Guideline on equipment to manage a difficult airway during anaesthesia

Background Paper

1. Introduction

Airway complications are a leading cause of morbidity and mortality in anaesthesia.[1] Effective management of a difficult airway is a core skill for anaesthetists, and depends on the timely availability of suitable airway equipment.

Australian coroners' cases involving "cannot intubate, cannot ventilate" (CICV) scenarios with tragic outcomes have highlighted the need for better management of airway emergencies.[2,3] Deficiencies in equipment have been identified in coroners' reports. One coroner noted that "the importance of appropriately functioning equipment in an emergency does not just rest in the fact of the equipment itself, but also in the psychological support it provides to those dealing with the emergency".[2] In the Australian Incident Monitoring Study (AIMS), equipment deficiencies, which were mainly due to "failure to check", contributed to five of the 14 factors that were identified in the 85 difficult intubation reports.[4] The 1000 anaesthesia incidents reported to this study from 2002-2006 showed an appreciable increase in difficult and failed intubations compared with the first 2000 reports.[5] A review from the American Society of Anesthesiologists (ASA) closed claims database comparing claims for difficult airway management from two time periods, 1985-1992 and 1993-1999, showed improvement in death/brain death categories from difficult airway management during induction of anaesthesia, but not during other phases of anaesthesia.[6]

The Australian and New Zealand College of Anaesthetists (ANZCA) has defined the minimum requirement for basic airway equipment in operating suites and other anaesthetising locations in its professional document *PS55 Recommendations on Minimum Facilities for Safe Administration of Anaesthesia in Operating Suites and Other Anaesthetising Locations*. This document states that in every anaesthetising location equipment for managing difficult intubations must be readily available in all locations where endotracheal intubation is electively performed. *PS55* does not however specify the items and conditions required to manage a difficult airway.

A number of professional societies have developed guidelines for equipment and techniques for managing difficult airways on the basis of literature reviews and expert consensus.[7-14] All of these guidelines recommend a dedicated airway cart. Despite this, a recent audit in New Zealand identified inconsistencies and deficiencies in the airway equipment available in a major metropolitan area. Alarmingly, some sites lacked any emergency airway equipment.[15]

The health and disability services standards from Standards New Zealand require emergency equipment to be accessible, stored correctly, not expired, and stocked to a level appropriate to the service setting.[16] In Australia, the regulation of medical devices is overseen by the Therapeutic Goods Administration. Published and draft International Organization for Standardization (ISO) documents also apply to airway management equipment (ISO 7376:2009 (E), ISO 11712:2009).[17,18] It is likely, however, that these standards are not as well known or accessible to anaesthetists as those published by ANZCA.

It was therefore apparent that a new professional document from ANZCA was needed to specify the equipment required to manage a difficult airway, the locations in which it should be kept, and the quality assurance measures that should be implemented to ensure that it is always available and in good working condition. The process of developing such documents had recently been revised[19], and includes the development of a background paper outlining the basis for the recommendations in the document. Here we describe the development of the background paper for ANZCA professional document PS56, and report its contents.

2. Methods

We aimed to develop expert consensus, supported by published evidence where available, and then to consult with ANZCA national and regional committees and other experts, in accordance with *A01 Policy for the Development and Review of Professional Documents*. Expert workshops were held at ANZCA House, Melbourne, on April 6 and July 12, 2008 to develop preliminary consensus on the equipment needed to manage a patient with a difficult airway. Individuals known to have an interest in airway management, or who expressed an interest in contributing were invited to participate (see table 1, below and overleaf). Contributors were asked to identify all relevant publications, both from their existing databases, and from the references within these articles. Searches were also undertaken of Medline and Pubmed, using the following terms: Airtraq, Bonfils, Bullard, C Trach, Combitube, cricothyroidotomy, Easytube, endotracheal intubation confirmation, endotracheal tube introducers, extubation, fibreoptic intubation, Henderson laryngoscope, Light wand, laryngeal mask airway (LMA), LMA Fastrach, LMA Proseal, McCoy laryngoscope, Miller laryngoscope, Optical stylet, retrograde intubation, Transtracheal jet ventilation, Truview, videolaryngoscopy, Viewmax, equipment, airway management, difficult intubation.

Table 1. Participants in the difficult airway management workshops, 2008-2010

Name	Comment	April (A), July (J), Teleconference (T) or All (All)
Professor Alan Merry, FANZCA, FFPMANZCA, FRCA	Primary facilitator	All
Dr Margie Cowling, FANZCA	Convenor of April Workshop	A
Dr Paul Baker, FANZCA		All
Associate Professor Brendan Flanagan, FANZCA		All
Dr Keith Greenland, FANZCA		J,T
Dr Richard Morris, FANZCA		J,T
Professor Harry Owen, FANZCA		A
Associate Professor Richard Riley, FANZCA		A,T
Professor Bill Runciman, FANZCA, FJFICM		All
Associate Professor David A Scott, FANZCA, FFPMANZCA		All
Dr Reny Segal, FANZCA		A
Dr Wilhelm Smithies, FRCA		J,T

Administration:		
Ms Pauline Berryman	Quality and Safety Officer, ANZCA	All
Mr John Biviano	Director, Policy, Quality and Accreditation, ANZCA	A

At the workshops selected participants provided brief presentations on aspects of airway management, supported by the references identified above; these were followed by in depth discussion, with the aim of reaching consensus on the issues canvassed. Consideration was given to rating supporting evidence according to the GRADE system[20,21] as high, moderate, low and very low, and to grading recommendations as strong or weak. The proceedings were recorded in summary form.

Following the workshop lead participants (PAB, AFM) collated the information, and produced a working draft, which was then subjected to an iterative process of reviewing and editing. The first iteration involved the other participants of the workshop and members of the Airway Management Special Interest Group (Australian and New Zealand College of Anaesthetists, Australian Society of Anaesthetists and New Zealand Society of Anaesthetists) and resulted in a document entitled "preliminary draft". The second iteration involved ANZCA's established consultation process for professional document development, overseen by its Council, through its Quality and Safety Committee, and involving its regional committees and New Zealand National Committee (see table 2). Feedback from this consultation was then incorporated into the background paper and professional document by members of the expert working party, and submitted to Council through the Quality and Safety Committee for approval. These documents were promulgated with pilot status for approximately one year, during which further feedback was sought, with a view to producing definitive versions in 2011.

Table 2. Consulted individuals and organisations

Organisation
ANZCA regional committees
ANZCA NZ National Committee
ANZCA Quality and Safety Committee
Airway Management Special Interest Group*
Obstetric Anaesthesia Special Interest Group*
Dr Kym Osborn
SPANZA Dr Peter Kempthorne, Dr Patrick Farrell, Dr Tom Watson, Dr Niall Wilton, Dr Elizabeth Prentice.

