

THESIS FOR M.D. EXAMINATION.

---

# ETHER ANÆSTHESIA IN CHILDREN.

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By R. B. WADE.

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Sydney :

F. CUNNINGHAME & Co., PRINTERS, 146 PITT STREET.

1904.

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**E**THER has been the sole or main anæsthetic agent that I have used in the following 304 cases, and I have given a list of the number of times it was given for each of the operations.

## LIST OF CASES.

	C. & E.	E.
Hydro-nephrosis ... ..	1	
Scraping Sinus ... ..	26	1
Empyema ... ..	10	1
Abscess ... ..	20	3
Sequestrotomy ... ..	7	
Tenotomy ... ..	16	1
Tarsectomy ... ..	10	2
Hernia ... ..	21	
Laparotomy ... ..	4	
Circumcision ... ..	7	21
Adenoids ... ..	14	18
Tonsils and Adenoids ... ..	8	44
Nævus ... ..	4	3
Examination ... ..	5	1
Osteotomy ... ..	5	
Intussusception ... ..	4	2
Nephrectomy ... ..	1	
Excision of Hip ... ..	2	1
Hydatid of Lung ... ..	2	
Removal of Appendix ... ..	2	
Hydrocele ... ..	3	1
Opening Knee-joint ... ..	1	
Excision of Glands of Neck ... ..	3	1
Trephining Skull ... ..	2	
Trephining Mastoid ... ..	1	
Excision of Testicle ... ..	1	
Spur of Septum ... ..	2	
Amputation of Thigh ... ..	...	1
Miscellaneous ... ..	15	6
	<hr/>	<hr/>
	197	107
	<hr/>	<hr/>

I found myself dissatisfied with the use of chloroform as an anæsthetic agent to children after having given about 300 cases of it, and set about to try if ether could not be made to take its place. I first of all tried ether alone with a Clover's inhaler for children of five to ten years of age, but found that it had to be

discontinued on account of the fright produced by the suffocating feeling of the inhaler; I next tried the preliminary anæsthetisation with chloroform, followed by ether to continue and maintain the condition for the remainder of the operation; this method was continued with for nearly 200 cases, but, for reasons detailed below, I thought it better to do without the chloroform altogether, and tried ether only from beginning to end of the operation; and this, more especially that practice in the use of it has shewn me the way to give it without interfering with the patient's comfort, I now use always, and consider the most satisfactory and safest anæsthetic that can be given to young children.

The youngest child to whom I have given it was  $1\frac{1}{2}$  days of age, and I have given it to all ages from this up to 14 years. It has been given most frequently to those between 2 and 5 years.

The ether used has been pure Ethylic Ether Sp. Gr.  $\cdot 72\text{--}75$ . Merck's, Gehe's, Elliot's, and Squibb's have been used, and all act equally well.

The preliminary preparation that I recommend to parents is a purgative (castor oil or Gregory's powder) the night before; bread and milk is allowed 6 hours before, and a cup of beef tea three hours before the operation. In the case of infants on the breast the last feeding is allowed not less than 3 hours beforehand. For operations of any length the children are always laid upon a hot-water bag on the operating table.

The various methods used were, in a few cases, ether by the Clover's mask; this was soon discontinued. I next tried a preliminary anæsthetisation with chloroform followed by ether from the Clover's inhaler, but found with it that masseteric spasm was frequent, much mucus was secreted, and with these a tendency to asphyxiation, so that it too was soon discarded. Next came the semi-open method preceded by chloroform, a modified Rendle's mask being used.

Later, and this method was used for some 200 cases, the child was given chloroform till the reflexes were nearly lost, or at other times till the movements became inordinate, and then ether was given on the same open mask for the remainder of the anæsthetic.

The plan I now use is to give ether throughout on an open mask, using a Skinner's mask, which is simply a wire frame over which is spread a single layer of lint, on to the top of which is poured the ether in the quantities required.

Ether is given in most cases to children in the United States, especially in the Northern States; the method there in use is a towel wrapped in a piece of paper and twisted into a cone with a sponge or piece of wool inserted into its apex, and on this the ether is poured in drachm doses at a time.

Turnbull (1) prefers the use of an Allis' inhaler, which is a cuboidal-shaped inhaler, perforated at the top, and with many parallel strips of flannel running across the lumen of it. Woodhouse Braine (2) uses small cones of lint and drops the ether on

it. These are all examples of the semi-open method. Rowell (3) gives the A.C.E. mixture till crying has ceased, and then continues with ether from a Clover's inhaler. Kopetsky (4) recommends the nitrous-oxide-ether sequence for children as well as adults. Hewitt (5) says "It is impossible to produce anæsthesia with ether by the open method except in infants and extremely exhausted subjects."

I have been able to anæsthetise children of any age up to 14 years by the open method, and have found that up to 8 years there is no difficulty, children over this age require a larger dose, and take more time to become anæsthetised, but the most difficult of these, even, can be got under in less than ten minutes.

The reasons for abandoning the closed or semi-open methods of administering it in favour of the open were, that in the two former it was more difficult to give in the early stages without causing the patient to struggle and become terrified, owing to the feeling of suffocation that is caused, and further that much more mucus is excreted with them, and also duskiness of colour is more pronounced.

Another reason was that in them the mask had to be completely removed while it was being recharged, with the result that the patient could not be kept at one constant point of anæsthesia, and this would favour the occurrence of vomiting during the operation.

In the semi-open method there is no way of graduating the supply.

In the closed and semi-open methods the same air is re-breathed again and again, and the asphyxial element is made use of to produce and maintain anæsthesia.

