Crisis management during anaesthesia: awareness and anaesthesia

G A Osborne*, A K Bacon, W B Runciman, S C Helps

Background: Patient awareness during general anaesthesia has considerable potential for severe emotional distress in the patient as well as professional, personal, and financial consequences for the anaesthetist.

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

Method: The potential performance of this structured 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: Of the first 4000 reports received by AIMS, there were 21 incidents of patient awareness under general anaesthesia, and 20 of patients being paralysed whilst awake from “syringe swaps” before induction of anaesthesia. In 12 of the 21 reports there was an obvious cause, most commonly a low concentration of volatile agent (8 of 12 reports). The AIMS “core” crisis management algorithm would have detected the cause of awareness in all of these cases. In nine reports the cause of awareness appeared unremarkable, and in these the algorithm would not have been expected to detect or prevent awareness. Volatile agent monitoring would have prevented some cases of awareness, as would bispectral index electroencephalographic (BIS) monitoring. The role of BIS monitoring is still contentious, but it should be considered for high risk patients.

Conclusion: Awareness should be minimised by thorough checking of equipment, particularly vaporisers, and frequent application of a structured scanning routine. Awareness may occur during crisis management and aftermath protocols should include patient follow up to detect and manage awareness when it occurs.

Recent studies have highlighted the significance of awareness in present day anaesthetic practice. A large prospective Scandinavian trial found a rate of awareness of between 0.1 and 0.18%,1 and previous studies have reported an incidence of 0.2–0.4%.2 Awareness has considerable potential for patient morbidity including severe emotional distress and post-traumatic stress disorder.3–4 It also has important professional, personal, and financial consequences for the anaesthetist associated with this problem.5–6 Although awareness is usually perceived as an outcome after anaesthesia, rather than an event managed in isolation, it was thought to be useful to review awareness related incidents reported to the Australian Incident Monitoring Study (AIMS) in association with crisis management. Awareness may need to be considered in the differential diagnosis for any patient with the combination of unexplained sweating, tachycardia, and hypertension. In addition, the likelihood of awareness may be increased during many crisis situations, when anaesthesia can be inadvertently or deliberately light.

This report builds on a previous report of AIMS incidents related to awareness in the context of crisis management and also includes cases reported in a larger series of over 8000 AIMS reports.6

In 1993, a “core” crisis management algorithm, represented by the mnemonic COVER ABCD—A SWIFT CHECK (the AB preceeds COVER for the non-intubated patient), was proposed as the basis for a systematic approach to any crisis during anaesthesia where it is not immediately obvious what should be done, or where actions taken have failed to remedy the situation.7 This was validated against the first 2000 incidents reported to AIMS. AIMS is an ongoing study which involves the voluntary, anonymous reporting of any unintended incident which reduced, or could have reduced the safety margin for a patient.8–9 It was concluded that if this algorithm had been correctly applied, a functional diagnosis would have been reached within 40–60 seconds in 99% of applicable incidents, and that the learned sequence of actions recommended by the COVER portion would have led to appropriate steps being taken to handle the 60% of problems relevant to this portion of the algorithm.9 However, this study also showed that the 40% of problems represented by the remainder of the algorithm, ABCD—A SWIFT CHECK, were not always promptly diagnosed or appropriately managed.10 It was decided that it would be useful, for these problems, to develop a set of sub-algorithms in an easy to use crisis management manual.11 In this work, AIMS incidents related to awareness have been extended from those reported in the first 2000 incidents, to those in the first 4000. This study reports on the potential place of the COVER ABCD—A SWIFT CHECK algorithm in the diagnosis and initial management of actual or potential awareness, provides an outline of a specific crisis management sub-algorithm for these problems during general anaesthesia, and provides an indication of the potential value of using this structured approach.

METHODS
Of the first 4000 incidents reported to AIMS, those which made reference to awareness were extracted and analysed for relevance, presenting features, type of surgery, cause,
management, and outcome. The COVER ABCD—A SWIFT
CHECK algorithm, as presented elsewhere in this set of
articles,15 was applied to each relevant report to determine the
stages at which the problem might have been diagnosed and
to confirm that activating the COVER portion would have led
to appropriate initial steps being taken. As awareness is not
completely dealt with by this algorithm, a specific sub-
algorithm was developed (see fig) and its putative effective-
ness was tested against the reports. How this was done is
described elsewhere in this set of articles.16 The potential
value of this structured approach (that is, the application of
COVER ABCD—A SWIFT CHECK to the diagnosis and initial
management of this problem, and the application of the sub-
algorithm for awareness) was assessed in the light of the
AMS reports by comparing its potential effectiveness for
each incident with that of the actual management, as
recorded in each report.

