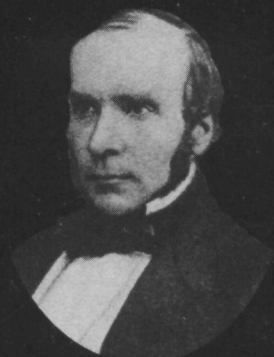


The History of Anesthesiology

Reprint Series: Part Four



Guedel



Snow



Miller

SIGNS AND STAGES OF ANESTHESIA

To render one insensible to surgical pain was a long sought blessing, but it soon became evident that the agents producing this could also — when not administered properly — produce death.

Patient safety was greatly enhanced by these early efforts noting the signs and stages of ether anesthesia. Included are:

Francis Plomley, *Operations upon the Eye*, January, 1847.

John Snow, *On the Inhalation of the Vapour of Ether in Surgical Operation*, September, 1847.

Arthur E. Guedel, *Third Stage Ether Anesthesia*, April, 1920.

Albert H. Miller, *Ascending Respiratory Paralysis under General Anesthesia*, January, 1925.

THE LANCET.

A Journal of British and Foreign Medical and Chemical Science, Criticism,
Literature and News.

MDCCCXLVII.

IN TWO VOLUMES ANNUALLY.

VOLUME I.

EDITED BY

THOMAS WAKLEY, SURGEON,

M.P. FOR THE METROPOLITAN DISTRICT OF FINSBURY,
AND CORONER FOR THE COUNTY OF MIDDLESEX.

LONDON:

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EXTIRPATION OF A LARGE TUMOUR.

By JOHN CHARLES HALL, M.D., M.R.C.S., East Retford.

THE Reporter for THE LANCET of a case in which an operation was last week performed on a patient under the influence of the vapour of ether, remarked, "All we want at present are facts faithfully recorded, whatever the result." I am quite aware it is impossible to draw a correct conclusion from one or two operations, and therefore feel it a duty I, in common with every other medical man, owe to the profession, to record from time to time the result of our experience. I last week mentioned two operations, performed by myself, on patients when under the effects of this all-powerful remedy. I now communicate the result of another operation, far more severe—an operation for the removal of an enormous tumour, which required a long, difficult, and tedious dissection, and which could only be effected slowly, and with very great care, from the nature of the highly important parts in direct contact with the tumour.

CASE.—Mrs. G—, aged fifty-three. I was requested by F. Blagg, Esq., Surgeon, of South Leverton, to give my opinion on the case of a lady who had been under his care for a tumour on the side of the neck. The substance was first observed about fourteen years since, and had slowly increased, until two years ago, when it began very rapidly to enlarge, and appeared, to use the lady's own words, "daily to press more upon her windpipe." It extended from the side of the trachea, downwards and backwards, over the sterno-cleido-mastoid muscle, its anterior edge, as far as we could ascertain, being in close contact with the carotid artery. As the tumour was rapidly increasing, and as it already interfered a good deal with the comfort of Mrs. G—, I proposed its immediate removal,* and my friend Mr. Blagg agreeing with me, it was fixed that I should remove it, which, with his valuable assistance, I accomplished, without giving the slightest pain to the patient.

January 25th, 1847.—Mrs. G— willingly consented to inhale the ether, which she did from the apparatus of Mr. Robinson; in five minutes she said she "was going off"—the pulse had then risen from 70 to 100—in eight minutes it was 120—the pupils dilated, the breathing quick, but no stertor. I then pinched the hand sharply, and spoke to her; she appeared insensible to pain; the face was covered with moisture. I now commenced the operation by making an incision from six to seven inches in length through the skin, and then proceeded carefully to dissect out the tumour, a work of considerable time and difficulty, from the firm nature of the adhesions of the tumour to the surrounding tissues, as well as from the very great caution necessary, from the very important parts in immediate contact; the inner borders of the sterno-cleido-mastoid muscle had been partially displaced, and the carotid artery was in close contact with the tumour, and could be felt, both by Mr. Blagg and myself, pulsating at the bottom of the wound. The operation lasted about sixteen minutes, during the whole of which time she only moved twice, when the vapour tube was again placed in her mouth; she answered somewhat incoherently, if questioned during the operation, and appeared perfectly indifferent to, if not unconscious of, what was going on. There was not the least quivering of the muscles on the first application of the knife. Mr. Blagg remarked it appeared as though I was demonstrating the parts on a dead body. She drank a little brandy-and-water twice during the operation, and appeared quite insensible, until three or four arteries, which bled rather freely, had been tied. As there was a good deal of oozing from the whole bed of the tumour, I sponged it with cold water, on which she said, "was I going to do it?" and appeared highly delighted when told by Mr. Blagg it was all over. A better proof cannot be given of the insensibility to pain, during the time she was under the influence of ether, and the return to it when it had ceased, than the fact of her complaining much, on my tying another artery, which began to bleed freely, and I did not think it necessary to place her under the influence of the vapour again.

Mrs. G— (and I may remark that we have here the testimony of a lady of fortune and high character) declared, "she felt no pain during the operation." She added, "I felt nothing, for I knew nothing. The first thing I remember after I went off, was hearing something fall into a basin." This was the tumour, which I threw down into a vessel near me, as soon as it had been removed. She was very cheerful an hour after the operation, remarking that the wound felt very

* I have often seen these fatty tumours acquire an enormous size. I have one now in my possession that I removed five years ago, which weighed nearly seven pounds. The tumour, in this case also, was many pounds in weight.

might be hazardous, and no prudent practitioner will use it without first making a very careful examination of the condition of his patient. Since the above was written, I have seen Mrs. G—, (twenty-four hours after the operation,) who appears going on as well as possible.

Grove-street, East Retford, Jan. 1847.

OPERATIONS UPON THE EYE.

To the Editor of THE LANCET.

Sir,—On Saturday, Jan. 16th, three successive and successful operations were performed at the Kent Ophthalmic Institution, Maidstone, whilst the patients were under the influence of ether, administered by myself, by means of an apparatus obtained from Mr. Hooper, Pall Mall East.

The first case was a labourer, named D—, aged nearly sixty, living at Bransted, a cataract patient, and the operation was the removal of a tumour, about the size of an orange, on the back of the skull, between the vertebra of the neck and the left ear. It required about seven minutes' inhalation before the patient became insensible, when the operator, Mr. Woolcott, made the first incision into the tumour, which was extracted in less than another minute. The patient seemed quite insensible to pain from the use of the knife, and only evinced some symptoms of uneasiness when the sponge was applied. The vessels having been taken up, the patient exhibited symptoms, for about one minute, similar to those of noisy intoxication, which quickly subsided, and he exclaimed, "I'm coming to now." "You must not come to yet," was the reply; "we are just preparing. Do you still wish to have the operation performed?" "Yes," was the rejoinder; "you may go on; I won't flinch." He was then shown the tumour, and seemed much delighted to find that the operation had been performed whilst he was unconscious, declaring that he had not suffered the slightest pain. The wound was then strapped, and the patient arose, apparently in an excellent humour, and without exhibiting any symptom of exhaustion or fatigue.

The second case was one of fistula lacrymalis in a middle-aged man, who, in a few minutes, was brought under the influence of the ether. The operation was performed without the least consciousness on the part of the patient.

The third was a case of strabismus in a boy, aged fourteen years. In this case some time was spent before the boy could be rendered sufficiently insensible for the operation. The first effect of the ether was a state of semi-intoxication, attended with a desire to go up-stairs, and it required considerable strength to prevent the patient from making the attempt to do so; but in about ten minutes from the commencement of the inhalation, he was in a profound state of intoxication. The operation having been completed, and as soon as the patient had somewhat recovered, he exclaimed, in a high tone of voice, and with great energy, "I have been going to heaven; I have been seeing the angels, and I don't know what all! I have been going to heaven, that's all I know about it! Angels and trumpets are blowing!" He continued to talk in this strain for ten minutes, after which he became sick and sleepy, as if recovering from a state of intoxication produced by spirituous liquors. The medical gentlemen present at these operations were, besides myself, and Mr. Woolcott the operator, Mr. Canton, of the Charing-cross Hospital; Dr. Huxley, of the County Lunatic Asylum; Mr. Sedgwick, Mr. Dickson, Mr. W. G. Sedgwick, Mr. Gould, and one or two other persons. Mr. Canton, who had witnessed several cases of the application of ether in the London hospitals, stated that these were the most successful cases he had seen.

