THE SURGICAL REQUIREMENTS OF NARCOSIS AND THE AVAILABLE METHODS.*

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THE old criteria of what constitutes surgical anaesthesia have undergone a marked change since the introduction of asepticism in surgical procedure. It has now become possible to undertake prolonged and complicated operations upon most regions of the body, which, when all environing circumstances are favourable, prolong the life of the patient or cure him of his malady. These environing circumstances fall equally within the province of the anaesthetist and the surgeon. They are (1) the condition of the patient, especially as regards the efficiency and sufficiency of his circulatory, respiratory, and metabolic systems, his resistive powers to trauma; (2) the character and duration of the operation, especially as regards its insult on tissues and extent of shock evolved by the concomitant trauma; (3) the characteristics of the anaesthetic employed, especially as regards its reaction towards tissues and liability to produce shock.

In the early days of surgical narcosis one criterion of the efficiency of anaesthesia was demanded—insensibility to pain. All the methods employed culminated in this. They were intermittent in plan, so much was given, and when conjunctival reflex, or absence of response to slight trauma, was obtained, the supply of anaesthetic was suspended until evidence of return to consciousness warned the administrator that a further supply of the anaesthetic was required. This system, while providing a valuable help to the anaesthetist, yet increased the risk to the patient, since he was constantly see-sawing between oblivion and dawning sensation, and also because he was subjected to an uneven dosage of the anaesthetic, at one moment large, at another small. The douche method of employing chloroform, which has persisted, supplies an example of this. When a drachm is poured upon the domette cover the strength of vapour it supplies is 3 per cent. vapour at first, and this, after five aspirations, drops to 2 per cent., and so on, to be raised again to 3 per cent. when a fresh douche is poured on.

The first great advance in anaesthesia was achieved when a continuous system of supply was introduced. At this period, in the case of ether, an inhaler, either closed or semiclosed, was employed; but chloroform, although used from a dosimetric inhaler by a few experts, was in the main employed by the plan of constant dropping upon an absorptive surface.

The physiological counterpart of mere loss of perception of pain is the lulling to sleep of the higher brain centres. Dastre has painted in vivid colours the gradual procession of events during narcosis—the initial excitation, the subsequent paresing of the centres, those most highly differentiated first, those involved in automatic and vital processes last. But the effects are continuous and there are no definite halting points—insensience, fall of blood pressure involving a poor supply of blood to the central nervous system, impaired lung ventilation, gradually lessened force of breathing and slowing of the rhythm of respiration, gradual but progressive suppression of tissue metabolism by abolition of the biochemical action, then heart standstill, respiratory collapse and tissue death.

It is, perhaps, an easy matter—at least, the power can be acquired—to render a patient anaesthetic and maintain him at that; but, rightly or wrongly, in many cases this is not enough for the surgeon's purposes. The lower reflex centres, as Crile has pointed out, remain more or less active, and unconscious muscular movements may in many instances be provoked by stimuli originated by the steps of the operation. The rigidity of the recti abdominis muscles, the opprobrium alike of the surgeon and the anaesthetist, is, in fact, either an asphyxial effect of overdosage or a reflex protective response to peripheral

stimuli which is frequently produced in anaesthesia over an habitually painful area. The rigidity is a muscular action quite on all-fours with the sudden flexion of the thighs upon the pelvis so common in children during the operation of circumcision.

The abolition of all muscular movements, muscular flaccidity, slow shallow breathing, and abeyance of reflexes are demanded, desiderata which are obviously far more than mere anaesthesia, and it was for this reason that I employed the term "narcosis" rather than "anaesthesia" in the title of this paper. As an example of this let me refer to the modern operation of enucleating the tonsils. The surgeon in this case requires that chloroform shall be given, that the muscles of the velum palati shall be absolutely flaccid, that the pharyngeal reflexes shall be practically extinguished, and then, through the exigencies of the operation, he more or less occludes the air passages during his manipulation of the tonsil. There is as a rule but little bleeding, but occasionally, through some defect in the method of anaesthetizing or through some surgical mischance, there may be smart haemorrhage causing further interference with respiration. This in a profound degree of narcosis cannot but make for difficulty, and often for acute danger.

It is clear, then, that the exigencies of the operation may call for a degree of narcosis far transcending the third degree, that is, the stage of anaesthesia. This depth of narcosis has to be arrived at before the operation is commenced, and the danger arises of overdosage during the period of induction. When, however, the actual operation is in progress new factors come into play. It has been shown by Leonard Hill and others that a condition of profound narcosis, when the medullary centres controlling circulation and respiration are both deeply drugged by the anaesthetic and deprived of properly oxygenated blood, they are more than commonly prejudiced by any superadded interference with respiration. Such a contingency may arise during operations on the mouth, nose, pharynx, and glands, and be caused directly through the necessary steps of the operation. It may result in thoracic or abdominal operations through fluids expelled from the lungs or stomach, which drown the patient whose laryngeal reflex has been allowed to become abolished. Other effects produced by the anaesthetic directly, but brought about indirectly by the operation, are that during prolonged operations the tissues of the patient suffer from prolonged contact with the anaesthetic, especially if that agent is given in large quantity or in a concentrated form, and "shock"—anaesthetic shock—becomes developed. Again, the actual progress of the surgeon's work, by causing haemorrhage, trauma—that is, damage to tissues, and especially dragging upon viscera and the visceral peritoneum—will produce "shock." Thus when the dangers of the period of induction are passed the patient becomes beset by the peril of shock due alike to surgical and anaesthetic causes. This peril may be immediate, and lead to death upon the table, or delayed so that the patient expires within the following twenty-four hours or later. I am assuming that this shock is a necessary result of an inevitable operation, and as such must be accepted. The anaesthetist's duty will consist in adopting measures to counteract as far as possible such a danger.

