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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).

This article is accompanied by an editorial. Please see Can J Anesth 2013; 60: this issue.

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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

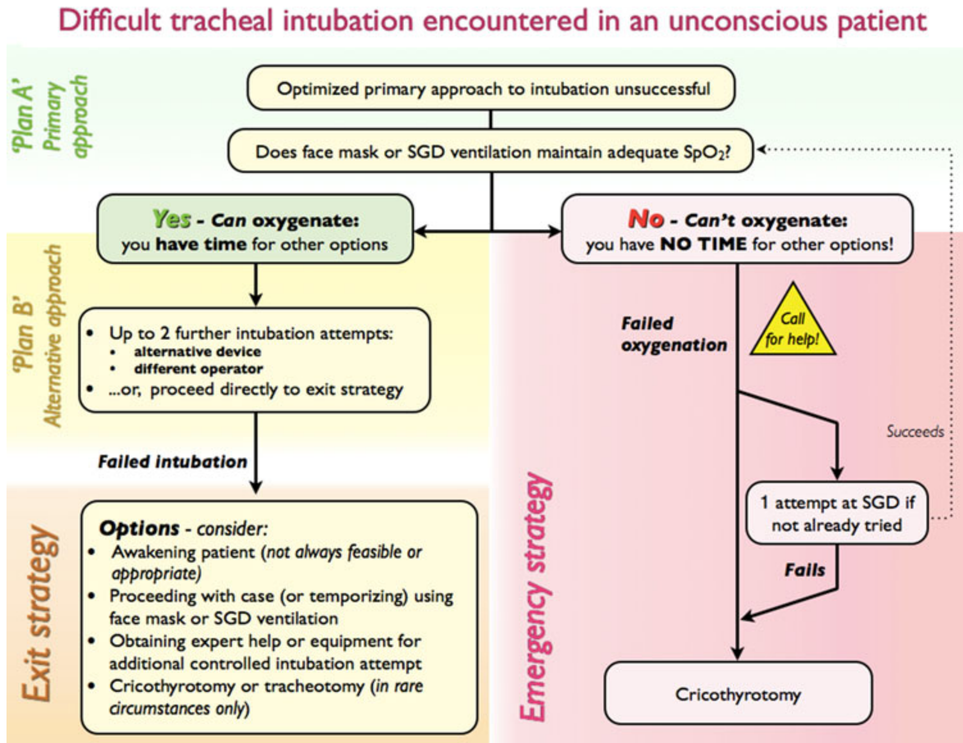

Fig. 1 Flow diagram: difficult tracheal intubation encountered in the unconscious patient. SGD = supraglottic device

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	$\geq$ 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	$\geq$ 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 (≥ 4-mm ID) cannula by either cannula-over-needle or Seldinger wire-guided (e.g., Melker) techniques, or percutaneous insertion of a narrow bore (≤ 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.

