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ORIGINAL ARTICLE

Crisis management during anaesthesia: obstruction of the natural airway

T Visvanathan, M T Kluger, R K Webb, R N Westhorpe

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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: Obstruction of the natural airway, while usually easily recognised and managed, may present simply as desaturation, have an unexpected cause, be very difficult to manage, and have serious consequences for the patient.**Objectives:** To examine the role of a previously described core algorithm "COVER ABCD-A SWIFT CHECK", supplemented by a specific sub-algorithm for obstruction of the natural airway, in the management of acute airway obstruction occurring in association with anaesthesia.**Methods:** The potential performance for 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:** There were 62 relevant incidents among the first 4000 reports to the AIMS. It was considered that the correct use of the structured approach would have led to earlier recognition of the problem and/or better management in 11% of cases.**Conclusion:** Airway management is a fundamental anaesthetic responsibility and skill. Airway obstruction demands a rapid and organised approach to its diagnosis and management and undue delay usually results in desaturation and a potential threat to life. An uncomplicated pre-learned sequence of airway rescue instructions is an essential part of every anaesthetist's clinical practice requirements.

Obstruction of the natural airway occurs quite commonly in association with general anaesthesia. Laryngospasm and bronchospasm, although forms of airway obstruction, are regarded as distinct entities by most anaesthetists and are dealt with elsewhere in this set of articles.^{1,2}

Risk factors include a history of sleep apnoea or previous airway difficulties with anaesthesia, obesity, maxillary hypoplasia, mandibular retrusion, bulbar muscle weakness, cervicothoracic kyphosis, and specific obstructive lesions such as infected or oedematous structures or adenotonsillar and lingual hypertrophy.³ Effective manoeuvres for alleviating airway obstruction include head tilt, chin lift, jaw thrust, and oropharyngeal or nasopharyngeal airways, all of which can be combined with continuous positive airway pressure.⁴⁻⁶

A number of additional factors may contribute to or cause obstruction of the natural airway (for example, a tumour mass or a granulomatous larynx) and/or make positive pressure ventilation of the lungs difficult by face mask (for example, a facial injury or deformity, a full beard), but difficulties also may be encountered in patients with no obvious predisposing factors. Some of those who obstruct during spontaneous ventilation under anaesthesia may also be difficult to ventilate by mask and, in a further subset, the larynx may be difficult or impossible to visualise. As these problems may occur unexpectedly and as the consequences for the patient may be serious, it is important that they are recognised immediately and handled promptly and effectively.

In 1993 a core crisis management algorithm, represented by the mnemonic COVER ABCD-A SWIFT CHECK, was proposed as the basis for a systematic approach to crisis management during anaesthesia (the AB precedes COVER for the non-intubated patient), 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 the original Australian

Incident Monitoring Study (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

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.⁷ 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.⁷⁻⁹ It was decided that it would be useful, for these problems, to develop a set of specific sub-algorithms in an easy to use crisis management manual.¹⁰ This study reports on the place of the AB COVER CD-A SWIFT CHECK algorithm in the diagnosis and initial management of obstruction of the natural airway, provides an outline of a specific crisis management sub-algorithm for this problem during 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 airway and obstruction were extracted and analysed for relevance, presenting features, causes, diagnosis, management and outcome. Those due to laryngospasm were excluded, as were those in which the trachea had been intubated. The AB COVER CD-A SWIFT CHECK algorithm was applied, as presented elsewhere in this set of articles,¹⁰ 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 management of obstruction to the natural airway is not dealt with by this algorithm, a