ANZCA: Australian and New Zealand College of Anaesthetists
SPANZA: The Society of Paediatric Anaesthetists in New Zealand and Australia

* Australian and New Zealand College of Anaesthetists, Australian Society of Anaesthetists and New Zealand Society of Anaesthetists

At the close of the one year pilot, feedback on the professional document and background paper was sought from regional/national committees, the Faculty of Pain Medicine Board, the ANZCA Trainee Committee, the Quality and Safety Committee and the Airway Management Special Interest Group. At this time, the document was renamed *T04 Guidelines on Equipment to Manage a Difficult Airway During Anaesthesia* (as opposed to *TG4 Equipment to Manage a Difficult Airway During Anaesthesia* when first promulgated). No changes to technical content were considered necessary at this time. In October 2012 the "technical" category of professional documents was abolished and as a consequence, the document was rebadged as *PS56*.

3. Methods

A list of airway devices, manufacturers and the manufacturers' city and country of origin are listed in table 3. References identified and deemed relevant are cited below and are included in the list of references.

Table 3. Airway devices and manufacturers (city and country of manufacture) quoted in this article

Airway device	Manufacturer, city, country
Bullard laryngoscope®	ACMI Corp.; Southborough, MA, USA
UpsherScope Ultra™	Metropolitan Medical Inc.; Winchester, USA
GlideScope videolaryngoscope®	Saturn Biomedical Systems; Burnaby, BC, Canada
McGrath laryngoscope®	Aircraft Medical; Edinburgh, UK
Airtraq®	Prodol, Vizcaya, Spain
Pentax-AWS system® ("AirwayScope")	Pentax Corp.; Tokyo, Japan
Bonfils Retromolar Intubation Fiberoscope®	Karl Storz Endoscopy; Tuttlingen, Germany
Berci-Kaplan DCI videolaryngoscope®	Karl Storz Endoscopy; Tuttlingen, Germany
C-Mac videolaryngoscope™	
Shikani Optical Stylet (S.O.S.)™	Clarus Medical; Minneapolis, MN, USA
Levitan FPS (First Pass Success) scope™	Clarus Medical; Minneapolis, MN, USA
Foley Airway Stylet®	Clarus Medical; Minneapolis, MN, USA
Aintree catheter™	Cook Critical Care; Bloomington, USA
Trachlight™	Laerdal Medical; Wappingers Falls, NY, USA
Intubating Laryngeal Mask (Fastrach)™, C-Trach™, Classic LMA™ and LMA-ProSeal™	The Laryngeal Mask Company Ltd; Maidenhead, UK
ILMA™ reusable silicone endotracheal tube	Euromedical; Sungai Petani, Malaysia
Berman Oropharyngeal Airway™	Vital Signs; Totowa, New Jersey, USA
Rusch Viewmax™ laryngoscope blade	Rusch Inc.; Duluth, Germany
Flexiblade™	Arco Medic Ltd.; Omer, Israel
Truview®	Truphatek, Netanya, Israel.
Cookgas Air-Q™ intubating laryngeal airway	Cookgas LLC; Saint Louis, MO, USA
Combitube™	Tyco Healthcare Nellcor Mallinckrodt, Princeton, NJ, USA
EasyTube™	Rüsch, Teleflex Medical Group; Kernen, Germany
Eschmann endotracheal tube introducer™	SIMS Portex; Hythe, Kent, UK
Frova intubating introducer™	Cook Medical Inc.; Bloomington, USA
Ambu® aScope™	Ambu; Ballerup, Denmark

Few of these studies evaluated devices in comparison with a contemporary gold standard in patients with difficult airways. Furthermore, relevant evidence concerning equipment is difficult to obtain in a prospective randomised manner. Many of the published case series are heterogeneous or apply to patients with normal airways. Overall, we identified few large prospective randomised trials or meta-analyses to guide decisions on airway management or equipment.[22-24] It follows that the published evidence supporting many points in *PS56* is typically moderate to very low.[13] On the basis of common sense[25] and clinical experience, the key recommendation that an adequate selection of appropriate equipment should be readily available soon enough to avoid the onset of irreversible brain damage in an unexpected CICV scenario was graded "strong", but recommendations favouring one device over another similar device were in general graded as "weak".

The agreed recommendations have been incorporated into *PS56 Guidelines on Equipment to Manage a Difficult Airway During Anaesthesia*, available at http://www.anzca.edu.au/resources/professional-documents.

4. Discussion

Principles related to the management of a difficult airway

Successful management of the difficult airway requires technical skill[26] and appropriate equipment. *PS56* provides generic advice to anaesthetic practitioners and departments. It is not intended to be an exhaustive list of available equipment, but rather to provide guidance to essential categories of equipment from which items can be chosen. Selection of equipment should be based on evidence and decided on the principles of standardisation, redundancy and a culture of safety.[27] Standardisation avoids unwanted duplication and facilitates familiarity with carefully selected equipment. Familiarity and confidence with the chosen equipment are key factors contributing to a successful outcome. Redundancy provides backup when first line ventilation or intubation equipment fails. It is important to recognise that every device and technique is associated with a failure rate, and therefore backup plans and equipment are essential. Patient safety should come ahead of considerations of convenience or economy.

Many difficult intubations are unpredicted[12], so emergency airway equipment should be immediately available wherever airways are managed. This equipment should be of high quality.[28,29] There are important differences between some brands of airway equipment in terms of quality and function.[28,29] For this reason, a number of brands have been identified in *PS56* when such data are available or data to support an alternative are lacking. Furthermore, there are examples of differences in performance between disposable and reusable items even within the same brand.[28]

Equipment should be kept in a dedicated container with clear labelling to streamline use in an emergency.[15] All staff working within operating suites and other anaesthetising locations should be familiarised with the container's location and contents.[15] Removal of airway equipment from airway containers is very common.[15] Airway containers are required to be completely stocked and a method such as breakable seals and regular checking should be implemented. In addition, the quality of this airway equipment should be regularly checked and meet recognised standards.[30] Oesophageal intubation can be difficult to diagnose clinically[31], so equipment to diagnose oesophageal intubation should be immediately available wherever airways are managed.[8] Remote operating sites are sometimes poorly equipped[15], but require the same standards of airway equipment for safe airway management. One way of achieving this cost-effectively is by use of a "grab-bag". A grab-bag is a dedicated portable container including essential emergency airway management equipment. A pre-formulated strategy is recommended for extubation of the difficult airway, and a plan to manage possible post-extubation hypoventilation.[8,10,32]

The effective use of airway equipment in an emergency requires that it is presented in an orderly manner, that users are familiar with it, and that they have the skills to use it. Therefore, airway equipment should be prioritised and the contents of the emergency container kept to a minimum. Changes to the contents should be evidence based, or at least guided by expert advice; where possible any new equipment should be evaluated against the known gold standard.[30]

A difficult airway may be recognised and managed electively, or unrecognised and managed in an emergency. The emphasis in management shifts from intubation with a predicted difficult airway to ventilation and oxygenation with an unpredicted difficult airway. The airway difficulty may arise with ventilation or intubation and a surgical airway may be required. A review of algorithms for difficult airway management highlights the evolution of and inconsistencies between different documents caused by a lack of evidence to support many statements.[33] This leads to considerable variation in definitions for “airway”, “ventilation”, “laryngoscopy” and “intubation”. The evolution of these definitions is discussed elsewhere.[33]

Priorities when managing a difficult airway include the maintenance of oxygenation and ventilation and the avoidance of trauma.[7,34] Selection of airway equipment should reflect these priorities. Ancillary equipment or devices which facilitate the maintenance of oxygenation and ventilation and improve intubation success should be given priority.