RESULTS
The 130 incidents identified, 35 that used the keyword in a
sense other than to describe events related to patient
awareness during or associated with anaesthesia were
excluded. Twenty other incidents were thought to have low
potential to cause awareness under general anaesthesia and
patients were not interviewed postoperatively by the reporting
anaesthetist. A detailed review of these incidents has not
been included in this work.

Among the remaining 75 incidents there were 21 cases of
awareness under general anaesthesia; in 34 other cases under
general anaesthesia, although there was no awareness, there
was sufficient concern about the possibility for patients to be
interviewed postoperatively to determine if it had occurred;
and in 20 cases, patients were inadvertently paralysed while
still awake by unintended administration of muscle relax-
ants. In most, this was by “syringe swaps” immediately

AWARENESS

SIGNS
There may be no obvious signs (1)*
- Hypertension
- Tachycardia
- Reflex activity: Withdrawal/movement
- Coughing/straining
- Pupillary dilation
- Sweating/tears

HIGH RISK SITUATIONS (2)
- Patient factors: History of drug/alcohol abuse
- Highly anxious patient
- Previous awareness
- Equipment problems (3)
- Vaporiser leaking/empty/malpositioned
- Incorrectly calibrated vaporiser
- Nitrous oxide run out (4)
- Failure of drug delivery with TVA

Drug errors (4)
- Syringe swap causing paralysis before induction
- Syringe swap causing non-delivery of opioid/sedative

Anaesthetic technique
- Deliberate light anaesthesia during crisis management or
caesarean section
- Opioid based anaesthesia
- Regional/local anaesthetic techniques
- Anaesthesia with paralysis (5)

Other problems
- Laryngospasm/airway obstruction
- Difficult/prolonged intubation (6)
- Delayed extubation

EMERGENCY MANAGEMENT
- Stop painful stimuli
- Verbally reassure the patient
- Rapidly deepen anaesthesia
- Consider amnestic drugs: e.g. benzodiazepine
- Plan follow up:
  - In the recovery ward and the next day (7)
  - As necessary, before discharge

The sub-algorithm forms a facing page of the
* Numbers in brackets refer to Notes in the right hand panel

FURTHER CARE
- Interview the patient post operatively as soon as possible, and several
days later (7)
- Reassure the patient
- Explain what has happened
- Be honest and sympathetic
- Arrange for follow up
- Go through “After the crisis” → page 70*

NOTES:
21 cases of awareness under general anaesthesia were reported to AMS. In
43% the conduct of the anaesthetic appeared unremarkable, and was only
discovered postoperatively by an un splitted patient complaint. The COVER-
ABCD algorithm would have detected almost all causes of awareness where it
was actually suspected but would have been ineffective in patients who were aware but
lacked physical signs to indicate its presence.

1) There may be no signs to indicate awareness. In 43% of 21 cases of
awareness under general anaesthetic, there were no remarkable changes
to alert suspicion.

2) Commonest causes under general anaesthesia included:
- low concentration of volatile agent 38%
- in association with a crisis 23%
- failure to check equipment 19%
- justified risk taking 10%

3) The most frequently identified cause of awareness under general
anaesthetic was a low concentration of volatile agent. The commonest
preventable cause was secondary to a failure to check equipment,
specifically the vaporiser. There were 2 reports related to total intravenous
anaesthesia, caused by failure to deliver the drug to the patient. Failure to
deliver nitrous oxide was also reported.

4) There was another group of 20 incidents involving accidental paralysis
whilst awake. The majority involved syringe swaps immediately prior to
induction, particularly suxamethonium for opioids.

5) If full paralysis is avoided except where absolutely necessary there is a
greater chance that a patient will be able to indicate that they are aware.

6) There were 2 reports of awareness during difficult intubations.

7) Awareness may not manifest for several days after the incident.

These notes comprise a reverse side of a page of the
before induction of general anaesthesia. In 15 of these cases, patients had unpleasant recall of being paralysed while awake.

1. Incidents of awareness under general anaesthesia.

Details of incidents that were consistent with patient awareness under general anaesthesia are listed in table 1. There were nine (43%) cases of awareness in which the conduct of anaesthesia appeared unremarkable. There were no intraoperative presenting signs in six of these cases. Awareness in this group was often revealed by unsolicited postoperative patient complaints. There were two cases of awareness during electroconvulsive therapy (ECT) that occurred in the same session, raising the possibility of an unrecognised drug or equipment problem.