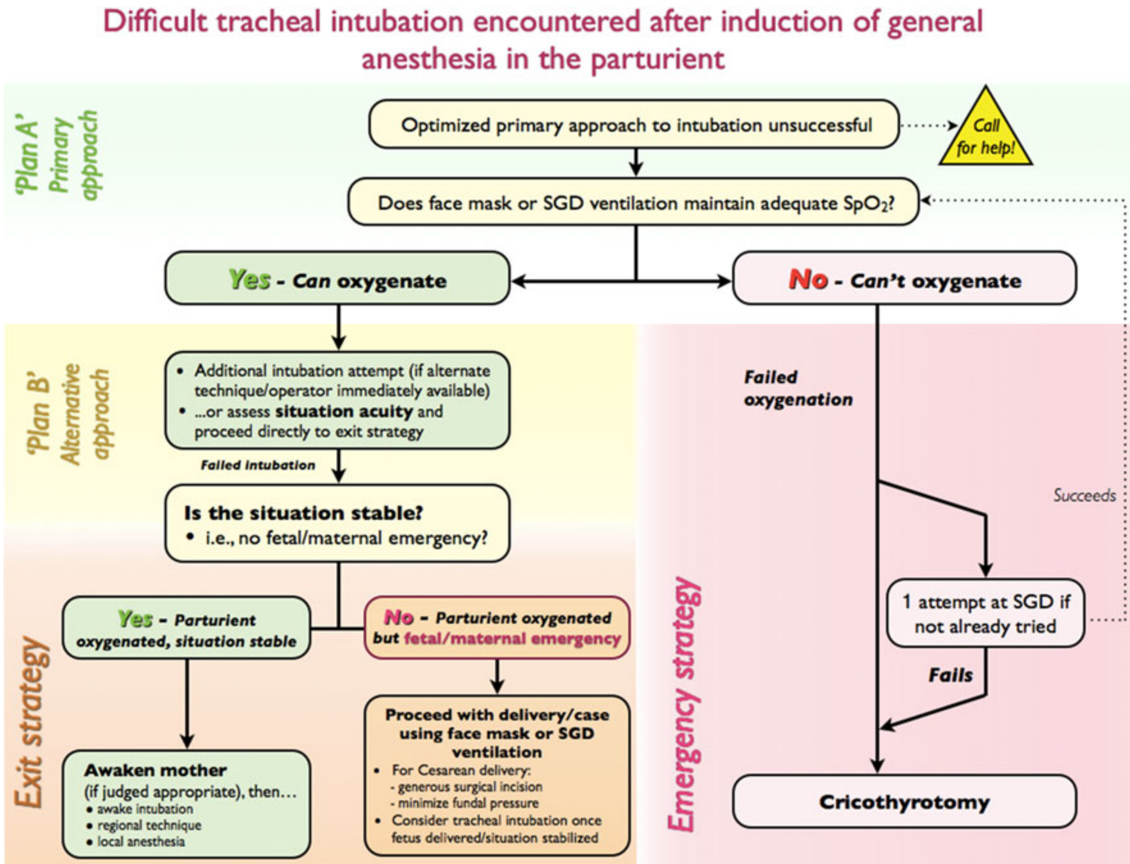

Fig. 2 Flow diagram: difficult tracheal intubation encountered after induction of general anesthesia in the parturient. SGD = supraglottic device

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™), 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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SPECIAL ARTICLE

The difficult airway with recommendations for management – Part 2 – The anticipated difficult airway

Prise en charge des voies aériennes – 2e partie – Recommandations lorsque des difficultés sont prévues

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Abstract
Background *Appropriate planning is crucial to avoid morbidity and mortality when difficulty is anticipated with airway management. Many guidelines developed by national societies have focused on management of difficulty encountered in the unconscious patient; however, little guidance appears in the literature on how best to approach the patient with an anticipated difficult airway.*
Methods *To review this and other subjects, the Canadian Airway Focus Group (CAFG) was re-formed. With representation from anesthesiology, emergency medicine, and critical care, CAFG members were assigned topics for review. As literature reviews were completed, results were presented and discussed during teleconferences and two face-to-face meetings. When appropriate, evidence- or consensus-based recommendations were made, and levels of evidence were assigned.*
Principal findings *Previously published predictors of difficult direct laryngoscopy are widely known. More recent studies report predictors of difficult face mask ventilation, video laryngoscopy, use of a supraglottic device, and cricothyrotomy. All are important facets of a complete airway evaluation and must be considered when difficulty is anticipated with airway management. Many studies now document the increasing patient morbidity that occurs with multiple attempts at tracheal intubation. Therefore, when difficulty is anticipated, tracheal intubation after induction of general anesthesia should be considered only when success with the chosen device(s) can be predicted in a maximum of three attempts. Concomitant predicted difficulty using oxygenation by face mask or supraglottic device ventilation as a fallback makes an awake approach advisable. Contextual issues, such as patient cooperation, availability of additional skilled help, and the clinician's experience, must also be considered in deciding the appropriate strategy.*
Conclusions *With an appropriate airway evaluation and consideration of relevant contextual issues, a rational decision can be made on whether an awake approach to tracheal intubation will maximize patient safety or if airway management can safely proceed after induction of general anesthesia. With predicted difficulty, close attention should be paid to details of implementing the chosen approach. This should include having a plan in case of the failure of tracheal intubation or patient oxygenation.*

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

This article is accompanied by an editorial. Please see Can J Anesth 2013; 60: this issue.

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Résumé

Contexte *Une planification adaptée est essentielle afin d'éviter la morbidité et la mortalité lorsqu'on prévoit des difficultés dans la prise en charge des voies aériennes. De nombreuses recommandations émises par des sociétés nationales mettent l'emphase sur la gestion des difficultés rencontrées chez le patient inconscient. Toutefois, il n'existe dans la littérature que peu de suggestions sur la façon d'approcher le patient chez qui les difficultés sont prévisibles.*

Méthode *Afin de passer en revue ce sujet et d'autres, le Canadian Airway Focus Group (CAFG), un groupe dédié à l'étude de la prise en charge des voies aériennes, a été reformé. Les membres du CAFG représentent diverses spécialités soit l'anesthésiologie, la médecine d'urgence et les soins intensifs. Chaque participant avait pour mission de passer en revue des sujets précis. 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.*

Constatations principales *Plusieurs éléments permettant de prédire la laryngoscopie directe difficile sont connus. Des études plus récentes décrivent aussi les éléments permettant d'anticiper des difficultés lors de la ventilation au masque facial, de la vidéolaryngoscopie, de l'utilisation d'un dispositif supraglottique ou de la réalisation d'une cricothyrotomie. Tous ces éléments doivent être pris en compte lors de l'évaluation du patient chez qui des difficultés sont anticipées lors de la prise en charge des voies aériennes. De nombreuses études rapportent une morbidité accrue liée à des tentatives multiples d'intubation trachéale. Planifier de procéder à l'intubation trachéale après l'induction de l'anesthésie générale n'est donc recommandé que pour les patients chez qui la ou les techniques prévues ne nécessiteront pas plus de trois tentatives. Il est recommandé de prioriser d'emblée une approche vigile dans les cas où des difficultés reliées à l'utilisation du masque facial ou d'un dispositif supraglottique sont prévues. L'établissement d'une stratégie de prise en charge doit tenir compte d'éléments contextuels telles la collaboration du patient, la disponibilité d'aide supplémentaire et de personnel qualifié, et l'expérience du clinicien.*

Conclusion *Une évaluation adaptée des voies aériennes ainsi que les éléments contextuels propres à chaque situation sont les bases qui permettent de déterminer de manière rationnelle si l'intubation trachéale vigile est apte à optimiser la sécurité du patient, ou si la prise en charge des voies aériennes peut être réalisée de manière sécuritaire après l'induction de l'anesthésie générale. Lorsqu'on prévoit des difficultés, une attention particulière doit être portée aux détails nécessaires au succès de l'approche envisagée. De plus, il convient d'avoir un plan en cas d'échec de l'intubation trachéale ou si l'oxygénation du patient s'avérait difficile.*

What other recommendation statements are available on this topic?