Further, the Skinner's mask is not cumbersome, is easily managed, the frame can be easily sterilised, and fresh sterile lint can be used for each case.

**AMOUNT USED.**—In children up to 5 years an average struck of the amount given to produce anæsthesia was 1 oz., from this age up to 12 was  $1\frac{1}{2}$  oz.  $2\frac{1}{2}$  oz. was the largest amount used, and this was for a child of nine.

Once anæsthetised it need only be given in small quantities  $\frac{3}{4}$  of an oz. every 15 minutes, the quantity varying, of course, according to the age, size, and general condition of the patient; the thin, anæmic, wasted children needing but little as compared to the amount used on a robust, healthy child.

The time taken to render the child anæsthetic varies pretty well according to age, those under 4 years averaging 4 minutes, and some of these have only taken  $2\frac{1}{2}$  minutes, from 4—8 take 5 minutes, and from this age up to 12 the average works out at between 5 and 6 minutes; the longest time taken was 9 minutes, and this was in a child of 9 years.

Various factors come in as regards the question of time: a struggling crying child with deep breaths takes less time; if the ether is pushed too rapidly at first, holding of the breath, and

later salivation, and coughing will result in a prolongation of the time taken.

Mention is made by Hoffman (6), Howard Kelly (7) and Shank (8) of the fact that in the early stages of ether anæsthesia, viz., during the second stage, when, if the patient is talking, he becomes incoherent, or suddenly ceases, and when inco-ordinate movements of the limbs occur, there is a moment when small operations, such as tonsillotomy, dilating the sphincter ani, or opening abscesses, may be performed without reflex response by the patient or any consciousness of it.

I have tried this recently in children in 10 cases, 4 of tonsils and adenoids, 5 of adenoids, and 1 of abscess, and find that it can be done with much success, the child not struggling, although movements may occur, but they are of the aimless character usually apparent at that time of anæsthesia, the patient is not conscious, and remembers nothing of it afterwards. The recovery from the anæsthetic is prompt, nearly as much so as after gas, and in each case the child was ready to be taken home within fifteen minutes of the completion of the operation.

Vomiting did not occur in any of them.

Judging from these few cases there seems to be a large field for the use of this plan, provided the operator is quick and the operation small.

**SEQUENCE OF EVENTS.—1ST STAGE—**The child is seen on the operating table in one of two conditions, either placid and quiet, or as more generally happens is frightened and crying and objects to the presence of the mask in front of its face.

The mask is held about an inch away from the child's face, and one or two drops of the ether are poured on, followed in another five seconds by two or three more, and the amount increased at each dropping, which must be at short intervals; in this way the patient becomes gradually accustomed to the ether vapour, and, as far as I have seen, shows no distaste to it if it is given slowly thus.

If, at the onset, the child is crying, it is often found that after a few drops have been given it will suddenly cease and may continue quiet for the remainder of the time, but at times after the ether has been given for about a minute, and more especially if the drug has been crowded on too rapidly, there may be an outburst of crying and struggling, or the patient will hold its breath. The more slowly and gradually the ether is given in these early stages the less frequently will there be struggling while consciousness is still present.

The child may talk during this stage, and be quite coherent, then gets quickly incoherent, or, if crying, suddenly ceases, or if quiet, with no line of demarcation to show it, passes into the second stage.

**SECOND STAGE.—**In this stage there is loss of consciousness, so that small operations may be performed at this moment;

there are inco-ordinate movements of the limbs, speech is incoherent, breathing is deeper and more regular, and the patient may laugh or cry. Mucus is now secreted, but not in large quantities.

At this time the ether is given in greater quantities, 20-30 drops every 20-30 seconds; if too much is given the respiration becomes catchy, or the breath may be held altogether, the mucus becomes profuse, and cough may occur.

The pulse, at this time, has generally decreased in rate, owing to the loss of consciousness doing away with the increased rate that fear had occasioned. The respirations are more regular and are increased in number and depth, the face becomes flushed and the body too, causing the ether rash perhaps to show out; the conjunctivæ are injected, the lachrymal glands secrete freely, and perhaps sweating may occur.

The colour is good, unless the drug has been given too freely, when, from mucus and holding the breath, it may become dusky.

The conjunctival and corneal reflexes are active, the pupils are generally semi-dilated about 3 mm. in diameter, and do not react to light, or they may be of ordinary size and react to the light reflex.

As the end of this stage is being reached, it is often of benefit to hasten the onset of anæsthesia, and as now the drug may be pushed without the risk of causing coughing or excessive mucus secretion, I generally (except in the case of the younger children) hold the hand lightly over the outside of the lint, the object being to concentrate the vapour and allow of it being inhaled in greater quantity.

Struggling and excitement have now ceased, and the patient passes into the 3rd stage.

Struggling and increased excitement during the 2nd stage are not more marked with the open method than with the closed, and much less than with the semi-open, although it is generally stated that the admixture of air in the early stages gives rise to increased excitability.

**THIRD STAGE.**—This is the stage of surgical anæsthesia, and may be recognised by flaccidity of the limbs, deep regular breathing, the rate being increased; the pulse is now accelerated, full, and of slightly lower tension than before the anæsthetic. The conjunctival reflex is completely in abeyance, or at the most very slightly marked, the corneal reflex is diminished, but still allowed to remain active. The pupils are small, of the normal size, and as anæsthesia is continued gradually become smaller, about 1mm. in diameter, and they react well to light. (This is the degree of anæsthesia to which I keep children for all purposes of operation). There may still be some mucus, but less than during the second stage, the colour is good, the face slightly flushed, and occasionally, should the day be hot or the patient anæmic, as the result of septic troubles, there may be a profuse perspiration.