In the first place, the condition of the patient at the time of the operation and before its commencement requires careful study. He may be practically normal or be in an advanced state of pre-existent shock. Take the two conditions: on the one hand, a robust man of, say, 25 years of age, with a rapidly growing sarcoma of the thigh, and, on the other, the stout, emphysematous man of 70, suffering from intestinal obstruction with faecal vomiting. Between these degrees one meets with every degree of incipient shock. Secondly, the anaesthetist has to gauge the recuperative power of his patient. No obvious shock may exist before the operation has commenced, but there is marked anaemia, the blood pressure is low, the lung ventilation is abnormally slight, and the kidneys are what Sir Andrew Clark was wont to term "inadequate." This type of patient will develop shock rapidly, and will withstand the insult to his tissues with difficulty.

SHOCK.

To comprehend the plan of campaign which the anaesthetist must adopt, it is essential that there should be a

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clear understanding of what is meant by the term "shock," and what are its physiological causes.

The salient features of shock are—fall of blood pressure, lowered temperature, weak breathing with greatly diminished lung ventilation. The causes are usually ascribed to exhaustion of the vasomotor nervous mechanism arising from frequent peripheral stimulation through sensory tracts. It is assumed that blocking of these tracts by means which remove temporarily their conductivity will prevent this shock. It appears that some forms of trauma induce greater degrees of shock than others—thus dragging upon viscera, peritoneal structures, crushing, tearing, and rough handling induce the maximal result. Depletion of the nervous centres of blood, or supplying them with blood of poor quality or which contains a toxic ingredient—for example, a super-venous character, an excess of carbonic dioxide, excess of ether, of chloroform or other anaesthetic—will predispose to shock and intensify its effects.

Assuming that these views really cover the ground of shock pathogenesis, various means have been suggested whereby shock may be eliminated or diminished. Leonard Corning, many years ago, suggested blocking the sensory area of operation by tightly fitting cords on the heart side of the area involved, and injection of an analgesic into the site of operation, in order to render the terminals of the sensory nerves apathetic. He further suggested injections into the theca of the cord, with the view of blocking all stimulation along the sensory roots.

We are now familiar with Schleich's infiltration method of local analgesia, Oberst's attempts to block large sensory nerves in their continuity, and von Bier's subarachnoid injection, the technique of which has been so successfully practised and improved by A. E. Barker.

Unfortunately the problem, like most of those presented by the practice of anaesthesia, cannot be stated in such simple terms; and, further, most of the methods mentioned, even if they fulfil their intention and remove or diminish shock to an appreciable extent, are liable to introduce fresh and often dangerous complications into the case. Perhaps we avoid the perils of Scylla only to be swept into the vortex of Charybdis. As regards the effect of inhalational anaesthetics upon anaesthesia, it is argued that while on the one hand they may induce lowering of blood pressure and diminish lung ventilation, so on the other hand they may, if given in diminished doses, fail to block sensory areas, and thus increase shock. An ingenious theory, which, however, has not been experimentally proved, was propounded, that in light anaesthesia sensory stimulation, when it reached the cord, escaped from its normal channels through the fact that the cord regulating systems were thrown out of gear, and so the exciting effects overflowed into neighbouring nerve channels, and led to a number of reflex results which could only arise under narcosis. Hence, we are told, the danger of light anaesthesia is one with which we have to reckon. It would appear that we get it both ways. Much of this argument, I submit, arises from a confusion of terms, if not of thought. Without venturing to disparage the brilliant work done by Crile, elucidatory of surgical shock, we must bear in mind that his views are not accepted by all as covering the ground he proposed to travel. This has recently been enforced by Malcolm.¹ Shock, as we meet with it in our everyday work, is sharply divided into two conditions: (1) Sudden, such as shows itself in a patient apparently in absolute safety and revealing no shock phenomena until some surgical procedure is performed, such as tearing away a prostate, and (2) gradually developing conditions marked by a falling blood pressure and diminished pulmonary ventilation. Even if exhaustion of the vasomotor centres through overstimulation exists in the second state it hardly explains the first. There appears to be ground for the belief that besides fatigue of the medullary centres and synapses, other causes are at work in bringing about the complex condition which we term shock. Vasomotor dilatation which should result from exhaustion of the centres is by some denied, and indeed vasomotor constriction with gradually developing cardiac tetanus is declared to be produced by those procedures which are provocative of shock. Yandell Henderson has extended the researches of Meischner, Mosso, Haldane, and others, and applied the acapnia theory as explicative of shock. Starling and Jerusalem endorse