Many developed countries have published national guidelines and recommendations on management of the difficult airway. Most of these recommendations emphasize management of the already unconscious patient in whom difficulty has been encountered.

Why were these recommendations developed?

Little guidance is provided by many of the existing guidelines on planning and decision-making for the patient with an anticipated difficult airway. These recommendations were developed to help address this gap.

How do these statements differ from existing recommendations?

These statements aim to address situations where the patient with a predicted difficult tracheal intubation can be safely managed after induction of general anesthesia or where an awake approach should be considered.

Why do these statements differ from existing recommendations?

These recommendations differ from existing consensus guidelines to reflect the widespread availability of recent innovations in airway management equipment and clinicians' increasing familiarity with these newer devices.

Contents

When planning how to approach the anticipated difficult airway, the primary focus should be on ensuring adequate oxygenation and ventilation and not simply on intubating the trachea. Management of the anticipated difficult airway follows an assessment of the probable success of ventilation by face mask or supraglottic device (SGD) as well as direct or indirect (e.g., video) laryngoscopy, tracheal intubation and surgical airway access.[1] Unfortunately, predicting difficulty with these measures remains an imperfect science. Furthermore, surveys suggest that clinicians' management choices vary widely even when significant difficulty is predicted.[2-4]

There is agreement in many national consensus guidelines on the importance of performing an airway evaluation to predict difficulty with airway management.[5-10] Unfortunately, once identified, some guidelines fail to provide sufficient guidance on how to proceed, simply implying that tracheal intubation should be performed awake when difficulty is anticipated. Certainly, as highlighted by the 4th National Audit Project (NAP4) from the United Kingdom, airway-related patient morbidity and mortality can occur following induction of general anesthesia when difficult tracheal intubation is predicted.[11] Sponsored by the Difficult Airway Society and the Royal College of Anaesthetists, the NAP4 study reported complications of airway management associated with nearly three million airway interventions in the United Kingdom during a 12-month period. Difficulty had been anticipated in most of the 43 operative patients in whom the initial attempts at tracheal intubation failed. The most common problem identified was the "failure to plan for failure".[11] When difficulty is anticipated, airway management after induction of general anesthesia can be justified only when the risk of failure to oxygenate is low and when an appropriate backup plan can be quickly implemented.

Historically, airway assessment has focused mainly on predictive tests of successful direct laryngoscopy. These tests had limited sensitivity and specificity, resulting in both unanticipated failures to obtain a view of the larynx[12] and unnecessary awake tracheal intubations. Patient safety was assigned a higher priority than comfort so awake intubations were appropriately advocated when uncertainty existed. Nevertheless, with recent innovations (e.g., video laryngoscopes) and alternative methods of providing oxygenation (e.g., supraglottic airways), it may be that more patients can be safely managed after induction of general anesthesia.

This article, the second of two publications, seeks to address the approach to a patient with an anticipated difficult airway as well as implementation of the chosen approach. The first article in the series addressed difficult tracheal intubation encountered in the already unconscious patient.[13] The two publications aim to provide recommendations and a cognitive framework to inform clinician decision-making in the interest of patient safety, regardless of specialty or practice environment.

Methods

The methods presented are identical to those described in the companion article[13] and are reproduced here for the benefit of the reader. 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.[5] 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 on two occasions 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 manuscripts was distributed to all members for review prior to submission.

The strength of a recommendation and assignment of level of evidence were modelled after the GRADE system, as per previously published criteria.[14,15] 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,[14] 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, recommendations reflect the consensus opinion of the authors.

Airway evaluation: anticipating the difficult airway

An airway evaluation should be performed on every patient requiring airway management (Strong recommendation ***for,*** level of evidence ***C***). For the patient requiring tracheal intubation, an airway evaluation is performed primarily to help decide if intubation can be safely performed after the induction of general anesthesia (with or without maintenance of spontaneous ventilation) or if intubation should proceed with the patient awake. Even if a lack of patient cooperation precludes a complete airway evaluation or the option of awake intubation, performing this step serves as a "cognitive forcing strategy"[16] to encourage appropriate planning and preparation for the airway intervention, however undertaken.