The amount of ether given is now diminished, and the hand removed from the mask; the quantity now needed to maintain anaesthesia is from 15-30 drops each minute, and this quantity may be gradually slightly lessened the longer the progress of the operation. Hewitt (9) says that by means of Leonards Hill's Sphygmometer the arterial tension is found to remain constant or falls 5-10mm. of mercury. Turnbull (10) says there is a pronounced rise in blood pressure, followed much later by a fall; that the primary influence of the drug is to stimulate both the heart and vase-motor centres.

My own experience as gauged by the rough test of the pressure of the finger in estimating the pulse tension, is that there is always an appreciable fall in blood pressure during anaesthesia, although during the stage of excitement there may be an appreciable rise.

#### ILLUSTRATIVE CASES.

- E.B., 4 years. Tarsectomy. Heart and chest normal.
- 5.35 p.m. Ether started, pulse 116, resp. 20; child quiet and not excited.
- 5.40 ,, Been quite quiet, no struggling; slight mucus, color good, pup. small, imm. react. to light, corn. reflex active; P. 140, R. 24.  
Oper. begun, 40 c.c. used.
- 5.50 ,, P. 144, R. 24; some rigidity of arms has persisted.  
A little mucus.
- 5.55 ,, P. 144, R. 26; same as before.
- 6.2 ,, P. 144, R. 26; ether withdrawn, color good, less mucus, arms still rigid, pup. small and react., corn. reflex active; 140 c.c. in all used.
- 6.5 ,, Oper. over; moving head and limbs.  
Vomited once afterwards.
- G.L., 6 years Tonsils and adenoids.  
Soft mitral systolic murmur; P. 108, R. 28.
- 3.28 p.m. Oper. begun.
- 3.29 ,, P. 108, R. 30.
- 3.30 ,, P. 108, R. 36; pup. medium react., corn. reflex active.
- 3.33 ,, Oper. started; corn reflex sluggish, pup. smaller react; ether administered a little too quickly, with the result that there was a good deal of mucus secreted, but only enough to cause some cough, and not enough to cause any asphyxiation.



- 3.34 p.m. Oper. over.  
Amount used,  $1\frac{1}{2}$  oz. No crying or struggling at all during the administration. Vomited twice afterwards.
- F.L.,  $2\frac{1}{2}$  years. Circumcision. Heart and chest clear.  
Before operation, P. 120, R. 24 ; sobbing ; well-nourished, florid.
- 4.7 p.m. Ether started.
- 4.9 ,, R. 28, P. 132 ; quietly crying occasionally ; pupils medium react.
- 4.10 ,, R. 32, P. 132 ; deep breathing ; some mucus.
- 4.11 ,, Conj. reflex slightly present, pupils small, react. ; ready for op.
- 4-12 ,, P. 144, R. 48 ; pupils small and react. ; some mucus and salivation, slight crowing on cutting prepuce, colour good.
- 4.15 ,, R. 42, P. 144 ; colour good, corn. reflex slightly active, conj. gone, pupils small, react. ; sweating and mucus diminished, 20 drops every 40 sec.
- 4.18 ,, R. 42, P. 140.
- 4.20 ,, Ether withdrawn, mucus bubbling, colour good, corn. reflex active ; R. 38, P. 140.
- 4.22 ,, Operation finished.
- 4.24 ,, Moaning, crying a moment later.  
Was under more deeply than usual ;  $1\frac{1}{2}$  oz. used ; hot day ; no vomiting one hour afterwards.
- H.I.,  $1\frac{3}{4}$  years. Abdominal tumour.  
Heart and chest clear.  
Operation-exam.  
Before oper., P. 148, R. 44.
- 5.23 p.m. Ether started.
- 5.25 ,, P. 148., R. 48 ; reflexes active, pupils moderately dilated, do not react to light.
- 5.26 ,, Corn. reflex becoming sluggish.
- 5.27 ,, Some slight movement of legs ; pup. moderate, no react. to light ; corn. refl. present, dull ; ether used 65 c.c.  
Examination begun.
- 5.29 ,, P. 132, R. 44 ; exam. over ; ether stopped ; 70 c.c. used.
- 5.31 ,, Eyes open, pup. contracted, react. movement of limbs.

- 5.34 p.m. Answering questions; no vomiting.  
Temp. of room 90 F.  
Hands over mask after first two minutes.  
No vomiting afterwards.
- V.P., 6½ years. Oper.: opening abscess of leg. Heart and chest clear.  
Before oper. P. 116, R. 32.
- 4.44 p.m. Ether begun.
- 4.47 ,, P. 120, R. 28.
- 4.50 ,, P. 128, R. 30; eyes open and staring; moving limbs; pup. moder., react., corn. refl. very active.
- 4.54 ,, Oper. started, but not quite ready; slight reflexes of limbs; corn. refl. active, pup. small, react.
- 4.56 ,, Oper. over. Color good; corn. refl. was never quite lost; temp. of room 90 F. Hands were kept over mask the whole time after the first two minutes. The patient was never completely under, but there was never any shock. No reflex movement after the skin incision.  
Vomited once afterwards.
- N.N., 10½ years. Tonsils and adenoids. Heart and chest clear.  
P. 96, R. 24.
- 3.38½ p.m. Ether begun.
- 3.41 ,, P. 138, R. 28.
- 3.44 ,, P. 120, R. 26.
- 3.46 ,, P. 128, R. 28; pup. contracted, light reflex active, corn. reflex sluggish; some mucus and coughing; colour good. Ready for operation.
- 3.47 ,, Oper. over; slightly dusky from blood collecting in pharynx.  
Amount used 2½ oz. Vomited once only.
- M.H., 4 years. Adenoids.
- A.C., 9 years. Abscess of neck.

