Crisis management during anaesthesia: hypertension

A D Paix, W B Runciman, B F Horan*, M J Chapman, M Currie

Background: Hypertension occurs commonly during anaesthesia and is usually promptly and appropriately treated by anaesthetists. However, its recognition is dependent on correctly functioning and calibrated monitors. If it is not diagnosed and/or promptly corrected, it has the potential to cause significant morbidity and even mortality.

Objectives: To examine the role of a previously described core algorithm “COVER ABCD–A SWIFT CHECK” supplemented by a specific sub-algorithm for the management of hypertension occurring in association with anaesthesia.

Methods: The potential performance of this approach for each of the relevant incidents among the first 4000 reported to the Australian Incident Monitoring Study (AIMS) was compared with the actual management as reported by the anaesthetists involved.

Results: There were 70 reports of intraoperative hypertension among the first 4000 incidents reported to AIMS. Drug related causes accounted for 59% of all incidents. It was considered that, properly applied, this structured approach would have led to a quicker and/or better resolution of the problem in 21% of the cases.

Conclusion: Once hypertension is identified and confirmed, its rapid control by the careful use of a volatile anaesthetic agent, intravenous opioids, or rapidly acting antihypertensives will usually avoid serious morbidity. If hypertension is unresponsive to the treatment recommended in the relevant sub-algorithm, an unusual cause such as phaeochromocytoma, carcinoid syndrome, or thyroid storm should be considered.
HYPERTENSION

PRECIPITATING FACTORS (1)*
Give particular consideration to:
  Drug errors (1)
  Awareness or light anaesthesia (2)
  Pre-existing hypertension (3)
  Airway problems (4)
  Surgical factors (5)
  Hyperventilation (6)
  Unusual/uncommon conditions
  Pheochromocytoma
  Hyperthyroidism
  Malignant hyperthermia
  Raised intracranial pressure
  Fluid overload

EMERGENCY MANAGEMENT
Complete COVER ABCD–A SWIFT CHECK (7)
Confirm the blood pressure change is real (8)
Deepen anaesthesia/assess depth
Specifically consider vasopressors, stop them (9)
Inform and interrogate the surgeon; cease stimulation
Recheck for drug errors and delivery of anaesthesia
Consider an appropriate dose of opioid (10)
Consider antihypertensive therapy;

BE CAUTIOUS USING HYPOTENSIVE AGENTS IF THE POSSIBILITY OF LIGHT ANAESTHESIA EXISTS
Consider GTN 50 μg in 500 ml 5% dextrose and start at 0.1 ml/kg/hr (adult dose 5-10 ml/hr)
If tachycardia is troublesome:
  Give atenolol 0.015 mg/kg IV bolus injections (11)
  Titrate drugs against effect

* Numbers in brackets refer to Notes in the right hand panel.

FURTHER CARE
Review and treat probable cause(s)
See precipitating factors and (1) to (9) below
Resolution will usually follow
Consider invasive blood pressure monitoring

NOTES:
It was judged that correct use of COVER ABCD followed by the hypertension sub-algorithm would have identified the specific cause in 79% of 70 relevant incidents reported to AMS. In 21% no obvious cause was apparent, but was assumed to be a combination of light anaesthesia and/or excessive surgical stimulation and in all cases was effectively treated by rapidly deepening anaesthetic depth.
  1) Drug errors, secondary to drugs being given – 40%, or following drugs unintentionally not being given – 14%
  2) Presumed light anaesthesia – 21% of reports. Due to inter-individual variation, failure to deliver agents: vapouriser, nitrous oxide, syringe driver failure.
  3) Preoperative hypertension – 61% of the 252 reports received by AMS.
  4) Causes included hypovolaemia, hyperventilation and hypoxia.
  5) Surgical stimulus, water intoxication, aortic arch clamping.
  6) Hyperventilation in 11%. Due to hypovolaemia, sode lime exhaustion, sticking valve in circle system, inadequate fresh gas flows in non-rebreathing circuits.
  7) Use of the COVER ABCD–A SWIFT CHECK algorithm identified 73% of incidents reported to AMS.
  8) Use a sphygmomanometer and auscultate the blood pressure.
  9) When using a arterial line, check the zero and calibration. In 4% of cases the hypertension was serious.
  10) Inadvertent vasopressor administration was the commonest reported cause – 40%.
  11) After reviewing the drugs administered to date, give opioids if judged appropriate, i.e. fentanyl 0.25–0.5 mg/kg aliquots, titrated to effect.
  11) Esmolol, a β blocker with a rapid onset and short duration of action, in a dose of 0.25–0.5 mg/kg may be a better choice if available.

These notes comprise a reverse side of a page of the Crisis Management Manual10.

Figure 1 Hypertension.

intubation, and three involved hypertension which was a consequence of poorly controlled preoperative hypertension. Four reports of spurious hypertension (table 1) were each due to equipment malfunction. All of these were excluded, leaving 70 reports of the 252 for analysis.

