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SPECIAL ARTICLE

The difficult airway with recommendations for management – Part 1 – Difficult tracheal intubation encountered in an unconscious/induced patient

Prise en charge des voies aériennes – 1re partie – Recommandations lorsque des difficultés sont constatées chez le patient inconscient/anesthésié

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Abstract

Background *Previously active in the mid-1990s, the Canadian Airway Focus Group (CAFG) studied the unanticipated difficult airway and made recommendations on management in a 1998 publication. The CAFG has since reconvened to examine more recent scientific literature on airway management. The Focus Group's mandate for this article was to arrive at updated practice recommendations for management of the unconscious/induced patient in whom difficult or failed tracheal intubation is encountered.*

Methods *Nineteen clinicians with backgrounds in anesthesia, emergency medicine, and intensive care joined this iteration of the CAFG. Each member was assigned topics and conducted reviews of Medline, EMBASE, and Cochrane databases. Results were presented and discussed during multiple teleconferences and two face-to-face meetings. When appropriate, evidence- or consensus-based recommendations were made together with assigned levels of evidence modelled after previously published criteria.*

Conclusions *The clinician must be aware of the potential for harm to the patient that can occur with multiple attempts at tracheal intubation. This likelihood can be minimized by moving early from an unsuccessful primary intubation technique to an alternative "Plan B" technique if oxygenation by face mask or ventilation using a supraglottic device is non-problematic. Irrespective of the technique(s) used, failure to achieve successful tracheal intubation in a maximum of three attempts defines failed tracheal intubation and signals the need to engage an exit strategy. Failure to oxygenate by face mask or supraglottic device ventilation occurring in conjunction with failed tracheal intubation defines a failed oxygenation, "cannot intubate, cannot oxygenate" situation. Cricothyrotomy must then be undertaken without delay, although if not already tried, an expedited and concurrent attempt can be made to place a supraglottic device.*

Résumé

Contexte *Actif au milieu des années 1990, le Canadian Airway Focus Group (CAFG), un groupe dédié à l'étude des difficultés imprévues dans la prise en charge des voies aériennes, a émis des recommandations sur ce sujet dans une publication datant de 1998. Le CAFG s'est réuni à nouveau pour passer en revue la littérature scientifique*

(Please see Appendix 2 for authors' affiliations, attributions, and disclosures).

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récente concernant la prise en charge des voies aériennes. Dans cet article, le CAFG s'est donné pour mission d'émettre des recommandations visant la prise en charge du patient inconscient ou anesthésié qui présente des difficultés d'intubation significatives.

Méthode *Dix-neuf cliniciens ayant une formation en anesthésie, en médecine d'urgence ou en soins intensifs composent le CAFG actuel. Les participants ont passé en revue des sujets précis en consultant les bases de données Medline, EMBASE et Cochrane. Les résultats de ces revues ont été présentés et discutés dans le cadre de téléconférences et de deux réunions en personne. Lorsqu'indiqué, des recommandations fondées sur des données probantes ou sur un consensus ont été émises. Le niveau de confiance attribué à ces recommandations a aussi été défini.*

Conclusion *Le clinicien doit avoir conscience des lésions qu'il peut infliger lors de tentatives multiples d'intubation trachéale. Il est possible d'éviter de telles lésions en abandonnant rapidement une technique d'intubation infructueuse afin d'opter pour une méthode alternative (ou 'plan B') à condition que l'oxygénation par masque facial ou par l'utilisation d'un dispositif supraglottique s'avère possible. Nonobstant la ou les techniques choisies, un maximum de trois tentatives infructueuses mène à la conclusion qu'il s'agit d'un échec d'intubation et devrait inciter le clinicien à adopter une stratégie de retrait. Une situation dans laquelle il est impossible de procéder à l'oxygénation du patient à l'aide d'un masque facial, d'un dispositif supraglottique ou de l'intubation endotrachéale est qualifiée de scénario cannot intubate, cannot ventilate. Il est alors impératif de procéder sans délai à une cricothyrotomie, à moins que l'insertion d'un dispositif supraglottique n'ait été tentée. Celle-ci peut alors être effectuée rapidement et parallèlement à la réalisation de la cricothyrotomie.*

What other statements of recommendation are available on this topic?

In 1998, Canadian recommendations were published on management of the unanticipated difficult airway. More recent national recommendations and guidelines on difficult airway management have been published in the USA, the United Kingdom, and other western European countries.

Why were these recommendations developed?

Canadian recommendations were overdue for an update. Since the last review, many new devices useful in difficult airway management have been introduced. In addition, the Anesthesia Closed Claims Project and other observational studies have highlighted potential areas for improvement in management of the difficult and failed airway.

How do these statements differ from existing recommendations?

These statements reflect current evidence and thinking on an appropriate response to difficult airway management encountered in the unconscious/induced patient. The importance of engaging an exit strategy after a limited number of attempts at tracheal intubation is emphasized, as is a simplified response to a failed oxygenation, "cannot intubate, cannot oxygenate" situation.

Why do these statements differ from existing recommendations?

These statements differ from existing recommendations in order to simplify decision-making when failed tracheal intubation or failed oxygenation is encountered in the unconscious/induced patient.

Contents

DISCLAIMER:

Care has been taken to confirm the accuracy of the information presented and to describe generally accepted practices. The authors accept that medical knowledge is an ever-changing science that continually informs, improves, and alters attitudes, beliefs, and practices.

Recommendations are not intended to represent or be referred to as a standard of care in the management of the difficult or failed airway.

Application of the information provided in a particular situation remains the professional judgement and responsibility of the practitioner.

Bedside predictors of difficult tracheal intubation are imperfect. Accordingly, when general anesthesia (GA) is induced despite predictors of difficult intubation, many cases prove unchallenging. Conversely, unanticipated failure of tracheal intubation by direct laryngoscopy or other technique can occur when no such challenges were expected. Encountering difficult tracheal intubation in the unconscious patient is a concern, as many studies involving several specialties have documented increasing patient morbidity with multiple tracheal intubation attempts.[1-5]

Other hazards associated with difficulty in airway management have been highlighted in recent publications. Studies of closed legal actions[6-8] related to airway management and the recent 4th National Audit Project (NAP4) of the Royal College of Anaesthetists and the Difficult Airway Society in the United Kingdom[9,10] have helped direct attention to problem areas. In the NAP4 study, a prospective registry was created of major complications related to airway management occurring over a 12-month period in all 309 National Health Service hospitals in the United Kingdom. Complications were reported if they led to death, brain damage, need for emergency surgical airway, unanticipated intensive care unit (ICU) admission, or prolongation of ICU stay.[9] The results of the audit provide considerable insight into causes of airway management-related morbidity and potential areas for improvement.

This first of two publications addresses airway management in the unconscious patient when difficult tracheal intubation is *encountered*. The second publication will focus on options and the approach to the patient when difficult airway management is *anticipated*.[11] Taken together, the articles are intended to assist the practitioner with recommendations for airway management when confronted with a difficult or failed airway, regardless of where in the hospital an airway intervention occurs.

Methods

The Canadian Airway Focus Group (CAFG) was originally formed in the mid-1990s and published recommendations for the management of the unanticipated difficult airway in 1998.[12] Four of the original CAFG members rejoined the current iteration, and the first author invited an additional 14 clinicians with an interest in airway management to participate. The current Focus Group includes representatives from anesthesiology, emergency medicine, and critical care.

Topics for review were divided among the members, and participants conducted a literature review on their topic(s). Electronic literature searches were not conducted according to a strict protocol, but participants were instructed to search, at a minimum, Medline and EMBASE databases together with the Cochrane Central Register of Controlled Trials (CENTRAL). Search strings were determined by individual participants. A worksheet was completed for each topic with details of the search strategy, a synopsis of the relevant studies, an overall summary of findings, the perceived quality of evidence, and the author's suggestion(s) for strength of recommendation (see below). Once finished, worksheets were made available to the CAFG membership on a file hosting service.

The Focus Group convened regularly by teleconference, and face-to-face meetings occurred twice during the 24 months taken to complete the process. Worksheet authors presented their topics to the members, who then arrived at consensus on overall quality of evidence and any recommendations. In the event that evidence was of low quality or altogether lacking, "expert opinion" by consensus was sought. Finally, a draft of the completed manuscript was distributed to all members for review prior to submission.

The strength of a recommendation and the accompanying level of evidence were modelled after the GRADE system, as per previously published criteria.[13,14] When made, formal strength of recommendations adhere to the following descriptors:

- **Strong recommendation *for*** – most patients should receive the intervention; most patients in this situation would want the recommended course of action;
- **Weak recommendation *for*** – most patients would want the suggested course of action, but some would not; the appropriate choice may vary for individual patients.
- **Strong recommendation *against*** – most patients should not receive the intervention; most patients in this situation would not want the suggested course of action;

- **Weak recommendation *against*** – most patients would not want the suggested course of action, but some would; the appropriate choice may vary for individual patients.

Three levels of evidence were applied,[13] as follows:

- **Level of evidence A** (High) – systematic reviews of randomized 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.

When a level of evidence is not specifically supplied in this manuscript, recommendations reflect the consensus opinion of the authors.

Definitions

The following definitions of terms are presented to clarify their use in the text. Some definitions have changed from the 1998 iteration of these recommendations to reflect the increased use of alternatives to direct laryngoscopy (DL) and ventilation with a supraglottic device (SGD).

Difficult airway: A difficult airway can be defined as one where an experienced provider anticipates or encounters difficulty with any or all of face mask ventilation, direct or indirect (e.g., video) laryngoscopy, tracheal intubation, SGD use, or surgical airway.