These two both had ether given them for just short of two minutes till speech was incoherent, when the operation was begun.

Neither felt anything of the operation, as was elicited by questioning afterwards, though during the course of the manipulations movements of the limbs occurred, but, to all appearances, not as a reflex response to the steps of the operation.

There was no shock, and in two or three minutes they were sitting up and talking rationally.

The course I have adopted is to keep the child at the lightest degree of anæsthesia consistent with the safety of the patient as regards reflex shock, and with the comfort of the operator; by the latter I mean that no muscular action should interfere with his actions, the muscular movements being of two sorts, those of the limbs when the patient has not reached the third stage, or tightness of the abdominal muscles during intra-peritoneal operations, which may necessitate a deep degree of anæsthesia to overcome it.

The degree then that I have found most suitable is the stage where the breathing is deep and regular, the pupils small, and reacting to light actively, and the corneal reflex acting sharply.

At this degree there is no vomiting while under, the limbs are flaccid, and even in operations where reflex action is most to be expected, viz., in those involving handling the intestines, or cutting the prepuce, I have found no change in the pulse, respiration or pupils, thus showing that the degree of anæsthesia was sufficient.

In a leading article in the *Therapeutic Gazette* (11) it is stated that patients are frequently over-saturated with the ether leading to renal complications.

Probyn-Williams (12) says: "Ether is often abused by soaking the patient with the drug; when full anæsthesia is established very little ether is needed to keep up the condition. When too long continued the patient becomes water-logged with secretion, leading to bronchitis and pulmonary troubles."

I find that if light anæsthesia only, as above described, is used, that the after effects, as vomiting and nausea, caused by the persistence of the ether on the breath for perhaps days, when the subject is kept heavily under, the post-operation shock is much lessened, and the recovery of consciousness is much accelerated. I have seen the patient answering questions rationally before removal from the operating room after an operation of an hour's duration. Again, as Probyn-Williams holds, it does away with the water-logging occurring during the prolonged recovery, and so may decrease the pulmonary complications that at times do occur.

Since it is to these, viz., nausea, vomiting, post-operative shock, renal and pulmonary complications, that the chief objections to ether are raised; it is a gain to be able to diminish if not altogether prevent them.

## COMPLICATIONS.

Vomiting may occur during the course of the operation, but is then due to insufficient anæsthesia, and what I believe is often the reason, is that, instead of keeping the vapour tension comparatively even, the patient is allowed to come partially out

by reason of pouring on a large quantity and allowing it to evaporate before the next dose is poured on.

Another factor in its production during very light anæsthesia is that, instead of keeping the head on one side and so allowing the mucus to drain out of the angle of the mouth, the head is held so that the mucus passes over the pharyngeal wall and causes reflex vomiting, and this I have noticed in operations about the neck or face where the head is often moved, vomiting frequently occurs immediately after a change of its position, and is due, I believe, to trickling of mucus and saliva over the pharyngeal mucosa.

To avoid vomiting the child should be kept deeply enough under to abolish the pharyngeal reflex; this is done during the stage above described, and in addition the head should be kept well over on its side and the excessive secretion allowed to drain away on to a towel on the pillow.

Some observers recommend a wick of some absorbent material placed just inside the cheek to act as a drain, but as the secretion is generally thick it does not do so well as simply having the face on its side.

Mucus secretion and salivation are always present to a greater extent than in chloroform, and if excessive and not allowed to drain away in the manner just mentioned are apt to cause some asphyxiation.

There was duskiness of colour in 5 out of the 304 cases, 3 of these occurred when the Clover's inhaler was used, and the other 2 when the open method. In all except these 5 the colour was good throughout and the mucus caused no embarrassment to the respiration.

Respiratory embarrassment may occur from dropping back of the tongue, combined with an excess of mucus, but pushing the angle of the jaw forwards and allowing the mucus to drain out of the angle of the mouth will always be enough to relieve the condition. In these cases I have never had to resort to tongue traction, nor do I agree with the practice of swabbing out the pharynx and mouth to get it clear of the secretion, as the mechanical irritation always increases the flow of secretion, and makes the condition worse than before.

As regards reflex shock which is said to occur from surgical procedures during light anæsthesia, I may say that I have never seen it happen during ether anæsthesia, viz., no indication of it as shown by alteration of the pulse or condition of the pupils.

Reflex interference with the respiratory functions does happen, as manifested by reflex spasm of the glottis, lasting for 5 to 10 seconds, but never ending in cessation of respiration as is the case with chloroform. This I have had happen in three cases where circumcision was being done, and at the moment of cutting the foreskin, the child being but lightly under. Apart from these cases I have seen none where the respiration was reflexly interfered with.

OVERDOSE. — Rowell (13) has seen cases of overdose where the Clover's inhaler was used. In one case where the C-E sequence was used, I found that I had given an overdose of chloroform, the stoppage of respiration occurring a few seconds after the chloroform had been stopped, and while the first dose of ether was still on the mask ; it was due, I feel certain, to too much chloroform having been left on the mask, and the deeper respiration entailed by the ether stimulation causing an overdose to be inhaled. (The child recovered after 2 or 3 minutes of artificial respiration).