Nothing could be more satisfactory than the above cases; and from the number of operations already performed in most of the public hospitals of this country and the United States of America, there can be no doubt of its applicability to all surgical operations, however severe and prolonged, not only on the human body, but on the bodies of animals also. Messrs. Staughton and Plomley, veterinary surgeons of this town, have, within these few days, with the assistance of myself and Mr. Woolcott, performed the most severe and difficult operations on dogs, without the least pain; and with a very simple apparatus, suggested by myself, animals can be made to respire the ether more readily than human beings.

I have breathed the ether on several occasions, and think its effects may be divided into three stages or degrees. The first is merely a pleasurable feeling of half intoxication; the second is one of extreme pleasure, being similar to the sensations produced by breathing nitrous oxide, or laughing gas; there exists in this stage a perfect consciousness of everything said or done, but generally an incapability of motion; in this stage, also, there is not exactly an insensibility to pain, but rather an indifference, "a care-for-nothing sort of feeling;" and if surgical operations are done in this stage, the patients almost always recover before the operations are completed, and the results are unsatisfactory. There can be no doubt that most of the failures may be attributed to this cause, as occurred to-day in a boy operated upon by Mr. Ferguson, at King's College Hospital.

The third stage, the only one, I think, for performing operations in, is one of profound intoxication and insensibility. The individual is completely lost to pain, and to external impressions; the muscles become prostrate, the circulation lessens, and the temperature falls; but the mind is often revelling in the most pleasurable regions, as in a dream; this, no doubt, depending much upon the temperament of the individual, and probably, also, on the physical effects of the operation on the nerves, as very often there is a considerable moaning, and an attempt to move, when under the influence of the knife.

There appears to be some difference of opinion as to the action of ether upon the system; but there can be but little doubt, that when taken into the lungs, its elements rapidly unite with the oxygen of the arterial blood, rendering it venous, and that it stops the metamorphosis of the tissues, producing a diminution of the temperature of the body, and also a diminution of vital energy, in the same way as the vapour of alcohol, only with greater rapidity.

I remain, Sir, your obedient and humble servant,
FRANCIS PLOMLEY, M.D., F.L.S., &c.

ETHERIZATION IN TETANUS.

To the Editor of THE LANCET.

Sir,—I see, by your leader of the 16th inst., that in your remarks upon the utility of etherization you state that "some have thought of its extension to medicine, and tetanus and hydrophobia have been mentioned as likely to be benefited by its use. Any such trials will assuredly end in disappointment; these diseases being diseases of motion, not of sensation." &c. You will perhaps be pleased to learn that this opinion is strictly borne out by fact, as far as the results of a single example can be relied upon. Having recently had a very severe case of tetanus under my care, I thought that I would give the ether a trial; I found, however, what a little reflection might have taught me, that it was even worse than useless, and that the spasms were fearfully augmented by every attempt at inhalation. As the action of ether is strictly, as far as I have been able to judge, confined to the cerebral portion of the nervous system, and as the excito-motory system is known to manifest an increase of action in proportion as volition is obliterated, (witness paraplegia, decapitation, &c.) it might be predicted that diseases in which the true spinal marrow is mainly implicated would not be reached by the ether, but would be aggravated by it. Excuse this hasty note, and believe me, dear Sir, yours obediently,

Bury St. Edmund's, Jan. 1846.

W. H. RANKING, M.D.

Correspondence.

REPLY TO DR. MARSHALL HALL.

To the Editor of THE LANCET.

Sir,—In last Saturday's LANCET appears a letter from Dr. M. Hall, in which he endeavours to vindicate himself from the charge, brought against him in the last number of the Medico-Chirurgical Review, of unjustifiable cruelty in the performance of experiments upon living animals. One would suppose, from the tone of that letter, and of the accompanying extract from his work, "On the Circulation of the Blood," that the experiment which called forth our

and the effusion of blood, it was very difficult to accomplish; the instrument therefore penetrated through the dura mater into the brain. The immediate effect was paralysis of the opposite side of the body; the animal, when placed on the ground, falling on that side, and being unable to rise. It managed, however, to struggle to the wall and corner, when, on being raised, it supported itself by leaning the paralyzed side against it. On introducing the finger, and pressing on the brain anteriorly, the eyelids closed, and the animal appeared as if asleep, breathing heavily." "The cerebrum was next completely broken up and removed, and the top of the skull taken off. The pupil of the eye became very much dilated, and the animal lost all sensation."

Can it be conceived that the infliction of such horrible suffering (for the animal, it would seem, was quite sensible at the commencement of the experiment) is necessary for the elucidation of any important truth, or for the advancement of that science on which, according to Dr. Hall, "not only the preservation, but the restoration, of strength and health depend." We cannot believe that even he will give the sanction of his authority to the repetition of so revolting an exhibition.

To base the justifiableness of vivisections on the permission or injunction to "kill and eat," is, to say the least of it, a strange misapplication of scriptural language. He who gave that permission, hath also told us—and how startling is the announcement—that "not even a sparrow falleth to the ground without His knowledge."

It would be easy to show how utterly opposed to the very principles which Dr. Hall has himself laid down in the extract quoted from his work on the Circulation, was the experiment upon which we have commented, not to mention some other experiments described or hinted at in the recently-published volume of the "Practical Observations and Suggestions;" but this is unnecessary at present.

THE REVIEWER OF DR. HALL'S OBSERVATIONS &c. IN THE LAST NO. OF THE "MED.-CHIR. REVIEW."

* * The questions to be decided are—1. Are experiments on living animals, or vivisections, as they have been nicknamed, justifiable? We suppose there can be no doubt of the affirmative, or else the whole science of physiology falls to the ground. 2. Granting the first position, did Dr. Marshall Hall ever devise and perform an operation without such an end in view as to justify its performance? We believe not. We have ourselves seen Dr. Hall perform a great number of his experiments, and we have ever seen him follow the humane principles laid down by himself in the introduction to the Physiology of the Circulation.—ED. L.

MIDWIFERY FEES.

To the Editor of THE LANCET.

Sir,—Being an honest follower of Esculapius, I am profoundly ignorant of "Secondaries' Court," and hope to remain equally unacquainted with Mr. Secondary James, who estimates very lightly the services of a medical man.

This learned gentleman is made to state, in the *Morning Chronicle* of the 7th instant:—"Two guineas now-a-days appeared a handsome price for an accouchement. He thought few ladies who kept their carriages would give more than 5*l.* 5*s.*" What will Dr. Locock say to this new and legal adjudication of fees? I should like to know, Mr. Editor, what justice there is in Mr. Secondary James fixing in so summary a manner the sum of 2*l.* 2*s.* No fact more than this judicial interference with our fees proves the necessity for an effective system of registration; for upon that will follow a fair system of undisputed remuneration.—Yours truly,

London, Jan. 1847.

ADVERSO JACOBO.

COURTS-MEDICAL.—WIGAN v. GREGORY.

[LETTER FROM MR. W. ROBINS.]

To the Editor of THE LANCET.

Sir,—I cannot help thinking the majority of your readers will be ready to admit that the cause of Wigan *versus* Gregory should be considered in some other light than as a mere personal dispute; and that some more lasting effect ought to be produced by it than by an ordinary nine days' wonder. In my humble opinion, there are, in this case, circumstances which *must* produce, sooner or later, such an impression on the pro-

ON THE
INHALATION
OF THE
VAPOUR OF ETHER
IN
SURGICAL OPERATIONS:

CONTAINING A
DESCRIPTION OF THE VARIOUS STAGES OF ETHERIZATION,
AND
A STATEMENT OF THE RESULT OF NEARLY EIGHTY OPERATIONS IN WHICH
ETHER HAS BEEN EMPLOYED IN ST. GEORGE'S AND
UNIVERSITY COLLEGE HOSPITALS.

BY
JOHN SNOW, M.D. UNIV. LOND.
FELLOW OF THE ROYAL MEDICAL AND CHIRURGICAL SOCIETY,
LECTURER ON FORENSIC MEDICINE.

LONDON:
JOHN CHURCHILL, PRINCES STREET, SOHO.

1847.

ON THE
INHALATION
OF THE
VAPOUR OF ETHER
IN
SURGICAL OPERATIONS.

THE point requiring most skill and care in the administration of the vapour of ether is, undoubtedly, to determine when it has been carried far enough. In order to communicate, with some degree of clearness, what I have been able to observe by close attention to the subject, I shall divide the effects of ether into five stages or degrees; premising, however, that the division is, in some measure, arbitrary,—that these different degrees run gradually into each other, and are not always clearly to be distinguished,—and that the language I have used has been chosen with the sole object that my meaning might not be mistaken.

