ANZCA
AUSTRALIAN AND NEW ZEALAND COLLEGE OF ANAESTHETISTS

Transition from supraglottic to infraglottic rescue in the "can't intubate can't oxygenate" (CICO) scenario

Report from the ANZCA Airway Management Working Group

November 2014

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This report was written as part of the development process by the Australian and New Zealand College of Anaesthetists (ANZCA) for difficult airway management. The content of this review relates to the prevention, identification and management of *decision to proceed* to emergency surgical airway in the critical event of being unable to ventilate or oxygenate a patient having induced general anaesthesia. This is referred to as the "can't intubate, can't oxygenate" (CICO) scenario.

This report forms the basis for ANZCA professional document PS61 and its accompanying background paper (PS61-BP).

Series editor: Leonie Watterson[1]

Authors: Leonie Watterson, Adam Rehak,[2] Andrew Heard,[3] Stuart Marshall[4] for the Australian and New Zealand College of Anaesthetists' Airway Management Special Interest Group (SIG), Airway Management Working Group (AMWG).

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1. MBBS FANZCA MClinEd, Clinical Associate Professor Sydney Medical School, Director, Sydney Clinical Skills and Simulation Centre, senior staff specialist, Department of Anaesthesia and Pain Management, Royal North Shore Hospital.
2. MBBS FANZCA, Senior staff specialist anaesthesia, Department of Anaesthesia and Pain Management, senior instructor, Sydney Clinical Skills and Simulation Centre Royal North Shore Hospital.
3. FRCA FANZCA, former chair, Western Australian Airway Group, consultant anaesthetist, Royal Perth Hospital.
4. MBCHB M Human Factors MRCA FANZCA, Director of Research, Monash Simulation, Monash Healthcare, Clinical Director, Simulation Education, Centre for Health Innovation. Unit co-ordinator, Perioperative Medicine (POM5004) and Human Factors for Patient Safety (MPH5285). Monash University.

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Executive summary

CONTEXT

The ANZCA Airway Management SIG Airway Management Working Group (ANZCA AMWG) was convened in 2012 with the purpose of developing an Australian and New Zealand airway management algorithm and a corresponding ANZCA professional document supported by relevant background papers. The group aimed to present the best available evidence based on literature, or in areas where evidence was lacking, on consensus opinion. Group members worked in sub-groups of two to four on the following five topics:

Topic 1: Evidence for morbidity and mortality arising from CICO events.

Topic 2: Assessment of the airway that supports safe and effective airway management.

Topic 3: Barriers and enablers influencing transition to infraglottic rescue in CICO events.

Topic 4: A recommended procedure for infraglottic rescue.

Topic 5: Effective adoption of international practice and collaboration.

AIMS

This paper presents work conducted on topic one and topic three. The aim of this series is to present opinion, supported by evidence and recommendations regarding the quality of management of transition from supraglottic rescue to infraglottic rescue in the “can’t intubate can’t oxygenate” (CICO) event.

BACKGROUND TO THIS SERIES

“Can’t intubate can’t oxygenate” (CICO) used in this document is failure to deliver oxygen as a result of airway obstruction that persists despite all reasonable supraglottic (rescue) airway management manoeuvres. CICO is an infrequently occurring event but one which the professional and lay communities expect to be prevented through good judgment and, when it does arise, to be capably managed by the airway proceduralist working effectively with a clinical team.

Infraglottic rescue is accepted as the appropriate management of the CICO event, however there are concerns within the healthcare community that this infrequent event is managed sub-optimally. Various enabling and inhibiting factors have been suggested including clinical issues, such as ill-defined clinical criteria defining CICO, and human factors, including organisational (systems) design, cognitive performance and team factors.

SERIES STRUCTURE AND KEY FINDINGS

A wide range of sources was reviewed in this series; these sources including systematic reviews, original research, audits, reports of adverse registries, coronial inquiries and opinion papers. With the exception of three systematic reviews (Law JA Broemling N Cooper RM et al, 2013; Marshall S D, 2013; Schmutz J Manser T, 2013), the information and advice presented in this series is based on level C evidence (Guyatt G, 2006). The evidence confirms CICO is a rare event and implies that a larger volume of cases involving airway obstruction are managed with less serious outcomes however, cautionary advice that improvement is warranted is also evident.

This work is presented as a series of five standalone, cross-referenced opinion papers in addition to this summary and an introductory paper that presents the context, definition of terms and search methodology. Each of the five papers presents an overview of evidence from the searched literature. This is synthesised into key points representing the opinion of the authors, and includes recommendations for practice. These are presented at the beginning of each paper.

The focus of each paper is as follows:

Part 0: Introduction, definitions and methodology

Overview

- Provides contextual information, defines the key terms used in this series and outlines the methods employed in the literature searches.

Part 1: Mortality and evidence of sub-optimal care arising from CICO events

Overview

- Reviews the published literature for evidence of impact of CICO events on mortality and patient safety including evidence that the event is managed sub-optimally.

Key findings

- There is sufficient evidence to feel concerned that clinicians, including anaesthetists, other critical care clinicians and their teams, are not sufficiently prepared to prevent, recognise and or manage a CICO event.

Part 2: Clinical criteria for infraglottic rescue

Overview

- Examines what, if any, clinical criteria support a decision to declare a CICO event prompting a shift in the focus of management from supraglottic to infraglottic rescue.

Key findings

- Several position papers, decision-support algorithms and cognitive aids have been published that provide guidance on the prevention and management of airway obstruction.
- Close inspection reveals reasonably strong agreement that a CICO event should be declared in conjunction with failed supraglottic rescue – this includes manoeuvres related to face-mask ventilation, endotracheal intubation and ventilation via supraglottic rescue devices such as the laryngeal mask airway.
- They differ in the extent to which they emphasise these three above-mentioned groups of manoeuvres and in respect to whether and by how much they quantify a maximum number of attempts in relation to them. A range of two to four attempts is recommended for endotracheal intubation and up to two attempts for insertion of supraglottic airway devices. This series recommends no more than three attempts at endotracheal intubation and no more than two attempts at insertion of laryngeal mask airways, the most commonly used supraglottic airway devices in Australia and New Zealand.
- Some guidelines recommend that oxygen should be delivered via a supraglottic route without interruption, where possible and an exit strategy such as awakening the patient is observed.
- There is less guidance in respect to the significance of oxygen saturation and time. This review cautions that if not already evident, a fall in oxygenation is imminent when criteria for failed supraglottic rescue in the three pathways are met. It recommends that irrespective of oxygen saturation, clinicians should strongly consider calling for help after one pathway has been attempted unsuccessfully and should declare intent and mobilise resources for infraglottic rescue when two pathways are substantially unsuccessful. Concern should be upgraded if at any point oxygen saturation falls below 90 per cent.
- Recently published cognitive aids provide advice to mobilise resources for infraglottic rescue when two of the three above-mentioned pathways are exhausted. This series adopts that same recommendation. It also notes that in practice clinicians may move through these pathways in a non-sequential manner and at any point may have partially attempted one or more pathways.

Part 3: The role of human factors

Overview

- Presents evidence that associates human factors with enablers and barriers to the prevention and management of CICO, including organisational (systems) safety, cognitive performance and team behaviours.

Key points

- Organisational, individual and team factors are strongly interrelated human factors that contribute substantially to prevention and management of airway emergencies including CICO.
- Clinicians are vulnerable to errors resulting from unproductive cognitive processes or factors such as stress fatigue and high task workload that reduce cognitive resources and lead to errors. Clinicians should monitor their performance for these effects. Activation of pre-prepared responses and effective crisis behaviours should be employed to optimise these factors.
- Teamwork is vital to ensure tasks are executed in a timely well co-ordinated manner without errors. Team members promote good performance by being knowledgeable of the practice guidelines, rehearsed in their execution, and prepared to support team leaders in an evolving emergency. This requires them to speak up if concerned. The behaviour of the team leader and culture within the team will enable or inhibit this. Team leaders should encourage other team members to speak up if concerned and this advice should be written into cognitive aids.
- Finally, clinicians should practise in environments that are conducive to good performance. These include using evidence-based locally relevant guidelines, resources, equipment and communications systems with which they have been trained. They should have access to other experts. Ideally they should train in teams but at a minimum should adhere to a common set of guidelines and procedures. The physical environment of the operating theatre or setting in which airway management occurs should be optimised to promote team co-ordination and situation awareness through display of cognitive aids, layout of relevant equipment, team leadership and effective emergency communication, the latter including briefings and updates and closed loop communication.

Part 4: Management of transition

Overview

- Looks at the evidence from parts 1, 2 and 3 recommends strategies contributing to minimisation or mitigation of CICO.

Key points

In order for clinicians to be prepared for this event, multiple performance shaping factors must be optimised.

- Firstly, the event should be prevented where possible through vigilant assessment and monitoring of patients who are at risk of CICO. This involves a timely decision to secure the airway, avoiding general anaesthesia unless risk of CICO is mitigated and a conservative approach to extubation. It goes without saying that clinicians should have advanced training and experience in supraglottic airway management, in respect to face-mask ventilation, endotracheal intubation and supraglottic rescue devices such as the laryngeal mask airway, before they sedate patients at risk of airway obstruction.
- Secondly, there must be some criteria, practice guidelines or standards that support clinicians' decision-making regarding declaring CICO and initiating infraglottic rescue.
- Thirdly, clinicians and their teams should be trained and adequately rehearsed regarding the use of these tools, the practical procedures entailed in infraglottic rescue and the equipment they will use, in their setting. Response to a potentially evolving CICO event will then largely be a matter of activation of pre-rehearsed strategies.
- Fourthly, clinicians should be aware of cognitive, team and organisational factors that influence performance and have the ability to optimise these (see part 3).

Part 5: Features of cognitive aids that best support the management of CICO

Overview

- Evaluates the evidence for the routine use of cognitive aids (CAs) in CICO events and their design features.

Key points

- Several position papers, decision-support algorithms and cognitive aids have been published that provide guidance on the transition from supraglottic rescue to infraglottic rescue in airway emergencies. However, not all of these specify whether their intended use is to guide training and rehearsal conducted in preparation of an emergency; to guide decision-making and performance during an airway emergency; or some other purpose such as standard setting and or quality assurance activities. It is unlikely that a guideline, presented in a single format, could achieve all of these purposes. In particular, content rich documents that are effective as training guides are not well suited to be used in real-time to support decision-making or prevent common errors such as memory failure, communication errors and assertiveness issues.
- There is a role for simple cognitive aids whose purpose is to be used at the bedside to remind people of the more detailed decision-aids they have used in training activities, prompt users to follow best practice at high-risk points and prevent key performance errors during an evolving emergency.
- Drawing from evidence presented in this series the key recommended features and inclusions of a cognitive aid for CICO are listed below. The aid should:

    1. Be easily accessible to all members of the team and embedded in everyday routine practice, such as case briefings.
    2. Show airway assessment, decision to induce general anaesthesia and CICO as related events.
    3. Emphasise supraglottic rescue and express this as three pathways or categories: face-mask ventilation, endotracheal intubation and supraglottic rescue devices.
    4. Suggest clinical criteria for declaring CICO, for example, the maximum number of attempts at endotracheal intubation and SaO2.
    5. Include prompts (as questions, reminders or practice points) for steps at high risk of faulty decisions, omission or delay including:

        5.1 Consider awake intubation/tracheostomy in high-risk patients.

        5.2 Attempt all three supraglottic pathways: FMV; ETT; LMA.

        5.3 Call for help.

        5.4 Attempt to deliver oxygen via a supraglottic pathway at all times.

        5.5 Awaken the patient if feasible.

        5.6 Mobilise resources for infraglottic rescue when two supraglottic pathways are unsuccessful.

        5.7 Declare CICO when three supraglottic pathways are unsuccessful.

        5.8 Initiate infraglottic rescue immediately a CICO is declared.

        5.9 Team members should be encouraged to speak up at any time if concerned.

        5.10 Use specific criteria to guide extubation and monitor carefully afterwards.

6. In respect to graphical layout use simplified text and graphics. Avoid branching algorithms.

Several useful aids have been recently published that address some of these points. It may also be beneficial for developers or users of content rich guidelines to adapt these into simple cognitive aids using the above advice. An example of how these might be represented graphically is shown in **Appendix I**.

FULL LIST OF RECOMMENDATIONS

These are extracted from each paper and provided as a list in **Appendix II.**

REFERENCES – EXECUTIVE SUMMARY

Guyatt G, G. D., Baumann MH, et al. G (2006). Grading strength of recommendations and quality of evidence in clinical guidelines: report from an American College of Chest Physicians Task Force. Chest 129, 174-181.

Law JA Broemling N Cooper RM et al. (2013). The difficult airway with recommendations for management--part 1--difficult tracheal intubation encountered in an unconscious/induced patient. Can J Anaesth, 60(11), 1089-1118. doi: 10.1007/s12630-013-0019-3.

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Introduction and methods

1. AIMS

The primary aim of this series of papers is to present evidence regarding the quality of management of transition from supraglottic rescue to infraglottic rescue in the “can’t intubate can’t oxygenate” (CICO) event.

Recommendations from this evidence will support the development of a cognitive aid and bedside strategies supporting the optimal management of this event. These are intended to complement and not replace existing decision aids.

Detailed evidence on particular supraglottic and infraglottic rescue strategies are beyond the scope of the paper and are not included.

2. DEFINITIONS

In this context we use the following definitions:

1.1 **Supraglottic rescue** used in this document is the collective term for airway rescue manoeuvres delivered at or above the level of the glottis. Alternative terms for supraglottic rescue, used elsewhere, include supraglottic airway management, upper airway management, upper airway oxygenation and airway management. The particular techniques encompassed by this term, broadly contained within the three procedures of face-mask ventilation, endotracheal intubation, and ventilation via supraglottic devices such as the laryngeal airway, are used in day-to-day airway management and are not restricted to declared emergencies.

1.2 **Can’t intubate can’t oxygenate** (CICO) used in this document is failure to deliver oxygen as a result of upper airway obstruction (at or above the immediate subglottic region) which persists despite all reasonable supraglottic rescue manoeuvres. Alternative terms for CICO include “can’t intubate can’t ventilate” (CICV). The definition of CICO used in this document implies that persistent attempts at supraglottic rescue are unlikely to succeed. Consequently the only remaining option is to bypass the obstruction. While we recognise that CICO may alternatively be caused by obstruction in the mid trachea and that low oxygen states may be compounded by obstruction in the lower trachea or lungs, this paper will not explicitly address these events. The widely agreed response to a definitive CICO event is infraglottic rescue. Hence, in this document the criterion of failed supraglottic rescue, encompassed by the three above-mentioned procedural pathways, indicates the need to definitely declare CICO and perform infraglottic rescue.

1.3 **Infraglottic rescue** used in this document is delivery of oxygen after accessing the trachea in the infraglottic region across the anterior aspect of the neck, either percutaneously or surgically. It comprises two key components: obtaining trans-tracheal access and oxygenating via the trachea. Alternative terms include percutaneous emergency oxygenation (PEO) (Heard AM, 2013), surgical airway, surgical cricothyroidotomy, cannula cricothyroidotomy and cricothyrostomy (Henderson JJ, 2004) (Heidegger T Gerig HJ Keller C, 2003).

1.4 **Transition** used in this document is the phase of care leading up to, and including, a committed declaration of a CICO event. Transition may have an ill-defined beginning – signs of airway obstruction are evident and have not been resolved by one or more commonly employed manoeuvres within the three above-mentioned groups of procedures. The majority of these cases will be quickly and successfully managed by further supraglottic rescue manoeuvres and/or awakening the patient. Thus we assume transition infrequently involves an actual declaration of CICO, but always involves a justifiable concern of an impending CICO. In that instance it also includes the decision to shift the focus of the resuscitation from supraglottic rescue to infraglottic rescue.

3. CONTEXT

The ANZCA Airway Management SIG Airway Management Working Group (ANZCA AMWG) was convened in 2012 with the goal of developing an Australian and New Zealand airway management algorithm and a College professional document supported by relevant background papers. This group consisted of specialist anaesthetists with a minimum of five years of practice post fellowship. All members of the group were recognised within the Australian anaesthesia community for their involvement in one or more of the following fields related to airway: research, education, simulation and human factors. The committee recognised that the work of other international groups was relevant to the Australian and New Zealand anaesthetic community. In addition it identified several topics for which work done to date was either limited or not sufficiently relevant to inform best practice in the Australian setting. These topics were:

Topic 1: Evidence for airway related morbidity and mortality.

Topic 2: Assessment of the airway.

Topic 3: Factors influencing transition to infraglottic rescue in CICO events.

Topic 4: A recommended procedure for infraglottic rescue.

Topic 5: Effective adoption of international practice and collaboration.

This paper presents work conducted on topic 1 and topic 3.

4. BACKGROUND TO TOPIC 3

Infraglottic rescue is accepted as the appropriate management of the “can’t intubate can’t oxygenate” (CICO) event however significant barriers, to be addressed in this series, may delay the achievement of this in practice.

A number of interventional procedures have been described for the two key components of infraglottic rescue: (1) obtaining trans-tracheal access and (2) oxygenating via the trachea (Heard, 2013; Henderson JJ, 2004). Numerous supraglottic airway management devices and techniques have been described, many of which are commonly used in routine and emergency airway management. These can be broadly classified into three procedural pathways: (1) endotracheal intubation, (2) face-mask ventilation and (3) ventilation via a supraglottic airway device among which the laryngeal mask airway is well known (Chrimes N, 2013). Several guidelines, algorithms or cognitive aids have been published to guide the transition from supraglottic rescue to infraglottic rescue in an emergency featuring critical airway obstruction (Heidegger T Gerig HJ Keller C, 2003).

Despite the established work there are concerns within the healthcare community that this infrequent event is managed sub-optimally (Greenland KB Acott C Segal R et al, 2011). As presented in part 1, while some evidence points to lack of rehearsal or basic competency in respect to the procedural execution of infraglottic rescue in a declared CICO event, other evidence points to sub-optimal management of the transition leading up to declaration of CICO. Various contributory factors have been suggested including both clinical issues, such as ill-defined clinical criteria defining CICO, and counterproductive behaviours among clinical teams, the latter contributing to poor situational awareness, sub-optimal communication and flawed decision-making. Human factors science, encompassing cognitive and organisational psychology, provides evidence that clinician behaviour is influenced by a range of interrelated factors, including emergency cognitive functioning, socio-cultural attitudes and behaviours within teams and systems design. Logically these should also apply to CICO events.

5. METHODOLOGY

5.1 Phase 1: Expert working group – generation of research questions

A systematic review of the literature calls for the generation of a specific research question, however the committee noted that this topic was not easily reduced to a specific question. Subsequently, the committee brainstormed this topic with the goal of generating one or more relevant research questions to guide a review of evidence. Every committee member was invited to submit a written reply to the question "What factors (affecting both airway clinicians and their colleagues) influence the decision to transition from supraglottic to infraglottic (trans-tracheal) rescue in management of a compromised airway?"

Responses were grouped into themes and refined into the following research questions:

1. Is the CICO event a serious patient safety problem and is it managed sub-optimally [topic 1]?
2. What clinical criteria if any should prompt the decision to transition from supraglottic to infraglottic rescue as the focus of management?
3. To what extent do the following human or non-technical factors affect management of transition in CICO:

   a. Organisational or systems factors.

   b. Human cognition/error.

   c. Team culture and behaviours.
4. How should transition be managed in respect to human factors?
5. What features of cognitive aids, including algorithms and practice guidelines, best support the management of CICO?

