CHLOROFORM ANAESTHESIA; WITH SPECIAL REFERENCE TO ITS USE IN MIDWIFERY PRACTICE.

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PROLOGUE.

In selecting the above as a subject of Thesis, I have particularly at heart, and am sympathetically mindful of the many disadvantages under which country practitioners have to labour over the exhibition of chloroform in midwifery cases.

Bearing in mind the great distances which frequently separate the residence of one rural practitioner from that of his proximate neighbour, the probable impossibility of summoning timely aid to an obstetrical operation is so apparent as to scarcely require to be dwelt upon. In towns, however, the circumstances are entirely different, and if a medical neighbour be on his rounds, or elsewhere, when an urgent call arrives, the messenger may only have to go down the next street to find another practitioner. But the country doctor may have to send a great distance and over a wild country, only to find perhaps that his friend is as many miles away as himself at a case of a similar nature. All this time the patient may be suffering untold agony, and the exigencies of the case are, as often as not, of such a kind that relief ought to have been given, or the child delivered, at the time when the messenger started upon his fruitless errand. The patient may now have been lying in a dangerous state, six or eight hours having perhaps elapsed before the messenger's return from his futile attempt to secure assistance. Accordingly, after all this precious time has been wasted, but two alternatives remain open to the physician in charge of the case, either (a) to deliver with forceps without chloroform (which often the patient will not allow) the woman already debilitated, it may be to the danger-point, by an intense suffering that it would obviously be imprudent to aggravate, or (b) to wait probably a score of hours for the arrival of the medical neighbour alluded to as busily engaged in a similar case elsewhere, with the result that the patient remains, as it were, between life and death for a considerable part of the subsequent convalescence. This sequel of a prolonged and difficult labour I have experienced more than once, but
particularly in a case of the kind which was, by force of unforeseen and uncontrollable circumstances, such as described, and which was kept waiting for a day and a half. Now, if the chloroform had been given at the proper time, what a difference it would have made to all parties concerned, both during the labour and after it!

I am, of course, well aware of the rule—time-honoured in its observance, and enunciated by anaesthetists of an experience that at once constitutes them authorities upon the subject—that chloroform is to be administered by a practitioner other than the one who delivers the patient with the instruments; the object being, obviously, to allow of the operator's undivided attention being devoted to his responsible and, in most cases, by no means easy manipulations. To adhere strictly to this rule, excellent as it may be, is, as I think must be apparent from the foregoing remarks, frequently impossible in country practice, at least in one so scattered as mine. It therefore behoves the rural practitioner to neglect no opportunity to accustom himself to the administration of anaesthetics in general and of chloroform in particular, so as to gain that confidence and dexterity bred of experience, so that, in a complicated labour case he may be able to work entirely on his own initiative and without assistance.

The indications for giving chloroform at the proper time are: (1) The patient is so much better able when she is fairly strong to withstand the evil effects of the drug. (2) The patient makes a better recovery than would otherwise be the case. (3) There is a reduction in the amount of her sufferings which under other circumstances, especially when no progress is being made, would have to be patiently endured by the woman. (4) In certain instances even a short delay may mean the death of the child or, may be, that of the mother as well. The following case will serve to make this point clear: Late one night, I was called to a confinement about ten miles from my residence. On arriving, I found the patient, a stout, plethoric, multipara, had endured severe labour pains for over fifteen hours and was by this time in a very exhausted condition. On making the usual vaginal examination, I became aware of the case being one of twins, and the presentation a hand and forearm of one child protruding into the vagina and firmly interlocked with the head of the other child on the brim of the pelvis. The
pains were of uncommon severity, and the os uteri appeared to be in a state of tonic contraction. Notwithstanding that the patient had a fatty and dilated heart—both usually regarded as important contraindications to the use of the drug—I forthwith decided in the patient's interest, and without any assistance beyond that of an aged neighbour, to give chloroform. This done, I found it possible to push the head of the presenting child back into the uterus, and subsequently, and without using undue force, to return the arm and hand of the twin. I now found no difficulty in successively turning both children and delivering them by the breech. Both mother and children did very well afterwards.

This was obviously a case in which every moment was precious. There was absolutely no time to send for extra medical aid, even were such available; and, owing to the contracted state of the uterus, nothing could be done until the patient was put under the influence of an anaesthetic.

PHARMACOLOGY OF CHLOROFORM.

No one should attempt to utilise so potent an agent as chloroform in labour without being thoroughly familiar with its action, advantages, and disadvantages, and its other pharmaceutical and physiological attributes. I purpose, therefore, giving some account of the drug from these standpoints.

Chloroform was discovered by Soubeiran in 1831, its chemical formula ascertained by Dumas in 1835; and Dr. (subsequently Sir) J. Y. Simpson, of Edinburgh, first used it for pain-killing purposes in 1847. Since then, its action as a poison has engaged almost as much attention as its therapeutic uses. And, although it has again and again conquered in the almost annual contest with new candidates for favour as anaesthetics, this very preeminence is doubtless due to the diligent study which has been given to its dark side, and the precautionary measures that have been suggested. Indeed, it is scarcely possible to find any other substance except chloroform which combines, within so narrow a compass, properties at once so salutary and so deadly as regards its action on the human body—properties, too, which, although exactly contrary, pass,
by almost imperceptible gradations, one into the other.

SYNONYMS AND FORMULA.


SOURCE.

Chloroform is prepared by the distillation of a mixture of alcohol, chlorinated lime, and slaked lime; purifying with washing in water and sulphuric acid; agitating with slaked lime and calcium chloride; and, finally, adding absolute alcohol. The object of using sulphuric acid is to char and remove the hydrocarbons (without affecting the chloroform), the lime to free it from acid, and the calcium chloride to get rid of the moisture.

The following equations indicate the changes occurring during the process of manufacture:

1. \[2 \text{C}_2\text{H}_4\text{O} + \text{O}_2 \rightarrow 2\text{CH}_2\text{O} \text{ (aldehyde)} + 2\text{H}_2\text{O}\]
2. \[\text{C}\text{H}_3\text{O} + 3\text{Cl}_2 \rightarrow \text{C}_2\text{HCl}_3\text{O} \text{ (chloral)} + 3\text{HCL}\]
3. \[2\text{C}\text{HCl}_3\text{O} + \text{Ca}(\text{HO})_2 \rightarrow 2\text{CHCl}_3 + \text{Ca}_2\text{HO}_2 \text{ (calcium formate)}\]

CHARACTERS.

Chloroform is a very mobile, colourless, transparent, volatile liquid. It has, when evaporated, a peculiar, but pleasant, odour, which some persons characterise as "sweet" on account of the impression simultaneously made by the vapour on the nerves of taste in the mouth, the sensations of smell and taste being peculiarly blended. It has a very pungent sweet taste. It should have a specific gravity of 1.495 at 62°F., and be neutral to test paper. According to Regnault (Jahresb., 1863, p. 70), the boiling point of pure chloroform is 140.2°F.; according to Liebig (Ann. Chem. Pharm., clxi, 182) - who, according to Watts (Dictionary of Chemistry), discovered it soon after Soubeiran (1832) - 141.8°F.; according to Pierre, 68°F., with the barometer at 772.52 mm. of mercury. Dumas places its vapour density at 4.189, and Regnault at 4.230. The
density of chloroform vapour is 59.75, expressed in terms of hydrogen, which is 1. Pierre states that it remains liquid and transparent at -16°C., but may be solidified by the cold resulting from its own evaporation. Ten parts are soluble in seven of alcohol; it dissolves in ether, olive-oil, and turpentine; but only to the extent of one part to two hundred of water, in which it sinks in heavy drops. Snow finds that it dissolves in 288 times its volume of water. Strictly speaking, it is not inflammable, but if its vapour be decomposed and passed into a spirit-lamp flame, it burns with a greenish smoky flame, with the evolution of fumes of hydrochloric acid. Snow remarks that there are three drops to a grain of the liquid, and as a minim of it weighs a grain and a half, there are nine drops in two minims. One grain of chloroform produces 0.787 of a cubic inch of vapour at 60°F., while its specific gravity is 4.2. Serum of blood at 100°F., and at the ordinary pressure of the atmosphere, will dissolve about its own volume of vapour of chloroform. Under ordinary circumstances the vapour of chloroform has, of course, no separate existence, but it always mixes with air. It can exist in a pure state only when the temperature is raised to 140°F. or upwards, or when the pressure of the atmosphere is in a great measure removed by the air-pump. The quantity of chloroform that the air will hold in saturation at different temperatures, under the ordinary pressure of the atmosphere, depends on the elastic force of the vapour of these atmospheres. It is governed by a law precisely analogous to that by which the amount of watery vapour which the air will hold in solution is determined. Chloroform will keep well if stored in a cool, dark cupboard in small bottles. Some chloroform made during the Russian War, with 2 per cent. added ethyl alcohol, by MacFarlan, has kept in a good condition since 1857. For satisfactory preservation Dott (The Purity of Chloroform for Anaesthetic Purposes. Pharm. Jour. and Trans., 1882, p.789) considers one-tenth of a per cent. of alcohol sufficient. If, owing to circumstances, as, for example, its storage, by oversight, in an obstetric bag, chloroform has been laid aside for some time, it should not be used without first being carefully tested. The B. P. (1898) chloroform is so alcoholised as to give it a specific gravity of from 1.490 to 1.495; but if alcohol be present in excess of the standard, the
specific gravity will, of course, be lower than this. It is said (René du Bois-Reymond: On a New Method of Purifying Chloroform. Lancet, Dec. 19, 1891) that chemically pure chloroform obtained by Pictet's freezing process does not require this addition of alcohol in order to preserve it.