Awareness was associated with low concentrations of volatile agent in eight (38%) cases. In two of these this was a deliberate choice in the management of hypotension. The volatile agent was turned off too early in another case where surgery was unexpectedly continued rather than completed, and turned off accidentally in another during the management of an intraoperative pneumothorax. One case of awareness was caused by an empty vapouriser and three were due to malpositioned vapourisers.

In the 12 cases of awareness other than in the group in which the anaesthetic record appeared unremarkable, failure to check equipment (four cases; 34%) was the most prominent contributing factor. All four involved failure to check vapourisers and three of the four involved malpositioned vapourisers. These incidents outnumbered those due to justified risk taking (two cases; 17%), faulty technique (two cases; 17%) and inadvertent slips and lapses (two cases; 17%). Five cases (42%) were associated with crisis management situations. Of these, two were associated with deliberate decisions made in the management of intraoperative hypotension, one was due to a slip made during the management of a pneumothorax, and two occurred when anaesthesia became light during difficult intubations.

If awareness had been suspected in each of these 21 cases, the underlying cause would have been identified by COVER ABCD in 12 (57%), with eight identified by “vapouriser” and four by “drugs”. Those that would not have been identified were in the group in which anaesthesia appeared unremarkable. However, it should also be noted that in about half of all cases there were no obvious intraoperative signs alerting the anaesthetist to the possibility of awareness. Tachycardia and/or hypertension were mentioned as presenting signs in only five cases (24%). The occurrence of awareness during unremarkable anaesthesia and the apparent lack of signs to warn of its presence—particularly lack of autonomic signs—in such a large proportion of patients limits the likely success of any algorithm for identifying awareness, even if volatile agent monitoring is used.

2. Incidents under general anaesthesia with the potential for awareness, but in which awareness was excluded at patient follow up (n = 34).

Details of the incidents in this group are included in table 2. In this group, incidents associated with low concentrations of volatile anaesthetic agents were again prominent, and were involved with 14 of 34 cases (41%). In three cases the volatile agent was turned off deliberately because of intraoperative hypotension. It was turned off early in one case when the timing of the procedure’s end was misjudged, accidentally turned off intraoperatively in two cases, and accidentally not turned on from the start of another. Incidents with malpositioned vapourisers were also again prominent in this group (three cases).

Twelve (35%) of these incidents were due to slips or lapses and 11 (32%) were due to failure to check equipment, with five (15%) involving failure to check vapourisers.

Six incidents (18%) were associated with crisis management situations, consisting of three cases with hypotension, one with difficulty in ventilation, one difficult intubation and one difficult emergency tracheostomy. Four cases (12%) presented with intraoperative hypertension and/or tachycardia.

In all 34 of these cases patient signs or other events aroused suspicion of patient awareness. The underlying potential cause of awareness should have been identified by use of COVER ABCD in at least 33 (97%) cases. In one case, a faulty vapouriser that delivered lower than the indicated concentration was only identified by the lack of odour in the circuit, a diagnostic measure not mentioned in the present algorithm.

3. Incidents in which patients were accidentally paralysed while awake.

Details of these 20 incidents are included in table 3. Most patients had clear recall of the incident and found the experience significantly distressing. The majority of cases involved syringe swaps (suxamethonium/opioid) immediately before induction of anaesthesia. The true nature of what

