

Crisis management during anaesthesia: awareness and anaesthesia

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

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*Dr Osborne died before this research was published.

See end of article for authors' affiliations

Correspondence to:
Professor W B Runciman,
President, Australian
Patient Safety Foundation,
GPO Box 400, Adelaide,
South Australia, 5001,
Australia; research@apsf.net.au

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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 while 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 course of anaesthesia 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 management⁷ and also includes cases reported in a larger series of over 8000 AIMS reports.⁸

In 1993, a "core" crisis management algorithm, represented by the mnemonic COVER ABCD—A SWIFT CHECK (the AB precedes 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.⁹ 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.¹⁰

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.^{9–11} 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.¹² 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,¹² 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 effectiveness was tested against the reports. How this was done is described elsewhere in this set of articles.¹² 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 AIMS reports by comparing its potential effectiveness for each incident with that of the actual management, as recorded in each report.

RESULTS

Of 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 relaxants. In most, this was by “syringe swaps” immediately

AWARENESS	
SIGNS	FURTHER CARE
There may be no obvious signs (1)*	Interview the patient post operatively as soon as possible, and several days later (7)
Hypertension	Reassure the patient
Tachycardia	Explain what has happened
Reflex activity: Withdrawal/movement	Be honest and sympathetic
Coughing/straining	Arrange for follow up
Pupillary dilation	Go through “After the crisis” → page 70*
Sweating/tears	
HIGH RISK SITUATIONS (2)	NOTES:
Patient factors: History of drug/alcohol abuse	21 cases of awareness under general anaesthesia were reported to AIMS. In 43% the conduct of the anaesthetic appeared unremarkable, and was only discovered postoperatively by an unsolicited patient complaint. The COVER-ABCD algorithm would have detected almost all causes of awareness where it was actually suspected but would be ineffective in patients who were aware but lacked physical signs to indicate its presence.
Highly anxious patient	(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.
Previous awareness	(2) Commonest causes under general anaesthesia included:
Equipment problems (3)	low concentration of volatile agent 38%
Vaporiser leaking/empty/malpositioned	in association with a crisis 23%
Incorrectly calibrated vaporiser	failure to check equipment 19%
Nitrous oxide run out (4)	justified risk taking 10%
Failure of drug delivery with TIVA	(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.
Drug errors (4)	(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.
Syringe swap causing paralysis before induction	(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.
Syringe swap causing non-delivery of opioid/sedative	(6) There were 2 reports of awareness during difficult intubations.
Anaesthetic technique	(7) Awareness may not manifest for several days after the incident.
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	These notes comprise a reverse side of a page of the Crisis Management Manual²⁰.
Stop painful stimuli	* Page references refer to the Crisis Management Manual²⁰.
Verbally reassure the patient	
Rapidly deepen anaesthesia	
Consider amnesic drugs: eg. 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 Crisis Management Manual²⁰.	
* Numbers in brackets refer to Notes in the right hand panel	

Figure 1 Awareness.

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 vaporiser and three were due to malpositioned vaporisers.

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 vaporisers and three of the four involved malpositioned vaporisers. 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 “vaporiser” 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 vaporisers 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 vaporisers.

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 vaporiser 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 Incidents involving awareness under general anaesthesia (n = 21)

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

MUA, manipulation under anaesthesia; ECT, electroconvulsive therapy.

Table 2 Incidents with potential for awareness, where patients were followed up (n = 34)

Details	Cases	Intraoperative presentation
Incidents related to volatile agents and vaporisers		
Vaporiser off. Accidental	4	Tachycardia, hypertension, lacrimation, movement
Vaporiser off. Deliberate	3	Movement
Malpositioned vaporiser	3	Hypertension, circuit leak, patient movement
Empty vaporiser	1	Lacrimation
Cracked vaporiser mount	1	Circuit leak
Faulty vaporiser	1	Patient movement
Patient difficult to ventilate	1	Circuit leak
Incidents related to ventilators		
Leak, oxygen entrainment	3	Patient movement, oxygen analyser
Ventilator not turned on	1	Suspicion
Incidents related to circuit leaks		
Common gas outlet problem	3	Circuit leak, oxygen analyser
Leak elsewhere	1	Circuit leak
Incidents related to oxygen flush mechanism		
Oxygen flush jammed on	2	Oxygen analyser, direct observation
Incident related to transfer of patient from induction room to theatre		
Delay, without anaesthesia	1	Patient movement
Incidents related to total intravenous anaesthesia		
Failure to deliver anaesthetic agent	2	Hypertension, patient movement
Miscellaneous incidents		
N ₂ O delivery failure	5	Tachycardia, hypertension
Difficult intubation	1	Suspicion
Difficult tracheostomy	1	Suspicion

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,⁷ 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 SCAN mode of the SCARE protocol¹² 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.¹³

Table 3 Incidents where patients were paralysed while awake

Aetiology	Number of incidents
A Syringe swaps	
Suxamethonium/fentanyl	6
Suxamethonium/pethidine	1
Suxamethonium/unspecified opioid	1
Suxamethonium/atropine	1
Suxamethonium/gentamycin	1
Suxamethonium/metoclopramide	1
Atracurium/midazolam	2
Muscle relaxant/reversal, postoperative	2
Antibiotic/thiopentone	1
B Other	
Residual suxamethonium in injection port flushed into circulation with another drug given postoperatively	2
Atracurium by syringe pump, pre-induction	1
Suxamethonium mixed with fentanyl	1
Total number	20

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 after-math 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.¹⁴ 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,^{15–16} 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.^{17–19} 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.

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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 vaporiser (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 vaporisers (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.

having done the original hard work and participating in the development of the manuscript.

Authors' affiliations

G A Osborne, Senior Staff Specialist, Department of Anaesthesia and Intensive Care, Royal Adelaide Hospital and University of Adelaide, Adelaide, South Australia, Australia

A K Bacon, Consultant Anaesthetist, St John of God Hospital, Berwick, Victoria, Australia

W B Runciman, Professor and Head, Department of Anaesthesia and Intensive Care, University of Adelaide and Royal Adelaide Hospital, Adelaide, South Australia, Australia

S C Helps, Department of Medical Biochemistry, School of Medicine, Flinders University, Bedford Park, South Australia, Australia

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