5.2 Literature review of themes

Each of the above questions was investigated with a selective literature review using the Medline database together with the Cochrane Central Register of Controlled Trials. Search terms were identified by the group for each question and limited to English language publications in the last 10 years (**table 1**). Publication titles were scanned for relevance and those appearing to address the research question were extracted and their abstracts were reviewed. Relevant publications including meta-analyses, research studies, audits, literature reviews, book chapters, editorials and opinion pieces were considered for inclusion. Grey literature was examined using sources such as websites of airway societies and specialist anaesthesia colleges along with associated publications, conference proceedings and media releases. Additional references were identified from the reference lists of selected articles.

5.3 Levels of evidence

For consistency, our group has observed a previously published framework for grading quality of evidence (Guyatt G, 2006) also adopted by the Canadian Airway Focus Group (CAFG) in its work on guideline development for the difficult airway (Law JA Broemling N Cooper RM et al, 2013). The following three levels of evidence were applied:

- Level of evidence A (high) – systematic reviews of randomised controlled trials (RCTs), RCTs without important limitations, or observational studies providing overwhelming evidence.
- Level of evidence B (moderate) – RCTs with limitations, observational studies with significant therapeutic effect.
- Level of evidence C (low) – RCTs with significant limitations, observational studies, case series, or published expert opinion.

5.4 Manuscript review and consensus opinion

The manuscripts were prepared in five parts corresponding to the above-mentioned questions. The body of each part contains a review of selected references. With few exceptions the evidence identified was generally at level C. Level A and B evidence is flagged. The text was summarised or synthesised as the opinion of the authors in the key points presented at the beginning of each part. The manuscripts were peer-reviewed by the working group.

Table 1: Search methodology

Question	Mesh headings in search strategy	Database
1.	Anaesthesia/anesthesia or anesthesiology and Mortality or death and Difficult airway or failed intubation or can't intubate can't oxygenate or can't intubate can't ventilate or Cricothyroidotomy or surgical airway	PubMed/Medline Cochrane www.ncis.org.au Coroners reports *ANZCA Bulletin* NAP4 website Difficult Airway Society
2.	As above	As above
3.	Decision-support; algorithm; heuristic and Anaesthesia/anesthesia or anesthesiology or Difficult airway or failed intubation or can't intubate can't oxygenate or can't intubate can't ventilate or cricothyroidotomy or surgical airway	Medline, CINAHL, Pschinfo
4.a	This theme was added as an additional theme after review of other themes	
4.b	"Airway management", "assertion" and " adverse events", " teamwork climate", "teamwork and medicine", "medical error and team communication", "human factors" and "situation awareness", "patient safety", "medical error", "interprofessional relations", "physician-nurse relationships", "communication", "safety", can't intubate can't ventilate, cricothyroidotomy Mica Endesley; James Reason; shared mental models	Medline, CINAHL, Pschinfo
4.c	"Assertion/assertiveness" and "adverse events" "teamwork climate", "teamwork and medicine", "medical error and team communication", "human factors" and "situation awareness", "patient safety" "medical error", "interprofessional relations", "physician-nurse relationships", "communication" "safety"	Medline, CINAHL, Pschinfo

6. REFERENCES – INTRODUCTION AND METHODS

Chrimes N, F. N. (2013). The Vortex Approach: Management of the Unanticipated Difficult Airway: E Book. Monash Anaesthesia, http://monashanaesthesia.org/difficultairway/vortex/ ([Accessed June 2014]).

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Schmutz J Manser T. (2013). Do team processes really have an effect on clinical performance? A systematic literature review. Br J Anaesth.

Part 1: Mortality and evidence of sub-optimal care in CICO events

1. AIMS

This paper examines published evidence regarding the impact of CICO events on mortality and patient safety including evidence that the event is managed sub-optimally.

2. KEY POINTS

2.1 There is limited evidence on the incidence of CICO. This is derived from a few cohort studies and the NAP4 audit of serious airway emergencies. This predicts CICO is a rare event occurring in approximately 1:10,000 to 1:50,000 of routine general anaesthetics although some evidence suggests it may be up to 10 times more frequent in settings outside of the operating theatre such as intensive care and the emergency department.

2.2 Evidence for outcomes of CICO is derived from cohort studies, adverse event reporting activities such as audit, coronial inquiries and reports from closed claims insurance registries and research; the latter including survey and experimental studies under simulated conditions. The outcomes of CICO events are relatively poor, accounting for up to 25 per cent of anaesthesia-related deaths with less information available to predict outcomes in other settings.

2.3 Several risk factors for CICO can be gleaned from the literature. CICO events appear to be more likely in patients with airway infections, malignancy, trauma or congenital deformations as well as surgery on the neck. However, several deaths from CICO have occurred in the context of elective anaesthesia in patients of all ages without these conditions. In this context risk factors for CICO are also risk factors for difficult intubation and difficult ventilation. If present, these are identifiable on clinical examination during routine pre-operative assessment.

2.4 Overall the incidence of CICO is very low compared with the incidence of difficult intubation and the prevalence of people in the community with the above-mentioned risk factors. This implies that anaesthetists and other clinicians effectively manage risks and successfully intervene in airway obstruction the vast majority of the time. However, the community has very low, if not, zero tolerance for preventable death from CICO and the small number of preventable deaths identified in the literature has led opinion leaders to conclude that both risks and evolving events are not managed to an acceptable standard. Evidence from experimental studies suggests clinicians are not prepared for the event and underestimate risks. Evidence provided in part 3 addressing “organisational safety” and “human factors” suggests that lack of preparedness at an organisational level is widespread.

2.5 Evidence for sub-optimal care highlighted the following aspects of clinical performance:

2.5.1 **Clinical judgment:** Inadequate risk assessment and judgment regarding the decision to secure the airway by attempting intubation via laryngoscopy after induction of anaesthesia or sedation as opposed to using awake techniques, such as awake tracheostomy and awake fibreoptic intubation. Sub-optimal assessment of risks and poor judgment in airway planning are recurrent themes in the literature. CICO can also occur as a result of post-surgical haematoma or swelling or delayed inflammation after endotracheal extubation and the benefit of hindsight has been used to suggest that assessment of risk has been inadequate in these circumstances.

2.5.2 **Practice variation:** Existing guidelines vary in respect to indicators/criteria for declaring CICO. There are also several different recommended procedural approaches to infraglottic rescue.

2.5.3 **Time delays:** Failure to attempt emergency surgical airway or a delayed decision to do so, often occurring in the context of repeated attempts at unsuccessful strategies such as laryngoscopy by anaesthetists.

2.5.4 **Incomplete supraglottic rescue:** Neglect of techniques related to face-mask ventilation; intubation or, in particular, insertion of supraglottic devices (for example, LMA) occurred in all settings, and in particular in non-anaesthesia settings. Abstaining from the use of NDMRs in a CICO event is considered as sub-optimal care by the Difficult Airway Society (DAS) group.

2.5.5 **Technical knowledge and skills:** Evidence from a small number of research studies and surveys suggests that clinicians lack a deployable plan for the management of a CICO event and are inadequately trained in a technical sense; lacking knowledge of equipment, omitting steps in algorithms and performing surgical airway slower than arbitrary benchmarks. Evidence from audit supports this, demonstrating a relatively high incidence of failure on first attempt at emergency surgical airway, especially using cannula-based techniques.

2.5.6 **Cognitive and behavioural (human) factors:** While few audits or mortality enquiries specifically set out to investigate the roles of cognitive and behavioural (human) factors some authors concluded that these appeared to play a large role in the sub-optimal management of CICO events. For example: cognitive errors associated with task fixation and poor co-ordination and decision-making among teams of clinicians were implicated in promoting persistent futile attempts at intubation, neglect of other forms of supraglottic rescue and avoidance of infraglottic rescue. Inadequate assertiveness among nursing staff was felt to compound this.

2.5.7 **Organisational safety.** Evidence provided in part 3 addressing organisational safety and Human Factors suggests that lack of preparedness at an organisational level is widespread.

3. DETAILED FINDINGS

3.1 Audit and medical record review

By providing a denominator, audit data are useful in identifying the incidence of an event within a population and, depending on the data collected, other useful information regarding the aetiology of the event. Seven prospective audits or retrospective medical record reviews were identified that have been published within the past 10 years that provide useful information on CICO events. Summarised below, these relate to patients undergoing intubation or suffering an airway-related complication in a critical care setting.

All of these confirm the incidence of CICO in the perioperative setting is very small, representing a small proportion of both uncomplicated and difficult airways. They do, however, suggest a slightly higher incidence in settings outside the operating theatre, such as intensive care or emergency departments. They also demonstrate that the effectiveness of infraglottic rescue, commonly termed as “emergency surgical airway” varies; a small number of mortalities were reported despite this being attempted. Some suggest better outcomes when at-risk airways are identified and managed with awake tracheosomy, if feasible.

1. An observational study of all anaesthetics performed in one hospital over four years from 2004 to 2008 (Sachin Kheterpal, 2009) identified 53,041 attempts at mask ventilation of which 19 cases involved difficult intubation and impossible mask ventilation (0.04 per cent). Of these 15 were eventually intubated successfully, two patients received a surgical airway and two patients who were awakened and underwent successful fibreoptic intubation. No deaths or serious long-term outcomes were reported.

2. An audit performed over an 18 month period in one hospital with the aim of validating a recently introduced “Can’t intubate cant ventilate algorithm” failed to identify a single case of CICO from 11,000 cases of anaesthesia involving intubation. (Combes X Jabre P Amathieu R et al, 2011).

3. A prospective audit of all drug assisted emergency intubations performed in all emergency departments (EDs) in the UK over a two week period (Benger, 2011) revealed the total number of patients undergoing emergency intubation was a small percentage of the total presentations - 0.12 per cent, or approximately one in every 800 ED attendances. The majority were performed by unsupervised anaesthesia registrars. No CICO events were reported however the authors concluded that this low level of exposure to intubation by emergency department personnel raises the risk of CICO, particularly after hours.

4. Another group conducted a prospective audit of emergency intubations in the emergency department to determine the frequency of and primary indication for surgical airway (Lindsay A. Reida, 2011). Over an eight-year period 5/2524 (0.2 per cent) patients undergoing emergency department intubation required a surgical airway following failed intubation.

5. Another group (Berkow et al., 2009) reported trends in the frequency of CICO and emergency surgical airway before and after over a 10-year period following introduction of a multifaceted airway-management program. The number of emergency surgical airways decreased from 6.5 +/- 0.5 per year for the four years before program commenced to 2.2 +/- 0.89 per year after program commenced.

6. A retrospective review of medical records of patients admitted to one hospital from July 1996 to June 2006 (Christopher T. Stephens, 2009) aimed to determine the number of patients requiring intubation and emergency surgical airway within the first 24 hours of admission with acute trauma. Within this cohort 31/32,000 (0.1 per cent) of patients requiring emergency intubation also required emergency surgical airway, all of which were performed successfully.

7. Medical records of patients who underwent awake tracheostomy or were converted from cricothyrostomy to tracheostomy over a three-year period in one regional hospital were reviewed (Altman KD Waltonen JD Kern RC, 2006). In this series 90 patients underwent awake tracheotomy, and seven were converted from emergency cricothyrostomy to tracheostomy. No severe complications occurred in the awake tracheostomy group and three severe complications occurred among the seven patients converted from cricothyrostomy to tracheostomy: anoxic brain injury in each, leading to death in two. Subsequently this group recommended that awake tracheostomy should be considered and performed in a timely manner in any patient with impending or ongoing airway obstruction or with potential for difficult intubation.

3.2 Adverse event registries – The NAP4 Report

Adverse event registries provide pooled data on adverse events, which are generally specified in terms of adverse outcomes. These data are considered useful sources of information regarding infrequently occurring events. Denominator values need to be extrapolated.

The 4th National Audit Project of the Royal College of Anaesthetists and Difficult Airway Society (NAP4) was a prospective registry for voluntary reporting of major complications of airway management leading to death, brain damage, admission to (or prolongation of stay on) ICU or performance of emergency surgical airway during 12 months through 2008-09 in all 309 NHS hospitals of the four countries of the UK (Cook, Woodall and Frerk, 2011). It is estimated that this audit represents a denominator of 2.9 million episodes of patient care. It has attracted considerable interest as the cases submitted were gathered from the clinical settings of anaesthesia, intensive care and the emergency department. Additionally, the cases were reviewed and appraised by an expert committee in respect to contributory causes and perceived quality of care.

A total of 55 cases were reviewed in the case series on anaesthesia-related adverse events (chapter 7) (Cook et al., 2011) of which the patient died in nine cases and suffered permanent airway injury or anoxic neurological deficit in five cases. Nineteen cases were associated with difficult intubation of which at least five cases were considered sub-optimally managed on the basis that persistent attempts (five or more) at laryngoscopy were made without proceeding to infraglottic rescue. Poor team working and group decision-making when multiple anaesthetists became involved were frequently implicated.

A total of 80 cases of emergency surgical airway were reported across all critical-care settings (chapter 13) (Cook et al., 2011). Of these, 58 were associated with anaesthesia. Numeric details are shown in the extract below:

"There were 58 cases where an emergency surgical airway was attempted. Forty-three were head and neck cases and the 15 others came from a range of surgical specialties and included two caesarean sections, three laparotomies, three thoracic surgery cases, two incision and drainage of abscess and five other cases (cervical vertebral fracture, fractured arm, minor gynaecology, hernia, PEG). Four patients died as a result of airway complications. Two patients made a partial recovery: one was left with a permanent tracheostomy, the other also had continuing respiratory compromise. Fifty patients were reported to have made a full recovery. In eight of the 58 cases emergency surgical access to the airway failed completely and the patient either died (two cases), was woken up (one case) or the airway was rescued by tracheal intubation (five cases). In 13 cases more than one technique was used before oxygenation was restored or attempts to secure a surgical airway were abandoned."

Of the total cases, 20 resulted in death or permanent neurological deficit, six of the 20 cases that resulted in death or permanent injury whom were associated with anaesthesia, five of which had advanced laryngeal or tracheal malignancy. The expert group's reviews nominated a number of examples of perceived sub-optimal care. In half of the cases risk factors for CICO were presented although the anaesthetists appear to have used poor judgment in underestimating these risks. In 14 cases, the anaesthetists neglected to consider awake techniques, such as awake fibreoptic intubation or awake tracheostomy. Persistence with intubation was also noted by this expert group and attributed to task fixation. In contrast, in some instances care was considered sub-optimal because surgical airway was attempted prematurely without a reasonable attempt at supraglottic rescue or without administration of a muscle relaxant as an adjuvant to intubation; both aforementioned strategies are considered optimal practice in this situation.

In other instances it was noted that the technique failed on first attempt. It remains unclear whether choice of technique or operator experience are primarily responsible, as unsuccessful first attempts were often cannula cricothyroidotomy performed by anaesthetists while successful non-cannula techniques were generally performed by more experienced ear, nose and throat surgeons. In any case, failure was not in itself used as an indicator of sub-optimal care and many of these cases were rescued by either performing an alternative surgical airway technique, succeeding with intubation or some form of supraglottic rescue or awakening the patient (Cook TM MacDougall-Davis SR, 2012).

3.3 Medical litigation databases: The ASA Closed Claims Project

The American Society of Anesthesiologists (ASA) Closed Claims Project, established in 1984, analyses closed claims cases involving anaesthesia-related complications that result in malpractice suits involving participating medical indemnity organisations in the US. These datasets represent approximately one-third of anesthesiologists practicing in the US. Several authors have undertaken reviews of airway-related complications from this dataset (Cook TM, 2010; Metzner J Posner KL Lam MS Domino KB, 2011; Peterson GN, 2005).

A total of 5230 cases were managed between 1990 and 2007 of which difficult intubation and critical airway obstruction represented 5 per cent and 2 per cent respectively. Within these cases, 42 per cent (79 cases) progressed from intubation difficulty to CICO. Indirect evidence of sub-optimal management is derived from the report's key lessons, which suggest a tendency for anaesthetists to persist with repeated attempts at intubation with a consequent delay in infraglottic rescue. The report emphasised three key lessons relevant to CICO:

1. During airway emergencies, persistent intubation attempts were associated with death or permanent brain damage.
2. The laryngeal mask airway (LMA) was not an effective rescue technique in some claims in which multiple prolonged attempts at conventional intubation were made.
3. Surgical airway should be instituted early in the management of a difficult airway.

3.4 Findings of coroner's inquests

Coroners' inquests provide detailed information on cases derived from multiple sources and include the points of view of lay people as well as expert opinion. Recommendations from coronial inquests published in Australia in the past 10 years identify a number of deaths occurring in the perioperative period that were attributed to a "can't intubate can't oxygenate" (CICO) situation.

In four of these cases the patients were adults admitted for surgical drainage of dental abscess. Two of the patients died under the direct care of an anaesthetist: one during induction of anaesthesia and the other within two hours of extubation in the recovery ward. (Office of the State Coroner Queensland, 2014) (Office of the State Coroner Western Australia, Accessed June 2014-b) The others suffered delayed airway obstruction while on the general ward approximately six hours after extubation. In other settings two patients, one adult and one child, died during induction of anaesthesia for elective surgical procedures. Both of these patients had clinical signs of a difficult airway during the pre-anaesthetic assessment, including a marked congenital torticollis in the adult (Office of the State Coroner Western Australia, Accessed June 2014-a).

Relative to the number of anaesthetics performed in Australia in the past decade, this small series of cases suggest either i) the incidence of CICO during anaesthesia is very low, possibly as a result of appropriate decisions regarding awake techniques or, ii) more patients are surviving the event, implying anaesthetists are mainly successful at supraglottic airway rescue techniques. Alternatively, it implies anaesthetists are making appropriately timed decisions to perform infraglottic rescue techniques and are performing them successfully.

These small number of infrequently occurring cases of CICO have, however, been broadly discussed, analysed and used to recommend extensive, specialty wide changes in practice. This exaggerated or amplified impact suggests the community has low tolerance for deaths from CICO scenarios, a view supported by the coroner's report of one of the aforementioned cases of dental abscess: "While I am not satisfied any one individual in the scenario caused or contributed to the problems incurred I do consider the community does not expect a person in the situation of the deceased to die in a major teaching hospital from airway compromise under those circumstances (referring to dental abscess)" (Australia, 24/03). The cases involving dental abscess have been the focus of several articles written with the aim of identifying key lessons on the management of this condition (Office of Safety and Quality in Healthcare, 2007, accessed June 2014) (Greenland KB Acott C Segal R et al, 2011a) (Greenland KB Acott C Segal R et al, 2011b).

In the cases of the two patients suffering CICO during elective anaesthesia, the coroner recommended care by the anaesthetists was sub-optimal not because infraglottic rescue was sub-optimal, but because the anaesthesia technique selected was inappropriate for these patients who had difficult airways identified during pre-anaesthesia assessment.

However, against contemporary standards of care the two cases involving adults with dental abscesses and the child have attracted some criticism from within the anaesthetic community as there was no attempt to perform an emergency surgical airway; infraglottic rescue having been enshrined in difficult airway guidelines in recent years (see part 2). These cases provide some evidence that decisions regarding infraglottic rescue by anaesthetists are sub-optimal (Greenland KB Acott C Segal R et al, 2011a) (Greenland KB Acott C Segal R et al, 2011b). This mirrors opinion regarding the care of Elaine Bromiley, who died from a CICO event in the context of elective anaesthesia in the UK.

