ANAESTHESIA WITH HYPOTENSION FOR FENESTRATION*

BY

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This paper is a report on a small series of cases of anaesthesia for fenestration of the labyrinth in which a technique of "planned hypotension" was used.

THE OPERATION

The object of the fenestration operation is to overcome the obstruction offered to the transmission of sound-actuated waves by the fixation of the footplate of the stapes in the oval window by osteosclerotic bone. This is achieved by providing an opening in the wall of the bony labyrinth that will allow free movement of labyrinthine fluids in response to transmitted sound waves (Cawthorne, 1952). This was described as a one-stage endaural procedure by Lempert (1938).

The operation itself falls naturally into two parts (Hall, 1945): (1) the preparation of the middle ear, i.e. essentially a modified radical mastoidectomy; and (2) the trephining of the bony labyrinth, which is carried out under low-power magnification. The fenestra is then covered with a skin flap which is rotated from the wall of the external auditory meatus in continuity with tympanic membrane. The entire procedure in the present series occupied about four hours.

ANAESTHETIC REQUIREMENTS

The anaesthetic requirements for this operation are: (1) a smooth light anaesthesia of prolonged duration; and (2) the absence of bleeding, which may occur (a) during the incision from skin and soft tissues, (b) during the mastoidectomy from bone, and (c) during the actual trephining of the labyrinth from bone or from the skin flap.

It will be appreciated that, when working on the bony labyrinth under magnification, even a minute amount of haemorrhage will cause embarrassment to the surgeon—and, indirectly, to the anaesthetist! However, bleeding at this stage will not only render difficult—or, as has happened, impossible—the technical accomplishment of the operation: bleeding into the fenestra may well jeopardize a successful result by causing a post-operative serous labyrinthitis (Hughes, 1951) and subsequent closure of the fenestra, a not infrequent complication. In this connection, Gillies (1953) states that "the success of a procedure such as fenestration for otosclerosis depends largely on an

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ischaemic field of operation and the absence of reactionary haemorrhage and clot formation afterwards.” In another article (Gillies, 1950) he reviews the relationship of anaesthetic factors to surgical haemorrhage.

PHYSIOLOGICAL AND PHARMACOLOGICAL CONSIDERATIONS

The factors influencing the degree of haemorrhage from a wound are:

1. The arterial blood pressure which varies as the product of the cardiac output and the peripheral resistance.
2. The local venous pressure, which is to some extent dependent on gravity, and can therefore be influenced by posture.
3. The state of the peripheral capillaries, which is related to the carbon dioxide tension of the blood.
4. The mechanism of blood clotting.

Although each must receive due consideration, it is with the first of these factors that we are chiefly concerned, and especially with the question of peripheral resistance.

Planned Hypotension.

The idea of planned hypotension to reduce surgical haemorrhage was introduced by Griffiths and Gillies in 1948, when they achieved it using the total spinal technique for thoraco-lumbar splanchnicectomy and sympathectomy. In a stimulating paper, they maintain that hypotension is of serious import only when the causative mechanism is haematogenic and is relatively innocuous when of neurogenic origin, the important differential factor being the state of the capillary bed; further, in acute total sympathectomy, the reduction in peripheral arteriolar resistance enables a pressure slightly in excess of 30 mm. Hg (which represents the sum of the venous pressure and the colloid osmotic pressure of the plasma) to maintain an adequate capillary circulation—in the presence of a normal blood volume and capillary tone.

The major part of the peripheral resistance is situated in the arteriolar bed (Best and Taylor, 1945). If this is removed by arteriolar vaso-dilatation it is evident that a relatively low head of pressure (e.g., 60 mm. Hg) will suffice to drive blood through into the capillary bed where the normal pressure is less than 30 mm. Hg and where oxygen/carbon dioxide exchange and tissue respiration occur.

Pharmacological Sympathectomy.

