*Allegiance.* It is important to remember that our allegiance is tripartite in nature; our first allegiance is to the medical profession of which we are a part; secondly to the public and lastly to our specialty. The latter, that is the welfare of our selves and our specialty, is apt to appeal to us as all-important; and yet our own selfish interest is promoted in the long run by recognition of our obligation as citizens of our community and as members of the medical profession. We are apt to learn this fact too late. Many concessions that are for the good of ourselves and our specialty are secured through the aid and cooperation of lay boards of directors of hospitals, of public officials who direct hospital activities and of other medical specialists. Specialization in the practice of medicine is obviously necessary in this modern world. The field is too broad for each of us to comprehend every phase in all its details. The advantage of specialization is the opportunity it affords us to perfect ourselves more completely in a restricted field. The disadvantage of specialization lies in isolation, and in the temptation to lose

interest in medicine as a whole. General medical meetings and those of the various surgical specialties deserve the attention of the anesthetic specialist. Journals other than anesthetic must be furnished with a reasonable number of papers by anesthesiologists. Such papers, however, need to be of a different character than those written for the special attention of anesthesiologists. Joint discussions of mutual problems with the rest of the profession are beneficial to all who are influential in the medical staff of hospitals. The old adage "you scratch my back and I'll scratch yours" has a great deal of truth in it. The opinions of the anesthesiologist who works hard for community betterment, who serves faithfully and well in his local, county and state medical organization will be taken seriously when new hospitals are being built, when attitudes toward our specialty are being formulated or when laws governing the practice of anesthesia are being promulgated.

In spite of a contrary opinion of the uninitiated, no medical specialty has such intimate or so many interlocking relationships with other specialties and with medicine in its broadest sense as does anesthesiology. My own personal opinion is that we need, as I believe all specialists need, an initial orientation period of not less than three years after graduation before we choose our specialty. In the U. S. A. these three years can best be spent in what we call general practice. Time thus spent permits us to observe the various specialties and their interrelations and determine which specialty appeals to us most. It also makes for maturity and self-reliance in the period of special training. The three years will be compensated for in more rapid progress as a graduate student and thorough familiarity with the "business" of becoming a useful citizen and of conducting one's practice once he finishes training. A knowledge thus gained, of the viewpoint of others, of their problems; and sympathy for their difficulties is most useful. A feeling of certainty that he has chosen the right specialty, of confidence in his work and of assurance that he can succeed, are the results of this deliberate adoption of anesthesia as a life work.

*Service.* As specialists it is scarcely necessary to state that the foundation of our usefulness must be the best service of which we are capable, rendered both to patients and surgeons. I only mention it here for two reasons. One, because I myself have been guilty of sacrificing the one for the other on occasion. The other because



there are in our country anesthetic departments where research or teaching or both are looked upon as more vitally important than service. Skill at the operating table together with knowledge of all the ramifications which are now called anesthesiology are the "sine qua non" of the specialist. Without them neither teaching nor research can be conducted safely or effectively. When the service we render is less than the best our specialty fails to justify its existence.

*Teaching.* Once we have become a competent anesthetist we should consider it a privilege as well as a duty to teach other doctors whenever possible what we have been permitted to learn. Methods of teaching are as varied as the individuals who teach. Formal curricula and descriptions of methods used in certain institutions have been published. A method which is suited to one set of circumstances may be inadequate or impractical in another. This is not the place to consider details of that sort. I do wish to emphasize, however, our duty to contribute all we can to the knowledge of the fundamentals of anesthesiology to every medical student and every young doctor. There are two reasons for this: first, it is our duty to see that every licensed physician is capable of administering an anesthetic safely when he is confronted with the necessity of doing so. This, I believe, just as I believe that every anesthetist is a physician who must be capable of making a diagnosis and treating a patient surgically or medically when a more competent practitioner is not available. In smaller communities many doctors devote a part of their time to administering the occasional anesthetic (in the British Empire they are called "General Practitioner Anaesthetists"). They can do so with safety to patients and satisfaction to themselves. They deserve all the help and encouragement possible from the specialist. A second reason for instruction of other physicians by the anesthetist is that anesthesiology is founded upon a rational concept of the functions of respiration and circulation. Acute disturbances of these functions are the daily concern of the anesthetist. Who better than he, therefore, can impart to others the fundamental understanding and the technical "tricks" which are frequently life-saving measures if applied at once when no anesthetist is near. When respiration is obstructed, extremely depressed or arrested from whatever cause the nearest doctor should be able to come to the rescue. To our disgrace in the U. S. A., and because of the neglect of anesthetic teaching, firemen, policemen and other

lay rescue squads sometimes are asked to assume authoritative supervision of accidents even in the presence of physicians. Such conditions are a disgrace to us.