**IMPURITIES.**

The occurrence of dangerous or fatal symptoms during chloroform anaesthesia has been attributed to the presence of impurities. Thus question is still far from having passed the stage of controversy; for, whilst impurities and decomposition produced have certainly at times been responsible for these phenomena, the latter have frequently been known to appear whilst using a chloroform that has stood the recognised tests for purity. Of these the following are some of the more important: (1) It should have the specific gravity and boiling point already mentioned. Substances having a higher or lower boiling point than chloroform itself may contaminate it. Thus, Mentin, of Warsaw (Pharm. Jour. and Trans., 1888-89, p. 991) found, on taking 49 c.c. of a sample of chloroform purchased from an ordinary commercial source, that 6.5 c.c. came over at 59°-60° C., 30 c.c. from 60°-61°, and 12.5 c.c. above 61° C. (2) It should be transparent and colourless. (3) It should be neutral to test paper. (4) It should have an agreeable, non-irritating odour. (5) On evaporation from a watch-glass no residue should remain, either of water or substances with a pungent odour. For example, Mentin's sample, referred to above, gave a residue on spontaneous evaporation which weighed .002 grm., and consisted of well-defined acicular crystals surrounded by a yellowish liquid. It had a most disagreeable odour of nitro-benzol and tobacco, and when inhaled produced giddiness and headache. After forty-eight hours the smell was replaced by that of benzoic acid. When the residue was heated over a watch-glass and partly evaporated, the remainder turned brown and evolved a smell like that of burnt elastic. The chloroform from which this residue was obtained had in one-half of the cases in which it was used produced dangerous symptoms. (6) It should give no brownish coloration, or only the faintest, when shaken with concentrated sulphuric acid. (7) A similar phenomenon should not be observed when heated to boiling point with caustic potash. (8) Addition of a solution of nitrate of silver should cause no precipitation. According to Yvon
(Pharm. Jour. and Trans., 1882, p. 711), impure chloroform changes the colour of an alkaline permanganate solution from a violet to a green, but has no colour-reaction when the chloroform is pure. This test is not reliable as the change of colour described by this author occurs with the small quantity of alcohol which is usually added to the chloroform to preserve it. There are several firms who manufacture chloroform for anaesthetic purposes, whose names it is unnecessary to mention here, and in these the fullest confidence may be reposed. But the purest of chloroform may undergo decomposition in air and sunlight, with the formation of carbonyl chloride. The latter impurity Professor W. Ramsay (Lancet, Jan. 23, 1897, p. 240) found in many of the samples of commercial chloroform analysed by the addition of a baryta solution, a white film appearing at the junction of the two liquids. He proposes (Nineteenth Century, April, 1898), therefore, to prevent the contamination of chloroform by carbonyl chloride by keeping a little slaked lime in the chloroform bottle, which at once converts it into chalk and calcium chloride, which are inert and harmless and inert, and removes any hydrochloric acid present. The latter and free chlorine are always present when decomposition has occurred, and can be detected by a reddening reaction with lithmus paper, formation of a precipitate with nitrate of silver, and liberation of iodine from a solution of iodide of potassium. The chloroform, according to Kappeler, may be contaminated with aldehyde, formic acid, and acetic acid. The latter is converted into cacodyloxide by the method of Roscoe and Schorlemmer (A Treatise on Chemistry, 1884). For this purpose the acid is saturated with caustic potash, evaporated with a small quantity of powdered arsenic trioxide, and the mixture heated in a test-tube, when the characteristic smell is perceived. Alcohol is best detected by making a watery extract of chloroform, which is then gently warmed, a few crystals of iodine added, and then so much caustic potash that the solution becomes colourless; after standing a few hours, or at most a night, a bright yellow precipitate of iodoform will be thrown down, and the characteristic six-sided tablets or six-sided stellar groups may be examined microscopically. By this test 1 part of alcohol in 2000 parts of water may be detected. Kappeler (Anaesthetica) states that alcohol can be easily detected (1) by a turbidity which appears when equal parts of oil of almonds and chloroform
are shaken together, (2) by the coagulation of white of egg when a few drops of the suspected chloroform are added, and (3) by the milky appearance of the drops of chloroform allowed to fall through a cold solution of potassium bichromate, acidulated with dilute sulphuric acid, green when present in chloroform. As already mentioned, an excess of the standard amount of alcohol in chloroform will lower the specific gravity of the latter below 1.48. This would also happen were ether an adulterant of the chloroform. Ether can also be detected by dropping into the chloroform a watery solution of iodine. The chloroform is pure when its drops are of an amethyst colour and transparent, but ether is present when these assume a dark red colour. Furthermore, ether would dissolve, like alcohol, crystals of nitro-sodic sulphide of iron, which are quite insoluble in pure chloroform. Methyl compounds give to the chloroform a blackish colour when it is treated with sulphuric acid. According to Kappeler, a black, oily layer forms when chloride of zinc is added to the chloroform. Roussin (Art. Chloroform in Watt’s Dictionary of Chemistry) states that pure chloroform shaken with di-nitro-sulphide of iron remains colourless; but if it contain ethylic alcohol, ether, or wood spirit, it will acquire a dark colour. Kappeler has also obtained this reaction with aldehyde and amyl alcohol. The presence of such chlorine compounds as dichloretane and ethylene dichloride is suggested by the formation of a white coating of chloride on bright metallic sodium at the boiling point. According to Roscoe and Schorlemmer, pure chloroform does not attack this metal. As a corroborative test these authors state that chloroform evolves the combustible gas ethylene when heated with alcoholic potash.

**PHYSIOLOGY OF CHLOROFORM.**

**EXTERNAL APPLICATION.**

When applied to the skin and allowed to evaporate, chloroform produces a sense of coldness, and exerts a local anaesthetic effect. It may pass into the blood through this channel also, provided the external conditions (hindering its evaporation into the atmosphere, etc.) are complied with. Short of this, it produces a redness or vesication. Bernard (Leçons sur les Anesthésiques et sur
Asphyxie) states that even in dilute aqueous solutions it quickly destroys the irritability of the muscles, rendering them "chloroform-rigid", and producing, microscopically, cloudy and other structural changes. Brunton (Therapeutics, vol. ii, p. 79) believes that chloroform acts as a powerful solvent of protagon, the essential ingredient of the nerve-centres and of the nerves themselves. Dastre finds that when injected under the skin it produces a local anaesthetic effect, but owing to its caustic action on the tissues it passes but slowly into the general circulation, and deep anaesthesia is not obtainable by reason of the free elimination which takes place during its passage through the lungs. Intravenous injection will, however, produce general anaesthesia; which effect, in animals, Brown-Squard was able to produce by the application of the drug over large surfaces of the skin.

**ACTION IN THE BLOOD, AND UPON THE CIRCULATION, AND RESPIRATION.**

The blood changes produced by chloroformisation have not yet been satisfactorily determined. Various views and hypotheses founded upon a priori reasoning, on the well-known chemical and physical properties of this agent, have led to numerous mistakes as to its behaviour in relation to the blood, and many errors under the test of experiment have had to be abandoned. For example, Clemenz thought that the rapidly fatal action of chloroform was due to its not containing any oxygen, because we cannot conceive of life without oxygen. Others thought that chloroform sometimes rapidly abstracted oxygen from the blood, or decomposed it into prussic acid and sal ammoniac, etc. (Schiedeberg: Arch. f. Physiol Heilk., viii, 1867). Harley (Trans. Roy. Med. Chir. Soc., 1864, p. 159) states that chloroform diminishes the power of the constituents to unite with oxygen and to give off carbonic acid, and his views have been endorsed by Oliver and Garrett (Lancet, Sept. 9, 1893), and others. Harley holds chloroform responsible for various degrees of disintegration of the red blood cells, and his theory has been corroborated by McKendrick, Wittich, Boetticher, and Sansom (Chloroform, its Action and Administration. London, 1885). Boetticher found, as did Sansom about the same time, that under certain conditions the blood of animals (certain kinds) is acted upon by chloroform in such a way that the blood-corpuscles are dissolved, and the haemoglobin crystallises out; in human blood
chloroform produces the same solution, but crystals are not formed.