AIRWAY OBSTRUCTION	
<p>SIGNS</p> <p>Noisy, poor or absent ventilation Increased inspiratory efforts/tracheal tug Paradoxical chest/abdominal movements</p> <p>MANAGEMENT</p> <p>Cease stimulation/surgery 100% oxygen (1)* Try chin lift/jaw thrust (2) Request immediate assistance (3) Consider allowing the patient to wake up, or Ensure adequate depth of anaesthesia (4) and Visualise and clear the pharynx/airway (5) If the problem is laryngospasm → page 12** If the problem is regurgitation → page 16** Insert oral and/or nasal airways Reposition head, apply chin lift/jaw thrust (2) Try "team" mask CPAP/IPPV (3) IF YOU CANNOT VENTILATE (6) Have someone feel the pulse and call out the SpO₂ (1) (7) If not already paralysed Consider suxamethonium and atropine, see (8) and (9) on page 13** Make one attempt at intubation under direct vision IF YOU CANNOT INTUBATE Consider a laryngeal mask (8) IF THIS FAILS Do an immediate cricothyrotomy Ventilate with 100% oxygen IF YOU CANNOT VENTILATE VIA AN ETT Consider: Misplaced/kinked/blocked ETT → page 7** Bronchospasm → page 22** Pneumothorax → page 46** Consider possible obstruction distal to ETT: Try pushing a small tube past it or push the obstruction down one bronchus and ventilate the other lung with a clean tube.</p> <p>The sub-algorithm forms a facing page of the Crisis Management Manual¹⁵. * Numbers in brackets refer to Notes in the right hand panel. ** Page references refer to the Crisis Management Manual¹⁵.</p>	<p>FURTHER CARE</p> <p>Review the patient to:</p> <ul style="list-style-type: none"> confirm a clear airway exclude pulmonary aspiration exclude post obstructive pulmonary oedema explain what happened <p>There is a risk of awareness: go and see the patient in the ward later on explain again and reassure them (9) advise them to warn future anaesthesiologists.</p> <p>NOTES:</p> <p>It was judged that correct use of the algorithm would have led to earlier recognition of the problem and/or better management in 11% of the 62 relevant incidents reported to AIMS.</p> <ol style="list-style-type: none"> (1) Desaturation was documented in 65% of cases. (2) This may relieve mild laryngospasm and some obstructions. See (4) on page 13* (3) Tasks for "team" include mask CPAP/IPPV and subsequent intubation or cricothyrotomy, if necessary. Ask for 4 people Person I to hold mask and jaw with 2 hands and intubate. Person II to hold emergency oxygen and button squeeze the bag. Person III to ensure adequate anaesthesia and IV access. Person IV to find and pass equipment and help others. (4) This will often relieve laryngospasm and is a prerequisite for pharyngoscopy and suction. 14% of cases of laryngospasm presented as airway obstruction. (5) This is vital at this stage, half of the incidents reported had blood, secretions, a foreign body, or intrusive mass. Obviously, an intrusive mass cannot be cleared; care should be taken not to cause bleeding. This step is also important before mask CPAP or IPPV to prevent aspiration. (6) Get an assistant to have a scalpel and tube ready for you, as this will save time once the decision to proceed with cricothyrotomy is made. (7) There were 4 cardiac arrests, 3 dysrhythmias and 1 death. (8) The LMA is easy to insert and works well in about 95% of cases. It does not provide airway protection. See Caponas.¹⁶ (9) Provide written advice and document this in the medical record. <p>These notes comprise a reverse side of a page of the Crisis Management Manual¹⁵. * Page references refer to the Crisis Management Manual¹⁵.</p>

Figure 1 Obstruction of the natural airway.

specific sub-algorithm for airway obstruction was developed (see fig 1), and its putative effectiveness was tested against the relevant reports. The potential value of this structured approach—that is, the application of AB COVER CD—A SWIFT CHECK to the diagnosis and initial management of this problem, followed by the application of the sub-algorithm for obstruction of the natural airway (fig 1)—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 first 4000 AIMS reports, there were 62 cases of obstruction of the natural airway in which laryngospasm was thought not to be the cause. Most (87%) presented clearly as airway obstruction, but the remainder (13%) presented as desaturation. Major physiological change, morbidity, or mortality occurred in over half (55%) of all incidents (table 1). Desaturation occurred in 40 cases (65%), cardiac arrest in four patients (7%), one of whom died, and cardiac dysrhythmia in three (5%). There were two cases of post-obstructive pulmonary oedema and one case each of

Table 1 Physiological change following airway obstruction (n = 62)

Physiological change	n	%
No change	4	6.5
Minor change	20	32.0
Major change	30	48.0
With cardiac arrest	3	5.0
With death	1	2.0
Not reported	4	6.5

pulmonary aspiration, cerebral oedema, and pneumothorax. In only four cases (6.5%) were there no adverse sequelae.