Henderson's experimental work, and show that deficiency of carbonic dioxide in the blood causes diminution of the cardiac output, and fall of blood pressure. An optimum tension of carbonic dioxide in the blood exists which gives the maximum cardiac output per minute,² and it is probable that this optimum rises as the temperature of the blood in the coronary system falls. Yandell Henderson's observations show that in such operations as abdominal sections, which are most liable to engender shock, the exposure of large serous surfaces leads to a rapid loss of carbonic dioxide from the blood stream. It will be evident from your clinical experience that the cases in which most anxiety is present are those which, on the one hand, give rise to vagal action, cardiac inhibition, respiratory failure, and sudden fall of blood pressure, and on the other, those of patients who are the subjects of abnormal terror. In dealing with the first class we should achieve our object if we were able to block the afferent or sensory impulses by local or intrathecal injections, or by paring the vagi nerves and vagus centres.

But even if we adopt the measures for blocking the sensory paths, and do so effectively, we fail to eliminate the psychic shock, which in its turn produces severe and even fatal shock effects, even though no pain is experienced. In this way we fail to "minister to a mind diseased." Nor can we control vagal interference by any degree of narcosis which is compatible with the proper performance of circulation and respiration. With the narcotizing by anaesthetic agents of the vagal centres, destruction of the kindred vasomotor and other centres in the medulla oblongata must occur. Indeed, it has been experimentally proved in the case of chloroform—at all events, in dogs—that one of the effects of large doses, that is, high percentages of vapour, is to superinduce hyperexcitability of the vagal centres, so that even slight sensory stimulation usually produces cardiac standstill. From this inhibition, if the blood circulating through the tissues contains a certain tension of the anaesthetic, the heart cannot escape. In order to understand the practical aspects of the subject with which I propose to conclude my paper, we must refer to the after-effects of anaesthetics. It is not enough for us to carry our patient through the dangers of the period of induction and the stress of the operation: we have to order our measures so that he may not succumb to increasing shock, pneumonia, renal catarrh, uraemic convulsions, acidosis, glycosuric coma, developing after the completion of the operation. I will not occupy your time with discussing how far the anaesthetic is accountable for these disasters. In the case of pneumonia³ and renal complications⁴ I have dealt at length with the matter elsewhere. All these effects depend upon the actual quantity and dosage of the anaesthetic employed. The mechanism by which they are produced is, no doubt, complicated by the nature of the operative procedure, by starvation too rigidly enjoined before the administration, and often by the concomitant asphyxial element which certain methods of giving anaesthetics allow to creep in. The main point, however, so far as the anaesthetic is concerned, is the effect upon the tissues produced by the elimination of the drug. Upon the cells of the liver, of the kidneys, and of the lungs the brunt mainly falls. We know that the effects of the various anaesthetics differ, those into which a haloid salt enters being the most destructive to protoplasm, but we cannot doubt that the injury to the tissues concerned must vary directly as the amount which has to pass from the blood through the excreting organs. In too many cases this question of elimination is lost sight of, and because an anaesthetic offers supreme safety for brief operations it is vaunted as safest under all conditions.

We come, then, to the practical issues of this paper—how to deal with particular types of patient; how to deal with particular classes of surgical procedure.

THE EXAMINATION OF THE PATIENTS.

We may roughly class the patients into:

1. Normal.
2. Mechanically deficient.
3. Asthenic.
4. Those with circulatory abnormality.
5. Those with respiratory abnormality.
6. Those with metabolic abnormality:
 - (a) The obese; (b) hepatic derangement; (c) renal derangement.

7. Those with some affection of the central nervous system.
8. Those with general disease—for example, lymphatism.
9. The alcoholic and those addicted to a drug habit.

1. Normal Patients.

The only points of especial interest about normal patients are those of age—the very young and the very old—physique, and nerve stamina. Physique is the most important consideration; age must be reckoned less by years than by the evidences of tissue wear and tear. It is always worth remembering that a patient who has withstood the stress of life until an advanced age has a great reserve store of strength, and will win through crises which would be fatal to younger and less robust persons. Personal history, the mode of life and habits as regards exercise, food, alcohol, all help. The very young have a less stable nervous system, lose heat rapidly, and suffer early from shock; they readily fall the victims to nerve storms, and fear or fright damages them more than others. Rapidity of the induction of anaesthesia, and very gentle handling should be guiding principles, and one must never lose sight of the importance of giving as little of the anaesthetic as is possible after the induction is completed. It is surprising how little is really required, and the danger of continued administration of an anaesthetic in a strength which is even slightly above what is adequate rapidly damages the delicate tissues of the child. Above all things, unlearn the old dictum that children and parturients enjoy immunity towards chloroform, and, I would add, accept with caution the other dictum, "chloroform before six and after sixty," because ether is a valuable anaesthetic for even younger children if given properly, wisely, and for not too prolonged a period.

As to physique, I would add a caution about powerful muscular persons, apparently in the heyday of manly vigour. As a rule, such tolerate anaesthetics, certainly during the induction period, less well than do the feeble and languishing. Remember the chances of heart strain, athlete's heart, conditions which tell against a patient who struggles during the induction. For such types of persons nitrous oxide gas is the best agent for commencing; then ether may be given, even if chloroform has been decided upon for the period of maintenance of anaesthesia. This sequence should also be employed for alcoholics in middle life.