Any anaesthetist who may be called upon to manage a paediatric emergency, however infrequently, will need at least basic skills in managing paediatric airways, and to be familiar with at least one device for a difficult paediatric airway. Paediatric airway equipment should be stored separately from adult equipment and should be available in a suitable range of sizes. Where obstetric patients are managed, additional equipment may prove useful.[35,36]

Ventilation devices

The gold standard basic equipment for controlled ventilation is a self-inflating bag and mask for bag-mask ventilation (BMV), supplemented by oropharyngeal or nasal airways. This equipment is required by ANZCA professional document *PS55 Recommendations on Minimum Facilities for Safe Administration of Anaesthesia in Operating Suites and Other Anaesthetising Locations*.

Airway devices that include a ventilation orifice above the glottis are commonly referred to as “supraglottic” (for example, classic laryngeal mask airway or cLMA™, Combitube™) and those designed to deliver gas below the vocal cords are “infraglottic” airways (for example, endotracheal tube, cricothyroidotomy device). The term “extraglottic” was suggested by Brimacombe[37], who argues that some devices have components in the hypopharynx or upper oesophagus and are therefore anatomically infraglottic. Classifications have been proposed to describe the increasing variety of ventilation devices.[37,38] One simple classification divides airways into first and second generation depending upon the use of mechanisms to protect against gastric aspiration.[39] Further classification might include single or reusable devices.

All the current international airway algorithms include extraglottic devices in airway carts. In the presence of a difficult airway, an extraglottic airway can be used for ventilation throughout surgery, as a conduit for intubation, or as a secondary rescue device and ventilation/oxygenation bridge. There is now a wide group of devices in this category. Selection of an extraglottic airway as a rescue ventilation device and/or a conduit for endotracheal intubation, should be determined after considering the relative contraindications which include limited mouth opening, obstruction of the airway at or above the glottis, disrupted airway and high lung compliance.

The cLMA™ and its variants have been investigated by various groups as airway rescue devices.[40-44] Safe and effective use of the cLMA™ as a rescue device in non-fasted patients following failed tracheal intubation in general surgery and in obstetric surgery have also been reported.[45] The use of

the cLMA™ and its variants as airway rescue devices in the difficult airway and in the CICV situation has been recommended by the American and Canadian Societies of Anesthesiologists[10, 46] and the Difficult Airway Society (UK)[7]. The cLMA™ is considered a useful device in neonatal resuscitation and is included in the 2005 European Resuscitation Council guidelines for neonatal resuscitation.[47] Case studies suggest that the cLMA™ can provide suitable ventilation when BMV and endotracheal intubation fails, but a Cochrane review found no eligible studies comparing LMA with BMV in neonatal resuscitation.[24] The cLMA™ has the advantage of being readily available. It is also easy and safe to use as a ventilation device, and can function as a conduit for endotracheal intubation. However, limitations of the cLMA™ as a conduit for endotracheal tube insertion include its relatively long length, narrowness and aperture bars.[7] Endotracheal intubation with a flexible bronchoscope through a cLMA™ requires either an appropriately long tracheal tube such as a Mallinckrodt® reinforced tube (31 cm long, size 6.0 mm or 6.5 mm for size 4 or 5 LMA respectively)[48], a nasal RAE™ tube, a microlaryngoscopy tube, or a two stage procedure with an Aintree™ catheter.

A large number of laryngeal masks from different manufacturers are now available commercially. Only a few of these products have been evaluated in clinical trials.[30] Laryngeal masks should comply with the ISO standard, which concerns supralaryngeal airways and connectors.[18] This standard assists the operator by requiring dimensional disclosure to match the appropriate size flexible bronchoscope or endotracheal tube with the laryngeal mask. The efficacy of many disposable extraglottic devices as a conduit for endotracheal intubation is unproven. Extraglottic ventilation devices which have proven function as conduits for endotracheal intubation or flexible bronchoscopy are desirable for management of a difficult airway. Any new product should also perform at least as well as a recognised gold standard.

The LMA-Fastrach™ or ILMA™ is a device designed for use in both anticipated and unexpected difficult intubations, and for ventilation and intubation after failed intubation with other techniques. It can be used for awake intubation[43], in cardiopulmonary resuscitation[49], and as a rescue and primary airway management device.[50] It has been used prehospital, in the emergency department and operating rooms.[44,51] Use by inexperienced operators[52] and in patients with unstable cervical spine with neck immobilisation, and the lateral position[53] has been reported. In a group of 111 patients with Cormack Lehane grade 4 views and failed rigid laryngoscopy and/or intubation, insertion of the ILMA™ and ventilation was successful. First pass intubation attempt with the ILMA™ was then only 65.2 per cent successful. This reached 92 per cent within five attempts. In a study of 254 patients with varying pathology, the ILMA™ was successfully inserted in all patients with three or fewer attempts.[43] The number of intubation attempts can be reduced by applying the Chandy manoeuvre. This involves aligning the internal aperture of the ILMA™ and the glottic opening by finding the optimum degree of sagittal rotation in order to maximise ventilation. This is followed by a slight anterior lift of the ILMA™ handle in order to move the ILMA™ away from the posterior pharyngeal wall prior to insertion of the endotracheal tube (ETT).[43] Both fibreoptic bronchoscope guidance[43] and light wand guidance[54] through the ILMA™ can also reduce the number of insertion attempts required. The ILMA™ also minimises the risk of aspiration.[55] Intubation through the ILMA™ on the first attempt is not always reliable, and this uncertainty could limit its use. The ILMA™ is an established supraglottic airway device, which enables ventilation and intubation in both anticipated and unexpected difficult airway situations.[43]

The LMA CTrach™ is an improved version of the ILMA™ with built-in fibreoptic imaging and a detachable viewer which provides a direct view of the larynx as the ETT is passed through the vocal cords. This feature increases first-attempt and overall success rates from 73 per cent and 90 per cent for the ILMA™ [56] to 96 per cent and 98 per cent for the LMA CTrach™.[57-59]