In 2 other cases, where the C-E sequence was used, but after the chloroform had been discontinued and ether alone used for fully 15 minutes, there were signs of overdose, as instanced by loss of corneal reflex, dilated pupils, not reacting to light, and the respirations becoming shallow, although they did not reach the stage of stoppage of respiration. They soon recovered on withdrawing the anæsthetic.

Hewitt (14) says that cardiac failure is practically impossible under ether in moderately healthy subjects, but that in those with feeble, dilated, or diseased hearts cardiac syncope may occur, suddenly due, he thinks, to a slight asphyxial condition super-added while struggling.

In the series of cases I have seen it, viz., syncope, twice, once in a girl of 7 years much wasted, and anæmic, and deeply jaundiced, with only a few days to live. Ether was given this child with the result of sudden cessation of the pulse at the wrist, followed immediately by shallow respirations quickly stopping altogether ; the sequence of events was that just as the patient was entering upon the 2nd stage she became suddenly pallid, the pulse at the wrist was imperceptible and within one or two seconds the breathing stopped. She recovered after one or two minutes of artificial respiration, and chloroform was then tried with exactly the same result, and she did not long survive her return to the ward. The second case was in a boy of 12 years who had had his thigh so injured in a railway accident as to need amputation ; there had been great loss of blood, and at the beginning of the anæsthetic the pulse was 160, running, and of low tension, the face was quite yellow and bloodless. In this case, too, just after the 2nd stage was entered into, the pulse became suddenly imperceptible at the wrist, the respirations shallow, and the pupils dilated ; the anæsthetic was discontinued and an intravenous injection of saline solution, 750 c.c., was given, with the result that the pulse picked up and the operation was completed without further accident.

That these are not cases of overdose is, I think, shown by the failure of the pulse before that of the respiration, and the fact that the patients, although but little anæsthetic was given, were only at the commencement of the 2nd stage when it happened.

Foreign bodies in the larynx, such as vomited material, tonsils, blood, &c., may occur with ether as with other anæsthetics, and the treatment is the same for them.

**RECOVERY.**—In the shorter operations such as tonsillectomy, or removal of adenoids, in which the patients may be got just fully under, that is, with corneal reflexes sluggish, and then the ether discontinued, the duration of the anæsthesia is two to three minutes when struggling occurs, and in another 3—5 minutes the child will be able to answer questions rationally unless vomiting should have occurred, at the conclusion of which there is a period when the child lies half-asleep and is disinclined to take any notice of things around, although they can generally be roused to do so. This stage may last any time from 10—20 minutes, after which the child is sufficiently recovered to walk, although the stupid, dazed condition will remain for some time longer.

After longer anæsthetics the child will be able to be roused within 10 minutes of the end of the operation, but will be very dull and stupid, and clear consciousness will not return for some hours afterwards, the time depending in great measure on the temperament of the child rather than on the quantity of the anæsthetic.

During recovery the only trouble to be guarded against is that of vomiting, with the risk of any food that has not left the stomach getting down into the larynx ; this is guarded against by keeping the head well on its side and allowing the food to drain out of the angle of the mouth.

**AFTER EFFECTS.**—Vomiting is supposed to be more constant after ether than after chloroform, and it probably is so as a general rule, but the lighter the degree to which anæsthesia is carried and kept, and consequently the less ether there is used, the less is the subsequent nausea and vomiting.

I have found that in giving ether in the manner above described, that the vomiting after it is not more than after chloroform, and that in more than half the cases, even where the operation was prolonged, there was no vomiting at all afterwards. (The majority of the shorter ones were about the throat, consequently blood was swallowed, and vomiting ensued.)

The main factor concerned in ether vomiting, unlike that of chloroform which is due to its action on the central nervous system, is the presence of irritating bodies in the stomach.

Hess (15) thinks it is due in part to swallowed mucus impregnated with ether, and in part to ether excreted by the gastric mucous membrane. He recommends copious draughts of hot water to wash out the stomach and also to flush out the excretory organs so as to get rid of the ether out of the system.

Luke (16) says: "Severe sickness is really less common after ether than after chloroform, and is due to swallowing mucus impregnated with ether, which irritates the stomach."

One finds the vomited material is of three sorts—(1) mucus and saliva smelling strongly of ether ; (2) bile ; (3) blood which has been swallowed, and it is the presence of these, which may be termed foreign bodies, that cause the vomiting.

The vomiting during anæsthesia is either food, mucus, or bile, generally mucus, but towards the end of a long operation there is occasionally bile vomited. After the anæsthetic there is either mucus or bile, generally the former.

The causes then seem to be either mucus and saliva saturated with ether and irritating the stomach, bile which has been regurgitated from the duodenum, or blood which has been swallowed during or after an operation on the throat or post-nasal space.

The remedy for the first is to keep the head on the side and prevent any secretion being swallowed, and that this does prevent it is seen by the fact that more than half the cases are free from vomiting.

The bilious vomiting cannot be prevented except by preventing any preliminary vomiting of mucus, which will tend to set up reverse peristalsis of the stomach, and so to favour the entrance of bile into it.

Children who have swallowed blood almost invariably return it again, although I have seen a few rare cases after removal of tonsils and adenoids where it has not happened. The remedy is to keep the child's head so inclined that the blood will flow out of the mouth, or nose, rather than into the pharynx, but it is almost impossible to prevent some being swallowed.

Prof. London, of Berlin, quoted by Turnbull (17), uses oxygen after ether, and finds a rapid recovery of consciousness, with almost entire absence of nausea, headache, or vomiting, and these symptoms do not recur.