In seven cases a foreign body (packs or swabs in five cases, a denture in one, and an oesophageal stent in one) and in 11 cases blood or secretions (infraglottic mucus or blood in four) contributed to the problem. Airway obstruction was unexpected in 17 of these 18 cases. Removal of the foreign body and suctioning (via a bronchoscope in one infraglottic case) solved the problem completely in seven cases; eight patients

were intubated (intubation was reported as being difficult in one); two patients coughed up large mucous plugs, and one death followed bleeding into the lower respiratory tract from a "mini" tracheostomy.

In a further 12 patients anatomical problems contributed to the difficulty. In nine patients there was a tumour or polyp intruding into the airway, four of which were completely unexpected. Of the other three cases, one was due to unexpected laryngeal oedema, one due to facial oedema, and one to pre-existing facial deformity. Eight of these 12 cases were intubated (seven of which were described as difficult intubations) and two required cricothyrotomy or tracheostomy. Thus, overall, airway obstruction was completely unexpected in 22 of the 32 cases with identifiable predisposing or causative factors; 15 patients required intubation and two required surgical airways.

In 30 cases the airway obstruction was unexpected and no predisposing factor could be identified; 17 required intubation, two of which were described as difficult intubations. In the remaining two cases muscle relaxants were inadvertently given to awake patients and airway obstruction was the presenting sign. Both of these patients required intubation. Thus, overall, of the 62 cases of airway obstruction, 52 were completely unexpected, 34 required intubation (of which nine were difficult intubations), 32 had identifiable predisposing or causative factors, and two required a surgical airway.

When the AB COVER CD-A SWIFT CHECK algorithm was applied to each report, it was considered that the majority of cases would have been detected at the A (Airway) stage of the AB preceding COVER, at either the SCAN or CHECK level.⁹ However, eight patients (13%) presented as desaturation and hence would have been detected at the C2 ("Colour") stage of COVER. It was considered that the nature of the problem would nearly always have been detected at the A stage of the AB preceding COVER at the CHECK level, but that it would still be worthwhile going through the full algorithm in order to identify the occasional rare cause such as inadvertent administration of a sedative drug or a muscle relaxant. The actions recommended by the COVER algorithm (100% oxygen, turning off the vaporiser and, if necessary, removing the patient from the anaesthetic machine and circuit) were all considered reasonable immediate steps. It was also considered that carrying out the recommendations of the sub-algorithm outlined in fig 1 would have constituted an acceptable course of action in all cases. When the potential effectiveness of the structured approach, represented by the AB COVER CD-A SWIFT CHECK algorithm and the sub-algorithm for airway obstruction (fig 1) was compared with that of the actual management as documented in each of the 62 incident reports, it was considered that, properly applied, the structured approach would have led to a quicker and/or better resolution of the problem in seven cases (11%). These were cases in which problems arose because of persistent attempts at intubation when ventilation was not attempted (one case) or was not possible, or in which prolonged attempts at non-invasive airway management were made when intubation or cricothyrotomy appear to have been indicated (six cases).

DISCUSSION

Management of the airway is one of the fundamental skills of anaesthetic practice. It would appear, however, that this management may occasionally lack direction or be poorly organised, and this may lead to morbidity and possible mortality. Analysis of the 62 relevant AIMS reports has confirmed, not surprisingly, that airway obstruction may have many presentations, degrees of severity, and methods of resolution. This is reflected in the range of suggested

algorithms and management plans for dealing with problem airways.¹¹⁻¹³ Some of these involve complex decision trees and/or flow diagrams when what is needed in a dire emergency is a simple set of instructions. Such instructions will not handle every conceivable situation as these problems are frequently multifactorial. However, it is suggested that the advantages of following a structured sequence of actions would outweigh the disadvantages. Most anaesthetists are very familiar with the management of airway problems. However, in 11% of the incidents reported the problem was not well managed. In these cases it was felt that the outcome would have been improved if the algorithm in fig 1 had been followed.

