ANAESTHESIA WITH PROFOUND HYPOTENSION FOR MIDDLE EAR SURGERY

A. R. Kerr

SUMMARY

To produce a blood-free field for middle ear surgery performed with the operating microscope, the arterial systolic pressure was reduced to less than 50 mm Hg in 700 patients by means of thiopentone–halothane–nitrous oxide in oxygen anaesthesia together with pentolinium tartrate. In 84% the results were excellent, in 12% moderately good and they were poor in 4%. There were more unsatisfactory results in males (22.8%) than in females (11.4%). In spite of the arterial pressure being reduced to very low values in many instances, there was no mortality or morbidity which could be ascribed to the technique.

It has become generally recognized in recent years that haemostasis for middle ear surgery presents special problems for the anaesthetist because the 40× magnification of the operating microscope makes even minimal bleeding appear major. Many anaesthetic techniques have been devised to deal with this problem. It is accepted that any technique employed must be as safe as possible, since the conditions being treated are seldom life-threatening.

Current methods include:

1. Halothane anaesthesia with a head-up tilt
2. Lytic cocktails combined with halothane anaesthesia
3. Neuroleptanalgesia with or without general anaesthesia
4. General anaesthesia and controlled ventilation, with or without ganglion-blocking agents, or beta-blocking agents
5. Halothane anaesthesia with ganglion-blocking agents

The present paper records our experience in 700 patients using the last of these methods: halothane–nitrous oxide in oxygen anaesthesia with spontaneous ventilation together with pentolinium, with the aim of reducing systolic pressure to less than 50 mm Hg.

METHODS

Selection of patients

Only those patients who were physically fit were submitted to this hypotensive technique, in order to minimize the risk of any complication which may result.

Age. It is well known that younger patients are more resistant to hypotensive drugs, especially the ganglion-blocking agents (Enderby, 1954), and for this reason patients younger than 20 yr were excluded from the study; 66 yr was chosen as the upper limit.

Physical condition. Patients with a significant history of previous cardiovascular disease were excluded. Those suffering from dyspnœa were excluded also and especially patients with clinically obvious emphysema. Patients with diabetes, anaemia, polycythaemia or a history of thyroid or renal disease were excluded also. If varicose veins were present, this was noted at the visit before operation and a pillow was placed under the legs during the surgical procedure, as a precaution.

Drugs. Patients who were undergoing prolonged steroid therapy were excluded. Every woman of child-bearing age received a letter, which was enclosed with her notice of admission, asking her to discontinue any contraceptive pills.

Operations performed

The 700 operations performed in this series were:

- Stapedectomy or revision 301
- Myringoplasty 252
- Mastoidectomy 16
- Combined approach tympanoplasty 54
- Reconstruction of the middle ear 26
- Destruction of labyrinth/Teflon shunt 10
- Exploration of middle ear (miscellaneous) 41

One hundred and three patients underwent hypotensive anaesthesia on more than one occasion, 88 receiving it twice, 12 on three and three on four occasions.
Anaesthetic

Premedication consisted of papaveretum 20 mg and hyoscine 0.4 mg, which was administered i.m. to every patient 1 h before operation. Atropine was avoided because the associated tachycardia causes a resistance to profound hypotension (Kerr, 1969).

Anaesthesia was induced with thiopentone, followed by suxamethonium to facilitate endotracheal intubation with a cuffed tube. Anaesthesia was maintained with halothane in 66% nitrous oxide in oxygen with spontaneous respiration. The proportion of oxygen in the anaesthetic mixture was increased as the arterial pressure decreased, so that during profound hypotension 50% nitrous oxide in oxygen was given with occasional periods of 100% oxygen. The concentration of halothane was maintained in the range 1.5–2%. A Ruben expiratory valve was included in the circuit.

Before the operation commenced the table was tilted 10° head-up and remained in that position throughout the operation. Pentolinium was administered either at this stage or, if the operation was expected to be prolonged, the injection was delayed so that the total hypotensive period did not exceed 2 h.