We in the U. S. A. felt that our early efforts to teach both the undergraduate medical student and the graduate preparing to specialize in anesthesia were handicapped by a lack of appreciation of the need on the part of those who directed medical schools and hospitals. In recent years, however, our embarrassment is of quite a different sort. The demand for competent teachers far exceeds the supply. Teaching is a specialty in itself, demanding long training and experience. Many of our medical schools are forced to appoint to advanced rank in their faculties, persons who, although capable as clinical anesthetists are far from maturity and full capacity as teachers. It appears that only time can remedy this unfortunate situation.

*Research.* I have already said that the safety and the effectiveness of both teaching and research are dependent upon clinical mastery. I shall add only a word of caution. Investigation, and publication of the results, involves serious responsibility. Basic knowledge, mature judgment and controls are among the essential requirements. Most of us will do better to direct our energy along other lines until the time arrives when we have no doubt that we ought to become investigators. Early efforts in research can usually be directed more fruitfully at the improvement of accepted practices rather than toward excursions into untried pathways. Consultation with our confreres in the basic sciences and cooperative efforts with them in research tend to keep us within the bounds of legitimate endeavors which give some promise of fruitful results. Too many of the current publications dealing with anesthetic problems exhibit evidence of a narrow viewpoint. On the one hand, reports of laboratory experiments often show lack of the guiding and checking hand of the master clinical anesthetist; while on the other hand papers from the clinical side, still more frequently, give evidence of the author's lack of knowledge of well known facts in physics, physiology, pharmacology or other fundamental science. Consultation and cooperation can contribute much in research. Unjustified inferences or conclusions, once published, cannot be recalled; and yet they can mislead a great many readers.

#### 4. QUALITIES OF THE GOOD ANESTHESIOLOGIST.

*Physical.* In choosing anesthesia as a specialty the young physician must not be deceived by the popular misconception that the anesthetist leads an easy life. Too many persons have entered the practice of anesthesia because they were told that handicaps such as tuberculosis, arthritis, cardiac lesions and other disabilities necessitating restricted activity, would interfere less with their success than in other specialties. This is definitely not true. Long hours, night work, tiresome positions for long periods and plain hard work in general are the lot of every anesthetist who faithfully fulfills his obligations. There are many other specialties in which the occasional day or hour of rest will interfere less with rendering satisfactory service to patients and to the rest of the profession. The temptation to overtax one's strength and endurance is nowhere greater.

*Moral.* Patients who are under the influence of depressant and anesthetic drugs often experience modifications of their normal mental qualities. Inhibitions may be released and actions which normally would be rejected as incompatible with the patient's moral code, may appear to them temporarily as desirable conduct. The mentally unstable anesthetist without a strict moral code of his own may, as a result, be subjected to temptations less frequently encountered in other specialties.

When the anesthetist assumes "power of attorney" for his patient as he becomes unconscious, he becomes burdened with the obligation of seeing to it that others, orderlies, nurses and even surgeons on occasion or members of the patient's family do not take advantage of the patient during periods of unconsciousness or mental depression.

Drugs which produce pleasant mental changes, relief of pain and sleep are constantly and easily available to the anesthetist. Worry, overwork, sleeplessness and misery of many sorts create the temptation to seek relief by the use of the drugs, the administration of which constitutes our hourly employment. The abuse of alcohol, the parent substance of most of our anesthetic drugs, is likewise an ever present temptation to us.

Suicide, drug addiction and unreliable professional conduct resulting in malpractice and breaches of the code of conduct have all occurred in the lives of anesthetists. Forewarned is, to an extent

forearmed. It seems to me that a stable moral character is an especially essential quality of those who enter our specialty. Anesthesia does not constitute a "way out" for either the physical or the moral weakling who has unfortunately gained entrance to the medical profession.

*Mental.* A spirit of friendly cooperation is essential to the anesthesiologist's success. In the development of our specialty in the U. S. A., too many of us have embarrassed our efforts by failing to see and occupy our specific place in the surgical team. A modern surgical procedure is a joint effort of several persons. The position of the anesthesiologist in that joint effort is critical. If he will approach his duties in a diplomatic manner, if he will contribute his science and skill in the spirit of the "golden rule" he may serve as the balance-wheel which governs the smooth running of the machine of which he is a part. The anesthesiologist who fails to cooperate diplomatically misses the opportunity to contribute toward the best accomplishment of internist, surgeons and hospital management. In short, he can make or break the success of the surgical team.

