reflect that cases with heart affections do die suddenly, and that many patients with heart affections do have digitalis given them, it is not surprising that some cases with heart affections who are taking digitalis do die suddenly, but it is not quite logical to attribute the death to digitalis. As I have said, I have had a number of sudden deaths from auricular fibrillation in cases who were not taking digitalis, and I have given digitalis on the lines laid down here to a very large number of patients, and I have never had a sudden death among my own patients; but I must insist upon the effect of the drug being watched, and the drug stopped when the signs of a sufficiency appear. I have frequently seen in consultation patients who were in great distress, because the signs of a sufficiency were not recognized and the drug continued too long.

In these lectures I have endeavoured to draw attention to some of the more striking features of auricular fibrillation. It must not be supposed that I have exhausted the subject, for there are many phenomena which I have not considered, and many more which I have failed to observe. I meet frequently with cases which present new features, and I am at a loss to account for many of the symptoms. A wide field of investigation lies before the clinician, the physiologist, and the pharmacologist, but it is imperative, if ever the subject should be fully revealed, that the general practitioner should take his place as an investigator, for it is he who has the best opportunity of detecting its onset, and of watching the progress of individual cases.

INFUSION ANAESTHESIA :

THE USE OF NORMAL SALINE INFUSION AS A MEANS OF ADMINISTERING ETHER.

BY

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THE progress in the principles and technique of general anaesthesia has been marked in recent years by two considerable and separate advances. The first of these followed upon a long period devoted to the experimental study of the pharmacological properties of chloroform, and was based upon the demonstration of the fact that the inhalation of a vapour containing not more than 2 per cent. of chloroform was for all practical purposes free from danger. The establishment of this fact led to the invention and extensive use of numerous regulating inhalers; of these, perhaps the best known are the German Roth-Drüger, the French Dubois, and the English Vernon Harcourt. No sooner, however, had the advantages of these methods come to be realized than it began to be recognized that there are other dangers contingent upon the administration of chloroform than those which may develop during the actual course of the operation. The possibility that chloroform might be responsible for deaths occurring two or three days after it had been administered slowly won recognition for itself in spite of considerable opposition, and the conditions under which post-anaesthetic acidosis is most apt to develop are now fairly well defined. Although unanimity on this question is far from having been reached, one may venture to express the opinion that at the present day many anaesthetists would hesitate to administer and many surgeons would hesitate to consent to the administration of chloroform in cases of acute or chronic septic processes in the young, in states of inanition or of diabetes.

The increasing importance which is being attached to the possibilities of acidosis has naturally led to greater attention being directed to the use of ether, as that drug is undoubtedly less apt to produce this complication than is chloroform. The methods of administering ether formerly usual in this country very soon failed to justify themselves in the face of critical examination, and it was found that the closed inhaler was by no means so indispensable as had been supposed. The administration of ether by the open method, so long familiar in America, proved to be comparatively easy, and in a high degree satisfactory, in a large proportion of patients, specially the young and

weakly. It is questionable, however, whether the method would ever have come into extensive use in this country had it not been for the discovery that by combining the actions of certain narcotics and of atropine with that of ether an anaesthesia could always be obtained which had almost all the advantages of chloroform anaesthesia and none of its special dangers. The establishment of the value of the scopolamine-morphine-atropine-ether combination was the second great step in the development of general anaesthetics in recent years, and the opinion may be ventured that at the present time there is no anaesthetic of more general applicability. In regard to the comfort of the surgeon and the safety of the patient during the operation, in regard to post-anaesthetic acidosis, and finally in regard to post-anaesthetic gastric and pulmonary complications, this method, when applied to all classes of surgical practice, gives on the whole results which are decidedly better than those of chloroform. It is probable that this opinion would be most likely to meet with opposition in relation to post-anaesthetic lung complications. That it is, however, not altogether unsupported by evidence is shown by the following records from some of the German surgical clinics.

Anaesthesia Produced by Chloroform or Ether.

Surgeon.	Number of Laparotomies.	Percentage of Lung Complications.
Korte	3,909	7.2
Czerny	1,302	3.9
Kümmel	1,754	2.5
Trendelenburg	1,829	5.4

Anaesthesia Produced by Ether Administered by the Open Method.

Surgeon.	Number of Laparotomies.	Percentage of Lung Complications.
Krönlein	1,409	0.56

However much one may be disposed to allow for the effect of the personal factor in the making of these observations, the figures show an advantage on the side of the use of ether by the open method so great as to be unmistakable.

