A PHYSIOLOGICAL CONTRIBUTION TO THE PROBLEM OF CHLOROFORM ANAESTHESIA.*

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ALLOW me to preface my remarks by the briefest possible reference to the three diagrams. They are the diagrams that I utilized seven and six years ago at Montreal and at the Society of Anaesthetists to illustrate and emphasize what in my opinion are three capital points in the doctrine of safe anaesthesia.

The first point, illustrated by the diagram of the comparative effects of Et_2O and CHCl_3 , is that ether is less powerful than chloroform, that CHCl_3 is more dangerous than Et_2O , from which I continue to draw the inference that the ignorant use of CHCl_3 for the purposes of minor surgery is not justified.

The second illustrates the parallelism between the action of anaesthetics upon nervous tissues and upon cardiac tissues.

The third illustrates and emphasizes the fact that CHCl_3 is not an uncertain reagent, but that it produces effects strictly proportional to the mass in which it acts. From this second portion of my inquiry I drew the inference and stated as a practical rule that CHCl_3 for purposes of anaesthesia should be administered in dilution with air at a percentage of not below 1 per cent. and not above 2 per cent.

Fig. 1.—Showing that chloroform is more powerful than ether. A drachm of chloroform is physiologically equivalent to an ounce of ether.

By a fortunate conjuncture, you have brought together men possessing an extensive clinical experience of CHCl_3 , like your Chairman, Dr. Eastes, and Dr. Hobday, with students of the subject from the laboratory standpoint—and may I name myself in that capacity?—and, among our foreign visitors, Dr. Guglielminetti, who has been kind enough to give us an opportunity of witnessing in action an apparatus that has been considerably used in Germany during the past year for the regulated administration of CHCl_3 .

It had been my original intention to confine to-day's demonstration to that of the apparatus now before you—the wick vaporizer—which has been in use in this laboratory for the last two months, to fulfil in more simple fashion the indication so well fulfilled by Dubois's apparatus of supplying to a patient—cat, dog, or man—a volume of CHCl_3 and air of desirable and easily-regulated dilution, and in volume more than sufficient for the requirements of normal respiration.

The Dubois apparatus is, in my opinion, as safe an apparatus as can be made. On the other hand, it is heavy, expensive, and of a complicated appearance. I must say, however, that I cannot admit that these disadvantages outweigh the supreme advantage of safety. In my own case or in that of a relative, if anaesthesia were required, I should certainly

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require Dubois's apparatus to be used. I am not alone in this opinion; it is shared by every competent and disinterested person who has witnessed the apparatus in use and mastered its principle. It is now in action; a cat is placed under a bell-jar, through which CHCl_3 and air nominally at 2 per cent. is being pumped at a rate of 10 to 20 litres per minute, precisely as it is pumped through an open facepiece for clinical purposes. Surgical anaesthesia will be induced in not less than five minutes, and not more than ten minutes.

Fig. 2. Showing the parallelism of action of some anaesthetics upon nervous and upon cardiac tissues.

I say nominally 2 per cent., and shall control this value by means of this glass bulb that you see upon the delivery tube.

This method of estimation is in point of fact the most important part of my communication, and whatever the time at my disposal, be it short or long, I wish to make the demonstration and the explanation of this matter deliberately and intelligibly.

The principle upon which the method is based is as follows:

1,000 c.cm. of CHCl_3 vapour weigh 5.325 mg.

1,000 c.cm. of atmospheric air weigh 1.293 mg.

Difference ... 4.032 mg.

that is, 1,000 c.cm. of CHCl_3 vapour replacing 1,000 c.cm. of air gives an increment of weight of 4.032 mg., or, that is, 1 c.cm. of CHCl_3 vapour replacing 1 c.cm. of air gives an increment of weight of 4 mg., or, that is, 2.5 c.cm. of CHCl_3 vapour; 2.5 c.cm. of air gives an increment of weight of 10 mg., so that with a 250 c.cm. bulb, each 2.5 c.cm. of CHCl_3 vapour, that is, each 1 per cent., is represented by an increment of weight of 10 mg. The bulb on the delivery tube of the Dubois now in action is stoppered, removed, and placed on the balance; the increment of weight is found to be 26 mg.: the percentage of CHCl_3 vapour in the atmosphere by which this cat was chloroformed was therefore 2.6, and I shall not trouble you with the temperature correction now, for it is negligible for our present purpose, and a 265 c.cm. bulb has been taken to allow for our average room temperature of 18° with the barometer at 760 mm.