Subsequently, Enderby (1950) achieved this acute total sympathectomy by pharmacological means using pentamethonium iodide (C5), which paralysed the autonomic ganglia, thus abolishing vaso-motor tone.

It was realized early that posture was an important factor in bringing about the desired fall in blood pressure. This “controlled circulation” can thus bring about a postural ischaemia, which finds an obvious field of application in operations on the head and neck. In a later paper (Enderby and Pelmore, 1951) improved results were described using hexamethonium bromide (C6).

The Methonium Compounds.

The pharmacology of the methonium compounds has been extensively studied by Paton and Zaimis (1948, 1949, 1951).
and others. These methonium compounds are polymethylene bistrimethylammonium salts with the formula 

\[(\text{CH}_3)_n \text{N}^+ (\text{CH}_2)_8 \text{N}^+ (\text{CH}_3)_n \] 2Br or I, where \( n = 6 \) for hexa- and 5 for penta-methonium.

Two of them (pentamethonium and hexamethonium) act on the autonomic nervous system as specific ganglionic blocking agents, by interfering with the transmission process at the ganglionic synapse itself. This interference is produced by the mechanism of "receptor competition"—i.e. they compete successfully with acetylcholine (the release of which is not interfered with) for receptor groups on the ganglion cell membrane. Their action is thus analogous to that of curare at the motor end-plate of the somatic nervous system.

On the sympathetic side of the autonomic nervous system their chief effect is, of course, to produce a hypotension, the degree of which depends on several factors:

1. Initial level of blood pressure. The fall in systolic blood pressure appears to bear a direct relationship to its initial level. It is suggested that the resting sympathetic tonus is subject to considerable individual variation.

2. Posture. The relaxation of vennotoric tone is possibly a factor of importance in producing the dry field (Paton, 1951). Gravity is brought into play to assist the venous return from the site of operation to the heart.

3. Choice of Drug. The consensus of opinion indicates that hexamethonium is rather more powerful and certain in its action than pentamethonium—although Barnett (1951) disagrees. Paton and Zaimis (1951) state that the relative potencies of the two drugs (in the rabbit) are as follows:

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<th>C5</th>
<th>C6</th>
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<tr>
<td>(a)</td>
<td>80</td>
<td>100</td>
</tr>
<tr>
<td>(b)</td>
<td>33</td>
<td>100</td>
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</table>

It is thus evident that the "spectrum of ganglionic sensitivity" varies with each drug; while C5 is only four-fifths as effective as C6 in paralysing the sympathetic ganglia, what is more important is the fact that C5 is only one-third as effective as C6 in paralysing the parasympathetic ganglia. Further, it will be seen that C6 exerts an equal effect on all autonomic ganglia, whereas C5 is about \( 2\frac{1}{2} \) times more effective on sympathetic than on parasympathetic ganglia. This, in my opinion, makes C5 the drug of choice for controlled hypotension, and is an important point in the avoidance of "side-effects" due to paralysis of the parasympathetic ganglia—for example, in the bowel and bladder.

4. Dosage. There is an optimal dosage which will paralyse the ganglia, and to exceed this will not produce any greater fall in blood pressure—although the fall may be more prolonged (Enderby, 1950).

It would appear from the present series of cases that the best results are obtained by using a large initial dose of pentamethonium (up to 100 mg.) followed, if required, by a supplementary dose of hexamethonium (up to 50 mg.). It is un-
necessary and unprofitable to exceed this dosage.

Their specificity of action and freedom from true side effects (i.e. actions other than ganglionic blockade) has rendered these drugs of value in anaesthesia.

PRESENT SERIES

The present series of cases consists of twenty fenestrations which although only a small number represents over eighty hours anaesthetic time.

The patient is usually a fit young woman, more often blonde (Cawthorne, 1952). The average age was 34 years, the youngest being 19 years and the oldest 46 years.

The pre-operative examination included a haemoglobin estimation and, in most cases, an electrocardiogram.

Premedication consisted of papaveretum 1/3 grain (20 mg.) and hyoscine 1/150 grain (0.45 mg.).