By trial and error, the following dose scale of pentolinium evolved and has been found to give consistent and adequate hypotension:

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Dose</th>
</tr>
</thead>
<tbody>
<tr>
<td>20–40 yr</td>
<td>25 mg</td>
</tr>
<tr>
<td>41–50 yr</td>
<td>15 mg</td>
</tr>
<tr>
<td>51–60 yr</td>
<td>10 mg</td>
</tr>
<tr>
<td>Over 60 yr</td>
<td>5 mg</td>
</tr>
</tbody>
</table>

Monitoring

Arterial systolic pressure was recorded at 5-min intervals, using an upper arm cuff (inflated automatically) with a photoelectric cell pulse detector attached to the thumb (Air Shields PTB3). The heart rate was recorded continuously and monitored by an audible signal.

Classification of bleeding

The amount of bleeding in the 64 males and 48 females, who had an unsatisfactory result, was classified as follows:

<table>
<thead>
<tr>
<th>Type</th>
<th>Males</th>
<th>% of total</th>
<th>Females</th>
<th>% of total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slight</td>
<td>49</td>
<td>17.6</td>
<td>35</td>
<td>8.3</td>
</tr>
<tr>
<td>Moderate</td>
<td>10</td>
<td>3.6</td>
<td>10</td>
<td>2.4</td>
</tr>
<tr>
<td>Severe</td>
<td>5</td>
<td>1.6</td>
<td>3</td>
<td>0.7</td>
</tr>
<tr>
<td>Totals</td>
<td>64</td>
<td>22.8</td>
<td>48</td>
<td>11.4</td>
</tr>
</tbody>
</table>

Results

Arterial pressure

The lowest resting arterial pressure before anaesthesia in any patient submitted to profound hypotension was 100/65 mm Hg and the highest was 170/110 mm Hg. Patients with hypertension in excess of this were excluded from the technique, as it was felt that cardiovascular disease may have been present, even if undetected. The greater the resting arterial pressure, the easier it was to produce profound hypotension, but the converse with a low resting pressure was not the case.

Eleven patients in this study had been taking antidepressive drugs recently and all showed resistance to the hypotensive technique.

After the initial injection of pentolinium, the arterial pressure decreased quickly, reaching 60–70 mm Hg in a few minutes. Ideally, it continued to decrease for 10–15 min and then remained stable for the duration
of the operation. In cases with unsatisfactory haemostasis, however, either it failed to reach a profound level of hypotension or, having done so, it increased within a few minutes to approximately 70 mm Hg systolic. Most of these events were accompanied by tachycardia and bleeding. Additional injections of pentolinium failed to reduce the pressure and even large doses of procainamide had little or no effect. On the other hand, bradycardia was always accompanied by a good hypotensive effect and even heart rates of 40 beat/min were often recorded. In spite of this, the peripheral perfusion appeared to remain adequate at all times.

Table I shows the number and distribution of cases in whom adequate haemostasis was achieved. It is apparent that males were more resistant than females. Although, in a few patients, satisfactory haemostasis was obtained with a systolic pressure greater than 60 mm Hg, it was found that 30–45 mm Hg was the best range for good results. The figures in parentheses show the total number in each group.

In females there appeared to be a progressive increase in sensitivity to the hypotensive drug as age increased (table II), but in males the highest incidence of failure was in the young middle age group and not in the youngest age group. Why bleeding occurred in patients with a systolic pressure in the range 30–40 mm Hg is not apparent.

Complications after surgery
Some difficulty was encountered in restoring arterial pressure to normal in patients in whom the hypotension was either very profound or very prolonged. Patients in whom systolic arterial pressure decreased to 20 mm Hg or less, or patients who remained hypotensive for more than 2 h, generally required further methoxamine 20 mg i.v. to return them to normotensive values. Early in the series, one