In the first degree of etherization I shall include the various changes of feeling that a person may experience, whilst he still retains a correct consciousness of where he is, and what is occurring around him, and a capacity to direct his voluntary movements. In what I call the second degree, mental functions may be exercised, and voluntary actions performed, but in a disordered manner. In the third degree, there is no evi-

dence of any mental function being exercised, and consequently no voluntary motions occur; but muscular contractions, in addition to those concerned in respiration, may sometimes take place as the effect of the ether, or of external impressions. In the fourth degree, no movements are seen except those of respiration, and they are incapable of being influenced by external impressions. In the fifth degree, (not witnessed in the human being), the respiratory movements are more or less paralysed, and become difficult, feeble, or irregular.

If a middle-aged man, of about the average size, is supplied with air mixed with vapour of ether, in the proportion of 45 per cent. vapour to 55 per cent. air, and breathes it easily and without obstruction, he usually consumes about two drachms of ether per minute. It is not all absorbed, for a part is expired after passing no farther than the trachea. At the end of the first minute he is usually in the first degree of etherization; of the second minute, in the second degree; of the third minute, in the third degree; and at the end of four minutes, having inhaled an ounce of ether, in the fourth degree. If the inhalation is now discontinued, he commonly remains in this degree of etherization for one or two minutes, passes gradually back into the third degree, which lasts for three or four minutes, at the end of which time he is in the second degree, which lasts about five minutes, to give place to a feeling of intoxication and exhilaration, which lasts for ten or fifteen minutes or longer before it entirely subsides.

Having thus sketched an outline of the process of etherization, we may now proceed to examine the different states of it a little more closely.

Generally, all that the patient remembers of the effects of ether occurs whilst he is under its influence in the first degree only, and his feelings are usually agreeable—often highly so. I consider that it is not practicable to perform operations, in the absence of pain, without carrying the effects of ether further than this degree. Whilst the effect of the ether is going off, however,—after persons have been completely insensible,—they are not unfrequently free from the pain of an operation, which is still going on, at a time when the mental faculties have returned, together with the special senses of sight and hearing, and when they are consequently in what I have denominated the first degree. Of this degree, as it follows the others, we shall have to speak again. If etherization is not carried further than this degree it quickly subsides, without leaving any appreciable effects; but if the inhalation is continued, the second degree succeeds to this.

When the ether is administered in the method that I recommend, the patient usually passes quietly and quickly through the second degree of etherization without its being manifested in any way. As he is not questioned, the state of his mental faculties does not appear, and he passes rapidly into the next degree. Sometimes, however, when from the tendency of the vapour to produce coughing it is given in a more diluted form than usual, and occasionally, also, from peculiarity of constitution, this degree of the effect of ether is made

apparent by gesticulation, words, or attempts to move; and in hysterical females, sometimes by sobbing, laughing, or screaming. The patient often tries, by lifting up his hands or moving his head, to remove the inhaler from his face whilst in this stage. He feels something there interfering with his ordinary respiration, and the purpose and nature of it have passed from his mind; his endeavours are voluntary, but guided by instinct rather than reason. He can often be quieted by language addressed to him, and will do as he is bid, although unconscious of where he is,—as his answers, if he makes any, shew. At other times he is obstinate, or regardless of what is said. I believe that all the dreams which patients have when taking ether, occur only whilst they are under its influence in this degree. If the ether is discontinued at this stage of the inhalation, the patient goes back into the first degree, either immediately or in the course of a few minutes, according to the extent he has advanced, or the time he has been kept in this degree. According to what I have seen, a surgical operation would cause pain, if etherization were not carried farther than this degree, although, if the pain should not arouse the patient and bring him back to the first degree, he would probably not remember it. But it would be more difficult for the surgeon to operate with this amount of etherization than without ether.* It appears that surgical opera-

* From accounts that I have heard of two or three cases, it seems probable that if the patient were kept for some time in this stage of etherization, by breathing very diluted vapour, an immunity from pain might in some cases result; and this is corrobora-

tions have often been performed in this stage, and several eminent surgeons were at one time opposed to the use of ether, on account of the struggling which they supposed to be inseparable in most cases from operations performed under its effects.

When the patient has been more deeply etherized, he is often totally insensible to a surgical operation, as the effect of the ether is going off, whilst he is under its influence only to the second degree. Of this we shall speak below.

To proceed to the third degree. It is stated above that if the patient moves or struggles, when under the influence of ether in the second degree, his movements are guided by volition, though not by knowledge or reason; but if he struggles in the third degree of etherization his movements are not voluntary, any more than the struggling in hysteria or epilepsy. Usually, however, there is no struggling. The patient may have moved his eyes about in the second degree, and even directed them to objects, but in this degree they are stationary, or if they do move, their motions have nothing of a voluntary character. They are sometimes turned upwards as in sleep, but I think not so frequently as in the next degree. The eyelids may be either open, or partly or tightly closed, but in either case, if lifted or moved by the finger, the orbicularis palpebrarum contracts. The breathing is usually regular and somewhat

rated by an observation I made on a bird, which had been for ten minutes in an atmosphere containing ten per cent. of vapour of ether; but it is not likely that such a plan of administering ether would generally succeed, or be so good as that usually adopted.

deep; the patient lying still, or, if sitting, having a tendency to slide out of the chair; but occasionally the limbs are rigidly contracted, and when this is the case the patient sometimes holds his breath for several seconds at a time. He may moan in this degree of etherization, but never gives utterance to articulate sounds, which are always an indication that he has not advanced farther than the second degree, or has returned to it. Therefore the performance of a surgical operation in this stage would not cause a person to cry out in articulate sounds, unless it roused him, and caused him to return to the second degree; it might, however, cause him to groan and flinch. If this degree is well established, and if the patient has been detained in it, at the same point, by inhaling at intervals, or by inhaling dilute vapour, an operation may usually be performed without producing any other effect than a distortion of the features expressive of pain, and, perhaps, a slight moaning, and an increased frequency of respiration, and, in some instances, a general rigidity of the muscular system. If this degree of etherization is not well established when the operation begins, the first cut may cause a sudden contraction of the whole muscular system. Persons in a full state of health, and more particularly those in a state of plethora, are much more liable to struggling and rigidity in this degree, than those whose strength is reduced by illness; and if from any cause the supply of atmospheric air is limited, and something of asphyxia is combined with the etherization, I believe that the struggling is more liable to occur, and is more severe.

There is never any recollection of operations in this degree, even when symptoms of pain have been exhibited, and there is scarcely ever, I believe, any sign of pain in this degree, when it succeeds to the fourth, as the influence of the ether is subsiding. If the exhibition of ether is discontinued in the third degree, the patient goes back into the second degree immediately, or in the course of two or three minutes.

In the fourth degree all the muscles are relaxed, and the limbs hang down, or rest in any position in which they are supported. The eyelids fall down over the eyes, or remain as they are placed by the finger. The eyes are either turned up or remain central. The breathing is deep, regular, and automatic, and there is often snoring. The muscles of the face partaking in the general relaxation, the countenance is devoid of expression, having a placid appearance as in a sound sleep. Sometimes the lower jaw has a tendency to droop; the mouth is partly open, and the features are so relaxed, that the countenance is altered, and has the vacant appearance seen in paralysis, idiocy, or a helpless state of drunkenness; and if there is at the same time snoring and blowing of the lips in respiration, as now and then happens, an appearance is met with that would be truly alarming, if we did not know that it was only due to an agent which is flying away every moment in the breath, to leave the patient, in a few minutes, without any permanent trace of its having been there. In this degree of etherization the patient always remains perfectly passive under every kind of operation; and as the muscles are completely relaxed,

this is the proper stage for the reduction of dislocations. The patient never begins to snore until he has reached the fourth degree, or is passing into it from the third, and from all that I have hitherto observed, I believe that when he snores from the effects of ether, he is always totally insensible to every thing which is done to him. This degree of etherization seldom continues more than two or three minutes after the process of inhalation is left off, and I have never kept the patient in this stage more than five or ten minutes; but in operations of long duration have allowed the effects of the vapour to diminish somewhat from time to time. The integrity of the functions of respiration and of circulation is not impaired in this degree. The breathing is generally deeper than usual, and although it has been somewhat stertorous in two or three instances, yet it continued with great regularity, and the stertor subsided in a minute or two. The pulse is distinct and of good volume, even in patients affected with hectic, in whom, just before the inhalation, it was small and hard. It is usually accelerated, as in all the other stages of etherization. The sensibility of the glottis and pharynx continues in this degree, for the blood which flows backwards in operations on the nose and mouth is all swallowed, none of it getting into the trachea.