3.5 Research studies

Research studies in the form of surveys or experimental studies in simulation laboratories contribute to the evidence regarding preparedness of clinicians to recognise and manage CICO. The strengths and limitations of these studies should be appraised on a case-by-case basis. Several studies concluded that medical staff are sub-optimally prepared to manage CICO based on their apparent knowledge of equipment or procedural skills related to trans-tracheal cannulation and ventilation.

3.5.1 An observational study of 38 US-based anaesthesiologists (Borges et al., 2010) conducted with the aim of evaluating the efficacy and duration of benefit of simulation-based training in difficult intubation and CICO identified that two-thirds of the subjects omitted at least one of the five practice points emphasised in the American Society of Anesthesiologists (ASA) difficult airway algorithm including: calling for anaesthetic and/or surgical help; limiting laryngoscopy to two or less attempts; initiating supraglottic rescue with a laryngeal mask airway and avoidance of fibre-optic bronchoscopy. The mean pre-training time to achieve cricothyroidotomy was 205.5 ± 61.3 seconds and time to achieve ventilation was 356.9 ± 117.2 seconds. Benchmark times for these outcomes have not been agreed upon although non-sustained improvements were noted in this cohort for a period up to six weeks post training.

3.5.2 An observational study aimed to assess the preparedness for emergency surgical airway of UK-based anaesthetists and anaesthetic assistants identified both groups had knowledge gaps when asked to nominate an appropriate technique for emergency surgical airway and describe the storage location and correct use of their preferred equipment (Leslie, 2009). For example of the 97 anaesthetists studied, only 37.1 per cent chose a method of tracheal access in keeping with Difficult Airway Society guidelines and only 42 per cent of the 37 per cent who opted for the jet ventilator could demonstrate the appropriate oxygen outlet on the anaesthetic machine for this device. Only 5.2 per cent of anaesthetists and 29 per cent of anaesthetic assistants knew the location of both airway trolleys in their department. The median time [interquartile range (range)] to insufflate the dummy lung for the remaining 21 anaesthetists was 30 [23-32 (5.5-60)] seconds.

3.5.3 An observational study of the management of unanticipated difficult airway by 21 UK-based anaesthetists (Kuduvalli PM Jervis A Tighe SQ et al. 2008) showed evidence for both reassurance and concern. It was reassuring that no anaesthetists needed to be prompted to initiate infraglottic rescue within 60 seconds (although all subjects were aware of the study objectives) and 90 per cent successfully achieved a surgical airway with mean times to cannulate and ventilate via the trachea of 24 and 39 seconds respectively. Of some concern was that correct cannula insertion technique and use of the jet insufflator was demonstrated in only 55 per cent and 20 per cent of subjects. The median number of deviations from the DAS guidelines was three out of 15 practice points for can't intubate can ventilate and 12 for CICO.

3.5.4 A study of 102 anaesthesiologists (Wong DT, 2003) aimed to determine the minimum number of attempts required to perform cricothyroidotomy on a mannequin after setting an arbitrary benchmark time of 40 seconds. The success rate rose rapidly with attempts and plateaued above 90 per cent after four attempts noting younger subjects appeared to achieve the benchmark time after fewer attempts.

3.5.5 Doctors in general intensive care units in the UK were surveyed in respect to airway management strategies, staffing and airway equipment availability in their units (Astin J King EC Bradley T et al, 2012). While 38 per cent of respondents reported using individualised airway management plans for patients with higher risk airways, based on a snapshot of patients currently admitted in those units, only 19 per cent of the patients identified as "at risk" had such a plan in place. Action plans for the management of unanticipated tracheal tube and tracheostomy displacement were available in only 7 per cent and 10 per cent of ICUs, respectively, and 27 per cent of respondents reported no training in recognition and management of these events. Few respondents could describe the equipment available for emergency trans-tracheal access on their ICU and 13 per cent had no training in its use.

3.6 Topic reviews and “point of view’ publications

Several topic reviews provide useful secondary source information on the scale of this problem.

3.6.1 A comprehensive review of adverse events related to airway complications (Cook TM MacDougall-Davis SR, 2012) gathers evidence on the incidence and management of CICO from medical litigation “closed claims” or mortality databases from several countries (US, Canada, UK) and two national critical incident databases, the AIMS registry (Australia) and the recently published NAP4 audit of airway-related complications within the UK. From this review, which analyses datasets from the past 25 years, it seems reasonable to make the following generalisations: CICO is rare; the outcome of this event is poor, accounting for up to 25 per cent of anaesthesia-related deaths; the poor outcome is largely attributed to failure to perform emergency surgical airway or a delayed decision to do so and human factors appear to play a large role in sub-optimal care. This review also highlights some of the complexity associated with definitions and context. For instance the incidence of CICV in this review is estimated at 1:5000 of all general anaesthetics of which one-tenth progress to require surgical airway. Using the definition of CICO adopted by other authors, CICO is declared at the point all other supraglottic airway rescue strategies have failed; using this definition surgical airway is warranted in 100 per cent of CICO events.

3.6.2 Approaching this topic from a different angle, another group cites the above-mentioned mortality from CICO and uses publications from organisational psychology and human factors to explain instances of sub-optimal management, with particular emphasis on reluctance to perform emergency surgical airway. The review presents a systems model aimed to improve its management by incorporating quality assurance practice guidelines, training and behavioural modification (Greenland KB Acott C Segal R et al, 2011b). This review is cited again in the following chapters.

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Part 2: Clinical criteria for infraglottic rescue

1. AIMS

This part examines what if any clinical criteria define a CICO event and subsequent transition from supraglottic to infraglottic rescue as the focus of management.

2. KEY POINTS

2.1 CICO should be prevented, where possible, by thorough pre-anaesthesia assessment, which informs the development of a series of airway plans. In any one scenario, the primary plan should include the consideration of the option for an awake technique, such as awake fibreoptic bronchoscopy or awake tracheostomy; the back-up plan would feature one or more of a range of supraglottic rescue techniques and the emergency plan would involve a pre-rehearsed procedure(s) for infraglottic rescue.

2.2 A CICO event is declared in conjunction with all of the following: failed endotracheal intubation, failed face-mask ventilation and failed oxygenation via supraglottic devices such as the LMA in the context of falling or persistently low oxygenation.

2.3 Face-mask oxygenation should be declared failed after several airway manoeuvres have been attempted including optimal positioning of the head, two-handed, two-operator technique, insertion of oro and or naso-pharyngeal airways and inspection of the oropharynx to remove foreign bodies.

2.4 Endotracheal intubation should be declared failed when three optimised intubation attempts are unsuccessful, including both direct laryngoscopy and indirect (standard and hyper-angulated video laryngoscopy and/or flexible fibre optic bronchoscopy) laryngoscopy and optimisation of muscle relaxants. Intubation may be declared failed with fewer than three attempts under certain circumstances if reasonable evidence suggests further attempts will be counterproductive to supraglottic rescue by wither FMV or SGD.

2.5 Oxygenation via supraglottic devices should be declared failed when two attempts have been made with different sizes or types of devices.

2.6 In practice, clinicians may move through these pathways in a non-sequential manner and at any point may have partially attempted one or more pathways.

2.7 If not already evident, a fall in oxygenation is imminent when criteria for failed supraglottic rescue in the three pathways are met. Thus irrespective of oxygen saturation, clinicians should strongly consider calling for help after one pathway has been attempted unsuccessfully and should declare intent and mobilise resources for infraglottic rescue when two pathways are substantially unsuccessful. Concern should be upgraded if at any point oxygen saturation falls below 90 per cent.

2.8 Where the first line approach to infraglottic rescue is percutaneous cannulation of the trachea, an argument may be made in some circumstances to cannulate the trachea in preparation for the administration of percutaneous oxygen before CICO is definitely declared. Surgical approaches should be withheld until CICO is definitive. Oxygen delivery with a suitable device should commence immediately CICO is declared and the trachea is accessed.

3. OVERVIEW

Guidance on the management of difficult intubation and or difficult ventilation scenarios is provided in the published work of agencies and committees responsible for published algorithms or practice guidelines. Five of these were reviewed for this series:

- The American Society of Anesthesiologists (ASA) Task Force (Apfelbaum JL and Nickinovich DG, 2013).
- The Difficult Airway Society (DAS)(Henderson JJ, 2004).
- The Canadian Airway Focus Group (CAFG)(Law JA Broemling N Cooper RM et al, 2013).
- Dr Nicholas Chrimes and Peter Fritz (Vortex Model)(Chrimes N, 2013).
- Dr Andrew Heard (Heard, 2013).

Collectively, these bodies of work are supported by evidence derived from a comprehensive review of published research and or robust expert committee-based opinion. Some of this work is compared in a paper by Heidegger et al (Heidegger T Gerig HJ Keller C, 2003). These guidelines largely focus on clinical management. They broadly agree in respect to the principles of management however vary in respect to the scope of airway management addressed, the layout of the guidelines and emphasis given to key messages pertaining to goals of management and the maximum number of attempts at direct laryngoscopy and insertion of supraglottic devices.

Evidence from adverse event registries and coronial inquests do not provide generalisable evidence from which to make recommendations regarding criteria for declaring CICO, however their findings would appear to support the recommendations made in the above publications.

4. RECOMMENDATIONS OF INDIVIDUAL PRACTICE GUIDELINES

4.1 The American Society of Anesthesiologists (ASA) Task Force

The American Society of Anesthesiologists (ASA) practice guidelines for the management of the difficult airway were developed by a task force of 10 members in conjunction with a review of published evidence. The guidelines address all phases of management of the difficult airway from pre-anaesthesia assessment to emergency surgical airway in conjunction with a CICO event. It somewhat assumes that the final goal is the insertion of a tracheal tube however this is not the case for at least half of elective anaesthetics. It includes a sequential conceptual algorithm in regard to specific airway strategies including face-mask ventilation and ventilation via a supraglottic device such as an LMA. It does not recommend a specified number of attempts for intubation, supraglottic devices or quantify a definition for failed oxygenation.

4.2 Difficult Airway Society (DAS)

The UK-based Difficult Airway Society presents decision-support aids for management of a series of difficult airway events (Apfelbaum JL and Nickinovich DG, 2013; Difficult Airway Society). Like the ASA guidelines these assume that intubation is the definitive goal. The core set is presented as plan A, B, C and D with variations for contextually specific scenarios including rapid sequence induction and the obstetric patient. Assuming the scenarios and plans are experienced in sequence, plan C assumes reasonable attempts at intubation have been exhausted and difficulty is then experienced with ventilation, evidenced by falling saturation below 90 per cent despite a range of manoeuvres performed in conjunction with face-mask ventilation and plan D advises up to two attempts with different sized LMAs before embarking on infraglottic rescue. DAS recommends not more than four attempts at conventional or direct laryngoscopy and not more than two attempts at indirect intubation with intubating LMA or video laryngoscopy. The DAS plans also assume the vocal cords are relaxed and that an appropriate decision has been made initially regarding induction of anaesthesia and reawakening the patient.

4.3 Canadian Airway Focus Group (CAFG)

The Canadian Airway Focus Group (CAFG) an expert group of 19 experts published an algorithm for management of the unconscious/induced patient in whom difficult or failed tracheal intubation is encountered (Law JA Broemling N Cooper RM et al, 2013). The algorithm is supported by a review of the literature and evidence-based recommendations. This incorporated a review of nine published research studies addressing the optimal number of intubation attempts and other criteria for declaring CICO.

It assumes decisions have been made regarding awake techniques and commences at the point the primary plan for intubation is unsuccessful after induction of anaesthesia. Similar to the DAS and ASA guidelines the CAFG algorithm assumes the starting point is failed endotracheal intubation as opposed to difficulty encountered with a primary plan that involved facemask ventilation or supraglottic device. Similar to the DAS and ASA guidelines the CAFG algorithm includes supraglottic airway support manoeuvres in the categories of face-mask ventilation and ventilation via a supraglottic device.

Based on evidence from five Level B and four Level C studies the recommendations emphasises the hazards of repeated attempts at intubation and specifies that intubation should be declared ‘failed’ after a maximum of three attempts, including attempts with a video laryngoscope. It strongly emphasises embarking on an exit strategy once intubation is declared unsuccessful the exit strategy including options for awakening the patient, proceeding with surgery using a supraglottic technique or emergency surgical airway.

The algorithm specifies that CICO, defined as ‘failure to oxygenate’ in conjunction with failure of intubation, face-mask ventilation and ventilation after on attempt with a supraglottic device is an indication for emergency surgical airway. The Focus Group was reluctant to recommend a specific arterial oxygen saturation (SaO2) trigger for defining a failed oxygenation/CICO situation but forecasts that SaO2 falls rapidly below 90 per cent reflecting the O2 Hb Dissociation Curve.

4.4 Vortex™ Model

The Vortex™ model developed by Drs Nicholas Chrimes and Peter Fritz (Chrimes N, 2013) presents a conceptual guide to supraglottic airway management in which manoeuvres are organised into three categories: endotracheal intubation, face-mask ventilation and ventilation via supraglottic devices (for example, LMA). The model supported by selected citations is presented as a visual metaphor of a funnel depicting progression to CICO as airway manoeuvres are attempted unsuccessfully. Like the DAS plans the Vortex™ recognises there are multiple manoeuvres aimed at optimising airway management within each category but does not assume sequential progression through them. The model recommends that a CICO event should be declared only after appropriate rescue attempts have been made in each category and these have failed to restore a clear airway. The model is accompanied by an aide memoire for these individual manoeuvres and specifies no more than three attempts at intubation.

4.5 Andrew Heard

Recommendations for management of the difficult airway in the transition to the CICO scenario are presented in the E Book on this topic published by Dr Andrew Heard (Heard, 2013). These recommendations are based on the author’s personal experience in a wet-lab training environment and published research and supported by selected citations. They include a circular algorithm including oxygenation attempts via the three categories described above: facemask ventilation, LMA insertion and endotracheal intubation. Noting a lack of strong evidence the book recommends a number of specific strategies within these categories including no more than three attempts at intubation and no more than two attempts with different size and of types of LMAs. The recommendations also assume the vocal cords are relaxed.

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Part 3: The role of human factors

CONTENTS

a. Organisational (systems) factors.

b. Human (cognitive) error.

c. Team behaviours.

1. AIMS

Organisational safety practices are critical in averting CICO events and preparing individuals and teams to manage them as they evolve. Also critical are the behaviours of individuals and teams during point-of-care management of patients with evolving obstructed airways or at risk of these. This part looks at the evidence that associates the three above-mentioned human factors with CICO, explores their interdependencies. Strategies contributing to minimisation or mitigation of CICO are presented in part 5.

2. KEY POINTS

Human factors

Factor 1. The evolution and management of CICO events is explained by human factors and organisational safety concepts such as latent (system) and active (human) errors along with models that forecast their interdependencies in catastrophic accidents.

Organisational (systems) factors

Factor 2. Organisational science provides strong evidence for the role of multifaceted programs in reducing latent organisational errors including. Components of these programs include: adherence to best practice guidelines, standardised practices and equipment, use of checklists, routine training aligned with decision-support tools, cultivation of teamwork, quality assurance and reporting of adverse events.

Factor 3. These are enshrined within the principles of “The High Reliability Organisation” whose key elements are aimed at prevention of risks, building resilience to unresolved risks and cultivating a culture of safety. The latter is a holistic value, held by staff at all levels of the organisation, and expressed as practice aimed to prevent, detect, report and resolve risks. It emphasises the importance of open assertive communication among staff particularly when power gradients exist. A key example relevant to CICO is active listening to, and encouragement of assertiveness by, colleagues, particularly more junior doctors and nurses.

Human (cognitive) error

Factor 4. Cognitive science provides substantial evidence that no amount of systems preparation will eliminate human (cognitive) errors. While acknowledging the evidence supporting guidelines and standardisation, scientists within the cognitive science domain caution that exclusive adherence to prescriptive practices neglects particular human thought processes and behaviours that are expressed in novel, dynamic, time critical, stressful circumstances. In these circumstances two subconscious cognitive processes are highly evident: (1) decision-making by experts deviates from prescriptive (normative) practice into contextually dependent (naturalistic) patterns that are less well supported by checklists and other procedural rules; and (2) cognitive errors increase, largely as a result of task loading and sensory overload. The design of safety programs should anticipate and manage these processes. While organisational safety interventions are partially effective in mitigating their risks, a number of strategies delivered at the point of care are likely to be effective:

a. Use of cognitive (memory) aids that use simplified content and symbols to remind people of the more detailed decision-aids they have used in training activities. These should prompt users to follow best practice at high-risk points. They should support the whole team.

b. Self-awareness by clinicians of their vulnerability to errors and self-monitoring to detect and rectify errors, or unproductive cognitive processes or factors such as stress fatigue and high-task workload, which reduce cognitive resources and lead to errors.

c. Encouragement of other team members to provide input and raise concerns.

d. Activation of pre-rehearsed practices aimed at identifying evolving problems and methodically working through them.

e. Optimisation of the physical environment to promote situation awareness.

Team behaviours

Factor 5. Team behaviours influence clinical performance measured in terms of situation awareness, decision latency, task management and task completion time. Poor situation awareness is a form of cognitive error associated with other cognitive errors. Key team attributes and behaviours include: shared mental models, role clarity, co-ordination, communication, leadership, decision-making and monitoring.

3. DEFINITIONS AND TERMS

The substantial role played by human factors (HF) in causation and outcomes of CICO became evident as the literature was reviewed. Human factors are the study of how interactions between organisations, tasks, and the individual worker impact on human behaviour and affect systems performance (Clinical Human Factors Group). Several key concepts or principles are commonly included in discussions of human factors. These include theories on “human error”, the concept of “organisational errors” and related concepts, such as the high reliability organisation (HRO) and patient safety culture.

Each of these is supported by extensive work undertaken within the fields of cognitive and organisational psychology. In an effort to condense these, we can describe human error largely in terms of cognitive failures that lead to misinterpretation of information, omission of intended actions or commission of unintended actions (Reason J, 1995a) and organisational, latent or systems errors as unresolved threats resulting from multiple factors, such as faulty equipment, sub-optimal training, poorly designed protocols, inadequate allocation of resources and unpredicted demands (Bognor MS, 1994). Reason’s well known “Swiss cheese” model of error explains that human and latent errors are generally benign in isolation however the confluence of several latent errors creates conditions for catastrophic accidents that can be triggered by one or more unpredictable human errors (Reason J, 1995b).

4. ORGANISATIONAL (SYSTEMS) SAFETY

Organisational safety science takes a holistic approach to the study of errors. Its proponents assume that latent errors are predictable, identifiable and can be more reliably eliminated than human errors (Bognor MS, 1994). The concept of “resilience” – those things that “good” organisations and people do to prevent and mitigate catastrophes – is also promoted. Several key principles of organisational safety are galvanised in the concept of the high reliability organisation (HRO) including an acceptance of the inevitability of latent and human errors matched by proactive measures to identify and eliminate and or increase resilience to them (Sutcliffe, 2011). In practice this involves a multifactorial approach, including adherence to best practice guidelines, standardised practices and equipment, use of checklists and cognitive aids, routine training, quality assurance and reporting of adverse events and cultivation of teamwork (Bion JF Abrusci T Hibbert P, 2010; Sutcliffe, 2011). Underscoring these is a safety culture permeating the attitudes of staff at all levels within an organisation and rewards assertive questioning of concerns and reporting of errors (Rall and Dieckmann, 2005) (See table 1).