### Summary

In congratulating the Brazilian medical profession on the inauguration of the first Journal of Anesthesiology published in a Portuguese-speaking country, and the second in Latin America, an attempt has been made to discuss experiences of anesthesiologists in the U. S. A. which may prove useful in the development of the Specialty of Anesthesia in Brazil.

The intimate relationship of anesthesia to medical practice in general has been stressed. Fundamental knowledge of basic principles rather than the new, glamorous and spectacular has been recommended as a foundation of our specialty. Certain of our outstanding obligations, to ourselves and to others, have been outlined. And lastly have been discussed some physical, moral and mental qualities which seem to the author necessary to the success of the specialist in Anesthesia.

# Editorial

RALPH M. WATERS

Through the cooperation of the anesthesiologists in São Paulo, there has recently come to hand a short manuscript which is the oration Dr. Ralph M. Waters delivered at the Inaugural Ceremony of the Third Congress of the World Federation of Societies of Anesthesiologists, held in São Paulo, Brazil, in 1965. The simple beauty of this presentation, the kind reminiscences associated with it, and the wide perspective inherent in its thoughts, should be available to each member of our profession. We salute Dr. Waters and are happy that he continues to share his philosophy with us from time to time.

EDITOR

Years ago I read a book. It is called *Van Loon's Lives* and was written by an imaginative Dutchman named Hendrik Van Loon. I found it a collection of ghost stories. In it are described a series of Saturday night dinners at which the guests, usually invited in pairs, turned out to be sample characters from history. Erasmus and Sir Thomas More made an interesting evening. William the Silent and General George Washington came together. Plato and Confucius were guests another evening. In other words, the book is the story of meetings of ghostly characters from the past, the history of whom made it probable that their conversations would be entertaining and instructive.

The last two medical meetings which I attended convinced me that, so far as modern medicine and anesthesia are concerned I am now, and long have been, a ghost.

When I received this magnificent invitation to come to São Paulo and bring my wife to this meeting, I thought: "Ah-ha!, they have read *Van Loon's Lives* and had the same reaction which I had when I read it so long ago, namely, how nice it would be to gather together some of the characters who had to do with the origin of the use of drugs and methods to relieve pain, the *preanesthesiologists*, if you will." And I thought, "What a wonderful idea that is and how grand it will be to see and talk to some of those old fellows!" I thought to myself, "These wonderful Brazilians have deduced, rightly, that Ralph Waters is now a near-ghost and we might as well include the old fossil in our list of invitations." So here I am with my good wife, and even my daughter, after all these years in the limbo of retirement.

It seems to be working out that way. I have already seen two shadowy figures in the lobby who remind me very much of Rev. Priestley and Anton Lavoisier, probably asking each other whether Karl Scheele really deserved any of the credit for discovering oxygen. It was good to note that Lavoisier's head seemed firmly in place.

So I know the party is on. I am sure that I shall run into Tom Beddoes, probably hanging onto the arm of Humphrey Davy, and trying to claim credit for giving him his start in life and the opportunity to write that classic of all pharmacological classics on nitrous oxide, with the awesome title, *Researches, Chemical and Philosophical, chiefly concerning Nitrous Oxide or Dephlogisticated Nitrous Air and Its Respiration*, by Humphrey Davy, Superintendent of the Medical Pneumatic Institute.

That he did the work and wrote the book before he was 21 years old does not detract from its scientific value, and reading it now explains why the poet Coleridge, when asked why he attended Davy's chemical lectures at the Royal Institution in London, said: "I go to Davy's lectures to learn beautiful figures of speech."

But I shall run into other interesting personages, I am sure. I hope to find Fritz Serturmer, the once pharmacist of Paderborn who spent so much time and effort finding out why one prescription for opium won him the praise of the physician who wrote it, while the next might get him an unpleasant "bawl-

ing out" because the patient to whom it was administered got no relief from pain at all.

I'd like to tell Fritz what a wonderful boon to suffering humans the isolation of morphine and the establishment of alkaloids on a firm basis has been for the past 150 years.

You may wonder why the committee on arrangements has not provided a special meeting room for the ghosts. I think they realized that all ghosts are of a retiring disposition and that, when they were active in life, meetings were infrequent or nonexistent. Presiding officers and all that were not common as now. Of course, if Frank McMechan gets here, he will be disappointed not to have a formal meeting. But without his wonderful wife, Lorette, he might have difficulty in navigating his little wheelchair. With her in days gone by, they surely traveled to the ends of the earth, and few indeed are the regions where their influence is not still felt, wherever anesthetists or anesthesiologists gather for meetings, or where papers on these subjects are read or published.

