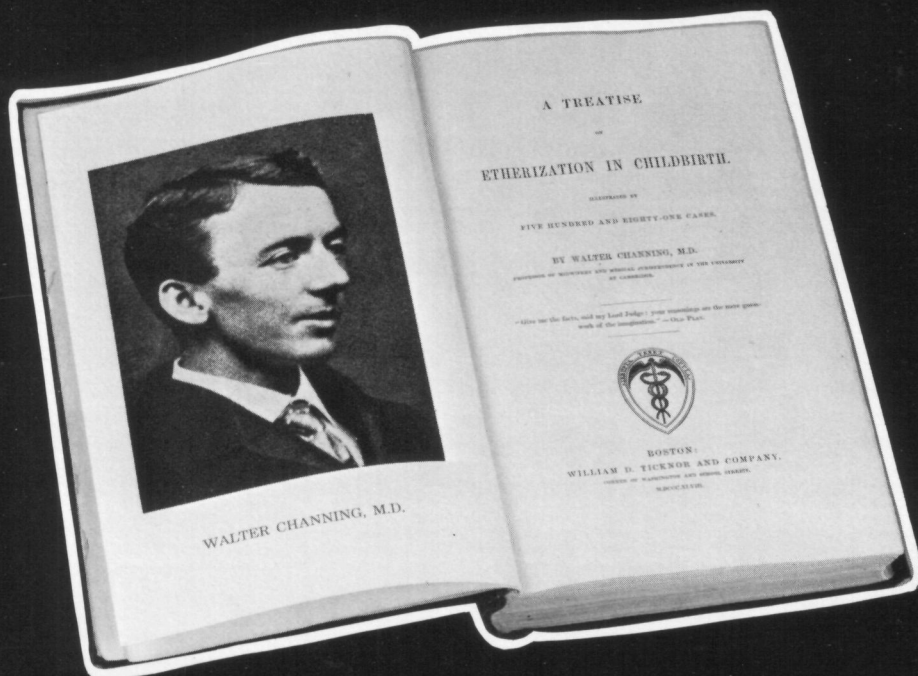


# The History of Anesthesiology

Reprint Series: Part Six



## OBSTETRIC ANESTHESIA

Following upon Simpson's use in 1847 of ether for obstetric delivery, controversy arose on moral grounds over the significance of pain for the parturient. Although this dilemma could not be solved on a scientific basis, the public more or less settled the issue, women seeking relief from pain even as they do today. The argument then turned to the probability of benefit conferred by anesthesia upon the physiology of labor. Professors James Y. Simpson of Edinburgh and Walter Channing of Cambridge, Massachusetts, espoused the affirmative while ably opposed by Charles D. Meigs of Philadelphia. Channing, by means of a questionnaire, attempted to prove his point, the results manipulated and published in his classic treatise on Etherization in Childbirth.

Around the turn of the century cocainization of the spinal cord for delivery was introduced in Germany and the U.S.A. But not until the thirties, when Cleland delineated the sensory pathways from uterus and vagina, was it possible to advocate the rational use of caudal and epidural anesthesia for delivery. Virginia Apgar then addressed her efforts to evaluation of the condition of the newborn, by means of a scoring system. Obstetric anesthesia, now an esteemed subspecialty, has made great strides toward solution of many of the questions that arose in the beginning. But it must be admitted that many problems remain unsolved.

ACCOUNT  
OF A  
NEW ANÆSTHETIC AGENT,  
AS A  
SUBSTITUTE FOR SULPHURIC ETHER  
IN  
SURGERY AND MIDWIFERY,

BY  
J. Y. SIMPSON, M.D., F.R.S.E.,  
PROFESSOR OF MIDWIFERY IN THE UNIVERSITY OF EDINBURGH;  
PHYSICIAN-ACCOCHEUR TO THE QUEEN IN SCOTLAND, ETC.

“I esteem it, the office of a Physician, not only to restore health, but to mitigate  
pain and dolours.”—BACON.

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COMMUNICATED TO THE MEDICO-CHIRURGICAL SOCIETY OF EDINBURGH,  
AT THEIR MEETING ON 10TH NOVEMBER 1847.

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THIRD THOUSAND.

EDINBURGH:  
SUTHERLAND AND KNOX, PRINCES STREET.  
LONDON: SAMUEL HIGHLEY, 32 FLEET STREET.

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MDCCCLVII.

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INSCRIBED

TO

M. J. DUMAS,

MEMBER OF THE INSTITUTE,

DEAN OF THE FACULTY OF SCIENCES, PARIS,

&c. &c. &c.



## ON CHLOROFORM.

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FROM the time at which I first saw Ether-Inhalation successfully practised in January last, I have had the conviction impressed upon my mind, that we would ultimately find that other therapeutic agents were capable of being introduced with equal rapidity and success into the system, through the same extensive and powerful channel of pulmonary absorption. In some observations, which I wrote and published in February last, relative to the inhalation of sulphuric ether in midwifery, I stated that, in several obstetric cases, I had used ergot of rye in this way, along with ether.—(See *Monthly Journal of Medical Science*, pp. 724; and 795, case of successful inhalation of opium, to arrest the vomiting of pregnancy.)

With various professional friends, more conversant with chemistry than I am, I have, since that time, taken opportunities of talking over the idea which I entertained of the probable existence or discovery of new therapeutic agents, capable of being introduced into the system by respiration, and the

possibility of producing for inhalation vaporizable or volatile preparations of some of our more active and old established medicines: and I have had, during the summer and autumn, ethereal tinctures, &c., of several potent drugs, manufactured for me, for experiment, by Messrs Duncan, Flockhart, & Co., the excellent chemists and druggists of this city.

Latterly, in order to avoid, if possible, some of the inconveniences and objections pertaining to sulphuric ether,—(particularly its disagreeable and very persistent smell, its occasional tendency to irritation of the bronchi during its first inspirations, and the large quantity of it occasionally required to be used, more especially in protracted cases of labour,)—I have tried upon myself and others the inhalation of different other volatile fluids, with the hope that some one of them might be found to possess the advantages of ether, without its disadvantages. For this purpose, I selected for experiment and have inhaled several chemical liquids of a more fragrant or agreeable odour, such as the chloride of hydro-carbon (or Dutch liquid), acetone, nitrate of oxide of ethyle (nitric ether), benzin, the vapour of iodoform, &c.\*

\* In talking over, with different chemists, what fluids might be sufficiently volatile to be respirable, and hence deserving of being experimented upon, Mr Waldie first named to me the Perchloride of Formyle as worthy, among others, of a trial;—Dr Gregory suggested a trial of the chloride of hydrocarbon, &c. I have been deeply indebted to Dr

I have found, however, one infinitely more efficacious than any of the others, viz., Chloroform, or the Perchloride of Formyle, and I am enabled to speak most confidently of its superior anæsthetic properties, having now tried it upon upwards of thirty individuals. The liquid I have used has been manufactured for me by Mr Hunter, in the laboratory of Messrs Duncan, Flockhart, & Co.

Chloroform was first discovered and described at nearly the same time by Soubeiran (1831), and Liebig, (1832); its composition was first accurately ascertained by the distinguished French chemist, Dumas, in 1835.—See the *Annales de Chimie et de Physique*, vols. xlviii. xlix. and lviii. It has been used by some practitioners internally; Guillot prescribed it as an anti-spasmodic in asthma, exhibiting it in small doses, and diluted 100 times.—(See Bouchardat's *Annuaire de Therapeutique* for 1844, p. 35.) But no person, so far as I am aware, has used it by inhalation, or discovered its remarkable anæsthetic properties till the date of my own experiments.

It is a dense, limpid, colourless liquid, readily

Gregory and Dr Anderson, for their kindness in furnishing me with the requisite chemical agents for these experiments;—and also to my assistants, Dr Keith and Dr Duncan, for the great and hearty zeal with which they have constantly aided me in conducting the inquiry.



evaporating, and possessing an agreeable, fragrant, fruit-like odour, and a saccharine pleasant taste.

As an inhaled anæsthetic agent, it possesses over sulphuric Ether the following advantages :—

1. A greatly less quantity of Chloroform than of Ether is requisite to produce the anæsthetic effect; usually from a hundred to a hundred and twenty drops of Chloroform only being sufficient; and with some patients much less. I have seen a strong person rendered completely insensible by six or seven inspirations of thirty drops of the liquid.

2. Its action is much more rapid and complete, and generally more persistent. I have almost always seen from ten to twenty full inspirations suffice. Hence the time of the surgeon is saved; and that preliminary stage of excitement, which pertains to all narcotizing agents, being curtailed, or indeed practically abolished, the patient has not the same degree of tendency to exhilaration and talking.\*

\* In practice I have found that any such tendency, even with ether, is avoided by, 1st, giving the patient from the first a large and overwhelming dose of the vapour, and 2ndly, by keeping him perfectly quiet and still, and preventing all noise and talking around him. I have elsewhere insisted on the importance of these points. (See the numbers of the *Monthly Journal of Medical Science* for March, 1847, p. 726, and for September, p. 154). In the paper last re-

3. Most of those who know from previous experience the sensations produced by ether inhalation, and who have subsequently breathed the Chloroform, have strongly declared the inhalation and influence of Chloroform to be far more agreeable and pleasant than those of Ether.

4. I believe, that considering the small quantity requisite, as compared with Ether, the use of Chloroform will be less expensive than that of Ether ;

ferred to, I took occasion, when discussing the conditions requisite for insuring successful etherization, to observe, “ *First*, The patient ought to be left, as far as possible, in a state of absolute quietude and freedom from mental excitement, both during the induction of etherization, and during his recovery from it. All talking and all questioning should be strictly prohibited. In this way any tendency to excitement is eschewed, and the proper effect of the ether inhalation more speedily and certainly induced. And, *Secondly*, with the same view, the primary stage of exhilaration should be entirely avoided, or at least reduced to the shortest possible limit, by impregnating the respired air as fully with the ether vapour as the patient can bear, and by allowing it to pass into the lungs both by the mouth and nostrils, so as rapidly and at once to superinduce its complete and anæsthetic effect; \* \* \* a very common but certainly a very unpardonable error being to exhibit an imperfect and exciting, instead of a perfect and narcotizing dose of the vapour. Many of the alleged failures and misadventures are doubtless entirely attributable to the neglect of this simple rule;—not the principle of etherization, but the mode of putting it in practice being altogether to blame. But, *Thirdly*, whatever means or mode of etherization is

more especially, as there is every prospect that the means of forming it may be simplified and cheapened.

5. Its perfume is not unpleasant, but the reverse ; and the odour of it does not remain, for any length of time, obstinately attached to the clothes of the attendant,—or exhaling in a disagreeable form from the lungs of the patient, as so generally happens with Sulphuric Ether.

6. Being required in much less quantity, it is much more portable and transmissible than Sulphuric Ether.

7. No special kind of inhaler or instrument is necessary for its exhibition. A little of the liquid diffused upon the interior of a hollow-shaped sponge, or a pocket-handkerchief, or a piece of linen or paper, and held over the mouth and nostrils, so as to be fully inhaled, generally suffices in about a minute or two to produce the desired effect.\*

adopted, the most important of the conditions required for procuring a satisfactory and successful result from its employment in surgery, consists in obstinately determining to avoid the commencement of the operation itself, and never venturing to apply the knife *until* the patient is under the full influence of the ether-vapour, and *thoroughly and indubitably soporized by it.*" In fulfilling all these indications, the employment of Chloroform evidently offers great and decided advantages, in facility and efficiency, over the employment of Ether.

\* When used for surgical purposes, perhaps it will be found to be

I have not yet had an opportunity of using Chloroform in any capital surgical operation, but have exhibited it with perfect success, in tooth-drawing,\*

most easily given upon a handkerchief, gathered up into a cup-like form in the hand of the exhibitor, and with the open end of the cup placed over the nose and mouth of the patient. For the first inspiration or two, it should be held at the distance of half an inch or so from the face, and then more and more closely applied to it. To insure a rapid and perfect anæsthetic effect—more especially where the operation is to be severe—one or two teaspoonfuls of the Chloroform should be at once placed upon the hollow of the handkerchief, and immediately held to the face of the patient. Generally a snoring sleep speedily supervenes; and when it does so, it is a perfect test of the superinduction of complete insensibility. But a patient may be quite anæsthetic without this symptom supervening.

\* A young dentist who has himself had two teeth extracted lately, —one under the influence of Ether, and the other under the influence of Chloroform,—writes me the following statement of the results:—“About six months ago I had an upper molar tooth extracted whilst under the influence of Ether, by Mr Imlach. The inhalation was continued for several minutes before I presented the usual appearance of complete etherization; the tooth was then extracted; and, although I did not feel the least pain, yet I was conscious of the operation being performed, and was quite aware when the crash took place. Some days ago I required another molar extracted on account of tooth-ache, and this operation was again performed by the same gentleman. I inhaled the vapour of Chloroform, half a drachm being poured upon a handkerchief for that purpose, and held to my nose and mouth. Insensibility took place in a few seconds; but I was so completely *dead* this time, that I was not in the very slightest degree aware of any thing that took place. The subsequent stupifying effects of the Chloroform went off more rapidly than those of the Ether; and I was perfectly well and able again for my work in a few minutes.”

opening abscesses, for annulling the pain of dysmenorrhœa and of neuralgia, and in two or three cases where I was using deep, and otherwise very painful galvano-puncture for the treatment of ovarian dropsy, &c. I have employed it also in obstetric practice with entire success. The lady to whom it was first exhibited during parturition, had been previously delivered in the country by perforation of the head of the infant, after a labour of three days' duration. In this, her second confinement, pains supervened a fortnight before the full time. Three hours and a-half after they commenced, and, ere the first stage of the labour was completed, I placed her under the influence of the Chloroform, by moistening, with half a tea-spoonful of the liquid, a pocket handkerchief, rolled up into a funnel shape, and with the broad or open end of the funnel placed over her mouth and nostrils. In consequence of the evaporation of the fluid, it was once more renewed in about ten or twelve minutes. The child was expelled in about twenty-five minutes after the inhalation was begun. The mother subsequently remained longer soporose than commonly happens after Ether. The squalling of the child did not, as usual, rouse her; and some minutes elapsed after the placenta was expelled, and after the child was removed by the nurse into another room, before the patient awoke. She then turned round and

observed to me that she had “enjoyed a very comfortable sleep, and indeed required it, as she was so tired,\* but would now be more able for the work before her.” I evaded entering into conversation with her, believing, as I have already stated, that the most complete possible quietude forms one of the principal secrets for the successful employment of either Ether or Chloroform. In a little time she again remarked that she was afraid her “sleep had stopped the pains.” Shortly afterwards, her infant was brought in by the nurse from the adjoining room, and it was a matter of no small difficulty to convince the astonished mother that the labour was entirely over, and that the child presented to her was really her “own living baby.”

Perhaps I may be excused from adding, that since publishing on the subject of Ether Inhalation in Midwifery, seven or eight months ago,† and then for the first time directing the attention of the medical profession to its great use and importance in natural and morbid parturition, I have employed it, with few and rare exceptions, in every case of labour that I have attended ; and with the most delightful results.

\* In consequence of extreme anxiety at the unfortunate result of her previous confinement, she had slept little or none for one or two nights preceding the commencement of her present accouchement.

† See *Monthly Journal of Medical Science* for February, p. 639 ; for March, p. 718 and 721 ; and April, p. 794, &c.

And I have no doubt whatever, that some years hence the practice will be general. Obstetricians may oppose it, but I believe our patients themselves will force the use of it upon the profession.\* I have never had the pleasure of watching over a series of better and more rapid recoveries; nor once witnessed any disagreeable result follow to either mother or child; whilst I have now seen an immense amount of maternal pain and agony saved by its employment. And I most conscientiously believe that the proud mission of the physician is distinctly twofold—namely, to alleviate human suffering, as well as preserve human life.

#### CHEMICAL CONSTITUTION OF CHLOROFORM.

Formyle is the hypothetical radical of Formic acid. In the red ant (*Formica rufa*) formic acid was first discovered, and hence its name. Gehlen pointed it out as a peculiar acid; and it was afterwards first artificially prepared by Doebereiner.

\* I am told that the London physicians, with two or three exceptions only, have never yet employed ether-inhalation in their Midwifery practice. Three weeks ago, I was informed in a letter from Professor Montgomery of Dublin, that he believed that in that city, up to that date, it had not been used in a single case of labour.

Chemists have now devised a variety of processes, by which formic acid may be obtained from starch, sugar, and, indeed, most other vegetable substances.

A series of Chlorides of Formyle are produced when chlorine and the hypochlorites are brought to act on the chloride, oxide, and hydrated oxide of methyle, (pyroxylic or wood spirit). In the same way as formic acid may be artificially procured from substances which do not contain Formyle ready formed,—so also are the Chlorides of this radical capable of being procured from substances which do not originally contain it.

Chloroform, Chloroformyle, or the Perchloride of Formyle, may be made and obtained artificially by various processes,—as by making milk of lime, or an aqueous solution of caustic alkali act upon chloral,—by distilling alcohol, pyroxylic spirit, or acetone, with chloride of lime,—by leading a stream of Chlorine gas into a solution of caustic potass in spirit of wine, &c. The preparation which I have employed, was made according to the following formula of Dumas :—

“ R Chloride of lime in powder, . . .	lb. IV.
Water, . . . . .	lb. XII.
Rectified Spirit, . . . . .	f 3 XII.