Reflex shock occurring during ether has not been seen in my list of cases, but one has often seen the pulse and general condition go down hill during the course of a prolonged operation, or one where much hæmorrhage has occurred; at the same time, the pulse and general condition, other things being equal, keep better under ether than with chloroform or any mixture of the two. There is, however, a drawback to this sustained circulatory excitement, and that is, that after the ether is withdrawn there is a corresponding fall of blood-pressure, and a condition of shock, and this occurs after the patient is returned to bed. Should a large amount of the drug have been given and especially if the patient has been kept deeply under, the after shock is more profound and of longer duration than if the patient had been lightly anæsthetised or some other anæsthetic used such as chloroform.

**RESPIRATORY SYSTEM.**—A great difference of opinion exists amongst the various observers as to the occurrence of pulmonary after-effects.

Buxton (18) says ether produces excessive bronchial secretion in children (he gives it to them with a Clover's inhaler). That many cases of ether pneumonia have been reported, but that few are really due to ether itself, but rather to the patient's removal through draught, cold passages.

Silk (19) says "There is no evidence that lobar pneumonia occurs after ether with greater frequency than might be expected from the usual rate of incidence of the disease."

Kopetsky (20) states that in 20,000 cases at the Gouverneur Trachoma Hospital, where the nitrous oxide-ether sequence was given, there was no case of ether pneumonia.

Luke (21)—“Bronchitis is a bugbear almost unknown when ether is given by modern methods.”

Probyn-Williams (22) considers that if ether is too long-continued, the patient becomes water-logged with secretion, leading to bronchitis and pulmonary troubles.

Stoss (23) gives a series of 200 cases in children, and advocates the use of ether as quicker, safer, and free from sudden stoppage of respiration. No pneumonia occurred in this series.

Hewitt (24) has seen several cases of respiratory trouble occur after ether.

Crouch and Corner (25) record 10 cases in 2,400 ether administrations, 7 of bronchitis, and 3 of broncho-pneumonia, one of these dying.

Poucet (26) thinks the after effects of ether are due to infection before or after the operation, and that pulmonary incidents are as frequent in those not narcotised as in those who are.

Amongst my list of cases there was one where broncho-pneumonia occurred, after an operation for intussusception, on the second day; but there was an element of doubt as to its causation, for it was shortly afterwards found to have a fibrinous rhinitis, and the question arose whether it was not due to the inhalation of septic particles from the nose during the anaesthetic rather than to the irritation of the ether vapour itself. The C.E. sequence was given in this.

Out of 304 cases, then, there only occurred one case subsequent to the ether, and there is no proof to show that it was due to it.

That pneumonia and bronchitic troubles do occur after ether is proved by the observations of Hewitt, Crouch and Corner, and the statistics of the Anaesthetic Committee of the British Medical Association.

The factors at work causing these respiratory troubles are probably the water-logging of the tissues by saturating the child with the drug; the inability to clear the lungs after abdominal operations, where cough is inhibited by pain on using the abdominal muscles; a third factor may be that of want of cleanliness, the closed inhalers are not built on principles that admit of their sterilisation, and it is quite as easy to conceive the respiratory affections after ether to be due to the inhalation of septic particles from an unclean mask as from irritation of the ether vapour.

**RENAL SYSTEM.**—As in the respiratory system, the accounts of different observers are absolutely contradictory, but the work of Buxton and Levy seems the most conclusive from a clinical standpoint.



Kemp (27), from experiments on dogs, showed that diminished secretion of urine and albuminuria occurred almost immediately after the commencement of the inhalation of ether, whereas in chloroform the secretion was copious, and albumen only appeared at a late stage and in small quantities. He says that sulphuric ether has its own "specific" effect on the kidney apart from general conditions.

Buxton and Levy (28) found the "specific" effect of Kemp to be only evidenced (in experiments on dogs) after prolonged administration or repeated large doses of ether.

They found in a series of cases, 37, where ether was administered, that the quantity of urine was diminished for the first 24 hours, but this was due, they thought, to a diminished quantity of fluids in the body resulting from the preparation of the patient, that albumen did not occur unless in cases where it was pre-existing, and that it disappeared more often after the ether than it was increased in quantity.

They say that it is only when the patient is soaked with ether that the specific after effects appear.

Hewitt (29) has never seen any renal complications, and says, considering the number of patients with albuminuria who are operated on in the large hospitals without noticeable after-effects, that it seems that there is not much risk from its use.

Stoss (30) had no nephritis in his 200 cases in children.

Turnbull (31) thinks the objection to ether as regards kidney troubles as compared to chloroform is that it irritates the kidneys more on account of the greater quantity taken, although bulk for bulk it is less irritating.

In a leading article in the *Therapeutic Gazette* (32) it is said that apart from actual renal disease there are three factors in the production of anuria after ether, and are (1) degree of saturation; (2) exposure of the patient's body to the cold; (3) reflex, from operations on the genite urinary tract.

In my series of cases I have never noticed any renal complications, though my chances of observing the urines afterwards has necessarily been small and the question of albuminuria occurring as a sequel to the ether has not been looked for, still nothing to draw attention to the kidneys has been apparent.

In all cases in which I have given ether, over 1,000, I have seen two in adults where renal troubles have occurred secondary to the ether, both in women with healthy kidneys, in one anuria occurred and lasted 48 hours, and the kidney excretion was slowly re-established; in the other anuria for 24 hours, and it was quickly regained; this patient has since had ether administered without any disturbance of her kidney functions. In neither of these was there any albumen in the urine passed after the anuria was over, the urine being merely very concentrated and heavily loaded with urates.