A complete airway evaluation should include an assessment of not only the predicted ease or difficulty of tracheal intubation (Tables 1 and 2) but also the predicted success of fallback options to achieve oxygenation, such as face mask ventilation (Table 3), SGD use (Table 4), and surgical airway (Table 5)[1] (Strong recommendation ***for,*** level of evidence ***C***). As the number of predictors of difficulty increases, so does the probability of actually

Table 1 Predictors of difficult direct laryngoscopy[17,20-35]

- Limited mouth opening
- Limited mandibular protrusion
- Narrow dental arch
- Decreased thyromental distance
- Modified Mallampati class 3 or 4
- Decreased submandibular compliance
- Decreased sternomental distance
- Limited head and upper neck extension
- Increased neck circumference

Table 2 Predictors of difficult GlideScope™ and Trachlight® use

Predictors of difficult GlideScope™ use[36,37]
• Cormack-Lehane Grade 3 or 4 view at direct laryngoscopy
• Abnormal neck anatomy, including radiation changes, neck scar, neck pathology, and thick neck
• Limited mandibular protrusion
• Decreased sternothyroid distance
Predictors of difficult Trachlight® lighted stylet use[38,39]
• Thick neck
• Neck flexion deformity
• Large tongue/epiglottis

Table 3 Predictors of difficult face mask ventilation[40-44]

• Higher body mass index or weight
• Older age
• Male sex
• Limited mandibular protrusion
• Decreased thyromental distance
• Modified Mallampati class 3 or 4
• Beard
• Lack of teeth
• History of snoring or obstructive sleep apnea
• History of neck radiation

Table 4 Predictors of difficult supraglottic device use*[45-53]

• Reduced mouth opening
• Supra- or extraglottic pathology (e.g., neck radiation, lingual tonsillar hypertrophy)
• Glottic and subglottic pathology
• Fixed cervical spine flexion deformity
• Applied cricoid pressure
• Male sex*
• Increased body mass index*
• Poor dentition*
• Rotation of surgical table during case*

*Some of the listed predictors are device-specific: the latter four predictors originate from a single study using the LMA Unique™[53]

encountering problems.[17,18] In addition to physical examination and a history of prior difficulties provided by the patient, records of previous airway interventions, imaging studies, electronic databases and letters carried by the patient should be considered if time permits and records can be sourced. Other contextual issues must also be considered, including patient cooperation, the clinician's skill and experience, availability of additional skilled help, and whether the desired equipment is accessible.[19]

Options when difficult tracheal intubation is anticipated

Avoiding tracheal intubation

When difficult tracheal intubation is anticipated in the surgical patient, it may be feasible to proceed without general anesthesia or with general anesthesia but without tracheal intubation. However, if general anesthesia with tracheal intubation would normally occur for the procedure, a careful risk-to-benefit assessment must be undertaken before proceeding without an airway secured by a tracheal tube. The following options can be considered:

Proceeding with regional or infiltration anesthesia: Regional (e.g., neuraxial or peripheral nerve block) or infiltration (local) anesthesia may be an option for surgery, with the following provisos:

- Easy access to the airway during the case is advisable;
- The nerve block must be compatible with the estimated duration of the surgical procedure;
- Interrupting the surgery must be feasible in case an intraoperative awake intubation or re-do of the block is required;
- The necessary equipment and expertise must be available to manage the airway in case complications of the block result in loss of consciousness or respiratory compromise.

If regional or local anesthesia is elected in the patient with anticipated difficult tracheal intubation, the surgical safety briefing should include the anesthesiologist's planned strategy for conversion to general anesthesia, if required intraoperatively.

General anesthesia using SGD or face mask ventilation: Successful use of SGDs has been reported in patients who are known or suspected to be difficult to intubate by direct laryngoscopy.[56-60] Nevertheless, the NAP4 study documented cases where inappropriate use of a SGD to avoid difficult tracheal intubation resulted in patient morbidity.[61] If difficult tracheal intubation is predicted but intubation is not absolutely required for the safe conduct of general anesthesia, use of a SGD may be considered provided the patient is at low risk of aspiration and a plan has been made for managing intraoperative failure of ventilation or oxygenation.

Deferring surgery: For the elective surgical patient with predicted difficult tracheal intubation, the option of not proceeding with surgery at that time (or at all) should be considered. This choice may be especially relevant if working in unfavourable conditions (e.g., lacking access to difficult airway equipment and/or additional skilled help), as may be the case in some remote locations. Under such

Table 5 Predictors of difficult cricothyrotomy[54,55]

- Difficulty identifying the location of the cricothyroid membrane:
  - Female sex
  - Age < 8 yr
  - Thick/obese neck
  - Displaced airway
  - Overlying pathology (e.g., inflammation, induration, radiation, tumour).
- Difficult access to the trachea through the anterior neck:
  - Thick neck/overlying pathology
  - Fixed cervical spine flexion deformity

circumstances, airway management might be deferred until suitable equipment and/or expertise is in place.

The out-of-operating room (OR) emergency: Management of the emergency patient with known or presumed difficult tracheal intubation cannot be deferred. Nevertheless, it may be possible to sustain oxygenation using nasal cannulae with high flows of humidified oxygen, noninvasive ventilation (e.g., continuous or bilevel positive airway pressure), assisted face mask ventilation, or placement of a SGD pending the arrival of additional expertise or equipment for tracheal intubation. Occasionally, this may permit an underlying condition (e.g., congestive heart failure or acute respiratory failure) to be treated to the point that tracheal intubation is no longer required.[62-65]

Proceeding with tracheal intubation: options

When difficulty is predicted and tracheal intubation cannot be avoided, a number of options exist for how to proceed. Further details on the following options appear in subsequent sections.

Awake tracheal intubation: This can occur via the oral or nasal transglottic route, awake tracheotomy, or awake cricothyrotomy. This is generally facilitated by local anesthesia, with or without judicious sedation.