2. Mechanical Difficulties.

It would take too long to consider all these conditions; I propose to deal with:

- (a) Obstruction in the air passages.
- (b) Postural interference with respiration necessitated by the exigencies of the operation.
- (c) Interference with respiration due to intrathoracic or intra-abdominal disease.
- (d) Interference with respiration due to disease or injury to the central nervous system, such as cerebellar tumours, pressure upon or damage to the spinal cord producing paralysis of respiratory muscles.

(a) *Obstruction in the Air Passages.*—The operation for removing post-nasal adenoid growths and hypertrophied tonsils, although regarded as a simple affair, yet to the anaesthetist presents grave difficulties. Its dangers are evidenced by the disproportionate number of deaths which occur during its performance. The patients are commonly delicate, often lymphatic, and generally fat and soft, and their pulmonary ventilation and blood pressure are below the normal. The operation may be very simple and rapidly performed, but on the other hand it often presents unforeseen difficulties and so becomes prolonged. Nitrous oxide gas with oxygen is undoubtedly sufficient for the rapid operator to perform removal of the adenoid masses, but does not allow deliberate tonsillotomy or tonsillectomy in addition. The attempt when made leads to scrambling, rough manipulation, and undue interference with respiration. These make for haemorrhage and shock. Children of the type to which I refer cannot with impunity suffer any blood loss or sustain shock. Personally I regard ethyl chloride as a dangerous anaesthetic for these cases, as it depresses the circulation, but when followed by ether it gives us an excellent sequence. It is often urged by surgeons that ether for these cases causes more bleeding than chloroform, leads to excessive salivation, and so renders the operation more difficult. However, if

ether is properly administered and all asphyxial conditions are avoided, excessive bleeding need not occur, while by its use the shock is minimized. For complete tonsillectomy, when cautious and slow enucleation is performed, one is compelled to select a chloroform mixture, and the 1 volume of alcohol in 10 of chloroform is, I think, far better than the A.C.E. or C.E. mixtures. Crile has suggested that for all operations on the mouth and nose pharyngeal plugging and anaesthesia carried on through an intubation tube should be practised, and this plan, although hardly practicable for the cases we are discussing, is valuable for tongue and jaw cases.

Alternative methods are prolonged chloride of ethyl administered by Barton's apparatus; open ether induction followed by ether vapour given through a tube from a warmed chamber through which warm air or oxygen is carried.

A class of cases which are difficult to manage is that which includes goitres and granular growths pressing upon or displacing the trachea. Involvement of the laryngeal nerves increases the danger. There is a complication in goitre cases which is sometimes lost sight of: the tendency these patients have to profuse secretion both from the salivary and tracheal glands. When the thyroid enlargement is associated with the other symptoms of Graves's disease the acme of danger is attained. Chloroform used by the older methods led to, or was associated with, a high mortality, and this led Kocher and others to extol the merits of local injections by Schleich's infiltration method. This plan, admirable though it is in small adenomatous cases, fails to remove one grave factor causing fatality—it does not abrogate either traumatic or psychic shock. Nitrous oxide, even with oxygen, causes too much turgescence, and increases respiratory difficulties. With ethyl chloride the patient is either too deeply or too lightly narcotized, the level of anaesthesia can hardly be maintained. Ether given by closed methods undoubtedly increases turgescence, and provokes increase of saliva and mucus, which interfere with breathing. Mrs. Dickinson Berry, who has used an open ether method largely in these cases, insists that with care it can be safely and advantageously employed.

The safest method if ether is used is to inject atropine gr. $\frac{1}{10}$, or this together with morphine and scopolamine, half an hour before giving ether by the open method. In this way a certain diminution of the bronchial secretion can in some cases be obtained, but in my own experience this dose of atropine will not always prevent salivation, and if it does it is liable to cause discomfort for hours, owing to the dryness of the mouth and pharynx.

I have given anaesthetics to a large number of cases of goitre, both simple, malignant, and exophthalmic, and I have used chloroform in low percentage vapour with a copious stream of oxygen. This plan has so far answered extremely well, and possesses the great advantage that one can readily lighten and deepen narcosis as the steps of the operation demand. Although I have never employed rectal etherization for these cases, I have done so for laryngectomy, but the plan, valuable as an alternative, has inherent objections which make it less useful now that we possess accurate means of giving chloroform in definite percentages.

I may mention here that Crile regards the main danger of exophthalmic goitre operations as consisting in the abnormal dread—that is, "psychic shock"—which is usually existent. He would overcome this by daily injections of scopolamine and morphine under the pretext of examination, and when the patient is accustomed to these he withholds from him the knowledge that an operation will be performed, increases the dose of the injection, and administers a general anaesthetic; then the tumour is removed. This plan, although ingenious, might involve the surgeon in pains and penalties if the patient became recalcitrant or his friends intervened after a fatal issue.

(b) *Postural Interference with Respiration.*—The lateral and the prone decubitus, especially in obese and heavy patients, and when in the former case the arm is allowed to fall upon the chest, may cause complete cessation of respiration. The use of an arm rest, or, failing that, the holding up of the uppermost shoulder by an assistant, will obviate the danger. But under no circumstances must cyanosis be overlooked or allowed to increase; oxygen in such contingencies is of the utmost value.