REASONS OF EMPLOYMENT OF ETHER IN PREFERENCE TO CHLOROFORM.—Not to enter into the

controversy still existing as to chloroform v. ether, I will try and briefly give some of the reasons that prompted me to give up chloroform in favour of ether anæsthesia.

(1) The undoubted liability there is for deaths to occur on the table under chloroform.

Chaldecott (33) collected a list of 50 deaths under chloroform during operations for tonsils and adenoids or adenoids only; he recommends ether on an open mask for children under 1 year and the Clover's inhaler over that age.

Halstead (34) says that adenoids is the expression of a general diathesis—the lymphatic—shown, according to Kolisko, by a persistent thymus, enlarged lymph glands, adenoids, tonsils, enlarged follicles of the pharynx, stomach and intestine, tendency to acute dilatation of the heart and hyperplastic condition of the arterial system. Says that chloroform is especially dangerous, and recommends the use of ether, as many deaths have occurred during the use of the former.

Max Mader (35) thinks the lymphatic diathesis is dangerous, quotes a death in a child of 15 years under chloroform.

Potauf first investigated and connected many sudden chloroform deaths with this diathesis.

Laquer (36), Mignon (37), and Broca (38) all give instances of death in similar cases under chloroform.

Pott, Nordmann, and Recklinghausen have reported sudden deaths during cold baths in children with this diathesis.

Hensler saw a sudden death after ether in a case with enlarged thymus.

All these cases go to show the danger of chloroform in operations on tonsils and adenoids, where, most of all in children, chloroform is recommended, and stand for themselves as an argument against its use.

Hewitt (39) says: "It is a mistake, however, to suppose that children are not so susceptible as adults to the toxic effects of chloroform, and that with them fatalities are practically unknown." He quotes Comte, who found that in 232 deaths from chloroform, 21 occurred in children.

Weir (40) states that up to 1890 no deaths had been recorded under ether when given to children under 12 years of age.

Kopetsky (41): "The use of chloroform is more dangerous than that of ether, as up to 1900 Weir reported 21 deaths in children under chloroform, and none under ether." "Children are frightened, scream, struggle, and Hare says 'exhaust their vase-motor system and dilate their heart, then take a deep breath, and, if much chloroform is on the mask, the result is a stoppage of respiration.'"

McCardie & Marshall (42) state that chloroform is by no means devoid of risk to children, and give as their reasons that "reflex acts are more marked and also more quickly

abolished by anæsthetics than in adults, so that there is more danger from a reflex spasm of the glottis, and also from the loss, by their early abolition, of certain reflex signs that act as guides, such as the corneal reflex which is lost before anæsthesia is complete."

Poucet reported a death, in 1902, from ether in a child with valvular disease.

It is impossible to get reliable comparative statistics in children as to the relative frequency of deaths during ether and chloroform, but there are many deaths reported from chloroform, but I have only been able to find two up to the present under ether.

(2) Reflex shock during light anæsthesia is greater in chloroform than in ether; by reflex shock, I mean the reflex laryngeal spasm leading perhaps to cessation of breathing and weakness of the circulation which is induced during light anæsthesia by operations on parts where the reflexes are particularly sensitive, as the prepuce, or the intestines.

In ether, contrary to what happens in chloroform, the child may be but very lightly under and yet show no reaction at all to these stimuli.

The reflexes are much more reliable in ether, when given by the open method, than in chloroform in children; in the latter there is frequently a period of sleep just before the third stage is entered on, that closely simulates anæsthesia, and is often only found out by the child struggling as the skin incision is made; in chloroform the corneal reflex is frequently of no value as a guide, and the pupils are often useless for some time, being dilated and not reacting to light, although as the time of anæsthesia lengthens they generally come down and react well to light

In ether narcosis in children, on the other hand, there is no period of sleep, the corneal reflex is always to be relied on to indicate the depth of anæsthesia, and, apart from a few exceptional cases, the pupils are a good guide; in these cases they are dilated and do not react to light, although the child is not deeply under, and they may persist in this condition for 10 to 15 minutes.

(4) My experience goes to confirm that of Luke, who finds that vomiting is not more severe after ether than after chloroform.

(5) That respiratory troubles do occur after ether cannot be gainsaid, but I think that care in the administration and a light degree of anæsthesia will go far towards obviating their occurrence, that they are due, not merely to the irritation of the ether vapour, but in a large measure to the inhalation of harmful material in the buccal mucus, or to septic particles from an unsterilised inhaler; and I think that the risks of death from post-operation respiratory troubles after ether are more than counterbalanced by the risk of death on the operating table with

chloroform, and the odium that operation incurs from the publicity of a coroner's inquest.

(6) Buxton and Levy have, I think, conclusively shown that renal troubles are no more to be feared after ether than after chloroform, provided light anæsthesia only is maintained.

(7) The working margin between a surgical anæsthesia and overdose is very much wider in ether than it is in chloroform, with the former it is difficult though possible to poison a child by an overdose, whereas with the latter it needs only a few drops to bring the child through the period of safety into one of the gravest danger.

REASONS FOR EMPLOYING ETHER ONLY.—(1) My reasons for abandoning the C—E, or A.C. E—E sequence was that to be consistent one should employ either one or other drug only, that the most dangerous period with chloroform was in the early stages, viz., “in getting the patient under,” and consequently to use the C—E sequence was to discard the chloroform only when its period of greatest danger was over, and the drawbacks to its use no longer so marked.