Anaesthetic Technique.

The patient is placed on the operating table and the pulse and blood pressure taken. Anaesthesia is induced with thiopentone 500–750 mg. followed by a relaxant, usually gallamine (Flaxedil) 60–80 mg., to facilitate intubation. The lungs are inflated with oxygen, the cords sprayed with 2 per cent amethocaine, and a No. 10 or 11 oral endotracheal tube lubricated with 2 per cent cinchocaine is passed. This is connected with a No. 4 Magill’s T-piece to the Boyle’s apparatus and anaesthesia maintained with nitrous oxide (7 l.) and oxygen (3 l.) with intermittent thiopentone as required.

The blood pressure is again taken and the patient, strapped to the table, is postured in the 30° reverse Trendelenburg position, the head being held steady by a head-band. On taking a further blood pressure reading it is usual to find a fall, although the systolic pressure is not as a rule below 100 mm. Hg.

RESULTS

The posture used is illustrated in figures 1 and 2, while table I summarizes the results obtained. The average dose of thiopentone was 1200 mg. The average dose of hypotensive drug (calculated as C5 and excluding procaine amide) was 128 mg.; this maintained the systolic blood pressure below 80 mm. Hg for an average time of about one hour. The “result” indicates the state of the operative field as assessed by the surgeon. This is not always directly related to the level of the blood pressure.

DISCUSSION OF CASES

Cases 1 and 2 were given a slow intravenous drip of normal saline as a vehicle for injections, but this was found to be both unnecessary and undesirable. In these cases, also, hypotension was induced as soon as the patient was postured and maintained at a systolic blood pressure of 60–80 mm. Hg for three hours throughout almost the entire procedure. Although these patients showed no ill effects it was considered unnecessary to maintain the hypotension for so long. Accordingly, in subsequent cases bleeding from skin and soft tissues was controlled by prior injection of 1 per cent lignocaine and adrenaline 1/100,000 and by the use of the diathermy; bleeding from bone during the mastoidectomy was controlled by posture and thiopentone; while pentamethonium
was reserved to control bleeding from bone during the actual fenestration, a procedure occupying rather less than an hour.

Case 3 (fig. 3) illustrates a point concerning the choice of relaxant. It might be thought rational, when using pentamethonium in any event, to use decamethonium (C10) as a relaxant for intubation. This case in fact received decamethonium 4 mg. without showing marked respiratory depression, but the subsequent course of hypotension was unsatisfactory in that, even with a dosage of pentamethonium as high as 300 mg. and a steep tilt (40°) on the table, it was possible to lower the systolic blood pressure below 80 mm. Hg only for a short time. There seems to be a possibility of antagonism between these two drugs, although Davison (1951) states that he has not noticed this.

Suxamethonium chloride (Scoline) was used in three cases, but it was found that its very brevity of effect necessitated the early introduction of trichlorethylene to prevent the patient straining on her endotracheal tube. The use of trichlorethylene was clearly undesirable when electro-
cardiograms were being taken. Accordingly, reversion was made to the use of a modest dose of gallamine, respiration being assisted as required. No increase in bleeding was noticed.

A dry operative field cannot, of course, be achieved without meticulous attention to the patency of the airway and the efficient excretion of carbon dioxide. Thus, in two cases in which there was a fair amount of oozing, slight improvement was obtained (after a time) by the use of an open T-piece arrangement as described by Bullough (1952).

A point concerning the choice of hypotensive drug is illustrated by Case 8 (fig. 4). Although hexamethonium is rather more powerful and certain in its action than pentamethonium, nevertheless, as already stated, the latter is preferred. However, it may be extremely difficult to maintain a satisfactory degree of hypotension with this drug, especially in a fit young man. In this case pentamethonium 90 mg. produced a satisfactory fall in systolic blood pressure from 150 mm. Hg to 55 mm. Hg, but it soon started to rise, and in 20 minutes was 70 mm. Hg. As a further gradual rise in blood pressure was anticipated, and the fenestra was not yet near completion, a test dose of 100 mg. of procaine amide
(Pronestyl) was given. This was followed by doses of 600 mg. and 300 mg. As a result of this, the systolic blood pressure fell again to 55 mm. Hg and remained below 70 mm. Hg for a further half-hour, thus allowing the fenestra to be completed in a bloodless field.