Table 1: Elements of safety culture (from Rall and Dieckmann)

- Low-ranking personnel raise safety issues and challenge ambiguity regardless of hierarchy or rank.
- Calling for help is encouraged and occurs frequently, even (or especially) by experienced personnel.
- Explicit communication is frequent.
- The hierarchy is flat: leaders listen to juniors, juniors are encouraged to speak up, calling for help is routine regardless of rank.
- People are rewarded for rationally erring on the side of safety, even when their credible concerns turn out to be wrong.

Application of organisational safety principles to CICO

Anaesthesia was one of the first healthcare disciplines to embrace patient safety science. The classic features of CICO events – rare and catastrophic but occurring in a context of routine work and numerous identifiable latent errors – are easily explained by error theory. Several authors have outlined frameworks for multifaceted systems-wide solutions aimed at reducing human errors such as neglecting of delaying surgical airway in CICO events (Fischer QA, 2009; Greenland KB Acott C Segal R et al, 2011; Rall and Dieckmann, 2005; Watterson, 2012). One institution published results showing substantial reductions in the incidence of CICO events after introducing a staged multifaceted program (Berkow LC Greenberg R S Kan KH et al, 2009). The five key components of this are shown in table 2.

Table 2: Key elements of one institution's program aimed at reducing CICO

1. Information: Patients were reported to a centralised database; they were given special hospital identification bands and written information for future reference by medical personnel; and they were encouraged to enrol in the MedicAlert difficult intubation registry.
2. Evaluation: The anaesthesia preoperative evaluation form was redesigned to target more specific issues in airway assessment; patients with possibly difficult airways were noted on the operating room (OR) schedule.
3. Equipment: Standardised difficult airway carts were placed to be readily accessible in the ORs, obstetric unit and intensive care units.
4. Training: Regularly scheduled training sessions were developed for staff and residents, including a "difficult airway" rotation for residents and twice-yearly interdisciplinary grand rounds.
5. Oversight: An interdisciplinary team was formed to serve as expert resources, trainers, and supervisors of the program.

5. HUMAN (COGNITIVE) ERROR

Occurring in parallel with organisational safety science, cognitive science provides substantial evidence for the role of cognition and behaviour in patient safety.

Naturalistic decision-making

As described above a core principle of organisational safety is to minimise risks through standardisation of practice, including compliance with guidelines. This assumes clinicians use "normative" decision-making processes based on logical selections of best options supported by criteria in algorithms and checklists. However, extensive research demonstrates that under novel and stressful situations experts use "naturalistic" methods of decision-making that draw on unconscious cognitive strategies drawing on memory and experience such as pattern recognition, hypothesis generation and forward planning (Klein G, 2002; McRobert A, 2013).

Proponents of cognitive science caution that the normative approach to decision-making prescribed by standardised processes and operating procedures neglects some aspects of human performance in emergency situations and creates risks for poor decision-making. (Carvalho PVR dos Santos IL Vidal MCR, 2005). As explained below we also understand that decision-making is prone to cognitive errors such as fixation or sensory inattention.

Evidence for cognitive failure in CICO

Anaesthesia is a high-risk discipline for errors caused by factors that place strains on cognitive resources (Schull JE Redelmeiert DA, 2001). Time critical, novel situations with ill-defined features and changing goals widely acknowledged as hallmarks of crises across numerous domains are familiar to most anaesthetists and numerous analogies have been made with other industries facing similar challenges (Gaba DM, 1994).

Part 1 of this series identifies performance lapses that have been associated with preventable episodes of CICO or serious outcomes resulting from it. Human error is implicated on a number of occasions. The investigation into the death of Elaine Bromiley concluded that task fixation by a team of anaesthetists and lack of assertiveness by nurses contributed to the omission of infraglottic rescue in this case (Clinical Human Factors Group). The NAP4 audit concluded that task fixation and poor co-ordination and decision-making were implicated in promoting persistent futile attempts at intubation, particularly noted among anaesthetists, while errors of omission possibly led to neglect of alternative forms of supraglottic rescue and avoidance of infraglottic rescue, somewhat more evident among other critical care clinicians (Cook, Woodall, and Frerk, 2011; Cook, Woodall, Harper and Benger, 2011). Poor judgment regarding choice of technique, failure to call for help, cognitive errors and poor teamwork occurring with the context of ill-preparedness and apparent lack of training were highlighted by the authors.

Human factors contributing to errors

A range of factors contribute to errors, some of which influence attitude, such as organisational culture and peer pressure and others that reduce cognitive resources including task novelty, workload and lack of experience. Many factors are interdependent (table 3) (Schull JE Redelmeiert DA, 2001).

Table 3: Human factors contributing to poor performance in clinical emergencies

Table 1: Pitfalls when treating patients *in extremis*

Pitfall	Example
Individual	
Need for rapid decisions	Patient suffering cardiogenic shock
Increased complexity	Intubating a trauma patient
Mistakes made due to stress	Neglecting to check drug allergies in meningitis
Failure of people to see themselves as part of a team	Not identifying a leader among multiple physicians at a resuscitation
Team	
Difficulty coordinating conflicting actions	Prioritizing chest x-rays, intubation and physical examination
Poor communication	Not informing nurses of provisional diagnosis
Reluctance to question those with seniority	Failing to question an incorrect epinephrine dose
Failure to establish clear goals and roles	Frequent changing of residents on a cardiac arrest team
Presence of conflicting occupational cultures	Willingness of firefighters, paramedics or physicians to vary standard protocols at a cardiac arrest
Context	
Incomplete clinical data	Delays in obtaining a hospital chart
Family members unavailable or unhelpful	Determining whether a DNR order has already been decided on
Frequent interruptions of thinking and actions	Receiving a summons by pager while inserting a central line
Diminished vigilance and fatigue	Calculating the phenytoin dose for a seizing toddler at 4 am

Overall human factors were noted in 40 per cent of all airway complications submitted to the NAP4 register and were contributors to poor outcome in one quarter (Cook and MacDougall-Davis, 2012). A follow-up investigation of 12 cases of airway complications submitted to the NAP4 registry by anaesthetists were analysed using a human factors investigation tool. This identified that human factors recognised to contribute to errors were present in every case with a median (range) of four (1 to 10). The most common mentioned were situation awareness (for example, failures to anticipate, wrong decision), job factors (for example, task difficulty, staffing, time pressure) and person factors (for example, tiredness, hunger, stress) (Flin R Fioratou E Frerk C et al, 2013).

It is clear that stress impairs cognitive function in respect to memory retrieval (Kuhlmann, Piel and Wolf, 2005) and on operator performance during complex emergencies (Carvalho, dosSantos and Vidal, 2005; Kontogiannis, 1996). In a simulator study, the time to perform cricothyroidotomy was slower when anaesthetists were placed in stressful, time-pressured conditions (Suri BJ Hillerman CMendonca C).

6. TEAMWORK

Team work has various definitions although many published frameworks include several of the following elements: task management, shared mental models, role clarity, co-ordination, communication, leadership, decision-making and monitoring (Flin R Glavin R Maran N, 2010; Sevdalis N Lyons M Healy AM, 2009). A recent meta-analysis of teamwork in healthcare concluded poor teamwork contributes to errors by reducing the quality of team process factors such as those mentioned above. These team process behaviours in turn influence clinical performance measured in terms of situation awareness, decision latency, task management and task completion time (Schmutz J Manser T, 2013). Poor teamwork is also considered to diminish individuals' performance through stress and poorly managed workload. Supportive teams may detect errors and may also compensate for knowledge deficiencies in individuals.

The influence of teamwork on management of patients in CICO events is frequently inferred in the evidence presented in part 1 although this hasn't been directly investigated. Inadequate teamwork was considered to contribute to poor management in 14 per cent of cases submitted to NAP4 and directly cited in respect to co-ordination and communication in three of 12 cases analysed in the above-mentioned follow-up study by Fioratou. This study concluded that "supportive teams may detect cognitive errors if team members feel able to raise suggestions and concerns" (Fioratou E Flin R Glavin R, 2010; Glavin R, 2011). This has emerged as a prominent theme across the literature.

Other studies relating to the operating theatre environment support these findings. A study of anaesthesia teams managing simulated emergencies found evidence of limited understanding of the roles and capabilities of team members across professional boundaries, limited sharing of information and limited team input into decision making with a perceived impact on task distribution and the optimal use of resources within the team (Weller JM Janssen AL Merry AF et al, 2008). Other studies have had similar findings (Undre S Sevdalis N Healey A et al, 2006). As reported in the above study, nurses in particular report that it is difficult to speak up and feel they have insufficient input into decision-making.

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Part 4: Management of transition

CONTENTS

Factor 1. Being prepared to respond.

Factor 2. Managing ambiguity.

Factor 3. Preventing and detecting cognitive failure.

Factor 4. Optimising team support and communication.

Factor 5. Monitoring attention and minimising delays.

1. AIMS

This part looks at the evidence from parts 1, 2 and 3 recommends strategies contributing to minimisation or mitigation of CICO.

2. KEY POINTS

Several key aspects of performance observed in CICO events are influenced by individual, team and organisational factors operating interdependently and the contextual features of a CICO emergency. These should be optimised. Performance elements and strategies to optimise them are listed below as direct statements:

2.1 Be prepared to respond

- Institute locally relevant, multifaceted safety programs, which include registries of at-risk patients, best practice guidelines and decision aids, standardised equipment that matches the guidelines, rosters and communication processes that mobilise specialist care quickly, incident reporting and quality audits.
- Ensure clinicians undergo routine training that is contextualised relevant to setting and which includes: emergency planning, application of cognitive aids including transition from plan A to B etc, airway "time-outs", team roles, procedural skills and use of equipment.

The remaining points relate to strategies that are employed during and evolving airway emergency.

2.2 Manage ambiguity

- Use a cognitive aid that reminds people of the more detailed decision aids they have used in training activities, prompts users to follow best practice at high-risk points and prevent key performance errors.
- Be guided by specific clinical criteria when defining CICO.
- Seek input from colleagues on decision-making.

2.3 Prevent and detect cognitive failure

- Use cognitive (memory) aids that use simplified content and symbols to prompt users to follow best practice at high-risk points and are available to all members of the team.
- Be self-aware of vulnerability to errors and self-monitor to detect and rectify errors or unproductive cognitive processes that lead to fixation errors or reduce cognitive resources.

- Manage stress.
- Invite team members to provide input and raise concerns.
- Activate methodical pre-rehearsed emergency responses and problem-solving practices.
- Optimise the physical environment to promote situation awareness.

2.4 Optimise team support and communication

- Activate pre-rehearsed team practices to optimise co-ordination, communication and situation awareness.
- Share information using effective language such as: team briefing, closed loop communication and situation reports.
- Invite team members to provide input and raise concerns.

2.5 Monitor attention and minimise delays

- Mobilise resources early.
- Break key tasks into steps such as separating infraglottic rescue into (1) trans-tracheal access and (2) emergency oxygenation.
- Use cognitive aids to prompt progress at points at risk of delay.

Factor 1: Be prepared to respond

Much of the evidence indirectly suggests clinicians are psychologically and practically ill prepared to manage CICO events. This encompasses a raft of factors including lack of agreement on best practice with subsequent lack of response plans among individual clinicians and teams, poor knowledge of and practical skills with infraglottic rescue procedures and low familiarity with relevant equipment. The NAP 4 authors stress the crucial importance of full preparation involving training, institutional preparedness and personal preparedness. “The skilled, prepared anaesthetist will have numerous options to manage failure and will have decided the appropriate strategy (next step) before starting” (Cook and MacDougall-Davis, 2012). These are presented in part 3.

Factor 2: Manage ambiguity in decisions about CICO

The concept of systems ambiguity helps to explain why otherwise well-trained personnel fail to follow apparently clear and accepted best practice. In relation to CICO, this dilemma is observed in the reluctance to perform a surgical airway (Greenland KB Acott C Segal R et al, 2011).

As presented in part 2, numerous expert groups have published best practice guidelines intended as decision aids to be used in preparation for the management of the difficult airway. These demonstrate reasonable convergence of opinion in four aspects of practice:

1. Avoiding general anaesthesia in extremely high-risk patients.
2. Pre-oxygenating and maintaining oxygenation at all times, including continuing with supraglottic rescue after commencing infraglottic rescue.
3. Attempting supraglottic rescue via three modalities (intubation, face mask and LMA).
4. Transitioning to infraglottic airway when options for supraglottic rescue are exhausted.

However evidence presented in part 1 suggests clinicians may still succumb to ambiguity at these key stages of care; for instance the decision to induce general anaesthesia, optimal supraglottic rescue, and determining the point at which an airway if definitely obstructed and unlikely to respond to further attempts at supraglottic rescue, as well as procedural aspects of infraglottic rescue.

The care of patients with complex conditions involves many individual instances of clinical decision-making involving numerous care providers. Current opinion in critical care supports the use of decision-support tools and cognitive aids and recommends integrated approaches aimed at stronger coupling of clinical cues with therapeutic responses through strategies such as "clarification of expectations from care providers with respect to guideline compliance through education, use of visual cues to indicate the status of (critical care) patients with respect to a particular guideline, development of tools that provide an overview of information critical for guideline compliance, use of standardised orders, clarification of roles of care providers and use of decision-support tools" (Gurses AP Seidl KL Vaidya V et al, 2008).

Applying these principles to CICO we could argue that the four key practice points in the published decision-aids are not expressed strongly enough. At the bedside this could potentially be improved by adding a simple memory or cognitive aid that emphasises the key practice points and error-prone steps reflected in the existing decision-support tools, which are useful when one is familiar with them but too detailed to be derived in emergency conditions if memory fails. This includes demonstrating a link between identification of at-risk airways and the worst-case scenario of CICO. The variation seen across published algorithms in respect to maximum number of recommended attempts at laryngoscopy creates further ambiguity. This could be reduced if agreement could be reached, even at an institutional level, on recommended number and type of supraglottic rescue techniques. The strong association between cognitive error, team culture and decision making also highlights the key role of support and input from team members in making contextually appropriate decisions prior to committing to general anaesthesia and or as the event evolves.

Summary of strategies to reduce ambiguity (regarding appropriate point to declare CICO)

1. Use a cognitive aid that emphasises key performance errors such as failure to attempt other supraglottic techniques when intubation is unsuccessful.
2. Be guided by specific clinical criteria when defining CICO (see part 2).
3. Call for help and seek input from colleagues on decision-making by inviting all members of team to make suggestions or raise concerns.

Factor 3: Preventing and detecting cognitive failure

Cognitive errors are considered notoriously difficult to prevent (Bognor MS, 1994). There are numerous classifications and theories of error. Human error is defined in this paper as cognitive failures such as frequency gambling, freezing, denial that leads to misinterpretation of information, faulty problem solving, omission of intended actions or commission of unintended actions (Reason J, 1995b). James Reason broadly distinguishes between errors of intention and planning as "mistakes", which occur in the context of problem solving in novel situations and errors associated with inattention as "slips and lapses" that result from failure in the execution and/or storage stage of an action (Reason J, 1995a). "Knowledge-based mistakes" involve greater complexity and ambiguity than "rule-based mistakes", the latter of which reflect a misinterpretation of a cue. Our knowledge of CICO events suggests that errors occurred at all of these levels, however the more complex form of knowledge mistakes are mainly observed.

Cognitive scientists such as James Reason propose that strategies that increase automaticity in novel situations may reduce mistakes. Several of these rely on pre-prepared strategies such as training with decision aids and design of the working environment to optimise situation awareness. Others involve point-of-care practices, such as use of memory aids and self-monitoring for detection of faulty cognitive processes.

Self-monitoring is not an automatic process. This is evident in failures associated with naturalist decision-making. Fioratou applied a series of experiments from cognitive science addressing the relationship between experience and problem solving in anaesthesia. This highlighted that unhelpful reliance on past experience promotes faulty cognitive reasoning processes, such as frequency gambling, freezing and denial, which contribute to task fixation errors (Fioratou E Flin R Glavin R, 2010). This paper highlighted adaptive problem solving strategies such as mindfulness, trial and error and searching for environmental cues. This paper also refers to task fixation in the Elaine Bromiley case, advising anaesthetists to use other people as a source of insight.

David Gaba, the developer of Anaesthesia Crisis Resource Management (ACRM) recommends anaesthetists work methodically and activate pre-rehearsed emergency practices such as: vigilant observation, verification (of abnormal cues), problem recognition, prediction of future states, precompiled responses, co-ordination of activities, workload management strategies and re-evaluation cycles (Gaba DM, 1994).

A study of stress in surgeons may provide useful advice for anaesthetists. Although stress had both positive and negative effects, undue levels of stress impaired judgment, decision-making and communication. Senior surgeons reported having developed sophisticated strategies, including physical relaxation, control of self, distancing techniques, team communication and leadership. They describe positive self-talk as a means of reducing both cognitive and emotional stress responses, applying this strategy to “calm down, improve their own confidence and focus, and guide themselves along the decision-making process with logical instructions” (Cordula MW Kneebone RL Woloshynowych et al, 2006).

As previously mentioned, encouraging and accepting open assertive communication with team members is highly recommended *(*Glavin R, 2011).

These principles are easily incorporated into institutional quality and training programs. A program developed by Australian anaesthetists presents CICO within a human factors framework (Watterson, 2012). This program encourages anaesthetists to become more aware of CICO by creating a “brand-name” for it within their institutions. Key aspects include a cognitive aid, matched equipment and a quality assurance tool. In this program, the procedure of infraglottic rescue is taught in the context of integrated scenarios involving teamwork and assertive communication. The curriculum and materials are available as open-access educational resources (Watterson, 2013).

Summary of strategies to improve cognitive performance

a. Use cognitive (memory) aids that use simplified content and symbols to prompt users to follow best practice at high-risk points and are available to all members of the team.

b. Be self-aware of vulnerability to errors and self-monitor to detect and rectify errors or unproductive cognitive processes that lead to fixation errors or that reduce cognitive resources.

c. Manage stress.

d. Invite team members to provide input and raise concerns.

e. Activate pre-rehearsed methodical practices.

f. Optimise the physical environment to promote situation awareness.

Factor 4: Optimising team support and communication

The “input process output” model described by McGrath (McGrath JE, 1964) is an established model for examining teamwork. According to this framework, inputs are preconditions influencing the attributes and behaviours of the team while working together (such as communication, leadership, co-ordination and decision-making [Schmutz J Manser T, 2013]). Organisational safety principles are considered essential in optimising preconditions for effective teamwork. Education in turn is an important element of organisational safety.

The literature contains numerous publications describing teamwork education. Seven of the 28 studies in Schmutz and Manser’s meta-analysis were educational intervention studies and concluded that teamwork training improves team performance measured either in improved team processes or outcomes listed in the above section on teamwork. Many of these interventions were delivered in simulated environments, using crisis resource management (CRM) methodology and addressing topics such as human factors, situation awareness, communication and leadership.

CRM training was applied to anaesthesia by David Gaba in the 1990s. This training is commonly delivered in simulation environments where complex emergencies are recreated and managed by teams under “safe” conditions. Retrospective analysis is conducted as reflective debriefs that encourage teams to explore the roles of non-technical skills in performance (DeAnda and Gaba, 1990). Non-technical skills can be defined as “the cognitive, social, and personal resource skills that complement technical skills, and contribute to safe and efficient task performance” (Flin R Glavin R Maran N, 2010). Examples of non-technical skills included in CRM training are presented in table 2 (Rall and Dieckmann, 2005).

Table 2. Key points of crisis resource management (CRM).