Difficult face mask ventilation: It has been suggested that inadequate mask ventilation may be more difficult to recognize than its complete absence.[15] Although various definitions relating to difficulties with mask ventilation have been proposed,[16-18] ease of mask ventilation is best described as a continuum from no difficulty to impossible. Difficult face mask ventilation may be signified by manipulations required for its facilitation, including adjustments of the head and neck, the use of adjuvants (e.g., an oral or nasal airway), use of exaggerated jaw lift, two-handed face mask application, and the assistance of a second operator.

Difficult laryngoscopy: Laryngeal exposure using DL is generally quantified using the Cormack-Lehane grade[19] or one of its modifications.[20,21] Most authorities agree that grade 1 and 2 views, where most or some portion of the glottis is seen, represent easy DL, while grade 3 and 4 views represent difficult and failed DL, respectively, even if tracheal intubation itself succeeds. The same classification can be employed when indirect techniques, such as video laryngoscopy, are utilized. Regardless of the technique used (DL or indirect laryngoscopy), the specific device should always be described in addition to the view obtained, the number of attempts, and the ancillary maneuvers required to achieve the result.

Difficult tracheal intubation: The success of direct or indirect laryngoscopy and tracheal intubation should be assessed independently, regardless of the technique. Difficult tracheal intubation can be defined as one or all of the following:[12]

- Multiple attempts or more than one operator required;
- An adjunct such as a tracheal tube introducer ("bougie") is required to facilitate tracheal intubation;
- An alternative intubation device is required after unsuccessful use of the primary, "Plan A" device.

A common reason for difficulty with tracheal intubation is a poor laryngeal view; however, if a Cormack-Lehane 1 or 2 view is obtained but difficulty occurs with directing or advancing the endotracheal tube (as may happen with video laryngoscopy), it is reasonable to describe this in some form of narrative. Alternatively, difficulty can be quantified using a scale based on several parameters.[22]

Difficult SGD use: Difficult or failed oxygenation and ventilation with an SGD may result from difficulties accessing the patient's mouth or hypopharynx, achieving a seal,[23] or ventilating the lungs.

Difficult transtracheal surgical airway: A surgical airway can be achieved by percutaneous needle-guided cannula methods or by an open operative technique. A difficult transtracheal surgical airway is one that requires excess time or multiple efforts.

Failed airway: Defining a failed airway helps serve notice to the clinician that a different course of action may be needed to minimize the potential for harm to the patient:

- Failed tracheal intubation can be defined as failure to achieve successful tracheal intubation in a maximum of three attempts, irrespective of the technique(s) used.
- Failed oxygenation ("cannot intubate, cannot oxygenate" [CICO])[24] has occurred if, in the face of failed tracheal intubation, the patient cannot be successfully oxygenated by employing face mask or SGD ventilation.

Extubation of the difficult airway: Extubation is unsuccessful when a tracheal tube is removed but requires unanticipated replacement. This replacement (including tracheal tube exchange) can be difficult or fail. A clear definition of difficulty does not exist, but it is reasonable to assume that the difficulty further contributes to rather than resolves a deteriorating situation. A high-risk extubation can be described on two axes: the risk of not

Table 1 Approximate incidence of difficulty with various airway interventions – by hospital location

	Operating Room, %	Obstetrics, %	Emergency Department, %	Intensive Care, %	References
Difficult face mask ventilation	0.8-7.8	no data	no data	no data	([15,16,18,25-29])
Impossible face mask ventilation	0.01-0.15	no data	no data	no data	([15,16,18,25])
Cormack-Lehane Grade 3 (Grade 4) view by direct laryngoscopy	0.8-7.0 (0.1-3.2)	1.7-3.6 (0.1-0.6)	6.1 (2.4)	11 (0.7)	([19,25,26,29-34])
≥ 3 attempts at tracheal intubation	0.9-1.9	no data	3.6-11.0	6.6-9.0	([2-4,34-40])
Difficult or failed SGD ventilation	0-1.1	0-1.0	no data	no data	([41-46])
Surgical airway	.002-0.02	no data	0.05-1.7	no data	([1,36,37,47-50])

SGD = supraglottic device

tolerating extubation and the risk of re-intubation being difficult or unsuccessful. Extubation of the patient with a difficult airway is addressed in the second article in this series.[11]

Incidence and scope of the problem

The published incidence of difficult airway management interventions varies substantially (Table 1). Although different definitions, patient populations, and clinician experience make these figures difficult to compare directly, a few trends emerge. Perhaps one of the more significant trends is the higher occurrence of difficulty encountered in locations outside of the operating room (OR).

Management of the difficult and failed airway in the unconscious/induced patient

Most airway management is performed in an unconscious patient, usually pharmacologically induced for surgical anesthesia. Outside the OR environment, a critically ill patient may be induced for the sole purpose of securing the airway or may already have been unconscious on initial presentation.

Airway management in the induced surgical patient may involve SGD or face mask ventilation, tracheal intubation, or rarely, a primary cricothyrotomy or tracheotomy. Difficulty may be encountered with any of these modalities and should be met with an appropriate response.

The primary approach to tracheal intubation: "Plan A"

For the unconscious/induced patient requiring tracheal intubation, the clinician's primary "Plan A" approach may have been facilitated by DL or an alternative to DL, such as video laryngoscopy. Alternatives to DL may be chosen as the primary approach due to anticipated difficulty with DL, their utility in teaching, or clinician preference. The chosen technique should be suited to the context of patient anatomy and pathophysiology, operator familiarity, and the practice environment. The probability of first-attempt success should be maximized by familiarity with and attention to equipment and adjunct (e.g., malleable stylet or tracheal tube introducer) preparation, patient positioning, and optimal pharmacotherapy.[51]

Response to difficulty encountered in the unconscious patient

Difficult direct laryngoscopy: If a poor view is obtained during attempted DL despite proper positioning of the patient and the laryngoscope blade tip, optimizing maneuvers should occur, such as application of external laryngeal pressure (Strong recommendation ***for***, level of evidence ***B***). Unless contraindicated by C-spine precautions, additional head lift (to accentuate lower neck flexion and head/upper neck extension) may also be helpful.[52-54]

External laryngeal pressure is effective at improving the view during DL.[55-63] This maneuver is distinct from cricoid pressure, applied to the cricoid cartilage to help prevent passive regurgitation of gastric contents. In studies, cricoid pressure resulted in no improvement[64-66] or a worse[64,67-69] view with DL; hence, a recommendation can be made *against* its use for the sole purpose of improving the view during DL if used instead of laryngeal pressure (Weak recommendation ***against***, level of evidence ***C***). External laryngeal pressure and head lift can be performed sequentially during the first attempt at DL.

There is little evidence that an automatic blade change is an effective strategy for a second attempt at DL unless a specific anatomic finding during the initial laryngoscopy suggests a benefit. Examples include a long, floppy epiglottis that could be directly elevated with a longer curved, or straight blade, or a suspicion that a Macintosh

blade is too short to completely advance into the vallecula, thus failing to engage the underlying hyoepiglottic ligament.

The tracheal tube introducer has been extensively studied as an adjunct to DL. It is an effective aid to tracheal intubation faced with a restricted view during DL[20,25,38,70-74] and may also be useful with some video laryngoscopes. If a restricted (e.g., Cormack-Lehane grade 2b or 3)[19,20] view obtained during DL persists after optimization maneuvers such as external laryngeal pressure or additional head lift, use of a tracheal tube introducer should be considered (Strong recommendation ***for***, level of evidence ***B***). The CAFG recommends immediate availability of a tracheal tube introducer at all airway management locations.

Difficult video laryngoscopy: There are three independent tasks with video laryngoscopy, namely, laryngeal exposure, delivery of the tracheal tube to the laryngeal inlet, and advancement within the trachea. Use of a video laryngoscope will generally result in a good laryngeal view, although blades with more angulation or curvature will enable better exposure. The following techniques can facilitate passage of the tracheal tube: preparing a tracheal tube with a preloaded stylet with a curvature matching that of the video laryngoscope blade, partial withdrawal of the blade to provide a wider visual field, and deliberately not seeking a full view of the larynx before attempting passage of the tube. Once placed through the glottic opening, withdrawing the stylet 5 cm will help circumvent impingement of the tracheal tube tip on the anterior tracheal wall, permitting gentle tube advancement. Rotation of the tube may also address impingement. Video laryngoscopes with channeled blades (e.g., Airtraq®, Ambu® AWS, and KingVision™) also exist to facilitate delivery of the tracheal tube. Failure to achieve a view of the larynx with video laryngoscopy can be minimized by suctioning the oropharynx prior to initial blade insertion.

Difficult face mask ventilation: Difficult face mask ventilation of the unconscious patient before or between tracheal intubation attempts should be addressed with a graduated response, including placement of an appropriately sized oropharyngeal and/or nasopharyngeal airway, use of a two-handed mask hold, and exaggerated head extension, unless contraindicated (Strong recommendation ***for***, level of evidence ***C***).

The two-handed face mask hold facilitates ventilation by projecting the mandible anteriorly into the mask, which pulls the tongue forward and further opens the airway. It also provides an improved mask seal. Ventilation can be provided by an assistant or by the anesthesia machine ventilator if the patient is in the OR.

Cricoid pressure may make face mask ventilation difficult, especially if applied with excess force.[75] If cricoid pressure has been applied and difficult face mask ventilation is deemed unresponsive to the foregoing measures, progressive release of pressure should be considered (Weak recommendation ***for,*** level of evidence ***C***).

If difficult or impossible face mask ventilation persists despite corrective maneuvers, a SGD should be placed or tracheal intubation should be undertaken if not already attempted.[15,76,77] Failure to ventilate with a SGD can often be resolved by ensuring an adequate depth of anesthesia, appropriate (e.g., no more than 60 cm H_2O) cuff inflation, reinsertion of the device with a fully deflated cuff, or placement of a larger SGD.