The ProSeal™ with its oesophageal access port and ability to provide higher seal pressures is particularly suitable for cases needing positive pressure ventilation, and also where access to the

gastrointestinal tract is desirable.[60] This device is suitable for spontaneous and positive pressure ventilation in routine and emergency anaesthetic procedures.[61] The ProSeal™ serves as a rescue device for failed intubation[41] in known or unexpected difficult airways. It is also useful for establishing an airway during resuscitation in profoundly unconscious patients with absent glossopharyngeal and laryngeal reflexes when tracheal intubation is not possible. The ProSeal™ can be used with the Aintree catheter and flexible bronchoscope as a conduit for endotracheal intubation in adults[62], but the disposable version of the ProSeal™, the Supreme LMA™, is not reliably compatible with the Aintree catheter.[63] The ProSeal™ is suitable for adult and paediatric patients.[64,65] Protection against large volume regurgitation with the ProSeal™ has been reported.[66] Careful technique is required when inserting the ProSeal™ in order to avoid malposition and failure of the device in adults[67] and children.[68] Even with correct placement, airway obstruction can occur as a result of the ventral cuff of the ProSeal™ causing compression of the glottis or supraglottis.[69] Reported incidence of airway obstruction with the ProSeal™ varies with the size of the mask (0.4 per cent[70] in adults, 6.6 per cent with the size 2.5[71] and 10 per cent with the size 1.5[64]). In a randomised series of 46 consecutive neonates and infants, the size 1.0 ProSeal™ (which lacks a dorsal cuff and bite block) formed a more effective seal than the cLMA™, suggesting that the size 1.0 ProSeal™ might have a benefit in newborn infants requiring high airway pressures for ventilation.[72] In summary, the ProSeal™ allows higher airway leak pressure and separates the respiratory and digestive tracts. These features may provide better conditions for controlled ventilation in children than the cLMA™, but further evidence is required.[73]

The i-gel™ airway is a second generation extraglottic airway with an integrated gastric drainage tube and a bite block. It is made of a medical grade thermoplastic elastomer and features a non-inflatable anatomical periglottic seal. It has a shorter stem than an equivalent size cLMA™ and is available in three sizes (3, 4 and 5), predominantly for adult patients. This device is suitable also for rescue ventilation[74,75], and also functions as a conduit for flexible bronchoscopy guided endotracheal intubation.[76,77]

The Cookgas® Air-Q™ intubating laryngeal airway is an extraglottic airway designed as a conduit for endotracheal intubation with a standard ETT. This is possible with or without the assistance of a flexible bronchoscope, in adults and children.[78,79] The Air-Q™, in a pilot study of 59 patients, was successfully inserted and used as a ventilation device in all patients, but of 19 intubated patients, only 58 per cent were successfully intubated on the first attempt, and 74 per cent were intubated overall, using a blind intubation technique.[80]

The Combitube™ is a valuable emergency airway device which combines the function of an oesophageal obturator airway and a conventional endotracheal tube. It has a role as a ventilation/oxygenation bridge and secondary rescue device.[81] The Combitube™ has demonstrated superiority over other supraglottic ventilation devices in resuscitation in relation to ease of ventilation and insertion.[82,83] The device has advantages in patients with massive bleeding, regurgitation and limited mouth opening.[84] It also minimises the risk of aspiration.[55] Complications are rare[85,86] but include piriform sinus perforation, oesophageal laceration and tongue engorgement. These complications can be minimised by avoiding Combitube™ use with oesophageal pathology, ensuring loss of gag reflex before insertion, using minimum cuff inflation volumes, using the small adult size (SA – 37F), applying the “Urtubia manoeuvre”[87] (bend tip up before insertion) and using a laryngoscope.

The EasyTube® is a relatively new variant of the Combitube™ which has a non-latex cuff, an airway suitable for flexible bronchoscope insertion, and a single lumen distal tube. It is available in two sizes, a large size of 41 French for patients >130 cm height and a small 28 French for patients 90-130 cm. Bronchoscopy is possible through the EasyTube® with a 3.7 mm endoscope for the 41 Fr and a 2.8 mm endoscope for the 28 Fr. However, literature concerning this device is limited.[55, 88-93]

In summary, review of the literature supports using the cLMA™ or ProSeal™ for ventilation and oxygenation, the LMA-Fastrach™ as a rescue ventilation/intubation device and the Combitube™ as an emergency airway. There is inadequate evidence at present to support clear recommendations in relation to other extraglottic airways.

Direct laryngoscopy

Direct laryngoscopy and intubation with the Macintosh laryngoscope is the first line approach when managing the difficult airway including impossible bag and mask ventilation.[94] The Macintosh laryngoscope is regarded as the gold standard for direct laryngoscopy. A number of variants in design exist[95] including the American (A-Mac) and the English (E-Mac). The E-Mac has better illumination than the A-Mac.[96] In unexpectedly difficult laryngoscopy the E-Mac provided a better glottic view than the A-Mac.[97] Laryngoscopes with a high proximal flange, such as the A-Mac, might cause more trauma to the maxillary incisors.[98]

Macintosh modified the laryngoscope blade to allow the tip to "fit into the angle made by the epiglottis and the base of the tongue".[99] Tension by the tip of the Macintosh blade on the hyoepiglottic ligament in the vallecula, combined with upward tension on the base of the tongue and displacement of the tongue to the left, provides the view of the larynx.[100,101] To optimise this mechanism in different sized adult patients, a range of laryngoscope sizes is required, including sizes 2, 3 and 4. Adult patients with micrognathia and a short thyromental distance of 5 cm benefit from a size 2 Macintosh laryngoscope.[102]

The levering or McCoy laryngoscope is a modification of the Macintosh laryngoscope with a levering tip. However, subtle differences in the design of the tip may alter its performance compared to the Macintosh laryngoscope.[103] Less force is applied during laryngoscopy with the McCoy and hence the stress response is reduced.[104] Poor visualisation of the larynx may be improved by lifting the epiglottis, especially in necks fixed in the neutral position.[105] The McCoy lifts the relaxed epiglottis and expands the collapse of soft tissues around the laryngeal aperture.[106] A reduction in the anterior-posterior forces across the cervical region during tracheal intubation occurs with the McCoy.[107] The McCoy blade, when activated, provides a better view of the glottis in approximately 20 per cent of patients with manual in-line stabilisation than the Macintosh blade.[108] However, in a small proportion of laryngoscopies, the McCoy blade can make the view of the larynx worse.[109] With the head in the neutral position, the McCoy is associated with poorer views than the Macintosh blade[103], which is thought to be due to downward movement of the middle portion of the blade into the line of sight.[110] A straight McCoy blade based on the Seward blade is available in size 1 for paediatric use. The tip of this blade was designed to be placed in the valleculae.[111] A prospective randomised trial of normal infants found that the straight McCoy offered no advantage over the size 1 Miller blade, when the tip of the blade was placed beyond and posterior to the epiglottis.[112]

Use of a straight blade, such as the Miller, with the paraglossal straight laryngoscope technique (PGSLT) was originally described by Magill[113] and more recently by Henderson.[114] This technique is useful for buck teeth, over-riding teeth, large tongue, large floppy epiglottis, and failed Macintosh laryngoscopy. Failure occurs in 1-3 per cent of Macintosh laryngoscopies[10, 115] and is associated with a 44 per cent straight blade success rate.[116] The straight blade should be of sufficient length to trap and support the epiglottis. A prospective randomised trial of 161 patients compared the laryngoscopy view of the Miller and Macintosh blades. A much better view of the larynx was achieved in the majority of patients with the Miller blade using a paraglossal approach.[117] The straight blade using PGSLT has been successfully used to intubate difficult paediatric patients.[118,119] There is a variety of paediatric laryngoscope blades, including the paediatric straight McCoy size 1 (based on the Seward straight blade), Anderson-Magill, Robertshaw, Seward, Wis-Hipple, Henderson, Dörges and Flagg. Selection will therefore depend on individual experience and preference.