Within the last year it has become obvious that the superiority even of ether given by the open method is not to remain unchallenged. The great volatility of ether, and the necessity, therefore, of using it in enormous amounts when given by the open method, brings into prominence much more clearly than does chloroform the disadvantages inherent in the administration of anaesthetics by the respiratory tract. To this aspect of the matter a little further attention may perhaps be devoted, and an attempt made to enumerate some of the more obvious of the difficulties necessarily contingent upon the use of what may be called the respiratory method. In the first place, it limits one entirely to the use of highly volatile substances, and it would seem probable that if solubility rather than volatility were the only physical character demanded for the administration of an anaesthetic, pharmacological research might be able considerably to enlarge the number of available drugs. Secondly, the respiratory method must always in essence be indirect, the anaesthetic being absorbed from the vapour introduced into the air passages, so that the dose actually entering the blood is rendered variable by the notorious variability with which it enters the chest, being subject to all the accidents of laryngeal spasm, of respiratory spasm, and of variations in the depth and energy of respiration; furthermore, even supposing the vapour to be regularly introduced, it must be supposed that the absorption of it is greatly influenced by variations in the pressures to which it is exposed and by the presence of the large amount of mucus, the secretion of which it tends to excite. Thirdly, the exposure of the very great surface of the respiratory tract to an irritating vapour cannot but be regarded as a serious disadvantage and danger. To any one who has inhaled a breath or two of ether or of chloroform vapour it must always be a source of surprise that serious complications are not invariably produced by

a prolonged anaesthetic, as we know they quite frequently are. Fourthly, it is clear that to produce anaesthesia the anaesthetic drug must be introduced into the blood and maintained there at a certain percentage. Any further amount than this present in the body will act as a reservoir upon which the patient continues to draw after the administration has been stopped. Hence it must follow that it is an inherent disadvantage of the respiratory method that the absorption of the drug cannot be stopped abruptly, but must go on until the patient has rid himself of the vapour which fills his lungs and the anaesthetic-sodden mucus contained in his bronchial tubes and usually in his stomach as well. Many an anaesthetist has had cause to deplore the existence of this thoracic reservoir when during the administration of chloroform the patient has developed laryngeal spasm and has continued fatally to absorb the chloroform which was shut up in his lungs. The disadvantages of the respiratory method which have been enumerated in this paragraph are, it is obvious, greatly accentuated in all cases of intrathoracic disease. Fifthly, in operations on the mouth, jaws, or pharynx the difficulties of the surgeon, in the nature of the case quite great enough, are much increased by his having to share the field of operation with the anaesthetist, and it not infrequently happens that from time to time either the surgeon or the anaesthetist has to be content with a less

degree of technical perfection than he would have attained if he had not been embarrassed by the necessities of the other.

It is clear that the direct administration of an anaesthetic by the blood, if it can be safely effected, disposes of all these difficulties. For, being absolutely direct, the administration can be reduced to the minimum amount necessary, the drug can be introduced with perfect regularity and in an exactly measured dose, the administration can be stopped instantaneously, and the anaesthetist will know that there is no reservoir of the drug whatever upon which the patient can continue to draw, while, finally, the lungs are not exposed to irritation.

The possibility of administering ether intravenously does not seem to have been seriously entertained until within the last year or two. The method had been used upon animals experimentally by several observers before Burckhardt introduced the use of it in man. His immediate and striking success encouraged others to follow him, and all who have used the method speak of it with unqualified satisfaction. In April of this year Kummel, at the Berlin Surgical Congress, was able to report 90 cases. He speaks of the method very warmly. He found it particularly suitable in operations on the head and neck, and in patients greatly exhausted by prolonged and serious diseases. Such patients, he said, frequently leave the table in a much

Brief Summary of Cases in which Infusion Anaesthesia has been Employed.