<table>
<thead>
<tr>
<th>Systolic arterial pressure (mm Hg)</th>
<th>Age (yr)</th>
<th>More than 60</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>70 +</td>
<td>20–29</td>
<td>30–39</td>
<td>40–49</td>
</tr>
<tr>
<td>60 +</td>
<td>0 (0)</td>
<td>1 (3)</td>
<td>0 (5)</td>
</tr>
<tr>
<td>50 +</td>
<td>4 (13)</td>
<td>1 (9)</td>
<td>1 (8)</td>
</tr>
<tr>
<td>40 +</td>
<td>6 (8)</td>
<td>6 (11)</td>
<td>4 (7)</td>
</tr>
<tr>
<td>30 +</td>
<td>21 (22)</td>
<td>36 (43)</td>
<td>29 (34)</td>
</tr>
<tr>
<td>Under 30</td>
<td>4 (5)</td>
<td>6 (7)</td>
<td>9 (9)</td>
</tr>
<tr>
<td>Total</td>
<td>35 (48)</td>
<td>51 (74)</td>
<td>44 (64)</td>
</tr>
<tr>
<td>% of all male patients</td>
<td>76.8</td>
<td>60.7</td>
<td>68.9</td>
</tr>
</tbody>
</table>

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<th>Age (yr)</th>
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<td>0 (3)</td>
<td>0 (4)</td>
</tr>
<tr>
<td>50 +</td>
<td>2 (5)</td>
<td>1 (6)</td>
<td>1 (3)</td>
</tr>
<tr>
<td>40 +</td>
<td>6 (10)</td>
<td>9 (11)</td>
<td>10 (15)</td>
</tr>
<tr>
<td>30 +</td>
<td>42 (43)</td>
<td>46 (48)</td>
<td>55 (56)</td>
</tr>
<tr>
<td>Under 30</td>
<td>3 (3)</td>
<td>10 (10)</td>
<td>27 (28)</td>
</tr>
<tr>
<td>Total</td>
<td>53 (69)</td>
<td>67 (79)</td>
<td>99 (112)</td>
</tr>
<tr>
<td>% of all female patients</td>
<td>76.8</td>
<td>84.8</td>
<td>88.3</td>
</tr>
</tbody>
</table>

TABLE Ia. Male patients in whom satisfactory haemostasis was obtained

TABLE Ib. Female patients in whom satisfactory haemostasis was obtained
TABLE IIA. Male patients in whom haemostasis was unsatisfactory

<table>
<thead>
<tr>
<th>Systolic arterial pressure (mm Hg)</th>
<th>Age (yr)</th>
<th>Over 60</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No effect</td>
<td>20-29</td>
<td>30-39</td>
<td>40-49</td>
</tr>
<tr>
<td>70+</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>60+</td>
<td>0</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>50+</td>
<td>9</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>40+</td>
<td>2</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Over 60</td>
<td>1</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>Total</td>
<td>13</td>
<td>23</td>
<td>20</td>
</tr>
</tbody>
</table>

% of all male patients

TABLE IIB. Female patients in whom haemostasis was unsatisfactory

<table>
<thead>
<tr>
<th>Systolic arterial pressure (mm Hg)</th>
<th>Age (yr)</th>
<th>Over 60</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No effect</td>
<td>20-29</td>
<td>30-39</td>
<td>40-49</td>
</tr>
<tr>
<td>70+</td>
<td>4</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>60+</td>
<td>3</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>50+</td>
<td>4</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>40+</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>30+</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>16</td>
<td>12</td>
<td>13</td>
</tr>
</tbody>
</table>

% of all female patients

A male patient aged 46 yr was maintained at a systolic pressure of 40 mm Hg for 4.5 h and there was a further 12 h before his arterial pressure returned to normal. Neither he nor any of the other patients seemed to suffer harm to either mental or physical performance as a result of a delay in recovery. Subsequent cases, however, were limited to 2 h hypotension.

Sudden decreases of arterial pressure during the recovery period were caused by either sitting up too quickly, vomiting, or the administration of sedation. In nearly every patient recovery to consciousness did not seem to be unduly delayed as a result of the hypotensive technique.

No death, or obvious morbidity, occurred as a result of the technique in any patient in this series.

DISCUSSION

The arguments for and against induced hypotension can be examined from three aspects. The operating conditions required for the planned procedure; the ease of satisfying these; and the safety to the patient.