1. Know the environment
2. Anticipate and plan
3. Call for help early
4. Exercise leadership and followership
5. Distribute the workload
6. Mobilise all available resources
7. Communicate effectively
8. Use all available information
9. Prevent and manage fixation errors
10. Cross (double) check
11. Use cognitive aids
12. Re-evaluate repeatedly
13. Use good teamwork
14. Allocate attention wisely
15. Set priorities dynamically

From Rall and Gaba (2005, Miller’s Anesthesia 6th edition; Philadelphia: Elsevier Churchill Livingstone, pp 3021–3072) with permission.

Communication should be aimed at supporting team processes such as co-ordination, situation awareness and decision-making. Explicitness, timing, active listening, assertiveness have been identified as important communication practices (Glavin R, 2011). Communication that improves situation awareness and subsequent problem solving “before undertaking anaesthesia; and (about) difficulty or failure to the team when (emergencies) occur” is recommended by numerous groups (Cook and MacDougall-Davis, 2012).

Summary of strategies to improve teamwork

1. Activate pre-rehearsed team strategies to optimise non-technical practices.
2. Share information using effective language.
3. Invite team members to provide input and raise concerns.

Factor 5: Monitor attention and minimise delays

Delay in performing infraglottic rescue is a well-described problem in cases of established CICO. Again the causes for this appear to be multifactorial. Indecision in determining whether supraglottic rescue strategies have been exhausted is well described as have technical failure in execution of infraglottic rescue due to lack of training. However, the evidence revealing poor planning forecasts that practical delays will also occur.

Strategies that may improve speed of execution of key steps including infraglottic rescue:

1. Mobilise resources early. Pre-emptive mobilisation of resources and effective teamwork including allocation of tasks amongst team are well-described general principles of CRM (Gaba, 2010). There is growing support for a recommendation to mobilise resources for infraglottic rescue when two of the three supraglottic airway rescue pathways have been exhausted (Chrimes N, 2013; Heard AM, 2013; Watterson, 2012).

2. Break the key tasks into steps. Reducing complex care into discrete sequential steps may promote timely care at each step. Critical sequential steps that are described in CICO comprise: Supraglottic rescue by three pathways, infraglottic transtracheal airway access and infraglottic oxygenation.

3. Use cognitive aids to prompt progress at points of potential delay. Cognitive aids differ from their more detailed decision aids in that the former use simplified content and often use symbolism to remind or prompt action. Several cognitive aids have been published that aim to achieve this. These include the Vortex™ Model (part 5, figure 5)(Chrimes N, 2013) and the “CriCon” (part 5, figure 6)(Weingart S).

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Part 5: Features of cognitive aids that best support the management of CICO

CONTENTS

1. Routine use of cognitive aids (CAs) in difficult airway scenarios.
2. Distinction between decision aids and cognitive aids in emergency situations.
3. Published difficult airway cognitive aids.
4. Ideal design features of cognitive aids.
5. Features of CICO cognitive aids supported by evidence from parts 1, 2 and 3.
    a. Clinical content.
    b. Performance factors.
    c. Design features.
    d. Contextual aspects.

DEFINITIONS AND TERMS

Cognitive aids (CA) are "tools created to guide users while they are performing a task, or group of tasks, with the goal of reducing errors and omissions and increasing the speed and fluidity of performance" (Marshall S D, 2013).

AIMS

This part evaluates the evidence for the routine use of cognitive aids in CICO events and their design features.

1. KEY POINTS

1.1 **Routine use of cognitive aids in difficult airway scenarios.** There is strong support for the routine use of cognitive aids in the management of anticipated and unanticipated difficult airway scenarios.

1.2 **Use in the context of emergency situations:** Cognitive aids intended for uses in the context of emergency situations such as CICO should be distinguished from decision-support aids that are intended for use to support training. Emergency cognitive aids should be simple, low-content documents that aid memory recall, prompt users regarding frequently omitted steps or clarify difficult decision points. In contrast, decision aids, which are designed to support training and awareness of best practice, are generally more detailed documents. While they can be applied in non-emergency situations such as preparation for anticipated difficult cases, their higher levels of textual content make them difficult to follow in time-critical emergency situations.

1.3 **Published cognitive aids.** Several groups have published cognitive aids to support difficult airway scenarios including transition from supraglottic to infraglottic rescue. Earlier published cognitive aids such as those developed by the American Society of Anesthesiologists (ASA), Difficult Airway Society (DAS), and Canadian Airway Group have features of high content text-based decision-aids best suited to preparation stages of anticipated difficult airways or to develop mental preparedness of clinicians in case they encounter an unanticipated difficult airway. More recently published cognitive aids, such as the Vortex™ and CriCon2, use symbols and graphic metaphors that make them more suited to employ as cognitive aids during emergency situations. No cognitive aids published to date meet all the ideal features of a CICO cognitive aids based on the evidence from this series of papers.

1.4 **Ideal features of cognitive aids:** General design features outside of the context of CICO:

1.4.1 There is no evidence favouring one conceptual format of cognitive aid over another from the following list: goal-based treatment; conditional if-then prompts; reminders of frequently omitted steps or navigation of sequential steps.

1.4.2 There is no evidence favouring one graphical format over another from the following list: checklists of key practice points; sequential and/or branching flowcharts; symbols and graphic metaphors; or hazard alerts.

1.4.3 Evidence favours certain design features in the specific contexts of preparatory checklists and memory aids designed to reduce omission errors. It is generally considered that cognitive aids designed for emergencies should have simplified content and layouts to allow assimilation in a crisis.

1.4.4 New designs should not be implemented until testing has occurred

1.5 **Ideal features of CICO cognitive aids: Clinical content:** As per part 2 the most strongly endorsed features of existing decision aids are:

1.51 They depict common and or serious airway scenarios, which include: anticipated difficult airway; can't intubate where face-mask ventilation is adequate; can't intubate where face-mask ventilation is inadequate; CICO and the transition between these scenarios.

1.5.2 Alternatively they present supraglottic rescue as a non-linear relationship between three pathways: intubation, face-mask ventilation and supraglottic devices such as LMA.

1.5.3 They specify measurable criteria to minimise premature or delayed progression through transitional states. These criteria could include: type of interventions, number of attempts, and oxygen saturation level.

1.5.4 They highlight recommended clinical practice points (see 2.8.5).

1.6 **Performance shaping factors of cognitive aids:** As per part 1 the most concerning errors and performance failures are considered to be:

1.6.1 Failure to appreciate the risk of CICO in patients with anticipated difficult airways and neglect of options for awake techniques which may otherwise avert a CICO event or preparation of back-up plans in case CICO evolves after general anaesthesia is induced.

1.6.2 Omission of supraglottic rescue interventions in one or more categories (intubation, face-mask ventilation and supraglottic device [LMA]), which may otherwise avert a CICO event.

1.6.3 Factors that lead to omission or delay in performing infraglottic rescue when a definitive CICO exists such as task fixation and unassertive team members.

1.6.4 Delays in commencing infraglottic rescue.

1.6.5 Technical failures in performing infraglottic rescue.

1.7 **Context:** A CICO cognitive aids is unlikely to be meaningful if used outside of the contexts of:

1.7.1 The individual clinician who has trained against the cognitive aid and who is mentally prepared to activate the algorithm and physically prepared to perform the procedures.

1.7.2 The team who is familiar with the cognitive aid.

1.7.3 The organisation has a multifaceted pre-planned strategy for management of the difficult airway.

1.7.4 Complementary resources providing detailed content not included in cognitive aids.

RECOMMENDATIONS

Drawing from evidence presented in this series, the key recommended features and inclusions of a cognitive aid for CICO are listed below. The aid should:

1. Be easily accessible to all members of the team and embedded in everyday routine practice, such as case briefings.
2. Show airway assessment, decision to induce general anaesthesia and CICO as related events.
3. Emphasise supraglottic rescue and express this as three pathways or categories: face-mask ventilation, endotracheal intubation and supraglottic rescue devices.
4. Suggest clinical criteria for declaring CICO, for example, maximum number of attempts at endotracheal intubation and SaO2.
5. Include prompts (as questions, reminders or practice points) for steps at high risk of faulty decisions, omission or delay including:

5.1 Consider awake intubation/tracheostomy in high-risk patients.

5.2 Attempt all three supraglottic pathways: FMV; ETT; LMA.

5.3 Call for help.

5.4 Attempt to deliver oxygen via a supraglottic pathway at all times.

5.5 Awaken the patient if feasible.

5.6 Mobilise resources for infraglottic rescue when two supraglottic pathways are unsuccessful.

5.7 Declare CICO when three supraglottic pathways are unsuccessful.

5.8 Initiate infraglottic rescue immediately a CICO is declared.

5.9 Team members should be encouraged to speak up at any time if concerned.

5.10 Use specific criteria to guide extubation and monitor carefully afterwards.

DISCUSSION

Cognitive aids in healthcare

Cognitive aids are well established in healthcare. They are generally written tools presented in a range of formats including checklists, mnemonics, flowcharts or diagrams incorporating symbols or abstract representations of relationships between elements. Cognitive aids can be incorporated as visual displays and audible signals on electronic devices, the latter serving as substitutes for human readers.

Checklists and flowchart-based algorithms are the most commonly used cognitive aids in healthcare. In recent years, checklists have become increasingly used as safety tools used in the preparatory and emergent phases of clinical tasks to prevent omission, sequence and sidedness errors during the clinical procedures. The WHO Surgical Safety Checklist and institutional anaesthesia machine checks are examples. Flowchart-based algorithms support risk stratification and decision-making regarding therapeutic treatment. Many of these have branch points displaying criteria for groupings based on risk and corresponding recommended clinical practice guidelines. Others present options for treatment pathways using a conditional “if-then” format. There are numerous examples of these types of algorithms published within critical care settings, examples including risk stratification and management of chest pain, acute asthma and anaphylaxis.

COGNITIVE AIDS IN CICO – CURRENT PRACTICE

Sequenced flowchart algorithms

The majority of cognitive aids that incorporate the management of CICO feature branching flow-chart and text decision-support formats in which the sequence of scenarios encountered is pre-determined. For instance, they assume the failed ventilation scenario occurs after the failed intubation scenario and not before or during it. Several of these were developed in conjunction with evidence-based guidelines by expert consensus groups including the American Society of Anesthesiologists (ASA) Difficult Airway Guidelines (American Society of Anesthesiologists Task Force on Management of the Difficult Airway, 2003; Apfelbaum JL and Nickinovich DG, 2013) (figure 1), The Difficult Airway Society (DAS) Difficult Airway guidelines (plan C and D) (Henderson JJ, 2004) (figure 2) and the Canadian Airway Focus Group (CAFG) practice guidelines (Law JA Broemling N Cooper RM et al, 2013) (figure 3). These are compared and contrasted in a paper published by Heidegger et al (Heidegger T Gerig HJ Keller C, 2003). A number of studies or reports have been published in which smaller expert groups have developed cognitive aids to support local institutional implementation of difficult airway programs (Heidegger T Gerig HJ Keller C, 2003; Watterson, 2012) or for the purposes of conducting a study (Combes X Jabre P Amathieu R et al, 2011). Dr Andrew Heard’s Percutaneous Emergency Oxygenation Techniques (PEOT) for infraglottic airway rescue was developed by the author in conjunction with experimental studies conducted in a wet-training lab (Heard, 2013) (figure 4).

With the exception of Dr Heard’s algorithm, the evidence supporting these cognitive aids is vested in the literature reviews and, to varying degrees, guideline development methodology used by the consensus groups. They have not been validated under experimental conditions or cohort studies.

Non-sequenced decision-support design

A theoretical disadvantage of the sequenced algorithm design is that the algorithm generally assumes a fixed starting point, for instance failed intubation when applied to CICO and it does not provide for backwards steps. Some authors argue that this fails to represent real-world events in management of the difficult airway in which intubation may be attempted as a rescue strategy after difficulty has been encountered with an alternative primary strategy such as insertion of supraglottic device or face-mask ventilation. Some authors have represented this interdependence in the form of a circle containing three thematic elements of supraglottic rescue: intubation, face-mask ventilation and insertion of a supraglottic device such as the laryngeal mask airway (Heard, 2013). As discussed below there is increasing support to make these themes prominent in airway cognitive aids, however their symbolic representation in a cycle may theoretically encourage procrastination in respect to declaring CICO and commencing infraglottic rescue. The evidence presented in part 1 suggests this could be a valid concern if decision-making relied upon the cognitive aid in isolation from other strategies such as teamwork and communication.

The "Vortex™ model" of supraglottic airway management addresses some of the above-mentioned concerns and its design sacrifices content with the goal of addressing factors that affect individual and team performance (Chrimes N, 2013) (figure 5). The vortex cognitive aid visually emphasises the three broad categories of supraglottic airway rescue (endotracheal intubation, face-mask ventilation and ventilation via supraglottic devices [for example, LMA]) that are present but less obvious in the other cognitive aid. This is designed to prompt the user attempt supraglottic rescue in each category before declaring CICO.

The "CriCon" traffic light model (figure 6) also uses symbolism and metaphor to guide behaviour related to transition from supraglottic rescue to declaration of CICO (Weingart S).

A cognitive aid developed by a rural anaesthesia course curriculum working party focuses on the transition from supraglottic to infraglottic rescue including decision support for the declaration of CICO (Watterson, 2012) (figures 7 and 8). This cognitive aid incorporates Dr Heard's cognitive aid as the infraglottic component and also displays team roles. It has not been validated under experimental conditions or cohort studies.

EVIDENCE FOR USE OF COGNITIVE AIDS

As explained, few of the existing CICO cognitive aids have undergone validation in either experimental or cohort studies, thus creating dilemmas for organisations wanting to adopt and incorporate a cognitive aid into their difficult airway programs.

The evidence for cognitive aids in anaesthesia has been recently presented in a paper by Marshall et al (Marshall S D, 2013) who conducted a systematic review of the literature on cognitive aids used in the context of time critical anaesthesia emergencies to identify evidence for improved performance and whether recommendations could be made in respect to design, testing and implementation.

This paper identified validation studies of 22 cognitive aids used in anaesthesia-related emergencies. The majority of these studies evaluated cognitive aids based on decision-support flow-chart formats under simulated conditions, although the studies were heterogeneous in respect to primary outcome measures for example deviation from the cognitive aid, time to treat and errors. This review concluded cognitive aids improve technical performance based on improvements demonstrated in four studies. In two studies (Combes et al., 2004; Heidegger, Gerig, Ulrich, and Kreienbuehl, 2001) a defined algorithm was introduced along with education on its use, which resulted in a decrease in the airway failure rates.

This review concluded that cognitive aids have a less clearly defined role in improving non-technical skills and team behaviours in anaesthetic emergencies (Marshall, 2013). With specific reference to CICO, team behaviours (NTS) have been shown to improve when a cognitive aid is provided (Marshall and Mehra, 2014). This is most likely due to an offloading of the required memory by the cognitive aid leading to more cognitive resources being available for management of the team. In other anaesthetic emergencies such as malignant hyperthermia and anaphylaxis, cognitive aids have been shown to improve co-ordination, communication and leadership (Manser, Harrison, Gaba, and Howard, 2009; Marshall, Sanderson, McIntosh, and Kolawole, 2014).

The evidence for use of cognitive aids used more broadly in healthcare is also inconsistent, particularly as cognitive aids have been evaluated against a range of outcome measures, including adoption, compliance, change in physician practice and health outcomes. The heterogeneity of cognitive aids in respect to design features and purpose is also likely to influence measurements of effectiveness. The relative contribution of the cognitive aid in isolation is difficult to evaluate and the literature suggests their effectiveness is hard to measure and is sensitive to contextual factors such as institutional norms and culture, teamwork and training.

However, expert opinion tends to be overall in favour of the use of cognitive aids. This is summarised in a previous review of airway algorithms (Heidegger T Gerig HJ Keller C, 2003), which compares the advantages and disadvantages of the use of guidelines in general terms and applied to the difficult airway. These authors conclude: "although there is no strong evidence of benefit for any specific strategy or algorithm for management of the difficult airway, there is strong agreement that a pre-planned strategy may lead to improved outcome".

GENERAL DESIGN FEATURES

In an ideal world, the design of a cognitive aid would achieve several specifications. Firstly it would be suited to its primary clinical goal; for instance a cognitive aid designed for decision support would have different properties to one designed to prompt steps in a procedure. Secondly, it would suit the context in which it is intended to be used; contextual factors including the time frame (for example, time critical versus not time critical) and how the cognitive aid is intended to be used (for example, a dedicated reader uses the cognitive aid to direct the task versus the cognitive aid is referred to on demand by team members). The design would also be influenced by the performance elements that it is designed to improve, examples including decision-support at key points and role allocation among team members. Alternatively it would address the errors it is designed to avert examples including omission, sequence and sidedness errors, time delays and loss of team situation awareness.

Cognitive aids can be designed with a range of conceptual models including goal-based treatment; conditional if-then prompts; reminders of frequently omitted steps or navigation of sequential steps. In addition they vary in respect to their graphical format including checklists of key practice points; sequential and/or branching flowcharts; symbols and graphic metaphors; or hazard alerts. While it is recognised that the improper design of cognitive aids can lead to detrimental effects on performance there is no evidence favouring one conceptual model or format over another; these should be chosen to match the goal and context

DESIGN FEATURES IN SPECIFIC CONTEXTS

Checklists suited to preparatory checklists and team briefings

A number of factors relating to readability can affect the effectiveness of a cognitive aid including layout, volume of content, font and colour. Design principles have been published for pre-procedure checklists used in the aviation industry. These recommend design features such as prioritising critical steps, matching order of steps to real world order of practice, clumping long lists into thematic categories and including sign-off at the completion of the list (Degani A).

Memory aids

James Reason's work on omission errors recommends that complex procedures be broken in discrete tasks and analysed to identify the steps at highest risk of omissions or where omissions have high safety impact (Reason J, 2002). Memory aids should be created for these steps. Memory aids to reduce omission errors have the following five features:

1. Able to catch the user's attention at the critical time (Conspicuous).
2. Positioned as close as possible in time and space to the location of the necessary action (Contiguous).
3. Provide information about the "when" and "where" of the item to be remembered (Context).
4. Provide sufficient information regarding what has to be done (Content).
5. Allow the user to count off the number of discrete actions/tasks that need to be done (Count).

SUITABILITY FOR EMERGENCY SITUATIONS

Complex algorithms are not suitable to be used during time critical emergencies. Marshall proposes that in an airway emergency the ideal cognitive aid would not require paper or computer-based support but would be remembered, much like the DRSABC algorithm is remembered in Advanced Life Support (ALS) and Emergency Management of Sugical Trauma (EMST) training. The need for simplicity is recognised by other authors suggesting items need to be structured in a logical manner and support the work of the team (Degani and Wiener, 1993). Having a common framework aids teamwork by the sharing of "common ground" to refer back to (Klein, Feltovich, Bradshaw, and Woods, 2005). Where a complex algorithm must be used, the team must adapt to the algorithm, such as with the use of a "reader" of the cognitive aid (Burden, Carr, Staman, Littman, and Torjman, 2012).

Marshall postulates that clinicians' cognitive resources are reduced in time-pressured emergencies introducing risks of omission or sequencing errors as they carry out interventions. He proposes the main achievements of a cognitive aid should be to efficiently guide clinicians through the appropriate sequence of steps without errors or delays. In this context he proposes cognitive aids need to display four ideal attributes

1. It must be derived from "best practice" guidelines or protocols.
2. Its design should be appropriate for use in the context of the emergency situation.
3. It should be familiar, in a format that has been used in practice and training.
4. It should also assist other team members to perform their tasks in a co-ordinated manner.