Most of the major morbidity and mortality associated with airway obstruction is due to hypoxaemia. Desaturation was documented in two-thirds of the cases in this series and four patients went on to suffer a cardiac arrest. One patient had cerebral oedema following an hypoxic episode and one died. In one patient high positive airway pressures led to pulmonary barotrauma and a pneumothorax on the contralateral side to the obstructed lung, and there were two cases of post-obstructive pulmonary oedema following relief of obstruction of the non-intubated airway. Also, the difficulty of maintaining a patent airway may expose patients to excessive force from airway instrumentation which leads to an increased risk of direct trauma to all parts of the airway, from lips to tracheobronchial tree.

Speed in resolving airway problems is essential and is central to the management algorithm. Analysis of the reports supported the steps recommended in the airway obstruction sub-algorithm shown in fig 1. As hypoxia poses the most severe and immediate threat, the administration of 100% oxygen is mandatory in all cases of airway obstruction.

The algorithm recommends early clearance of the airway. In 18 cases the obstruction was simply due to a foreign body, blood, or secretions and in six cases clearance of the upper airway completely resolved the problem. It is important to ensure that the pharynx and airway are clear to prevent problems arising due to mask ventilation, including laryngospasm or aspiration.¹⁴

Key messages

- Sixty two (1.6%) of the first 4000 reports to the Australian Incident Monitoring Study involved obstruction of the natural airway during anaesthesia.
- Laryngospasm and bronchospasm, although forms of airway obstruction, are excluded here and dealt with elsewhere in this set of articles.
- Most (87%) presented obviously as airway obstruction but 13% presented as desaturation. Desaturation was actually documented in two thirds of the airway obstruction cases.
- Most morbidity and mortality from airway obstruction is due to hypoxaemia.
- Over half (55%) resulted in major physiological change, morbidity or mortality. Airway obstruction is always time critical and potentially dangerous.
- Airway obstruction was completely unexpected in 22 of the 32 cases with identifiable predisposing or causative factors; 15 patients required intubation, two required surgical airways.
- Correctly applied, the structured approach would have produced a quicker and/or better resolution of the problem in seven (11%) of the 62 cases.

The other options in the left panel of fig 1 should be cycled through rapidly. These are usefully supplemented by the information in the right panel of fig 1 that, together, form part of a Crisis Management Manual for anaesthesia.¹⁵ Ensuring availability of the necessary help and equipment preoperatively is important. Whenever possible, anaesthesia should be undertaken with skilled assistance available.

It is possible that this sequence may expose certain patients to interventions that might not be necessary. However, when anaesthetists persisted with airway manoeuvres that were ineffective without progression to other techniques, one death, three cardiac arrests, and one case of post-obstructive pulmonary oedema ensued. In another patient, persistent attempts at intubation led to hypoxia when insertion of an airway or laryngeal mask may have alleviated the problem sooner. Cricothyrotomy and/or tracheostomy must be considered early and instituted without hesitation if both intubation and ventilation are not possible. Fortunately, this situation arises in only 0.01–2 cases per 10 000 anaesthetics.¹¹

After the obstruction has been relieved it is important to consider possible sequelae. These include aspiration pneumonitis, post-obstructive pulmonary oedema, cerebral hypoxia or oedema, and trauma to any part of the airway, trachea, or bronchial tree. In all cases consideration should be given to maintaining an artificial airway until these conditions have either been excluded or managed in an appropriate manner.

Finally, it is important that a full explanation of events be given to the patient, that the problem be clearly documented in the anaesthetic record, and 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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Authors' affiliations

T Visvanathan, Staff Specialist, Department of Anaesthesia, The Queen Elizabeth Hospital, Woodville, South Australia, Australia
M T Kluger, Senior Staff Specialist, Department of Anaesthesiology and Perioperative Medicine, North Shore Hospital, Auckland, New Zealand
R K Webb, Senior Staff Specialist, Department of Anaesthesia and Intensive Care, The Townsville Hospital, Douglas, Queensland, Australia
R N Westhorpe, Deputy Director, Department of Paediatric Anaesthesia and Pain Management, Royal Children's Hospital, Parkville, Victoria, Australia

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