In the fifth degree, as met with in animals inferior to man, they remain motionless and flaccid as in the fourth degree, and respiration begins to be irregular, feeble, or laborious. The muscles of respiration begin to suffer the loss of power which already involved the

merely voluntary muscles. The sensibility on which respiration depends, and which has outlasted the special senses and common sensibility, now begins to be abolished under the effects of an increased quantity of ether. This is the stage immediately preceding death when animals are killed by ether, and there can be no doubt that it would be met with in the human being, if the vapour were exhibited so as to increase its effects to a dangerous degree beyond what is ever required. (1)* However nearly dead animals may be from ether, if the breathing has not actually ceased when the vapour is discontinued, they always recover, as was stated by the author, at the College of Physicians, when he had the honour of performing some experiments at the conclusion of Dr. Wilson's Lumleian Lectures, on the subject of Pain, in March last. This circumstance illustrates forcibly the great safety of the inhalation of ether, and how much it differs in this respect from asphyxia, and the exhibition of narcotics by the stomach.

The fifth degree of etherization has only been mentioned as a state to be avoided, and we proceed now to the degree which follows the fourth, when the patient is no longer kept in it; and this is the third degree, as it appears a second time. It is usually less marked now than when it preceded the fourth degree, and struggles and rigidity are less frequent,—seldom, if ever, taking place except they have previously occurred in the same degree, and not by any means constantly, when such has been the case. If struggles do occur,

* The numbers refer to the Appendix.

and especially if they are accompanied by moaning, as sometimes happens, and if a surgical operation is going on, it may appear to an inattentive observer that the patient is feeling pain, when such is not the case; for a closer attention will shew that the supposed signs of pain are not increased when cuts are made, or ligatures tied on the arteries; and if the ether is not re-administered, and the patient is allowed to recover still further during the operation, it will probably happen that in the second degree he will either lie perfectly calm, or talk in his dreams about subjects totally unconnected with pain, or the operation which is still going on. And it is not to be supposed that he is becoming less sensible as the effects of the narcotic are subsiding. I believe that pain is seldom felt in the stage of which we are treating—the third degree succeeding the fourth—and of course never remembered afterwards, as there is no knowledge or mental perception of it. This stage of etherization seldom lasts longer than from two to four minutes before it gives place to the second degree, if the inhalation is not resumed.

The second degree is usually much better marked as the patient is recovering from the ether, than when he is getting under its influence; it also lasts much longer at this time, the reason of which is obvious; for when he is inhaling the vapour he is quickly removed from this into the third degree, but when the inhalation is discontinued the vapour is got rid of, in a ratio varying directly with the quantity in the blood, which is a constantly decreasing ratio. The blood, in passing through the

capillaries of the lungs, shares its ether with the air taken into the air cells, and, consequently, the process of de-etherization becomes slower as it goes on (2). For this reason, also, this degree continues longer than the third, often lasting five minutes, and occasionally more than twice that period. The dreams which patients so often say that they have had during the operations, take place, I believe, only in the second degree of etherization; and generally in the recurrence of this degree, as the effects of the ether are subsiding, and more commonly after than during the operation. If the patient talks, it often happens that what he says is in accordance with what he afterwards remembers of his dreams, which often refer to early periods of his life; and a great number of patients dream that they are travelling. The impression of the length of the dreams can of course be no argument as to how long the person was dreaming, and that impression is often of a longer time than the whole period of insensibility; and I think that there is every reason to presume, that there can be no dreams or ideas of any kind in the third and fourth degrees of etherization, and that for a short time there is not only, as in a sound sleep, the absence of mental functions, but also the impossibility of their performance. Indeed, from a comparison of what patients sometimes express by words or gestures under the influence of ether, with what they say of their dreams, it would appear that the dreams which are remembered occur only when the patients are fast emerging from the second degree into a state of complete consciousness. Some of the mental states met with in this degree are highly interesting in

a psychological view, but the description of them does not form a necessary part of this small treatise. The laughing and crying, which are now and then met with in this degree, are not always the result of joy or sorrow, or even connected with any state of mind corresponding to the expressions, but resemble the laughing and crying of hysteria. The patient is often incapable of pain in the stage which we are considering, but not always so; very commonly he is so in a part of this stage, but if the operation continues he begins to shew signs of feeling it, and the inhalation has to be resumed before he passes into the first degree.

After the patient has recovered his consciousness of surrounding circumstances, there is usually a degree of exhilaration, or some other altered state of the feelings for a little time,—accompanied, sometimes, with a little confusion of the mind, and inability to walk steadily. This, which I have called the first degree of etherization, subsides more slowly than the other degrees, remaining, in some instances, half an hour in a marked degree, and to a slight extent for two or three hours. The patient often expresses his gratitude to his surgeon in more ardent and glowing terms than he otherwise would do if the remaining effect of the ether were not counteracting his usual reserve. Let us hope that *in æthere veritas* is as applicable as the old reading, and that, in these instances, we only witness the usual feeling of the public towards the medical profession. Commonly, the patient would feel pain if any part of an operation were performed in this stage, but not always; for, in some instances, the special senses of

sight and hearing, and complete consciousness and volition, return before common sensibility, and the operation may be going on, for a short time, without his feeling it, and perhaps, whilst he, thinking that it is concluded, is remarking that he did not feel it. But even in these exceptional cases the patient soon begins to complain, if the operation continues. Sensation usually, however, remains blunted for some time, and there is generally no smarting in the wound for a little time (often half an hour) after consciousness has completely returned.

The effects of ether were divided into three stages by Dr. Plomley, of Maidstone,* early in the year. The first degree in the above division would include his first two stages, and the next three degrees would be comprised in his third stage. M. Longet† divides etherization into that of the cerebral lobes, and that of the annular protuberance; and M. Flourens makes three degrees as follows:—

“Under the action of ether, the nervous centres lose their powers in regular succession; first, the cerebral lobes lose theirs, viz. the intellect; next, the cerebellum loses its, viz. the power of regulating locomotion; thirdly, the spinal marrow loses the principle of sensitiveness and of motion; the medulla oblongata still retains its functions, and the animal continues to live: with loss of power in the medulla oblongata, life is lost.” (*Gazette des Hôpitaux*, 20 Mars, 1847: quoted in *Brit. and For. Med. Rev.*)

* *Lancet*, Jan. 30.

† *Archives de Méd.*, Mars 1847.

My second degree corresponds to the etherization of the cerebral lobes of M. Flourens. There are, to be sure, occasionally, dreams and indications of disordered intellect, but these could not be recognized in animals, the subjects of his experiment. His next stage corresponds to my third degree; and his last, or the etherization of the spinal marrow, to my fourth degree. The division I have made from observations on patients, will, I think, be found to be better for practical purposes than this, which it very much resembles, of M. Flourens, the result of experiments on dogs; and it involves no theory about the functions of the nervous centres, which is perhaps an advantage, as those, particularly of the cerebellum, are probably not definitively known.

It will be observed, that the non-liability to pain does not correspond uniformly with the state of the patient in other respects when under the effects of ether, and that I have made the division into degrees, according to the other and obvious symptoms, and not according to that which could only be determined by the knife.

The question may be asked, whether the medical man can always determine in what degree of etherization the patient is, and by that means estimate correctly whether or not he is liable to pain. I am not sure that he always can, by the mere observation of the patient. I have never been deceived as to the degree of etherization, but then I always know the strength of the vapour which the patient is breathing, and by observing the length of time that he has been inhaling, and the depth of his inspirations, I know in what stage

he ought to be, and am in this way guided in the cases in which well-marked symptoms are absent. In many cases, the moment when an operation may, with propriety, be commenced, is indicated by unmistakeable signs; but, in other instances, it must be acknowledged that the point has to be determined by the consideration and balancing of several particulars. This, however, ought to be no obstacle; for it is only in this way that the medical man is guided in his usual avocations. His diagnoses and prognoses are generally arrived at by a mental operation of this kind, and not by the observation of some certain sign.

I have spoken of a knowledge of the strength of the vapour as being essential to a correct determination of the state of the patient at all times: and this brings us to the apparatus for the administration of the vapour, as, without a suitable one, the proportions of air and of vapour cannot be determined.

I had the honour of shewing that these proportions could be easily and precisely controlled by means of the temperature,* and of introducing an inhaler, by which the quantity of vapour in the air the patient breathes can be accurately regulated. It is made of metal, the best conductor of caloric, and placed in contact with water, the best and most convenient regulator of temperature; and, consequently, we are enabled to avail ourselves of the law which determines the quantity of vapour of ether that air will take up, and hold in sus-

* Med. Gaz., Jan. 22; and Lancet, Jan. 23.

APPENDIX.

The Notes refer to the Numbers in parentheses in the Text.

NOTE (1), p. 9.