### Table 1

<table>
<thead>
<tr>
<th>Details</th>
<th>Intraoperative presentation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unremarkable anaesthesia with no obvious aetiology (n = 9)</td>
<td>Nil</td>
</tr>
<tr>
<td>Cardiac surgery. Aware at sternotomy</td>
<td>Tachycardia/hypertension</td>
</tr>
<tr>
<td>Cardiac surgery. Aware at sternotomy</td>
<td>Tachycardia/hypertension</td>
</tr>
<tr>
<td>Caesarean section. Aware at incision</td>
<td>Tachycardia/hypertension</td>
</tr>
<tr>
<td>Burns debridement. Aware during maintenance</td>
<td>Nil</td>
</tr>
<tr>
<td>Laparotomy. Aware during maintenance</td>
<td>Diaphoresis</td>
</tr>
<tr>
<td>Minor gynaecology case. Aware when positioned</td>
<td>Nil</td>
</tr>
<tr>
<td>MUA. Aware during manipulation</td>
<td>Nil</td>
</tr>
<tr>
<td>ECT. Aware at electrode placement</td>
<td>Nil</td>
</tr>
<tr>
<td>ECT. Aware at electrode placement</td>
<td>Nil</td>
</tr>
<tr>
<td>Incidents related to volatile agents and vapourisers (n = 8)</td>
<td>Nil</td>
</tr>
<tr>
<td>Laparotomy. Aware during maintenance</td>
<td>Nil</td>
</tr>
<tr>
<td>Vapouriser deliberately turned off (hypotension)</td>
<td>Nil</td>
</tr>
<tr>
<td>Eye procedure. Awareness at and after intubation. Vapouriser deliberately turned off (hypotension)</td>
<td>Tachycardia</td>
</tr>
<tr>
<td>Drainage of pilonidal abscess. Aware during maintenance. Vapouriser turned off, misjudgement of end of procedure</td>
<td>Nil</td>
</tr>
<tr>
<td>Wound debridement. Aware during maintenance</td>
<td>Nil</td>
</tr>
<tr>
<td>Vapouriser accidentally turned off during management of pneumothorax</td>
<td>Tachycardia</td>
</tr>
<tr>
<td>Gynaecological procedure. Aware during maintenance. Caused by empty vapouriser</td>
<td>Hypertension, circuit leak</td>
</tr>
<tr>
<td>Repair of umbilical hernia. Aware during maintenance. Malpositioned vapouriser</td>
<td>Hypertension</td>
</tr>
<tr>
<td>Auxillary block dissection. Aware during maintenance. Malpositioned vapouriser</td>
<td>Hypertension</td>
</tr>
<tr>
<td>Laminectomy. Awareness during maintenance. Malpositioned vapouriser</td>
<td>Circuit leak</td>
</tr>
<tr>
<td>Miscellaneous incidents (n = 4)</td>
<td></td>
</tr>
<tr>
<td>Suxamethonium sensitivity in patient intubated for cardioversion</td>
<td>Patient movement</td>
</tr>
<tr>
<td>Aware during difficult intubation</td>
<td></td>
</tr>
<tr>
<td>Aware during difficult intubation</td>
<td></td>
</tr>
<tr>
<td>Aware during intubation for respiratory arrest, due to extravasated intravenous access cannula</td>
<td></td>
</tr>
</tbody>
</table>

MUA, manipulation under anaesthesia; ECT, electroconvulsive therapy.
had occurred was not always rapidly recognised. One patient was intubated without the use of further drugs and in another there was a delay before the nature of the problem was recognised, during which time the patient’s clinical state became unstable with significant cardiac dysrhythmias.

**DISCUSSION**

In this, as in earlier work, the most frequently identified cause of awareness under general anaesthesia was a low concentration of volatile anaesthetic agent. The COVER ABCD crisis management algorithm would have detected almost all causes of awareness under general anaesthesia in situations where it was suspected and an obvious cause existed. This indicates that the frequent review of this algorithm in the SCARE protocol should help minimise the occurrence of awareness. The main limitation of this algorithm, which presumably would be shared by other clinically based algorithms, is its ineffectiveness in patients who are aware, despite apparently unremarkable anaesthesia and who lack physical signs to indicate its presence. The possibility of awareness under these circumstances underlines the value of the post-anaesthesia follow up consultation and the importance of keeping adequate anaesthetic records. To minimise the impact of awareness under such circumstances, it becomes important to obtain an adequate anaesthetic history to elicit any past history of awareness and consider raising the issue of possible awareness when obtaining informed patient consent, at least for patients with such a history and in procedures where the incidence of awareness may be higher than usual.

When awareness is suspected intraoperatively, application of COVER ABCD should allow for corrective action for most obvious causes. The use of the awareness sub-algorithm presented in the figure describes the further management where awareness is suspected. Verbal reassurance to the patient should be considered, as anaesthetic depth is deepened. When circumstances are such that patient instability makes deepening of anaesthesia difficult by more traditional means, the use of intravenous ketamine could be considered. The amnesic properties of intravenous benzodiazepines may be useful in some circumstances, but their successful action should not be relied on, and all patients suspected of experiencing awareness should be followed up early to determine if it has occurred. Complaints of awareness should be taken seriously and deserve full and frank discussion with the patient and further follow up. Awareness may occur during crisis management, and aftermath protocols should include its detection and management.

The major preventable cause of awareness in AIMS incidents to date is failure to check equipment, particularly the vaporiser, with problems caused by malpositioned vaporisers being particularly prominent. A thorough equipment check is therefore the most important step in reducing the incidence of awareness.

This study has also included information from incidents that did not result in awareness under anaesthesia, but were considered to have significant potential to do so. Incidents related to a low concentration of volatile agent were again prominent in this group, as were incidents that involved failure to check equipment, including vaporisers, together with slips and lapses. There were also two incidents related to total intravenous anaesthesia in this group that were caused by failure to deliver the intravenous agent to the patient. These were not detected by the alarm systems provided with the infusion pumps that were used. The use of total intravenous anaesthesia should incorporate frequent checks of drug delivery as part of a SCAN routine, preferably by marking and checking syringe plunger travel.