“Mix in a capacious retort or still, and distill as long as a dense liquid, which sinks in the water with which it comes over, is produced.”—(Gray’s *Supplement to the Pharmacopœia*, 1846, p. 633).



The resulting Perchloride of Formyle consists of two atoms of Carbon, one of Hydrogen, and three of Chlorine. Its specific gravity is much greater than that of water, being as high as 1.480. It boils at 141°. The density of its vapour is 4.2. It is not inflammable; nor changed by distillation with potassium, potash, sulphuric, or other acids.—(See Turner's *Elements of Chemistry*, 8th edition, p. 1009; Gregory's *Outlines of Chemistry*, part ii. p. 401; Fownes' *Manual of Elementary Chemistry*, p. 419; Thomson's *Chemistry of Organic Bodies*, p. 312; Loewig's *Organische Chemie*, vol. i. p. 498).

It is now well ascertained that three compound chemical bodies possess, when inhaled into the lungs, the power of superinducing a state of anæsthesia, or insensibility to pain in surgical operations, &c., namely, Nitrous Oxide, Sulphuric Ether, and Perchloride of Formyle. The following tabular view shows that these agents are entirely different from each other in their chemical constitution, and hence that their elementary composition affords no apparent clue to the explanation of their anæsthetic properties:—

	Propor. of Nitrogen.	Propor. of Oxygen.	Propor. of Carbon.	Propor. of Hydrogen.	Propor. of Chlorine.
Nitrous Oxide, }	1 Atom.	1 Atom.	...	...	..
Sulphuric Ether, }	...	1 Atom.	4 Atoms.	5 Atoms.	...
Chloroform,	...	...	2 Atoms.	1 Atom.	3 Atoms.

It is perhaps not unworthy of remark, that when Soubeiran, Liebig, and Dumas engaged, a few years back, in those inquiries and experiments by which the formation and composition of Chloroform was first discovered, their sole and only object was the investigation of a point in philosophical Chemistry. They laboured for the pure love and extension of knowledge. They had no idea that the substance to which they called the attention of their chemical brethren could or would be turned to any *practical* purpose, or that it possessed any physiological or therapeutic effects upon the animal economy. I mention this to show, that the *cui bono* argument against philosophical investigations, on the ground that there may be at first no apparent practical benefit to be derived from them, has been amply refuted in this, as it has been in many other instances. For I feel assured, that the use of Chloroform will soon entirely supersede the use of Ether; and, from the facility and

rapidity of its exhibition, it will be employed as an anæsthetic agent in many cases, and under many circumstances, in which Ether would never have been had recourse to. Here then we have a substance which, in the first instance, was merely interesting as a matter of scientific curiosity and research, becoming rapidly an object of intense importance, as an agent by which human suffering and agony may be annulled and abolished, under some of the most trying circumstances in which human nature is ever placed.

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#### POSTSCRIPT.

SINCE the above observations were sent to the press, I have—through the great kindness of Professor Miller and Dr Duncan—had an opportunity of trying the effects of the inhalation of Chloroform, to-day, in three cases of operation in the Royal Infirmary of Edinburgh. A great collection of professional gentlemen and students witnessed the results, and among the number was Professor Dumas of Paris, the chemist who first ascertained and established the chemical composition of Chloroform. He happened to be passing through Edinburgh, engaged along with Dr Milne Edwards, who accompanied him, in an official investigation for the French Government,—

and was, in no small degree, rejoiced to witness the wonderful physiological effects of a substance with whose chemical history his own name was so intimately connected.

I append notes, obligingly furnished to me by Professor Miller and Dr Duncan, of the three cases of operation. The two first cases were operated on by Professor Miller ; the third by Dr Duncan. In applying the Chloroform in the first case, I used a pocket-handkerchief as the inhaling instrument ; in the two last I employed a hollow sponge.

CASE I.—“ A boy, four or five years old, with necrosis of one of the bones of the fore-arm. Could speak nothing but Gaelic. No means, consequently, of explaining to him what he was required to do. On holding a handkerchief, on which some Chloroform had been sprinkled, to his face, he became frightened, and wrestled to be away. He was held gently, however, by Dr Simpson, and obliged to inhale. After a few inspirations he ceased to cry or move, and fell into a sound snoring sleep. A deep incision was now made down to the diseased bone ; and, by the use of the forceps, nearly the whole of the radius, in the state of sequestrum, was extracted. During this operation, and the subsequent examination of the wound by the finger, not the slightest evidence

of the suffering of pain was given. He still slept on soundly, and was carried back to his ward in that state. Half an hour afterwards, he was found in bed, like a child newly awakened from a refreshing sleep, with a clear merry eye, and placid expression of countenance, wholly unlike what is found to obtain after ordinary etherization. On being questioned by a Gaelic interpreter who was found among the students, he stated that he had never felt any pain, and that he felt none now. On being shown his wounded arm, he looked much surprised, but neither cried nor otherwise expressed the slightest alarm."

CASE II.—"A soldier who had an opening in the cheek—the result of exfoliation of the jaw—was next made to inhale. At first he showed some signs of moving his hands too freely; but soon also fell into a state of sleep and snoring. A free incision was made across the lower jaw, and from this the dense adhering integuments were freely dissected all round, so as to raise the soft parts of the cheek. The edges of the opening were then made raw, and the whole line of incision was brought together by several points of suture. This patient had previously undergone two minor operations of a somewhat similar kind; both of them had proved unsuccessful, and he bore them very ill—proving unusually un-

steady, and complaining bitterly of severe pain. On the present occasion, he did not wince or moan in the slightest degree; and, on the return of consciousness, said that he had felt nothing. His first act, when apparently about half awake, was suddenly to clutch up the sponge with which the Chloroform was used, and re-adjust it to his mouth, obviously implying that he had found the inhalation from it any thing but a disagreeable duty.

“This case was further interesting as being one of those operations in the region of the mouth, in which it has been deemed impossible to use ether,—and certainly it would have been impossible to have performed the operation with any complicated inhaling apparatus applied to the mouth of the patient.”

CASE III.—“A young man, of about twenty-two years of age, having necrosis of the first phalanx of the great toe, and ulceration of the integuments, the consequence of injury. The ulcerated surface was exceedingly tender to the touch—so much so, that he winced whenever the finger was brought near to it; and the slightest pressure made him cry out. After the removal of the dressings, which caused some pain and fretting, the inhalation was commenced, and the patient almost immediately\* became insensible,

\* Dr Christison, who was watching the result, informs me that this patient was affected in half a minute.

and lay perfectly still, while the diseased mass was being removed by amputation of the toe through the middle of the second phalanx. The inhalation was now stopped. The edges of the wound were then brought together with three stitches, and the wound dressed. The patient shortly afterwards awoke, looked round him, and gratefully declared his entire and perfect freedom from all pain and uneasiness during the operation."

The whole quantity of Chloroform used in these three operations did not exceed half an ounce,—and, as Professor Miller afterwards observed to the students that were present, if ether had been used, several ounces of it would have been requisite to produce the same amount of anæsthetic effect.

The following case occurred also to-day, to Mr Miller, in private practice. The notes of it and the subsequent remark are in his own words.

CASE IV.—“A young lady wished to have a tumour (encysted) dissected out from beneath the angle of the jaw. The Chloroform was used in small quantity (about a drachm), sprinkled upon a piece of operation sponge. In considerably less than a minute she was sound asleep, sitting easily in a chair, with her eyes shut, and with her ordinary expression

of countenance. The tumour was extirpated, and a stitch inserted, without any pain having been either shown or felt. Her sensations, throughout, as she subsequently stated, had been of the most pleasing nature ; and her manageableness during the operation was as perfect as if she had been a wax doll or a lay figure.

“ No sickness, vomiting, headache, salivation, uneasiness of chest, in any of the cases. Once or twice a tickling cough took place in the first breathings.”

I have, up to this date, exhibited the Chloroform to about fifty individuals. In not a single instance has the slightest bad result of any kind whatever occurred from its employment.

EDINBURGH, *15th November* 1847.

FINIS.





A TREATISE  
ON  
ETHERIZATION IN CHILDBIRTH.

ILLUSTRATED BY

FIVE HUNDRED AND EIGHTY-ONE CASES.

BY WALTER CHANNING, M.D.

PROFESSOR OF MIDWIFERY AND MEDICAL JURISPRUDENCE IN THE UNIVERSITY  
AT CAMBRIDGE.

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“Give me the facts, said my Lord Judge: your reasonings are the mere guess-  
work of the imagination.” — OLD PLAY.

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BOSTON:  
WILLIAM D. TICKNOR AND COMPANY,  
CORNER OF WASHINGTON AND SCHOOL STREETS.  
M.DCCC.XLVIII.

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Entered, according to Act of Congress, in the year 1848, by  
WALTER CHANNING,  
In the Clerk's Office of the District Court of the District of Massachusetts.

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BOSTON:  
PRINTED BY JOHN WILSON,  
No. 21, School Street.

TO

JAMES JACKSON, M.D.

PROFESSOR EMERITUS OF THEORY AND PRACTICE OF PHYSIC IN THE UNIVERSITY AT  
CAMBRIDGE, HONORARY MEMBER OF THE ROYAL MEDICO-CHIRURGICAL SOCIETY OF  
LONDON, ETC. ETC.

DEAR SIR,

Please to accept the accompanying volume. It is written, not as I would, but as I have been able. The remedy of pain was discovered in this city, and has already taken its place among the most important agencies for the benefit of man. It is due to it, that what it has accomplished should have its earliest embodiment in our own literature. In relation to Surgery, this has already been done in the publications of JOHN C. WARREN, M.D. Professor Emeritus of Anatomy and Operative Surgery, and GEORGE HAYWARD, M.D. Professor of Surgery, in the University at Cambridge; and of J. MASON WARREN, M.D.

Occupying a somewhat public position as a teacher of Midwifery, — a department of medicine which has derived special and vast benefit from the discovery referred to, — it seemed not out of place for me to collect, and present to the profession, the results of its application, amongst ourselves and elsewhere, to that branch of the medical art. This I have attempted to do in the following pages.

In my labor, I have not forgotten — nor do I forget, now that my work is done — that I received from you my earliest and most important lessons in the study of medicine. I was then a young man; and, now that I am an old one, it is to me a most pleasant office to ask your acceptance of this, the latest product of my professional life, and, with it, assurances of a grateful memory and a sincere respect.

Very truly your obliged friend,

WALTER CHANNING.

Boston, *September*, 1848.



# ETHERIZATION IN CHILDBIRTH.

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## PLAN AND OBJECTS OF THE WORK.

IN May, 1847, I published a pamphlet, containing a few cases of labor in which I had employed sulphuric ether with entire success. In July of the same year, a second edition of the same pamphlet, somewhat enlarged, appeared. Cases have gradually accumulated in my practice, in which etherization has been employed. They have been of the different classes of labor, and in sufficient variety and number too, to authorize a cautious generalization. It occurred to me, that these cases might be published, and possibly be of some service as guides, or authority, towards the farther employment of etherization. They were recorded as soon after the labor was over as circumstances allowed. I often wrote the case out immediately upon my return home from it, and the hour is sometimes mentioned. After some thought, it was determined to print the cases just as they were first put down. A different course might have improved their strictly literary character; but it could hardly have happened otherwise than that the freshness, if not the truth, of the impression made by the case, would have been affected by any new labor upon them.

In the meantime, etherization was in use here, and in different parts of the country, in midwifery practice. We were hearing of results through journals and newspapers. They existed alone. The thought occurred to me, that, with very little personal trouble, I might collect from various sources, facts in regard to etherization which would, in a much surer manner, make my work useful, than would any thing of my own which it might contain. A circular letter was prepared, and addressed to many physicians in Boston and vicinity, containing questions which embraced some of the most important points regarding the use of ether and chloroform.

My great, I had almost said my sole, object in this circular, — in short, in my whole efforts, — was to ascertain here at home, in the birthplace of etherization, what had been the precise results of many experiments, made by many physicians, of the employment of the remedy of pain. My object was to learn if this use of it had been *safe*, — safe both to *mother* and to *child*; and thus, as far as such results might reach, to contribute something towards settling the most important point concerning its further use, namely, that of its *safety*.

This matter of safety is especially dwelt upon, because much that is related to it, if not all else, has very little in it requiring present discussion or argument. I consider other questions as, in an important sense, settled, and therefore not demanding special attention. Thus we know that *pain* may be abolished by etherization. We know that voluntary or *animal power* is very much, if not wholly, suspended during this state. We know that *organic power* remains. Nay, more, we know that it is often increased, that of the womb for instance; and in the exceptional cases, in which uterine contraction is diminished, or in which it entirely ceases, we know that this is temporary, and that no danger to either mother or child has hence ensued. We know, finally, that during and in consequence

of etherization, circumstances highly favorable to safe as well as to easy labor arise. Among these may be enumerated the increase of secretions in the organs immediately concerned in labor, and a more perfect relaxation or dilatability than existed before its use. Dubois first made this last observation, and my latest experience of etherization confirms his early and important statement.

It was, then, to the question of safety, in our experience of etherization here, that my attention was directed in the questions in the circular. But do not for a moment, reader, consider this as a very simple or a single question. It has regard, indeed, to a single fact, — the well-being of mother and child. But to show that, in its uses here, etherization has been safe in midwifery practice, is to declare a most important fact. Safety in this matter involves whatever exists or is done in etherization, as a condition towards this great end. These conditions are few, and cannot be too often repeated. They are, 1st, Purity in the article used. 2d, Such an instrument as will allow the freest escape of the expired or *exhaled* air, and the due admixture of atmospheric air with the *inhaled*. A hollow sponge for ether answers every purpose; for its structure is such as to ensure these conditions. 3d, When *etherization* is produced, inhalation is to cease. This state is declared by the relaxed condition of the limbs, the inability to raise the eyelids at command, and cessation of complaint. The books are full of other conditions, and in these the diversity of individual observations and views is sufficiently declared. Suffice it to say concerning the mode of exhibiting ether-vapors, that, of the two methods recommended in midwifery, the one by Professor Simpson, which directs so much to be used, and after such a manner, as shall in the shortest time produce the fullest effects, — and the other recommended by observers here in the same practice, which seeks its object by a less quantity, and that moderately administered, — I think, of these the latter is decidedly to be preferred.



I am very glad to find, that my old friend and class-mate, Professor Mussey, of Cincinnati, takes the same view of the matter, and even extends its application to surgery.

With regard to contra-indications to etherization which are founded in other conditions, whether of co-existing functional or structural disease, — whether of heart, head, or lungs, — I have no experience or observation to offer. I have met with none. I believe I am borne out by fact, when I say, that, in the examinations which have been made of those who have died after etherization, it has not happened, in more than a single case, that any disease existed in any of the organs referred to, whereby to explain the death. The exception occurred lately in New York, and will be referred to more particularly hereafter. And farther it will hereafter be shown, by cases of known and grave structural disease, in which etherization has been employed as a remedy amongst us, that great relief has been afforded by it, and no suspicion, much less proof, furnished, that any untoward results have been produced or death accelerated by it. A case of confirmed phthisis is this moment under my care, in which chloroform has been very excessively and imprudently employed, and from which no other apparent troubles than nausea and vomiting have followed. These ceased when inhalation was omitted. Of contra-indications to etherization arising in diseases and lesions above alluded to, I have no experience to offer.

The object of the circular was to learn what had been the whole result of etherization, so far as it has been employed in midwifery amongst ourselves; and this in order especially to ascertain whether those who had used it had done well or ill, had lived or had died, — the question of *safety*.

The circular was addressed to many physicians. From some I learned that they had never employed etherization in midwifery; from others, that their experience furnished

nothing new. From one came the religious objection. One friend thus writes, and his short letter is a "whole history:" —

"Dear Doctor,

"I have used the ether in labor a considerable number of times, and with obvious benefit; but my observations have not been made with sufficient precision to be made the basis of statistical results.

"Yours, most truly,

"February 10."

"ENOCH HALE.

I give this letter with great pleasure. It contains, as far as the writer's experience goes, a very important answer to the great question of the circular, namely, of the entire safety of etherization. It says that its author has employed ether "a considerable number of times, and with obvious benefit." The character, the intellectual habits, the deep interest in all questions of science, and the caution of the writer in stating results, give to this short testimony of my friend, in favor of ether, great value.

From some, to whom I took the liberty to address the circular, I have received no answer. Thinking that in some of these instances my communication had miscarried, I sent another; and this, because I had learned that the physicians so addressed had valuable information to impart. I regret that I sent my circular in these cases. I acknowledge I had no other right to do so than that which some interest in good science bestows. If I exceeded such privilege in the instances referred to, I here make my best apology, and promise to offend in like manner no more.

From a great many came answers, in more or less detail, to the questions proposed; and, more than this, letters often accompanied them, giving at some length important cases and deliberate opinions. At first it was my purpose to publish, along with my own cases, tabular views of what I had been so very kindly and liberally favored with, together with the accompanying letters, and here rest the case. It

was an after-thought to devote some pages to a few of the topics which my subject so directly involves. That subject forms one of the most important epochs in medical history. Was it not due to it to say something of its history, of what it is in itself, of what it has done, and what appears to be its destiny?