Unsuccessful primary approach to tracheal intubation

An attempt at tracheal intubation may be unsuccessful despite optimized conditions and technique. In the induced/unconscious patient, this will most often be followed by face mask ventilation or, optionally, placement of a SGD. The success of oxygenation by face mask or SGD ventilation in this context dictates subsequent actions (Fig. 1). As long as oxygenation is non-problematic, the situation is stable, and if deemed appropriate, time exists for additional careful attempts at tracheal intubation. Conversely, the failure of face mask ventilation or a SGD to maintain adequate oxygenation after a failed attempt at tracheal intubation indicates a failed oxygenation/CICO situation (represented in the Emergency pathway on the right-hand side of the Fig. 1 flow diagram).

With non-problematic oxygenation, a second attempt at tracheal intubation can occur using the primary "Plan A" technique, but only if it is reasonable to presume that the factors contributing to the initial unsuccessful attempt can be addressed during the subsequent attempt. For example, an unsuccessful primary attempt at intubation using video laryngoscopy may yield information about the ideal curvature of a tracheal tube with preloaded stylet required for a second attempt.

The alternative approach to tracheal intubation: "Plan B" in the adequately oxygenated patient

An alternative "Plan B" approach to tracheal intubation should be employed if the primary approach is unsuccessful, if oxygenation remains non-problematic, and if further intubation attempts are planned. Experienced providers will often proceed to the alternative approach after only a single failed attempt with the primary device, recognizing the low incremental probability of successful intubation with a second attempt using the same device. In general, the

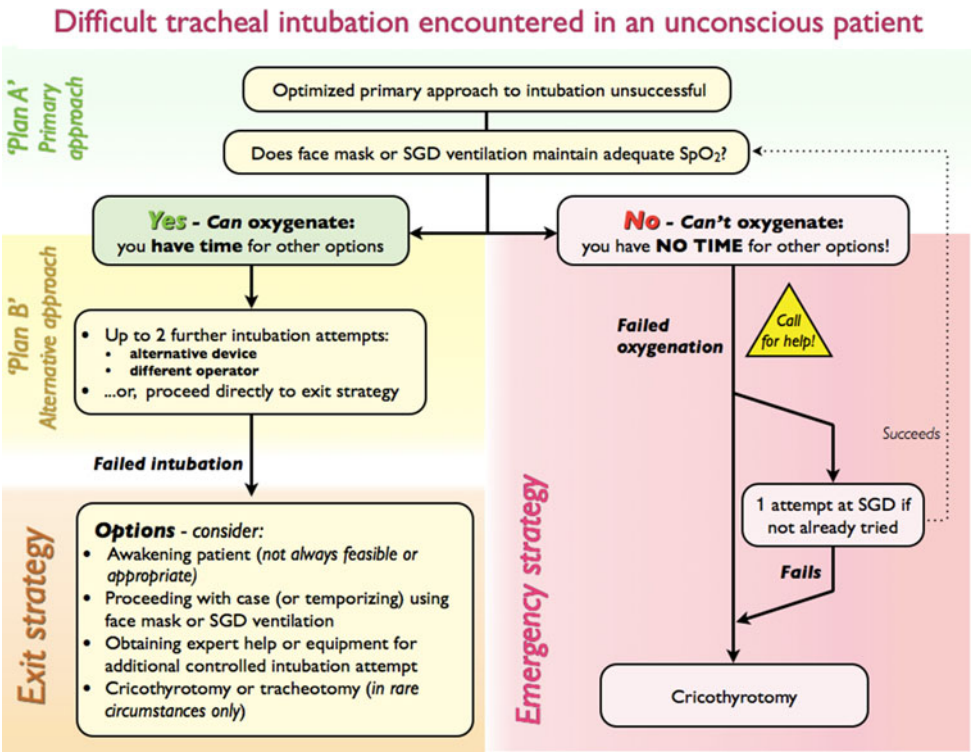

Fig. 1 Flow diagram: difficult tracheal intubation encountered in the unconscious patient. SGD = supraglottic device

alternative approach should be used after no more than two failed attempts at tracheal intubation using the primary approach and should employ a different device or operator.

Numerous alternatives to DL, used alone or in combination, have been proven effective in obtaining an improved view of the larynx and/or enabling successful tracheal intubation when DL is unsuccessful (Table 2). Many of the devices presented in Table 2 are indirect (e.g., video) laryngoscopes, although other techniques are also effective in experienced hands. Equally, there is also some evidence that DL-facilitated intubation may succeed should primary use of some of these same alternatives fail.[78,79] As such, an argument can be made that these alternative devices should complement and not necessarily replace DL at this time. Irrespective of the technique chosen, proficiency demands elective experience in human subjects.

There should be a reasonable expectation that the selected "Plan B" technique will address the reason, anatomic or otherwise, for failure of the primary approach. As with the primary approach, each use of the alternative device should be optimized, and a second attempt using the same device should occur only if made with a substantive change, e.g., a change in the size of the device, altered endotracheal tube/stylet conformation, or use by a more experienced operator. All clinicians with a mandate for airway management should be familiar with at least one alternative technique (e.g., video laryngoscopy) to DL to enable tracheal intubation (Strong recommendation ***for,*** level of evidence ***C***), and such equipment should be immediately available. When difficult or failed DL is encountered, proceeding with a "Plan B" alternative intubation technique without awakening the elective surgical patient is common practice and is probably safe, provided that oxygenation remains unchallenged.

Failed tracheal intubation in the adequately oxygenated patient: exit strategies

Limits to tracheal intubation attempts

Evidence continues to emerge that patient morbidity increases with the number of attempts at tracheal intubation (Table 3). Mainly derived from the critically ill population, it must be acknowledged that there is marked heterogeneity in harmful "outcomes" reported in these studies (e.g., aspiration, hypoxemia, hypotension, trauma etc.), including composite outcomes. Furthermore, there is variable use of neuromuscular blockade, and it is unclear if the apparent risk relates to the number of attempts required, additional exerted force, or the associated delay in successful intubation. Nevertheless, the studies do provide a warning that the number of attempts at tracheal intubation should be minimized, irrespective of practice location. Incremental risk must be assumed with each failed attempt such that a second or third tracheal intubation attempt should occur only if a

Table 2 Effectiveness of a selection of alternatives to direct laryngoscopy in the difficult airway

Population	Published benefit	Level(s) of evidence & references
LMA Fastrach™ (LMA North America Inc., San Diego, CA)		
Patients with failed Macintosh direct laryngoscopy (DL)	Successful ventilation/intubation	***C:*** ([43,70,80-85])
Patients with predicted difficult intubation by DL	Successful ventilation/intubation	***B:*** ([86-88])
		C: ([42,85,89-94])
Obese patients	Successful ventilation/intubation	***B:*** ([95])
		C: ([96])
Patients with manual in-line stabilization	Successful ventilation/intubation	***B:*** ([97])
		C: ([43,89,98])
air-Q™ (Cookgas LLC, St. Louis, MO)		
Patients with difficult laryngoscopy	Successful intubation (endoscopic-aided)	***C:*** ([92,99,100])
Bronchoscopic-aided intubation through a supraglottic device		
Patients with failed Macintosh DL	Successful ventilation/intubation	***C:*** ([43])
Patients with predicted difficult intubation by DL	Successful ventilation/intubation	***B:*** ([86]) ***C:*** ([101])
Bronchoscopic- and Aintree catheter-aided intubation through a supraglottic device		
Patients with predicted difficult intubation by DL	Successful intubation	***B:*** ([102]) ***C:*** ([103-105])
Intubating lighted stylets		
Patients with failed Macintosh DL	Successful intubation	***C:*** ([106])
Patients with predicted difficult intubation by DL	Successful intubation	***A:*** ([107]) ***B:*** ([108])
Patients with MILS	Successful intubation	***B:*** ([109])
GlideScope® videolaryngoscope (Verathon Medical Canada ULC, Burnaby, BC)		
Patients with failed Macintosh DL	Successful intubation	***B:*** ([78,110]) ***C:*** ([111-113])
Patients with predicted difficult intubation by DL	Improved view	***A:*** ([114,115]) ***C:*** ([116])
	Successful intubation	***A:*** ([117]) ***B:*** ([78,118,119]) ***C:*** ([115])
Patients with MILS	Improved view	***A:*** ([120]) ***B:*** ([121]) ***C:*** ([122-124])
	Successful intubation	***B:*** ([125]) ***C:*** ([121])
Patients with ankylosing spondylitis	Successful intubation	***C:*** ([126,127])
Obese patients	Improved view	***A:*** ([128-130]) ***B:*** ([131])
	Successful intubation	***A:*** ([129]) ***B:*** ([95,130]) ***C:*** ([132])
	Awake intubation	***C:*** ([133])
Patients with upper airway tumours	Improved view	***A:*** ([134])
McGrath® Series 5 video laryngoscope (LMA North America Inc., San Diego, CA)		
Patients with failed Macintosh DL	Successful intubation	***C:*** ([135,136])
Patients with predicted difficult intubation by DL	Improved view	***C:*** ([137])
	Successful intubation	***B:*** ([138])
	Awake intubation	***B:*** ([139])
Patients with MILS	Successful intubation	***B:*** ([140])
Obese patients	Improved view	***A:*** ([128])
Storz C-MAC® (with Macintosh blade) (Karl Storz Endoscopy, El Segundo, CA)		
Patients with failed Macintosh DL	Improved view	***B:*** ([141])
	Successful intubation	***B:*** ([141])
Patients with predicted difficult intubation by DL	Successful intubation	***A:*** ([142]) ***B:*** ([138])
Obese patients	Improved view	***A:*** ([128])
Storz C-MAC® (with D-blade) (Karl Storz Endoscopy, El Segundo, CA)		
Patients with failed Macintosh DL	Improved view	***B:*** ([143])
	Successful intubation	***B:*** ([143])
Patients with predicted difficult intubation by DL	Improved view	***B:*** ([144])
	Successful intubation	***B:*** ([144])