Poor illumination by the laryngoscope may compromise tracheal intubation.[96] Although the optimum level of laryngoscope illumination is not known[120], the ISO suggest illumination should exceed 500 lux at a distance of 20 mm from the tip of the blade for at least 10 minutes.[17] Illumination from the reusable Macintosh blade is decreased by placing a protective cover over the blade.[121] Light emitting diodes (LEDs) produce a cooler (blue-white) and brighter light than conventional bulbs.[122]

Laryngoscope blades and handles can be a source of infection, and proper cleaning procedures should be followed.[123] Disposable plastic laryngoscope blades are associated with a decreased success rate of tracheal intubation[124] and increased laryngoscopic forces can cause fracture to these blades.[125,126] Flexibility and breaking limits for laryngoscope blades have been specified by the ISO.[17] Some disposable metal blades performed poorly, and others reasonably well, when compared to the "standard" reusable Macintosh.[29] One argument for using disposable blades is based on the possibility that certain pathogens might be resistant to disinfection or even sterilisation, but Blunt and Burchett concluded that the risk to the patient of using poorly functioning airway equipment may be greater than the risk of acquiring transmissible spongiform encephalopathies.[127] Galinski et al suggest that conventional laryngoscopes be kept in reserve for difficult intubations.[128] For these reasons *PS56* recommends reusable laryngoscopes that comply with ISO standards.

Intubation guides and stylets

Early use of intubation guides and stylets is recommended for difficult laryngoscopy. However, persistent use of these devices can be traumatic, particularly in patients with difficult laryngoscopy presenting with Cormack Lehane views 3b and 4.

A large range of intubation guides and stylets is commercially available. These devices should be carefully selected on the basis of proven efficacy and safety. Large variability in performance can be found between different products.[129] This discussion will focus on devices of proven effectiveness and safety.

The Eschmann endotracheal tube introducer (EETI) is 60 cm long, allowing ETT exchange. The distal 2.5cm has a 35° Coudé tip which allows hooking under the epiglottis, steering around obstacles, tactile identification of tracheal rings and "hold-up" at the carina.[130] This multiple-use bougie is associated with a very low complication rate.[131,132] The introducer should not be held near the tip or introduced with forceps since this increases applied force and the risk of trauma. First pass success rate on simulated Cormack and Lehane (CL) Grade 3 mannequin studies was 85 per cent for the multiple-use EETI and 15 per cent for the single-use bougie (Portex Tracheal Tube Introducer, SIMS Portex).[28] Concerns about cross-infection due to re-used Eschmann endotracheal tube introducers, has led to single use only items being introduced. An example of such a single use item with a satisfactory first pass success rate is the Frova intubating introducer™. The adult Frova introducer™ is blue, has a curved 35° tip and a central lumen with removable Rapi-Fit® adapters permitting ventilation during its use and confirmation of endotracheal intubation by carbon dioxide detection or oesophageal detection device.[133] Success rates of the Frova introducer™ on mannequin studies are equivalent to the reusable Eschmann endotracheal tube introducer, and significantly better than other single use devices including the Portex™ introducer.[129,134] A prospective clinical study showed that the Frova introducer™ had a high success rate for tracheal placement but a potential to produce tracheal trauma.[135] Correct use of the Frova introducer™ avoids shaping and elicitation of "hold-up" and click when passing the laryngeal inlet, thereby minimising trauma.[136]

The Aintree Intubation Catheter™ (AIC) is 19 French, 56 cm long with an internal diameter of 4.7 mm. This allows a tight fit over a 4 mm fibreoptic bronchoscope leaving the distal 3 cm of the FOB exposed and free to flex and extend. The AIC is suitable to replace an ETT with a 7 mm inner diameter or larger. This device was specifically designed for intubation through the cLMA™, but is

also suitable for use through the ProSeal LMA™ and in situations where the cLMA™ may not be suitable.[62] The AIC is not always compatible with the Supreme LMA™.[63] A longer version of 83 cm is available to exchange endobronchial tubes. These catheters are supplied with removable Rapi-Fit® adapters which permit ventilation during the exchange procedure.

Malleable metal stylets aid intubation by improving placement of the ETT. The potential for trauma to the pharynx, larynx, trachea or oesophagus, caused by the stylet, can be reduced by ensuring that the stylet is positioned at least 2 cm from the tip of the ETT.[137] Intubation is enhanced by a "straight to cuff" configuration with a distal bend of 35°.[138]

Light wand

Intubation of the trachea under direct vision using a lighted introducer was first described by Macintosh and Richards in 1957.[139] Transillumination for nasotracheal intubation was described by Berman in 1959.[140]

These techniques rely on transillumination of the anterior neck to identify the location of the tip of the endotracheal tube. Using the glow from the wand, the device can be manoeuvred into the midline and down the trachea. This technique can be applied with a range of equipment including lighted stylets that are rigid and flexible, reusable and disposable, adult and paediatric. Interest in the light stylet has increased since the introduction of the Trachlight™.[141-143]

The Trachlight™ has comparable effectiveness and failure rate in comparison to direct laryngoscopy.[141] In a study of 479 patients, the Trachlight™ had a 1 per cent failure rate and a 92 per cent success rate on the first attempt. In this study, there were significantly fewer traumatic events in the Trachlight™ group than in the laryngoscope group. The Trachlight™ is also effective for nasal and oral intubation in patients with anticipated and unanticipated difficult airways.[143] Combined techniques have been described with the cLMA™ [144], ILMA™ [54], Bullard™ [145] and retrograde intubation.[146] The Trachlight™ has been used to aid double lumen tube insertion[147], and topicalisation of the airway prior to awake intubation.[148] It is suitable for patients with unstable cervical spines[149] and in patients with and without muscle relaxant.[150] Successful use of the Trachlight™ on four paediatric patients with failed direct and fibreoptic laryngoscopy has been reported.[151]

Retrograde intubation

Retrograde intubation has been used successfully in patients with anticipated and unanticipated difficult airways. It has also been used as a rescue technique following failed direct laryngoscopy, failed blind nasal intubation, failed bougie attempt, cLMA™ failure and failed flexible bronchoscopy. Indications include urgent airway establishment in the presence of blood and secretions, failed direct laryngoscopy, failed LMA, failed flexible bronchoscopy, unstable cervical spine and maxillofacial trauma.[152] A modified rapid retrograde technique has been described.[153] This has been used on three emergency patients with an average time of 10 seconds. The techniques and equipment required for this procedure have recently been reviewed.[154] Equipment includes a needle and saline filled syringe for cricothyroid puncture, a retrograde guide wire of 0.889-0.965 mm diameter which is at least 70 cm in length and a long anterograde airway exchange catheter. Smaller catheters and wires are used for paediatrics. The anterograde guide which is inserted over the retrograde guide provides rigidity for the advancing endotracheal tube. The anterograde guide can be an airway exchange catheter. A custom made retrograde intubation set includes all of these components (Cook Critical Care, Bloomington, IN, USA).