If John Snow does not show up, I shall be gravely disappointed. Since he had read nearly everything published for two or three hundred years before 1857 in the subjects of pseudochemistry and prephysiology, and verified or disproved by experiments of his own most of what he had read, he should still be the greatest well of information from which other ghosts, as well as modern anesthesiologists, could drink.

I don't know how you moderns would react to the idea, but I have always felt that it would be fun to meet and talk with some of the old chaps who never published much but, in their way, did contribute a lot to the development of ways of relieving pain. One of these who was scarcely recognized along the way was Gardner Q. Colton. One hundred years ago, you remember, he was travelling around the eastern part of the United States using nitrous oxide to illustrate chemical lectures to lay audiences. Horace Wells benefitted from such a lecture. But I think it would be amusing to hear him tell of his experiences with Dr. Evans, the Paris dentist and friend of Emperor Napoleon the III. When Evans took Colton back to Paris at the Emperor's request to enliven an exhibit at the World's Fair in 1867, he created quite a stir, I imagine, with his public demonstrations of nitrous oxide anesthesia. He went back to the United States to establish the chain of advertising dental parlors where painless extractions were performed. But the dentist Evans went across the channel to show London how Colton used nitrous oxide, for the benefit of Clover, Richardson, and the others, and so brought back to Britain the idea which Davy had suggested to them nearly 70 years before.

If modern anesthesiologists should corner the ghosts of Sir Benjamin Richardson and the dentist, Thomas Evans, I would suggest that they try to learn from them the technique of making friends and influencing people. They might develop a "presence" which would overcome many of the handicaps which some of them experience in dealing with picayunish hospital administrators.

I hope we shall find the shade of Sir Frederic Hewitt drifting about, whose knighthood came, I am sure, not from his "presence," but from his sterling scientific work as the author of the first really comprehensive textbook on anesthesia. I hope many more of the preanesthetists will show up during the week.

For the opportunity to join this Third Congress of World Representatives of those who try to relieve pain, I am most grateful to all you Brazilians, as well as to old friends from far countries. Every gathering which brings together people from all parts of the earth helps a little, I believe, to hasten the day when enmity among the various nations will come to an end, and when all people can unite in a world free from animosity and misunderstanding.

May this Congress continue to meet and grow in years to come, to the benefit not only of the members who attend it, but toward the promotion of peace and cooperation throughout the world.

# *ANESTHESIA FROM COLONIAL TIMES*

*A History of Anesthesia at  
The University of Pennsylvania*

*By*

JAMES E. ECKENHOFF, BS, MD, FFARCS

PROFESSOR AND CHAIRMAN OF THE DEPARTMENT  
OF ANESTHESIA, NORTHWESTERN UNIVERSITY



J. B. LIPPINCOTT COMPANY  
*Montreal*    &    *Philadelphia*

## *Foreword*

OVER the past century, the attitude of the American medical profession and of surgeons, in particular, toward the pioneers in anesthesia offers an excellent example of what zoologists have called the "instinct of territorial command" and "the pecking order," characteristics which sociologists find also in humans.

This beautifully written and detailed history of the attempts to relieve pain at the University of Pennsylvania shows very clearly the struggle that has been necessary there and in so many other medical schools of this country. In all too many localities, the "territorial dominance" of the hospital and faculty organization has had to be overcome. At the same time, one has seen the serious frustrations and humiliations suffered by the pioneers during their efforts to bring better methods, drugs, and technics to the service of those patients who come to doctors for the relief of their suffering.

Efforts such as these described at Pennsylvania are overcoming the dominance of anesthesia by nonanesthetists. At the same time, these efforts have eliminated much of the severity of the "pecking" endured by the pioneers. The faculty, the hospital, the surgeon, and the general public from which our patients come, have all benefited in ways just beginning to be appreciated.

As a thorough, workmanlike, and well-documented history of the Department of Anesthesia at the University of Pennsylvania, this monograph will long remain a model for other institutions to emulate. This history will also serve as a well-deserved monument to the labor, enthusiasm and ability of Robert Dripps, who deserves the highest praise, and of his associates.