The wick vaporizer consists of a 3-wick lamp with a breadth of wick of 66 mm., so that a length of 75 mm. exposes an area of evaporation of 50 cm^2 . I found by preliminary trial that at ordinary room temperature this area gave off rather more than 1 per cent. of chloroform vapour to a continuous air-current of 8 to 12 litres per minute, and that a second and third wick raised the percentage to about 2 per cent. and to

Fig. 3.—Showing that the effect of chloroform and air upon nervous tissue is in ratio with the concentration of the mixture.

nearly 3 per cent. The continuous air-stream was secured by a narrow orifice in a metal plate fixed in the tube leading to the vaporizer from an ordinary foot-bellows as used by glass-blowers. The figures of a particular trial made just previous to its application to the human subject were:

With 1 wick ...	1.3 per cent.
„ 2 wicks ...	1.9 „
„ 3 „ ...	2.8 „

In the present case air is being pumped through a bell jar at the rate of 10 to 15 litres per minute, with two wicks in action, giving an anaesthetic mixture that I guess to be at or about 2 per cent., my guess to be confirmed or not by means of the densimetric bulb placed in the course of the delivery tube. The cat in this second case will be anaesthetized in not less than five minutes, nor more than ten minutes. (This proved to be the case, and the percentage indicated by the densimetric bulb was 2 per cent. This precise figure was of course an accident.)

By a fortunate coincidence I have had the opportunity this morning of applying the method of estimation that you have just witnessed to a method of anaesthetization that Dr. Hobdey has employed in many thousand cases on dogs and horses without any accident that he could attribute to the CHCl_3 . In Dr. Hobdey's methods, CHCl_3 is delivered to the mask by a current of air passed over the surface of CHCl_3 instead of through the liquid itself as practised in the Junker apparatus. From the tests we made together this morning it turned out that the percentage by Dr. Hobdey's procedure came out at 1.9 and 2.2 in two successive trials.

By another fortunate coincidence Dr. Guglielminetti arrived in the laboratory half an hour ago with an apparatus

now before you that has been successfully used in Germany during the past year. I take it that you will be as interested as I am to witness the mode of action of this apparatus and a first test of its percentage of delivery which we shall at once make by means of a densimetric bulb. Dr. Guglielminetti will himself explain the apparatus to you in detail. I will merely remark, without expressing any opinion on the combination, that the apparatus is designed to supply to the facepiece a mixture consisting of (1) a measured volume of oxygen, (2) a volume of CHCl_3 vapour derived from a measured number of drops of CHCl_3 . In addition to this $\text{O}_2 + \text{CHCl}_3$ vapour, the patient inspires more or less air. As Dr. Guglielminetti has now set the apparatus, the delivery is 3 litres of O_2 per minute + 60 drops of liquid CHCl_3 per minute, which with ordinary respiration of a patient would be supplemented by the inspiration of 3 to 6 litres per minute of atmospheric air. We place a densimeter on the delivery tube to weigh the mixture of $\text{O}_2 + \text{CHCl}_3$, and compare it with the weight of O_2 alone. The difference of weight has come out at 44 mg., indicating 4.4 per cent. (or more precisely calculated 4.5 per cent.). If the patient to whom this mixture had been supplied breathed an additional 3 to 6 litres of air, the percentage of CHCl_3 in the inspired mixture would be 2.25 and 1.5.

I think you will be disposed to admit that a method of estimation enabling us to make expeditious determinations of CHCl_3 percentage, and in the course of a single day, in a lecture, which is notoriously an occasion of experimental difficulty and failure, to make an improvised determination of novel apparatus, is a valuable method.

Fig. 4.—Delivery of CHCl_3 and air at between 1 and 2 per 100 dilution by a wick vaporizer to an animal under a bell-jar, as practised in a physiological laboratory. For clinical use an open facepiece takes the place of the bell-jar.

PS.—The delivery of the Roth-Dräger apparatus shown by Dr. Guglielminetti was subsequently tested at leisure by Mr. W. L. Symes. With an oxygen delivery of 3 litres per minute the drop-rates of the chloroform tallied exactly with the indications of the scale, and the concentration of the chloroform vapour in the mixtures delivered to the mask was as follows:

Chloroform Evaporated.	Concentration of Chloroform Vapour in Mixture of Chloroform and Oxygen.
25 drops per minute	2.5 per cent.
50 drops per minute	5.3 per cent.
75 drops per minute	7.6 per cent.

Ninety-eight to one hundred drops was the delivery per 1 c.cm. liquid chloroform, so that the volume of chloroform vapour per drop of 1.37 c.cm. was as nearly as possible 3 c.cm.