It will be perceived that from some of my friends the communication of facts is small, sometimes not exceeding a single case. But that single case, is it without its interest? I answer no. It has its place in what has been done with ether, and deserves a distinct record in its literature. In its entire success, it teaches that it does not stand alone because of a want of confidence in the *safety* and whole benefit of etherization, and so gives positive support to these facts in our history. From some I learn that they have used, and mean to use, ether or chloroform, only when desired by the patient. No one can question the propriety of this course; but in thus dividing the responsibility, or laying its weight principally on the patient, I do not know of any one physician who has pursued this course because of his want of confidence in the perfect safety of etherization. Had he felt a doubt, had he had the smallest scruple concerning this its entire safety, would he have done that, or thought for a moment of doing it, which a sick and a most suffering woman asked for, nay demanded, but which to his mind involved the smallest danger? The whole question resolves into *safety* alone. It has nothing to do with men's notions of the value or the pleasure of pain. We dismiss this latter from the matter at once as wholly irrelevant. We know of *painless* labor, of labor wholly without *pain*; and in too many instances, not now to refer to them, in which the patient was unconscious of delivery, or knew nothing more of it in regard to suffering than of an ordinary defecation, which for the most part is pleasurable rather than painful, and who did not pay the penalty of death for the involuntary violation or temporary suspension of a natural law.

Let the reader, then, look at the true point at issue; and, above all, let him not be misled in his judgments by ignorance, by prejudice, or more especially by *a priori* reasoning.

Since receiving answers to the circular, I have, upon every opportunity, talked to my brethren of what has happened concerning etherization in their practice since they commenced it. I am told by all, that not an untoward occurrence has attended or followed its later use. From one, I learned that, since the newspaper accounts of alarming and even fatal cases in surgical operations, patients and their friends have sometimes held back from etherization in midwifery, and that he waits for it to be asked for. The influence is natural upon patient and physician. And it is both natural and wise to act accordingly. It, however, makes nothing against the use of the remedy of pain in childbirth, in which it is known never to have done harm, if an untoward result come of its use in some two or more cases of surgical practice, and in some diseases which are almost invariably fatal, as tetanus and hydrophobia.

The reader may look in this volume for the enunciation of principles concerning etherization which have come out of its facts, and which establish its place in practical medicine. I have examined the journals and papers in which these facts are scattered with a profusion which the importance of the subject certainly authorizes, and with a variety in reasoning or opinion which attaches to few other subjects, but which its novelty and extreme interest fully explain. We are told that every thing has two sides, and the one chosen depends on the point of sight. Etherization would seem to have as many sides as there are observers, and doctrines concerning it seem only limited by the number of observers. There is Dubois, with his faith and his fears so well nigh balanced, that one feels that he has been so taken with all sides of the matter, that he hardly seems to have looked thoroughly at any. And there is Simpson of Edin-

burgh, with his hosts of cases, the living witnesses of the safety of etherization, full of faith and of zeal. Mr. Travers says a man may die as well five days after etherization as twenty-four hours; and that he has known a limb, five days after death, smell of ether, the stump having become gangrenous. And this case has by some been elevated into a principle, that ether makes stumps gangrenous, and kills people in five days or twenty-four hours. How was it with Mr. Wells, of the English navy, who gives *one hundred and six* operations, in which he used ether-vapor? "No serious effects followed in any case." Not a case of gangrene occurred in a single stump of hundreds of amputations collected by Simpson, and not one after a single surgical operation in our own Hospital. Tetanus has been cured by ether, or recovery has followed its use. But it has not cured all. M. Roux has failed; and a writer says concerning this case, that "any such trials (namely, in cases of hydrophobia and tetanus) will assuredly end in disappointment; these diseases being *diseases of motion, not of sensation.*" The physiology may be true, but the fact is diverse. Patients do grow still, when etherized, both in hydrophobia and in tetanus. Spasms are controlled, nay, entirely overcome, by it. Positive *rest* ensues. We *infer* the abolition of *sensibility*. We *know* that *mobility* is abolished in etherization. Midwifery is full of teaching on this point. Muscles of voluntary motion become powerless. The limbs to which they are attached fall as dead, when raised and left to themselves; and, even when consciousness returns, this want of power sometimes remains. Ask a person in this condition of first waking after ether or chloroform, to raise the head to drink, or if he says he will do this, after handing him the vessel, witness his absolute, sure failure, and the question of the physiological action of ether, in this regard, is settled.

Mr. B. Cooper thinks much of the benefits of pain, which he calls a "*premonitory condition*"; no doubt fitting parts,

the subject of lesions, to *reparatory action*." He farther speaks of vessels losing the power of retraction, and so hemorrhage from small vessels follows. How wholly unlike this is the experience of other surgeons! How different are the results in midwifery! I mean established results, not such as come of mere conjecture, and which are offered as such.

M. Flourens shows the progress of etherization in regard to the nervous centres from the hemispheres to the medulla oblongata, with the inferential caution, that we must not let it reach the last. This knowledge is derived from countless experiments upon all sorts of animals, — men among the rest. The latter, I believe, have all survived, and so did not complete in themselves the experiment. But the poor lower orders have suffered terribly. Vivisections have been done without number and without mercy. It would seem, that ether had come to destroy life, not to save it. I have read the reports over and over, and doubt not for a moment that many animals have suffered, and many more have been killed, in the toil. But the end is not yet. Who is ready to determine, or have determined for him, a wholly practical question, by results of experiments on animals, which, in their whole history and proof, have no possible relation to the case of a suffering human being? It were easy to extend this narrative of effort and of result, of individual and multiplied fact, and of resulting individual opinion, concerning etherization abroad. But I refrain. A moment for home. How has it been with the etherization question here? The question has various answers. Men have tried etherization; and they who have done this most, whether in surgery or midwifery, have most advocated it. Men have not tried it at all; and it would seem, from the tone of their avowal, that they do not mean to try it. These show it little favor. There are whole communities in which nothing has been done with etherization in midwifery, and very little in surgery. Here, in

Boston, it has been tried in both. There has been no rush about it, however. The cautiousness in our sectional phrenological development, if M. Flourens will allow the allusion, has prevented a rush. Etherization in midwifery has been employed here now for a year; and, with some industry, my collections of cases do not much exceed five hundred. I have no doubt that many more exist; but, of the certain, I know of those only of which I give reports. The number is not large. But just add them to the hundreds and thousands which are furnished abroad, and they perform a distinguished part in a most important history. They, with all the rest, show that there has not been a case in which, during etherization in labor, any untoward circumstance has occurred. I cannot point to a single established case of disaster, during this state, for an exception even to the rule.

I had written thus far when I lighted upon two letters which much interested me, and from which I will make some extracts. The first is from Professor Simpson, of Edinburgh, to Professor Meigs, of Philadelphia. The extracts will occupy some space; but this matters little, if they will at all aid our inquiries.

Professor Simpson's letter is dated Edinburgh, January 23, 1848. He says: —

“The statements which I have already made, may show you to what an extent the chloroform is used in this country; and our chemists tell me that the demand for it steadily increases with them.

“In *surgery*, its use is quite general for operations, painful diagnosis, &c. My friend, Dr. Andrew Wood, has just been telling me of a beautiful application of it. A boy fell from a height, and severely injured his thigh. It was so painful that he shrieked when Dr. Wood tried to handle the limb; and would not allow of a proper examination. Dr. Wood immediately chloroformed him — at once ascertained that the femur was fractured — kept him anæsthetic till he sent for his splints — and did not allow his patient to awake till his limb was all properly set, bandaged, and adjusted.

“In *medicine*, its effects are being extensively tried as an anodyne, an anæsthetic, a diffusible stimulant, &c. Its anti-spasmodic powers in colic, asthma, &c. are everywhere recognized.

“In *midwifery*, most or all of my brethren in Edinburgh employ it constantly. The ladies themselves insist in not being doomed to suffer, when suffering is so totally unnecessary. In London, Dublin, &c. it every day gains converts to its obstetric employment; and I have no doubt that those who most bitterly oppose it now will be yet, in ten or twenty years hence, amazed at their own professional cruelty. They allow their medical prejudices to smother and over-rule the common dictates of their profession, and of humanity.

“No accidents have as yet happened under its use, though several hundred thousand must have already been under the influence of chloroform. Its use here has been a common amusement in drawing-room parties, for the last two or three months.

“I never now apply it with any thing but a silk handkerchief. In surgical cases and operations, the quantity given is not in general measured. We all judge more by the *effects* than the *quantity*. Generally, I believe, we pour two or three drachms on the handkerchief at once, and more in *a minute*, if no sufficient effect is produced, and we stop when sonorous respiration begins. Not unfrequently, spasms, rigidity, &c. come on; but they disappear as the effect increases, and none of us care for them any more than for hysteric symptoms; nor do they leave any bad effect. But the mere *appearance* of them is enough to terrify a beginner.

“I shall be glad to hear how the cause of anæsthesia gets on among you; and I remain, with great respect, very faithfully yours,

“J. Y. SIMPSON.”

Professor Meigs, in reply, says: —

“I presume you will, ere this date, have received copies of Professor Warren’s pamphlet on ‘Etherization,’ which may inform you very fully as to the use of the anæsthetic agent in the Massachusetts General Hospital and in Boston. That eminent gentleman is more reserved as to the obstetric employment of the agent; much more so, I understand, than either Dr. Channing, Dr. Homans, and other practitioners, who make use of it very commonly. In New York, as I learn, the surgical application of chloroform is common, while its obstetrical use has not as yet acquired a general vogue. . . . .

“As to its employment in midwifery here [in Philadelphia], notwithstanding a few cases have been mentioned and reported, I think it has not yet begun to find favor with accoucheurs. I have not exhibited it in any case; nor do I, at present, know of any intention in that way,



entertained by the leading practitioners of obstetrical medicine and surgery, in this city. I have not yielded to several solicitations as to its exhibition addressed to me by my patients in labor. . . .

"I freely admit — for I know it — that many thousands of persons are daily subjected to its power. Yet I feel that no law of succession of its action on the several distinct parts of the brain has been or can be hereafter ascertained, seeing that the succession is contingent. Many grave objections would perhaps vanish, could the law of the succession of influences on the parts of the brain be clearly made out, and its provisions ensured. There are, indubitably, certain cases in which the intellectual hemispheres are totally hebetized and deprived of power by it, while the co-ordinating lobes remain perfectly unaffected. In others the motor cords of the cerebro-spinal nerves are deprived of power, whilst the sensitive cords enjoy a full activity, and *vice versa*. . . .

"M. Flourens's experiments, and others, especially those by the younger Mr. Wakley, of the 'Lancet,' prove very conclusively that the aspiration of ether or chloroform, continued but a little longer than the period required for hebetizing the hemispheres, the cerebellum, the tubercula quadrigemina, and the cord, overthrows the medulla oblongata, and produces thereby sudden death. I fully believe, with M. Flourens, that the medulla oblongata is the *nœud vital*; and that, though later brought under the power of chloroformization, it is always reducible under it. Hence I fear, that, in all cases of chloroformal anæsthesia, there remains but one irrevocable step more to the grave.

"I readily hear, before your voice can reach me across the Atlantic, the triumphant reply, that an hundred thousand have taken it *without accident*! I am a witness that it is attended with alarming accidents, however rarely. But should I exhibit the remedy for pain to a thousand patients in labor, merely to prevent the physiological pain, and for no other motive, and if I should in consequence destroy only one of them, I should feel disposed to clothe me in sackcloth, and cast ashes on my head for the remainder of my days. What sufficient motive have I to risk the life or the death of one in a thousand, in a questionable attempt to abrogate one of the general conditions of man?"

As Professor Meigs's letter is on chloroform, it did not appear to me perfectly clear that his remarks concerning it were meant to be extended to sulphuric and chloric ether. To learn how this was, I at once sent to Professor Meigs a copy of my circular in a letter, in which I took the liberty to ask him such questions as particularly interested me, concerning his trials and his views on the whole subject.

It will be seen, in my first extract from Professor Meigs's reply to Professor Simpson, that reference is made to a work by Professor Warren, of Boston, on "Etherization," which speaks of his reserve as to its employment in midwifery, and of the freer use made of it by Dr. Homans and Dr. Channing, of Boston. In my very first effort to obtain facts from my professional brethren respecting etherization in childbirth, and I believe before Professor Warren's book was published, I addressed a copy of my circular to him; feeling particularly anxious to obtain a precise statement both of facts and opinions concerning the employment of etherization, in this application of it, derived directly from his own observations of its effects in midwifery. I was the more desirous to obtain this information from this source, as Professor Warren was among the first to use etherization in important operations in surgery, of which midwifery is a department, and because of the weight of his opinions with the community in which he lives, and abroad. I have not received his reply; but my impression is, that his remarks were intended as a lesson of caution, and not as the results of actual experience.

From Professor Meigs, almost by return of mail, I received the following reply to my letter. It is written in a spirit of so much kindness, so much courtesy, — is expressive of an interest so deep in the important and the true, — of so hearty a love of science, that I cannot withhold this public expression of my thanks to its honored author. As a mere matter of taste, it may be questioned if somewhat of that which is especially personal to myself might not have been left out of the print. But I prefer to publish the letter just as it is, and to take the chances with my reader concerning other and purely inferential matters.

" Philadelphia, April 26, 1848.

" Dear Sir, — I feel much honored by your letter of the 21st instant, covering certain interrogatories relative to the use of anæsthetic agents

in midwifery; and I beg you to accept my sincere thanks for the attention.

"I believe I have read all the articles, within my reach, that have appeared upon the anæsthetic practice; and I misconceive of my own motives, if the hesitation which hitherto has prevented me from employing either chloroform or ether arises from any other than a conscientious scruple as to the administration of remedial agents, that I do not deem it indispensably necessary to employ. I have as yet met with no such case, and have therefore remained an interested observer of what my brethren have deemed it expedient, and certain of them indispensable, to do in the matter. I am therefore incapable of answering your interrogatories; being without any clinical experience in the case.

"Seeing that so many thousands of persons have taken, and do daily take, advantage of the insensibility produced by etherization, to avoid the pain of surgical operations, one might well charge me with being cautious overmuch in so long refraining from adopting the remedy in my own practice; but it seemed to me, that the motives set forth for my recusancy, in a published letter to Professor Simpson, ought to be of weight sufficient to determine my action in the premises. The results thus far attained, although they are doubtless beneficent in most cases, are nevertheless mixed up with elements of distrust, as to the permanency of present opinions and indications of practice, so considerable, that I am most anxious to have a candid exposition of the motive for or against it; comprising an amount of intelligence, drawn from different sources, sufficient to lead the body of the profession to clear views of duty upon the point.

"I hold myself in readiness to yield to conviction upon sufficient evidence of the necessity and propriety of etherization in midwifery; but I beg leave to say, that this is a case in which I should hardly yield my opinions to the force of statistical returns, because I have no doubt of some physiological and therefore needful and useful connection of the pain and the powers of parturition, the inconveniences of which are really less considerable than has by some been supposed. If I am not here in error, I submit that no statistics ought to have a real power to convince. There are a few of my brethren here who have exhibited chloroform or ether in their obstetric cases. The instances are not numerous. Dr. Hodge and Dr. Huston, who enjoy a large share of the public confidence as obstetricians, tell me they have not yet resorted to the anæsthesia, nor do they at present feel inclined to do so. Perhaps, sir, when the volume you are preparing for the press shall have appeared, and we shall have become masters of the results obtained and collected by you, we may all give our adhesion to the recommendation. I shall take great pleasure in studying your work with care, as soon as I can get it from the booksellers.

"I have to-day received Ed. Wm. Murphy's pamphlet, which he was so good as to send me by the 'Acadia.' Dr. Murphy gives us accounts of *seven* cases, five of which were under his own observation. I cannot say, that any influence has been produced upon my mind, to change my purpose, by reading Dr. Murphy's cases and observations. In the seventh case particularly, I do not perceive any good fruits of the administration. The success was extraordinary, but can by no means be attributed to the chloroform.

"It is obviously, my dear sir, so much more agreeable to say yes than to say no to any honorable invitation, and it is so clear that you have many distinguished names to sustain the practice now common in Boston, that I could almost feel ashamed not to be on your side also; but if, after reading your forthcoming work, I shall find all my objections swept away by the power of truth, I shall hasten to confess my conversion, and my obligation to you. It is certain, that those who establish great practical truths, that are efficient in meliorating man's condition, are deserving of all honor and commendation.

"The motives that govern me thus far are connected with, or rather dependent upon, my views of the nature and offices of different parts of the brain. If you will do me the favor to look over Mons. Flourens's pamphlet, a copy of which I beg you to accept, you will perhaps see the course of my reasoning against etherization in obstetrics.

"We both seek the truth. I hope that you may find and establish it. In the meantime, I rest, with the greatest respect and esteem, your most obliged and very faithful servant,

"CH. D. MEIGS."

"Professor Channing."