RALPH M. WATERS  
*Christmas, 1965*



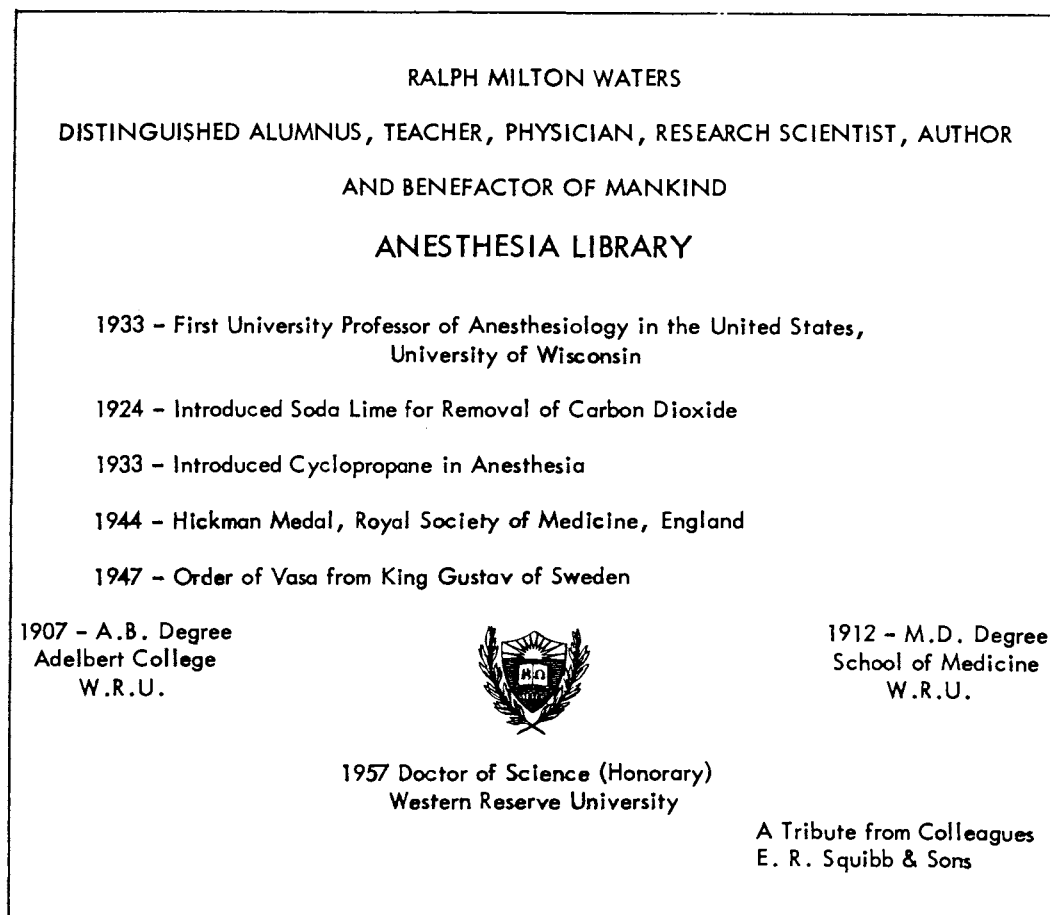
## INTRODUCTION

On October 9, 1883 the tiny village of North Bloomfield presented to Ohio, Ralph Milton Waters. This birth state of so many scholarly humanitarians, public servants, inventors, industrialists and scientists itself became enriched as it prepared this young inquiring mind through its development in: a happy home, a productive farm, grammar and high schools, Adelbert College and Western Reserve University School of Medicine, and the Cleveland German Hospital.

Doctor Waters has modestly narrated his own biography in "Pioneering in Anesthesiology". His life contributions to medicine in the practice of his science; to education in the training of his students; to humanity in the giving of himself through forty years of distinguished life-saving service; and to his colleagues and fellow scientists in recording his findings and experience in the medical literature, have sculptured a far more permanent record which has influenced almost every walk of American life through discovery and application of advancing principles in a new specialty in medicine.

In this program, and through the awarding of an honorary degree of Doctor of Science, this medical specialty and his parent university and his colleagues honor themselves in honoring him.

As an additional and perpetual tribute to him, we have designated our departmental library as the "Ralph M. Waters Anesthesia Library". Some of his colleagues have prepared a bronze tablet with the following inscription, to be appropriately placed in the Anesthesia Department of the University Hospitals of Cleveland:



The Foregger Company of New York, and his life-long friend and fellow scientist, Richard Foregger, have honored him and have rendered another distinguished service to our specialty, in preparing a large number of these selections of his scientific writings and addresses, copies to be presented to each of his former residents and to leaders in the specialty he pioneered.

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RESIDENTS TRAINED BY  
DOCTOR RALPH MILTON WATERS

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