Tracheal intubation after induction of general anesthesia:

- Induction with *ablation* of spontaneous ventilation using a bolus dose of sedative-hypnotic and optimizing intubating conditions with a neuromuscular blocking agent;
- Induction while *maintaining* spontaneous ventilation via inhalation of volatile anesthetic or infusion of a sedative-hypnotic such as propofol.

Especially in out-of-OR settings for urgent or emergency cases, tracheal intubation is sometimes facilitated only by moderate to deep sedation. While often successful, this approach may result in patient apnea, suboptimal intubating conditions (including reflex glottic closure with airway instrumentation), and regurgitation/aspiration due to gag reflex activation.

Very rarely, establishing femorofemoral cardiopulmonary bypass under local anesthesia may be indicated prior to induction of general anesthesia, chiefly when disease intrinsic[66-68] or extrinsic[69,70] to the tracheal lumen threatens complete tracheal obstruction with the onset of general anesthesia.

Deciding on awake or post-induction tracheal intubation

With anticipated difficult tracheal intubation that cannot be avoided, the clinician must decide if intubation can proceed safely after induction of general anesthesia or if it would be achieved more safely in the awake patient. Although complications up to and including loss of the airway can occur during attempted awake intubation,[71-73] an awake approach can potentially confer a safety benefit by having the patient maintain airway patency, gas exchange, and protection of the airway against aspiration of gastric contents or blood during the intubation process.

The following discussion and accompanying flow diagram (Figure) attempt to identify the relevant factors that must be weighed when creating a patient-specific airway strategy. Neither discussion nor flow diagram is meant to be prescriptive. Many factors impact the decision, including patient cooperation, consent, and the clinician's expertise.

Two primary questions should be addressed:

If general anesthesia is induced, is tracheal intubation predicted to succeed with the chosen technique(s)? Guidance to help answer this question comes from the published studies on predictors of difficult tracheal intubation. Most of these studies relate to direct laryngoscopy (Table 1). Fewer studies have been published on the predictors of difficulty using alternative techniques such as video laryngoscopy (Table 2). Thus, if the intended "Plan A" or "Plan B" intubation technique includes the use of an alternative to direct laryngoscopy, the clinician must estimate the probability of success *in his or her hands* under the prevailing conditions.

Data from within[74-76] and outside the operating room (OR)[77-81] point to increasing morbidity with multiple intubation attempts. Any doubt about whether tracheal intubation will succeed in the anesthetized patient in a maximum of three attempts using direct laryngoscopy or an alternative to direct laryngoscopy would favour an awake approach.