No.	Nature of Case.	Nature of Operation.	Sex.	Age.	Condition Before Operation.	Induction.				Course of Anaesthesia.	Duration of Operation.	Dose.		Condition at End of Operation.	Post-Anaesthetic Vomiting.
						Time in Minutes.	Struggling.	Cyanosis.	Vomiting.			Ether in Ounces.	Saline in Pints.		
1	Malignant glands in neck	Extensive dissection	M.	45	Good	7	—	—	—	Some variation in depth	2 h.	2½	1½	Good	—
2	Intestinal obstruction	Inoperable malignant growth, colotomy	F.	47	Fair	5	—	—	—	Ditto	2½ h.	3	1½	Good	—
3	Femoral hernia	Radical cure	F.	60	Good	10	—	—	—	Regular depth throughout	1 h.	1½	1½	Good	—
4	Carcinoma of colon; faecal fistula; abscess of abdominal wall	Resection of ascending and transverse colon, and part of stomach	F.	32	Fair	15	—	—	—	Ditto	3½ h.	4½	4½	Slight shock	—
5	Sarcoma of upper jaw	Excision of upper jaw and malar bone, with malignant tumour of pterygoid region	M.	72	Fair	15	Slight	—	—	Ditto	2½ h.	3	3	Good	—
6	Gastric haemorrhage	Exploration of interior of stomach and duodenum for persistent haemorrhage	M.	58	Bad	15	—	—	—	Ditto	1½ h.	2	2	Fair	—
7	Pyelonephritis	Dislocation of kidney; incision and drainage	M.	19	Bad	12	—	—	—	Regular and light	1 h.	1½	1½	Bad	—
8	Chronic appendix abscess; (?) growth	Drainage of abscess and removal of appendix	M.	45	Good	13	Slight	—	—	Regular depth throughout	1½ h.	2	2	Good	—
9	Abscess of lung	Exploratory incision of lung	F.	28	Poor	12	—	—	—	Ditto	1 h.	1½	1½	Poor	—
10	Malignant glands in neck	Extensive dissection	M.	50	Good	17	Slight	—	—	Ditto	1½ h.	3	3	Good	—
11	Carcinoma of rectum	Exploration; colotomy	F.	34	Good	15	—	—	—	Ditto	1½ h.	2½	2½	Good	—
12	Acute intestinal obstruction	Colotomy	F.	50	Fair	12	—	—	—	Ditto	1 h.	1½	1½	Good	—
13	Gall stones	Cholecystectomy and removal of stones from the common duct	F.	60	Good	17	—	—	—	Slight straining	2½ h.	3½	3½	Good	—
14	Double irreducible inguinal hernia, one hernia inflamed	Bilateral radical cure	M.	49	Good	15	Slight	—	—	Regular depth throughout	1 h.	3	3	Good	—
15	Deflected septum, adhesions to turbinates	Submucous resection	M.	24	Good	12	—	—	—	Ditto	1 h.	1½	1½	Good	—
16	Cerebral tumour	Extensive decompression operation	F.	31	Fair	14	—	—	—	Ditto	1½ h.	2	2	Good	—
17	Epithelioma of tonsil	Resection of parts of upper and lower jaws and lateral wall of naso-pharynx	M.	49	Fair	16	+	—	—	Some shock throughout	2 h.	3½	3½	Fair	—
18	Bronchiectasis	Removal of ribs	F.	18	Fair	15	—	—	—	Regular depth throughout	1½ h.	1½	1½	—	—
19	Carcinoma of breast	Excision	F.	52	Poor	14	—	—	—	Regular light anaesthesia; some collapse	½ h.	1½	1½	Poor	—
20	Carcinoma of rectum	Combined abdomino-perineal operation	F.	56	Fair	13	—	—	—	Some shock	2 h.	4½	4½	Fair	2
21	Septic peritonitis, puerperal	Incision; drainage	F.	33	Very bad	10	—	—	—	Regular light anaesthesia	¾ h.	1	1	Bad	—

better condition than they were in before the operation, and they come round quickly and without discomfort. In no case of the 90 did post-anaesthetic vomiting occur, and this in spite of the fact that in a large number of the cases the operations were done for abdominal diseases of the gravest kind. In the subsequent discussion Hagemann referred to 11 cases in which the method had been used in the Greifswald clinic with satisfactory results. Claremont, Wendel, Beitmann, König, and von Sawadzki had also used it. Wendel of Magdeburg laid particular stress upon the value of infusion anaesthesia in operations upon the thorax with the hyperatmospheric apparatus; he had never seen any serious effects from the use of the method.

Technique.

Burckhardt, the originator of the method, used an ordinary infusion apparatus containing a 5 per cent. solution of ether in normal saline. He allowed enough of the solution to run in to produce surgical anaesthesia, and then interrupted the stream until the patient showed signs of coming round, when the dose was repeated. Kümmel and his co-editor, Schmitz-Pföffer, soon realized that the total interruption of the stream of fluid brought with it a tendency to thrombosis in and about the cannula. To counteract this disadvantage they arranged two vessels, either of which could be put into communication with the cannula separately; one contained the ether solution and the other normal saline. The procedure followed was to run in a dose of the anaesthetic adequate to produce anaesthesia, then, in order to maintain the continuity of the stream, to continue the infusion with a slow stream of saline, repeating the process as necessary. The uneven anaesthesia produced in this way has disadvantages from the point of view of the anaesthetist as well as from that of the surgeon, and these are particularly obvious to those who have learnt by experience to appreciate the smooth anaesthesia which can be obtained with a regulating chloroform inhaler. To the anaesthetist the great objection to methods of administration by periodic doses of the anaesthetic is that there is necessarily produced a greater concentration of the anaesthetic in the blood after each dose than is essential for adequate anaesthesia. This principle has been so fully emphasized by those to whom we owe the introduction of the Vernon Harcourt apparatus that it is not necessary for it to be further laboured here. Fully aware of the importance of this principle, one recognized quite early that by the application of it the infusion method might be freed from a defect inconsistent with the best modern practice. The chief modification, therefore, which is introduced into the apparatus is an indicator rendering possible a minute graduation of the inflowing stream.