The extreme Trendelenburg and lithotomy positions also interfere with breathing—in the former case, through the venous congestion, evidenced by the face becoming deeply cyanosed; and in the latter, possibly through the thighs being pressed upon the abdomen, pushing up its contents, and so preventing the normal play of the diaphragm.

In the Trendelenburg position actual oedema of the soft tissues about the eyes may occur. A case of this character was published by Mr. Carter Braine. So extreme may be the dyspnoea caused by overflexion of the thighs in the lithotomy position that breathing under chloroform may cease, and cases have occurred in which only prompt recourse to artificial respiration has prevented a fatal result. Of course, in these cases the anaesthetic is a factor making for danger, since, in the postures indicated, the usual amount of anaesthetic is too much. The onset of cyanosis means the respiratory centre is not properly supplied with oxygen, and so the lethal dose is diminished. When this fact is remembered the remedies at once suggest themselves—a lessening of the strength of the vapour of the anaesthetic and the total amount of the anaesthetic given, while an abundant supply of oxygen is offered.

(c) As in the case of pressure exerted upon the trachea, so in that of interference with respiration through intra-thoracic and intra-abdominal tumours or collections of fluid in these cavities, the symptoms of dyspnoea often do not appear until the patients pass under the influence of the anaesthetic. While conscious they acquire the knack of adjusting their posture or what not, which enables them to breathe without apparent difficulty. When unconscious this power of adaptation to circumstances no longer exists, and dyspnoea, progressive to respiratory standstill, is liable to occur. The danger is due to impaired pulmonary ventilation, and the remedy lies in careful selection of the right anaesthetic, and adjustment of its strength to the capacity of the patient. Initial embarrassment of breathing contraindicates the use of an agent which will increase the dyspnoea by its local irritant quality, while it calls for a supply of oxygen to counteract the patient's difficulty of effecting sufficient pulmonary ventilation. But even if this necessary equilibrium is attained, there yet remains the danger of sudden death through incautious movement of the patient undertaken in order to facilitate the procedure of the operation. The more successful the anaesthetist may be in establishing satisfactory breathing under adverse conditions, the more liable is he to permit some sudden movement of the body, which may either allow fluid to pass from the diseased to the healthy lung, and so may water-log the only available air chamber, or may so disorganize the system of compensation effected as to produce fatal respiratory and heart embarrassments.

In the report of the British Medical Association published in 1900, certain deaths were associated with the inhalation of ether. In all of these persons the fatality arose through aspiration of faecal vomiting into the air passages. Probably no cases are more fraught with danger, and require more skill and judgement, than those in which we have to deal with intestinal obstruction with faecal vomiting. So soon as the muscular tonus is lost, the back pressure causes the stomach and intestinal contents to be regurgitated through the oesophagus into the pharynx, whence it is liable to be aspirated into the air passages. These patients are often *in extremis*, and their state does not permit of heroic measures. Lavage, valuable as it is, is only temporizing, for the stomach, once emptied, rapidly refills, and unless the condition of the patient admits of repeated washing out, the danger is not removed. I have suggested a means⁵ of combating the more serious cases by plugging the pharynx, and maintaining a free flow of the fluid through a stomach tube, while respiration and anaesthesia are carried on by means of intubation or a preliminary laryngotomy. Many surgeons prefer intrathecal injections in such cases, and I have seen some cases do extremely well. On the other hand, this procedure does not, in all instances, obviate aspiration of vomitus into the lungs, or prevent the fatal result. Further, the method imposes a severe strain upon the patient, who, even if he is without pain, remains conscious of the progress of the operation. Upon the whole, I believe a general anaesthetic in skilled hands offers the patient the best chance of life, especially if it is associated with local analgesia, practised upon the abdominal parietes,

thus enabling the surgeon to open the abdomen under light anaesthesia, and relieving the pressure due to the distension.

(d) Dyspnoea, through pressure in the region of the respiratory centre, or paralysis of the intercostal muscles, leaving intact only the mechanism for diaphragmatic respiration, desperate though the condition seems, may be met by a similar line of treatment. The respiratory centre is in such cases already narcotized by ineffectual respiration, and can only tolerate a minimal quantity of an anaesthetic, which should always be chloroform. Chloroform does not increase the respiratory work, as it does not fill the lung with watery secretion, nor does it stimulate the exhausted nerve centres and the fatigued heart muscle. Even a minimal amount of the anaesthetic will produce profound anaesthesia, while the associated tendency to a lowered oxygen content may be met by a free use of oxygen supplied from a cylinder. In desperate cases intubation and a rhythmic supply of oxygen, given alone or with the chloroform vapour, offers the best chance.