According to Schiedeberg (loc. cit.), it is highly probable that chloroform enters into chemical combination with the substance of the red blood discs; for, when the defibrinated blood and chloroform are mixed together, outside of the body, there is produced a peculiar albuminous precipitate, of the colour of red sealing-wax (chloroform coagulum), the chemical constitution of which shows a considerably greater percentage of chlorine than normal blood exhibits. On the other hand, the serum of blood, mixed with chloroform, contains about as much chlorine as normal serum. It would therefore appear that in this chloroform coagulum, from which very little chloroform can be recovered by simple distillation, this substance has entered into some peculiar combination with the blood-corpuscles. In the meanwhile the fluid portions appear not to contain any chloroform. It is a matter of great interest to note that in forming this compound chloroform loses its own peculiar and striking properties, so that, in medico-legal investigations on the presence of chloroform in the blood, it can never be recovered, except in extremely small or minimal quantities, from that fluid.

From an extensive experimental study Bonwelsch shows that chloroform, like alcohol and ether, retards tissue-changes in the blood. Blood mixed with chloroform gives up its oxygen (oxyhaemoglobin) to reducing agents far more slowly than normal blood does.

It should be remembered that these facts do not fully apply to the living human body, since they relate to the blood drawn from the veins.

Schiedeberg is inclined to believe that the combination of chloroform with the blood-corpuscles, which he had noted, does not occur in the blood through a living animal, since the combination which occurs outside the body is again broken up by exposure to the oxygen of the atmosphere. The constant presence of oxygen in the circulating blood, therefore, renders it unlikely that any such compound can be formed in life. The conclusions drawn by Sansom (loc. cit.) from the behaviour of chloroform with the blood are at least not to be implicitly relied on, since he does not hesitate to attribute the whole of the effects of chloroform to this solution of the corpuscles. Yet the facts just mentioned are valuable as furnishing us with finger-posts, as it
were, as to the direction our enquiries should take if we hope to succeed. That solution of the blood-corpuscles cannot well be the primary cause of the effects of chloroform: would appear, among other reasons, from the fact furnished us by Hermann, that even those members of the animal kingdom which have colourless blood are affected by this drug. Subsequently, this observer laid special stress on the effects of chloroform on protagoin, effects which he himself had demonstrated. These are common to all volatile anaesthetics. Protagoin is the substance which Liebrich first discovered in the brain-tissue. Volatile anaesthetics dissolve protagoin, and this solution, according to Hermann, may probably be the basis of their anaesthetic operations. It is, of course, quite outside the scope of this essay to consider the question of the existence of protagoin, or of its relations to lecithin. Under any circumstances we may safely admit that these agents are solvents for those constituents of the nerve-substance which contain phosphorus. Hermann's theory is, as he himself admits, by no means one that fully explains the part played by such substances in the vital actions of the nervous system. But it is one of the best representatives of that class of theories which seek to explain the action of chloroform, not by any altered constitution or properties of the blood, but by a direct action upon the nervous organs.

Regarding the effects of chloroform inhalation upon the pulmonary circulation of the frog McKendrick, Coats, and Newman describe four phenomena: (1) Retardation and then stoppage of the circulation; (2) indistinctness of the individual epithelial cells of alveoli and disappearance of their nuclei; (3) contraction in calibre of arterioles and capillaries; (4) disintegration of corpuscles.

We do not know much regarding the gases of the blood in chloroform anaesthesia. Bert, in his experiments with his "Mélanges titrés", found that as regards the blood, a progressive diminution in the quantity of oxygen and an increase in that of carbonic acid took place as the administration of the anaesthetic proceeded. These results were confirmed by De St. Martin (Recherches expér. sur la Respiration, p. 189. Cited by Oliver and Garrett, Lancet, Sept. 9, 1893). As regards venous blood Bert says that the oxygen again and again showed diminution, but the carbonic acid remained almost stationary.

The expression of functional disturbance of the
central organs of the nervous system appear to be the essential symptoms of chloroformisation. A short-lived exhaltation of the activity of these organs is succeeded by a more or less perfect suspension of this activity; a suspension which, in extreme cases, extends to those centres of the vegetative functions of the organism - respiration and circulation - which are usually not attacked. It is probably due to its physical properties that chloroform has the peculiar power of producing its narcotic effects, one after the other, in a far briefer space of time than is the case with most other narcotics. As quickly as it is received into the blood, and is again eliminated from it, so suddenly do its effects appear and disappear again. It has just been remarked that the action of chloroform is by no means limited in all cases to the organs which regulate the animal functions of life. And since this encroachment on the most important vital processes, those of respiration and the movements of the heart, are the special and almost only dangers of chloroform, it has for a long while been the earnest endeavour of physiologists to discover accurately the real causes which underlie these unwelcome properties. To this we owe a long series of careful experiments upon animals, which have been made with the purpose of discovering the causes of the toxic action of chloroform. Scheinesson (Dissert. Dorpat, 1866), studying the effects of chloroform inhalation upon the circulation of animals, observed that the movements of the heart became weaker, and the lateral pressure in the arterial system lessened, not only on this account, but because the vaso-motor centre in the medulla oblongata loses its irritability through the poison, and may even become completely paralysed. The weakening of the activity of the heart does not depend upon any influence from the nerve-centres, but depends rather on a direct alteration of the motorial power of the heart, which may be considered by some as due to a weakening of the automatic centres for movement in the heart itself - ganglia of the heart - or on direct weakening of the cardiac muscular fibres. These changes in the circulation, Scheinesson says, also the cause of the decrease in the bodily temperature, and of the retardation of tissue changes in the animals experimented upon.

The results of the experiments of the Committee of the Royal Medical and Chirurgical Society agree in the main with those of Scheinesson. (Med. Chir. Trans., vol. xlvii, 1864, pp.
In these, also, decrease of the arterial pressure, after a primary rise, was observed as a constant effect of the chloroform. The experiments of Lenz (Diss. Dorpat, 1853) with the haemodrometer, in which the swiftness of the blood-current in the carotid artery sank to one-seventh of its normal value, also speak strongly of the diminished propulsive power of the heart during chloroform anaesthesia. Vierordt, however, found a far less considerable diminution of the rapidity of the circulation—amounting to about four-fifths of the normal rate. The Glasgow Committee attributed the constant fall of the blood-pressure to a direct effect of chloroform upon the heart. The Hyderabad Chloroform Commission (Report, p. 837) referred this effect solely to narcosis of the vaso-motor system, and state that it is, if not a safeguard, absolutely harmless. The sudden fall in pressure reported by the Glasgow Committee they regard as the result of intercurrent asphyxia. MacWilliam saw a temporary rise of pressure in some cases, and he points to a vaso-motor depression with secondary cardiac dilatation as responsible for the subsequent fall. He considers that blood-pressure tracings alone are unsafe guides as to the strength and character of the heart's action or even of the ventricular beats, for he has observed a weak ventricular beat produce a large oscillation in the blood-pressure tracing, and vice versa, and also the occurrence of a great increase in the rapidity of the heart's action without the production of any appreciable rise in the blood-pressure.

Wood and Hare (Med. News, Feb. 22, 1890) state that chloroform produces first, a fall of blood-pressure due to inhibition of the heart or vaso-motor centre, and then a rise, due probably to reflex vaso-motor spasm; but this reflex inhibitory cardiac arrest is never permanent. According to Gaskell and Shore, there is an initial rise and subsequent fall of pressure, the former being due to a stimulation of the vaso-motor centre. According to them, and in view of the result of a series of their cross-circulation experiments (Brit. Med. Jour., Jan. 21, 1893), the subsequent fall of pressure is principally due to an effect of chloroform upon the heart, not to an action upon the vaso-motor centre as emphasised by the Hyderabad Commission. They believe that chloroform stimulated rather than depressed this centre; for they found that injections of the drug into the cerebral arteries caused a
rise in pressure which was still present at the moment when respiration ceased; and, furthermore, that when the Amyl nitrite was injected into the ligatured cerebral vessels and the intracranial pressure raised, the respiration failed before the vaso-motor centre. According to the Hyderabad Committee, and to MacWilliam, the characteristic fall of blood-pressure is to a certain extent protective, as it has the effect in preventing the absorption of fresh chloroform by the pulmonary blood-stream.