Apparatus.

A 5 per cent. solution of ether in normal saline flows from a reservoir, which is fixed 8 ft. above the floor level, through the indicator, and then through a warming chamber into the cannula, and so into the vein. The indicator consists of a cylindrical bulb with a capacity of 8 oz. When the apparatus is working, the lower half is full of the solution, while the upper half contains air. The solution flows from the reservoir into the bulb through a pipette, and drips on to the surface of the fluid below. The system being a closed one, the pressure within it is transmitted through the indicator by means of the air contained therein; hence it follows that the rate at which the solution drips from the pipette furnishes a satisfactory index of the rate at which it is entering the vein. The flow is entirely controlled by one tap placed immediately below the indicator. When once anaesthesia is established, the ease with which the apparatus is controlled leaves the anaesthetist more than usually free to watch the condition of his patient.

Method of Induction.

An hour before the induction a hypodermic injection is given, which consists of scopolamine gr. $\frac{1}{100}$, morphine gr. $\frac{1}{4}$, atropine gr. $\frac{1}{100}$.

These doses are to be regarded as typical of those required for a fairly robust adult; in other cases they may have to be modified according to the age and condition of the patient. The patient is placed on the operating table and the selected arm lightly bandaged to a splint to prevent flexion of the elbow; a few drops of eucaine having been injected into the skin, the vein is exposed through an incision of a third of an inch. The cannula having been tied in, it and the wound are packed round with sterile gauze. The strictest asepsis is, of course, preserved throughout this procedure. The solution is run in rapidly during the period of induction, which usually lasts about ten minutes.

Conclusions.

It is usually possible to attain surgical anaesthesia with the use of 8 oz. of the solution, while for the maintenance of the anaesthesia as little as a pint an hour (1 oz. of ether) is in most cases enough.

The most striking features of infusion anaesthesia are:

1. Extreme flexibility so that the condition of the patient can be adjusted with great nicety and can be changed in the direction of deepening or lightening of anaesthesia with really remarkable rapidity.

2. That the patient begins to come round very soon after the anaesthetic is stopped and is able to converse rationally within a few minutes.

3. That post-anaesthetic vomiting and pulmonary irritation are both of them extremely rare.

As might be expected in cases where the condition of the patient is extremely bad, saline infusion in itself has a beneficial effect.

In some of the earlier cases a transient haemoglobinuria occurred after the operation; since the establishment of the use of a 5 per cent. solution no such complication has been observed though it has been carefully looked for.

The accompanying table (see p. 975) gives a brief summary of the cases in which this method of anaesthesia has been used. Mr. C. W. Morris has assisted me in almost every case and rendered invaluable help. I should like to take this opportunity of thanking Messrs. Wilfred Trotter and Morriston Davies for the interest they have shown in the method and their help in elaborating the technique.

THE SYMPHYSEAL LIGAMENT OF THE PARTURIENT GUINEA-PIG.

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PARTURITION in the guinea-pig is accompanied by an extraordinary change at the pubic symphysis. Owen described the change in this way: Prior to parturition the symphyseal ligaments become soft and extensible, and the innominate gliding on the sacro-iliac joints diverge at the symphysis. After this process the symphysis quickly returns to its former or normal state, and in a few days presents only a little thickness and mobility.¹ I have been unable to ascertain if this was an original observation on the part of Owen.

In 1902 the British Medical Association met at Manchester, and Professor Stirling communicated a note to the Section of Physiology and Anatomy entitled, Parturition in the Guinea-pig.² The very large size and relatively mature condition of the guinea-pig fetus and the narrow pelvic outlet of the female guinea-pig led Stirling to examine the condition of the pelvis at the time of parturition, and he was astonished to find the separation of the two halves of the symphysis and the wide expansion of the ligament.

Recently I endeavoured to satisfy myself on this matter. A pregnant guinea-pig was isolated and when the little