3. Asthenic Patients.

Asthenic patients present perhaps the most difficult problem. We have to deal with individuals who possess little resistive power against "shock." All their tissues appear to have their vitality lowered, while their nervous system is particularly liable to reflex shock, and is least able to withstand it. The preparation of the patient in such cases assumes the utmost importance; all depletive measures become dangerous, and it is advisable, whenever possible, to insist upon a three days' preparation, involving absolute rest, dieting, and the use of appropriate drugs. In the case of these patients the fear element bulks large, and I am convinced that the preliminary use of scopolamine-morphine injection is valuable. If ether is to be used, and it is often advisable that this agent should be adopted, atropine must be added to the preliminary injection. The condition of these patients makes them peculiarly liable to untoward sequelae—protracted and severe vomiting, pulmonary and renal catarrh, even pneumonia and uraemia may occur, although I think they are most commonly due to the incautious employment of unduly copious quantities of the anaesthetic, and so are preventable. This forms an additional reason for employing scopolamine and morphine before the general anaesthetic, since they lessen the quantity of the general anaesthetic required to a remarkable degree, and so fend off from such patients their gravest dangers.

4, 5, 6. Circulatory, Respiratory, and Metabolic Inadequacy.

When we turn to circulatory, respiratory, and metabolic inadequacy, we find that whatever applies to these conditions, applies equally to asthenic patients, and the courses of procedure suggested for the several types correspond. I need hardly dwell upon what to-day is common knowledge—that an infirm heart will not be helped by undue stimulation, that a respiratory enfeeblement is probably circulatory when traced to its source, and that perverted metabolism after anaesthesia is the result less of the use than of the abuse of an anaesthetic.

That some patients who do not "die" upon the table from the anaesthetic, are killed by it ultimately, I have no doubt. In the acute mode of death the medullary centres are poisoned, but in the delayed death the tissues are poisoned by doses of the anaesthetic in excess of what they can eliminate without being destroyed. And this statement, I believe, applies equally to such general diseases (8) as lymphatism. If the normal individual can sustain a certain percentage of an anaesthetic, the abnormal patient succumbs to still less, and it is the acumen and judgement of the anaesthetist which enables him to adjust the dose of the anaesthetic to the patient's requirements.

Patients who either through self-habitation to alcohol or other drugs, or through medical use of narcotics, have become inured to them, are commonly difficult to anaesthetize. We all know the inconvenience—and worse—which meet us when anaesthetizing the heavy drinker and confirmed smoker. One deals with them on general principles, but it is worth while to remember that although such persons require large quantities of an anaesthetic, yet they are peculiarly liable to anaesthetic collapse. In the

case of alcoholics, it is important to get them "under" rapidly and without struggling, so that I recommend the nitrous oxide-ether sequence, even though chloroform is to be used ultimately.

DOSAGE AND METHODS.

We now come to the inquiry, What means have we of regulating our doses, what methods offer the best chances in these cases, and how do these methods satisfy the requirements of the surgeon, who seeks not anaesthesia only, but a degree of narcotism which will abolish many of those reflexes which persist in normal anaesthesia, and will carry the narcotism as far as the medullary centres, lowering blood pressure and lessening respiratory movements?

These are:

- (a) Ether given by the open method.
- (b) Chloroform given by a regulating dosage method.
- (c) Injection into subdural space.
- (d) Local analgesia—intravenous injection.
- (e) Nitrous oxide associated with local injection.
- (f) Mixed methods of morphine scopolamine, and inhalant general anaesthetics.

We must deal briefly with these modes of procedure under the three heads:

- (1) As regards the patient's welfare.
- (2) As regards the operative procedure.
- (3) As regards the convalescence.

(a) *The Open Ether Method.*—Many plans, differing in important detail, have been adopted in America, on the Continent, and in this country:

- (i) The drop method of the Mayons.
- (ii) Allis inhaler with drop or douche.
- (iii) Professor Dumont's quasi open plan.

It is usual to overcome the profuse secretion of mucus and saliva incident to inhaling copious doses of ether by a preliminary hypodermic injection of atropine, while in the case of nervous persons and of those whose condition renders it advisable to restrict the amount of the general anaesthetic used, a preliminary hypodermic of scopolamine and morphine should be given simultaneously with the atropine. This plan possesses the advantage in some cases of dulling the respiratory centre and so making the thoracic movements less pronounced. The forced breathing so common when ether is used is a serious impediment to the surgeon in abdominal operations; but it can be controlled usually, although not always, by the combination of morphine and scopolamine when injected an hour before the anaesthetic is given.

There is one caution needed in reference to open ether methods: They are liable to produce overstimulation, and so intensify shock. This is not inherent in the methods, for with care a light narcosis can be maintained, although, as a rule, the necessity for this is not kept in mind. When oxygen is used with the ether, as it should be, it masks the usual signs of this overstimulation, for instead of the patient's face becoming dusky it remains cherry-red; however, the slower respiration and the softening of the pulse, together with the wide dilatation of the pupils, will always prove a sufficient indication of the danger which is being incurred. I have seen several cases abroad of the evil effects of open ether methods, especially when "douching" was employed.

The very large quantity of ether inhaled is in itself an evil, as it imposes a great strain on the organs concerned in elimination. In spite of the escape of vapour into the room, and the associated discomfort to surgeons and nurses, there is a strong feeling among many surgeons that patients who are in a septic condition are less liable to post-operation death when "open" ether methods are pursued. Personally, I believe the dangers of post-operative acidosis when chloroform is given are due in most cases rather to overdosage by the anaesthetic and the intrusion of asphyxial complications.