It appears that procaine amide potentiates the hypotensive action of the methonium drugs in two ways (Mason and Pelmore, 1953): (1) by an additive vasodilatory effect, and (2) by increasing the refractory period of the heart muscle, thus preventing the compensatory tachycardia which often follows pentamethonium and tends to maintain the cardiac output.

Not in all young people, however, is

<table>
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<tr>
<th>Case No.</th>
<th>Age in years</th>
<th>Duration in hours</th>
<th>Thio-pentone in mg.</th>
<th>Hypotensive in mg.</th>
<th>Dosage of Thio-pentone in mg.</th>
<th>Blood pressure in mm. Hg</th>
<th>S.B.P. &lt;80 for (min.)</th>
<th>Table level post-op.</th>
<th>After four hours</th>
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<td>C5 160</td>
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<td>C5 120</td>
<td>C5 120</td>
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<td>160 85/45</td>
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<td>4</td>
<td>1800</td>
<td>C5 90 C6 50</td>
<td>C5 90 C6 50</td>
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<td>1000</td>
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<td>C5 100</td>
<td>130/85</td>
<td>45 100/60</td>
<td>112/80</td>
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<td>65 95/55</td>
<td>140/75</td>
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| Average  | 34           | 4.2               | 1200               | C5 128            | 59                             |

Table I: Anaesthesia with hypotension for fenestration. Synopsis of results.
Case 3 had 4 mg. C10 (for intubation) and 300 mg. C5 (in divided doses). There was considerable difficulty in producing a satisfactory degree of hypotension, but the operative field was fair and the functional result good.

Case 8 shows the effect of procaine amide in maintaining the hypotension produced by pentamethonium.
Case 15 was a young woman of 31 years with Hb 65 per cent. She showed a rather excessive fall in blood pressure (S.B.P. 40 mm. Hg) after the potentiation of 100 mg. C5 by 50 mg. C6 and 900 mg. procaine amide.

hypotension so difficult to maintain. Case 15 (fig. 5) illustrates this. A young woman of 31 years had had the operation postponed twice previously, once on account of anaemia, and she was very anxious to have it done. On this occasion her haemoglobin was 65 per cent and red blood cells 3.5 million/cu.mm., but it was decided, in view of her previous disappointments to proceed with the operation and to commence the treatment of her anaemia by a pint of blood post-operatively. On pre-operative examination occasional extrasystoles were felt at the wrist, but an electrocardiogram showed only sinus arrhythmia. Her blood pressure was 110/65 mm. Hg.

After 2 hours anaesthesia, when the surgeon was about to commence drilling out the fenestra, thiopentone 250 mg. followed by pentamethionium 100 mg. was given. The blood pressure fell from 114/60 mm. Hg to 70/40 mm. Hg; this was accompanied by a rise in pulse rate from 56/min to 96/min., but the operative field was dry. Some 20 minutes later, however, the blood pressure had risen to 80/45 mm. Hg, the pulse rate to 104/min., and the surgeon stated that there was some oozing from the bone around the fenestra. Since considerable difficulty had previously been experienced in maintaining in these young people the hypotension produced by pentamethionium, she was given hexamethonium 50 mg. followed by a further 250 mg. of thiopentone, and this was followed by 800 mg. of procaine amide (of which a test dose of 100 mg. had previously been given).
As a result of this rather intensive therapy the systolic blood pressure fell to 40 mm. Hg. This was the more disturbing since there was still marked respiratory depression due to the recent dose of thiopentone. Respiration was, of course, being assisted at this point, using 100 per cent oxygen. Operating conditions were now ideal! The tilt of the table was about to be reduced when a further reading showed the systolic blood pressure to be 50 mm. Hg: respiration was now almost adequate. Shortly thereafter the systolic blood pressure rose to 60 mm. Hg and adequate spontaneous respiration was resumed. Nitrous oxide was then reintroduced. The patient's colour was satisfactory throughout. On levelling the table at the conclusion of the operation, the blood pressure rose to 80/50 mm. Hg. Recovery was uneventful.