Table 2 continued

Population	Published benefit	Level(s) of evidence & references
Ambu® Pentax Airway Scope (Ambu Inc., Glen Burnie, MD)		
Patients with failed Macintosh DL	Successful intubation	***B:*** ([145-147]) ***C:*** ([148])
Patients with predicted difficult intubation by DL	Successful intubation	***A:*** ([117])
Patients with MILS	Improved view	***A:*** ([120]) ***B:*** ([123]) ***C:*** ([149])
	Successful intubation	***A:*** ([120,150]) ***B:*** ([123]) ***C:*** ([149])
Airtraq (Southmedic Inc., Barrie, ON)		
Patients with failed Macintosh DL	Successful intubation	***C:*** ([151])
Patients with predicted difficult intubation by DL	Faster intubation; reduction in intubation difficulty score	***B:*** ([152]) ***C:*** ([153])
	Successful intubation	***C:*** ([153])
Patients with upper airway tumours	Improved view	***A:*** ([134])
Flexible bronchoscopic intubation		
Anesthetized patients with failed Macintosh DL	Successful intubation	***B:*** ([154,155]) ***C:*** ([83])
	Successful intubation (with use of a laryngeal mask airway and Aintree catheter)	***B:*** ([102])
Patients with predicted difficult intubation by DL	Successful intubation	***A:*** ([86]) ***B:*** ([87]) ***C:*** ([139,156])
	Successful awake intubation	***B:*** ([139])
Anesthetized patients with MILS	Successful intubation	***B:*** ([157])
Clarus Video System (Clarus Medical, St. Paul, MN)		
Patients with predicted difficult intubation by DL	Successful intubation	***B:*** ([158])
Patients with C-spine immobilization or injury	Successful intubation	***A:*** ([159])
Storz Bonfils intubation endoscope (Karl Storz Endoscopy, El Segundo, CA)		
Patients with failed Macintosh DL	Successful intubation	***C:*** ([160-162])
Patients with predicted difficult intubation by DL	Successful intubation; awake intubation	***B:*** ([88]) ***C:*** ([163-165])
Clarus Shikani optical stylet (Clarus Medical, St. Paul, MN)		
Patients with MILS	Successful intubation	***B:*** ([121]) ***C:*** ([166])
Clarus Levitan optical stylet (Clarus Medical, St. Paul, MN)		
Patients with simulated difficult DL	Successful intubation	***B:*** ([74])

DL = direct laryngoscopy; MILS = manual in-line stabilization

different tactic is used and there is a reasonable expectation of success. Proceeding with more than three attempts at tracheal intubation requires compelling justification.

With the evidence of harm accruing from multiple attempts at tracheal intubation, an argument can be made for always including first-attempt success rates in future studies of intubation devices, techniques, or skills acquisition.

Failed tracheal intubation: exit strategies

Three failed attempts at tracheal intubation should be taken as an indication to declare a failed intubation situation. This should signal the team to pause and consider an exit strategy, to avoid repetitive ineffective intubation attempts that might result in harm to the patient. In the adequately oxygenated unconscious/induced patient, a number of exit strategies exist:

- **Awakening the patient.** The option of allowing the induced oxygenated patient to wake after failed tracheal intubation should be considered when feasible (***Weak*** recommendation ***for,*** level of evidence ***C***). Once awake and cooperative, awake tracheal intubation can be attempted in the spontaneously breathing patient. Alternatively, an elective surgical case could be deferred or potentially performed under regional or infiltration anesthesia. Oxygenation should be maintained with face mask or a SGD until the patient emerges from general anesthesia. Awakening the patient may not be possible or appropriate in an emergency, during an attempted resuscitation, or if the patient cannot cooperate with awake intubation or

Table 3 Adverse effects associated with multiple attempts at tracheal intubation

Author, year, (reference) (sample size)	Design, location	Overall LOE	Summary of Findings			
			Predictor	Outcome	Relative effect	Absolute effect
Sakles 2013 ([1]) ($n = 1,828$)	Single centre; observational cohort study in ED	B	≥ 2 attempts	One or more adverse events	aOR 7.5 (95% CI 5.9 to 9.6; $P < 0.001$)	263 of 495 (53%) *vs* 189 of 1,333 (14%)
Hasegawa 2012 ([2]) ($n = 2,616$)	Multicentre; observational cohort study in ED	B	≥ 3 attempts	All adverse events (major adverse event + dental or airway trauma, mainstem intubation)	aOR 4.5 (95% CI 3.6 to 6.1)	96 of 280 (35%) *vs* 213 of 2,336 (9%)
				Major adverse event (cardiac arrest, SBP < 90 mmHg, SaO_2 < 90%, regurgitation or esophageal intubation)	aOR 4.6 (95% CI 3.2 to 6.6)	63 of 280 (23%) *vs* 118 of 2,336 (5%)
Jabre 2011 ([167]) ($n = 650$)	Multicentre; observational cohort of prior RCT in ED	B	Difficult intubation as defined by IDS ([168]) score > 5	Complications	aOR 5.9 (95% CI 3.5 to 10.1; $P < 0.0001$)	48 of 73 (66%) *vs* 144 of 577 (25%)
				28-day mortality	aHR 1.6 (95% CI 1.04 to 2.4; $P = 0.03$)	26 of 73 (36%) *vs* 155 of 577(27%)
Martin 2010 ([3]) ($n = 3,423$)	Single centre; observational cohort study of non-OR intubations	B	≥ 3 attempts	Airway complications (aspiration, esophageal intubation, pneumothorax)	aOR 8.0 (95% CI 4.5 to 14.3; $P < 0.001$)	23 of 87 (26%) *vs* 121 of 3,215 (3.8%)
Griesdale 2008 ([4]) ($n = 136$)	Single centre; observational cohort in ICU	B	≥ 2 attempts	Severe complications (SaO_2 < 80%, SBP < 70 mmHg)	aOR 3.3 (95% CI 1.3 to 8.4; $P = 0.01$)	17 of 45 (38%) *vs* 16 of 91 (18%)
				Hospital mortality	aOR 0.81 (95% CI 0.34 to 1.96; $P = 0.65$)	12 of 45 (27%) *vs* 28 of 91 (31%)
Jaber 2006 ([169]) ($n = 220$)	Multicentre; observational cohort in ICU	C	≥ 3 attempts	Hypoxemia (SaO_2 < 80%)	cRR 1.7[1] (95% CI 1.0 to 2.7; $P = 0.06$)	12 of 30 (40%) *vs* 54 of 223 (24%)
				Hemodynamic collapse (SBP < 65 mmHg or < 90 mmHg for 30 min)	cRR 0.90[1] (95% CI 0.45 to 1.8; $P = 0.75$)	7 of 30 (23%) *vs* 58 of 223 (26%)
Mort 2004 ([5]) ($n = 2,833$)	Single centre; observational cohort study of non-OR intubations	C	≥ 3 attempts	Hypoxemia (SaO_2 < 90%)	cRR 6.7[1] (95% CI 5.8 to 7.6; $P < 0.0001$)	198 of 283 (70%) *vs* 268 of 2,549 (10.5%)[1]
				Aspiration	cRR 16.7[1] (95% CI 9.8 to 28.3, $P < 0.0001$)	37 of 283 (13%) *vs* 20 of 2,549 (0.8%)[1]
				Bradycardia (heart rate < 40 beats•min^{-1} if >20% decrease from baseline)	cRR 11.4[1] (95% CI 7.7 to 16.9, $P < 0.0001$)	52 of 283 (18.5%) *vs* 41 of 2,549 (1.6%)[1]
				Cardiac arrest	cRR 15.5[1] (95% CI 8.8 to 27.4, $P < 0.0001$)	31 of 283 (11%) *vs* 18 of 2,549 (0.7%)[1]
Mort 2004 ([170]) ($n = 60$)	Single centre; case series of patients with cardiac arrest of non-OR intubations	C	≥ 3 attempts	Hypoxemia (SaO_2 < 85%)	cRR 1.9[1] (95% CI 1.3 to 2.8; $P < 0.0001$)	37 of 37 (100%) *vs* 12 of 23 (52%)

Table 3 continued

Author, year, (reference) (sample size)	Design, location	Overall LOE	Summary of Findings			
			Predictor	Outcome	Relative effect	Absolute effect
Le Tacon 2000 ([171]) ($n = 80$)	Single centre; observational cohort in ICU	C	≥ 3 attempts	Any complication	cRR 3.0[1] (95% CI 1.7 to 5.2; $P = 0.0004$)	12 of 18 (67%) *vs* 14 of 62 (23%)
Rose 1994 ([39]) ($n = 18{,}205$)	Single centre; observational cohort of OR patients	C	≥ 3 attempts	Hypoxemia ($SaO_2 < 90\%$ or $PaO_2 < 60$ mmHg)	cRR 5.7[1] (95% CI 2.5 to 13.1; $P < 0.0001$)	6 of 326 (1.8%) *vs* 57 of 17,577 (0.3%)[1]
				Tachycardia (heart rate > 120 beats•min^{-1} for > 10 min)	cRR 1.8[1] (95% CI: 0.96 to 3.6, $P = 0.06$)	9 of 326 (2.8%) *vs* 263 of 17,577 (1.5%)[1]
				Hypertension (SBP > 200 mmHg for > 5 min)	cRR 2.7[1] (95% CI 1.4 to 5.3; $P = 0.002$)	9 of 326 (2.8%) *vs* 178 of 17,577 (1%)[1]
				Esophageal intubation	cRR 27.0[1] (95% CI 18.0 to 40.3; $P < 0.0001$)	33 of 326 (10%) *vs* 66 of 17,577 (3.8%)[1]
				Dental damage	cRR 30.8[1] (95% CI 9.1 to 104.8; $P < 0.0001$)	4 of 326 (1.2%) *vs* 7 of 17,577 (0.04%)[1]

aOR = adjusted odds ratio; cRR = crude risk ratio; aHR = adjusted hazard ratio; SBP = systolic blood pressure; SaO_2 = arterial saturation of oxygen; RCT = randomized controlled trial; IDS = intubation difficulty scale; ICU = intensive care unit; ED = emergency department; LOE = level of evidence; OR = operating room

[1] Calculated from values presented in manuscript

surgery under regional anesthesia. While there is no evidence to support the contention that awakening the elective surgical patient will confer an outcome benefit when tracheal intubation has failed, this option is supported by expert consensus to prevent deterioration to a failed oxygenation, "cannot intubate, cannot oxygenate" scenario.