CLINICAL CONTENT (TO BE ADDRESSED IN A CICO COGNITIVE AID)

It goes without saying that a cognitive aid should be relevant to its clinical application. Heidegger et al who authored the DAS algorithms compared all difficult airway cognitive aids published by 2005 and found reasonable agreement in respect to the clinical scenarios and the key interventions that warranted inclusion (Heidegger T Gerig HJ Keller C, 2003). The clinical scenarios of most concern are:

1. Anticipated difficult airway.
2. Unanticipated difficult intubation where face-mask ventilation is possible.
3. Difficult face-mask ventilation.
4. A can't intubate cant oxygenate (CICO) situation.

In respect to key practice points they concluded that all guidelines should strongly recommend:

1. An early call for help if any problem arises.
2. Maintenance of oxygenation throughout the whole procedure.
3. The option of awakening the patient at different steps.
4. The LMA and cannula or surgical cricothyroidotomy are essential techniques for management of the CICO scenario.

These scenarios and practice points are largely well represented in the difficult airway cognitive aids cited in Heidegger's paper however these recommendations may neglect other important content, in particular transitions between scenarios. Part 1 presents evidence that a small number of anaesthetists are not adequately assessing risks for anticipated airway and avoiding general anaesthesia. Similarly there is some evidence that the transitions between difficult intubation, difficult face-mask ventilation and CICO are not well managed. The above-mentioned cognitive aids present these as somewhat discrete sequenced steps with face-mask, LMA and infraglottic rescue being presented as conditional interventions after failed intubation. However as described in part 2 there is a growing tendency to distil and highlight LMA, face mask and intubation as three elements of supraglottic rescue that have a non-linear relationship (Chrimes N, 2013; Heard, 2013).

Part 2 presented the difficulties associated with defining the appropriate conditions to commence infraglottic rescue however reasonable agreement exists in respect to number of intubation attempts and the need to reasonably attempt supraglottic devices and face-mask ventilation. In respect to infraglottic rescue, a number of techniques are described including cannula and scalpel techniques, with Andrew Heard's algorithm gaining increased visibility and support in recent years (Heard, 2013).

PERFORMANCE RISKS IN CICO (TO BE ADDRESSED IN A CICO COGNITIVE AID)

Part 1 presents a range of factors attributed with sub-optimal performance in CICO events. The underlying causes for these errors are likely to be multifactorial and interdependent, however human error plays a substantial role. Human errors resulting from clinicians' stress and overloaded cognitive resources appear to fall into three categories:

1. Faulty judgment of risk leading to inappropriate choice of technique.
2. Omissions and poor recall of practice guidelines, in particular during supraglottic rescue.
3. Task fixations and errors in assessment of clinical signs and or adequacy of response to interventions regarding the value of persisting with supraglottic rescue.

Clinicians may also feel ill-prepared to undertake infraglottic rescue due to lack of training, rehearsal or familiarity with equipment. Detrimental team culture may impair assertiveness.

As per part 1, the most concerning errors and performance failures are considered to be:

1. Failure to appreciate the risk of CICO and the link between anticipated difficult airway and the sequelae of CICO. This could be made more prominent by including CICO in routine everyday decision-support aids.
2. Poor judgment and decision-making during risk assessment leading to neglect of options for awake techniques which may otherwise avert a CICO event or preparation of back-up plans in case CICO evolves after general anaesthesia is induced. This could be addressed by challenges or prompts before embarking on general anaesthesia.

3. Omission of supraglottic rescue interventions in one or more categories (intubation, face-mask ventilation and supraglottic device [LMA]), which may otherwise avert a CICO event. These could be addressed by features of memory aids that reduce omissions such as those described by Reason or graphical symbols such as the Vortex™ model.

4. Factors that lead to omission or delay in performing infraglottic rescue when a definitive CICO exists. These factors include floundering as a result of ambiguity; task fixation or other forms of cognitive error; and possibly team conflict. These could be addressed by specific criteria, observable by all team members that highlight deviation from desired practice. Language that includes team members and encourages assertion may encourage them to speak up.

5. Ineffective team communication in respect to making team members aware of the situation and reduced assertiveness amongst team members to seek clarification or prompt/challenge a clinician if treatment appears unsatisfactory. These may be addressed by: including references to "team" in the cognitive aid; including measurable criteria matched with recommended actions; include key questions to promote assertiveness for example "Is this a CICO?".

6. Delay in preparing for or commencing infraglottic rescue when CICO is imminent or established. This may be addressed by reducing tasks into discrete steps and using graphical symbols to demonstrate flow through transitions.

7. Inability to use equipment or technical failure in performing infraglottic rescue. This is better addressed in training. Supportive teams may assist.

CONTEXT

A CICO cognitive aid is unlikely to be meaningful if used of the following contexts:

1. **The individual clinician** who has trained against the cognitive aid and supporting resources and who is mentally prepared to activate the algorithm and physically prepared to perform the procedures: The clinicians intending to use the cognitive aid should be familiar with it well ahead of the event including complimentary resources, location and use of equipment and execution of procedures. Training should include these contextual details.

2. **Team context:** A CICO cognitive aid should be considered an aid to the team whose members are familiar with the cognitive aid, have access to it, understand its content and have an agreed plan on how to use it in an emergency.

3. **Systems context:** A CICO cognitive aid should be considered but one component of an institution's pre-planned strategy for management of the difficult airway; that strategy incorporating processes for early identification of at-risk airways, notification of personnel, activation of resources, equipment, training in technical procedures, human factors, teamwork and organisational culture and quality assurance reporting. These initiatives should be aimed at minimising CICO events and optimal management of those that occur.

4. **Complementary resources:** Given the importance of simplified content relevant supporting information should be available as separate supporting resources to key staff, who should be should be knowledgeable of these and appropriately trained in the practical implementation of supraglottic and infraglottic rescue.

5. **Overreliance on cognitive aids.** It is unlikely that a CICO cognitive aid could satisfy all of the ideal features presents above. This highlights the importance of effective individual and team training and a local organisational strategy. This will offload the cognitive aid, enabling it to be used to reduce human error.

ACHIEVEMENT OF EXISTING DECISION AIDS

Flowchart cognitive aids

In general the previously published flowchart cognitive aids are relatively high in textual content suggesting they aim to help prepare clinicians for difficult airway events and mainly achieve this via prompting recall of best-practice guidelines. They may promote team situation awareness if key members of the team were familiar with these algorithms. Some aspects of these are not well suited for use in emergencies. The high textual content may be difficult to follow. Branch points are designed to support decision-making between transitions however lack explicit guidance. Variation across different decision-aids for example in respect to recommended number of laryngoscopic attempts may exacerbate ambiguity that can be expected to be present in these events. We could also argue that the above-mentioned key clinical practice points in these decision-aids are not expressed strongly enough.

Dr Heard's algorithm for infraglottic rescue addresses the details of percutaneous transtracheal oxygenation as a discrete intervention assuming CICO has been declared. In this respect it is not directly relevant to discussions of transition. However several aspects are worth noting. The algorithm breaks the task into smaller discrete tasks such as distinguishing between cannula access versus oxygenation. This feature is recommended by James Reason as a strategy to reduce omission errors. In the context of CICO it may assist transition by enabling teams to prepare and even execute the step of cannula access in the lead up to declaring CICO. Secondly, by presenting a primary task and two back-up tasks it assists teams to forward plan their response. This may reduce delays.

Cognitive aids with symbols and graphical metaphors

The more recently published algorithms use graphical symbolism in favour of textual content. The Vortex™ model's abstract symbol of a funnel is used to depict transition toward a CICO situation in the form of diminishing options available to the user as supraglottic strategies are tried and fail. The end of the funnel is a point of depletion of options prompting the user to commit to CICO and infraglottic rescue. Reluctance to attempt infraglottic rescue has been identified in a number of coronial inquests as well as the NAP4 report. In this sense, the design of this cognitive aid directly targets human factors as causes of performance lapses, in particular task fixation. By providing three supraglottic rescue pathways (LMA, intubation and face mask) this cognitive aid protects against omission errors. By avoiding the flowchart format, the Vortex™ also enables supraglottic rescue strategies to be depicted in an integrated manner that reflects real-world practice somewhat more realistically than a sequential flowchart does. However to achieve these design features, the Vortex™ cognitive aid is low in content. It assumes users are familiar with the practical implementation of the three supraglottic pathways. A complimentary cognitive aid for these is presented separately in associated resources. There is also growing support for a recommendation to mobilise resources for infraglottic rescue when two of the three supraglottic airway rescue pathways have been exhausted (Chrimes N, 2013; Watterson, 2012). (Heard AM, 2013).

ANZCA COGNITIVE AID FOR TRANSITION TO CICO

Drawing on the principles outlined in this section, an example of cognitive aid that has been developed by the AMWG and might be used in practice is represented in Appendix I, which should be interpreted with its accompanying User Guide.