It will be perceived, that the objection of Professor Meigs is wholly and purely physiological. Etherization being given, this objection demands for its removal the law of succession of its action on the several portions of the brain, from the hemispheres to the medulla oblongata, should it happen to reach so far; while it is at the same time obvious, that no such law as this can be ascertained. It is hence an impossible objection, and the true question is whether it should for a moment influence practice. We know not what is the succession of events from the slightest impression made by ether or chloroform on the hemispheres, or upon any intervening point between them and the medulla oblongata. We know not, and cannot know, where safety ends, and danger begins, by any known action of the agent,

or by any law of its action. Examinations after death from etherization show every variety of results, from the slightest, or none at all, to the greatest. The heart is found in every condition of emptiness and fulness, and the blood is quite as remarkable for the varieties of lesion it presents. So is it with the lungs; and, in short, so is it everywhere. Then we have the results of vivisections, after etherization induced in animals expressly to produce death, that its lesions may be made manifest. Now, vivisections are accompanied by direct effects, which at once prevent all true reasoning from them to the medicinal uses of etherization. The transcendental physiology of Flourens, of Preisser and Melays, and the equally visionary teachings of Snow, have really no pertinence to such an issue. They explain nothing, and should not for a moment be allowed to touch the questions involved in etherization.

I have directed as much, if not more, attention to the state of the respiration and of the circulation, than to any other facts in the history of etherization. These functions have always seemed to me to demand the most attention. They depend on the integrity of the medulla oblongata for their regularity, and for their very continuance. Thus I have counted the pulse and the breathings before etherization. Then, while it was getting established, and during its most perfect state, I have known them to remain wholly undisturbed in the midst and pressure of the total abolition of consciousness and sensibility. The patient has been in a state of entire and perfect repose. It has been the completed work of a second. There has been no time for succession in action, or it has been too small to be measured, or the series of events noted. I have known labor to advance in this state of things and to terminate, and not a limb or a muscle to move, or the face to betray the slightest token of suffering. In another part of this volume, I have related a case in which volition and muscular power partially remained, or was regained during

deep etherization. The woman was evidently wearied with her position on the left side, and in the most methodical manner possible turned herself over to the right, and composed her limbs after such a manner as to secure to herself a most comfortable sleep; and sleep she did through the whole of the remainder of the labor. These cases have been perfectly safe.

I have said, that the law of succession of the action of etherization cannot be learned; and I will state some facts which show how impossible the attempt to learn this would, and must continue to be. This condition occurs in many, many instances in so short a time after inhalation as to make observation of any succession in events impossible. I have known it to take place completely after two full inspirations, so that not the least notice was taken of any thing said or done. I spoke of the state of the breathing of the pulse, and the subject will come up under other heads again. Let me here say, in addition to what was remarked of their general natural state, that sometimes we find the reverse. They are sometimes more rapid, sometimes slower, than natural. Sometimes the breathing is perfectly noiseless; at others it is a heavy, stertorous snoring. Professor Simpson speaks of this as occurring more frequently in his practice, than has been met with in the cases which have fallen under my own observation.

Not only has the physiological objection to the use of chloroform and ether prevented Professor Meigs employing them in midwifery practice, — and will continue to do so, since it is pretty clear that this objection cannot be obviated, — but it will be perceived, that this same objection has with the professor also destroyed the authority of statistics; a science which, in matters of fact, has been of the greatest practical regard and benefit. It makes no sort of odds, that a thousand or a million cases, duly reported and authenticated, have been most successfully and happily treated by etherization. The possibility, not the *proba-*

*bility*, — for this is denied in the very statement of the number who have safely used it, — the *possibility* of one case proving fatal *afterwards* (not in consequence of etherization, for this cannot be determined) would seem to be regarded as a valid objection by my highly respected correspondent to his ever employing it. At least, notwithstanding the thousands of cases in which etherization has been most successfully used by others, Professor Meigs, in amount, says he has not met with one in which he has thought this agency necessary, or in which it would have been usefully employed. The position of this distinguished professor, and the collateral support which that position, and especially his opinions in midwifery, get from the adhesion of Professors Hodge and Huston to the same, makes it a duty, in the discussion of our subject, to consider all the grounds of his not having employed the remedy of pain in labor. I do not understand, that his associates in doctrine and in practice, in this regard, have, any more than himself, employed ether or chloroform in childbirth. If they have not, is not the whole reasoning against their use strictly *a priori* in its whole nature? It is not only indifferent to, but wholly irrespective of facts, which are alike the sources and the basis of all inductive science. Its supporters do not ask, “What has occurred? — what has etherization done in childbirth? — how safe has it been to mother and child?” They ask what it *ought*, what it *should* do, upon certain physiological principles; and which show that, as far as we can see, it ought to be, or that it is very likely to be, fatal whenever used. The friends of etherization look to the simple fact, — to what actually has happened in childbirth, after using ether or chloroform. They can learn what this truly is, both from their own observation and from that of others. They know that these remedies of pain have been widely used, and with a success which attaches to no other known remedy in practical medicine. They look to the facts. They collect these;

and, when the time for philosophizing has come, they will with great pleasure use physiology, and all other collateral aid, in their important generalizations. While thus waiting, however, they do not reject the teachings of physiology. But in the very imperfect condition of this noble science, and more especially that department of it which concerns the nervous system, they are willing to take the guidance of simple fact, of daily observation, in the conviction that, if wisely followed, it will never lead them astray. It is simply and wholly in view of the great importance of our subject, that another opinion of Professor Meigs will now be referred to. It is a passage in his letter to Professor Simpson, and contains what seems to Professor Meigs a conclusive objection to the use of etherization in childbirth. We have already made the quotation, but repeat it for special remark : —

“ I readily hear, before your voice can reach me across the Atlantic, the triumphant reply, that an hundred thousand have taken it *without accident* ! I am a witness that it is attended with alarming accidents, however rarely. But should I exhibit the remedy for pain to a thousand patients in labor, merely to prevent the physiological pain, and for no other motive, and if I should in consequence destroy only one of them, I should feel disposed to clothe me in sackcloth, and cast ashes on my head for the remainder of my days. What sufficient motive have I to risk the life or the death of one in a thousand, in a questionable attempt to abrogate one of the general conditions of man ? ”

The “ alarming accidents ” are not stated to have happened in midwifery practice, and probably were not observed in childbirth in which etherization was employed. This opinion is partly derived from the statement of Professor Meigs, that he has never used this agency in labor, and partly from what is stated immediately after concerning the employment of chloroform for the pain of disease, and of surgical operations to which no objection is made. It will be perceived, that the objection to etherization is still a physiological one ; for the *pain* of labor is obviously, from



the whole language and reasoning of Professor Meigs, a *functional* pain. Now, here we join issue, and state what will be met with elsewhere in this volume, that the *functional* department of labor is the *contraction* of the womb, the dilatation of its mouth, vagina, and external organs, which are no more necessarily painful than are those which carry forward, and expel the contents of the rectum or bladder. There is no pain in the pure functional actions of the uterus. Pain is the consequence of *resistance* to the contractions of the womb, which the moving body, the foetus, encounters in its progress to birth. Pain in labor is the result, first, of the imperfect harmony of functional dilatability of the mouth of the womb, with the contractions of the organ; secondly, of a like state of the vagina; and, thirdly and specially, of a like condition of the perineum and external organs. It is in these contingencies, not natural elements of labor, that the whole *pain* of labor has its cause. The pressure of the unyielding head on the sacrum also takes its share in the production of the resistance which makes up the whole pain of labor. I do not refer to morbid conditions of the passages, such as excessive sensibility and others, with which all practitioners of midwifery are so well acquainted. I merely refer to functional conditions or disturbances, which are ordinarily met with, and which give rise to the agony of childbirth. Now, this state is one which demands relief. It does not necessarily belong to labor, since painless, or nearly painless, cases of labor are too common to allow of such a statement for a moment. It is to relieve the unnecessary suffering which results from those conditions referred to, that etherization is employed. And it gives the demanded relief, by increasing dilatability, diminishing or suspending sensibility, preventing exhaustion, increasing the secretions, taking away the disturbing action of the will; and thus produces results which strike the observer of the first case in which he witnesses it, as if a miracle had been performed in his presence.

A husband sat at the bedside of his wife, and witnessed her sufferings during labor for some hours. Soon after my arrival, and no contra-indications to etherization being present, she inhaled sulphuric ether-vapor. She very soon experienced its most happy effects, and expressed the positive pleasure which had replaced so much agony. The effect upon her husband was such, of this sudden and entire change in her whole state, that he became faint, left the room, and did not return to it till after the child was born.

Let it, then, be distinctly borne in mind, that etherization is not used to suspend *uterine contractions* (which it most rarely does), but to prevent *pain* ; and, in this way, to make labor safe and happy to both mother and child, and to secure a successful convalescence. The cases that follow will abundantly show how true and how general is this alleged effect of etherization, — the rapid recovery which follows its use. Perhaps no effect has been so frequently alluded to by patients as this. They may be unconscious of what happened during etherization, and are insensible to pain ; but the after condition is matter of distinct consciousness, and is always referred to with entire satisfaction.

Professor Meigs speaks of the depth of the sorrow he should endure, should he destroy one in a thousand cases, by using etherization in labor. Whence would come that sorrow ? Not on account of wrong-doing, certainly. For what better argument could he or anybody else have for employing the remedy of pain in the thousandth case, than the preceding nine hundred and ninety-nine perfectly successful ones ? Would it not at once occur to such experience as this, that the untoward result was in no sense the product of professional delinquency in the employment of a remedy, but that it was a result not to be looked for or anticipated, — which stands as the solitary exception to the universal rule, for such would such an exception make it, — which has hence no relation to practice, — and the

very existence and whole history of which begins and ends with the fact itself? Add to this the fact, that in not a single instance of the thousands of recorded cases of childbirth, has there been a single untoward result met with during etherization; and what farther argument do we want to support the position, that this agency in painful labor is not only most reasonably demanded by the sufferer, but that it is the solemn duty of the profession to afford to such suffering its certain relief?

Do not for a single moment let the question be regarded as an impertinence; for it has a most important bearing on the subject. It is this. What becomes of the other physiological objection already noticed; namely, that etherization may quite unexpectedly reach the medulla oblongata, and so suddenly destroy life? I ask, what becomes of this objection, in view of the open recommendation of this agent in medical and surgical contingencies by the opponents of its use in childbirth? Certainly the risk is as great in these, as in the childbirth employment of the same agent. Nay, experience has shown it to be much greater; for fatal results have come of it, as I shall show by and by, in surgical operations, while etherization has never touched the medulla oblongata in any childbearing woman.

I do not mean to support my position regarding etherization in childbirth, by referring to the uncertainties of therapeutics in practical medicine. It may not, however, be out of place to observe, that, often in the gravest diseases, the correctness of the treatment is a matter of inference from its results, rather than of *a priori* reasoning, or mere experiment in other like cases. And yet who would or should question the propriety, the wisdom of that course which has its determination in such reasoning or in such experiment? Sydenham, in his noble writings on epidemics, especially new ones; and Gooch, in his admirable paper on puerperal fever, have settled the laws of practice in most important diseases, and, in their wise cautions in the

use of powerful means, have proved that their confidence in their remedies and in themselves has not been misplaced, but has made the ages long to come their grateful debtors.

I have not confined myself to etherization in childbirth. I have devoted some pages to its employment in surgery and general medicine. I have done this for illustration, and especially for its bearings on labor, both in regard to its agency, and in explanation, and as argument for its safety in this practice. This part of the inquiry seems to me exceedingly pertinent to the whole object in my undertaking, and is surely one of the deepest interest. It forms a most important portion of the teachings of the remedy of pain, and shows how wide is the domain of human suffering which it covers and controls.

Another subject, — the untoward results of etherization. Cases have been collected from home and abroad, in which these results have been alarming, and even fatal. Where original sources of information concerning these cases could be reached, they have been referred to, and the answers to inquiries are recorded. Thus I have published from authentic sources important facts concerning the Cincinnati case; others from Dr. Bartlett, of New Bedford, of a case in which chloroform was inhaled for amusement; from Dr. Flint, of Roxbury; from Professor Parker, of New York; and an important correction of a newspaper report of a case of crushed thigh, in which amputation was done during insensibility from chloroform. The correction is by Dr. S. D. Townsend, one of the surgeons of the Massachusetts General Hospital.

The numbers which the cases bear belong to an arrangement for a special object. They have been retained, as answering the purpose quite as well as would initials of names, and without the objection which might have attached to their use.

The word *etherization* has been used as a generic term,

and to express that condition which follows the use of ethers of whatever kind. I have, for the most part, designated the particular agent employed for its induction; and, where this has not been done, no necessity existed for doing it.

The first seven cases in the series were published in a pamphlet referred to in the beginning of this section. They are reprinted without alteration, because of the personal interest with which they are regarded, and because of their immediate relation to, and direct agency in, what I have since done concerning etherization.

It has not been easy, in the composition of this work, to avoid occasional repetition of thought, doctrine, or fact. Reports of cases, and statements of opinion, have been constantly reaching me while writing; and I was not willing to withhold either, though at times it has not been always easy to give them the best place. But the repetitions referred to have not been without design. They sometimes present important truths in different aspects. Sometimes, in their wider application, they involve new and useful practical suggestions. Sometimes they are used for illustration.

As to arrangement, very little attempt has been made to render this exact. Subjects follow each other in sufficient order, however, to indicate somewhat their mutual dependence, while each section is complete in regard to the subject discussed.

In offering this work to my profession, I have only to say that it was undertaken, and is finished, in the hope of adding something to useful medical literature. It has occupied more time than I supposed would have been necessary for its completion. It has been written in the uncertain leisure of a professional life, which makes a daily and like demand on physical and intellectual power. It treats of a noble subject, — the *remedy of pain*. After ages of suffering, and of frequently and long intermitted pursuit of such a remedy, one has been discovered. It remains with the

profession to say whether it shall take its place among the permanent and most important agents in the treatment of disease, and in abolishing pain; or whether it shall pass away with the unimportant and undeserving, until another and a truer age shall revive and give it a wider sphere of usefulness and a surer perpetuity.

I have stated my views fully and freely. They are believed to have a legitimate basis in numerous and well-established facts. These facts have been reported, not to sustain a vague opinion, or to give importance and currency to a poor and an unsafe hypothesis. It is no part of the purpose of the following treatise to teach, or to leave it to be inferred, that untoward results have not followed, or will not again follow, etherization. But I can and do say, that I have not met with an untoward result in any case of midwifery in which etherization has been induced, which, by any violence or ingenuity of explication, can be ascribed to this state as its cause. I have met with no record of such.

Sincerely do I hope, that what of earnestness may be discovered in the pages which follow, or in those which have preceded, will be ascribed to interest alone in the truth; and that I shall be saved from any thing approaching the charge of a partizanship, of which neither my subject nor my self-respect need, or I trust would allow, the indulgence.

W. C.



## A Proposal for a New Method of Evaluation of the Newborn Infant.\*

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RESUSCITATION OF INFANTS at birth has been the subject of many articles. Seldom have there been such imaginative ideas, such enthusiasms, and dislikes, and such unscientific observations and study about one clinical picture. There are outstanding exceptions to these statements, but the poor quality and lack of precise data of the majority of papers concerned with infant resuscitation are interesting.

There are several excellent review articles<sup>1 2</sup> but the main emphasis in the past has been on treatment of the asphyxiated or apneic newborn infant. The purpose of this paper is the reestablishment of simple, clear classification or "grading" of newborn infants which can be used as a basis for discussion and comparison of the results of obstetric practices, types of maternal pain relief and the effects of resuscitation.

The principle of giving a "score" to a patient as a sum total of several objective findings is not new and has been used recently in judging the treatment of drug addiction.<sup>3</sup> The endpoints which have been used previously in the field of resuscitation are "breathing time" defined as the time from delivery of the head to the first respiration, and "crying time" the time until the establishment of a satisfactory cry.<sup>4</sup> Other workers have used the terms mild, moderate and severe depression<sup>5</sup> to signify the state of the infant. There are valid objections to these systems. When mothers receive an excessive amount of depressant drugs in the antepartum period, it is a common occurrence that the infants breathe once, then become apneic for many minutes. Evaluation of the breathing time is difficult. A satisfactory cry is sometimes not established even when the infant leaves the delivery room, and in some patients with cerebral injury, the baby dies without ever having uttered a satisfactory cry. Mild, moderate and severe depression of the infant leaves a fair margin for individual interpretation.

A list was made of all the objective signs which pertained in any way to the condition of the infant at birth. Of these, five signs which could be determined easily and without interfering with the care of the infant were considered useful. A rating of zero, one or two, was given to each sign depending on whether it was absent or present. A score of ten indicated a baby in the best possible condition. The time for judging the five objective signs was varied until the most practi-

\*Presented before the Twenty-Seventh Annual Congress of Anesthetists, Joint Meeting of the International Anesthesia Research Society and the International College of Anesthetists, Virginia Beach, Va., September 22-25, 1952.



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cable and useful time was found. This is sixty seconds after the complete birth of the baby. Insofar as possible, the rating was done by two observers only, but as the series progressed, the score as determined by the anesthesia resident present at the delivery was found to be sufficiently accurate. These ratings have been included in the present series.