- **Proceeding with surgery (or temporizing an emergency situation) using face mask or SGD ventilation**. As an exit strategy for failed tracheal intubation in the induced/unconscious patient, the benefit of proceeding with surgery under face mask or SGD ventilation must exceed the risk of foregoing tracheal intubation. In general, this will be easier to justify for brief or urgent surgeries, although risk of aspiration must be considered. If surgery proceeds under face mask or SGD ventilation, a plan should exist for difficulty with or failure of oxygenation during the case. The critically ill non-surgical patient temporized with face mask or SGD ventilation will likely still require tracheal intubation or a surgical airway, sooner rather than later.
- **Obtaining equipment or additional expert help for a further controlled attempt at tracheal intubation**. There is no doubt that minimizing tracheal intubation attempts is a sound principle. Nevertheless, the goal of engaging an exit strategy is *not* necessarily to prohibit more than three intubation attempts so much as to serve as a warning that further attempts may be attended by increasing patient harm and decreasing chances of success. Consequently, an "exit strategy" attempt at tracheal intubation should occur only with a high likelihood of success and a low probability of creating complications. For example, if a SGD had been placed after three failed attempts at tracheal intubation, bronchoscopy-aided intubation could have ensued via the SGD once an appropriate flexible bronchoscope became available. Alternatively, if additional expert help had been available, another attempt at intubation could have occurred with the same or a different device, being mindful of the need to avoid traumatizing the airway during the attempt.
- **Proceeding with surgical access**. In rare circumstances, it may be appropriate to proceed with surgical access (cricothyrotomy or tracheotomy) following failed tracheal intubation in the adequately oxygenated unconscious/induced patient. This may be required if awakening the patient is not an option, i.e., most often in urgent or emergency situations.

Failed tracheal intubation may be apparent and an exit strategy engaged *before* three attempts at intubation have occurred, even after a single unsuccessful attempt.

Failed oxygenation during attempted tracheal intubation: the emergency strategy

Failed oxygenation ("cannot intubate, cannot oxygenate" [CICO]) exists following failed tracheal intubation if the patient cannot be successfully oxygenated by optimized face mask or SGD ventilation (Fig. 1). Three corrective measures are vital: immediate recognition, a call for help, and preparation for proceeding rapidly with a surgical/transtracheal airway (most often cricothyrotomy in the adult patient).

Due to the rarity of this situation, clinicians commonly exhibit a lack of situation awareness when failed oxygenation/CICO is encountered, having become fixated on multiple unproductive attempts at tracheal intubation or SGD placement. The failure to recognize failed oxygenation/CICO and respond appropriately has been shown to delay cricothyrotomy, resulting in cerebral hypoxia and cardiac arrest.[6,9] It is imperative that all members of the assembled team be empowered to call for help or raise the need for emergency cricothyrotomy.

The Focus Group was reluctant to recommend a specific arterial oxygen saturation (SaO_2) trigger for cricothyrotomy in a failed oxygenation/CICO situation. Nevertheless, given the sigmoid shape of the oxyhemoglobin dissociation curve, as SaO_2 descends through 90%, the rate of desaturation will accelerate if efforts at oxygenation remain unsuccessful. A failed oxygenation/CICO situation with a rapidly declining SaO_2 despite maximum attempts at oxygenation should be taken as an indication for cricothyrotomy, especially with the onset of bradycardia.[172,173]

Published case series[174-176] and reports[38,177-180] have described successful rescue oxygenation in failed oxygenation/CICO scenarios with placement of a SGD. Although recommended by national guidelines in many countries,[12,17,172,181,182] evidence is lacking on whether outcome is improved with attempted SGD placement prior to cricothyrotomy in failed oxygenation/CICO situations. Regardless, if failed oxygenation/CICO occurs, one attempt should be made at placing an appropriately sized SGD familiar to the operator, unless this has previously failed (Strong recommendation ***for,*** level of evidence ***C***). During this SGD attempt, a second individual should simultaneously prepare equipment and the patient's neck for cricothyrotomy. If oxygenation is not restored via the SGD, immediate cricothyrotomy should proceed without further attempts at either SGD placement or transglottic tracheal intubation (Strong recommendation ***for,*** level of evidence ***C***). As it takes longer than cricothyrotomy, retrograde intubation is not recommended in failed oxygenation/CICO scenarios.

For emergency subglottic transtracheal access, cricothyrotomy is most often recommended in adults over tracheotomy, particularly when performed by a non-surgeon. This is advocated because the space is less vascular and more readily palpable.

Cricothyrotomy can be categorized as surgical or non-surgical. Surgical cricothyrotomy involves the use of a scalpel to incise the skin and cricothyroid membrane, with placement of a small (e.g., 6.0-mm internal diameter [ID] in the adult) endotracheal or tracheostomy tube. Other instruments needed for the procedure may include a tracheal hook, a Trousseau dilator, or a tracheal tube introducer.[183]

Non-surgical cricothyrotomy involves one of two options: percutaneous insertion of a wide bore ($\geq$ 4-mm ID) cannula by either cannula-over-needle or Seldinger wire-guided (e.g., Melker) techniques, or percutaneous insertion of a narrow bore ($\leq$ 2-mm) intravenous-type cannula. Narrow-bore cricothyrotomy with jet ventilation requires a high-pressure ventilation source in adults (not universally available in all airway management locations); it is more likely to result in breath stacking, barotrauma, catheter kinking, or dislodgement, and does not provide airway protection with a cuff. Of the available options, it is associated with the highest complication and failure rates.[6,9,10] Unless the clinician is very experienced with jet ventilation, this suggests that options in failed oxygenation/CICO in the adult patient should be limited to either the percutaneous needle-guided wide-bore cannula or the open surgical technique (Strong recommendation ***for***, level of evidence ***C***). Both percutaneous wide-bore cannula and open surgical choices allow the desirable option of placing a cuffed tracheal cannula/tube.

There is some evidence that the percutaneous needle-guided wide-bore cannula technique may be less effective than the open surgical procedure.[9,10,184] Nevertheless, a recent survey suggested that Canadian anesthesiologists were most comfortable with a percutaneous technique.[185] On balance, we recommend that adult cricothyrotomy should proceed with either a percutaneous needle-guided wide-bore cannula or an open surgical technique, governed by operator preference and equipment availability. Even so, mindful of the significant reported failure rates of the percutaneous techniques, clinicians must be prepared for immediate conversion to an open surgical technique should the percutaneous needle-guided technique fail.

Recent studies suggest that anesthesia providers may have difficulty with correctly identifying the cricothyroid membrane using external landmarks.[186,187] This may argue for always beginning cricothyrotomy with a 3-cm vertical midline incision over the presumed location of the cricothyroid membrane (Weak recommendation ***for***, level of evidence ***C***), at least in the patient with indistinct external landmarks. The cricothyroid membrane may then be more accurately identified within the incision, and the

cricothyrotomy can continue with either a needle-guided wide-bore cannula or surgical technique.

As one of the major complications of cricothyrotomy placement is false passage, correct cannula or tube location must be objectively confirmed using capnography or endoscopy.

Even if administering (or re-dosing) a neuromuscular blocking agent is not indicated as part of the initial management plan, once a failed oxygenation/CICO situation occurs, it should be considered to address possible laryngospasm and facilitate face mask ventilation (Weak recommendation ***for***, level of evidence ***C***).[48] Secondly, if bradycardia should occur, administration of epinephrine or atropine may forestall cardiac standstill. In both instances, these actions are to be delegated to an assistant and must not delay cricothyrotomy.

As an infrequently-performed yet life-saving procedure, all airway managers must acquire and maintain cricothyrotomy skills through educational programs. Cricothyrotomy equipment should be readily accessible, and all clinicians and ancillary staff should know its location.

Tracheal intubation confirmation

The persistent presence of exhaled carbon dioxide "appropriate to the clinical circumstance" provides objective confirmation of tracheal intubation.[12] Visualization of a tracheal tube between the cords or endoscopic visualization of the subglottic airway through a tracheal tube can provide additional confirmation.[12] Chest rise and auscultation, tube misting, chest radiography, and pulse oximetry are not robust indicators of successful tracheal intubation.

In the NAP4 study, many complications of airway management reported in the emergency department (ED) and ICU were related to unrecognized esophageal intubation or tracheal tube dislodgements. The inconsistent use of capnography for confirmation of tracheal intubation or the lack of continuous capnographic monitoring of already intubated patients was judged contributory.[10] Thus, capnographic confirmation of tracheal tube placement should occur for all hospitalized patients (Strong recommendation ***for,*** level of evidence ***B***), and ongoing continuous waveform capnographic monitoring should occur for the duration of intubation and ventilation (Strong recommendation ***for,*** level of evidence ***C***). The latter recommendation will facilitate early detection of tube dislodgement as well as inadvertent hyper- or hypoventilation.