As regards the direct effect of chloroform upon the heart, Snow concludes that primary cardiac paralysis only takes place with high percentages of the vapour, and that, provided precautions are taken to avoid such concentrations, the heart only fails secondarily to the respiration. Chloroform atmospheres of 3 to 6 per cent., in the case of cats, caused a stoppage of the breathing before arrest of the heart, — an interval in many cases of two or three minutes separating the cessation of respiration and cardiac movements, — but with atmospheres of 8 to 10 per cent. the action of the heart was always seriously affected and rendered extremely fatal, if it did not actually cease, at the time breathing was arrested. Similar were the results obtained by the Committee of the Royal Medical and Chirurgical Society, who dwell upon the fact that (1) the strongest doses of chloroform destroyed life by arresting the action of the heart, and that moderate doses considerably weaken cardiac action before death ensued, although respiration generally ceased before the heart’s action completely failed; (2) the strongest doses of chloroform in their experiments caused the pulse and respiration to cease nearly simultaneously (in from 1’ 20” to 1’ 45”), whilst the heart’s action continued a short time subsequently (from 3’ 10” to 5’ 20”), but when equally strong atmospheres were administered through an opening below the glottis, death was much more rapid, and the heart, as a rule, ceased to beat several seconds before the final arrest of the movements of the respiration; (3) with moderately strong and weak vapours little or no difference was observed whether the chloroform entered above or below the glottis; (4) a strong chloroform vapour did not cause a more permanent stoppage of the heart’s action than a mild vapour. The Glasgow Committee subsequently arrived at similar conclusions.

MacWilliam was the first to demonstrate that chloroform produces a varying degree of dilatation of the heart’s
cavities, commencing usually after the disappearance of the corneal reflex. According to him, this dilatation is participated in by both the auricles and both the ventricles but subsides as the anaesthetic is withdrawn; in some cases the dilatation was sudden and independent of rate; when the dilatation was extreme the heart failed, although rhythmic movements persisted for a while; the cardiac dilatation was neither due to fall of pressure nor dependent upon increased pulmonary resistance from vascular contraction, but was a direct result of the action of the chloroform on the cardiac mechanism itself. He admits, with the Hyderabad Commission, that the characteristic fall of blood-pressure under chloroform is due primarily to depression of the vaso-motor centre, but insists that dilatation of the heart is the chief factor. He noted that dilatation did not appear usually until after the fall of blood-pressure, and that in some cases the ventricle was thrown into a state of incoördinated fibrillary contractions - delirium cordis. MacWilliam's experiments have been confirmed by other observers.

The researches of Leonard Hill (Brit. Med. Jour., April 17, 1897, p. 959) have an important bearing upon the posture of patients during chloroform anaesthesia. He has proved by experiment that chloroform rapidly abolishes the vascular mechanisms which compensate for the hydrostatic effect of gravity; for when the body of a chloroformed animal is brought from the horizontal to the feet-down position, there is a far greater fall of blood-pressure -arterial- than occurs in the absence of chloroform anaesthesia. Hill considers the principal effect as being due to an paralytic state of the splanchnic vaso-motor mechanism leading to an accumulation of blood within the splanchnic area; an important factor being the failure of the respiratory pump.

REMOTE LOCAL ACTIONS.

Chloroform acts upon the kidney to a much less extent than does ether. Thomson and Kemp and Buxton and Levy have shown by their experiments that the secretion of urine is not diminished unless the general circulation be depressed, and that narcosis requires to be greatly prolonged for albumen to appear.

According to Osierlag, Ungar, Strassman, Thiem, Mester, Kast, and Fischer, the repeated administration of chloroform to the lower animals over a period of several
days produces fatty degeneration of various organs, especially of the liver, the cardiac and skeletal muscles, the kidneys, and the stomach. Bert, on examining an animal which ultimately succumbed to a chloroformisation of thirty-two days' duration, found an increased elimination of urea, but never albumen, sugar, or chloroform in the urine; the tissues were seen to have lost their fat; the muscles were pale and atrophied, and there was fatty infiltration of the liver.

**CAUSE OF DEATH FROM CHLOROFORM.**

The Committee of the Royal Medical and Chirurgical Society, appointed in 1864, to enquire into the uses and effects (physiological, therapeutical, and toxicai) of chloroform, collected and analysed 210 fatal cases (109 collected by the Committee and 101 collected by Kappelen) which occurred in the years 1848-1884. A difference was at once noticeable according as concentrated vapours were inhaled or dilute ones. The duration of life of the animals (dogs) was almost directly proportional to the concentration of the vapour. The concentrations — or as we should call them, dilutions — used were (1) weaker, if air containing from 1 to 15 per cent. of chloroform; (2) stronger, with at least 40 per cent. of chloroform in the air. In the weaker compound the intensity and quality of the symptoms produced were not much affected by the mode of breathing, whether through mouth or nose, or through an opening in the trachea. But when the strong concentrated vapours were used, through either mouth or nose, almost immediate slowing of the pulse (after 30 seconds), and respiration (after 105 seconds) occurred, and somewhat later, stoppage of the heart, in five minutes. But if the concentrated vapours were inhaled through an opening in the trachea, the heart stopped before respiration ceased. The pulse always vanished a little before the movements of the heart ceased. Concentrated vapours often caused an immediate, though sometimes brief, stoppage of respiration. This was absent when a mixture of 6 per cent. of chloroform in air was employed. This was always followed by an increased frequency of breathing, at first with greater, afterwards with less depth of the separate inspirations, which gradually decreased to nothing, and then began again afresh after from twenty to forty seconds. The fresh application of chloroform stopped them again. Section of the vagus nerve in chloroformed dogs had less effect than it has on
dogs not under chloroform. Chloroformisation after section of the vagus nerve diminished the consequences of the operation - increase of the frequency of the pulse and dyspnoea.

Some authors have considered that the primary cause of the occurrence of certain symptoms affecting respiration and circulation to be reflex irritation of the centres concerned. Dogiel (Arch.f. Anat. und Physiol., etc., 1886) and Holmgren (Virchow und Hirsch. Jahrb.).etc., 1887) considered the stoppage of the heart and the disturbed respiration, which they both noted as common in animals in the first stage of the action of chloroform, as the result of a previous reflex irritation of the vagus centre in the medulla oblongata, through one of the sensory nerves of the nose, or of the naso-laryngeal mucous membrane. Holmgren has shown, however, that only those branches of the trigeminar are affected which ramify in the naso-laryngeal mucous membrane. The phenomena in question are weakened after section of the superior laryngeal nerves, as well as of the vagus in the neck. These disorders are not produced in the first stage of inhalation if care be taken to avoid the above-named portions of the mucous membrane by giving the chloroform through a tracheal fistula.

A. W. Smith (One of the Causes of Death from Chloroform. Amer. Jour. Med. Sci., 1871) considers that a very common cause of stoppage of respiration in chloroform narcosis is to be found in the paresis (anaesthesia) of the termination of the sensory nerves in the lungs, induced by the chloroform - these nerve-endings being concerned, in the normal state, with the regular performance of the respiratory movements. Calling to mind the results of Breuer's experiments on the part played by the peripheral terminations of the vagus nerve in the act of respiration, we must admit that there is some foundation for this theory. According to Breuer, each inspiration causes an irritation of the sensory terminations of the vagus nerve by the very act of expansion of the lungs. It is carried by the centripetal vagus fibres to the centre for respiration, and an expiratory movement is at once set up. By a similar mechanism an inspiration is made to follow an expiration, so that in a certain series the movements of respiration are automatic and self-regulating. As the operation of the vagus plays a leading part in the whole of this mechanism, it is quite conceivable that sudden paralysis of the
sensibility of the lungs, especially when the central organs of respiration are simultaneously affected, must greatly contribute towards the stoppage of respiration. Richardson (On Death from Chloroform. Med. Times and Gaz., July 23, 1870, p. 35) believes that death from chloroform is brought about in many different ways, by functional disturbances of the various parts of the nerves belonging to or regulating the heart.

I do not think it necessary to consider in any detail the now celebrated controversy as to the relative merits of ether and chloroform. In this country— but not in America—it appears decided in favour of chloroform. The number of cases of death by the latter in surgical operations already relieve us from the necessity of discussing the question whether chloroform itself is really a cause of death, in spite of the well-known dictum of Sedillot: "Le chloroforme pur et bien employe ne tue jamais".