Extubation and endotracheal tube changing

Data from the ASA closed claims analysis from 1993-1999 showed 12 per cent of difficult airway claims occurred at extubation.[6] The ASA task force recommend a pre-formulated extubation

strategy for difficult airways.[8] This strategy might include the use of an airway exchange catheter for tube changing or protected extubation. Despite associated complications and the limited evidence supporting these devices[155], their availability and appropriate use is recommended by the task force.

Changing a paediatric cLMA to an ETT is possible with a guidewire and airway exchange catheters (Size 1 cLMA to a size 3.0 mm ETT with an 8 Fr Cook airway exchange catheter, size 1.5 cLMA to a 4 mm ETT with an 11 Fr catheter, size 2.5 cLMA to a 5.5 mm ETT with a 14 Fr catheter and size 4 cLMA to a 7.0 mm ETT with a 19 Fr catheter).[156] The pilot balloon of a cuffed ETT will not pass through a cLMA smaller than size 3.

Specialised endotracheal tubes

Specialised endotracheal tubes may be beneficial for difficult endotracheal intubation, particularly during fibreoptic intubation. Wire reinforced spiral tubes have been associated with less laryngeal impingement than standard polyvinyl chloride (PVC) tubes[157], but impingement can still occur.[158,159] The flexible tip of the Parker Flex-Tip™ tube provided greater initial success of fibreoptic intubation compared with a standard PVC tube[160] and less pain and trauma following nasotracheal intubation compared with a standard PVC tube.[161] The ILMA™ reusable silicone endotracheal tube compares favourably to both the standard PVC tube and the reinforced flexometalic tubes for nasotracheal intubation under general anaesthesia.[159] In the absence of an Aintree catheter, tubes suitable to intubate through a cLMA™ include the long flexometallic[48,162], nasal RAE™ [163] and the microlaryngoscopy tube.[164-166] Inadvertent intralaryngeal tracheal cuff placement and damage has been reported with standard length[167] and reinforced ETTs.[168]

The pros and cons of cuffed ETTs in paediatrics deserve careful consideration[169], and issues such as the outer diameter of ETTs, cuff design and cuff placement are important when choosing an appropriate paediatric ETT and avoiding trauma.[170] A prospective randomised controlled multi-centre trial of cuffed or uncuffed endotracheal tubes (ETT) in small children undergoing general anaesthesia found that cuffed ETTs do not increase the risk of post extubation stridor compared with uncuffed ETTs, reliably seal the airway at cuff pressures of ≤ 20 cm H_2O and reduce the need for ETT exchanges.[171]

Flexible bronchoscopy

Flexible bronchoscopy is primarily indicated for the elective management of the anticipated difficult airway. This includes a history of previous difficult intubation or predicted difficult bag-mask ventilation or predicted difficult intubation. Flexible bronchoscopy is also useful for unanticipated difficult intubation following failed direct laryngoscopy[172,173], and hence is recommended as a second line strategy in this situation. Flexible bronchoscopy is contraindicated for emergency airway management where immediate control of the airway is required, especially in the presence of deteriorating ventilation. On this basis, the flexible bronchoscope is not a mandatory device to be immediately available, but its availability is considered highly desirable, particularly in the hands of an experienced practitioner and combined with other airway equipment which facilitates oxygenation and ventilation during the procedure. The availability of a flexible bronchoscope within five minutes of each site where airways are managed is recommended and should be integrated with the difficult airway container or stored on a dedicated mobile tower.

Numerous case studies support flexible bronchoscopy for a broad range of clinical applications. These include airway management for patients with potential cervical spine instability[174], trauma[175], aspiration risk[176] and potential for dental damage.[177,178] Relative contraindications of flexible bronchoscopy include uncooperative patients for awake intubation, airway bleeding, tissue disruption and laryngeal obstruction with stridor. In a survey of New Zealand anaesthetists, the majority of respondents considered fibreoptic intubation to be the gold standard for expected difficult

airways.[179] Flexible bronchoscopes should be accompanied by ancillary equipment including light sources, bronchoscopy swivel connectors, endoscopy masks, intubating airways, wires, and equipment to apply local anaesthetic to the patient's airway.[15]

Flexible bronchoscopes are available in a range of sizes and are designed for different applications. For example, ultra-thin or neonatal bronchoscopes (2.2 mm diameter) allow a size 3.0 mm ETT, but lack a working channel. Detailed specifications are available from manufacturers.

Flexible bronchoscopes should be stored according to manufacturer's instructions to avoid damage, malformation and infection. Storage should be dry, clean, well ventilated and at normal temperature. This precludes storage of endoscopes curled up in portable containers. Ideally the endoscope should be hung straight. Care is needed to avoid infection, including the use of a sterile surface, sterile gloves, single use items such as airways, bronchoscopy elbows and endoscopy masks, and leak tested endoscopes.[180] Sterilisation of endoscopes should comply with ANZCA professional documents *PS28 Guidelines on Infection Control in Anaesthesia* and *PS55 Recommendations on Minimum Facilities for Safe Administration of Anaesthesia in Operating Suites and Other Anaesthetising Locations* as well as Australian and New Zealand standards.[181] The Ambu® aScope™ is a single use flexible bronchoscope which offers potential benefits including reduced patient-to-patient cross contamination. This device was released in 2010 and the evidence base is embryonic.

Non-standard laryngoscopes and rigid fibreoptic intubation aids

Rigid fibreoptic intubation systems can be classified into three groups[22]:

1. Devices based on conventional laryngoscopes with a blade. This group includes modified blades for direct laryngoscopy such as the Flexiblade™, McCoy and McMorrow. Another group in this category includes the Bullard®, WuScope, Upsherscope and more recently the Viewmax™ and Truview™ which feature light-bending blades for indirect laryngoscopy. The McGrath™, Berci-Kaplan™, C-MAC™ and Glidescope™ are videolaryngoscopes which allow indirect laryngoscopy and then require independent endotracheal tube and stylet for intubation.

2. Fibreoptic optical stylets placed within the endotracheal tube including the Bonfils®, Shikani™, Levitan™ and Foley®.

3. Devices for indirect laryngoscopy with an optical blade and a conduit for the endotracheal tube including the CTrach LMA™, Pentax-AWS® and the Airtraq®.