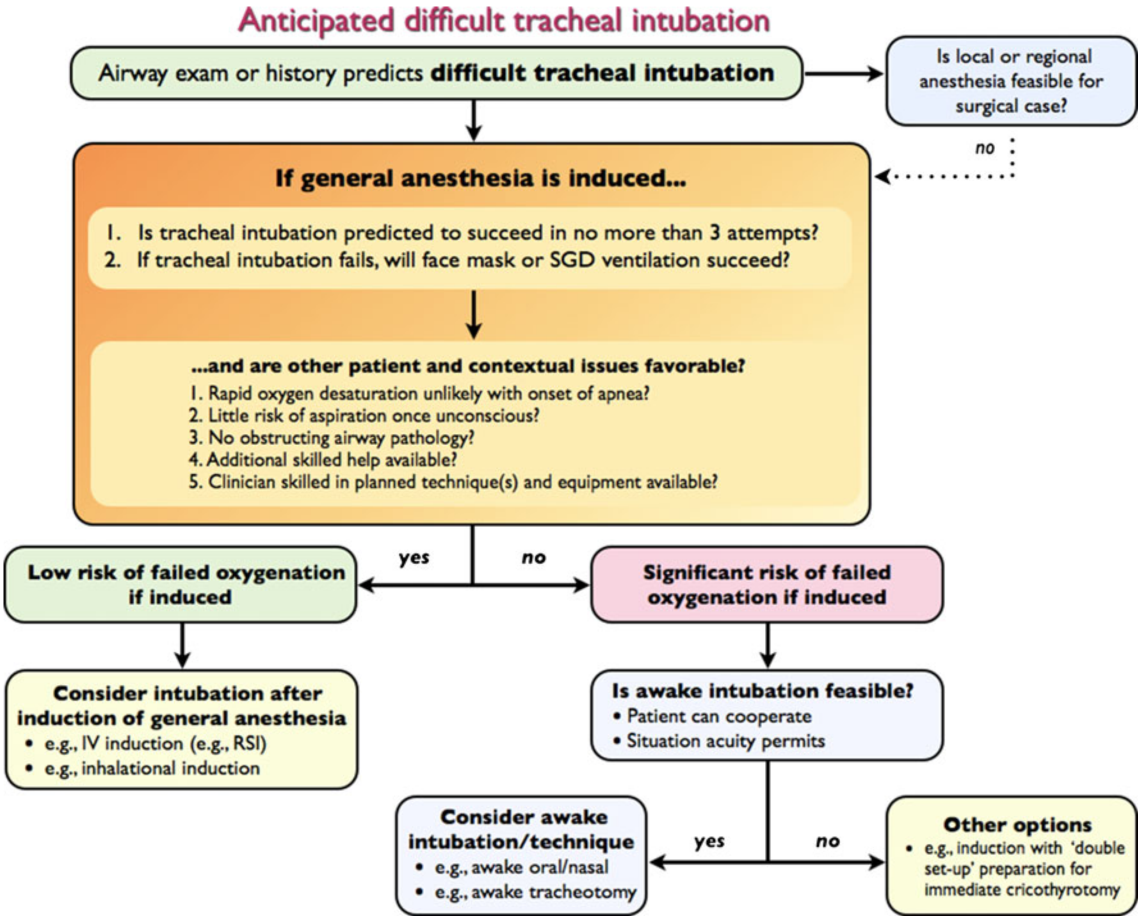

Figure Flow diagram: anticipated difficult tracheal intubation. SGD = supraglottic device; IV = intravenous; RSI = rapid sequence induction/intubation

If tracheal intubation fails, will oxygenation by face mask or SGD succeed? When difficult tracheal intubation is predicted, evaluation of the probable success of fallback oxygenation by face mask or SGD ventilation is especially warranted. Predictors of difficult face mask (Table 3) and SGD (Table 4) ventilation have been studied and published. In most situations, significant predicted difficulty with both tracheal intubation and face mask or SGD ventilation should be taken as a strong signal to consider awake intubation, particularly in the cooperative elective surgical patient (Strong recommendation ***for***, level of evidence ***C***).

It should be emphasized that overlap exists between some predictors of difficult direct and video laryngoscopy and those of difficult face mask ventilation. As such, when difficult laryngoscopy is predicted, a careful and deliberate assessment of predicted ease of face mask ventilation should occur. Consideration should also be given to the probability that successful ventilation by face mask or SGD may diminish with repeated intubation attempts.

Other patient or contextual issues may impact the decision of whether to proceed with tracheal intubation before or after induction of general anesthesia, and these issues should be considered[19] (Strong recommendation ***for,*** level of evidence ***C***). Although not an exhaustive list, if any of the following issues coincide with predicted difficult intubation, an awake approach may be most prudent:

Anticipated short safe apnea time: With the onset of apnea, rapid oxygen desaturation can be anticipated in the patient with decreased functional residual capacity, increased oxygen consumption, or low starting oxygen saturation. This will shorten the available time for intubation attempts before oxygen desaturation supervenes. Patients with respiratory or metabolic acidosis may also be less tolerant of apnea.

Significant risk of aspiration: When practical, awake intubation should be considered for the patient with predicted difficult tracheal intubation who is also at increased risk of regurgitation and aspiration of gastric contents.

Presence of obstructing airway pathology: Significant intrinsic, extrinsic, or incipient obstructing airway pathology should prompt consideration of awake management. In the NAP4 study, a number of cases were documented where attempted post-induction tracheal intubation resulted in serious patient morbidity in the presence of obstructing airway pathology.[76]

Additional skilled help not available: Skilled assistance during the management of a difficult airway is of considerable importance. Its absence should elevate the option of awake management (although this too may necessitate additional assistance).

Clinician inexperienced with planned technique or device not available: The clinician must be competent and experienced with the planned intubation technique(s) when a post-induction approach is contemplated, and the preferred device(s) must be readily available.

Thus, for the patient with anticipated difficult tracheal intubation, a post-induction approach may be considered if successful intubation is anticipated with the chosen technique(s) within three attempts, successful fallback oxygenation by face mask or SGD ventilation is predicted, and other patient and contextual issues are favourable.

Conversely, if there is a significant risk that tracheal intubation may require more than three attempts despite optimized conditions, face mask ventilation or SGD ventilation is also predicted to be difficult, or other patient and contextual issues are unfavourable (e.g., lack of additional skilled help), the risk of failed oxygenation is elevated and an awake approach is prudent (Figure).

The elective surgical patient with a difficult airway

The cooperative elective surgical patient must be optimized preoperatively and managed in the safest way possible. When difficult tracheal intubation is anticipated in this population, proceeding with post-induction tracheal intubation should occur only with an estimated margin of safety equivalent to that of an awake intubation (Strong recommendation ***for,*** level of evidence ***C***). Perceived time ("production") pressure must not be allowed to impact the decision.

The uncooperative patient with a difficult airway

A lack of patient cooperation may preclude the option of awake tracheal intubation. This subsection refers to the actively uncooperative patient (as with many pediatric patients or adults with cognitive impairment, brain injury, or hypoxemia) and not patient refusal or clinician discomfort with awake techniques. Patient refusal of an awake intubation is unusual when the technique and its rationale are advanced with confidence and empathy, along with the risks of the alternatives.

All options for proceeding with anticipated difficult tracheal intubation of the uncooperative patient involve risk: the clinician's job is to manage the risk. The benefit of proceeding with tracheal intubation at that time must exceed the risk of deferring intubation. If proceeding, even with an experienced airway manager in attendance, the location of additional skilled help should be established.