Requirements for operation

The degree of acceptable bleeding varies from one surgeon to another, but the surgeon involved in this series has always demanded a high degree of haemostasis (Ironside, 1976). In middle ear surgery “bleeding” or blood loss may be measured in fractions of a millilitre. Deacock (1971) measured the amount of loss in stapedectomy with an average of about 1 ml, although, in his series, haemostasis was not entirely satisfactory. It is felt that this state of profound hypotension becomes a necessity rather than the luxury hinted at by Enderby (1975) in his observations on the practice of deliberate hypotension.

It is easier to produce good haemostasis in a non-infected ear.

Reasons for methods used

Of all the techniques which are currently in use, from the “protected sleep” of Delarouelle (1971) with its very heavy medication and long recovery time, to the combined methods with associated ventilation, we are of the opinion that none gives the same degree of haemostasis together with ease of administration as the method described here.

Moderately deep anaesthesia is necessary to prevent coughing or straining with consequent bleeding as a result of an increase in venous pressure. The halothane-nitrous oxide in oxygen mixture was found to be satisfactory and an average concentration of 2% halothane gave an adequate depth of anaesthesia. In 12 patients the blood halothane concentration was measured and an average value of 9.98 mg% (SEM 2.03 mg) was obtained. Halothane has the added advantage of dilating the cerebral vasculature in proportion to its dosage (McDowall, 1967) so that the cerebral blood flow is well maintained at low values of arterial pressure (Fitch et al., 1975). It is believed by Eckenhoff (1974) that the head-up position will partly off-set any increase in cerebral blood volume. Halothane causes minimal changes in the serum lactate concentration and lactate/pyruvate ratio according to Cohen and others (1964), less than most other inhalation anaesthetic agents even with added hypotension (Nilsson and Siesjö, 1971).

In spite of the inclusion of a Ruben valve in the anaesthetic circuit, D. G. McDowall (personal communication) showed very high $P_{CO_2}$ values in some of the patients in this series. According to Wollman and others (1965), this might offer a measure of
protection to the CBF, although the observations of Okuda and others (1976) indicate that at low arterial pressures cerebrovascular responsiveness to $P_{CO_2}$ change is lost.

Pentolinium tartrate was chosen to produce hypotension because:

(a) it was easy to administer by a single-dose i.v. injection which outlasted the length of any operation
(b) there appeared to be no undesirable side-effects
(c) it was fairly consistent in its action, although some patients showed resistance to it (as indeed happens with all the ganglion-blocking agents)
(d) it was easy to reverse its action

Monitoring

At very low arterial pressures it is difficult to obtain accurate readings other than by electronic means or by direct measurement. Since it is not our practice to employ the latter routinely in cases of this nature, the Air Shields PTB3 monitor was used regularly. The accuracy of this apparatus was tested in 20 patients in whom direct measurement was performed in addition, and it was found that there was never more than 10% discrepancy between the two.

Arterial pressure values

The arterial systolic pressure range which gave the most satisfactory haemostasis was 30-45 mm Hg. In a few patients operating conditions were satisfactory above this value, and in a few bleeding occurred in spite of pressures in the low range. The reason for this is not immediately apparent.

Resistance in females seems to be entirely dependent on age, the younger the patient the more resistance, but with males the greatest resistance was in young middle age.

At first, this was thought to be associated with cigarette smoking, but further enquiries showed that this was not so. Perhaps it is coincidence that this is the age group in males in which alcohol consumption habits are well established (Morrison, 1964).

Use of beta-blockers

Resistance to profound hypotension was usually associated with tachycardia which was not altered by procainamide. The use of propranolol or practolol was considered, but in spite of the work of Hewitt, Lord and Thornton (1967), it was felt that the use of either of these drugs at very low pressures was to risk the possibility of irreversible cardiac failure—a view also expressed by Wylie and Churchill-Davidson (1972). It has been suggested that fractional doses of practolol could be tried with comparative safety, but so far this has not been attempted.

Absence of complications

During this series no patient appeared to suffer from cerebral hypoxia as a result of being subjected to this technique, even on repeated occasions in some cases. All patients have been examined as outpatients after operation, sometimes at intervals over many years, and in no case has any resulting mental disturbance been detected.