A recent quantitative review and meta-analysis of the performance of many of these devices by Mihai and co-workers found that the data are often heterogeneous and most data come from normal patients who are rarely difficult to intubate.[22] In their analysis, very few studies looked at difficult patients in significant numbers and there were only a few studies comparing devices with the gold standard Macintosh laryngoscope. An analysis of the literature up to November 2006 indicated that the Bonfils®, Ctrach LMA™ and Glidescope® had robust data and performed best in difficult patients, but the studies had limited numbers.

Since the review by Mihai, a number of large case series and prospective randomised trials involving patients with difficult airways have been reported concerning new intubation devices with favourable results when compared to Macintosh direct laryngoscopy.[23,182-186] Evidence is still lacking to support the replacement of standard laryngoscopes with non-standard devices for routine or difficult intubations and the results of large multicentre clinical trials of new airway devices are required.[187] When selecting non-standard laryngoscopes and rigid fibreoptic intubation aids, consideration should be given to the indications and application of each device, particularly the ability to maintain oxygenation and ventilation during use. Each device offers different features such

as ETT guidance systems, working channels, disposability and a range of sizes, which may determine their clinical suitability.[27]

The rigid ventilating bronchoscope is a valuable device for failed ventilation, particularly in the presence of foreign bodies, vomit, blood, or airway tumours, such as mediastinal masses. Unlike the flexible bronchoscope, the rigid bronchoscope can be used to ventilate a patient.

Confirmation of tracheal intubation

Unrecognised oesophageal intubation remains a leading cause of death and brain damage in anaesthesia and emergency medicine. This problem can occur with experienced, skilled anaesthetists as well as junior staff. Endobronchial intubation and inadvertent extubation are also common adverse events in adults and children.

The AIMS[4] documents that 85 of the first 2000 incidents reported (4 per cent) had difficulties with intubation. Oesophageal intubation (18 cases) was the commonest complication reported. In a recent review of the ASA closed claims database from 1993 to 1999[6], difficult airways were encountered throughout the perioperative period. Seven percent of the perioperative claims occurred in the recovery period and 67 per cent of these resulted in death or brain death. Outside locations were the site for 13 per cent of claims for difficult airway management problems in the ASA database.[6] Recovery rooms, off-the-floor locations and difficult intubation containers are often poorly equipped to detect oesophageal intubation.[15] Other contributing factors include suboptimal conditions, poor technique and inexperienced staff. Confirmation of correct tracheal intubation should occur with every case. Techniques and equipment for this important diagnostic step should allow the practitioner to rapidly and confidently confirm endotracheal intubation, even in the presence of cardiac arrest. Unfortunately there is no ideal test for correct endotracheal tube placement.

The only reliable methods of confirming tracheal intubation are visualisation of tracheal rings and carina with a flexible bronchoscope, and visualisation of the endotracheal tube passing through the vocal cords. Confirmation of tube placement with a range of tests including CO_2 monitoring with capnography, oesophageal detection devices such as the self inflating bulb and syringe, and colorimetric CO_2 detection devices may be useful, but can all yield false results.[188] Capnography is required in all operating rooms and is the standard for identification of endotracheal tube placement; however, it is associated with false positive and false negative results and capnographs are not always present in non-operating room environments.[15] Oesophageal detector devices, such as the oesophageal syringe and self inflating bulb, are inexpensive, disposable, small devices which are quick and easy to deploy and are more accurate than carbon dioxide detection methods in the presence of cardiac arrest. These devices can complement carbon dioxide detection and are examples of equipment redundancy, which is valuable when capnography results are negative or equivocal.[189] The self inflating bulb is appropriate for adults and children.[190,191]

Cricothyroidotomy

Equipment for emergency tracheal access is mandatory and should be immediately available at every operating site. This equipment is required whenever acceptable levels of oxygenation cannot be maintained using ventilation by face mask or extraglottic device, or endotracheal intubation.

Cricothyroidotomy is the technique of choice for adult emergency surgical airway access because of its speed, simplicity and safety. Supporting literature for various cricothyroidotomy techniques is very limited and consists of heterogeneous case series, mannequin studies, animal studies and expert opinion. There is no strong evidence to support one technique over another.

In adults there are three methods to achieve oxygenation and ventilation via the cricothyroid membrane.[192]

1. Surgical airway allowing a large lumen endotracheal or tracheostomy tube. Preferably this tube should be cuffed, allowing low pressure ventilation. For an adult cricothyroidotomy, the outer diameter of the endotracheal tube should not exceed 8 mm (6 mm ID).[193]

2. Large cannula (>4 mm) cricothyroidotomy set, often inserted using a Seldinger technique, enables ventilation with low pressures, results in little entrainment and requires a cuffed tube or obstructed upper airway for optimum ventilation with low lung compliance.[194]

3. Small cannula (2-3 mm), requires high pressure gas source, relies on a patent upper airway and entrainment may augment the inspiratory flow.

Expert opinion regards surgical cricothyroidotomy as the gold standard with the advantages of a cuffed tracheal tube allowing a high minute volume with low pressure ventilation using readily available inexpensive equipment.[195]

Large cannula cricothyroidotomy is favoured by some anaesthetists who prefer percutaneous needle access with a Seldinger technique.[196]

Small cannula cricothyroidotomy was favoured by the majority of respondents in a Canadian survey[197]; specialised cannulae with a low tendency to kink should be used[198] and a high pressure gas source that is pressure regulated (Manujet III), or flow regulated (Enk oxygen flow modulator) is needed. Flow adjusted volume ventilation can be achieved with the Enk oxygen flow modulator (OFM), and ventilation comparable to the Manujet III has been achieved in animal studies.[199,200] There are no human data supporting the use of the Enk oxygen flow modulator. The Enk OFM has the advantage of being a small, light weight, disposable item suitable for a portable equipment container; however, it requires a pressurised oxygen source and flow meter.

One CICV algorithm emphasises early oxygenation by cannula cricothyroidotomy or cannula tracheotomy and jet ventilation. Failure of this technique should lead to either surgical cricothyroidotomy if airway anatomy is palpable, or, if not, a scalpel incision and blunt finger dissection leading to cannula cricothyroidotomy and jet ventilation. Subsequent ventilation options then include either a cuffed large cannula cricothyroidotomy tube or a size 6.0 mm cuffed endotracheal tube.[201]

A cricothyroidotomy should be instituted early in the management of CICV in order to achieve a successful outcome.[6] This requires clinical expertise and rapid deployment of appropriate equipment.

Paediatric CICV

When selecting an appropriate paediatric emergency invasive airway technique, consideration should be given to both the practicality and safety of the surgical procedure as well as the appropriate form of ventilation. The SIAATRI Study Group, who published the only detailed evidence based "recommendations for airway control and difficult airway management in paediatric patients", states "It is mandatory to perform rapid tracheal access or transtracheal jet ventilation in emergency situations, whenever oxygenation cannot be granted with other devices". Supporting evidence are at level D and E on the Delphi list.[13]

Current opinion suggests that the techniques of choice for paediatric CICV are either transtracheal needle ventilation or tracheostomy.[13, 202-204] Some authors suggest specific techniques are age-related, with cricothyroid needle and bag ventilation from birth to 5 years of age, cricothyroid needle and jet ventilation from 5 to 10 years of age, and open cricothyroidotomy over 10 years of age.[205] Unfortunately, many aspects of these recommendations are as yet unsupported by evidence.