Additionally, NAP4 found that the absence of a capnographic waveform in the setting of cardiac arrest was sometimes incorrectly ascribed to the absence of pulmonary perfusion without consideration of either esophageal intubation or a completely obstructed tracheal tube or trachea.[9,10] This occurred in OR, ED, and ICU environments. In actual fact, the first 30 min of cardiac arrest with adequate chest compressions is often associated with an attenuated but present capnography trace when the tracheal tube is correctly situated and unobstructed.[188] A flat capnograph should prompt exclusion of a misplaced or blocked tracheal tube.

Continuous capnographic monitoring has also been recommended for patients without tracheal intubation who are undergoing deeper levels of procedural sedation (e.g., Ramsay sedation scores 4-6).[189]

The obstetric airway: special considerations

A higher incidence of failed tracheal intubation has been reported in the parturient than in the general surgical population.[31,32,190] Nevertheless, in series originating in jurisdictions with either a high volume of obstetrical general anesthetics or coverage limited to senior trainee or consultant anesthesia staff, the incidence of failed intubation is more consistent with that of general surgical cases.[30,191,192] This should not induce complacency, however, as multiple issues can converge and potentially contribute to airway-related morbidity in the parturient[193] (Table 4). To help mitigate these factors, it is essential that obstetrical units have appropriately trained staff and airway equipment that is immediately accessible and of the same quality and type (e.g., video laryngoscopes) as that used in the main surgical ORs of the facility (Strong recommendation ***for***, level of evidence ***C***).

Difficult and failed tracheal intubations may be avoided by the more frequent use of regional anesthesia for obstetric surgical procedures.[192,201,202] High levels of anesthetic skill and experience facilitate effective and rapid neuraxial anesthesia in many emergency situations.[202] On the other hand, as general anesthesia rates continue to fall, there is ongoing concern that trainees are not being adequately exposed to airway management of the parturient—many tertiary care centres now typically have general anesthesia rates of 5-7% for Cesarean delivery.[32,202]

Avoiding a bad airway-related outcome – first steps: Antenatal airway screening of all parturients should ideally occur to identify potential challenges.[30,203-205] Once a parturient with difficult airway anatomy is identified, good communication is crucial. A plan should be formulated with the attending obstetrician with the understanding that, if operative delivery is likely, it should occur under controlled conditions. Early placement of an epidural catheter should be considered. The catheter should be tested to confirm its efficacy so that rapid conversion to a surgical level of anesthesia can occur for emergency

Table 4 Factors with the potential to have an adverse impact on airway-related morbidity in the parturient

Parturient anatomy and physiology
• Reduced oxygenated apnea time due to increased oxygen consumption and decreased functional residual capacity.[194-196] Exacerbated by labour, increased body mass index (BMI), sepsis,[195] or suboptimal pre-oxygenation;
• Increases in parturient age and BMI increase the tendency toward pre-eclampsia and snoring;[197]
• Anatomic factors: weight gain, breast enlargement, and upper airway edema occurring with pregnancy-induced hypertension or prolonged labour;[198,199]
• Propensity to regurgitate gastric contents.
Environment
• Historically, many obstetric units have been in an isolated location:
– Units may be poorly equipped with airway equipment;
– Units can lack experienced anesthetic support;
• "Out of hours" work may preclude availability of help from other skilled colleagues.
Human factors
• Stressful nature of urgent Cesarean deliveries:
– Time pressure: most general anesthetics involve fetal or maternal emergency;
– Obstetrician expectation of rapid induction-to-delivery time;
– Patient and family expectations of a happy outcome: emotionally charged atmosphere.
System issues
• Jurisdictions allowing unsupervised junior trainees to perform general anesthetics in parturients – poor judgement and inexperience are the commonest extrinsic factors contributing to airway disasters.[9,200]

Cesarean delivery. If the epidural is not working and time permits, it should be re-sited. Once the need for general anesthesia becomes apparent, the attending anesthesiologist should perform a formal assessment of the airway. The patient should be given pharmacologic anti-aspiration prophylaxis (Strong recommendation ***for***, level of evidence ***C***).

For induction of general anesthesia, all parturients should be appropriately positioned (e.g., "ramped" as needed to ensure the patient's external auditory meatus is level with the sternal notch).[206] Pre-oxygenation should occur using high flow rates of oxygen, with tidal volume breathing for three minutes, if time permits, or eight deep breaths over 60 sec[207] (Strong recommendation ***for***, level of evidence ***B***). Cricoid pressure should be applied with induction and maintained as appropriate until the airway is secured. Succinylcholine is generally used to facilitate laryngoscopy if no contraindication exists. After induction, face mask ventilation with low insufflation pressures *can* occur while awaiting full onset of neuromuscular blockade. This is carried out both to extend oxygenated apnea time during tracheal intubation and to anticipate ease of face mask ventilation should a first attempt at intubation fail (Strong recommendation ***for***, level of evidence ***C***). Although this recommendation is a departure from the classic teaching of avoiding face mask ventilation during rapid sequence induction, the potential benefit of oxygenation probably outweighs the small risk of gastric insufflation causing regurgitation, especially if insufflation pressures are kept < 20 cm H_2O.[172,208]

Failed primary attempt at intubation encountered in an induced/unconscious parturient: If a first attempt at tracheal intubation fails despite optimized technique, gentle face mask ventilation should be resumed (Fig. 2), and help summoned. Cricoid pressure should be maintained unless thought to be contributing to difficulty. Any difficulty with face mask ventilation should be met with a standard response of oropharyngeal airway insertion, two-handed mask hold with exaggerated jaw thrust, incremental release of cricoid pressure, and if necessary, SGD placement. If oxygenation is non-problematic, a second tracheal intubation attempt can occur with the following provisos: there must be a reasonable likelihood of success based on findings at the initial attempt and a different technique (e.g., video laryngoscopy) or operator should be employed.

Exit strategy – failed tracheal intubation in the oxygenated parturient with *NO* fetal or maternal emergency: If tracheal intubation has failed and further attempts are predicted to have a low incremental likelihood of succeeding, the acuteness of the situation should be assessed. With no fetal or maternal emergency, the goal should be to maintain oxygenation and allow the parturient to emerge from general anesthesia. At that point, a decision can be made to revisit regional anesthesia (if not contraindicated) or proceed with awake tracheal intubation for general anesthesia. If face mask ventilation becomes difficult, a SGD should be placed to assist oxygenation while awaiting emergence from anesthesia.

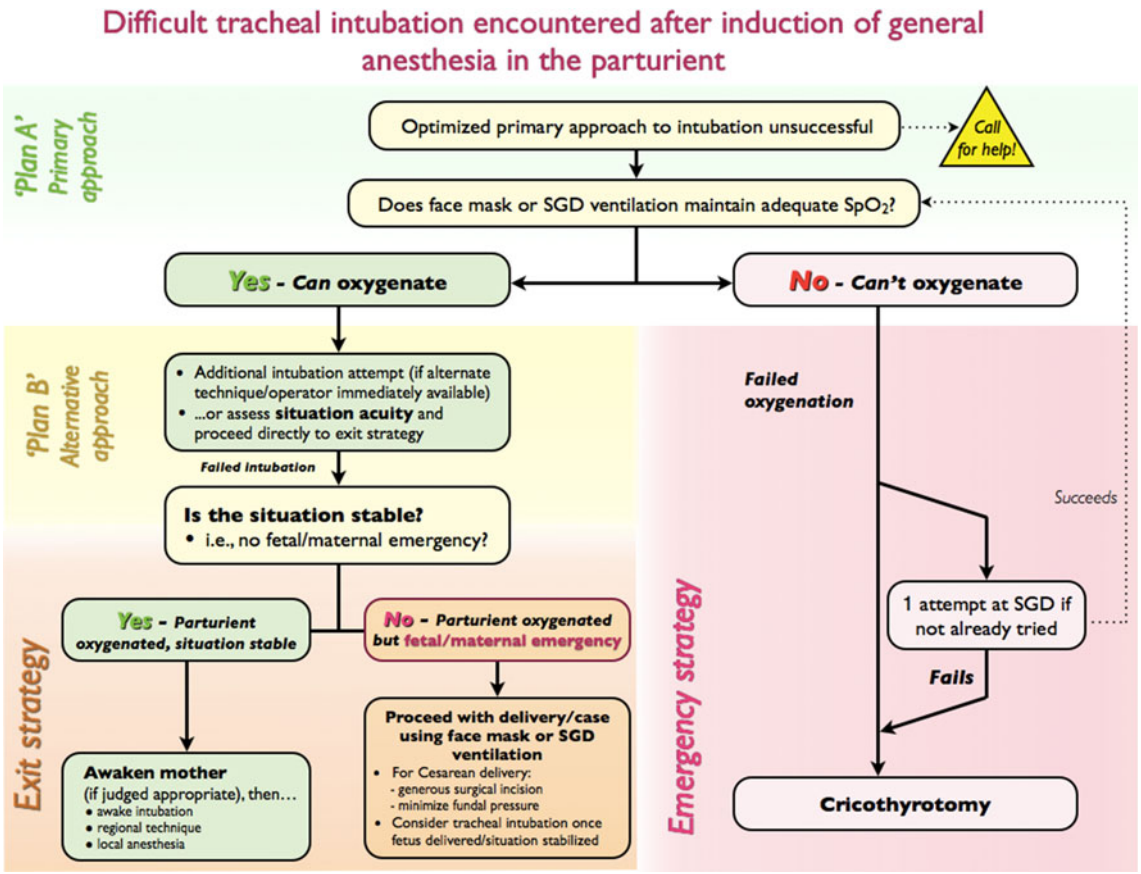

Fig. 2 Flow diagram: difficult tracheal intubation encountered after induction of general anesthesia in the parturient. SGD = supraglottic device

Use of a SGD with a second lumen to allow esophageal and gastric venting should be considered.