Figure 1: American Society of Anesthesiologists (ASA) Difficult Airway Algorithm

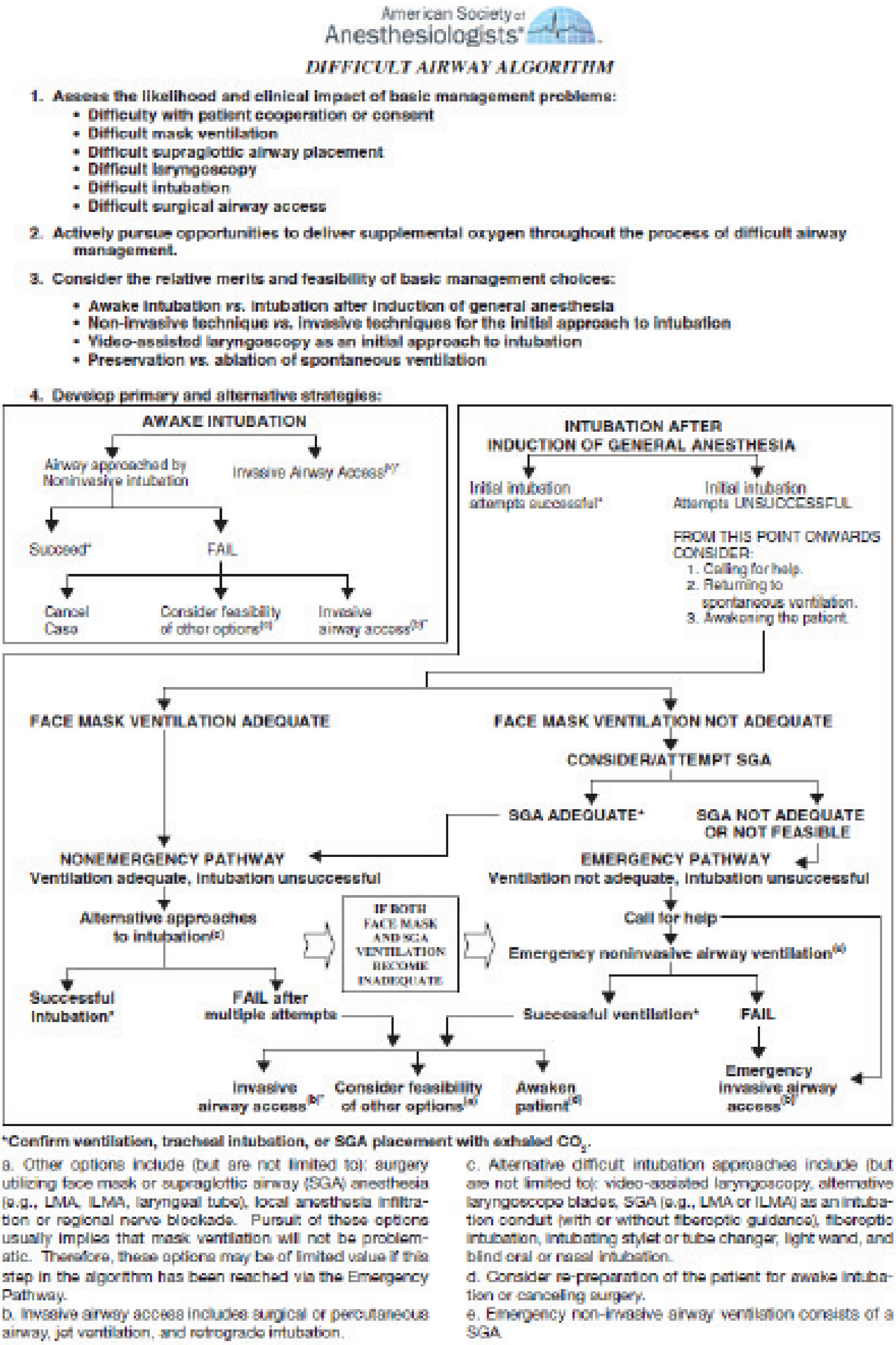


Figure 2: Difficult Airway Society (DAS) – Overview

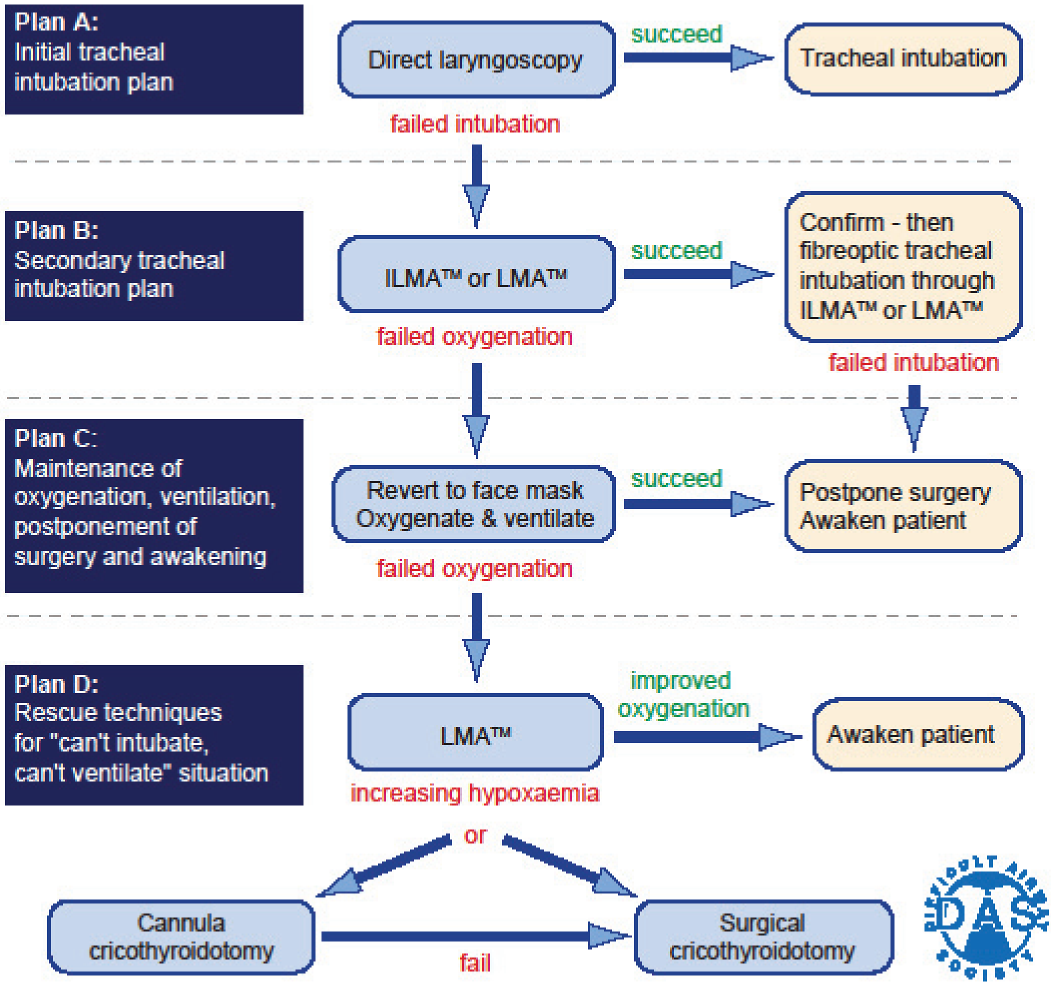


Figure 3: Canadian Airway Group Difficult Airway Algorithm

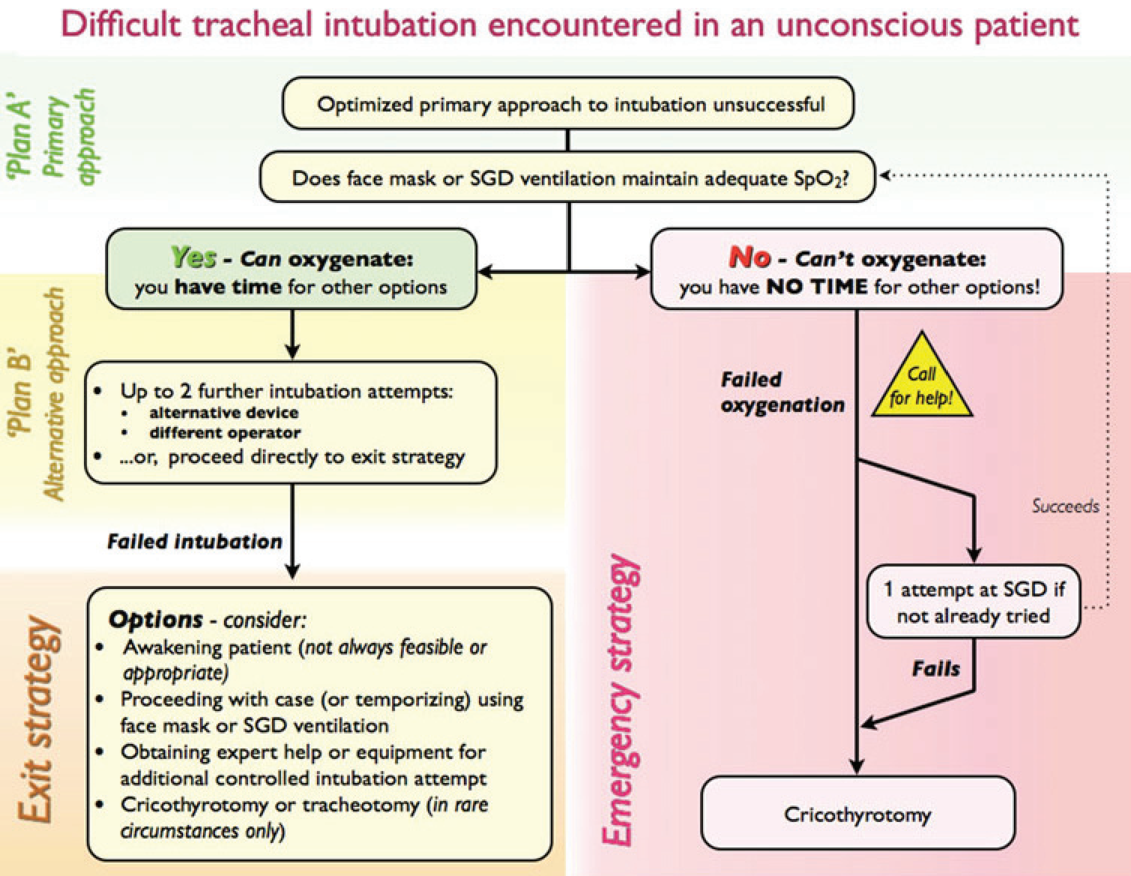


Figure 4: Dr Andrew Heard's algorithm for percutaneous emergency oxygenation

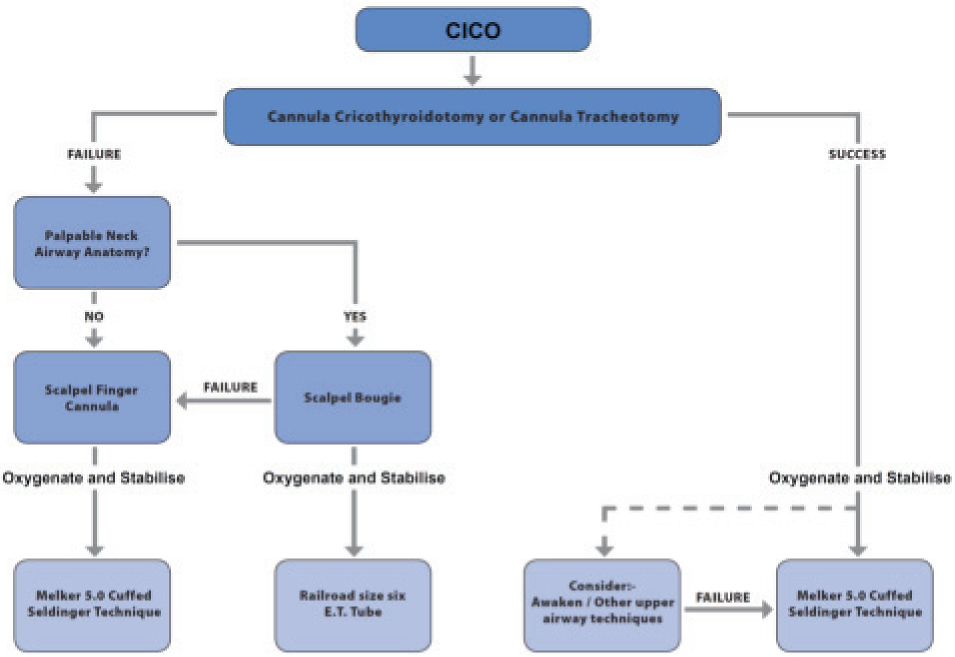


Figure 5: Vortex™ Model

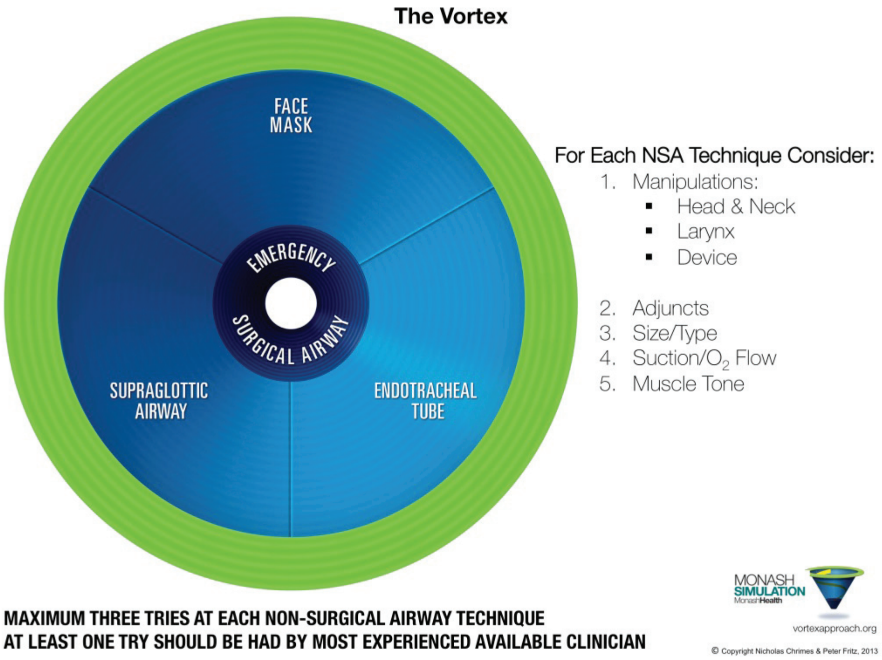


Figure 6: CriCon2

CricCon2

Simplified Cricothyrotomy Alert Posture

All	**Discuss/Feel/See Kit**
Risky	**Mark/Kit Bedside**
Crashing	**Inject/Prep/Open & Set Kit/ Scalpel in Hand**

Figure 7: Rural Health Continuing Education Critically Obstructed Airway Course Working Group

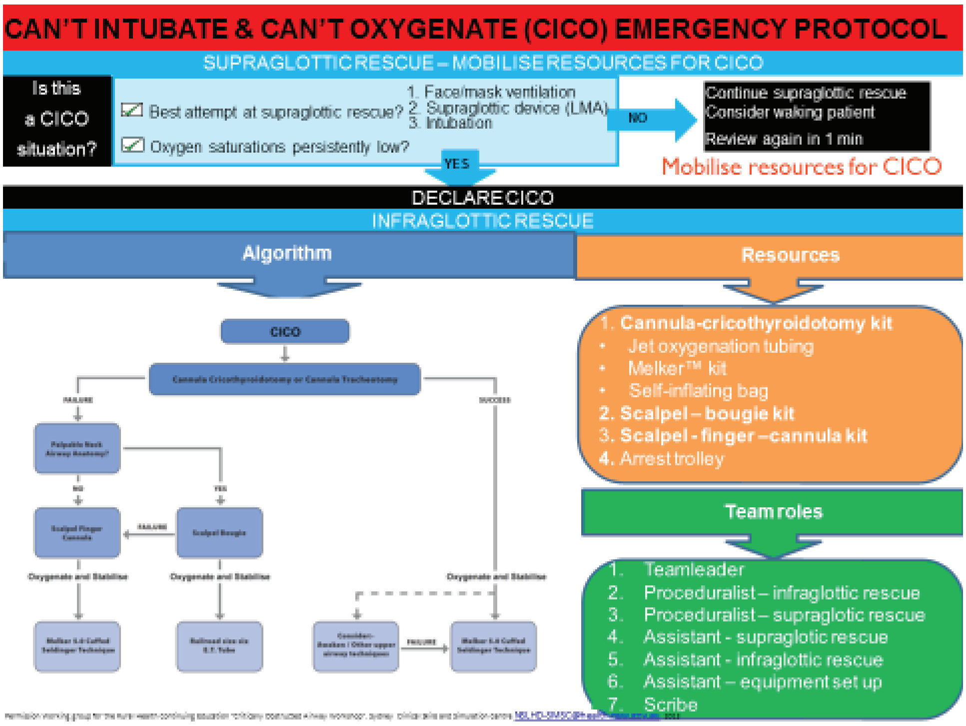
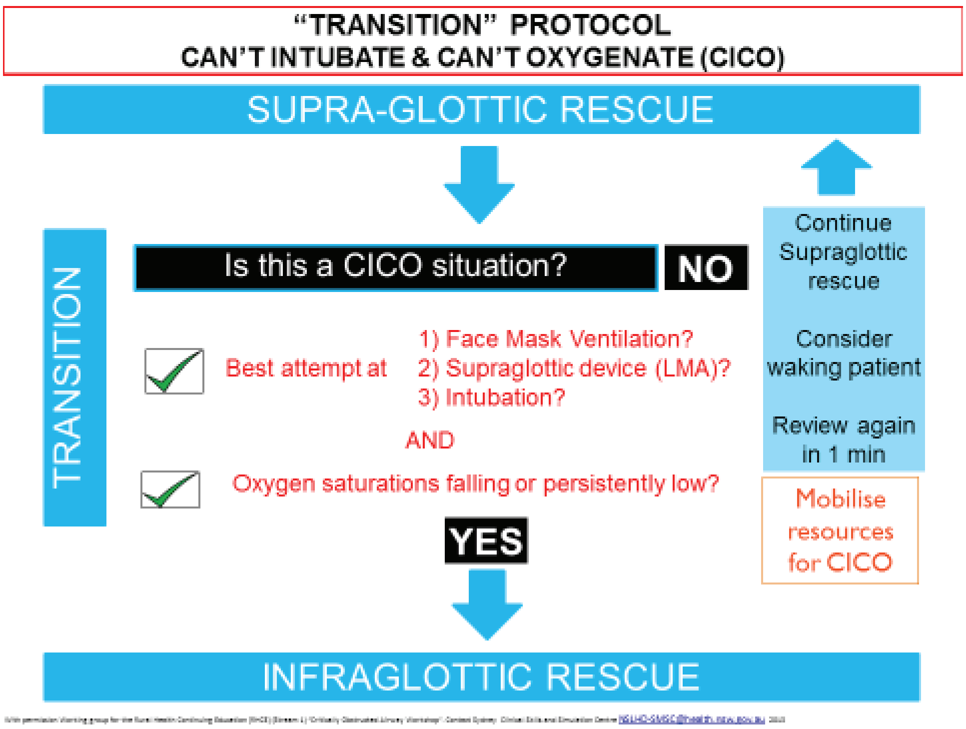


Figure 8: Rural Health Continuing Education Critically Obstructed Airway Course Working Group



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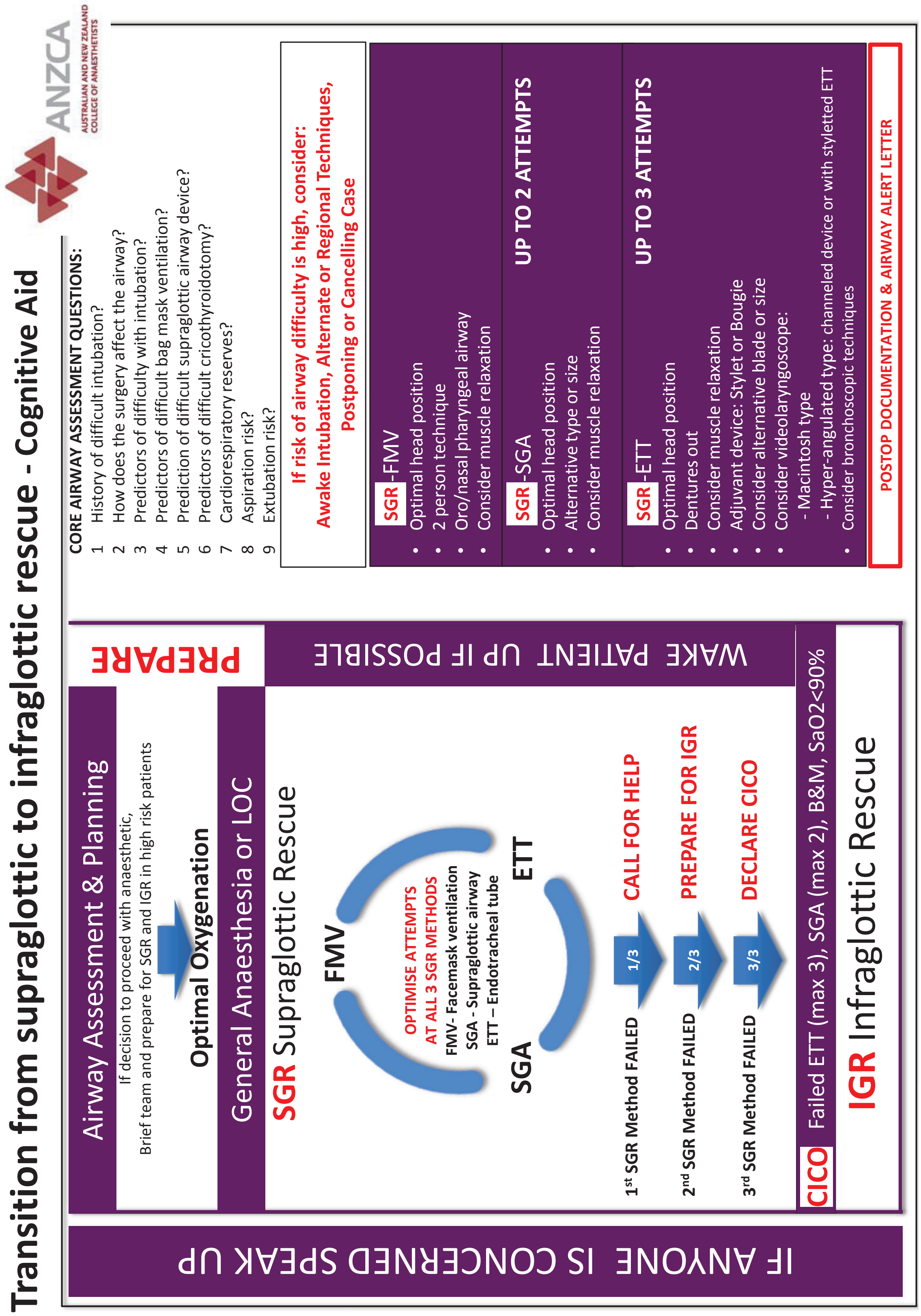
Appendix I: ANZCA Cognitive Aid and User Guide for Transition to CICO



Transition from Supraglottic to Infraglottic Rescue: User Guide

This cognitive aid's objective is to guide management of airway obstruction evolving to a 'Can't Intubate, Can't Oxygenate (CICO)' situation with strategies to prevent and identify the event and then manage the decision to transition to proceed to infraglottic rescue.

The guide summarizes recommendations in ANZCA PS61 and related publications developed in conjunction with the ANZCA Airway Management Working Group (AMWG). [1] Users should be familiar with these publications.

Overview

The **left side** of the aid presents a flowchart prompting airway management in different phases of evolving airway obstruction from pre-induction to declaration of CICO. Vertical side bars prompt users to communicate assertively (L) and or consider awakening the patient (R) at any time during the event. The **right side** (top) prompts users to assess risks for CICO that inform a clear plan to either induce anaesthesia or secure the airway with an awake method for endotracheal intubation or percutaneous trans tracheal access, or to opt for regional anaesthesia. The team is reminded to be prepared for supraglottic rescue (SGR) and infraglottic rescue (IGR). The **right side** (bottom) lists strategies for supraglottic rescue and prompts users to complete post event follow-up.

IDENTIFICATION OF RISKS AND AIRWAY PLANNING

Core Airway Assessment Questions

CORE AIRWAY ASSESSMENT QUESTIONS:

1 History of difficult intubation?
2 How does the surgery affect the airway?
3 Predictors of difficulty with intubation?
4 Predictors of difficult bag mask ventilation?
5 Prediction of difficult supraglottic airway device?
6 Predictors of difficult cricothyroidotomy?
7 Cardiorespiratory reserves?
8 Aspiration risk?
9 Extubation risk?

This section prompts users to assess the patient carefully and to make well informed primary and back-up plans that minimise risk of airway obstruction. Please refer to the separate Airway Assessment document (due online September 2015).

Key sources of information include:

1. Medical records and medical alerts detailing previous difficulties.

2. Knowledge of the surgery and input from the surgical team to determine how the surgery may affect the airway.
3. Assessment of predictors of risk in conjunction with different airway interventions will require physical examination, history taking and review of investigations. .
4. Assessment of risk also extends to:
5. Cardiorespiratory history and examination.
6. Assessment of aspiration risk.
7. Assessment of extubation risk.

This will tell you:

- If you have a difficult airway.
- If you predict your primary airway plan will be difficult.
- If you predict your rescue airway plans will be difficult.
- How much time you have available to achieve your airway management aim.
- Information to help plan emergence.

AIRWAY PLAN

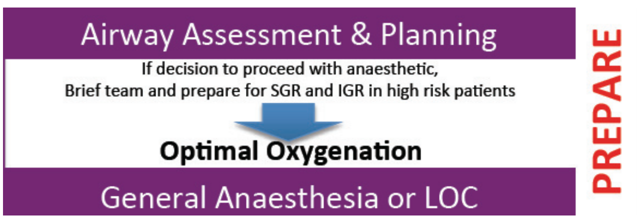
**If risk of airway difficulty is high, consider:
Awake Intubation, Alternate or Regional Techniques,
Postponing or Cancelling Case**

Ultimately these factors will determine:

- if you are going to proceed, defer or cancel the case.
- what your airway plan will be.

FLOWCHART

Airway Assessment and Planning



The red prompt PREPARE signals the proceduralist and team to be prepared, before inducing sedation or anaesthesia, to intervene with SGR, if airway obstruction or low oxygenation occurs.

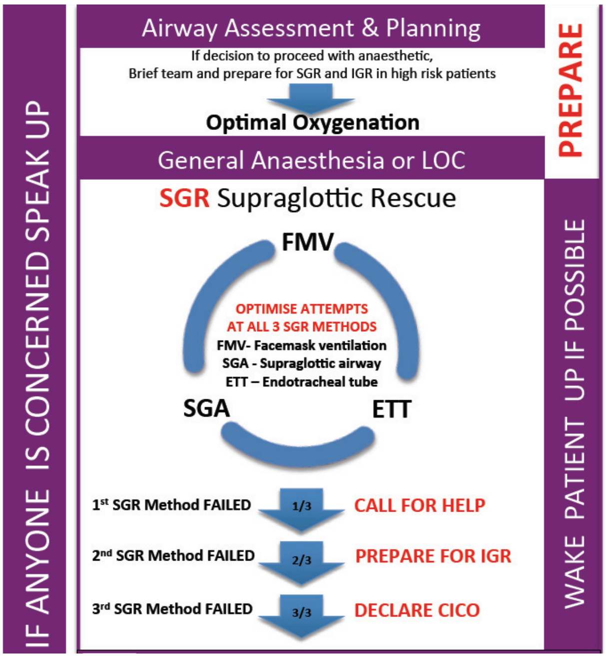
Specifically, for the proceduralist, it will involve optimizing your work area, communicating your plan to your team and ensuring the appropriate equipment is available.

Optimal oxygenation is the delivery of oxygen (preoxygenation, CPAP, apneic oxygenation) including patient positioning to ensure the best possible oxygenation of the patient.

Diminished consciousness is the end point at which time the initial airway management plan will be successful or not.

If it is unsuccessful, initiate SGR.

Supraglottic rescue (SGR)



SGR is conceptually organized into three categories: endotracheal intubation, face mask ventilation (FMV) and ventilation via supraglottic devices (e.g. LMA). Multiple manoeuvres aimed at optimizing airway management exist within each category. The model recommends optimal attempts at these without assuming strictly sequential progression through them. Several detailed guides are available. [2]

Method 1: When one pathway has been substantially attempted without success, then additional personnel and resources should be called for.

Method 2: When a second SGR pathway substantially fails, the IGR equipment should be prepared and the team should be made aware this will proceed if SGR is not imminently successful.

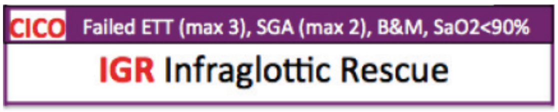
Method 3: When the third SGR pathway is unsuccessful and there is no imminent possibility of waking the patient up (see next point), then declare *"This is a CICO situation"*. The AMWG recommends the following definition: *"A CICO event is declared in conjunction with all of the following: failed endotracheal intubation, failed face mask ventilation and failed oxygenation via supraglottic devices such as the LMA in the context of falling or persistently low oxygenation."* (2). The AMWG

3

recommends SaO2 <90% as evidence for low oxygenation *in conjunction with* the abovementioned criteria.
Wake patient up if possible. Continuously review the opportunities, risks and benefits of waking the patient.