These remaining 70 reports were analysed for causes, treatment, and outcome from the hypertensive incident. The precipitating factors were most commonly drug related (41 reports, 59%), excessive surgical stimulation or light anaesthesia (15 reports, 21%), of which 13 were during general anaesthesia and two during regional anaesthesia), or equipment related (nine reports, 13%). Miscellaneous causes accounted for the remaining five reports (7%); these included two reports of water intoxication and one report each of carcinoid syndrome, pre-eclampsia and pheochromocytoma.

Table 2 shows the drug related causes and table 3 the equipment related causes.

In the majority of cases the anaesthetist deepened anaesthesia or corrected the primary cause—for example, repositioning the malpositioned vapouriser in six cases. In 22 cases (31%) specific intravenous antihypertensive therapy

Table 1 Causes of spurious hypertension

<table>
<thead>
<tr>
<th>Cause of hypertension</th>
<th>No of incidents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calibration drift of invasive device</td>
<td>2</td>
</tr>
<tr>
<td>Sphygmomanometer cuff herniation</td>
<td>1</td>
</tr>
<tr>
<td>Calibration error of non-invasive device</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>4</td>
</tr>
</tbody>
</table>

In all cases the error was detected by the use of a sphygmomanometer to auscultate the blood pressure.

Table 2 Drug related causes of intraoperative hypertension

<table>
<thead>
<tr>
<th>Cause of hypertension</th>
<th>No of incidents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vaspressor administration:</td>
<td></td>
</tr>
<tr>
<td>inadvertent, by anaesthetist</td>
<td>16</td>
</tr>
<tr>
<td>by a surgeon</td>
<td>6</td>
</tr>
<tr>
<td>IV adrenaline with local anaesthetic*</td>
<td>6</td>
</tr>
<tr>
<td>Anaesthetic failure:</td>
<td></td>
</tr>
<tr>
<td>failure to deliver volatile agent†</td>
<td>6</td>
</tr>
<tr>
<td>failure to deliver nitrous oxide</td>
<td>4</td>
</tr>
<tr>
<td>Unknown‡</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td>41</td>
</tr>
</tbody>
</table>

*Associated with epidural injection (n = 3), interscalene blocks (n = 2), cervical plexus block (n = 1).
†All six due to malpositioning of the vapouriser.
‡In three reports drug problems were mentioned but there were insufficient data for analysis.
Table 3  Equipment related causes of intraoperative hypertension

<table>
<thead>
<tr>
<th>Cause of Hypertension</th>
<th>No of incidents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ventilation problem:</td>
<td></td>
</tr>
<tr>
<td>Stuck valve</td>
<td>3</td>
</tr>
<tr>
<td>Hyperventilation</td>
<td>3</td>
</tr>
<tr>
<td>Soda lime exhaustion</td>
<td>2</td>
</tr>
<tr>
<td>Endobronchial intubation</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>9</td>
</tr>
</tbody>
</table>

was administered. A range of agents was used. Serious morbidity occurred in six cases; there were two reports each of myocardial infarction, pulmonary oedema, and awareness under general anaesthesia.

When the COVER ABCD–A SWIFT CHECK algorithm was applied to each report, it was considered that all cases of hypertension would have been detected at the SCAN level. It was considered that the cause of the hypertension, once identified, would have been detected at the V1 stage of COVER in 4% (hyperventilation due to hypoventilation), at the V2 stage of COVER in 9% (vapouriser not correctly seated on the back bar), at the E1 (endotracheal tube) stage of COVER in 1% (inadvertent endobronchial intubation), at the recheck/review stage of COVER in 20%, and at the D (drugs stage) of ABCD in 39%. Of the remaining 19 reports where a diagnosis was not made, it was considered that, in three cases, “spurious” hypertension secondary to pressure measuring device faults would have been detected at the R stage of COVER. In one other case there was a calibration error of a non-invasive measurement device. In the remaining 15 reports of the 19 (79%), no specific cause was identifiable at the time of reporting or upon consideration of the incident by AIMS reviewers. These results are summarised in table 4.

When the potential effectiveness of the structured approach represented by the COVER ABCD–A SWIFT CHECK algorithm and the special sub-algorithm for hypertension (fig 1) was compared with that of the actual management as documented in each of the 70 incidents, it was considered that, properly applied, the structured approach would have led to a quicker and/or better resolution of the problem in 15 cases (21%).

DISCUSSION

Hypertension is commonly encountered by anaesthetists, being mentioned in 252 (6%) of the first 4000 incidents reported to AIMS. Of these reports, 154 mentioned preoperative hypertension only. Pre-existing hypertension, particularly if untreated, increases the likelihood of intraoperative hypertension and of complications, as has previously been reported. A hypertension is common. The Framingham Study found that 20% of urban “whites” had blood pressures greater than 160/95 mm Hg, and almost half had pressures greater than 140/90 mm Hg. The incidence was even higher in “non-whites”.