In retrospect, it may well be that one factor which contributed to the somewhat precipitous fall in blood pressure was the moderate degree of anaemia. This would result in a decrease in the viscosity of the blood, and consequently in the peripheral resistance. Further, the hypotensive effect of the rather liberal supplementary dose of thiopentone would no doubt be aggravated by that circumstance.

IMMEDIATE POST-OPERATIVE MANAGEMENT

When the skin is closed the table is levelled and the systolic blood pressure, which as this stage is usually about 70–80 mm. Hg, now rises to about 90–100 mm. Hg. On withdrawal of anaesthesia, the patient's cough reflex is present; her pupils are, of course, large. Recovery from anaesthesia is not delayed and the patient is moving or even talking when the bandaging is complete. She is sent back to the ward with the sphygmomanometer cuff still in position and 2-hourly blood pressure readings are taken. She is kept flat for 4 hours at the end of which time the systolic blood pressure is found to be over 100 mm. Hg, although usually still below its normal level.

It is considered desirable to allow the blood pressure to rise gradually to its normal level during the afternoon. The use of vasopressor drugs is both unnecessary and unwise, and this may interfere with the natural processes of clotting and promote reactionary haemorrhage.

Post-operative sedation is assured by morphine ¼ grain (16 mg.) while nausea and vertigo of labyrinthine origin are controlled by promethazine 8-chlorotheophyllinate (Avomine) 25 mg.

POST-OPERATIVE COURSE AND COMPLICATIONS

Case 3, which had been rather unsatisfactory all through, since his blood pressure did not fall low enough, showed a fair amount of post-operative staining, and developed a haematoma of his wound which subsequently required evacuation. However, his functional result showed a good and sustained improvement in hearing.

There were two cases of urinary retention. Case 8, having passed 6 oz. (170 ml.) of urine in the evening, had some difficulty with micturition the following day; he was given 1 ml. (0.25 mg.) of Carbachol, passed 10 oz. (284 ml.) of urine, and had no further trouble. Case 16, a nervous young girl, also complained of difficulty
with micturition, and was catheterized twice.

As a result of the labyrinthenine irritation, nausea and dizziness were frequent in the first 48 hours and vomiting and nystagmus sometimes occurred. The pupils usually remained dilated for several hours due to paralysis of the ciliary ganglion, but in no case was this present the next day. Dryness of the mouth was a not infrequent complaint, possibly due to paralysis of the secreto-motor fibres from the submandibular ganglion; a simpler explanation, however, would be the by-passing of the normal respiratory passages by the endotracheal tube.

**RISKS OF HYPOTENSION**

No article on hypotension would be complete without some reference to the possible hazards involved.

In an indictment of hypotension, Davison (1953) talks of “the frequency of difficulty in reversing the hypotensive action of methonium” and states that “this commonly requires the administration of a vaso-pressor.” Mandow et al. (1954), using a very liberal dosage, concur. This has certainly not been my experience, confined as it has been to cases in which blood loss was not a factor. Although methyl-amphetamine (Methedrine) is always at hand, it has never been required; on the contrary, the chief difficulty has been to get the pressure down.