Snow showed that the most complete muscular relaxation was obtainable where ether was used; and when the operation calls for a very profound narcosis—that is, a degree transcending the third degree—ether is safer than chloroform, as it does not so readily paralyse the respiratory centre:

(b) That chloroform should be given by a dosimetric system is now generally conceded. The only matter of dispute is what plan is the best. Skilled workers rely upon their personal expertness when using an open drop or douche method, but such plans must be open to constant sources of error. The only really safe system is the use of an inhaler which accurately delivers definite percentages, and allows the anaesthetist to vary the strength of the vapour he is employing at will, and to meet the exigencies of the patient or the operation. Such inhalers are now obtainable, and, having a definite maximum, they are safer than when the patient receives unknown strengths, with no halting point between dosage and overdosage.

Of course, like all scientific apparatus, these inhalers require that the person using them should have mastered their mechanism.

The most portable of these dosimetric chloroform inhalers, and, as I think, the most satisfactory, is the Vernon Harcourt inhaler; and this is so, even although the inhaler in question is constructed on the "blow over," and not the "plenum," system.

(c) When one speaks of the method by intrathecal injection, one labours under some difficulties. It is extremely difficult to decide as to its merits merely from statistics. These are unfavourable when the results of a number of surgeons are grouped, but favourable when certain clinics are accepted as representative. That the plan is valuable in some cases cannot be denied, but that some patients run greater risks, suffer more severely from after-effects, and may be paralysed for weeks, seems to be true. The method commends itself to the surgeon, if muscular relaxation is obtained, but this is not always the case. The mental state of some patients is very deplorable under this form of analgesia, and to remedy this a preliminary injection of morphine and scopolamine is advised. The method has not shown itself so far to be of universal application; its technique is not always easy, and is hardly one which could be entrusted to a tyro. If successful the analgesia is admirable. If danger arises we possess no means at present with which to combat it. In England stovaine is commonly used in an isotonic solution by the method which A. E. Barker has so ably elaborated. Abroad tropacocaine, alpin, and novocain each has its admirers. Cocaine, although still used, is a dangerous drug, and should be avoided.

(d) Local analgesia need not detain us. It is admirable in those cases for which it is suitable, but I think should be avoided for any but trivial operations, especially if the patient is nervous and asthenic. When local insensibility is obtained by intra-vascular injections, there is a greater risk incurred than by use of an infiltration method. Indeed, this method must be admitted to be at present only upon its trial.

(e) The employment of nitrous oxide gas in major surgery has been adopted in order to obviate the reputed dangers of the more powerful anaesthetics. Bert commended it in his day, and the French surgeon Péan employed it largely. Its advantages are patent, and its inconveniences are probably not insuperable. The degree of narcosis obtained is not a deep one, and the dangers of asphyxial complications are always present. It is difficult to bring about complete muscular relaxation and to maintain anything like a uniform level of narcosis when this anaesthetic is used for any length of time, even although its use is combined with that of oxygen.

The method of using a preliminary injection of alkaloidal bodies before allowing the patient to inhale a general anaesthetic, or to be injected with stovaine, has now been thoroughly tried and proved to possess many advantages.⁶ The patient is rendered drowsy and free from apprehension; he requires less of the general anaesthetic and is hardly aware that he is taking it; the muscular relaxation is commonly, although not always, more complete than when a general anaesthetic is given by itself; the after-effects are usually slight and the post-anaesthetic sleep prolonged. The drawbacks are that the usual guiding phenomena of narcosis are lost, the reflexes, the pupillary and ocular phenomena, are profoundly modified; the danger of overdosage, of paralysing the medullary centres, is increased, so that the most unflinching attention must be paid to the patient's condition, which often demands complete removal of the general

anaesthetic even for prolonged periods. If cyanosis appears, this withholding of the anaesthetic is called for imperatively. It need hardly be said that when morphine is contraindicated on general principles it is better to avoid using scopolamine also, although this latter drug certainly renders the associated use of morphine more free from danger. The older method of employing morphine and atropine before chloroform or ether is, I think, less safe than the combined use of scopolamine, morphine and atropine. Some surgeons have extolled this injection method as a preliminary to the continuous inhalation of nitrous oxide-oxygen for even prolonged operations. The average doses are scopolamine $\frac{1}{100}$ grain, morphine $\frac{1}{10}$ grain, and atropine $\frac{1}{10}$ grain, given one hour before the general anaesthetic. Sometimes it is well to divide the dose, giving half an hour before and half just before the inhalation. It is commonly thought that young children are not so suitable for this method, and I have little experience of its use for them. As to dosage, although the amounts I have mentioned are usual, yet it is necessary to modify them according to the physique and state of the patient. Some robust men need more, some feeble persons require smaller doses. A word must be said about the after-treatment of these cases. The patients usually pass into a profound slumber when the operation is finished, and so need heedful watching for some hours, indeed until the narcotic effects of the injection and anaesthetic have passed off. As the respirations remain slow and shallow the progress of elimination is very slow, and the sleep may persist for a long time. The stupor need cause no alarm if the breathing is regular and adequate and albuminuria or glycosuria is known not to be present. I have no more time at my disposal, and must therefore conclude this brief summary of the means we possess to satisfy the demands of modern surgery, at the same time safeguarding our patients from unnecessary risks.