The question as to which stage of chloroform narcosis is the most exposed to the danger of death has been much and freely discussed. Apart from those rare cases in which the true cause of death must be sought, not in the chloroform used but in shock occurring after severe accidents, and sometimes from fear and mental emotion in very sensitive persons—cases which, though interesting, ought properly to be excluded from our consideration—we shall not be far from truth if we admit, with Billroth, that death may occur in all stages of narcosis. Sanson gives the following figures as regards this point:

<table>
<thead>
<tr>
<th>Stage of the operation, in which Death occurred</th>
<th>Snow.</th>
<th>Scutteten.</th>
<th>Kidd.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prior to the operation...</td>
<td>13</td>
<td>22</td>
<td>14</td>
</tr>
<tr>
<td>During the operation...</td>
<td>22</td>
<td>6</td>
<td>14</td>
</tr>
<tr>
<td>Soon after the operation...</td>
<td>6</td>
<td>12</td>
<td>7</td>
</tr>
</tbody>
</table>

The Committee of the Royal Medical and Chirurgical Society collected 109 cases, of which there died:
At the beginning of the inhalation
In the stage of excitement
Under imperfect anaesthesia
With perfect chloroform anaesthesia
After the operation was over
Not known at what period

or

Before they were perfectly under chloroform
During chloroform narcosis
Condition not known

Sex appears to have a remarkable influence as regards the dangers of chloroform anaesthesia, that is to say, an overwhelming majority of the fatal cases are in males. The following statistical materials, furnished by Sansom, represents the proportion between men and women, according to a variety of observations:

According to the Committee of the R.M.C.S. .........
72 males to 37 females.

" Snow ........ 3 " " 2 "
" Kidd ........ 4 " " 1 female.
" Sansom ........ 2-8 " " 1 "
" Scottteten ... 2 " " 1 "

This result, Sansom says, is all the more remarkable, inasmuch as the obstetric use of chloroform has given women almost a monopoly in its use.

There seems no special influence attached to the age of the patient. That very young children bear chloroform extremely well, as a rule, is evident from the operations one so frequently sees - hare-lip, etc. It would be rash, however, to decide on these grounds that very young children possess an absolute immunity from the effects of chloroform. Indeed, cases have been reported from time to time which would go to prove the contrary, and perfectly justify a strict observance of the usual precautions when administering the drug to this class of patients. The statistics of the Committee of the Royal Medical and Chirurgical Society only show that more chloroform deaths occur in the periods of life in which the greatest number of men are chloroformed. Thus:
Under 5 years there died .......... 0
From 5-15 " " " " ........................ 9
" 15-30 " " " " ........................ 30
" 30-45 " " " " ........................ 32
" 45-80 " " " " ........................ 2
At unknown ages " " " " ........................ 24

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<table>
<thead>
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<th></th>
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<tbody>
<tr>
<td></td>
<td>total</td>
</tr>
<tr>
<td></td>
<td>107</td>
</tr>
</tbody>
</table>

The factor of susceptibility, idiosyncrasy, constitution, or physical strength, seems to stand in this peculiar relation to chloroform, that robust and healthy persons seem far more exposed to the dangerous effects of the drug than delicate, weakly individuals who have been previously reduced by ill-health. In this Sansom discovers a certain law of tolerance. As a result of this law, chloroform is far less dangerous for women and children than men. In a similar way may be explained the fact that the largest relative number of fatal cases of chloroformisation have occurred in cases of very trifling surgical operations, minor cases, such as the extraction of teeth, the operation for the removal of ingrowing toe-nail, and so forth, where, for the most part, the patients have been considered in good health. In 107 cases of death from chloroform, in which the reason for it was given, and analysed by Sansom, we find that:

After very slight operations there died .......... 62
" more severe " " " ........................ 23
" amputation, lithotomy, etc. " " ........................ 7
" herniotomy, forceps labour " " ........................ 6
" delirium tremens & mania " " ........................ 4
" natural labour ........ " " ........................ 2

But it is perhaps as well not to take too seriously Sansom's arguments on this point as to the principle of tolerance. For an objection may fairly be raised that the total number of cases collected is not sufficient to allow of safe conclusions. And, again, it may be said that minor operations are far more common than severe ones, and must, therefore, in the nature of things, furnish a large number of fatal cases.

Regarding the question of intercurrent asphyxia dependent upon the direct effects of chloroform vapour, it is not possible to say exactly how much chloroform can be given to any one without danger to life, because it is in
most cases quite impossible to accurately estimate between the quantity of chloroform used and that actually inhaled, or, in other words, absorbed. However, all authorities agree in this, that the degree of concentration of chloroform vapour, the more or less perfect absence of atmospheric air in the respiratory medium, is of special importance. That concentrated vapours can destroy animal life in an exceedingly short space of time has been many times demonstrated by actual experiments; and surgical experience leads to the same conclusion. On the other hand, the actual quantity of chloroform inhaled, if spread over a long space of time, is of less importance, and Sansom calls attention to the fact that death very commonly occurs after a few whiffs only of chloroform, and much more rarely in the later stages of narcosis. The figures given by the Committee of the London Medical and Chirurgical Society, referred to, can scarcely be said to confirm this. Perhaps it would be better on this point also to suspend judgment. This much is, however, thoroughly established by cases, that very large quantities of chloroform may be inhaled safely enough, whilst death very often occurs from very moderate quantities. It is almost equally difficult to determine what is the fatal dose of chloroform, when taken into the mouth, and swallowed as a liquid. In six cases of this sort which ended fatally, from one-half to eight and a half fluid drachms of pure chloroform were taken.

The general experience of medical men would seem to establish the fact that certain morbid states of the system are particularly liable to danger from chloroform anaesthesia. Among these special prominence must be given to diseased conditions of the heart. Sansom insists, and rightly so, I think, that simple valvular incompetency, in the absence of fatty degeneration of the heart-muscle, does not render chloroform more dangerous, or contraindicate its use. This opinion has been amply corroborated by experience. But, as a rule, the important cardiac lesion which seems to be really a predisposing cause of the bad effects of the narcosis - fatty degeneration of the heart - is, unfortunately diagnosed only at the autopsy. Indeed, as regards this, we can scarcely talk of clinical experience, as Koehler does, for no case is known to have been chloroformed in spite of a previous diagnosis of fatty heart, and then, after death, this condition to have been found. But this is what we would understand, when we are
told of clinical experience being confirmed. That 21 out of 55 cases exhibited fatty hearts when examined post-mortem is just as much to the point as Kidd's experience, that, in 250 cases of sudden death, he never found a single case of degeneration of the heart. Whenever it is possible to diagnose this condition with absolute certainty, we should hold clinical observers inexcusable, if they admit chloroform in such cases. But at present the fact that chloroform is injurious in cases of fatty heart is the result, not of clinical experience, but of post-mortem findings. Sanson has collected 55 post-mortem records of fatal cases of chloroform, with special reference to the condition of the heart. In 21 cases the heart was perfectly normal; there was fatty degeneration in 18; in 14 it was pale, soft, and flabby; and in 2 cases there was valvular incompetency. As a primary cause of death from chloroform the presence of cardiac lesions has never yet been proved responsible.

That alcoholism may greatly increase the dangers of chloroform anaesthesia is generally agreed upon by competent observers. This has been observed not only in the cases where chloroform has been given to calm the excitement of delirium tremens, but also in operations upon drunkards, in whom chloroform narcosis is generally very difficult to induce, and runs an irregular and unfavourable course. Kidd has collected 9 cases in which chloroform, used as a remedy in delirium tremens proved fatal; and Sanson has brought together 8 other cases in which chloroform, administered to habitual drunkards for surgical operations, ended fatally. Without disputing that alcohol may serve as a predisposing cause of death from chloroform, I may add that it is not safe to assume that all these cases really died on this account. For, whenever a death occurs from chloroform, it can be readily understood that every effort will be made to remove a part, at least, of the blame from the chloroform itself, and the mode in which it was administered, and thus undue significance may be given to such conditions as the one named. Indeed, cases have been recorded in which drunkards of the most advanced kind, have exhibited great resistance to chloroformisation and passed through the ordeal without receiving the slightest injury from it.
PHENOMENA OF CHLOROFORM ANAESTHESIA.

FIRST STAGE, OR STAGE OF EXCITEMENT.