**Electrocardiographic Evidence.**

In a consideration of anaesthesia for the cardiac patient Hayward (1952), while pointing out that severe coronary artery disease may be symptomless, states: “provided the coronary arterial system is healthy, it is unlikely that coronary insufficiency will appear if hypotension is produced by ganglion blocking drugs as, in spite of a decreased coronary blood flow, the work of the heart and the metabolic needs of the cardiac muscle are reduced in proportion.” This is in direct contrast to the existing state of affairs when hypotension is produced by arteriotomy with concomitant vasoconstriction (Harris and Hale, 1947).

In order to ascertain whether there was any interference with the nutrition of the heart during the hypotensive period, electrocardiographic records were taken in several patients. As it was impracticable to apply chest leads in theatre, the classical limb leads were employed.

The results obtained in Case 17, a woman of 40 years, are typical: no change occurred in the electrocardiograms after 100 mg. of pentamethonium, although the blood pressure fell to 65/45 mm. Hg and the systolic blood pressure was maintained below 80 mm. Hg for an hour. The report read as follows: “No electrocardiographic abnormalities have been demonstrated in these patients. Cardiac upset might, however, be shown in older patients after long periods of hypotension, or where procaine amide was used as a hypotensive agent.”

Thus the evidence, so far as it goes, does not indicate any interference with the coronary circulation.

**Oximetric Evidence.**

Some concern has been expressed for the adequacy of the cerebral circulation during the hypotensive phase. Morris et al. (1953) found “a significant decrease in cerebral blood flow following marked
depression in the mean blood pressure in spite of a decrease in cerebral vascular resistance. Cerebral oxygen consumption was only slightly decreased due to a more complete extraction of oxygen from the blood flowing through the brain.” On the other hand, Hampton and Little (1953) quote Stone, who found the cerebral blood flow in young adults unchanged following a reduction in mean arterial pressure of 40–50 per cent by hexamethonium. Regarding the present small series of cases, the normal character of the respiration, the immediate recovery from anaesthesia, and the absence of any post-operative complications are clinical grounds for assuming that the cerebral circulation was unimpaired.

It has recently been possible, however, to carry out oximetry in four patients. The object of this has been to determine the percentage of oxygen saturation of the arterial blood of the forehead (and, by inference, of the brain) while the patient is in the reverse Trendelenburg position during the hypotensive state.

Principles and Method. A small area of the skin of the forehead is first histaminized by iontophoresis, for 3–5 minutes at a current of 1–2 mA, of an 0.6 per cent aqueous solution of histamine phosphate. The object of this is to produce a constant, maximum and rapid circulation therein, and enable arteriolar (rather than capillary) saturation to be measured by the cyclops, a photo-electric cell with red and green filters, which is placed over the spot. The method is based on the measurement of the intensity of light reflected by the blood: red light (600–680 nm) is strongly reflected by oxyhaemoglobin, and in this wavelength the logarithm of the reflected quantity of light is a linear function of the oxygen saturation (Zijlstra, 1951).

Results. In no case was there any significant alteration in the percentage oxygen saturation of the arterial blood of the forehead during the hypotensive phase, although the patient was in the reverse Trendelenburg position. This would tend to support the clinical evidence that the cerebral circulation is unimpaired during hypotension. In coming to this conclusion, it should be stressed that these patients are young fit adults with healthy elastic cardiovascular systems.

CONCLUSION

It would appear that planned hypotension using pentamethonium iodide is a safe procedure in fit adults undergoing fenestration of the labyrinth. Further, it produces the bloodless field which is not merely a help in the technical performance of this operation but is an essential to its ultimate success.

SUMMARY

The anaesthetic requirements for the fenestration operation are discussed. These lead to a consideration of the physiological factors influencing surgical haemorrhage, and the modification thereof, using planned hypotension achieved by the pharmacological sympathectomy produced by the metionium drugs. The anaesthetic technique used in a small series of fenestrations is then described, and the cases discussed in some detail, including their immediate post-operative management, subsequent post-operative course and complications. The risks of induced hypotension are finally con-
sidered, and some electrocardiographic and oximetric evidence is presented in support of the conclusion.

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REFERENCES

——— (1953). Anaesthesia, 8, 255.