The signs used are as follows:

(1) Heart Rate.—This was found to be the most important diagnostic and prognostic of the five signs. A heart rate of 100-140 was considered good and given a score of two, a rate of under 100 received a score of one, and if no heart beat could be seen, felt or heard the score was zero. If one attends the baby alone, it is easy to learn to look briefly at the epigastrium or precordium for visible heart beat, while palpation of the cord about two inches from the umbilicus is the most satisfactory method for determining the heart rate quickly, and avoids the area of clamping or tying of the cord. It is of great assistance to the person caring for the baby to have an assistant demonstrate by motion of a finger of one hand the heart rate as palpated by the other hand. In only three cases was a heart rate of over 140 detected, accompanied by arrhythmia in two of these infants. I was puzzled as to the proper way to rate this in these patients, but they were given a full score of two points. The tachycardia and arrhythmias were apparently related to an overdosage of a vasopressor drug during spinal anesthesia for cesarean section.

(2) Respiratory Effort.—An infant who was apneic at 60 seconds after birth received a score of zero, while one who breathed and cried lustily received a two rating. All other types of respiratory effort, such as irregular, shallow ventilation were scored one. An infant who had gasped once at thirty or forty-five seconds after birth, and who then became apneic, received a zero score, since he was apneic at the time decided upon for evaluation.

(3) Reflex Irritability.—This term refers to response to some form of stimulation. The usual testing method was suctioning the oropharynx and nares with a soft rubber catheter which called forth a response of facial grimaces, sneezing or coughing. Although spontaneous micturition and defecation are not a response to an applied stimulus, they were considered to be favorable signs if they occurred.

(4) Muscle Tone.—This was an easy sign to judge, for a completely flaccid infant received a zero score, and one with good tone, and spontaneously flexed arms and legs which resisted extension were rated two points. We are unable to agree with Flagg's description of spasticity<sup>6</sup> as a sign of asphyxiation of the infant. The use of analeptics in the baby did not influence this score because of the standardized early time of observation and rating.

(5) Color.—This is by far the most unsatisfactory sign and caused the most discussion among the observers. All infants are obviously cyanotic at birth because of their high capacity for carrying oxygen and their relatively low oxygen content and saturation.<sup>7</sup> The disappearance of cyanosis depends directly on two signs previously

considered—respiratory effort and heart rate. Comparatively few infants were given a full score of two for this sign, and many received zero in spite of their excellent score for other signs. The foreign material so often covering the skin of the infant at birth interfered with interpreting this sign, as did the inherited pigmentation of the skin of colored children, and an occasional congenital defect. Many children for reasons still mysterious to us, persist in having cyanotic hands and feet for several minutes in spite of excellent ventilation, and added oxygen. A score of two was given only when the entire child was pink. Several hundred children were rated at three or five minutes as well as at sixty seconds and in almost all cases a score of two could be given for color at these later times. This finding agrees well with the heel blood oxygen studies in 402 infants, conducted at Sloane Hospital during 1947-48.<sup>8</sup> In an occasional instance the color was worse at five minutes than at sixty seconds, and these cases were therefore missed with our usual method of evaluation.

It has been most gratifying to note the enthusiastic interest and competitive spirit displayed by the obstetric house staff who took great pride in a baby with a high score. The same trend of interest has been noted in another hospital which has undertaken the ratings of babies in this manner.<sup>9</sup>

### Material

**D**URING THE PERIOD of this report (seven and one-half months) 2096 infants were born in the Sloane Hospital for Women. Eighty four per cent of the anesthesia records of these births are on file. The missing 16 per cent are chiefly those with pudendal blocks or "natural childbirth" patients. The omission of these cases is regrettable for they form the best control group for any study on infant resuscitation. Little attempt will be made to analyze these figures statistically for the groups are still too small for such treatment.

Seventeen hundred and sixty charts were available for study. Twenty-seven infants were stillbirths, or a rate of 1.5 per cent. One thousand and twenty-one of the infants born alive were rated by the method just described and comprise the data for this report. Seven hundred and twelve infants were not rated.

<i>Type of Delivery and Score</i>		
	No. Infants	Average Score
Low forceps or spontaneous	843	8.4
Cesarean section	141	6.8
Midforceps delivery	17	6.9
Breech delivery	16	6.7
Version and breech extraction	4	6.3

The infants in the best condition one minute after birth are those born vaginally with the occiput the presenting part. The incidence of the use of low forceps in this clinic is 34 per cent and after a two

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year daily observation of routine deliveries it did not seem to be of value to separate the spontaneous deliveries from those in which low forceps were used. Delivery by any other means produced no difference in the infants. The score for all these was slightly less favorable than those born spontaneously or with low forceps.

**Cesarean Sections.**—The cesarean section rate at Sloane Hospital is 10.5 per cent during this period. The anesthesia methods for the 141 rated infants born by cesarean section are listed:

	Infants	Average Score
Spinal anesthesia	83	8.0
General anesthesia	54	5.0
Epidural or caudal	4	6.3

The method used for spinal anesthesia was a single dose of nupercaine 0.25 per cent made hyperbaric with dextrose, in doses ranging from 6 to 7.5 mg., or pontocaine® 0.3 per cent, hyperbaric, from 7 to 9 mg. A 22 gauge needle was used. No supplementary anesthesia was given to these patients until after the birth of the infant. General anesthesia in all cases was accomplished with cyclopropane and oxygen. In 20 cases to be discussed later a relaxant was used with cyclopropane. Fractional epidural or caudal anesthesia (0.75 per cent xylocaine®) was continued in 4 cases for cesarean section after a trial of labor.

The indications for general anesthesia in cesarean section are thought to be a history of syphilis, septicemia, severe hemorrhage, or a history of traumatic experience with spinal anesthesia. Although this method does not take into account maternal risk or antepartum fetal problems, it is apparent that the mothers of the potentially poor risk infants received spinal anesthesia. In spite of this and the frequent maternal hypotension, the condition of the infants after spinal anesthesia was definitely better than after general anesthesia. The average time for delivery of the infant after induction of general anesthesia was fourteen minutes and twenty-four minutes after the administration of spinal anesthesia.

There is questionable support of the theory<sup>10</sup> that infants who have been subjected to a trial of labor are in better condition than those in whom cesarean section was chosen electively, as indicated below.

	Infants	Average Score
Patients in labor	57	7.1
Patients not in labor	84	6.7

These small groups have been analyzed statistically<sup>11</sup> and are not statistically significant.

In obstetric circles there has been the subtle impression that the lower the cesarean section rate in a clinic, the better was the practice of obstetrics. There is a slight trend away from this idea, and that at times even cesarean section is a conservative form of therapy.<sup>12</sup>

We have felt that with individual attention to selection of anesthetic agents and their administration by competent anesthesiologists, that infant survival after elective cesarean section might be made as successful as after an uncomplicated vaginal delivery. That we have not yet reached this point is illustrated in the next table. The group of cesarean section patients who had no antepartum problems and in whom labor was not present (secondary and tertiary sections) was compared with a similar group of vaginal deliveries in whom no problems of any kind were apparent. All received spinal anesthesia. The condition of the infants delivered vaginally was better than those delivered by cesarean section.

	Infants	Average Score
Normal, elective sections	38	7.7
Normal, low forceps or spont.	38	9.0

The most obvious difference between the two groups is the presence of labor in those delivered vaginally and the absence of labor in the section group. We do not know whether this implies some beneficial effect of labor on respiration, circulation and general well-being of the infant.

The experimental reports on the lack of placental transfer of d-tubocurarine, flaxedil,<sup>®</sup> decamethonium<sup>13 14 15 16</sup> are intriguing. Several clinical reports seem to bear out this somewhat surprising finding. Other papers are in disagreement.<sup>17</sup> In an effort to test this possibility clinically, 20 patients received a relaxant intravenously as a means of keeping the patient from moving, accompanied by as light a plane of cyclopropane as would produce unconsciousness. Seventeen received d-tubocurarine, and 1 patient each received flaxedil,<sup>®</sup> succinylcholine and decamethonium bromide. Thirteen infants were rated.

	Infants	Average Score
Sections: Cyclopropane without relaxant	41	5.0
Sections: Cyclopropane with relaxant	13	5.0

In addition to the fact that there was no difference in the infant's condition with or without the use as a relaxant, 70 per cent of the infants with relaxant needed oxygen administration in some form, while the number needing oxygen after cyclopropane anesthesia alone was likewise 70 per cent. The infants are not in better condition with relaxants and nothing is to be gained by the use of curare or similar drugs for cesarean section anesthesia. The occasional maternal respiratory depression necessitating assisted respiration is a distinct disadvantage to the technique.

Breech Deliveries.—There were 16 cases of breech deliveries excluding twins and version and breech extraction. All but one who precipitated without anesthesia were anesthetized with general anesthesia in a plane as light as compatible with the obstetric maneuvers. Nitrous oxide, ethylene or cyclopropane were used for this purpose. The average score was 6.7, essentially the same as for cesarean section infants. Regional methods were not used in this small group.

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Twins.—Nine pairs of twins were delivered by a variety of methods. The average score of the 18 babies was remarkably good, 8.6, and probably reflects the use of minimal medication during the first stage of labor. The use of regional anesthesia, however, again produced better results than general anesthesia in this small series.

	Infants	Average Score
Twins—general anesthesia	14	8.2
Twins—regional anesthesia	4	9.8

The condition of the first twin was somewhat better than the second.

	Infants	Average Score
Twin A	9	8.9
Twin B	9	8.2

Midforceps Delivery.—The condition of the infants following midforceps delivery was the same as by section or by breech delivery. There was no difference relating to the anesthetic method.

	Infants	Average Score
Midforceps, general anesthesia	11	6.8
Midforceps, regional anesthesia	6	7.0

Low Forceps and Spontaneous Deliveries.—This large group showed some improvement in the infant's condition following the use of regional anesthesia.

	Infants	Average Score
General anesthesia	692	8.2
Spinal anesthesia	25	8.9
Epidural, caudal anesthesia	102	9.1
Pudendal or no anesthesia	24	9.2

### Prematurity

THERE WERE 70 infants in this series whose birth weights were between 500 and 2500 grams. The nonviable premature infants, under 500 grams, were excluded and considered to be abortions. The youngest child who has survived in the Premature Nursery of the Babies Hospital weighed 580 grams. Regional anesthesia again was associated with a better score for the child.

	Infants	Average Score
Premature, general anes.	44	8.0
Premature, regional anes.	24	9.2
Premature, no anes. ppt.	2	2.0

### Resuscitation

OXYGEN, SUCTION, some method of positive pressure, endotracheal tubes and an infant laryngoscope are present in every delivery room. Oxygen was used freely if the infant's condition was not good. The three types of administration used are:

- (1) Face oxygen, in which method oxygen is added to inspired air, but without increase in pressure at the face.
- (2) Positive pressure mask, in which a small mask is held snugly on the infant's face, and some degree of positive pressure is applied

to the pharynx.

(3) Endotracheal oxygen, in which direct laryngoscopy is performed, additional suction used if necessary, and intubation accomplished. Positive pressure usually with added oxygen is implied in this method.

The details of these methods and indications for their use as well as discussion of other resuscitative measures will be the subject of other communications.

Three hundred thirty six or 19.4 per cent of the 1733 living infants received oxygen by some method. Of this group  
156 or 46 per cent received face oxygen.  
111 or 33 per cent received positive pressure mask.  
13 or 4 per cent received endotracheal oxygen.  
56 or 17 per cent received an unspecified method.

The survival rate following the use of endotracheal oxygen in this clinic over a 3 year period is between 60 and 70 per cent of the cases in which it has been employed.

The incidence of the use of oxygen for the infant following the various routes of deliveries is as follows:

Cesarean section	54 per cent
Midforceps	8 per cent
Breech delivery	37 per cent
Low forceps and spont.	15 per cent

In 217 of 336 infants who received oxygen, ratings were obtained and the method of administration was recorded.

	Cases	Average Score
Face oxygen	117	6.7
Positive pressure mask	90	3.9
Endotracheal oxygen	10	2.1

In 14 of the group of 117 cases receiving face oxygen, a score of 9 or 10 was given, and these infants undoubtedly did not need the oxygen so administered.

Neonatal Deaths

THERE WERE 25 neonatal deaths in the entire group of 2096 deliveries, or a rate of 1.2 per cent. If the 38 stillbirths over 500 grams are included, the total fetal loss was 64 infants, or a rate of 3.0 per cent of total infants born. The distribution by type of delivery is as follows:

Type	Cases	Neonatal Deaths	Per Cent of type
Cesarean section	220	2	0.9 per cent
Breech deliveries	54	5	9.3 per cent
Low, midforceps and spont.	1822	18	1.0 per cent

Fourteen of the infants who died were under 2500 Gm. birth weight, representing a mortality of 7.8 per cent of the total number of

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premature infants born alive. Of the 11 mature infants who died, all had obstetric or medical reasons for their deaths. In this series anesthesia complications apparently did not contribute to the death of any case. Twelve of the infants who later died were rated at birth and averaged 2.3 points.

In order to check the approximate accuracy of the various scores, the fate of the infants in poor, fair and good condition was examined. After this initial experience, it seems to us that groups 8, 9, and 10 indicate infants in good condition, 0, 1, and 2, poor condition, and the remaining scores, fair condition.

Infants receiving 0, 1 or 2 scores	65
Deaths in this group 9 or 14 per cent	
Infants receiving 3, 4, 5, 6, 7 scores	182
Deaths in this group 2 or 1.1 per cent	
Infants receiving 8, 9, 10 scores	774
Deaths in this group 1 or 0.13 per cent	

Thus, the prognosis of an infant is excellent if he receives one of the upper three scores, and poor if one of the lowest 3 scores. From this we may also conclude that color as a sign is relatively unimportant when observed one minute after birth.

### Summary

A PRACTICAL METHOD of evaluation of the condition of the newborn infant one minute after birth has been described. A rating of ten points described the best possible condition with two points each given for respiratory effort, reflex irritability, muscle tone, heart rate and color. Various applications of this method are presented.

The author wishes to acknowledge gratefully the assistance and encouragement of H. C. Taylor, Jr., M. D. The data were collected with the technical assistance of Rita Ruane, R.N.

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# Surgery, Gynecology and Obstetrics

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## PARAVERTEBRAL ANÆSTHESIA IN OBSTETRICS

EXPERIMENTAL AND CLINICAL BASIS<sup>1</sup>

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PAIN in labor, in spite of the remarkable advances in anæsthesia during the past quarter of a century, still remains a necessary concomitant of normal delivery. There seem to be two valid reasons for this: first, the disadvantages of general anæsthesia and/or narcosis are enhanced in obstetrics by the peculiarly long period of administration, producing toxic effects on the child, the mother, or the uterus itself, which contra-indicate adequate dosage; second, the lack of definite knowledge concerning the paths of afferent nerves of the uterus to the cord, has prevented the scientific application of regional anæsthesia.

Regional anæsthesia, so successfully developed in other fields of surgery, should find its ideal application in obstetrics, if a method were developed whereby the sensory nerves could be blocked without appreciably affecting the motor nerves of the uterus. In this field, spinal anæsthesia not only lacks the safety of other forms of regional block, but also impairs the expulsive power of the uterus; whereas, caudal block does not relieve the pain of uterine contraction. Paravertebral block of nerve roots has not apparently been tried owing to the large number of them attributed to the uterus by clinical observations of areas of hyperæsthesia.

The purpose of this paper is to survey the present status of our knowledge of uterine afferent nerves, to present experimental proof *via* visceromotor reflexes of the location of these paths in the dog, to correlate these findings in man, to explain the error of conclusions hitherto accepted, and to demonstrate that the pain of uterine contraction may be abolished without affecting the contractions by paravertebral block of only two adjacent nerves.

PRESENT STATUS OF KNOWLEDGE OF  
AFFERENT NERVES OF THE UTERUS

Much conflicting evidence has been published on the afferent supply of the uterus.

Behan considered these fibers to be of cerebrospinal rather than sympathetic origin, that they come from the second, third, and fourth sacrals or the third and fourth sacrals—and that it is due to stretching of these nerves that pain is felt in labor. Nevertheless, experiments of caudal anæsthesia in labor at the Royal Victoria Maternity Hospital, Montreal, in 1927, demonstrated that although relaxation and insensitivity of the perineum and adjacent parts indicated that the sacral nerves had been successfully blocked, the labor pains were undiminished. These experiments are in accord with the salient fact discovered by Cotte, 1925, that all pain of uterine contraction, in dysmenorrhœa, is abolished by section of the superior hypogastric plexus. Leriche and Stricker, 1927, demonstrated the presence of sensory fibers in this plexus; and Fontaine and Hermann, 1932, proved that dysmenorrhœa and other forms of severe pelvic pain may be consistently relieved by its section as high as the inferior mesenteric ganglion: but its position on the anterior aspect of the aorta makes it too inaccessible for practical regional block. It is necessary, therefore, to trace the uterine afferents to the nerve roots.