Although the incidents that describe patients paralysed while awake do not fit with the conventional perception of awareness “under anaesthesia”, they nevertheless involve situations that are psychologically traumatic to patients and have the potential to cause morbidity from respiratory and cardiovascular instability. Although syringes should be carefully labelled before administration of general anaesthesia to help avoid such incidents, many of the incidents reported involved labelled syringes, and other strategies need to be
considered to minimise these incidents. These could include avoidance of the use of syringes similar to those used for relaxants for other drugs, and mental rehearsal of where syringes are placed and the order in which they will be given. An initiative arising from an earlier analysis of AIMS data was making syringes with red plungers available for use with relaxants to add an additional visual "cue"; sales of these have increased progressively both within Australia and internationally. Early recognition of what has happened is critical in the management of these incidents. Patients involved should be reassured verbally and wherever possible anaesthesia should be promptly induced, before any further substantial intervention—particularly intubation—is undertaken. Patients should be followed up and those with recall of the incident should be provided with an explanation of what happened and should be offered further follow up.

In conclusion, awareness under anaesthesia may occur despite apparently sound anaesthetic management and the lack of physical signs. In these circumstances, no algorithm can be expected to reliably detect or prevent awareness. When awareness is actually suspected, the use of COVER ABCD should reliably detect most obvious causes of awareness, provided that in the absence of a volatile agent monitor, the odour of the anaesthetic gases in the circuit is checked to exclude a significantly lower volatile agent concentration than expected. The incidence of awareness under anaesthesia should be reduced by careful checking of equipment, particularly vaporisers and the intraoperative use of the SCAN level of COVER ABCD. Awareness may occur during crisis management and this should be considered after crisis resolution. Aftermath protocols should include its detection and treatment. As previously stated, AIMS incidents suggest that the inadvertent paralysis of patients while awake is a significant cause of patient trauma that could be reduced by measures such as syringe labelling, together with other methods of clearly identifying syringes used for relaxants, and mental rehearsal of the positions of all syringes and the order in which they will be used. In countries in which they can be afforded, integrated drug administration systems, online volatile agent recognition and monitoring, and depth of anaesthesia monitors (for example, BIS monitoring and auditory evoked potentials) should prevent most cases of awareness. However, the cost-benefit of monitors may well be out of the range of even the best resourced hospital systems for use in all routine cases, especially as they appear not to prevent all cases of awareness. Perhaps meticulous attention should be paid to all the other measures described above, and BIS monitoring should be referred for higher risk patients.

Finally, it is important that a full explanation of what happened be given to the patient, that the event be documented in the anaesthetic record, and, if appropriate, that 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.

**ACKNOWLEDGEMENTS**

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**Key messages**

- Of the first 4000 incident reports to the AIMS there were 21 instances of patient awareness under general anaesthesia, 34 other cases where a postoperative interview was conducted to determine if it had occurred, and 20 more cases where patients were inadvertently paralysed while still awake due to unintended muscle relaxant administration.
- In nine of the 21 awareness cases there were no warning signs either before or during anaesthesia.
- In the remaining 12, failure to check equipment (34%) was the commonest contributing factor.
- In eight of the 21 cases the problem was too low a concentration of volatile agent being delivered from the vapouriser (low or off setting, empty or malpositioned).
- Of the remaining four cases, three were aware during endotracheal intubation.
- COVER ABCD would have identified the underlying cause in 12 of the 21 cases, if awareness had been suspected in all.
- In the 34 “possible awareness” cases, the causes most commonly involved vapourisers (13 cases), ventilators (four cases), circuit leaks (four cases), and oxygen flush problems (two cases).
- Twelve of the 34 cases (35%) were due to slips or lapses and 11 (32%) failure to check equipment.
- In six (18%) of these cases the awareness was associated with crisis management (three hypotension, one difficult ventilation, one difficult intubation, one difficult emergency tracheostomy).
- Most of the 20 “paralysed while awake” cases were the result of a “syringe swap” before induction of general anaesthesia. Most of these patients had clear recall and were significantly distressed.
- In this series the commonest identifiable cause was low concentration of volatile anaesthetic agent and the major preventable cause in AIMS is failure to check equipment.
- COVER ABCD algorithm followed by the awareness sub-algorithm should reliably detect most causes in any suspected awareness.
- Volatile agent monitoring, integrated drug administration systems, and the use of bispectral index electroencephalographic (BIS) monitoring in high risk patients is recommended.
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