[The address was followed by a detailed explanation of the apparatus mentioned.]

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PRELIMINARY NOTE ON EXPERIMENTAL INVESTIGATIONS ON THE PITUITARY BODY.

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In the last few years the bibliography concerning the pituitary gland has been steadily growing. Scarcely a month passes without a new work on the subject, either on the pituitary gland alone, or in connexion with the other glands of internal secretion. The present note cannot contain a summary of such an extensive bibliography, and we must refer our readers to the latest collected works on the pituitary gland, especially to that of Biedl, *Innere Sekretion*, 1910.¹

In our experiments we have tried only to determine what influence a complete or partial extirpation of the gland exercises on the organism. The first to perform such experiments was Horsley in 1886, after whom a series of authors (about twenty) repeated the experiments with results which were not uniform. In some investigations the animals succumbed soon after the operation, in others they survived for long periods. Among the more recent experimenters are Stöderius, Gemelli, Aschner, Ascoli, and Legrain, and especially Paulesco and Cushing. Of these writers the last named has conducted a series of researches for several years, and has with his colleagues treated the subject in great detail. The first three authors found that the removal of the gland does not always lead to death, but that at least the gland is essential in develop-

ment. The last three say that complete removal of the gland causes death very rapidly. Cushing says:

Total removal of the hypophysis leads inevitably to the death of the animal with a peculiar and characteristic train of symptoms—cachexia hypophyseopriva, that is, low temperature, slow respiration, typical flexion attitude of back and incurvation of tail, spasmodic opening of the jaws; the animals are drowsy, lethargic, anaesthetic to a painful stimulus, and finally pass into deep coma. Sometimes, however, death did not occur as promptly as Paulesco claimed; for puppies might remain in an apparently normal condition for at least three weeks before the terminal phenomena appear and the latter might persist for one to three days.

Removal of the posterior lobe, according to Paulesco and Cushing, does not produce the fatal symptoms, but only complete removal of the anterior lobe.

We have made experiments on 54 animals—namely, 20 cats, 21 dogs, and 13 monkeys—in which the pituitary gland was reached by either of two methods—(1) temporal, (2) palatal. The second method we have employed only in the cat. In the temporal method the opening of the skull was made on one side only, the left. In some cases we did not remove the gland, but only separated it from the base of the brain; in some others we cauterized the infundibulum. In about half of all the experiments we observed cerebral symptoms—*mouvements de menège*, hemiparesis, hemianopia, and in all monkeys temporary ophthalmoplegia on the side of the operation. All these symptoms gradually passed away. In all cases, with the exception of animals dying from operative shock, we have made a very careful microscopical examination of the sella turcica and of the base of the brain. Dr. Handelsmann will in a further paper give the full details of our experiments, and we will in the present note only describe the general conclusions arrived at.

Of the whole series of experiments, in 15 (2 cats, 9 dogs, and 4 monkeys) the gland—for example, pars anterior, pars posterior, and pars intermedia fissurae†—was completely removed; that is, we could not find even cells of the pars intermedia infundibuli. We had also some animals in which there were some few cells of the pars infundibuli remaining; but these animals we do not count as having had a complete removal of the gland (contrary to Cushing), because sometimes in these remnants we found quite active cells with colloid in the lumen of the acini, and so on. On the other hand, to show that after the so-called complete removal of the gland‡ all the animals do not always die quickly with symptoms of cachexia, as Cushing and Paulesco claim, we present the following facts.

Eight animals died within forty-eight hours—for example, from shock, haemorrhage, or infection. We do not consider that those authors who have obtained similar results are justified in ascribing these fatal results to the loss of the function of the gland. Of the remainder, three died within four days with no symptoms regarded by Cushing as characteristic of a cachexia; but where not due to one of the above-named causes were, in our opinion, attributable to oedema cerebri.

There remain four cases (all monkeys); in three of these death occurred naturally on the 13th, 14th, and 39th days, and one animal was killed in good health on the 115th day.

In the three instances in which the animal died naturally no “characteristic” symptoms were observed, and the animals became asthenic and died, as many monkeys do in captivity. However, we reserve, of course, any absolute opinion on these cases, as it is clear they may be claimed in support of the opposed view—namely, that the removal of the function of the gland is necessarily fatal. This absolute conclusion is, however, obviously negated by the fourth case.

Further, we have observed a parallel death-rate in animals in whom incomplete extirpations had been made.

It is clear that the whole question of the vital importance of the gland will require careful reviewal, and this has been rendered especially necessary by the researches of Cushing.

* Some of these animals were demonstrated at the meeting of the Physiological Society on March 18th, 1911, and the specimens from the same animals on July 1st, 1911.

† According to our view, the epithelial cells of the pars intermedia must be differentiated into those lining the cleft between the lobes (pars intermedia fissurae) and those forming a circle round the infundibulum (pars intermedia infundibuli).

‡ We say “so-called” because very possibly there is in some cases an accessory gland in the canalis cranio-pharyngealis which perhaps becomes hyperactive when the gland is removed.