THE circulation of the blood continues for a little time in animals after the respiration has been arrested by the influence of ether, and it ceases, apparently, from want of the respiration, and not from the direct effects of the ether. This I observed early in the year, but it was first made known by the Parisian physiologists. The reason of this, I believe, is not that ether is incapable of paralyzing the heart and blood-vessels, but that it sooner affects the medulla oblongata, and the nerves connected with it, than the ganglionic nervous system. Indeed, I have ascertained that such is the case, from observations I have made on frogs. If placed in air containing but 20 or 30 per cent. of vapour of ether, they very quickly become affected, probably from the rapid absorption of the vapour by the skin: in a minute or two the respiration ceases, and they have every appearance of being dead, except that the heart can be seen pulsating on the under side of the chest. If they are now withdrawn, the circulation continues, the ether gradually evaporates by the

skin, and respiration recommences, in a period varying from 5 to 15 minutes, according to the length of the previous exposure to the vapour: whilst, on the other hand, if they are allowed to remain in the air containing vapour, more ether continues to be absorbed, and in about five minutes the heart ceases to beat perceptibly, although its pulsations would continue for hours without the respiration, even in a frog immersed in water that has been deprived of its air by boiling. Some slight vermicular contractions of the heart, that would be visible on dissection, continue for a little time, and if the frogs are withdrawn from the vapour during this interval, and kept moist, they may yet recover, although they sometimes show no signs of life for an hour and a half.

Although etherization and asphyxia resemble each other in some respects, yet the rapidity with which frogs are affected with ether, whilst they are so very slowly asphyxiated by privation of air, proves that they differ widely, and shows clearly enough that the effects of the vapour of ether are not due to its excluding part of the oxygen of the air by the space it occupies, as might at first, perhaps, be supposed. That such is not the way in which ether acts I ascertained in a more direct way in the beginning of the year, by supplying artificially the oxygen so displaced, when I found that the peculiar effects of ether were produced in animals just as readily as before. If hydrogen, nitrogen, or any neutral gas which does not support life, were mixed with the air, in even half the quantity that vapour of ether is commonly mixed with it, the oxygen of the air,

over-diluted, would fail to be imbibed into the blood in exchange for carbonic acid, and the patient would suffer asphyxia, the blood being arrested in its passage through the pulmonary capillaries. The oxygen is often reduced by the vapour of ether to 10 or 11 per cent. of what the patient breathes, whilst if it were reduced but to 16 per cent. by a gas which is not absorbed, no increased efforts of respiration would prevent asphyxia from quickly supervening.* That nothing of the kind takes place during the inhalation of ether depends on the circumstance that the vapour is absorbed as fast as it reaches the air-cells of the lungs, leaving the oxygen in its usual proportion per cent.; and to get enough of it the patient usually enlarges his respiratory movements instinctively, as he would do if situated on a high mountain, where the air is much rarefied.

NOTE (2), p. 11.

When air is admitted to a liquid containing ether, the liquid parts with some of its ether to the air; whilst, if air containing ether is admitted to a liquid containing none, it parts with some of its ether to the liquid; and in either case a balance is established. The interposition of a thin animal membrane between the liquid and air, like that between the blood and the air

* See a paper "On the Pathological Effects of Atmospheres vitiated by Carbonic Acid Gas, and by a Diminution of the due Proportion of Oxygen."—*Edin. Med. Surg. Journ.*, Jan. 1846.

in the lungs, does not interrupt this interchange. The quantity of ether that a limited portion of air will withdraw in the form of vapour, from a liquid containing it, is determined by the temperature and the quantity in the liquid: for instance, if the liquid is saturated with ether, the air will become saturated also, for that particular temperature; if the liquid is half saturated, the air can only withdraw as much as will half saturate it; and so on, in a direct ratio, as I have ascertained by experiments. It is not improbable that some of the ether inhaled is decomposed in the body; but this does not alter the question of de-etherization in this manner, for assuredly by far the greater portion of the ether escapes by the breath unaltered.

Ether exists in the blood during etherization as a liquid, not as vapour. Although the temperature of the blood is a little higher than the boiling point of ether, yet it is capable of absorbing the vapour readily, and holding it in solution. 100 parts of water at 60° will hold in solution about 10 parts of ether, or rather more than 23 times their own volume of the vapour: at 100° —the temperature of the blood—water will absorb and hold in solution about half the above quantity, and it is capable of absorbing the vapour of ether, and holding it dissolved at all temperatures up to 212° , its own boiling point, but in a constantly diminishing quantity. Blood, on account of its density, absorbs less ether than water at corresponding temperatures; but it is capable of absorbing more than it has ever the opportunity of doing in the process of etherization.

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employed during the operation. Nausea and thirst, and vomiting, with its disagreeableness and its sequels of wound strain and pain are largely eliminated.

LOCAL ANESTHESIA IN CHILDREN.

When operating upon children under local anesthesia restraint is necessary while the anesthetic is being introduced. Figure 8 shows a simple manner in which this restraint may be employed without

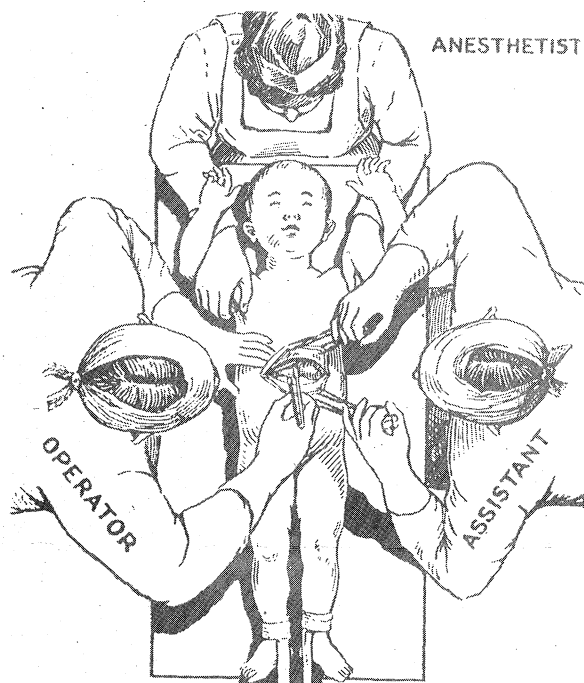


Fig. 8—Illustrating the method of controlling young children in operations under local anesthesia. By making traction on the arms the anesthetist controls the child when necessary.

in any way interfering with the technic of the operation. My experience of more than 100 operations performed on children under the age of fifteen shows that the restraint necessary is probably less than ten per cent. of that required during the administration of a general anesthetic and that this class of patients lend themselves exceptionally well to this form of anesthesia.

301 PHYSICIANS' AND SURGEONS' BLDG.

THE INTERSTATE ASSOCIATION OF ANESTHETISTS HAS BEEN ACCORDED THE DISTINCTION OF A JOINT MEETING WITH THE PENNSYLVANIA STATE MEDICAL SOCIETY, AT PITTSBURGH, OCTOBER 4-7. THE PROGRAM FOR THURSDAY AFTERNOON WILL BE DEVOTED TO PAPERS ON ANESTHESIA BEFORE A JOINT SESSION OF ALL THOSE IN ATTENDANCE. IT IS ALSO EXPECTED THAT THE NATIONAL ANESTHESIA RESEARCH SOCIETY WILL MEET AT THE SAME TIME AND PLACE. MAKE YOUR ARRANGEMENTS TO ATTEND. ALL THE ACTIVITIES OF THE MEETING WILL OCCUR IN THE WILLIAM PENN HOTEL.

THIRD STAGE ETHER ANESTHESIA: A SUB-CLASSIFICATION REGARDING THE SIGNIFICANCE OF THE POSITION AND MOVEMENTS OF THE EYEBALL.*

ARTHUR E. GUEDEL, M.D.,
INDIANAPOLIS, INDIANA.

This paper and the accompanying scheme of illustrations was used by the writer many times in teaching anesthesia with the A. E. F. in France.

The objects in presenting this paper are two: *First*, to encourage lighter and more even ether anesthesia; and *second*, to present some tangible form for didactic teaching of anesthesia to students.

Our literature up to date mentions four stages of anesthesia. The first stage, during which the patient experiences analgesia but does not lose consciousness; second, the stage of excitement; third, the surgical stage, and fourth, that stage beginning with cessation of respiration and ending with cardiac paralysis and death.

DEMANDS OF MODERN ANESTHESIA.