Insertion of a needle through the cricothyroid membrane in a child under the age of five is technically difficult because surface landmarks in children are more difficult to palpate and identify. In the neonatal age group, the cricothyroid membrane is small and the larynx is prone to cartilaginous damage during paediatric cricothyroidotomy.[206] The paediatric airway is malleable and prone to injury of the laryngeal mucosa, posterior perforation and subglottic stenosis.[193]

The successful use of paediatric transtracheal ventilation, below the cricothyroid membrane has been reported.[207,208] Successful transtracheal cannula ventilation with a bag has not been validated in children. A lung model study using 10 L/min of oxygen through a Mapleson C circuit and a 13 gauge Ravussin needle, failed to generate a minute volume of more than 3 L/min, with a range of upper airway resistances.[209]

A high pressure gas source is required to overcome high resistance found in transtracheal cannulae. Suitable ventilation devices include a pressure regulated injector, such as the Manujet III, and a flow regulated injector such as the Enk OFM. Pressure regulated devices, in the presence of small lung volumes, can deliver high tidal volumes with potentially dangerous airway pressures.[209] Devices such as the Manujet III provide pressure ranges on the regulator for different age groups (baby 0-1 bar (0-14.5 psi or 0-100 kPa), infant 1-2.5 bar (14.5-36.3 psi or 100–250 kPa), adult 2.5-4 bar (36.3-58 psi or 250-400 kPa)).

Self-made devices using oxygen tubing and a three way tap[210] have been criticised because of wasted assembly time[211], legal implications and inadequate capability as a bidirectional airway leading to potentially dangerous continuous gas flow[212-214], and are therefore not recommended.

In the presence of significant upper airway obstruction adequate lung deflation is of critical importance, in order to avoid severe morbidity.[192] Exhalation of 500 ml of gas through a 14 gauge cannula can take 30 seconds. [211]

The advanced paediatric life support guidelines[215] recommend setting oxygen flow at 1 L/min/year of age through a Y-connector. An I:E ratio of 1:4 is then recommended with a respiratory rate of 12 bpm. These flows have been experimentally validated using an Enk OFM and adjusting the formula to 1L/min/year for a tidal volume of 7ml/kg.[216] Flows above 15 L/min could be potentially dangerous with the Enk OFM which then fails to perform as an on-off device.

Cricothyroidotomy sets, such as the small Melker (3.5 mm ID, 3.8 cm length) (Cook® Medical Inc, Bloomington, USA), are commercially available, but this device is too large and potentially traumatic to laryngeal cartilages for children under five years of age. Product information states that use with paediatric patients should be determined by the attending physician.

A study by McLaughlin et al[217] describes a technique of emergency paediatric percutaneous tracheostomy. This technique uses a needle to locate the trachea first. Toye presented cases using a similar technique.[218]

Paediatric transtracheal and cricothyroidotomy airway devices have been recently reviewed.[204]

Sugammadex

Sugammadex antagonises profound neuromuscular block produced by aminosteroid neuromuscular blocking agents (rocuronium and vecuronium).[219,220] Sugammadex is ineffective in antagonising succinylcholine and benzylisoquinolinium neuromuscular blockers, such as mivacurium, atracurium, and cisatracurium.[221]

Sugammadex will facilitate the safe use of rocuronium for rapid sequence induction of anaesthesia by providing a faster onset-offset profile than that seen with 1.0 mg/kg succinylcholine. However, rapid reversal of profound neuromuscular blockade is only one aspect of the management of a CICV scenario. Oxygenation of the patient remains the priority in this situation and the administration of sugammadex should not delay this urgent requirement. One should also be mindful that reversal of neuromuscular blockade could make ventilation, intubation[222], or a surgical airway more difficult, and a delay in the management of oxygenation could have a detrimental effect, as seen when waiting for succinylcholine to wear off.[223] The reversal of other administered drugs such as intravenous induction agents, narcotics and volatile agents should also be considered.

Thus the use of sugammadex should not unduly delay performing an emergency surgical airway or carrying out other life-saving procedures as indicated.

5. Conclusion

When confronted with an unexpected difficult airway, a carefully selected range of equipment is essential for successful and safe patient outcomes. This equipment needs to be checked, in good working order and readily available to hand. There is no magical device or technique that will be suitable for all airway problems, so therefore a range of equipment is required. Appropriate airway equipment must be matched with procedural skill. Ideally, equipment should be chosen that has proven efficacy and is familiar to the practitioner. *PS56* provides guidance on the minimum equipment needed for managing unexpected difficult airways, based on expert consensus underpinned by the best available evidence.

Related ANZCA documents

A01 Policy for the Development and Review of Professional Documents

PS28 Guidelines on Infection Control in Anaesthesia

PS55 Recommendations on Minimum Facilities for Safe Administration of Anaesthesia in Operating Suites and Other Anaesthetising Locations

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Authors of PS56BP

Dr Paul Baker MB, ChB, FANZCA

Associate Professor Brendan Flanagan MB, BS, FANZCA

Dr Keith Greenland MB, BS, FANZCA, FHKCA

Dr Richard Morris FANZCA

Professor Harry Owen MB, ChB, MD, FANZCA, FRCA

Associate Professor Richard Riley FANZCA

Professor Bill Runciman BSc (Med), MBBCh, FANZCA, FJFICM, FHKCA, FRCA, PhD

Associate Professor David A Scott MB, BS, PhD, FANZCA, FFPMANZCA

Dr Reny Segal MB, ChB, FANZCA, NBEPTEeXAM, Chair, Airway Management Special Interest Group (Australian and New Zealand College of Anaesthetists, Australian Society of Anaesthetists and New Zealand Society of Anaesthetists)

Dr Wilhelm Smithies MB, ChB, FRCA

Professor Alan Merry MB, ChB, FANZCA, FFPMANZCA, FRCA, Hon FFLFM, Chair, Quality and Safety Committee, Australian and New Zealand College of Anaesthetists

Conflict of interest

Dr Paul Baker has received free airway equipment for research and teaching from a number of manufacturers listed in table 3.

Acknowledgements

We wish to thank Ms Pauline Berryman and Mr John Biviano for administrative support and advice and Dr Margie Cowling for her advice and contribution to the first meeting.

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Promulgated (as TG4 BP):	2010
Reviewed:	2011 (rebadged from TG4 BP to T04 BP)
Date of current document:	Nov 2011
Republished:	2012 (rebadged from T04 BP to PS56 BP)

ANZCA website: www.anzca.edu.au