Exit strategy – failed tracheal intubation in the oxygenated parturient *WITH* fetal or maternal emergency: If persistent fetal distress or a maternal emergency exists following failed tracheal intubation in the adequately oxygenated parturient, Cesarean delivery and/or maternal resuscitation can proceed with face mask or SGD ventilation. Cricoid pressure should be released for SGD insertion. Most Focus Group members agree that re-applying cricoid pressure is unlikely to be beneficial after placement of a SGD with an esophageal port. After failed tracheal intubation for Cesarean delivery under face mask or SGD ventilation in an emergency, the obstetrician should be requested to make a generous surgical incision and to minimize fundal pressure or use vacuum extraction at the time of delivery[209] (Strong recommendation ***for***, level of evidence ***B***). With uncomplicated and expeditious surgery, the procedure can be completed with face mask or SGD ventilation. If the case is complex, once the fetus has been delivered or the maternal emergency is stabilized, a cuffed tracheal tube can be placed under more controlled conditions (e.g., flexible bronchoscopic-aided intubation through a SGD), if required. If conditions permit, the surgery should be halted temporarily while the airway is secured, with optimized patient positioning and obstructing drapes moved aside.

A number of observational studies from outside North America have been published on using SGDs for elective Cesarean delivery in a select group of women. The subjects in these studies were of normal body mass index and well-fasted; they had anti-aspiration prophylaxis and underwent quick uncomplicated surgery. Although each study used a different version of the Laryngeal Mask Airway (LMA^{TM}), they were consistent in reporting a high rate of successful SGD placement and ventilation.[44-46] In North America, with general anesthesia reserved mainly for emergency cases and with parturients typically having a higher body mass index, SGDs cannot be recommended for elective Cesarean delivery at this time (Strong recommendation ***against***, level of evidence ***B***). Nevertheless, these and other studies[190] do support the early use of a SGD in any airway rescue scenario in the parturient (Strong recommendation ***for***, level of evidence ***B***).

Emergency strategy – failed intubation, oxygenation *NOT* possible with face mask or SGD ventilation:

Following a failed attempt at tracheal intubation, the failure to oxygenate the parturient with face mask or SGD ventilation (failed oxygenation/CICO) will also quickly result in fetal compromise. As with the general surgical patient, the default response to this scenario is cricothyrotomy, with a parallel bridging attempt at oxygenation with a SGD if not already tried. Once the patient is re-oxygenated via SGD or cuffed cricothyrotomy cannula, Cesarean delivery or further resuscitation can occur if a fetal or maternal emergency exists; however, if the situation is now stable, optionally, the patient can be awakened and a plan can be made for definitive care.

It must be emphasized that the failed oxygenation/CICO scenario implies a complete inability to oxygenate the patient. In this situation, the parturient will undergo rapid oxygen desaturation, indicating why further attempts at tracheal intubation are contraindicated and also why it would be impractical to allow the mother to wake.

Extubation and the postpartum period: Recent maternal mortality statistics from both the United States and United Kingdom indicate a shift in many airway catastrophes from induction of general anesthesia to the postpartum period, i.e., at emergence, in the postanesthesia unit, or when applied for postpartum surgical procedures.[210,211] Heightened vigilance during these phases is clearly required.

The pediatric airway: special considerations

Respiratory complications continue to be a major source of morbidity in children requiring airway management.[212,213] Despite this, difficult DL is rare in an otherwise healthy child. In an audit of 11,219 pediatric general anesthetics in a tertiary care centre, the incidence of difficult DL (Cormack-Lehane grade 3 or 4 views) was 4.7% in children less than one year of age and 0.7% in children older than one year.[214] In another audit of 24,165 anesthetics in a tertiary care pediatric centre, the frequency of unanticipated difficult tracheal intubations was 0.24% in children less than one year of age and 0.07% in children older than one year.[213] These figures may reflect a higher than expected incidence compared with that encountered in community hospitals due to referral bias.

Unexpected difficult face mask ventilation is also rare in pediatrics. When difficult mask ventilation is encountered, causes such as laryngospasm or gastric distension must be considered. Clinicians should include the unexpected in their differential diagnosis, such as congenital airway anomalies or airway obstruction by foreign bodies.[215] The pediatric airway is very susceptible to trauma when compared with the adult airway, and repeated attempts at intubation may result in more swelling and subsequent airway compromise. Rapid desaturation during apnea and a lack of patient cooperation are additional significant considerations.

Video laryngoscopy: Many case reports describe video laryngoscopy facilitating successful tracheal intubation in children with difficult airways. As with adults, the majority of current studies show that use of certain video laryngoscopes can facilitate an improved glottic view when compared with DL in pediatric patients with a reassuring airway exam. However, time to intubation is either unchanged or prolonged.[216-219] In one pilot study in pediatric patients with known or anticipated difficult airways, use of the GlideScope Cobalt™ resulted in a significantly improved glottic view compared with DL in 17 of 18 patients, although tracheal intubation failed when using the device in three of the 18 patients.[220] Despite the lack of published pediatric studies, video laryngoscopy has the potential to be useful in the pediatric difficult airway.

Cuffed *vs* uncuffed tracheal tubes in children: There is no direct evidence that use of a cuffed tracheal tube in children will cause more subglottic injury or iatrogenic stenosis than an uncuffed tube.[221,222] Use of a cuffed tracheal tube will minimize need for re-intubation,[221] decrease the potential for loss of effective ventilation,[223] and may protect against micro-aspiration.[224] As long as close attention is paid to maintaining an adequate air leak (i.e., occurring at < 20-25 cm H_2O) and/or monitoring cuff pressure, a recommendation can be made to use cuffed tracheal tubes for all difficult or emergency pediatric tracheal intubations (Strong recommendation ***for***, level of evidence ***B***).

SGDs in the difficult pediatric airway: Apart from case reports, little published evidence exists on the use of SGDs in the setting of difficult DL, difficult airway, or failed oxygenation/CICO situations in children. Case series support the use of SGDs, such as the LMA Classic™ and the air-Q® Intubating Laryngeal Airway, as conduits for intubation when difficult pediatric DL is encountered or anticipated.[99,100,225-227] In most of these series, intubation was facilitated with flexible or semi-rigid endoscopy through the SGD. In a failed oxygenation/CICO situation, as with adult recommendations, an attempt should be made to oxygenate the pediatric patient with a SGD while equipment is being prepared for a surgical airway.

Transtracheal/surgical airway: Failed oxygenation/CICO situations are rare in children. The best strategy for emergency transtracheal oxygenation in children under 8-10 years of age remains unclear. In this population, the cricothyroid space is underdeveloped, leaving needle tracheotomy or surgical tracheotomy below the cricoid

ring as the only options for transtracheal access. Depending on the pathology (e.g. subglottic stenosis, tracheal foreign body), rigid bronchoscopy may be the intervention of choice. In children older than eight to ten years of age, the vertical span of the cricothyroid space enlarges sufficiently to accommodate several of the commercially available cricothyrotomy products, although some of these devices have been associated with tracheal damage in animal models.[228,229]

The few reports on emergency transtracheal airway access in children under age 18 vary greatly in circumstances, equipment used, and patient age.[9,230-233] Experience with transtracheal catheters placed for *elective* pediatric surgical procedures suggests that, despite controlled conditions, use of jet ventilation through such catheters is associated with a significant rate of complications, including barotrauma.[234-236] Animal[237,238] and bench[239] modelling indicate that adequate oxygenation can be provided through transtracheal catheters without the use of jet ventilation.

In children younger than eight to ten years in a failed oxygenation/CICO situation, help should be summoned, and if not already attempted, a SGD should be placed while equipment is readied for surgical or needle tracheotomy (or rigid bronchoscopy, when indicated) (Strong recommendation ***for***, level of evidence ***C***). For the needle tracheotomy option, a kink-resistant[240] catheter specifically made for this purpose should be used. Oxygenation can be provided via an Enk Oxygen Flow Modulator™ (Cook Medical, Bloomington, IN) with a flow rate of 1 L per year of age[239] and an inspiratory-to-expiratory (I:E) ratio sufficient to allow expiration. As full expiration of tidal volume will not occur through the transtracheal catheter, continued attempts at airway-opening maneuvers and securing a definitive airway are essential.

Documentation following an encounter with a difficult airway

Appropriate documentation should be completed following every airway intervention, difficult or otherwise. The record should make specific mention of ease of face mask or SGD ventilation, the device used to perform tracheal intubation, the view obtained, and the number of attempts (Strong recommendation ***for***, level of evidence ***C***).

If airway management is difficult once, it seems intuitive that subsequent attempts will also be difficult, although patient, operator, or equipment factors may differ significantly. There is some evidence that a previously designated difficult or failed DL or intubation does confer a higher likelihood of encountering similar circumstances on a subsequent occasion.[29,241,242] However, pertinent high-level prospective outcome studies using precise definitions are currently lacking, and may never be published. Even so, experts agree that it seems likely that good documentation and dissemination of difficult airway information may reduce critical airway events. The CAFG advocates a multi-layered strategy appropriate to the local system when a difficult airway situation has been encountered. At a minimum, this should include clear and accurate documentation in the patient's medical record, personally informing the patient and the patient's surgeon, and providing a difficult airway letter to the patient with copies to both the chart and the primary care provider.

Electronic recording and alert systems are advances over traditional handwritten records. In-hospital alert bracelets and local or national databases (e.g., the MedicAlert Foundation) should also be considered. Such databases have the advantage of being widely accessible without restriction of space or jurisdiction.

While subjective, the trigger for invoking this multi-layered strategy may include factors such as an inability to visualize the larynx, very difficult or impossible face mask ventilation, or opinion that future airway interventions would occur most safely with the patient awake.