When significant difficulty is predicted and a lack of patient cooperation precludes the provider's usual awake intubation technique(s), one of the following options can be considered to facilitate tracheal intubation:

Maintenance of spontaneous ventilation

- Blind or bronchoscopic-aided nasal intubation (if not contraindicated), with or without use of gentle physical restraint, and application of local anesthesia as the situation permits;
- Judicious sedation with a pharmacologic agent less likely to have an adverse impact on airway tone or respiratory effort (e.g., ketamine, dexmedetomidine, or haloperidol), with application of local anesthesia as the situation permits;
- Induction of general anesthesia while maintaining spontaneous ventilation using inhalation of volatile anesthetic or an intravenous infusion of sedative-hypnotic.

Ablation of spontaneous ventilation

Occasionally, intravenous induction of general anesthesia using a bolus of sedative-hypnotic and neuromuscular blockade (e.g., rapid sequence intubation [RSI]) must be considered in the uncooperative patient with a difficult airway if techniques maintaining spontaneous ventilation have failed or are predicted to fail. This situation demands appropriate preparation, including a "double setup airway intervention", whereby personnel and equipment are standing by to enable immediate cricothyrotomy in the event of failed oxygenation. See the section titled "*The double setup airway intervention*".

The emergency patient with a difficult airway

Within or outside the OR, management of the critically ill emergency patient with a difficult airway is particularly challenging. Such patients generally have limited reserves, may be hypoxemic at presentation, difficult to adequately pre-oxygenate, and can rapidly desaturate with the onset of apnea. They must be assumed to be at increased risk of aspiration of gastric contents. Outside the OR, the risk of difficult tracheal intubation is higher and is associated with greater morbidity if multiple intubation attempts are required.[77-81] There may be difficulties with access to the patient and optimum positioning. Manual in-line stabilization of the cervical spine and cricoid pressure may interfere with insertion of the laryngoscope, laryngeal exposure, or insertion of SGDs. In some centres, non-anesthesiologists may have few opportunities for airway management. This can be compounded by a limited selection of equipment and lack of access to additional skilled help. Airway management generally cannot be cancelled or deferred, and poor patient cooperation can adversely impact both the completeness of an airway assessment and options (e.g., awake intubation) for tracheal intubation.

The foregoing factors place emergency patients at higher risk of complications during attempted airway management; however, the principles outlined in the preceding sections remain applicable. While the need for tracheal intubation is often urgent in the critically ill patient, when difficulty is anticipated, there is often time to achieve topical airway anesthesia for awake intubation or to enlist additional skilled help. When rapid sequence intubation is required and difficulty is anticipated, requisite preparations should occur (see PREPARATION section below).

Evidence that adverse events escalate with multiple intubation attempts in the critically ill population[77-81] suggests that the most expert airway manager available should perform airway interventions in the emergency patient.

Implementation – proceeding with anticipated difficult tracheal intubation

Awake tracheal intubation

Clinicians who manage difficult airways should be competent in awake tracheal intubation (Strong recommendation ***for,*** level of evidence C). For awake intubation, an antisialagogue is helpful prior to application of topical airway anesthesia, unless contraindicated. Adequate anesthesia of the pharynx, larynx, and trachea – and nasal cavity if nasal intubation is planned – can be applied topically or with nerve blocks. The semi-sitting or sitting position may provide greater airway patency and patient comfort and is recommended for the procedure when feasible. Sedation should be limited in an effort to retain airway patency and patient cooperation – amnesia is not necessarily a goal during awake intubation. Supplemental oxygen is useful and can be administered by nasal cannulae. Awake intubation in the elective surgical patient will most often proceed using a flexible intubating bronchoscope, but it can also occur with other devices alone or in combination (e.g., video laryngoscopes, optical stylets, light wands, or SGDs used as a conduit for bronchoscopic intubation). Direct laryngoscopy can be used for awake tracheal intubation (as may occur for the patient with relatively favourable airway anatomy and significant hemodynamic instability). Awake tracheotomy or cricothyrotomy performed under local anesthesia is an option and may be the safest approach in patients with symptomatic obstructing airway pathology.

Failed awake intubation

An awake intubation attempt may fail due to inadequate oropharyngeal or laryngeal airway anesthesia, excessive secretions or blood, very difficult patient anatomy, lack of patient cooperation, oversedation, or operator inexperience. If inadequate local anesthesia is the problem, before additional agent is administered, the total dose of local anesthetic already administered should be determined to avoid toxicity. If local anesthetic toxicity is a worry and the surgery is elective, the case may be deferred. The clinician must not feel compelled to proceed with post-induction intubation following failed awake intubation in elective surgical patients, as this has resulted in cases of major morbidity and death.[74] In contrast, for the emergency patient, if additional expertise is unavailable for another awake intubation attempt, with appropriate preparation, post-induction tracheal intubation must sometimes be undertaken.

Inadvertent loss of the airway during attempted awake intubation

Case reports have been published of complete airway obstruction occurring during attempted awake intubation.[71,72,82] This occurs most often in the setting of obstructing airway pathology;[74] possible etiologies include natural disease progression, excess sedation, reflex glottic closure, trauma from intubation attempts, or a direct adverse effect of local anesthetic on upper airway patency.[83,84] The latter phenomenon is infrequent, but it is important to be aware of this occurrence. This does not imply that awake transglottic intubation should be avoided in all patients with obstructing airway pathology, but it does mandate readiness to proceed rapidly with surgical access if oxygenation fails.