Evidence on the afferent connections of the uterus with the cord, by clinical observation of areas of hyperalgesia, is contradictory and inconclusive. Head found the pain of labor to be associated with tenderness over the eleventh thoracic segment definitely, often the twelfth, too, sometimes the tenth and occasionally the first lumbar; and the after-pains to be associated with the third sacral, as well as all these. MacKenzie observed that pain is felt between the umbilicus and pubis, across the back at the level of the top of the sacrum, and rarely referred to a lower level, but that it may extend from the tenth thoracic to the third lumbar nerves. Pottenger, while admitting that clinical observation of pain and sensation must of necessity be more or less uncertain,

<sup>1</sup>These investigations were begun at McGill University, 1927, and carried to completion at the University of Oregon, Department of Physiology, with the co-operation of Professor G. E. Burget 1930-1932. The clinical application was made at the Oregon City Hospital, 1932.

believed that uterine pain may be located anywhere in the areas of the tenth thoracic to the fifth lumbar, or even sacral segments. Head's conclusions are quoted in Cunningham's *Anatomy*: "Clinical observations indicate that afferent impulses reach the central nervous system from the uterus through the posterior roots of the tenth, eleventh, twelfth, thoracic nerves, the first lumbar, and the second, third, and fourth, sacral nerves." Kuntz, in his recent thorough and exhaustive text on the autonomic nervous system, 1929, gave these roots as bearing uterine afferent fibers; for which his reference was Cunningham. Yet, in 1922, Head recognized and explained the variability of these areas of hyperæsthesia, summing up his long unexcelled experience in these words: "Referred pain of visceral origin and the tenderness which accompanies it may be confined to the territory of a few segments only, representing the nerve supply of the affected organ. But in the larger number of cases met with in daily practice this is not the case; if the stimulus is extremely severe—as, for example, during an attack of gall stones or renal colic, the pain may spread widely, even in otherwise normal persons." That this is true of the severe stimulus of labor is supported by the observations of Gertsman, 1926, when he reported a case of gestation in a woman with a lesion of the cord at the level of the first lumbar vertebra, in which sensory and motor powers of the uterus were retained. He quoted Langley and Anderson in affirming that the sacral nerves did not take part in the innervation of the internal generative organs.

#### VISCEROMOTOR REFLEXES AS AN INDEX OF AFFERENT NERVES

In 1909, MacKenzie, having demonstrated clinically that abdominal muscles possess the power of contraction in small sections in response to visceral stimulation, coined the phrase "viscero-motor reflex." He considered this to be due to hyperirritability of the spinal cord in the vicinity of the visceral afferent neurones. He concluded that, as the motor supply is better known than the sensory, we might by this means more accurately ascertain the segment of stimulation in the cord. Never-

theless, in the absence of a means of accurately marking out the limits of motor activity, he based his conclusions in regard to the afferent supply of the viscera on sensory disturbances.

A method of recording visceromotor reflexes and of using them as an index of the afferent connections to the cord of any particular viscus, was worked out on the spleen by Cleland and Tait 1926, cats and dogs being used. It was found that widespread synapses occur within the cord from the limited afferent neurones to the extensive efferent neurones of the same organ. Since experience in 1927 with caudal anæsthesia in labor seemed to dispose of the idea of the sacral distribution of uterine afferents as erroneous, it was apparent that the afferent nerves of the uterus must enter the cord higher up—probably within the compass of the visceromotor reflexes.

Owing to the relatively greater number of thoraco-lumbar segments and relatively fewer sacral segments in the dog than in man, the problem of applying uterine afferent findings in the dog (by analogy) to man, would be difficult were it not for the works of Edgeworth and Head. Edgeworth, 1892, found the visceral afferent fibers to enter the cord, in the dog, between the first thoracic and the third lumbar, and between the seventh lumbar and the second sacral, thus leaving a gap of three segments. Head, 1893, found that in the human the distribution of the afferent sympathetic to the cord is between the first thoracic and the first lumbar, and between the fifth lumbar and the fourth sacral, thus leaving a gap of three segments. Since in each case the lower limit of the sympathetic distribution is the next to last sacral, one may, counting from below upward infer that the fourth lumbar in the dog corresponds to the second lumbar in man. Johnston, 1906, found that in all higher classes of vertebrates the arrangement of the spinal nerve roots along the trunk is the same. The relationship of afferent and efferent neurones in the cord, according to Pottenger, 1922, is preserved in the process of evolution; and, while some of the viscera are markedly displaced, they still keep their primitive nerve connections. The constancy of the analogy is further substantiated by the works of Bardeen, Ramström, and Sherrington.

## POSSIBLE EFFECT OF PARAVERTEBRAL BLOCK

That pain in labor may be relieved by paravertebral block of nerve roots is suggested by Kappis' work on other organs. A comparison of his findings of the afferent roots from particular viscera, with those of Head and others, show them to be much more limited in extent than areas of hyperalgesia have suggested. Nevertheless (perhaps because of the clinical impracticability of blocking the extraordinarily large number of segments attributed to it by areas of hyperalgesia) he did not, apparently, attempt to thus block uterine pain. Swetlow, 1926, relieved angina pectoris, in a case with hyperalgesia of the first and second thoracic segments, by paravertebral injection with novocain of the first and second thoracic roots; whereas Head's area of hyperalgesia for the heart extends from the first to the seventh thoracic.

Gertsman, 1926, referred to the experiments on animals of Ludwig, Muller, Balint, and Benedict, to show that the primary centers for contraction of the uterus must be situated *outside* the cord, and *in* the sympathetic ganglia of the pelvis. This is borne out by the experiments of Sir James Simpson, 1871, when he found that parturition was normal in sows from which he had removed the thoracic and lumbar cord, except that the last fetus of the litter remained in the vagina. That this was also true of the cat was shown in a similar experiment by Riemann, 1871. Rein, 1882, noted that spontaneous parturition in the rabbit, following the section of all the extrinsic nerves of the uterus, proceeded with abnormal rapidity. Cannon, 1929, reported parturition in a cat 6 weeks after the exclusion of all sympathetic impulses by removal of the sympathetic ganglia; and normal parturition has occurred in patients after resection of the superior hypogastric plexus had been previously performed for the relief of pelvic pain (Fontaine and Hermann). Moreover, Dellepiane and Badino, 1927, skilfully blocked this plexus by deep paravertebral injection, and relieved pain of uterine contraction without obstructing the course of labor. Whitehouse and Featherstone investigated the cause of increased tone and contraction of uterine muscle under spinal anæsthesia and decided that it

was due to the effect of paralysis of the lumbar cord on the para-sympathetic, third and fourth lumbar (thus contracting the circular muscle and relaxing the longitudinal or expulsive muscle). They inferred that paralysis of the sympathetic would have the opposite effect. Since it has been shown that the primary centers for uterine contraction lie in or beyond the sympathetic *ganglia*, however, it would appear that the blocking of a limited number of sympathetic *roots* should not interfere with the motor activity of the uterine muscle. Therefore should the uterine afferent sympathetic be found to be more limited segmentally than the uterine efferent sympathetic (as was shown to be the case with the spleen), paravertebral block should relieve the pain of labor without interfering with its normal course.

TECHNICAL DETAILS OF EXPERIMENTS<sup>1</sup>

The animals used for experiment were dogs and cats.

Since it was found that all anæsthetics and narcotics in doses adequate to prevent pain, depress the reflexes, the "spinal animal," with the cord transected just below the foramen magnum, was used. Artificial respiration was supplied by an air pump. To compensate for the fall in temperature normally appearing in the spinal animals, heat was applied by means of an electric reflector.

Stimulation of the visceral organ was effected either by minimal induction shocks through shielded electrodes to the organ, or its nerve, or by dilatation of the organ (with normal salt solution). The latter method was finally chosen as a more physiological one for the uterus. It was effected by means of a pressure bottle and rubber tubing to a Y tube cannula tied in the cervix. As a pressure gauge, a mercury manometer was interpolated, by a T tube connection, between the pressure bottle and the cannula. To produce a sudden intra-uterine pressure, the bottle was elevated to the desired height, and the pressure clamp released; whereas the more usual gradual distention was applied by pumping air into the pressure bottle, by means of a sphygmomanometer bulb.

Changes in muscle tonus were recorded on a revolving smoked drum, by means of a spring lever actuated by a silk thread attached to the cut end of the muscle. The spring was adjusted so as to balance the normal tonus of the muscle; and the direction of the thread was bent, by pulleys, into alinement with muscle fibers. Contraction of the muscle thus produced a downward motion of the lever, against the spring, to be recorded on the drum. A second spring

<sup>1</sup> My thanks are due Dr. G. E. Burget for having provided facilities and help for these experiments, and for his invaluable assistance both with them and this manuscript.

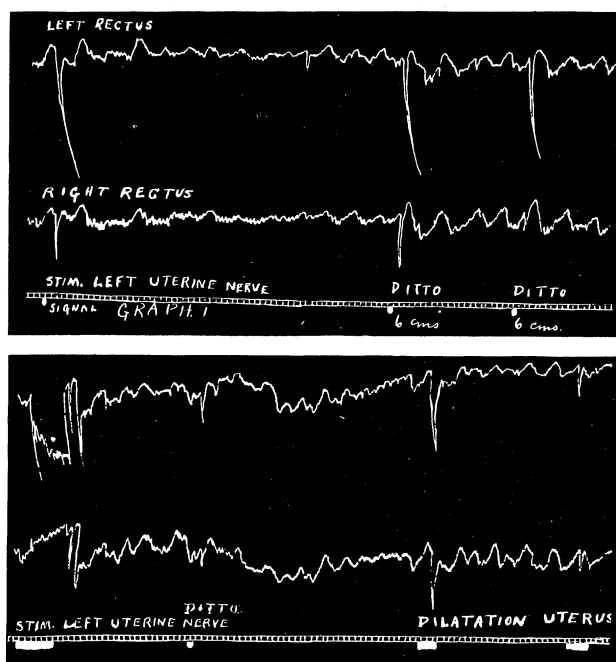


Fig. 1. To show that dilatation of the uterus is an adequate stimulus to its sensory nerves; and also some characteristics of the uterine visceromotor reflex. Contraction of the rectus produces a downward movement of the recording lever. Graph I.

lever was set directly below the other so that changes in tonus of two muscles (usually on opposite sides of the abdomen) could be recorded simultaneously.

The moment of stimulation was recorded by a signal marker on the drum actuated by a key that closed the circuit and produced the stimulation at the same time. A timer recorded two second intervals. The drum was made to revolve at the rate of  $1\frac{1}{4}$  inches per minute.

In order to immobilize the place of origin of the muscles, the pelvis was rigidly held by a strong clamp applied to the sacral tuberosity and fixed to the table.

#### IDENTIFICATION OF NERVES FROM THE FALLOPIAN TUBE AND UTERUS

Nerves were traced to the inferior mesenteric ganglion in the dog from the fallopian tube and the uterus by two entirely different routes. Nerve fibers from the fallopian tubes converged lateral to the ovary, to form a nerve trunk which accompanied the ovarian artery for a distance of 2.5 centimeters, then passed caudally and medially, and subperitoneally, to the inferior mesenteric ganglion. The uterine nerve, made up of fibers which accompanied the branches of the uterine artery from four segments of the uterus, was joined by nerve fibers from the cervix and vagina, and coursed along the uterine artery to a point 2 centimeters caudad to the cervix. From this point it was traced subperitoneally to the inferior

mesenteric ganglion. Nerve fibers were teased out under the binocular dissecting-microscope, and afferent fibers were identified under the high power microscope.

Before proceeding to the identification of the uterine afferent nerves, I found it necessary to determine the physiological adequate stimulus and to study the characteristics of the normal visceromotor reflex produced.

#### DETERMINATION OF ADEQUATE IMPULSE AND OF CHARACTERISTICS OF NORMAL UTERINE VISCEROMOTOR REFLEX

A female non-pregnant dog, was prepared for the recording of the visceromotor reflex. The peritoneal cavity was opened by a small midline incision just above the pubis, and the uterus delivered. The shielded electrode was applied to the left nerve at the level of the cervix; the vagina was opened in the midline, anteriorly, and a suitable cannula was inserted in the cervix. A suture was applied around the cervix (care being used to avoid the inclusion of any other structure, such as the sympathetic ganglion posteriorly), to prevent leakage. The cut edges of the vagina were then sutured around the cannula to arrest bleeding. Care was taken to restore the uterus to its normal position, thus preventing any tension on its nerves or attachments. The lower abdomen was then closed, in three layers, so as to prevent the incidental production of extraneous impulses from the viscera or peritoneum, and as a means of supporting the cannula steadily in place. The recording apparatus was then adjusted so as to balance the normal tonus of the muscles with the levers leveled.

The secondary coil was advanced until stimulation of the left uterine nerve produced a strong visceromotor contraction of the left rectus, and a lesser contraction of the right rectus. The pressure bottle was then gradually elevated until it was found that the sudden application of a pressure of 100 millimeters of mercury sufficed to produce a strong simultaneous contraction of both recti. When the pressure was gradually applied, a similar reflex occurred. As illustrated in Figure 1, dilatation of the uterus produced a visceromotor reflex of precisely the same character as that produced by stimulation of the uterine nerve—preceded by the same latent period and followed by a similar refractory period.

The indirect slight reflex contraction, produced in the right rectus by stimulation of the left uterine nerve had double the latent period of that produced in the left rectus—indicating the presence of intercolating neurones across the cord, and the relatively direct relation of the afferent and efferent neurones of the visceromotor reflex arc on the same side (Fig. 1).

A long series of experiments was performed on dogs and cats in various stages of pregnancy in the postpartum period, and in non-pregnant animals

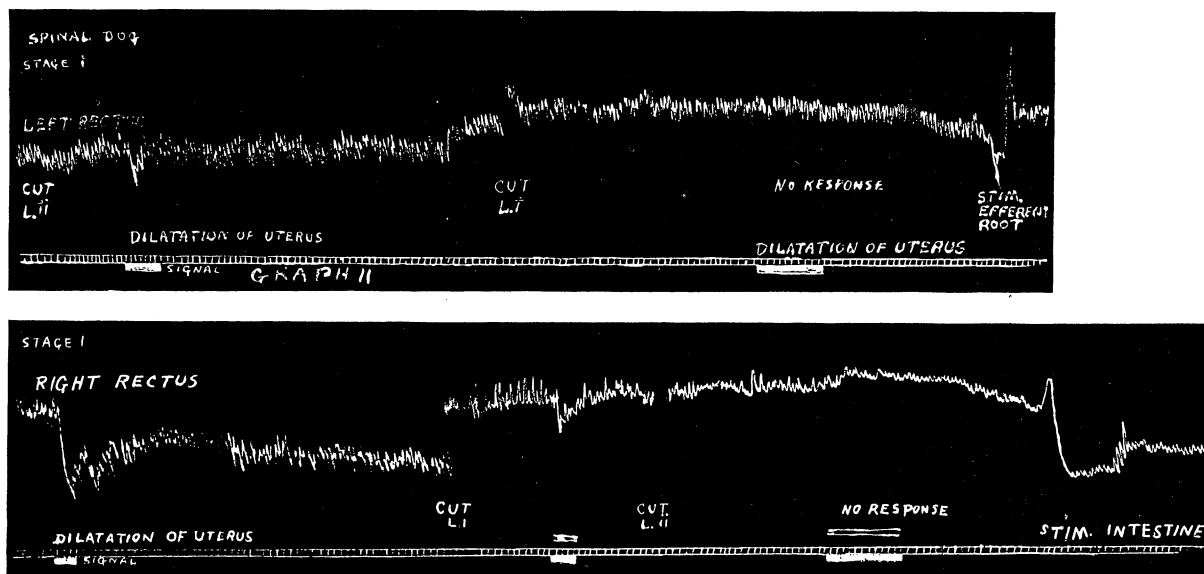


Fig. 2. To illustrate experiments to determine the nerve roots which carry the sensory fibers from the uterus: Series A, i.e. with minimum adequate stimuli (Graph II). Stage I (above) shows the upper limit to be the first lumbar. Stage II (below) shows the lower limit to be the second lumbar.

before the unusual characteristics of the uterine reflex were established. The reflexes occurred consistently even when the muscle was in a state of tremor. A gradual progressive fatigue of reflexes, however, began after a variable period averaging 2 hours (depending upon the condition of the animal and the extent of the operation performed upon it), but the latent period tended to remain the same. Since the visceromotor reflexes disappeared while the animal was still in good condition, an unusually long series would be necessary to determine the uterine afferent nerves. It was found that pregnant animals were unsuitable because the uterine visceromotor reflex was in a refractory state. Although it was found that the refractory state could be removed by intravenous injection of adrenalin, the effect was too transitory to be of practical value in this work. Incidentally adrenalin produced an initial contraction of the rectus fully as strong as that produced by visceral stimulation—indicating a relationship between the sympathetic system and skeletal muscle tonus. It was also found that afferent impulses from the uterus during the first 4 weeks postpartum produced a marked decrease in tone of the abdominal muscles, having the appearance on the graph of an inverted visceromotor contraction.