A reliable and early diagnosis of hypertension is only possible with accurate, regularly repeated measurements of systemic blood pressure. Monitor accuracy is dependent on correct maintained calibration of the zero point and on linearity throughout the measurement range. This is emphasised by the three cases in which spurious hypertension was recorded by invasive (n = 2) and non-invasive (n = 1) monitors due to calibration problems and one further report of a sphygmomanometer cuff bladder herniation giving rise to an erroneously high blood pressure.

Hypertension and tachycardia under anaesthesia have been shown to be independent risk factors for poor outcomes, particularly after long procedures.

Analysis of the AIMS reports has served to emphasise the fact that, while hypertension is usually readily detected and correct identification and treatment of the primary cause usually follows rapidly, a structured systematic approach is necessary to optimise management and outcome in atypical cases. It was judged that correct use of the COVER ABCD–A SWIFT CHECK core algorithm and the hypertension sub-algorithm would, properly applied, have led to earlier recognition and/or better management in 21% of relevant incidents reported to AIMS.

All cases of hypertension should be detected at the SCAN level and confirmed with a manual verification at the CHECK level of the COVER algorithm. The COVER portion of the algorithm yielded 34% of the causes; a further 39% were due to drug errors and would have been detected during the ABCD portion of the algorithm; 27% of causes of hypertension in this series remained undiagnosed. The sub-algorithm

Table 4  Level of identification of cause using the algorithm

<table>
<thead>
<tr>
<th>Level</th>
<th>No (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>V1 ventilation</td>
<td>3 (4)</td>
</tr>
<tr>
<td>V2 vapouriser</td>
<td>6 (9)</td>
</tr>
<tr>
<td>E Equipment</td>
<td>1 (1)</td>
</tr>
<tr>
<td>R Review/Recheck</td>
<td>14 (20)</td>
</tr>
<tr>
<td>D Drugs</td>
<td>27 (39)</td>
</tr>
<tr>
<td>Unidentified*</td>
<td>19 (27)</td>
</tr>
<tr>
<td>Total</td>
<td>70 (100)</td>
</tr>
</tbody>
</table>

*In 15 cases no specific cause could be identified by the AIMS reviewers and in four cases a cause was attributed (see text).

Key messages

- There were 70 incidents of intraoperative hypertension analysed from among the first 4000 reports to the AIMS database.
- In 41 (59%) of the analysed reports drugs were the precipitating cause.
- Excessive surgical stimulation or light anaesthesia accounted for another 15 reports (21%).
- There were nine reports (13%) involving equipment related causes.
- Serious morbidity (six cases) involved two each of myocardial infarction, pulmonary oedema, and awareness under general anaesthesia.
- A reliable early diagnosis of hypertension during anaesthesia is dependent upon accurate repeated measurements of systemic blood pressure and monitor accuracy. The latter is dependent upon correct maintained calibration and linearity throughout the measurement range.
- Once diagnosed, rapid control of hypertension (titration of volatile agent or of intravenous opioids or rapidly acting antihypertensives) is necessary to avoid potentially serious morbidity.
- In this series it was considered that, properly applied, the structured approach using the COVER ABCD–A SWIFT CHECK algorithm and the specific sub-algorithm for hypertension would have led to a quicker and/or better resolution of the problem in 15 cases (21%).
presented in fig 1 was relatively ineffective (four of 19 reports) at identifying the cause of the problem. However, in all cases, control of blood pressure would have been achieved by following the steps recommended in the hypertension sub-algorithm.

The use of the COVER ABCD algorithm will identify and treat the cause of hypertension in the majority (60%) of cases. However, the use of the sub-algorithm specific for hypertension would have been required in the 40% of reports in which this did not lead to resolution of the problem. In those instances where no obvious cause could be identified, it should be assumed to be due to a combination of light anaesthesia and/or excessive surgical stimulation and the patient depth of anaesthesia rapidly deepened. This will constitute effective treatment for the great majority of cases of hypertension where the cause remains obscure.

Hypertension can have serious consequences for the patient. Major morbidity occurred in six patients and consisted of two reports each of myocardial infarction, pulmonary oedema and awareness while under general anaesthesia. Once identified and confirmed, hypertension should rapidly be controlled by increasing volatile agent concentration or by titrating intravenous doses of opioids or rapidly acting antihypertensives. Failure to respond should alert the anaesthetist to the possibility of an overlooked or unusual cause. The complete algorithm should be carefully repeated at this stage. Should no cause be found, unusual conditions such as phaeochromocytoma, carcinoid syndrome, or thyroid storm should be considered.

Finally, it is important that a full explanation of what happened be given to the patient, that the event and the results of any tests should be documented in the anaesthetic record and that, if appropriate, the patient be given a letter to warn future anaesthetists. If a particular precipitating event was significant or a particular action was useful in resolving the crisis, this should be clearly explained and documented.

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REFERENCES