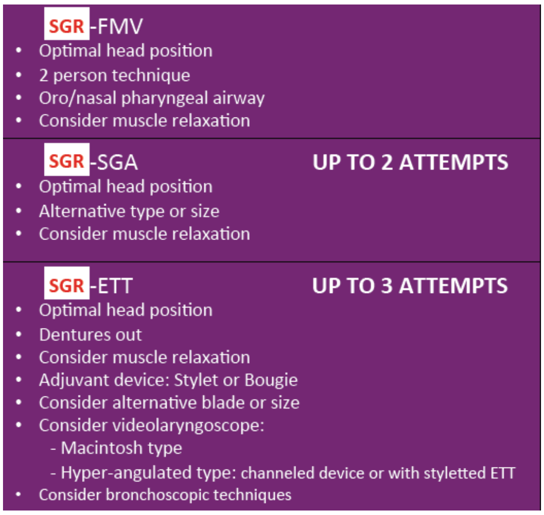
- ***If anyone is concerned "speak up"***. This is a very important component of the CA. It appears as a vertical bar to prompt anyone present to be assertive and raise a concern or ask for clarification at any time. It prompts the airway proceduralist to encourage people to speak up and to be open to suggestions

Infraglottic rescue (IGR)



Several procedures are described elsewhere for emergency percutaneous oxygenation of the trachea.

Supraglottic rescue (SGR) manoeuvres



A number of manoeuvres can improve effectiveness of SGR. Limited evidence is available guiding number and choice of manoeuvres however evidence does not support persistent attempts at SGR. [3] The AMWG recommends the following:

ETT (3 Maximum Attempts)

1. Primary operator first attempt
2. Primary operator Re-optimized attempt (different blade, position etc)
3. Responder's Best attempt

SGA (2 Maximum Attempts)

4

1. SGA attempt
2. Alternate SGA Attempt

Consider using up to two different supraglottic devices (e.g. Supreme LMA™/Classic LMA™/i-gel™) or other variations.

Documentation

POSTOP DOCUMENTATION & AIRWAY ALERT LETTER

Document the event and arrange appropriate follow-up including if relevant providing the patient with a written alert for the attention of clinicians providing future procedures.

References

1. *Guidelines for the Management of Evolving Airway Obstruction: Transition to the Can't Intubate Can't Oxygenate Airway Emergency*
   - ANZCA PS61: Professional Document http://www.anzca.edu.au/resources/professional-documents
   - ANZCA PS61 BP: Background paper http://www.anzca.edu.au/resources/professional-documents
   - Report from the ANZCA Airway Management Working Group, November 2014 http://www.anzca.edu.au/resources/college-publications
   - Airway Assessment Document (due late 2015)
2. 'Part 2: Clinical criteria for infraglottic rescue' in Report from the ANZCA Airway Management Working Group, November 2014
3. 'Part 1: Mortality and evidence of suboptimal care in CICO events' in Report from the ANZCA Airway Management Working Group, November 2014

Appendix II: Key points from individual papers

PART 1: MORTALITY AND EVIDENCE OF SUB-OPTIMAL CARE IN CICO EVENTS

1.1 There is limited evidence on the incidence of CICO. This is derived from a few cohort studies and the NAP4 audit of serious airway emergencies. This predicts CICO is a rare event occurring in approximately 1:10,000 to 1:50,000 of routine general anaesthetics although some evidence suggests it may be up to 10 times more frequent in settings outside of the operating theatre such as intensive care and the emergency department.

1.2 Evidence for outcomes of CICO is derived from cohort studies, adverse event reporting activities such as audit, coronial inquiries and reports from closed claims insurance registries and research; the latter including survey and experimental studies under simulated conditions. The outcomes of CICO events are relatively poor, accounting for up to 25 per cent of anaesthesia-related deaths with less information available to predict outcomes in other settings.

1.3 Several risk factors for CICO can be gleaned from the literature. CICO events appear to be more likely in patients with airway infections, malignancy, trauma or congenital deformations as well as surgery on the neck. However, several deaths from CICO have occurred in the context of elective anaesthesia in patients of all ages without these conditions. In this context, risk factors for CICO are also risk factors for difficult intubation and difficult ventilation. If present, these are identifiable on clinical examination during routine pre-operative assessment.

1.4 Overall, the incidence of CICO is very low compared with the incidence of difficult intubation and the prevalence of people in the community with the above-mentioned risk factors. This implies that anaesthetists and other clinicians effectively manage risks and successfully intervene in airway obstruction the vast majority of the time. However, the community has very low, if not zero tolerance for preventable death from CICO and the small number of preventable deaths identified in the literature has led opinion leaders to conclude that both risks and evolving events are not managed to an acceptable standard. Evidence from experimental studies suggests clinicians are not prepared for the event and underestimate risks. Evidence provided in part 3 addressing “organisational safety” and “human factors” suggests that lack of preparedness at an organisational level is widespread.

1.5 Evidence for sub-optimal care highlighted the following aspects of clinical performance:

1.5.1 **Clinical judgment:** Inadequate risk assessment and judgment regarding the decision to secure the airway by attempting intubation via laryngoscopy after induction of anaesthesia or sedation as opposed to using awake techniques, such as awake tracheostomy and awake fibreoptic intubation. Sub-optimal assessment of risks and poor judgment in airway planning are recurrent themes in the literature. CICO can also occur as a result of post-surgical haematoma or swelling or delayed inflammation after endotracheal extubation and the benefit of hindsight has been used to suggest that assessment of risk has been inadequate in these circumstances.

1.5.2 **Practice variation:** Existing guidelines vary in respect to indicators/criteria for declaring CICO. There are also several different recommended procedural approaches to infraglottic rescue.

1.5.3 **Time delays:** Failure to attempt emergency percutaneous oxygenation via the trachea or surgical airway, or a delayed decision to do so, often occurring in the context of repeated attempts at unsuccessful strategies such as laryngoscopy by anaesthetists.

1.5.4 **Incomplete supraglottic rescue.** Neglect of techniques related to face-mask ventilation; intubation or, in particular, insertion of supraglottic devices (for example, LMA) occurred in all settings, and in particular in non-anaesthesia settings. Abstaining from the use of muscle relaxants in a CICO event is considered as sub-optimal care by the Difficult Airway Society (DAS) group.

1.5.5 **Technical knowledge and skills:** Evidence from a small number of research studies and surveys suggests that clinicians lack a deployable plan for the management of a CICO event and are inadequately trained in a technical sense; lacking knowledge of equipment, omitting steps in algorithms and performing surgical airway slower than arbitrary benchmarks. Evidence from audit supports this, demonstrating a relatively high incidence of failure on first attempt at emergency surgical airway, especially using cannula-based techniques.

1.5.6 **Cognitive and behavioural (human) factors:** While few audits or mortality inquiries specifically set out to investigate the roles of cognitive and behavioural (human) factors, some authors concluded that these appeared to play a large role in the sub-optimal management of CICO events. For example: cognitive errors associated with task fixation and poor co-ordination and decision-making among teams of clinicians were implicated in promoting persistent futile attempts at intubation, neglect of other forms of supraglottic rescue and avoidance of infraglottic rescue. Inadequate assertiveness among nursing staff was felt to compound this.

1.5.7 **Organisational safety.** Evidence provided in part 3 addressing organisational safety and human factors suggests that lack of preparedness at an organisational level is widespread.

PART 2: CLINICAL CRITERIA FOR INFRAGLOTTIC RESCUE

2.1 CICO should be prevented, where possible, by thorough pre-anaesthesia assessment, which informs the development of a series of airway plans. In any one scenario of identification of difficult airway risk, the primary plan should include the consideration of the option for an awake technique such as awake fibreoptic bronchoscopy or awake tracheostomy; the back-up plan features one or more of a range of supraglottic rescue techniques and the emergency plan involves a pre-rehearsed procedure(s) for infraglottic rescue.

2.2 A CICO event is declared in conjunction with all of the following: failed endotracheal intubation, failed face-mask ventilation and failed oxygenation via supraglottic devices such as the LMA in the context of imminently falling or persistently low oxygenation.

2.3 Face-mask oxygenation should be declared unsuccessful after several airway manoeuvres have been attempted including optimal positioning of the head, two-handed, two-operator technique, insertion of oro and or naso-pharyngeal airways and inspection of the oropharynx to remove foreign bodies.

2.4 Endotracheal intubation should be declared unsuccessful when three optimised intubation attempts are unsuccessful, including both indirect and direct (video for fibre optic assisted) laryngoscopy and optimisation of muscle relaxants. Intubation may be declared failed with fewer than three attempts under certain circumstances if reasonable evidence suggests further attempts will be counterproductive to supraglottic rescue by wither FMV or SGD.

2.5 Oxygenation via supraglottic devices should be declared unsuccessful when two attempts have been made with different sizes or types of devices.

2.6 In practice, clinicians may move through these pathways in a non-sequential manner and at any point may have partially attempted one or more pathways.

2.7 If not already evident, a fall in oxygenation is imminent when criteria for failed supraglottic rescue in the three pathways are met. Thus irrespective of oxygen saturation, clinicians should strongly consider calling for help after one pathway has been attempted unsuccessfully and should declare intent and mobilise resources for infraglottic rescue when two pathways are substantially unsuccessful. Concern should be upgraded if at any point oxygen saturation falls below 90 per cent.

PART 3: THE ROLE OF HUMAN FACTORS

Human factors

3.1 The evolution and management of CICO events is explained by human factors and organisational safety concepts such as latent (system) and active (human) errors along with models that forecast their interdependencies in catastrophic accidents.

Organisational (systems) factors

3.2 Organisational science provides strong evidence for the role of multifaceted programs in reducing latent organisational errors. Components of these programs include: adherence to best practice guidelines, standardised practices and equipment, use of checklists, routine training aligned with decision-support tools, cultivation of teamwork, quality assurance and reporting of adverse events.

3.3 These are enshrined within the principles of “the high reliability organisation”, whose key elements are aimed at preventing risks, building resilience to unresolved risks and cultivating a culture of safety. The latter is a holistic value, held by staff at all levels of the organisation, and expressed as practice aimed to prevent, detect, report and resolve risks. It emphasises the importance of open assertive communication among staff, particularly when power gradients exist. A key example relevant to CICO is active listening to and encouragement of assertiveness by colleagues, particularly junior doctors and nurses.

Human (cognitive) error

3.4 Meanwhile, cognitive science provides substantial evidence that no amount of systems preparation will eliminate human (cognitive) errors. While acknowledging the evidence supporting guidelines and standardisation, scientists within the cognitive science domain caution that exclusive adherence to prescriptive practices neglects particular human thought processes and behaviours that are expressed in novel, dynamic, time critical, stressful circumstances. In these circumstances, two subconscious cognitive processes are highly evident: (1) decision-making by experts deviates from prescriptive (normative) practice into contextually dependent (naturalistic) patterns that are less well supported by checklists and other procedural rules and (2) cognitive errors increase, largely as a result of task loading and sensory overload. The design of safety programs should anticipate and manage these processes. While organisational safety interventions are partially effective in mitigating their risks, a number of strategies delivered at the point of care are likely to be effective.

3.5 Use of cognitive (memory) aids that use simplified content and symbols to remind people of the more detailed decision aids they have used in training activities. These should prompt users to follow best practice at high-risk points. They should support the whole team.

3.6 Activation of pre-rehearsed practices aimed at identifying evolving problems and methodically working through them.

3.7 Self-awareness by clinicians of their vulnerability to errors and self-monitoring to detect and rectify errors, or unproductive cognitive processes or factors such as stress fatigue and high task workload that reduce cognitive resources and lead to errors.

3.8 Encouragement of other team members to provide input and raise concerns.

3.9 Optimisation of the physical environment to promote situation awareness.

Team behaviours

3.10 Team behaviours influence clinical performance measured in terms of situation awareness, decision latency, task management and task completion time. Poor situation awareness is a form of cognitive error associated with other cognitive errors. Key team attributes and behaviours include: shared mental models, role clarity, co-ordination, communication, leadership, decision-making and monitoring.

PART 4: MANAGEMENT OF TRANSITION

Several key aspects of performance observed in CICO events are influenced by individual, team and organisational factors operating interdependently and the contextual features of a CICO emergency. These should be optimised. Performance elements and strategies to optimise them are listed below as direct statements:

4.1 Be prepared to respond

- Institute locally relevant, multifaceted safety programs, which include registries of at-risk patients, best practice guidelines (for training) and decision aids (to support real-time practice), standardised equipment that matches the guidelines and cognitive aids, rosters and communication processes that mobilise specialist care quickly, incident reporting and quality audits.
- Ensure clinicians undergo routine training that is contextualised relevant to setting and which includes: emergency planning, application of practice guidelines and cognitive aids including transition from plan A to B etc, airway "time-outs", team roles, procedural skills and use of equipment.

The remaining points relate to strategies that are employed during and evolving airway emergency.

4.2 Manage ambiguity

- Use a cognitive aid that reminds people of the more detailed decision aids they have used in training activities, prompts users to follow best practice at high-risk points and prevents key performance errors.
- Be guided by specific clinical criteria when defining CICO.
- Seek input from colleagues in decision-making.

4.3 Prevent and detect cognitive failure

- Use cognitive aids (memory) (see above) which are available to all members of the team.
- Activate methodical pre-rehearsed emergency responses and problem-solving practices.
- Be self-aware of vulnerability to errors and self-monitor to detect and rectify errors or unproductive cognitive processes that lead to fixation errors or that reduce cognitive resources.
- Manage stress.
- Invite team members to provide input and raise concerns.
- Optimise the physical environment to promote situation awareness.

4.4 Optimise team support and communication

- Use cognitive aids (memory) (see above) which are available to all members of the team.
- Activate pre-rehearsed team practices to optimise co-ordination, communication and situation awareness.

- Share information using effective language such as: team briefing, closed loop communication and situation reports.
- Invite team members to provide input and raise concerns.

4.5 Monitor attention and minimise delays

- Mobilise resources early.
- Break key tasks into steps such as separating infraglottic rescue into (1) trans-tracheal access and (2) emergency oxygenation.
- Use cognitive aids to prompt progress at points at risk of delay.

PART 5: FEATURES OF COGNITIVE AIDS THAT BEST SUPPORT THE MANAGEMENT OF CICO

5.1 **Routine use of cognitive aids in difficult airway scenarios.** There is strong support for the routine use of cognitive aids in the management of anticipated and unanticipated difficult airway scenarios.

5.2 **Use in the context of emergency situations:** Cognitive aids intended to be used in the context of emergency situations like CICO should be distinguished from decision-support aids that are intended for use to support training. Emergency cognitive aids should be simple low-content documents that aid memory recall, prompt users regarding frequently omitted steps or clarify difficult decision points. In contrast, practice guidelines/decision support aids, which are designed to support training and awareness of best practice, are generally more detailed documents. While they can be applied in non-emergency situations such as preparation for anticipated difficult cases, their higher levels of textual content make them difficult to follow in time critical emergency situations.

5.3 **Published cognitive aids.** Several groups have published cognitive aids to support difficult airway scenarios including transition from supraglottic to infraglottic rescue. Earlier published cognitive aids such as those developed by the ASA, DAS and Canadian Airway Group have features of high content text-based decision support aids best suited to preparation stages of anticipated difficult airways or to develop mental preparedness of clinicians in case they encounter an unanticipated difficult airway. More recently published cognitive aids such as the Vortex™ and CriCon2 use symbols and graphic metaphors that make them more suited to employ as cognitive aids during emergency situations. No cognitive aids published to date meet all the ideal features of a CICO cognitive aid based on the evidence from this series of papers.

5.4 **Ideal features of cognitive aids:** General design features outside of the context of CICO:

5.4.1 There is no evidence favouring one conceptual format of cognitive aids over another from the following list: goal based treatment; conditional if-then prompts; reminders of frequently omitted steps or navigation of sequential steps.

5.4.2 There is no evidence favouring one graphical format over another from the following list: checklists of key practice points; sequential and/or branching flowcharts; symbols and graphic metaphors; or hazard alerts.

5.4.3 Evidence favours certain design features in the specific contexts of preparatory checklists and memory aids designed to reduce omission errors. It is generally considered that cognitive aids designed for emergencies should have simplified content and layouts to allow assimilation in a crisis.

5.4.4 New designs should not be implemented until testing has occurred.

5.5 **Ideal features of CICO cognitive aids: Clinical content:** As per part 2, the most strongly endorsed features of existing decision-aids are:

5.5.1 They depict common and or serious airway scenarios, which include: anticipated difficult airway; difficult airway; CICO and the transition between these scenarios.

5.5.2 They present supraglottic rescue as a non-linear relationship between three pathways: intubation, face-mask ventilation and supraglottic devices such as LMA.

5.5.3 They specify measurable criteria to prompt progression through transitional states. These criteria could include: type of interventions, number of attempts, and oxygen saturation level.

5.5.4 They highlight recommended clinical practice points (see 5.8.5).

5.6 **Performance shaping factors of cognitive aids:** As per part 1, the most concerning errors and performance failures are considered to be:

5.6.1 Failure to appreciate the risk of CICO in patients with anticipated difficult airways and neglect of options for awake techniques which may otherwise avert a CICO event or preparation of back-up plans in case CICO evolves after general anaesthesia is induced.

5.6.2 Omission of supraglottic rescue interventions in one or more categories (intubation, face-mask ventilation and supraglottic device (LMA)), which may otherwise avert a CICO event.

5.6.3 Neglect of exist strategies such as awakening the patient.

5.6.4 Factors that lead to omission or delay in performing infraglottic rescue when a definitive CICO exists such as task fixation and unassertive team members.

5.6.5 Delays in commencing infraglottic rescue.

5.6.6 Technical failures in performing infraglottic rescue.

6.0 **Context:** A CICO cognitive aid is unlikely to be meaningful if used outside of the contexts of:

1. The individual clinician who has trained against the cognitive aid and who is mentally prepared to activate the algorithm and physically prepared to perform the procedures.
2. The team who is familiar with the cognitive aid.
3. The organisation has a multifaceted pre-planned strategy for management of the difficult airway.
4. Complementary resources providing detailed content not included in cognitive aids.

7.0 **Recommendations:** Drawing from evidence presented in this series the key recommended features and inclusions of a cognitive aid for CICO are listed below and demonstrated graphically in Appendix I. The aid should:

1. Be easily accessible to all members of the team and embedded in everyday routine practice, such as case briefings.
2. Show airway assessment, decision to induce general anaesthesia and CICO as related events.
3. Emphasise supraglottic rescue and express this as three pathways or categories: face-mask ventilation, endotracheal intubation and supraglottic rescue devices.
4. Suggest clinical criteria for declaring CICO for example, max number of attempts at endotracheal intubation and SaO_2.

5. Include prompts (as questions, reminders or practice points) for steps at high risk of faulty decisions, omission or delay including:

    5.1 Consider awake intubation/tracheostomy in high-risk patients.

    5.2 Attempt all three supraglottic pathways: FMV; ETT; LMA.

    5.3 Call for help.

    5.4 Attempt to deliver oxygen via a supraglottic pathway at all times.

    5.5 Awaken the patient if feasible.

    5.6 Mobilise resources for infraglottic rescue when two supraglottic pathways are unsuccessful.

    5.7 Declare CICO when three supraglottic pathways are unsuccessful.

    5.8 Initiate infraglottic rescue immediately a CICO is declared.

    5.9 Team members should be encouraged to speak up at any time if concerned.

    5.10 Use specific criteria to guide extubation and monitor carefully afterwards.