#### DETERMINATION OF AFFERENT CONNECTIONS OF UTERUS WITH THE CORD

*Series A—with minimum adequate stimuli.* A mature non-pregnant female dog was prepared for the recording of the uterine visceromotor reflex by the "sudden pressure" method of stimulation, in the manner described in the first experiment. The animal was then strapped in the prone position; and

the spinal cord was exposed by a laminectomy narrow enough to avoid laceration of the vessels, but wide enough to gain access to the posterior dorsal roots, and reaching from the eighth thoracic to the sacrum. Care was taken to avoid touching the cord, and to procure effectual hæmostasis. The dura was then longitudinally incised in the midline. The animal was turned on its right side, and the pelvis was immobilized, and the left rectus was connected to the recording apparatus. The minimal adequate impulse for the uterine visceromotor reflex was determined (100 millimeters of mercury), and the reflex found to be normal. When the upper, cut edge of the dura mater was seized and gently raised up, the fan-like distribution of the sensory fibers from the dorsal nerve roots to the cord was brought into prominence, and could be cut without touching the cord or the efferent root. By this technique, therefore, starting with the cauda equina, in successive order from *below upward*, the sensory roots were divided on the left side. Following each nerve section, a minimal adequate stimulus was applied to the uterus, and the visceromotor reflex recorded.

Section of the sacral roots and lower lumbar roots produced no change in the strength of the response. After section of the second lumbar, the reflex was diminished, though still well marked. When the first lumbar root was divided, the reflex was abolished. That the motor side of the reflex arc was still active was shown by mechanical stimulation of the ventral root (Fig. 2).

The animal was then fixed upon its left side and the right rectus was attached to the recording lever. A minimal adequate stimulus to the uterus was followed by a visceromotor reflex 3 centimeters in depth. The right dorsal nerve roots were then cut

from *above downward* in order to determine the lower limit of the uterine afferent distribution to the cord. After section of the first lumbar, the visceromotor reflex had suddenly diminished to 1 centimeter in depth. When the second lumbar had been divided, there was no response to uterine stimulation. Nevertheless stimulation of the intestine by traction on its mesentery produced a visceromotor contraction (Fig. 2).

Apparently the afferent fibers from the uterus in the dog enter the cord only by the first and second lumbar roots.<sup>1</sup>

*Series B—with increasing stimuli showing spread of impulses to adjacent segments through opposite roots.* First stage: A mature non-pregnant dog was prepared for experiment in the manner previously described except that the gradual pressure method of stimulation was used in order that pressure could be readily increased. After laminectomy the animal was fixed upon its right side for recording, and the left rectus was attached to the recording apparatus. A strong, sustained visceromotor contraction followed—after a 2 second latent period—dilatation of the uterus with a pressure of 160 millimeters of mercury. In successive order, then, from *below upward* commencing at the fourth lumbar, the left dorsal roots were cut, and an intra-uterine pressure of 160 millimeters was applied after each, while the resulting visceromotor reflex recorded.

After the fourth, third, and second left lumbar were cut, the promptness of response was still the same, and the amount of the visceromotor contraction was undiminished. After the first lumbar was cut, however, there was a sudden prolongation of the latent period from 2 seconds to 5 seconds, and the amount of the visceromotor reflex contraction was suddenly markedly diminished. The depth of contraction measured less than one-third of previous reflexes and the duration of increased tone was also cut down about two-thirds. Section of successive roots and stimulation up to 240 millimeters of mercury produced only slight and further delayed responses; until after the tenth thoracic was cut no response could be elicited. Nevertheless, stimulation of the efferent root produced a strong contraction; and presence of the knee-jerk, and other tendon reflexes showed the animal to be still in good condition. (Graph III, Fig. 3).

Second stage: Similar operation in another mature non-pregnant dog, except that the left dorsal roots were cut from *above downward*.

Strong uterine visceromotor reflexes were demonstrated and continued to be characteristic and uniform after the eleventh, twelfth, thirteenth thoracic and first lumbar were cut. Latent period in each case was short and equal. After the second lumbar was cut, latent period was suddenly prolonged by about 3 seconds. The contraction became atypical.

<sup>1</sup>The author wishes to thank Professor John Tait of McGill University for his encouragement in the planning and pursuit of these experiments.

It was gradual and shallow, in spite of powerful stimulation (over 240 millimeters of mercury).

After the third lumbar was cut, reflexes from the uterus were still present, but were very shallow and exhibited a similar prolongation in latent period.

Right dorsal roots were then cut, because it seemed apparent that these atypical reflexes were not coming through the left dorsal roots; but must have been relayed across the cord through synapses with the right uterine afferent fibers. As expected, after this possible source of error had been eliminated, uterine dilatation no longer elicited a visceromotor response of any kind.

The cord was then stimulated at its cut end and found to be still very active. That other visceromotor reflexes, having their afferent roots above the cut segments, were still present, was ascertained by pulling on the stomach mesentery, when a strong contraction of the rectus occurred (Graph IV, Fig. 3).

To check these results many similar experiments were performed. Because of the severity and length of necessary operative trauma, and the tendency toward fatigue of reflexes, many experiments were inconclusive. However, a series of ten successful experiments—six of the first stage and four of the second stage, in which the presence of other reflexes at the end showed the animal to be still reacting normally—agreed exactly with the above findings in respect to the localization of the sensory roots of the uterus by the exhibition of normal reflexes. Atypical reflexes with delayed latent period differed, however, in the extent of their spread: depending upon the intensity of stimulus, and the general condition of the animal. These delayed reflexes were demonstrated up to four segments cranial, and two segments caudal to the first and second lumbar, inclusive.

*Series C—with increasing stimuli and opposite roots cut.* First stage: Similar operation on non-pregnant mature dog except that all right dorsal roots were cut before the experiment was begun on left visceromotor reflexes.

From *below upward* left dorsal roots of the fifth, fourth, third, and second lumbar were cut, and characteristic visceromotor reflexes were elicited. After the first lumbar was divided visceromotor reflexes failed to appear in spite of eight successive well spaced stimulations by intra-uterine pressure beginning at 160 millimeters of mercury and gradually increasing. The motor side of the reflex arc was then shown to be very active (Graph V, Fig. 4). This experiment was repeated in a recently pregnant dog in which the characteristic relaxation, instead of contraction, occurred in response to dilatation of the uterus. These reflexes were abolished after the first lumbar was cut.

Second stage: In a female non-pregnant dog in which all right dorsal roots were cut, before the experiment was begun on the left visceromotor reflexes, the left roots were cut from *above downward*. The visceromotor reflexes were very strong until sud-

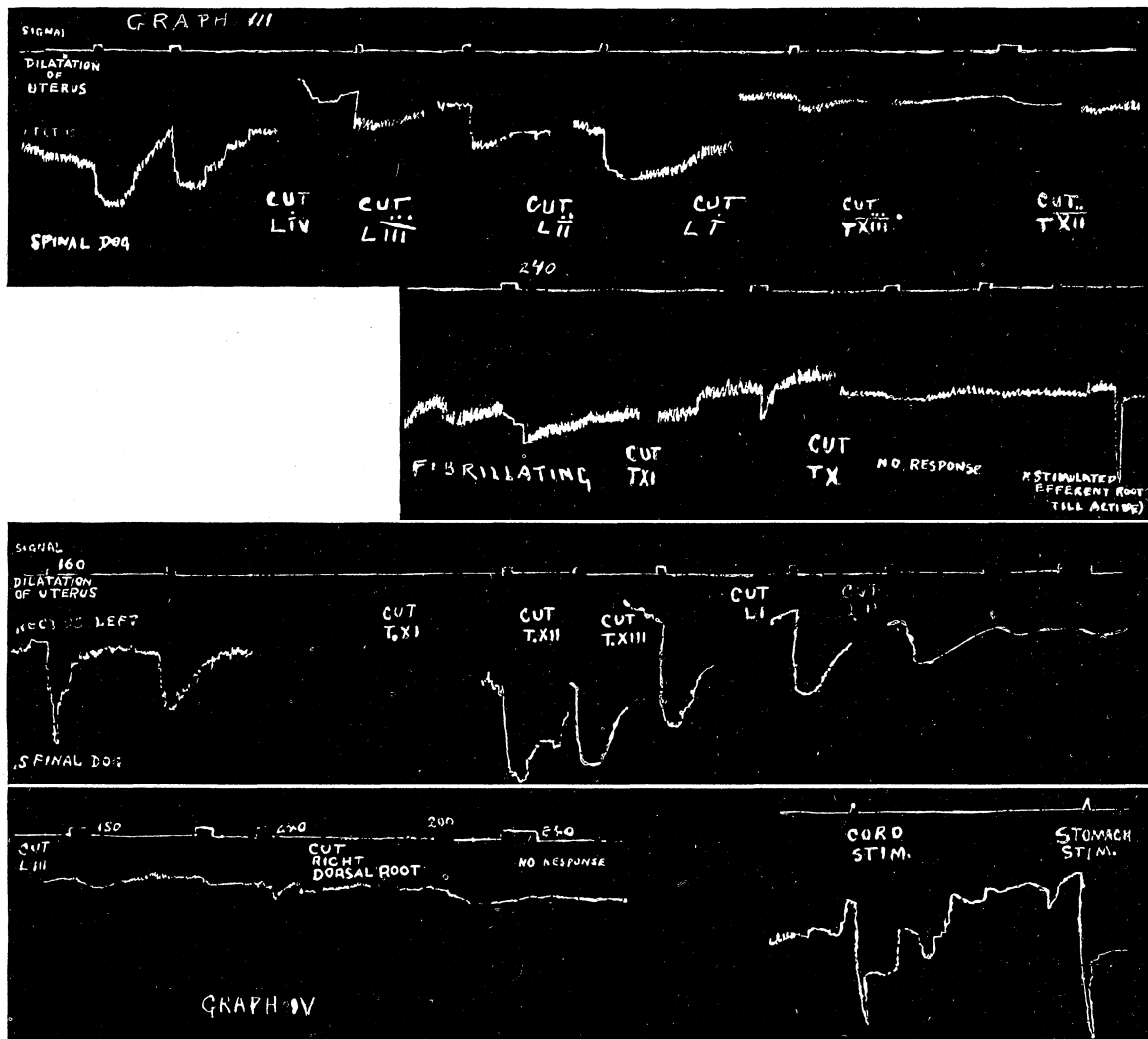


Fig. 3. To illustrate experiments Series B using stimulation strong enough to produce an effect in segments adjacent to the ones receiving the afferent impulses. Stage I (above) shows the upper limit of normal reflexes to be the first lumbar (Graph III). Stage II (below) shows the lower limit of normal reflexes to be the second lumbar (Graph IV).

denly completely abolished after the second lumbar was cut, in spite of very strong stimulation. Then the efferent root was pinched and a strong response occurred (Graph VI, Fig. 4).

#### DEDUCTIONS AND CORRELATING EXPERIMENTS

1. Afferent fibers from the uterus enter the spinal cord, in the dog, through the first and second lumbar roots.

2. Hyperminimal stimulation (so common in visceral disease) is capable of producing visceromotor effects in segments of the spinal cord adjacent to those which receive the afferent impulses. This spread of afferent impulses along the cord has been demonstrated as far as four segments from the point of entry.

*Parturition after section of afferent fibers of uterus.* In two dogs, the first and second lumbar nerve roots, and their rami communicantes were resected so as to remove those nerve structures which would ordinarily be anesthetized by paravertebral block. They became pregnant, and normal parturition occurred at term in each case. It was deduced that the motor mechanism of parturition would not be impaired by a paravertebral block of the afferent roots.

*Determination of corresponding roots in man.* Although the analogy of the arrangement of afferent nerves in dog and man was well substantiated, the hypothesis that the lumbar



nerve roots were numbered two higher in the dog than in man required experimental proof before the clinical application was undertaken. It was conceived that this could be furnished by the experimental determination in the dog of the segments of the abdominal wall associated with afferent impulses from the fallopian tube, because in man this organ does not usually send sufficiently strong painful impulses to cause spread to segments adjacent to those receiving the afferent impulses, and therefore its afferent supply, by areas of hyperæsthesia, could be relied upon for comparison: eleventh and twelfth thoracic and first lumbar.

In this experiment the visceromotor reflex arc was interrupted on the motor side just lateral to the muscle instead of at the afferent root. By the same method of elimination as before, it was determined that the first, second, and third lumbar nerves only, carried the impulses from the fallopian tube to the rectus. From this experiment the hypothesis was found to be correct, and it was deduced that the uterine afferent roots in the human are the eleventh and twelfth thoracic (Fig. 5).

#### CLINICAL APPLICATION<sup>1</sup>

##### CASE 1. Paravertebral block with novocain.

Mrs. F. G. was admitted to the Oregon City Hospital on May 3, 1932, at 9:00 a.m., having pains about every 10 minutes, with a history of six previous labors in each of which she had had prolonged first stage pains (with several remissions) and a rigid os. After several hours in hospital a remission of uterine activity occurred. At 4:30 a.m., May 5, pains recommenced, and by 6 o'clock, were strong, every 6 to 7 minutes. By rectal examination, the cervix was found to be thick and closed and being pushed downward, without dilatation, with each pain. By drawing a pin lightly over the abdomen, in the longitudinal direction, from above downward and from below upward (Head's method), hyperalgesia was found to be confined to an area in the lower abdomen, the upper transverse boundary of which was one-third the distance from the umbilicus to the pubis, and the lower boundary of which was at Poupart's ligament, that is, the eleventh and twelfth thoracic.

With the patient on her left side, at 6:00 a.m., the eleventh and twelfth thoracic nerve roots, on both sides, were injected paravertebrally with 5 cubic centimeters of 1 per cent novocain (Pauchet's method). The patient ceased moaning with her uterine contraction. At 6:20 a.m., the uterus became

prominent and on palpation was found to be hard (in strong contraction) but the patient's expression remained unchanged. The uterine contraction lasted 30 seconds. Upon questioning, the patient said that she had felt a "numb sensation, but no pain." The area of hyperalgesia had disappeared and had given place to analgesia over the eleventh and twelfth thoracic segments. During the 3 hours following, twenty-one painless contractions were observed. No change after the sensory fibers were blocked, in the strength of contraction of the uterus could be appreciated by palpation; nor was the frequency or duration of contraction affected. As could be expected from the small amount of novocain required, no toxic effects were observed; and the rate and quality of the heart beats of mother and child showed no change. The patient went into another depression of uterine activity, and since this occurred before the analgesia had worn off there was no return of pain. The cervix had thinned out considerably but was still rigid. The patient was sent home. She later contracted a general impetigo infection, on account of which reinjection was withheld (despite her request for same) when pain recommenced.

##### CASE 2. Paravertebral block with nupercaine.

Mrs. R. R., weight 260, gave a history of prolonged preliminary pains with her first labor. Due on July 4, 1932, she began to have slight irregular pains at noon on June 26th. By 4 p.m. the pains had become regular every 3½ minutes, lasting about a half a minute but the presenting part was still at the brim of the pelvis.

Hyperæsthesia was found to be confined to the eleventh and twelfth thoracic segments. At 4:45 p.m. the eleventh and twelfth roots were injected paravertebrally, each with 5 cubic centimeters of nupercaine, 1:1,000. During the next hour and a half a record of 29 contractions was made, each lasting from one half to one minute. There was no pain, but the patient was conscious of each contraction, describing it as a numb sensation in the suprapubic region. As far as could be judged by palpation, there was no difference between the painless contractions and those that were observed before the paravertebral block. The areas of hyperalgesia were replaced exactly by analgesia. No significant change in rate or quality of maternal or fetal heart, or any toxic symptoms or signs could be ascertained. At 7 p.m. the patient was still having painless contractions. At 8:30 p.m. analgesia had disappeared. At 8:40 p.m. hyperalgesia was elicited over the eleventh and twelfth thoracic skin segments. By 9:08 p.m. the patient was again complaining of hard pains, seemingly more severe than heretofore. At 9:45 p.m., it was found that hyperæsthesia had extended to include tenth, eleventh, and twelfth thoracic, and third, and fourth lumbar. One hour later pains subsided. Since the patient was in the country, reinjection when labor again started, was not attempted.

CASE 3. Paravertebral and caudal anæsthesia in labor using novocain.

<sup>1</sup>Thanks are due Doctors Guy and Frank Mount, and the nursing staff of the Oregon City Hospital for their co-operation.