Copies of a difficult airway alert letter (e.g., Appendix 1) should be stocked in locations where airway management regularly occurs. The content and structure of information contained in airway alerts should be clear and complete to maximize both patient safety and the potential for future database research.

The corollary of performing good documentation is the need for clinicians to augment the bedside airway assessment by seeking additional information from a hospital chart, letter, or database sources, when available, especially when significant difficulty is anticipated. Nevertheless, as highlighted by NAP4, anticipating difficulty is of no benefit unless the airway management strategy is modified accordingly.[243]

Education in difficult airway management

Management of the difficult airway requires technical and non-technical skills.[244] Technical skills are defined as the specific medical knowledge and procedural ability required for managing the airway. Non-technical skills are generalizable skills required to manage dynamic high-risk/low-frequency crisis situations. These non-technical skills include leadership, teamwork, situational awareness, task management, and decision-making.[245]

Dedicated experiential learning and deliberate practice is beneficial for airway management, but because difficult airways are low-frequency events, it is not appropriate to learn best management algorithms and techniques in the

clinical setting.[246] As an alternative, simulation provides a proven platform for the acquisition of airway-related technical skills without risk to patients. These skills transfer well to the clinical setting across different learner experience and various device and simulation modalities.[247-250] Unfortunately, learning patterns and curves of airway-related technical skills cannot be generalized, as they vary and depend on a clinician's cumulative experience in the simulated and live setting.[251-254] There is no "magic number" for competence in using a particular device or for managing a specific situation. Non-technical skills must also be learned and have been shown to improve with repeated simulation scenarios;[255-257] however, further research is needed to show that the acquisition of non-technical skills translates to improved patient outcomes in the clinical setting.

Most importantly, there is demonstrable evidence that both technical and non-technical skills in difficult airway management weaken with time.[258,259] The infrequency of these clinical events demands that proficiency be addressed through continuing education workshops that provide an opportunity for active experiential learning and formative assessment with feedback. Simulation has been used to improve difficult airway management skills in practicing physicians, with improvement being retained for as long as a year.[260] Educators are currently researching the maximum time interval before significant attrition of skills in order to guide continuing professional development revalidation guidelines.

Summary of recommendations

Face mask ventilation

1. Difficult mask ventilation of the unconscious patient should be met with a graduated response, including use of an oropharyngeal and/or nasopharyngeal airway, use of a two-handed face mask hold, and exaggerated head extension, unless contraindicated – **Strong recommendation *for*, level of evidence C.**
2. If difficult face mask ventilation is encountered unresponsive to standard measures of oropharyngeal airway insertion, two-handed mask hold and exaggerated head extension, a trial of progressive release of any applied cricoid pressure should be considered – **Weak recommendation *for*, level of evidence C.**

Supraglottic device use

1. If a failed oxygenation, "cannot intubate, cannot oxygenate" (CICO) situation occurs, one attempt at placing an appropriately sized SGD familiar to the operator should be performed to attempt rescue oxygenation, unless this has previously failed – **Strong recommendation *for*, level of evidence C.**

Tracheal intubation

1. All clinicians with a mandate for airway management should be familiar with at least one alternative technique to DL (e.g., video laryngoscopy) to enable tracheal intubation – **Strong recommendation *for*, level of evidence C.**
2. If a poor view is obtained during DL despite an appropriately positioned patient and laryngoscope blade tip, external laryngeal pressure should be applied to improve the view – **Strong recommendation *for*, level of evidence A.**
3. Cricoid pressure should not be applied for the sole purpose of improving the view during DL – **Weak recommendation *against*, level of evidence B.**
4. If a restricted view obtained during DL persists after optimization maneuvers such as application of external laryngeal pressure or additional head lift, use of a tracheal tube introducer should be considered – **Strong recommendation *for*, level of evidence B.**
5. Capnographic confirmation of tracheal tube placement should occur for all patients in all hospital locations – **Strong recommendation *for*, level of evidence B.**
6. Continuous capnographic monitoring should occur in all hospital locations for all patients with an intubated trachea – **Strong recommendation *for*, level of evidence C.**
7. If failed intubation is encountered, when feasible, the option of allowing an induced oxygenated patient to wake should be considered as an exit strategy – **Weak recommendation *for*, level of evidence C.**

Emergency surgical airway

1. In a failed oxygenation/CICO situation, if oxygenation is not restored via a SGD, immediate cricothyrotomy should occur without further attempts at either SGD placement or transglottic tracheal intubation – **Strong recommendation *for*, level of evidence C.**
2. For emergency cricothyrotomy in the adult patient, unless the clinician is very experienced with jet ventilation, options should be limited to either the percutaneous needle-guided wide-bore cannula or an

open surgical technique – **Strong recommendation *for*, level of evidence C**.

3. At least in the patient with indistinct external landmarks in the neck, cricothyrotomy (by any technique) should begin with a 3-cm vertical midline incision over the presumed location of the cricothyroid membrane – **Weak recommendation *for*, level of evidence C.**
4. Even if not indicated as part of the initial management plan, once a patient is in a failed oxygenation/CICO situation, administering (or re-dosing) a neuromuscular blocking agent should be considered to address possible laryngospasm and facilitate face mask ventilation – **Weak recommendation *for*, level of evidence C.**

Obstetrics

1. After failed tracheal intubation during induction of GA for emergency Cesarean delivery, if proceeding under face mask or SGD ventilation, the obstetrician should be requested to make a generous surgical incision and to minimize fundal pressure or use vacuum extraction at the time of delivery – **Strong recommendation *for,* level of evidence B.**
2. Early use of a SGD should be considered in any airway rescue scenario in the parturient – **Strong recommendation *for,* level of evidence B.**
3. As with the general surgical patient, the default response to a failed oxygenation/CICO scenario in a parturient is cricothyrotomy, with a parallel bridging attempt at oxygenation with a SGD if not already tried – **Strong recommendation *for,* level of evidence B.**
4. Obstetrical units should have appropriately trained staff and good, easily accessible airway equipment of the same quality and type (e.g., video laryngoscopy) as that used in the main surgical ORs of the facility – **Strong recommendation *for,* level of evidence C.**
5. Once the need for general anesthesia becomes apparent, the attending anesthesiologist should perform a formal airway assessment of the obstetrical patient, including localization of the cricothyroid membrane – **Strong recommendation *for,* level of evidence C.**
6. For induction of general anesthesia in the parturient, appropriate patient positioning and pre-oxygenation should occur – **Strong recommendation *for,* level of evidence C.**
7. With induction of general anesthesia in the parturient, face mask ventilation with low insufflation pressures *can* occur after induction while awaiting onset of the full effect of a neuromuscular block – **Strong recommendation *for,* level of evidence C.**

Pediatrics

1. Cuffed endotracheal tubes should be used in difficult or emergency pediatric tracheal intubation – **Strong recommendation *for,* level of evidence B.**
2. For children younger than 8-10 years in a failed oxygenation/CICO situation, help should be summoned, and if not already attempted, a SGD should be placed while equipment is readied for surgical or needle tracheotomy (or rigid bronchoscopy, when indicated) – **Strong recommendation *for*, level of evidence C**.

Documentation

1. Appropriate documentation should be completed following every airway intervention, difficult or otherwise. The record should make specific mention of the ease of face mask or SGD ventilation, the device used to perform tracheal intubation, the view obtained, and the number of attempts – **Strong recommendation *for,* level of evidence C.**

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Appendix 1

Sample template of a difficult airway alert letter: to be given to the patient following a difficult airway encounter, with copies to the hospital chart and the primary care provider. Modified from a previously published example.[12]

[*Your Institution*]

Date: _____

Dear _____:

During most general anesthetics (sleep for surgery), it is necessary to put a breathing tube into the patient's trachea (windpipe). This tube assures oxygen flow to the lungs, heart, brain, and other vital organs.

It is more difficult to place the breathing tube for you than for most people.

It is very important that you show the form on the back of this letter to any anesthesiologist who takes care of you in the future. Your anesthesiologist will be in a much better position to take good care of you if forewarned of this situation.

You should get and wear a MedicAlert bracelet stating **"Difficult Tracheal Intubation".**

If you or your doctors have any questions regarding this matter, please contact the Department of Anesthesiology at the [*Your Institution*], using the above address and telephone number.

Yours sincerely

_____, MD

_____ (Name, printed)

[Your Institution]

To Whom It May Concern:

This patient was anesthetized at the [*Your Institution*] for the following elective ☐ non-elective ☐ case (*please specify procedure*):_____.

Placement of an endotracheal tube was found to be **difficult** using:

- direct laryngoscopy ☐ (view obtained was Cormack-Lehane: **Grade 3** ☐ **Grade 4** ☐)
- other intubation technique(s) ☐ (*please specify*): _____

Comments: _____

Bag/mask oxygenation with an oropharyngeal airway was:
Easy ☐ Difficult ☐ Impossible ☐ Not attempted ☐

Comments: _____

Oxygenation via a supraglottic device (SGD) was:
Easy ☐ Difficult ☐ Impossible ☐ Not attempted ☐

Comments: _____

The airway was ultimately secured:
Asleep ☐ Patient awakened, awake intubation performed ☐ Proceeded with mask or SGD ☐

Other/Comments: _____

If airway secured asleep, successful method was:
- Direct laryngoscopy ☐ (…with blade change ☐ or adjunct, e.g. tracheal tube introducer ☐)
- Video laryngoscope (e.g., GlideScope®, C-MAC, McGrath™ or other) ☐
- Lightwand (e.g., Trachlight™) ☐
- Flexible bronchoscope (FB) ☐
- LMA Fastrach™ or other intubating SGD ☐ … (with blind ☐, or FB-guided ☐ tube passage)

Other/Comments: _____

Suggested consideration(s) for future anesthetics:
- Awake intubation after application of topical airway anesthesia ☐
- Other ☐ (*Please specify):*_____

_____

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