When chloroform is brought close to a patient, the first thing the latter notices is a burning feeling in the nose and conjunctiva, as well as remarkable sweet taste in the mouth. Tears and saliva are generally secreted more abundantly, and the latter commonly causes efforts to swallow, which frequently bring considerable quantities of chloroform vapour into the stomach, so that the patient may vomit forthwith. If air charged with chloroform be now breathed continuously for some time, we get in different individuals a number of symptoms, which are as multiform, indefinite, and varying as the psychical conditions of the individuals; they defy any precise description or analysis. All I can attempt to do is to describe some of the chief characteristics, and at the same time mention some of the varieties for which individuality and external conditions are responsible. Usually there is observed during this so-called first stage, or stage of excitement, a striking alteration in the behaviour and the expression of the patient's feelings. Most commonly this change of feeling is a cheerful one, manifested by laughing, gay gestures, singing, etc., but it is not rare to find the patient melancholy, weeping and wailing, and sometimes very angry, and there may be, moreover, a temporary mania. It is impossible to say on what this behaviour depends, or why it assumes such different aspects in different cases. People who are generally cheerful become lachrymose, mild individuals turn angry, the modest and retiring assume a boldness and shamelessness, and vice versa, in a manifold and complex variety. Just in the same way, under the influence of chloroform narcosis, the patient's character alternates from grave to gay, from lively to severe, to which condition, indeed, the slightest degrees of alcoholic intoxication bear a close resemblance. In the very beginning, as a rule, the senses are not much affected; but their activity is so very speedily. Thus, those who are chloroformed very soon become conscious that their senses are rendered more acute - there is a peculiar sharpness about them, a vast increase of particular sensations, for example, the ticking of a watch becomes like the strokes of a sledge-hammer, and not infrequently the whispers of the bystanders are heard with amazing distinct-
ness. Other senses besides hearing are sometimes, but less commonly, intensified in the same way. The sense of sight, as a rule, is affected in an exactly contrary manner—a cloud seems to come over the eyes, and prevents the surrounding objects from being seen clearly, and at last things seem in a state of chaotic confusion. Taste very soon becomes, as it were, lost, and at last all the senses become more or less impaired and defective. As a rule, consciousness remains intact during the first stage, although necessarily affected by the false colouring of the anomalous sensations, I have just described. The reflective faculties are therefore unimpaired, so that questions are answered correctly. Indeed, there are many patients who give correct answers during this stage as regards their sensations. But many others are so altered as to be quite oblivious of those around them, or of the circumstances in which they are placed. In their condition of half-awake and half-asleep they busy themselves with the past, give vent to their innermost feelings, and declaim loudly like those under delusions, or as if they were dreaming aloud; they sing and pray as if they were at their public or private devotions, and answer incorrectly, or not at all, when they are questioned. Lastly, although such cases are rare, we meet with those who, after inhaling a few whiffs of chloroform, fall rapidly into a deep slumber, without any trace of a preliminary stage of excitement. The objective symptoms of this first stage are, as a rule, exceedingly well marked. The face is flushed, the forehead bedewed with perspiration, the pupils are manifestly contracted, and the body makes either definite, voluntary, and well coordinated movements (e.g., tries to sit up, walk, hit out, etc.), or is moved spasmodically (generally with extreme tension of the muscles) hither and thither with no apparent object. Hiccups and vomiting often set in, the pulse seems diminished and is usually of lesser resistance than usual. Sensation is by no means uniformly affected during this stage; many patients complain of crawling sensations (formication) as of insects, felt in the extremities, and unpleasant feelings of pricking and stinging in the skin—symptoms which are generally associated with diminished sensibility to external irritants. Even in this early stage partial or complete anaesthesia of the skin has frequently been observed. The duration of this stage of excitement seems subject to no rule, and the limits of
variation are very wide, and do not seem to be at all definite.

SECOND STAGE, OR STAGE OF DEPRESSION.

The second effect of chloroform on the nerve centres is to cause their depression. If the inhalation be vigorously pushed, it is commonly found that a very few minutes suffice to change the scene. The previous excitement is either suddenly or more gradually allayed; the talking, singing, swearing, and so forth, is hushed, the muscles become relaxed and limp, the arms are dropped, the flush on the face vanishes, and deep sleep is indicated by very audible snoring. The relaxation of the muscles very soon extends all over the body. The masseter muscles perhaps resist the longest. Breathing is deep and slow, as in those who sleep; the movements of the heart are somewhat weakened, but still regular. The pupils now become somewhat dilated, and when narcosis is quite complete the ball of the eye can be touched without exciting any reflex movements of the eyelids; there is, in fact, perfect anaesthesia, and now is the time that the severest operations may be performed without the patient experiencing the slightest pain: reflex movements are not excited and the depression of the vital functions are still within safe limits. The general rule seems to be that sensibility lingers longest in the region of the sensory branches of the fifth cranial nerve, at the tip of the nose, and in the two temporal regions. The lower limbs and other parts of the body may be quite insensible to pain, whilst the conjunctiva still gives rise to movements of a reflex nature.

THIRD STAGE: MAXIMUM EFFECTS.

It is still very easy, if chloroform be pushed still further, to reach a third and very undesirable stage, in which death occurs, for the most part, very suddenly, sometimes under the guise of syncope, sometimes taking the form of asphyxia. Herein lies the special risk of chloroform, that danger comes before it is expected, and that what are termed unfavourable or dangerous symptoms are generally the immediate forerunners of death. In fact, death treads on the heel of danger. A sudden stoppage of the pulse or breathing, a sudden paleness overspreading the face, cyanosis or duskiness of the lips and dilatation of the pupils, and sometimes sudden relaxation of the sphincters, the passage of urine and faeces, vomiting, a sudden stoppage of the flow
of blood during an operation - these are the alarm signals; and of these, sometimes one, sometimes another, most prominently attracts the attention of the onlookers. I have previously discussed the physiological questions concerned in this condition; and need only repeat here, that it is by no means easy to say, in a given case, whether cardiac paralysis - syncope - or the respiratory centre has brought about the unfortunate ending. I may grant that the first method is the commoner one, and at the same time the more quickly fatal one, since attempts at resuscitation are generally quite useless; whilst anomalies of respiration, conditions of apnoea, or mechanical obstruction of breathing, in consequence of paralysis of the tongue and of its falling back and obstructing the aperture of the glottis, and similar conditions, can generally be remedied by appropriate means. In the first class of cases, the face, as a rule, grows pale, and one notes a stoppage or irregularity of the pulse, whilst respiration continues a little longer; in the latter class of cases, the various disturbances of respiration and the interruption of breathing precede the stoppage of the pulse. Death is not seldom quite sudden. Violent cramp-like muscular movements must also be regarded as an unfavourable symptom, which commonly ends in sudden death. This, according to Sansom, is particularly to occur in those who have been habitually addicted to the vice of intemperance, and in whom the induction of narcosis is often a matter of considerable difficulty. I have previously said that it is scarcely possible to indicate precisely the stage of narcosis in which chloroform is the most dangerous. Indeed, there are not wanting competent authorities who insist that unfortunate accidents are more apt to occur at the very beginning of the chloroformisation, often too, after only a few whiffs of the drug, than they are in the earlier stage of the anaesthesia.

STAGE OF REACTION.

If the inhalation be discontinued (in those cases in which the desired anaesthesia has been obtained) without any untoward complication, the narcotised patient generally awakes suddenly, as from a deep sleep, in from one-half to three-quarters of an hour, without the faintest knowledge of what has happened in the interval. After some slight delirium and confusion, the senses gradually return. Vomiting often occurs in these cases, but there is
seldom any other abnormality. Serious sequelae are hardly ever known to occur. In rare cases, however, the course of the narcosis is so far abnormal as to be complicated by general convulsions, of varying severity. These convulsions, which are sometimes epileptiform and sometimes of a tetanic character, may occasionally be sources of considerable danger, in so far as they involve more or less deeply the muscles of respiration. The real nature and cause of the convulsions is simply conjectural at present.