(2) Another reason was that in several cases, in which I took records of it, where the C—E sequence was used, I found that the slow depressed pulse of the chloroform circulation, instead of showing a rapid rise in rate when the chloroform was withdrawn and the ether substituted, took some time to reach its normal rate, and the average time before the rapid pulse of the exalted ether circulation was reached, averaged from 12 to 15 minutes. This did not occur to the same extent in the A.C.E.—E sequence, and if I had to employ any form of chloroform again before ether I should use the A.C.E. mixture.

(3) I found that with care (although there was difficulty until I found that the ether had to be given very slowly at the commencement) the children do not object to the ether on the open mask in the early stages in spite of its unpleasant taste and smell, and that now I do not have a greater proportion of them struggle against the ether than I used to against the chloroform; the cases where struggling and crying occur are due rather to the general condition of fear than to the unpleasantness of the drug.

The disadvantages of ether are its disagreeable taste and smell, especially after the operation, when it clings to the patient's breath and clothing; the possibility of pulmonary complications, and this I have no doubt when more light is shed on the causation of the trouble, there will be found means to obviate; the most important is that after a prolonged operation—especially if much of the drug has been given—the reactionary shock is deeper and more profound than after other agents, although this can be remedied by giving the patient circulatory stimulants before the operation is concluded and the stimulating effect of the ether has worn off.

The operations, in which its use is contra-indicated, are those where a mask cannot be conveniently applied to the face, as a

continuous supply is necessary to maintain anæsthesia; these operations include any on the face for whatever purpose, and those for hare-lip, cleft palate or operations on the tongue.

I do not think albuminuria is a contra indication to it, so long as light anæsthesia only is maintained; I have given it for opening a hydro-nephrosis and for nephrectomy without ill effects.

In operations on the chest and in those whose lungs are affected by disease, ether can, I believe, be given with safety. In this series ether was given to 11 cases of empyema, and to two of hydatid of the lung, and even to a case where laparotomy had to be done in a child in the middle of an attack of lobar pneumonia, and in none of these did additional respiratory troubles manifest themselves and the case of pneumonia had its crisis at the expected date, and was seemingly not affected injuriously by the ether.

There are two classes of cases where I have given both chloroform and ether, and with equal danger, they are cases where I think no general anæsthetic should be given.

Those with laryngeal obstruction with marked cyanosis, such as occur in diphtheria, or in the case of tumors pressing on the trachea; in these only local anæsthesia should be used. I have seen, in seven cases of this kind, the breathing suddenly stop after only a small quantity of the anæsthetic had been given; five were with difficulty recovered by means of artificial respiration after the tracheotomy was done, and the other two lost altogether. In these chloroform was used, but I feel sure that the fatal result would have been the same had ether been employed.

(2) Where the patient is very debilitated and anæmic as the result of prolonged illness, such as in old septic conditions, or as the result of some acute infection; or, when the patient is almost bloodless from severe hæmorrhage.

Da Costa and Kalteyer (44) investigated the blood changes during ether anæsthesia, and found (1) polycythemia, rarely an oligocythemia, and this is due to a lessening of the watery elements of the plasma, and so a concentration of the blood. It is probably not due to the increased proliferation, which does occur in the hæmopoietic tissues, and is nature's effort to replace the destroyed cells, but the three casual factors are—1st. The preparation by purges, &c.; 2nd. The anæsthetic state; 3rd. The post-operative stage, all rendering the blood more concentrated.

The anhydraemia is usually most marked at the termination of the anæsthetic stage.

The hæmoglobin is always reduced absolutely.

They, together with Hamilton Fish, think that general anæsthetics should not be given if the hæmoglobin value is below 50%. They operated in two cases where the hæmoglobin was below 40%, and in each case death on the table was narrowly averted. Mikulicz says 30% is the lowest level at which operations should be attempted.

In cases where it is low, and operation is imperative, care should be used to avoid preliminary drain on the blood as by purgation.

In this class of cases one finds the following sequence of events; the patient comes as usual through the first into the second stage, and after a very short period of excitement and while the drug (whether chloroform or ether) is only being given in small quantities, the pulse becomes suddenly imperceptible, the breathing shallow, and may stop altogether, the colour is livid, the corneal reflex lost, the pupils dilated; if breathing has stopped they may be recovered by the aid of artificial respiration, but it is only temporary and death ensues some minutes or hours later. Two of these cases which I have referred to in the early parts of this paper occurred in my series of cases.

The work of Da Costa and Kalteyer point to the prognostic value of a preliminary blood examination before attempting to give an anæsthetic in these cases.

In one of these cases I found an intravenous injection of saline solution tided the child over the period of anæsthesia, and think that in cases where operation is demanded it would be of the greatest use in carrying the patient through the operation, especially where there is an anhydræmic condition of the blood.

The following are briefly the conclusions that I have come to as regards ether anæsthesia, by the open method in children:—

(1). That it is a safer general anæsthetic than chloroform, and from a comparison between it and chloroform, which I have given in some 300 cases in children, it occasions less anxiety and fewer accidents occur (fatal or otherwise) during its administration.

(2). That, apart from the initial stages where some practice in its use is necessary, it is the easiest anæsthetic to give.

(3) That the time taken to anæsthetise the child is not longer than with other drugs.

(4) That it should only be given to the degree of light anæsthesia when it will be found that:—

- (a) The reflexes, which as a rule are useless in children, are to be absolutely relied on as guides.
- (b) The after vomiting is less.
- (c) Renal troubles are not to be feared.
- (d) Respiratory troubles are not of frequent occurrence.
- (e) Reflex shock is never seen.
- (f) The child stands the surgical shock better while on operating table, and that the later reactionary shock is not so pronounced as when deep ether anæsthesia is employed.

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