Modern anesthesia requires more than this. The knowledge that the patient is in the third or surgical stage is not now sufficient. We should be able to say at any time in just what part of the third stage we are carrying anesthesia. The latitude of third stage anesthesia with ether is great, so great that the patient may easily be given more ether than necessary without being in any immediate danger. Postoperative toxemia is in direct proportion to the amount of ether administered. The patient may be carried lightly with good relaxation and quietude, and suffer but slight postoperative toxemia from the ether, or he may be carried for an hour in the deepest part of the third stage with immediate safety so far as the anesthetic is concerned, but the postoperative toxemia will be great. Light anesthesia, if it be acceptable to the surgeon, is infinitely better than deep anesthesia. We have known this for a long time, but have not known that there is a very light stage of surgical anesthesia which affords the surgeon as much ease and comfort in operating as the state of deepest third stage anesthesia. We have often stumbled onto this stage,—one of quietude and tranquility, but were usually alarmed by the apparent respiratory depression, and by withdrawing all ether, have usually lost it.

Many of our anesthetists, even of today, state that it is necessary to watch only the respiration of the patient in order to determine the degree of

*Read before the Indianapolis Medical Society, April, 1919; the Indiana State Medical Association, at Indianapolis, September, 1919, and the Sixth Annual Meeting of the Interstate Association of Anesthetists, at Cincinnati, September 15-17, 1919.

anesthesia present. However, our better anesthetists realize that they must take note of every available sign in their work if they are to do it well.

VALUE OF EYEBALL AND PUPIL.

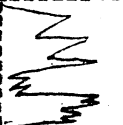

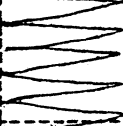
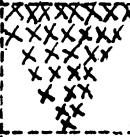
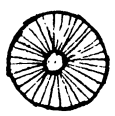
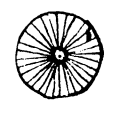
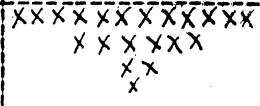

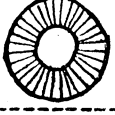
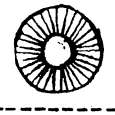

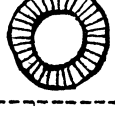
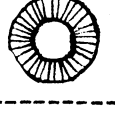
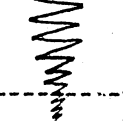
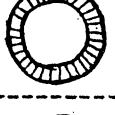
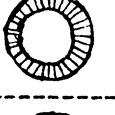
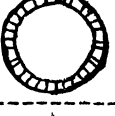
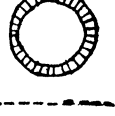
In my experience, which includes over 10,000 cases conducted personally and by my assistants in France, the eyeball with its position and movements has afforded a sign which, in proper classification, is reliable and cannot be ignored. The oscillation

B, C, D, E and F, and takes into consideration various signs separately and in conjunction with each other.

COLUMN A—SHOWING RESPIRATION WITH ANESTHESIA GOING DOWN.

There is no regularity or rhythm to the respiration of the second, or stage of excitement. From experience we recognize the transition from the second to the third stage, by the inauguration of

SCHEMATIC CHART SHOWING THE SIGNIFICANCE OF
CERTAIN REFLEXES UNDER VARIOUS STAGES
OF ETHER ANESTHESIA.

Stages of Anesthesia	Respiration Anesthesia going Down Up		Eyeball	Pupil Without With Morphin		Larynx Up and Down Movement
First Stage						
Second Stage						
Third Stage	First Stratum					
	Second Stratum					
	Third Stratum					
	Fourth Stratum					
Fourth Stage						
Column	A	B	C	D	E	F

marks the stage of ideal anesthesia after the first ten or fifteen minutes of administration has elapsed.

I have divided third stage ether anesthesia into four strata. The accompanying chart presents a correlation of the various signs found in the different strata of the third stage. Attention is called in this paper only to the third stage, inasmuch as there is nothing new to be said of the first, second and fourth stages. The chart consists of columns A,

respiration that is rhythmical and exaggerated. The exaggeration is marked and continues so, almost without change, provided there is a continuance of sufficient ether to carry the anesthesia progressively downward throughout the first, second and third strata of the third stage. However, as the fourth or deepest stratum of this stage is entered, the respiration shows beginning depression. This depression continues progressively downward through

the fourth stratum until its complete cessation marks the transition into the fourth stage.

COLUMN B—RESPIRATION WITH ANESTHESIA COMING UP.

After respiration has ceased as the fourth stage is entered, the ether has been removed and respiration started by artificial means, it will begin as it left off, with shallow movements. As the patient unloads his excess of ether coming up, the respirations grow in depth progressively, the rhythm being maintained, until the upper border of the fourth stratum is reached. Here there is an exaggeration corresponding to that in Column A at the same level. As the patient continues to come out, this exaggeration continues as in column A, throughout the third and second strata. As the lower border of the first or upper stratum is reached there occurs the beginning of a quieter respiration. Why respiration should become quiet at this point with anesthesia coming up, I do not know; but it does. It becomes progressively quieter as the first stratum is traversed upward, until at the upper border it apparently almost ceases. This is just before the patient comes out to the coughing or vomiting state. This respiratory state of quietude has often alarmed us and not infrequently has caused the surgeon to pause in his work to inquire the condition of the patient. True, to one who has not been watching closely the progress of the anesthesia, to one who judges the degree of anesthesia by the respiration alone, the finding suddenly of this quiet respiratory stage is apt to be alarming. Under the old rule of "When in doubt, wait!" which by the way is always a good rule to follow, the ether would be removed and the patient soon found vomiting or becoming unquiet. However, there need be no doubt about the degree of anesthesia here. The question to be decided is a simple one. Is the patient just ready to come out, or to go out? In other words, is he in the first stratum of the third stage, or in the fourth stratum. The answer to this lies in the eyeball.

COLUMN C—THE EYEBALL: ITS MOVEMENT OR ITS POSITION.

The eyeball offers one of the most important signs in anesthesia today. *As long as the eyeball is oscillating or is in an eccentric position though stationary, there is no danger that too much ether has been given. Aside from extraneous circumstances, such as positional asphyxia, hemorrhage, or shock, if the eyeball is moving or is stationary but eccentric, the patient is safe and in good condition.*

As the patient enters the first or upper stratum of

the third stage, either from above or below, there is manifest a partial paralysis of the motor oculi muscles. Either there will be an intermittent contraction and relaxation, or variations of these, causing a rhythmical oscillation of the eyeball, or there will be a stronger tonic contraction of one set than of another, resulting in a stationary but eccentric globe. Occasionally in the alcoholic, or the individual of high reflex nervous tension, in place of the above there will occur a peculiar slight twitch of the globe, usually in a lateral direction. This twitch may not occur until from three to five seconds after the lid has been raised for inspection, therefore this inspection should not be momentary. When this twitch does occur, whether late or early, it means the same thing as above, namely that there is only a partial and not a complete paralysis of the motor oculi muscles.

Whether there be a rhythmical oscillation, an eccentric stationary globe, or the twitch just mentioned, the meaning is the same: the patient has not had too much anesthetic and, other things being equal, is in an ideal stage of surgical anesthesia.

As seen in the accompanying chart, the motion or eccentricity of the eyeball is greatest at the extreme upper border of the first stratum of the third stage. As anesthesia progresses downward from here this motion or extreme position decreases progressively until the second stratum of the third stage is reached. The transition from the first to the second stratum is marked by the cessation of the eyeball movements, or by the change from *eccentric* stationary to *centric* stationary position of the globe. This is the point at which the paralysis of the motor oculi muscles becomes complete.

With anesthesia going down there is no further movement of the eyeball, no further contraction of any of the motor oculi muscles.

THE PROBLEM OF RAPID INDUCTION.

In hospital anesthesia as it is conducted today, with the hurry to have the patients ready for the waiting surgeon, they are forced under rapidly, either with straight ether or with the nitrous oxid, or ethyl chlorid, or some other ether sequence. They are usually taken to the knife before there has been time to "even them up," or before they have settled down to an even ether saturation. Consequently, at first, there is a deeper degree of anesthesia necessary for quiet relaxation than that indicated by the partial paralysis of the motor oculi muscles. Here it is up to the anesthetist to put the patient, in the beginning, down to the second or even the third stratum, as herein illustrated, but to

allow him to come up to the first stratum, that of the oscillating or eccentric eyeball, as soon as possible, and to maintain him there.

In this state the patient presents a better operative general condition than in the second or third stratum, because of the quiet respiration. As a rule it is as satisfactory to the surgeon as the fourth or deepest stratum.

In anesthesia with ether, carried for an hour or more, if the eyeball be *kept oscillating* the patient will usually emerge shortly from the anesthetic and there will be less nausea and depression than we have formerly experienced. By watching the eyeball reflex internes are now conducting better anesthesia than before.

If it were always possible to use as much time as one desired in the induction of ether anesthesia, the patient could, in the course of fifteen minutes or so, be carried gradually to this first stratum of the third stage and anesthesia be there maintained throughout the operation. But for some inexplicable reason, in most hospitals, the idea of saving time is to *start* the operation. Its finish may come when it will.