**CHLOROFORM IN LABOUR.**

**GENERAL CONSIDERATIONS.**

Chloroform appears of all anaesthetics to be the most suitable for use during labour, in which, indeed, its use is as justifiable as in surgical operations, and indispensable when forceps have to be applied or other operative manipulations performed. Furthermore, it is of more value here than in most surgical operations, as it speedily produces an analgesic effect without materially affecting uterine contractions. The patient passes into a dreamy, restful condition, with somewhat deep respirations, and a pleasant feeling of numbness in the extremities; and directly facilitates the progress of parturition by vanishing all bearing down and the tension of the abdominal and pelvic muscles, and any local crampy or neuralgic conditions existing. The patient, as mentioned, passes into a halcyon state, while the consciousness is preserved. When the drug is given to the "obstetric degree" only, which is usual. It is remarkable what intense contractions of the uterus may take place when the patient remains in this state and without their being noticed by her. The contractions are little, if at all altered; any primary diminution in their frequency seems to depend entirely upon the patient’s quiet condition, and soon regulates itself. In fact, the uterine contractions become stronger than before, and usually, therefore, more efficient, since the struggling of the woman, and the contractions of her abdominal muscles, are, for the most part, allayed. Between the contractions she remains quiet, and with their return only manifests resentment in the shape of restlessness, bearing down, or other harmless evidences of disturbance. With the cessation of the pains quietude returns and no pain is experienced,
at least she does not complain of any, being half asleep. In parturition more than any other condition is this ideal analgesic effect of chloroform observed; the effect being the more striking the more has been the previous agony and induced debilitation; and to produce this blissful condition only very small quantities of the drug are required. But if the administration of this anaesthetic be prolonged, the same stages of narcosis may be induced as in other cases. The pains grow more sluggish, the intervals between them longer, and when deep narcosis is induced, they diminish and finally disappear. In addition to this, there may be vomiting; as the patient has probably rejected the contents of the stomach or been fasting before the anaesthetic was inhaled, this complication is of rare occurrence. As this state of deep narcosis - with its abolition of the pains and dangers to the system generally - is seldom required or attempted in labour, it may be regarded as safe and frequent to continue the mere obstetrical degree of anaesthesia as long as the exigencies of the case demand - for hours perhaps. I have often in practice convinced myself of the truth and value of this, and believe that the increased frequency of the heart and respiration which accompany each pain, just as appreciable when the patient is chloroformed as before it, is, for the most part, the cause of the safety with which chloroform can usually be given in labour. Furthermore, it appears probable, if not certain, that chloroformisation of the mother has no injurious effect upon the foetus. According to Runge (Arch.f.exper.Path.) this drug so lowers the blood-pressure of the mother, that the child in utero may, in consequence, perish without the mother succumbing. But as clinical experience of prolonged chloroform narcosis in child-birth does not confirm this observation, it cannot be regarded as unimpeachable and consistent with actual facts. There is, it is true, evidence which goes to prove that chloroform is present in the expelled placenta, where it might be derived from the maternal blood that is still adherent; moreover, it had been demonstrated that the reducing substance which is found in the urine of persons who have inhaled chloroform, is also present in the urine of children whose mothers inhaled it, and that such reducing substance is found in the foetal circulation; and that the drug therefore passes into the foetal circulation. Probably this is not injurious to the child: the problem remains open for the future to solve.
The accoucheur in administering chloroform in labour must be prepared for to take upon himself a certain amount of risk; but, when one remembers how few cases of the kind are fatal when the anaesthesia is not pushed to its fullest degree, one may feel justified, after all possible precautions against accident have been taken, in giving it unhesitatingly, even in labours which otherwise run a normal course, as soon as the pains become very severe; and cause great excitement and exhaustion by their long duration – due regard being, of course, given to any individual susceptibilities, as well as the ordinary contraindications (diseases of the lungs, heart, and blood-vessels). In the absence of the above-mentioned conditions (severity of pains, etc.), chloroform must not be given; that is to say, never to get rid of the suffering of labour alone.

Though the use of chloroform in labour in the moderate doses described is practically free from risk, it must be borne in mind that when the drug is pushed to its fullest degree, this almost absolute immunity from fatality is not to be relied on. Indeed, it is a great mistake to suppose, as many apparently do, that chloroform accidents during parturition are unknown. I have already referred to several in one of the former statistical tables. Many others are on record. The reasons, I think, that there are comparatively few accidents during childbirth are:

(1) The patient is usually at the best and strongest period – the prime – of life. (2) As a rule, she suffers from no organic disease, and is thus better prepared to withstand safely the physiological effects of the drug than those previously weakened by disease, or the conditions for the relief of which they are brought to operation.

(3) The position in which she is placed – on the left side – admits of the tongue falling forward, thereby allowing of the respiratory movements to be performed unimpeded.

(4) No very deep anaesthesia, at least for any length of time, is either necessary or, as a rule, utilised. Atthill, whose forty years' experience of chloroform in obstetric practice makes his words momentous, ascribes the safety of this anaesthetic to the fact that there is in these cases seldom an entire cessation of the involuntary expulsive efforts, and as at the expiration of each of these, comparatively deep inspiration follows, it may tend to obviate the occurrence of asphyxia. Tubby's views are in
accord with these; and Galabin thinks that the undue vaso-
motor dilatation, which might otherwise result from the
choroformidation, is prevented by the high abdominal
pressure intrinsic to the distension of that part of the
body by the enlarged and pregnant uterus.

METHOD OF ADMINISTRATION.

GENERAL PRINCIPLES.

The condition of the patient will furnish the clue as
to the time for commencing the anaesthesia. It may be as
early as the period of dilatation. In general, it is as
well to desist during the exit of the child, since the
assistance of the fully conscious woman is often necessary
for the preservation of the perineum. The anaesthetic
should only be inhaled during the pains; it is in this way
that the desired object will be most easily and quickly
attained, since respiration is accelerated during the
pains, and any struggling against the odour of the drug is
most rapidly overcome. The chloroform should be removed
when the pains subside. When the inhalation is finished,
the patient should not be waked, but be allowed to recover
spontaneously; after the birth of the child, the uterus
must be supervised with special care.

SPECIAL PROCEDURE.

I will now proceed to describe what appears to me, from
an experience that has been by no means inconsiderable, the
best method of administering chloroform and operating at
the same time, it being understood that the accoucheur
does both himself, no assistant being available.

The Accoucheur's Preparations.

Having decided by auscultation and the usual clinical
tests that the patient is of a physique such as offers no
contraindications to chloroform anaesthesia, the husband,
or nearest relative, should be given to understand that,
owing to certain circumstances (describing them), it is
necessary to give chloroform, and formal consent obtained.
It now behoves the accoucheur to take such steps as will
result in his instruments being thoroughly sterilised. This
can be readily effected by immersing them in a jug of
carbolic lotion. This is placed near enough to the bed as
to allow the forceps to be within easy access as required.
Every obstetric bag should contain a pair of tongue forceps.
My personal preference in this direction is a Kocher's artery forceps. The fact of its being devised for a purpose other than obstetrical in no way detracts from its great utility in the latter class of cases. It can be applied to the waistcoat so as to remain attached to it and be readily taken off when wanted. A mouth-gag is likewise a most useful accessory in one's outfit; but such can be readily improvised from a strong piece of wood cut into a suitable shape. A hypodermic syringe, containing ether or strychnine, should always be within reach throughout the operation, and, moreover, charged ready for use at a moment's notice. The operator's hands should now receive a thorough disinfection, and a basin of carbolic lotion placed at the bedside so that the process may be repeated as often as necessary by immersion of the hands and arms therein.

Preparation of the Patient.

The patient's face should first be well anointed with vaseline to prevent irritation of the skin by the drug; her clothing is to be loosened about the waist and neck to remove any possible interference with respiration, and false teeth or any other foreign substance that is in the mouth is to be taken out, lest it should be swallowed as the patient loses consciousness. The accoucheur should ascertain and satisfy himself that the bowels and bladder of the patient have been recently evacuated; if not, an enema of soap and water must be given at once. In most cases it is a good rule to give a dose — from one to one and a half ounces — of whisky or brandy, slightly diluted, just before the inhalation is commenced. The advantages of giving it undiluted — which most accoucheurs prefer — are:

1. It does not make the patient sick, as it often does when water is added.
2. It lessens the amount of chloroform that is required to produce and sustain the necessary anaesthesia.
3. It gives confidence to the nervous patient.

Position of the Patient.

It is very important to have the patient placed in a suitable position; and the best undoubtedly is on her left side, with the hips well out over the edge of the bed. This position should always be taken up before the inhalations are commenced; otherwise the physician, who is frequently without proper assistance, has a great deal of unnecessary work lifting and dragging the woman about at a time that
she feels like a dead weight. The whole secret of being able to apply the forceps with ease and rapidity consists in having the hips of the patient well out over the edge of the bed. If this is not done, there is almost certain to be difficulty when the upper blade of the instrument is being introduced. All preparations and sundry details should be seen to before the patient is anaesthetised, so that the practitioner's undivided attention may forthwith be concentrated upon his responsible, and at times by no means easy undertaking.

Administration.

The chloroform ought to be of the first quality (see previous remarks regarding this), and given from a drop-bottle of convenient size. The best inhaler in these cases, I have found to be Skinner's Mask. Its advantages are: (2) It permits of a good deal of the patient's face being seen. (2) It allows of a large amount of air getting to the patient's mouth and nostrils along with the chloroform. (3) It is easy to remove and replace again when required—a very important factor when one is working single-handed.

The physician must now request absolute silence from the bystanders. It is sometimes necessary to be somewhat peremptory in demanding this as there may be a good deal of noise and talking going on, which disturbs and excites the patient as she is going under the influence of the drug. The inhaler should be well charged with chloroform and held at first a fair distance from her face, and then gradually brought down to it. If the inhaler is immediately placed over the face, the patient feels a choking sensation, begins to struggle, and thus gets out of her proper position on the bed.

During the administration of chloroform there are two important indications to be met: (1) To give plenty of it—not drop by drop as is sometimes seen. (2) To give plenty of air. For the latter the inhaler—or in the absence of it a small handkerchief folded square—should occasionally be removed some distance from the face, so that the patient may obtain a few breaths of air only slightly mixed with chloroform, after which the inhaler is returned to its former position.