There were no renal complications after operation. Urinary secretion was not measured at the time of hypotension. Renal blood flow decreases during anaesthesia, but Miles and others (1952) showed that this decrease is less during ganglionic blockade and that urinary secretion ceases when the arterial pressure decreases below 70 mm Hg. Best and Taylor (1973) also state that renal arteries undergo shut-down at under 60 mm Hg, but they do not specify the type of hypotension under which this occurs. Clearly hypotension as a result of ganglionic blockade with dilated renal vessels will be quite a different situation from hypotension as a result of haemorrhage with consequent renal vasoconstriction.

Brierly and others (1969), studying Rhesus monkeys, induced profound hypotension by both drugs and haemorrhage, and found a patchy necrosis of the brain. It is to be hoped that the results of this series will show that this does not appear to apply to anaesthetized man.

Disadvantages

The technique described has few disadvantages. It can be used only in patients who are comparatively fit, there are age limitations, some patients, particularly males, show some resistance and there is a limitation on the duration of hypotension. Nevertheless, the method described produced satisfactory operating conditions for this intricate type of surgery in a high proportion of cases without any evidence of morbidity after operation.

ACKNOWLEDGEMENTS

I wish to thank Mr W. M. S. Ironside for his encouragement over the years, Professor D. G. McDowall for patient advice and help with the writing of this paper, and Miss I. M. Kennedy for much secretarial assistance.

REFERENCES


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ANESTESIA AVEC HYPOTENSION PROFONDE

POUR LA CHIRURGIE DE L'OREILLE MOYENNE

RESUME

Pour obtenir un champ opératoire exsangüe, afin de pouvoir procéder à une intervention chirurgicale sur l'oreille moyenne à l'aide d'un microscope opératoire, on a abaissé la pression systolique artérielle à moins de 50 mm Hg sur 700 malades, grâce à l'anesthésie par le thiopentone—l'halothane—le protoxyde d'azote dans l'oxygène ainsi que par le tartrate de pentolinium. Les résultats ont été excellents dans 84 % des cas, modérément bons dans 12 % des cas, et médiocres dans les autres 4 % des cas. Les résultats ont été moins satisfaisants sur les hommes (22,8 %) que sur les femmes (11,4 %). En dépit du fait que la tension artérielle a été réduite à de très faibles valeurs, et ce dans de nombreux cas, il n'y a eu aucune mortalité ou morbidité attributable à la technique utilisée.

NARKOSE BEI NACHHALTIGER HYPOTENSION

FÜR MITTELOHRCIRURGIE

ZUSAMMENFASSUNG

Um eine unblutige Fläche für eine mit dem Operationsmikroskop durchgeführte Mittelohr chirurgie zu erzeugen, wurde der arterielle, systolische Blutdruck in 700 Patienten auf wenigerals 50 mm Hg ab durch Anwendung von Thiopenton-Halothan Stickstoffoxydul in Sauerstoffnarkose zusammen mit Pentolinium-Tartrat abgeschwächt. Die Ergebnisse waren bei 84 % der Patienten ausgezeichnet, mässig gut bei 12 % und bei 4 % schlecht. Bei Männern (22,8 %) waren die Ergebnisse unbefriedigender als bei Frauen (11,4 %). Obwohl der arterielle Blutdruck in vielen Fällen auf sehr niedrige Werte abgeschwächt wurde, trat keine Sterblichkeit oder Krankhaftigkeit auf, die dem Verfahren zugeschrieben werden könnte.

ANESTESIA CON HIPOTENSION PROFUNDA EN

CIRUGIA DEL OIDO MEDIO

SUMARIO

Para producir un campo exangüe para cirugía del oído medio, efectuada con el microscopio de operaciones, la presión arterial sistólica fue disminuida a menos de 50 mmHg en 700 pacientes mediante tiopental—halotano—monóxido de nitrógeno en anestesia con oxígeno, junto con trártaro de pentolínio. En el 84 % los resultados fueron excelentes, en el 12 % moderadamente buenos, y en el 4 % eran pobres. Hubo más resultados insatisfactorios en los varones (22,8%) que en las hembras (11,4%). A pesar de haberse reducido la presión arterial a valores muy bajos en muchos casos, no se produjo ninguna mortalidad ni morbilidad atribuibles a la técnica.