In finishing the consideration of Column C of the accompanying chart, it is important to say that when the respiration is found very quiet and seemingly depressed to a considerable degree, *the eye must be inspected*. If the eyeball is oscillating or eccentric the stage of anesthesia is right and ether should be continued. If the eyeball is *stationary on center* with the pupil dilated, the anesthesia is too deep, and ether should be discontinued at once.

COLUMN D—PUPIL WITHOUT MORPHIN.

Morphin is so universally used as a preanesthetic narcotic, either alone or in combination with other drugs, that this column is of only relative importance. Before the advent of the use of morphin generally for this work we were taught that the pupil may be dilated, but that it must react to light. *Without morphin the pupil, in the average case, does not begin its dilation until the lower part of the second or upper part of the third stratum is reached. Therefore the dilated pupil, even without morphin, is an indication of anesthesia being too deep.*

COLUMN E—PUPIL WITH MORPHIN.

The statement has often been made that when morphin is given in combination with atropin in the usual proportions of 1/4 and 1/150 gr., the pupillary reflex will be the same as when no morphin is given. This is not true. With this combi-

nation the pupil will not as a rule dilate as early in anesthesia as when no morphin has been given.

It is safe to assume that when morphin has been given, no matter in what combination, a dilation of the pupil in the conduct of anesthesia is a manifestation of careless technic on the part of the anesthetist.

NOTE: Columns D and E of this chart cannot be considered accurate for all cases. But though they may not be accurate, they are sufficient to show that in neither case is it necessary to have any dilatation of the pupil in order to secure quiet and relaxed anesthesia.

An apropos note is here in order. No anesthesia can be safely relaxed and quiet, no matter how much ether be given, if the respiratory passages be not kept freely open, or if the patient be sub-oxygenated. Where the respiratory passages cannot be kept constantly open, pure oxygen should be administered, whether through the ether or separately. Only thus in certain cases can the patient be relaxed.

COLUMN F—THE LARYNX; ITS MOVEMENTS.

Although an ancient sign, this movement of the larynx is not to be ignored, especially in this classification. With the eyeball moving or eccentric the danger in conduct of the anesthesia is not that the patient may "Go out," but that he may "Come out." *There is usually at all times a rhythmical movement of the larynx up and down with the respiration. There is always the exaggerated movement of this organ up and down with swallowing. This is well manifest in the induction.*

This movement of the larynx in swallowing is of importance here in that it assists the anesthetist in guarding against vomiting during the operation. *With anesthesia coming up, at the extreme upper border of the first or upper stratum of the third stage, just before the patient comes out to the vomiting or second stage, there will occur, in the average case, an exaggerated up-and-down movement of the larynx, half a minute or so before vomiting takes place. If the little finger of the mask-holding hand be allowed to rest over the larynx, this exaggerated movement may be detected immediately it begins. There is yet time to increase the amount of ether gradually, sufficient to carry the patient back where he belongs without permitting retching or vomiting. I say gradually, because if at this stage a concentrated ether vapor be suddenly administered, there will usually follow laryngeal, or pharyngeal spasm, with coughing.*

THE REFLEXES UNDER OTHER ANESTHETICS.

Although this paper is intended primarily to cover the third stage of *ether anesthesia*, the significance of the eyeball in this classification is not limited to ether alone.

These signs hold good with any anesthetic agent now commonly in use, no matter what attention has been paid to preanesthetic narcotics. Morphine in any combination does not influence them. Neither does chloral or its allied drugs. *The eyeball signs are constant.*

NITROUS OXID-OXYGEN.—With this mixture alone, I have never been able to get a patient anesthetized beyond the stratum of the oscillating or eccentric eyeball where the anesthesia was properly conducted. Proper nitrous oxid-oxygen anesthesia requires a pink or rose-colored patient. As long as this color is maintained it is quite out of the ordinary, if not impossible, to carry the anesthesia beyond the first stratum as herein illustrated. In *improper* anesthesia with this agent, the asphyxial element being allowed to enter, it is, of course, quite possible to so intoxicate the patient with carbon dioxid that there will occur a complete paralysis of the motor oculi muscles and a complete dilatation of the pupil. This is inexcusable technic.

ETHYL CHLORID.—Properly handled, this agent is an excellent substitute for nitrous oxid and therefore deserves mention. There is much that is new in the way of observation of the action of this agent that cannot be considered here. Suffice it to say, that with ethyl chlorid, administered slowly, as long as there is maintained only a partial paralysis of the motor muscles of the eyeball, the anesthesia is entirely safe. Ethyl chlorid should not at any time be given beyond this point.

CONCLUSIONS.

1. This is a plea for lighter and better anesthesia.
2. It is a plea for better teaching of anesthesia in our medical schools and hospitals.
3. As long as we note any movement or eccentric position of the eyeball, aside from that which might be normal for the occasional patient, that patient has not had too much anesthetic; but after anesthesia has been well inaugurated, he has had quite enough.
4. The upper part of the third stage, namely, the first stratum, is anesthesia entirely as satisfactory to the surgeon as the second, third or fourth stratum of the third stage.

517 HUME MANSUR BLDG.

ANESTHESIA IN WAR SURGERY

NITROUS OXID ANESTHESIA.*

It would seem as though someone were trying to take away all the glories and thrills of an operation, when he introduces an anesthesia that eliminates the after-effects that are so characteristic of ether and chloroform, as well as increases by 20 per cent. the chances for recovery.

As an anesthetic for use in the United States Army, nitrous oxid was first suggested to the American Red Cross Commissioners, in France, by Colonel George W. Crile, M. C., U. S. A., who also made the suggestion that plant for its manufacture be erected there in order to insure a sufficient supply for all the army hospitals. To the efforts of Colonel Alexander Lambert, then Chief Surgeon of the American Red Cross, is largely due the plan that brought such highly successful results.

The best medical authorities concur in the opinion that nitrous oxid as an anesthetic is the least dangerous as

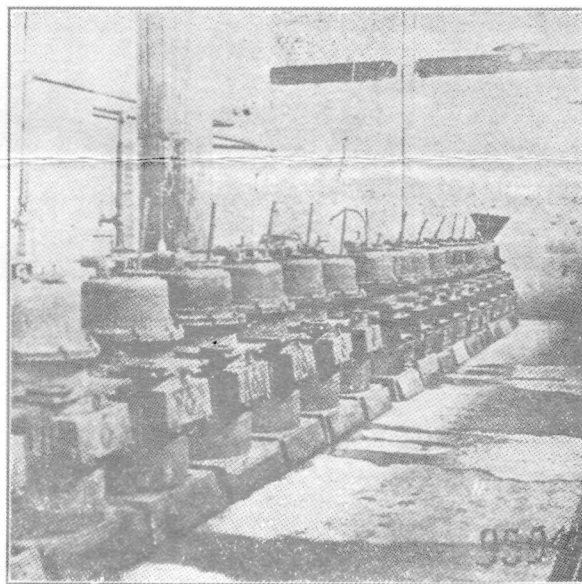


Fig. 1—Nitrous oxid generators in the American Red Cross Plant in Paris.

well as the best adapted for use when operating upon cases of shock. As compared with ether and chloroform, perhaps a review of the chemical effects of these upon the patient will serve to prove the superiority of nitrous oxid. Great muscular exertion or wounds of the muscles cause lactic acid to be disseminated through the blood in large quantities. The body rids itself of the acid by oxidizing it, and for the most part gives it off through the lungs. When chloroform and ether are introduced into the blood that is already filled with lactic acid, they stop the oxidizing process. This results in an acid condition which will in many cases cause death. The use of nitrous oxid with oxygen allows the natural oxidation to proceed uninterruptedly. To quote Colonel Lambert's tersity: "The use, therefore, of nitrous oxid anesthesia

* Supplied by the News Service of the American Red Cross. Courtesy of Mr. Foster, New York City Headquarters.

(Continued on page 60.)

Ascending Respiratory Paralysis Under General Anesthesia

ALBERT H. MILLER, M.D.

PROVIDENCE, R. I.

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ARTHUR E. GUEDEL, M. D.

Beverly Hills, Calif.

613 N. Elm Drive.

May 31 - '36

Albert H. Miller M.D.
Providence, R. I.

Dear A.H.:—

Thanks many times for sending me the R. I. Journal, and for your generous reference to my work. I do not feel that these stages of anesthesia are my work. They are rather the work of my friends, and mine all run together.