The above remarks do not apply, of course, to a case in which one simply gives the drug to lessen the sufferings of the labour-pains: in that case the mask is placed over
the mouth and nose of the patient at the beginning of a pain, and the material with which it is covered is kept wet with the drug as long as the pain lasts. The mask is to be removed from the face at the end of each pain and not replaced until the beginning of another. A close watch must be kept of the patient's pulse and especially of her breathing and the general appearance of her countenance.

Shortly after muscular relaxation occurs, and before the cornea is quite insensible to the touch the lower or left blade of the forceps may be inserted, having previously washed one's hands in the lotion provided for that purpose. My personal preference is decidedly in favour of the Axis traction instruments invented by Professor Simpson of Edinburgh. The lower blade is usually easily and rapidly applied, and, when it is in its proper place (handle well back towards the perineum), the handle may be given to one of the women, or trained nurse, present, to hold, at the same time impressing upon her the necessity for keeping it perfectly straight and rigid. Now one may return to the patient's head and give more chloroform until the cornea is just insensible to the touch. The upper or right blade can now be applied. This is readily accomplished, as a rule, if the patient is in the position described; the rapidity and facility of the manoeuvre entirely depends upon the woman being in the "obstetric position". The screw of the instrument may now be worked tight and the handle adjusted to the traction rods. If the patient shows signs of coming out of the anaesthetic about this time, the forceps may be left in position, and more chloroform given, and the arrangement of the traction rods, etc., completed.

The delivery of the foetus is now a matter of no difficulty in ordinary cases. The physician can go to the patient's head when necessary to give more chloroform, and then return to his post, and gradually, but intermittently, pull down the presenting head. In cases of elderly primiparae I am in the habit of chloroforming deeply when the head is ready to be brought over the perineum. This relaxes the muscles of that region and almost invariably prevents its rupture.

In cases of turning, where an anaesthetic is necessary, chloroform can be given in the same principle — doing as much as one can while the patient is quiet and leaving off to give more chloroform when she shows signs of becoming restless.
The above procedure, though perhaps slow, is, in my opinion, the safest when one has to anaesthetise and deliver the patient single-handed.

COMPLICATIONS AND UNFAVOURABLE SYMPTOMS: PRECAUTIONS TO PREVENT, AND TREATMENT WHEN ARISING.

CHLOROFORM COUGH

This may be referred to here. When chloroform is administered at night by either gas or lamp-light, many persons, including physicians and nurses, suffer from irritation of the larynx of a most severe type, due probably to the disintegration of the drug by the flame and liberation of chlorine gas. This causes paroxysms of coughing, which often make it necessary for the sufferer to leave the room, and in one case at least death has resulted from the violence of the attack. The patient usually escapes because she is anaesthetised to such a degree that the irritating effects of the chlorine are unnoticed by her larynx. This untoward action of the drug can usually be prevented by keeping a large-sized cloth soaked with ammonia suspended from the chandelier or near the lamp. The ammonia will combine with the chloroform to form the bland and unirritating muriate of ammonium. Care must be taken, of course, to avoid overdoing the matter and make the remedy worse than the disease by filling the room to suffocation with the fumes of ammonia, but this will not happen if the ammonia cloth is merely kept wet with the liquid. It must hang near the light, and if the irritating effects of the chloroform are to be felt more ammonia must be used, for a sufficient quantity will almost invariably produce the desired effect.

HEART FAILURE.

As a rule this is noticed, when occurring, during the early period of the chloroform administration and while the details of anaesthesia are receiving undivided attention. Any signs of pallor should be at once noted and the pulse felt. Should the condition of the latter indicate any weakness of the heart's action, the inhaler must be immediately withdrawn, the tongue pulled forward with the forceps, and artificial respiration commenced. In practice I have found Sylvester's method — pressure on the ribs — in these cases most convenient and useful.
wet towels is, however, often sufficient; as may also be friction with a rough towel over the nose, lips, and face generally. Failing a reaction with these methods, one may, as a last resort, inject the ether or strychnine, which we have already alluded to as being placed near the bedside for use in an emergency as this.

DANGER FROM INSUFFICIENT AIR.

A sufficient amount of atmospheric air mixed with the chloroform, all the while that it is being administered, is the chief element of safety. The moment any threatening symptoms are noticed, the drug must be withdrawn.

OVERDOSE.

Great care should be taken that no more chloroform is given than is necessary to effect one's purpose. When a dose has been given that renders the patient insensible to pain, the inhaler should be removed. Should the patient become restless while introducing the forceps, the blade can be quickly withdrawn and returned to the jug containing the carbolic lotion, and some more chloroform administered. The aphorism in these cases is "always to keep the patient on the border-line of insensibility." Some patients breathe very lightly at times and then begin to breathe rapidly and deeply. Care must be taken in these cases to remove the inhaler for a while; otherwise they are apt to inhale more chloroform than is desirable or than one would consider possible.

LARYNGEAL CLOSURE BY THE EPIGLOTTIS.

The accident of the obstruction of the laryngeal aperture by the falling backward of the tongue is indicated by the impairment of respiration. The sound produced is so characteristic as to be unmistakable, and should at once attract attention. The mouth must be forced open with the gag, and the tongue seized with the forceps and pulled forwards. The relief given by this simple procedure is very striking. The forceps should not be removed from the tongue until the delivery is accomplished.

THE STRUGGLES OF THE PATIENT.

There is danger during the stage of excitement if the patient be forcibly restrained and the inhaler be not withdrawn. She should not be forcibly held down, but allowed to raise herself; she will not move about much if not forcibly prevented. All that is necessary, therefore,
to do is to remove the inhaler for a few breaths, and then gradually bring it back, all the while following the movements of the head until she subsides into quiescence: as a rule, this does not take long.

POST-PARTUM HAEMORRHAGE.

As this is more apt to occur after chloroform anaesthesia than under other circumstances, great care must be taken to prevent it. The uterine muscle, after chloroform, is in a state of relaxation, and does not contract so well as it usually does when no anaesthesia is administered. The treatment is to keep up a firm pressure with the hand, for some time after delivery, on the uterus, so as to ensure proper contraction. The accoucheur should remain in the house a longer time after the birth of the child than he would do under normal circumstances.
REFERENCES

Aselepiad of Jan., 1892.
Cl.Ed., lvii
Bernard; Claude: Lecons sur les Anesth. et sur l’Asphyxie.
1875.
Brunton; Sir Lauder: Pharmacology and Therapeutics, p. 111,
3d, edn.
Bradbury: Lancet, June 24, 1899, p. 1685.
Bickersteth, E.R.: On the Mode of Death from the Inhalation
xvii, p. 220.
Alcohol before Chloroform."
Dastre: Les Anesthesique, 1890.
Dioscorides: De Med. Nat., Bk. iv, Sec. 78 (contains earliest
allusion to the employment of narcotics
for the relief of pain).
De St. Martin: Recherches expér. sur la Resp.
Fehling: Arch. f. Gyn., ix, p. 313.
Galen: Lib. iv, p. 207.
Homer: Odyssey, iv, 220 (contains earliest reference to the use of a narcotic).
Kappeler: Anaesthesia.
Kundel: Handb. der Toxikol., Pt. i, 1890, p. 449.
Lenz: Dissert. Dorpat., 1893.
Lahs: Arch. f. Gyn., xi, p. 22.
Olshausen: Samml. klin. Vort., 1872, No. 44.
Oliver and Garrett: Lancet, Sept. 9, 1893.
Richardson: On. Death from Chloroform. Med. Times and Gaz., 1870, July 23, p. 35; Asclepiad, Jan., 1892; The
Hospital, Mar. 17, 1894, p. 431.

Report of the Hyderabad Commissioners, 1889.


Report of the Second ditto, 1893

" " Third " 1901.

Richet: Dict. de Physiol.


Rosenberg: Berl. klin. Woch., 1895, Nos. 1 and 2.

Schiedeberg: Arch. f. Physiol. Heilk., viii, 1887.


Scheinesson: Dissert. Dorpat, 1868.


Snow, Jno.: Chloroform and Other Anaesthetics, 1858.

Simms, Marion: The Discovery of Anaesthetics.


Smith, Grieg: Ibid., Mar. 12, 1892.


Sokoloff: Wratsch, St. Petersburg, 1891, No. 4.

Silvester, Henry R.: The Discovery of the Physiological Method of Inducing Respiration in Cases of Apparent Death from Drowning, Chloroform, Still-Birth, Noxious Gases, etc., 1863.


Turnbull: Artificial Anaesthesia, p. 252.


Yweifel: Berl. klin. Woch., 1874, No. 21; Arch. f. Gyn., x, p. 400; xii, p. 235.