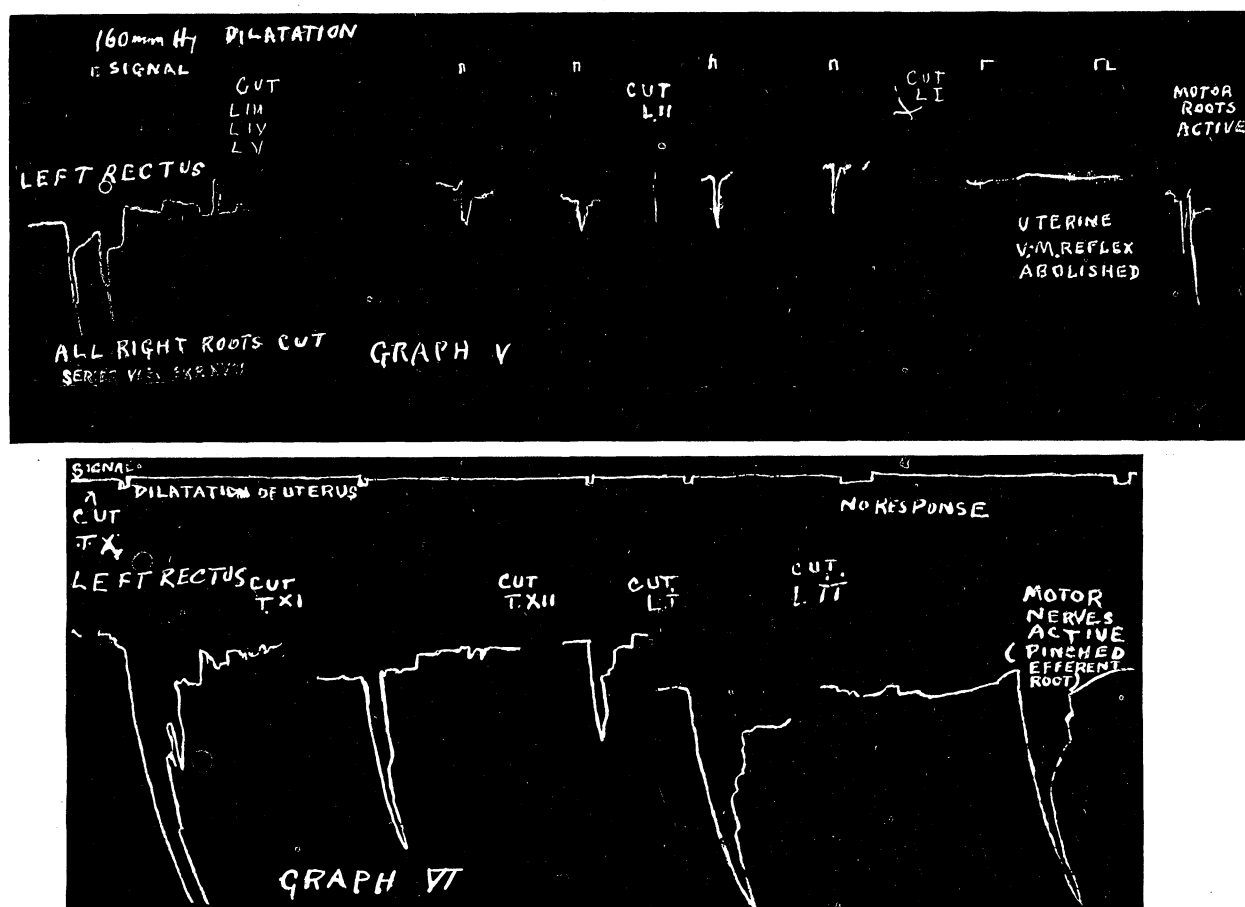


Fig. 4. To illustrate experiments Series C in which, after the opposite nerve roots were cut, no strong stimulus could produce reflexes above the first lumbar or below the second lumbar (Graphs V and VI).

A primipara, Mrs. W. J. V. O., was admitted to the Oregon City Hospital at 5:15 a.m., May 30, having slight pains at irregular intervals. Rectal examination at 6 p.m. showed the cervix to be dilated to a diameter of 5 centimeters. Hyperæsthesia was found definitely to correspond to Head's areas, the eleventh and twelfth thoracic segments, and moderately increased tone was palpated in the lower abdomen corresponding to the area of hyperæsthesia. The patient complained of a steady soreness or backache at the level of the top of the sacrum, chiefly over the left sacro-iliac joint, more severe with each pain. By 6:20, uterine contractions were strong every 3 to 5 minutes lasting for one and a half minutes, causing the patient to cry out loudly for relief. She wanted anything but ether (which had caused vomiting when given for a minor operation, and a prolonged gastric disturbance afterward) and willingly consented to regional block. 6:25 to 6:35 p.m., injection of both eleventh and twelfth thoracic nerve roots paravertebrally with 5 cubic centimeters, novocain 1 per cent. 6:40 to 6:44 p.m., two strong uterine contractions palpated, but complete analgesia, except for pain in back which persisted as a soreness.

6:47 p.m., strong uterine contraction of 35 seconds duration, without crampy pains, and the soreness in back "not as bad as it was." 6:51 to 7:03 p.m., five strong uterine contractions without cramp-like pain, lasting between one, and one and a half minutes. Patient states she feels like going to sleep, as backache is better. 7:05 to 7:15 p.m., six contractions with slight suprapubic cramp-like pain at onset, increasing in severity with each pain.

Hyperæsthesia was found to be now present over the twelfth thoracic area, whereas the eleventh was still analgesic. Apparently the twelfth root had been inadequately blocked. Rectal examination showed labor to be proceeding with cervix now 8 centimeters in diameter. Fetal heart was loud, rate 140. 7:15 to 7:45 p.m., analgesia in eleventh segment remained constant while contractions continued every 3 to 5 minutes with pain. 7:50 p.m., reinjection twelfth thoracic using adrenalin and novocain (mm. 1 to 5 c.cm.). 8:00 to 9:15 p.m. cramp-like pain abolished while strong contractions continued at 2 to 3 minute intervals, but pain (of stretching?) felt low down in the region of the symphysis pubis and in the back. 9:16 p.m., caudal block with 35 cubic centimeters of

novocain 1 per cent, with adrenalin, was followed by cessation of all pain. Uterine contractions then stopped. Analgesia had extended up to the level of the ninth thoracic segment and down the legs.<sup>1</sup> Cervix fully dilated. Patient vomited. Fetal heart strong, 148. 10:35 p.m., palpable strong contractions about one minute in duration, every 5 minutes with only an ache in left sacral region. 11:00 p.m., paravertebral analgesia had worn off and patient is complaining of cramp-like labor pains. Sodium amyral, 6 grains, was given. 12:30 to 1:40 a.m., pains every 2 minutes. Patient crying out for another nerve-blocking injection. 1:40 a.m., caudal block with 20 cubic centimeters novocain 1 per cent abolishing the stretching pains in the region of the symphysis pubis and back, but not affecting pains of contraction. No toxic symptoms appeared in either mother or child. 2:39 a.m., delivery was completed by low forceps, without causing pain; and relaxation was so complete that there was not the slightest abrasion of the perineum. The baby was unusually prompt to stretch its arms and legs, to cry lustily. The placenta was expressed intact at 2:50 a.m. Total blood loss measured 6 ounces. The tone of the uterus remained good. Baby regained birth weight on fifth day. Involution of the uterus was normal.

CASE 4. Paravertebral block, novocain with epinephrine and caudal, nupercaine without epinephrine.

Mrs. J. W. a multipara at term, was admitted to the Oregon City Hospital, at 2:35 p.m., June 28, 1932, with slight irregular labor pains. By 8:30 p.m. she was complaining of strong pains, at 4 to 5 minute intervals, lasting 20 to 30 seconds. Rectal examination showed the cervix to be  $\frac{1}{2}$  centimeter thick and 2 centimeters in diameter. Hyperæsthesia was elicited over the eleventh and twelfth thoracic areas. At 9:00 p.m., the eleventh and twelfth roots were injected paravertebrally, each with 5 cubic centimeters of 1 per cent novocain, plus epinephrine, and the pain of uterine contraction was no longer felt. Hyperæsthesia had disappeared and given place to analgesia over the same area. Blood pressure was 140/80. Uterine contractions were so strong that it was presumed that labor would be completed within 4 hours and caudal block was therefore given at 9:40 using 20 cubic centimeters nupercaine 1/500. Patient was now completely comfortable, while at intervals of  $2\frac{1}{2}$  to 5 minutes, the uterus went into strong contraction, rising up into a round hard ball. Between 9:45 and 11:30 p.m. 25 such contractions were observed—lasting from  $\frac{1}{2}$  to  $1\frac{1}{2}$  minutes, becoming progressively longer and stronger, but without the slightest sensation of pain. At 11:30 p.m. examination showed that labor was progressing, the head being much lower and the cervix thinned out and dilated to 8 centimeters in diameter. The fetal heart was heard loudly in the right flank at 160. From 11:30 p.m. to 12:30 a.m. the

patient continued to be free from pain, but had a numb feeling of tightness in the lower abdomen, while contractions proceeded every 3 minutes. At 11:45 p.m., hyperæsthesia was found to be returning to the eleventh and twelfth thoracic areas, but analgesia was still present to deep pinching. Analgesia was still present in the perineum, showing caudal anæsthesia to be still active. At 12:00 p.m. "show" appeared (with dilatation of the cervix), and the patient was instructed to bear down with contractions. At 12:33 a.m.,  $3\frac{1}{2}$  hours after paravertebral injection, the patient began to have pain with contractions, which were of the same character and frequency as before. At 12:50 a.m., there was some "bulging" and the membranes were ruptured. The presentation was persistent occiput posterior. At 1:30 a.m., under light ether anæsthesia, as the pain had become severe, paravertebral block was attempted, with 5 cubic centimeters of  $\frac{1}{2}$  of 1 per cent novocain. On coming out of anæsthetic, patient still complained of pains, and it was found that the perineal analgesia had disappeared. Instead of repeating the caudal block, in this case, ether was given while the baby was delivered by Scanzoni rotation at 2:10 a.m. The baby cried well spontaneously. The placenta was delivered intact at 2:20 a.m. Blood loss was not abnormal. The fundus remained firm. No sedative of any kind was used until after the effect of the regional anæsthetic had worn off. No toxic effects were observed.

CASE 5. Paravertebral block with nupercaine 1:1,000 and epinephrine, and caudal block with nupercaine 1:500 and epinephrine.

Mrs. R. B., age 35, was admitted to the Oregon City Hospital on June 21, 1932, with pre-eclamptic toxæmia of 3 months' duration, becoming severe during the preceding week. She gave a history of chronic invalidism and difficult labors. After a week of medical treatment her blood pressure was 182/114, pulse 118, hæmoglobin 59 per cent, albumen 2 plus, phenolsulphonephthalein total output 23 per cent, and toxic symptoms became severe. On July 1, 9:30 a.m. caudal block with 20 cubic centimeters of nupercaine 1:500 plus epinephrine was given, and a Voorhees bag painlessly inserted. Patient continued to be comfortable, except for an occasional slight contraction-pain, until 3 p.m., when she began to complain of regular pains. At 3:30 p.m. hyperæsthesia was found in the eleventh and twelfth thoracic areas, and analgesia was still present in the perineum from caudal block of 6 hours previous. At 4 p.m. paravertebral injection of eleventh and twelfth thoracic roots on each side (using 5 cubic centimeters of nupercaine 1:1,000 to which had been added epinephrine) was done. The cramp-like pain of uterine contraction was immediately abolished. The bag was expelled at 4:15 p.m. At 4:40 p.m. labor was progressing satisfactorily with painless contractions every 2 to 4 minutes. Cervix was 8 centimeters dilated.

As the analgesia in the perineum disappeared "stretching" pains were felt low down in the region

<sup>1</sup>Such a diffusion along the extradural space to higher nerve roots was prevented in subsequent injections by using only 20 cubic centimeters for caudal anæsthesia. The possibility of variability in anæsthesia of the birth canal could be avoided by blocking the individual afferent roots should the experimental determination of their location be accomplished.

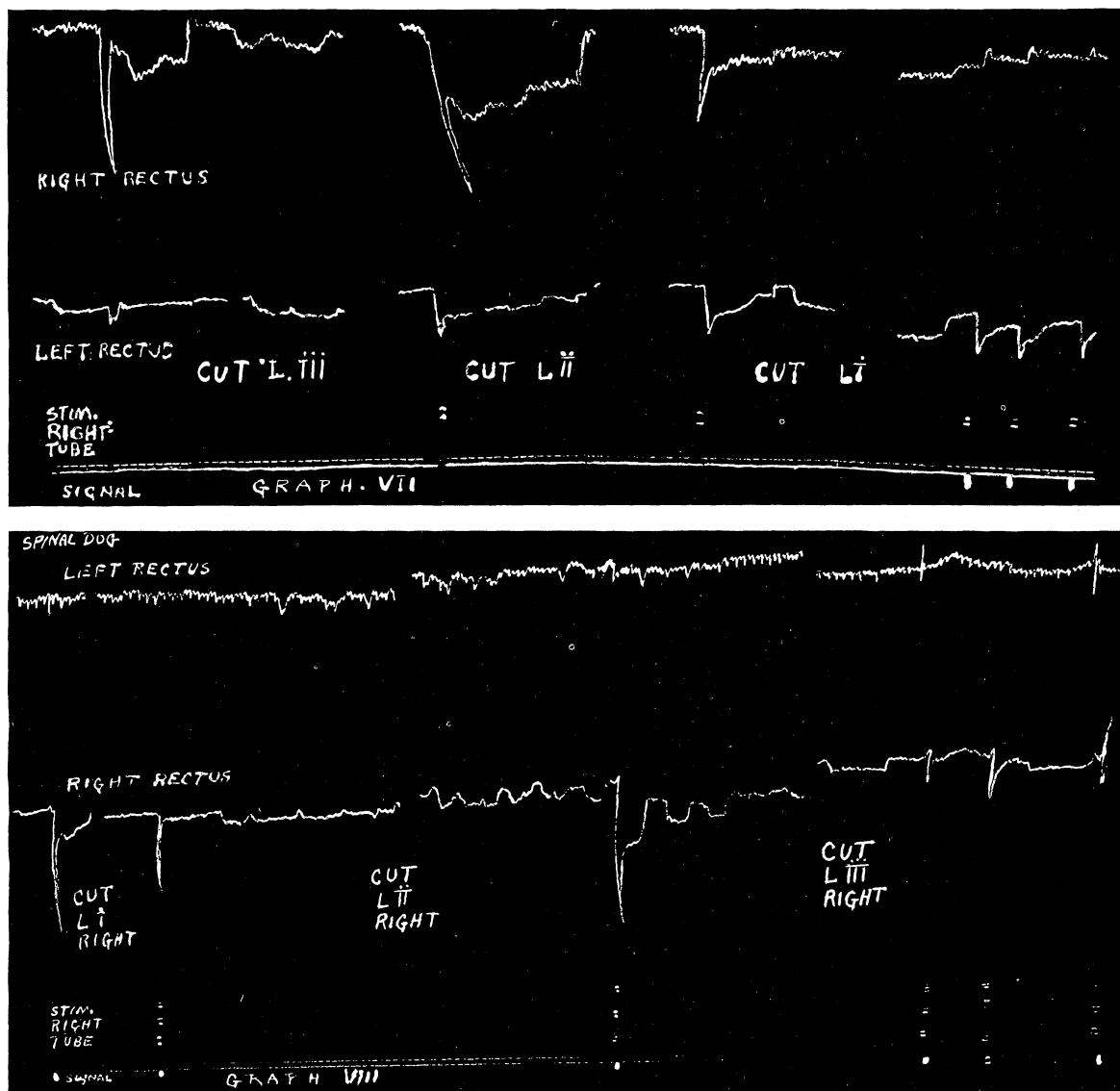


Fig. 5. To illustrate the experiments to determine the segments of the abdominal musculature involved (by hyper-tonicity) in stimulation of the right fallopian tube, i.e. Graph VII, the upper limit reached after the first lumbar was cut, Graph VIII, the lower limit reached after the third lumbar was cut. The tonus of the left rectus is simultaneously recorded above as a control.

of the symphysis pubis becoming severe enough to require repetition of caudal block at 6:45, 20 cubic centimeters of nupercaine 1:1,000 and novocain 1 per cent, equal parts. After this the only remaining discomfort was a feeling of fullness in the bladder aggravated with each contraction. This was relieved by catheterization of about 16 ounces. Spontaneous delivery occurred at 7:35 p.m. without the mother being aware of the birth. The baby cried promptly and well. The placenta was expressed at 7:48 p.m. One cotyledon was missing and was removed manually without pain. Blood loss was unusually slight. The fundus remained firm. There was no pain of contraction felt at any time during the labor after

the paravertebral block. No sedative was given after the preliminary hypodermic preceding bag induction. Mother's pulse, palpated steadily from caudal block to delivery remained steady at 104, and no toxic effects of anæsthetic were apparent at any time during the labor.

#### CONCLUSIONS

1. The pains of labor are made up of two components, namely: (a) that due to uterine contraction which is transmitted by afferent fibers through the eleventh and twelfth thoracic roots; (b) that due to stretching of the

birth canal, which is transmitted through certain undetermined sacral roots.

2. Paravertebral block of eleventh and twelfth thoracic roots will abolish the pain of uterine contraction for a length of time varying with the type of anæsthetic used, without appreciably affecting the tone of the uterus or the degree, frequency, or duration of contractions.

3. The pain of dilatation of the birth canal may be abolished by caudal block with about 20 cubic centimeters of novocain 1 per cent or nupercaine 1:500 for varying lengths of time dependent on the type of anæsthetic used, without depressing the tone or contractions of the uterus.

4. While the eleventh and twelfth thoracic roots are blocked, there is no hyperæsthesia; whereas in the absence of such anæsthesia the painful impulses may spread in the cord to produce hyperæsthesia in other segments adjacent to those receiving the painful impulses.

5. The combination of paravertebral and caudal anæsthesia, in a safe dosage, is feasible in labor, and the block, which may last as long as 8 hours, may be safely repeated.

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Thanks are due to the staff of the Oregon Medical School Library for their kind assistance in locating references, and in translations, also to the Surgeon General's Library.