It is too bad that our necessity for earning the dollar prevents us from getting together oftener. I have missed the contacts more and more because I have been able to attend meetings less and less. I promise myself that I will get around, and then when the time comes I find an excuse to stay at home. My loss.

I have often thought and I believe more as I study the question that your description of Ascending Respiratory Paralysis was one of the most helpful pieces of work that we have had in this generation. I appreciate it very much.

Thanks again for your generosity, and with best wishes and highest esteem, I am

Sincerely

A handwritten signature in cursive script that reads "Art Guedel". The signature is written in dark ink and is positioned below the word "Sincerely".

Ascending Respiratory Paralysis Under General Anesthesia

ALBERT H. MILLER, M.D.
PROVIDENCE, R. I.

ASCENDING RESPIRATORY PARALYSIS UNDER GENERAL ANESTHESIA *

ALBERT H. MILLER, M.D.

PROVIDENCE, R. I.

As a result of the inhalation of a general anesthetic, there develops a progressive ascending paralysis of the muscles of respiration, the extent of which provides a valuable indication of the depth of anesthesia. The muscles that are used in quiet respiration are the diaphragm, which carries on abdominal respiration; the levatores costarum and intercostales externi, which bring about costal inspiration, and the intercostales interni and triangularis sterni, which aid in expiration. All of these costal muscles are innervated by the intercostal nerves, originating in the twelve dorsal segments of the spinal cord. The diaphragm obtains its nerve supply through the phrenic nerve from the fourth cervical segment. An ascending paralysis will affect the costal muscles, innervated from the dorsal portion of the spinal cord, much sooner than the diaphragm, the nerve supply of which originates in the midcervical portion.

From the standpoint of the anesthetist, the abdominal respiration can be noted from inspection. The costal respiration is judged by placing the flattened tips of the fingers lightly on the chest, in the mammary line, on either side, midway between the nipple and the clavicle. In usual, quiet respiration, "the movement is fairly equally balanced between chest and abdomen, the abdominal being somewhat in excess."

TYPES OF RESPIRATION UNDER GENERAL ANESTHESIA

Under general anesthesia, the following types of respiration are to be noted:

Exaggerated Thoracic Type (T. +).—Inspiration is produced by expansion of the chest without movement

* Read before the Eastern Society of Anesthetists, New York, Oct. 20, 1924.

of the diaphragm or abdominal wall, or with retraction of the abdominal wall. This type of respiration is rarely encountered during anesthesia if the airway is kept free. It has been noted in some cases in which inflammatory lesions affecting the peritoneum of the diaphragmatic region were present. In these cases, exaggerated thoracic respiration persisted throughout the operation.

Mixed, or Usual, Type (M.).—During inspiration there is a synchronous expansion of the chest and protrusion of the abdominal wall.

Delayed Thoracic Type (D. T.).—The chest expands during inspiration notably later in the respiratory cycle than occurs the contraction of the diaphragm.

Abdominal Type (A.).—Inspiration is brought about entirely by the contraction of the diaphragm, with protrusion of the abdominal wall but without movement of the chest.

Exaggerated Abdominal Type (A. +).—During each inspiration, the abdominal wall rises while the chest retracts. Expiration is marked by retraction of the abdominal wall and expansion of the chest.

These types of respiration, in the order given, result from a progressive ascending paralysis of the respiratory muscles. I will first note the occurrence of these types in the course of ether anesthesia.

METHOD OF ETHERIZATION EMPLOYED

For the benefit of any who may wish to repeat the observations, I will describe the method of etherization employed. The patient has a physical examination on the night before operation. To adult patients, a hypodermic of morphin, $\frac{1}{6}$ grain, and atropin, $\frac{1}{150}$ grain, is given, one-half hour before the time set for operation. Before the anesthesia is commenced, the patient is placed on the operating table as nearly as practicable in the required posture. A blood pressure cuff and stethoscope are applied to one arm. On a convenient chart, operative and anesthetic data are noted. The anesthesia is started with pure nitrous oxid gas. The inhaler is first carefully fitted to the face, with the gas bag filled but not distended and the air valve open. The change from gas to air is made without perception by the patient. Gas is administered until the patient is unconscious. Signs of deep anesthesia are never

allowed to appear. During an expiration, the ether inhaler is substituted for the gas inhaler and fitted closely to the face. The ether inhaler is a 7 inch paper and towel funnel lined with a strip of polished metal. It contains a strip of fluffed gauze, 36 inches long and 18 inches wide. Before the inhaler is placed on the face, the gauze has been moistened with 2 drams of liquid ether. Ether is added at the rate of 3 drops a second for five minutes and afterward at a slower rate, in carefully measured amounts, throughout the operation. Mechanical obstruction of the airway is never permitted. Cyanosis is never allowed. Excitement is unusual. Such an exact method of measurement is essential to any valuable observations of the results of anesthesia.

TYPES OF RESPIRATION UNDER ETHER ANESTHESIA

At the commencement of the anesthesia, respiration is of the usual or mixed type. As anesthesia deepens, after a period of delayed thoracic respiration, the abdominal type appears. The change from mixed to abdominal respiration may be abrupt and, in this case, may be accompanied by some form of respiratory difficulty. Cessation of respiration, coughing, retching, or signs of excitement may occur at this time. When the change is gradual, the process is an interesting one to note. Each thoracic inspiration begins a little later in the respiratory cycle than the preceding one. Abdominal respiration continues without interruption. Thoracic inspiration is at first a trifle delayed. After a few inspirations, thoracic inspiration is found commencing midway in abdominal inspiration. A little later the thoracic inspiration is found still further delayed, and finally there comes an abdominal inspiration with no corresponding thoracic movement. Respiration of the abdominal type is then established and may continue throughout the anesthesia. If the anesthetic dosage is further increased, the paralysis of the costal muscles becomes more complete, and the condition of exaggerated abdominal respiration occurs. The costal muscles have become so relaxed that on inspiration the chest wall retracts rather than expands. This is an indication of profound anesthesia. If the anesthetic dosage is lessened, the costal paralysis will be diminished and the type of respiration will change

from exaggerated abdominal to abdominal, from abdominal to delayed thoracic, and finally back to the usual type of respiration. This reverse change regularly happens at the close of etherization, so that within a half hour from the end of the operation the respiration is of the usual, mixed type. Respiration of the abdominal type may occur early or commence late in the course of the anesthesia.

In the series of cases that were studied for this paper, the type of respiration noted at the end of thirty minutes anesthesia was mixed in 37 per cent. of the cases, delayed thoracic in 12 per cent., abdominal in 28 per cent., and exaggerated abdominal in 23 per cent. The types of respiration vary constantly according to the anesthetic dosage. In this series of cases, mixed or delayed thoracic respiration corresponded with the second of Guedel's divisions of the third stage of anesthesia in 24 per cent. of the cases; with the third division, in 76 per cent. Abdominal or exaggerated abdominal respiration corresponded with the second division in 0.08 per cent.; with the third division, in 99.02 per cent. Mixed respiration persisted usually when a comparatively small amount of the anesthetic had been administered. When a large amount of ether had been used, the respiration regularly took on the exaggerated abdominal type. The type of respiration varied independently of posture, the rate of respiration, the pulse rate and the blood pressure reading.

EFFECT OF NITROUS OXID-OXYGEN

When nitrous oxid-oxygen without ether was the anesthetic, mixed respiration generally persisted, and the abdominal and exaggerated abdominal types were less frequently encountered. This is in accordance with our belief that nitrous oxid-oxygen affects the vital functions to a less degree than does ether when administered in considerable dosage.

INDICATION OF ANESTHETIC DOSAGE

As an indication of the actual depth of anesthesia, we can arrange the types of anesthesia in the following order, beginning with the lightest anesthetic zone:

1. Mixed or usual type.
2. Delayed thoracic type.
3. Abdominal type.
4. Exaggerated abdominal type.

Each of the types in this arrangement indicates a deeper plane of anesthesia than the one preceding. Even if the patient's muscle tone persists and relaxation is not sufficient for the surgeon's best work, exaggerated abdominal respiration is a sign of profound anesthesia. In operations in the region of the diaphragm, respiration of the exaggerated abdominal type is likely to impede the surgical work. The costal muscles are paralyzed by the anesthetic, and the whole respiratory burden must be carried by the diaphragm. Attempts to fix the abdominal muscles by retractors cannot be completely successful in this condition. The remedy is a smaller rather than a larger anesthetic dosage. Failure to realize this has sometimes resulted in the death of the patient from an overdose of the anesthetic without producing the desired condition of abdominal relaxation.

As an index to the depth of anesthesia, observations of the type of respiration are of special value as a direct indication of the effect of the anesthetic on a vital function; in fact, the vital function of greatest importance in anesthetic work.

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