Post-induction tracheal intubation when difficulty is predicted

Preparation

When difficulty is predicted and the decision is made for tracheal intubation after induction of general anesthesia, the following preparations should occur (Strong recommendation ***for,*** level of evidence ***C***):

- The patient should be placed in an optimum position with adequate pre-oxygenation;
- Equipment should be prepared for the primary intubation approach (Plan A);
- A familiar alternative intubation device should also be immediately on hand (Plan B);
- A suitably sized SGD should be prepared for use;
- The location and availability of additional skilled help should be established;
- An "exit strategy" plan for failed tracheal intubation should be articulated to those participating in the patient's care. Such a pre-emptive briefing should be encouraged and does not suggest an expectation of failure; rather, it increases the likelihood of a coordinated and effective response by those involved. The exit strategy is the plan to engage if tracheal intubation is unsuccessful within a maximum of three attempts. It exists to alert the clinician to avoid further potentially harmful attempts at tracheal intubation. In the adequately oxygenated patient, exit strategies include awakening the patient (if not an emergency), temporizing with face mask or SGD ventilation, obtaining more expertise or equipment for a further careful intubation attempt (if this has a high probability of success), or very rarely, a surgical airway.[13]

Pre- and peri-intubation oxygenation

All patients with an anticipated difficult tracheal intubation and planned post-induction intubation should be pre-oxygenated with 100% oxygen for three minutes of tidal volume breathing, eight vital capacity breaths over 60 sec,[85] or until F_EO_2 exceeds 90%[86] (Strong recommendation ***for***, level of evidence ***B***). There is evidence that oxygen desaturation with apnea can be further postponed if pre-oxygenation is undertaken with the patient in the semi-seated (Fowler's) position or with the stretcher or table in the reverse Trendelenburg position.[87-91] Apneic oxygenation[92] via nasopharyngeal catheter[93,94] or nasal cannulae[95] may also be beneficial during attempted tracheal intubation.

Equipment choice

No recommendation can be made for the use of a particular device or class of device for post-induction tracheal intubation when difficulty is predicted. Video laryngoscopes can be effective in enabling a view of the larynx and facilitating intubation when direct laryngoscopy has failed or is predicted to fail. Other classes of intubation device can be similarly effective when difficult tracheal intubation is predicted, including blind intubation with a lighted stylet or via the Fastrach™ laryngeal mask airway. Some clinicians may be facile in using the flexible bronchoscope for post-induction intubation, with or without use of a SGD as a conduit. Optical indirect laryngoscopes, such as the Airtraq™ or Bullard™ laryngoscope, are also effective and can be video enabled. Most important is the clinician's estimation that the chosen device will successfully address the anatomic reason for predicted difficulty with tracheal intubation, that he or she is experienced with its use, and that it is available.

Ablation or maintenance of spontaneous ventilation

Conditions for tracheal intubation are generally considered to be optimized with ablation of spontaneous ventilation by administration of a sedative-hypnotic and neuromuscular blocking agent. However, inhalational induction of general anesthesia has been suggested as a method to facilitate intubation when difficulty is anticipated. The theoretical safety advantage afforded by inhalational induction (or induction by infusion of a sedative-hypnotic, e.g., propofol) relates to maintenance of spontaneous ventilation and therefore oxygenation during the induction process.[96] While inhalational induction is commonly used in the pediatric population, in adults, it can take time to attain a sufficiently deep plane of general anesthesia for airway instrumentation without provoking reflex glottic closure. Furthermore, as consciousness is lost during anesthetic induction, the activity of the upper airway dilator muscles is attenuated, rendering the pharynx vulnerable to collapse during inspiration.[97,98] The tendency of an airway to collapse is compounded in the presence of negative intraluminal pressures generated on inspiration within a narrowed airway.[97] If airway collapse occurs during induction with spontaneous ventilation, it can be somewhat mitigated by head extension[99] and use of a nasopharyngeal airway while the patient is still in a light plane of anesthesia.[83]

Checking for efficacy of face mask ventilation after induction, before administration of a neuromuscular blocking agent

Before administering a neuromuscular blocking agent (NMBA), confirmation that face mask ventilation is possible following the induction of general anesthesia has been advocated as a patient safety measure.[100-102] The theoretical advantage of withholding NMBAs until after successful face mask ventilation has been demonstrated is that if significantly difficult face mask ventilation is encountered, the patient could be allowed to awaken and the airway subsequently secured awake.[103] However, a review by Calder and Yentis revealed that this recommendation was not based on published evidence when it was first mentioned by Stone and Gal in the third edition of Miller's *Anesthesia*.[102,103] Furthermore, data from three prospective studies suggest that neuromuscular blockade improves or has no effect on face mask ventilation, but never worsens it.[104-106] Once the decision is made to proceed with tracheal intubation after the induction of general anesthesia with ablation of spontaneous ventilation, no recommendation can be made for or against the practice of checking for efficacy of face mask ventilation prior to administration of a NMBA. This applies to patients with both anticipated easy and difficult tracheal intubation.

Use of a short- or intermediate-acting NMBA

No recommendation can be made on whether to use a short- (e.g., succinylcholine) or intermediate-acting NMBA to facilitate tracheal intubation when difficulty is anticipated. In a failed oxygenation "cannot intubate, cannot oxygenate" (CICO)[107] situation, there is theoretical evidence that even succinylcholine may not wear off in time to prevent hypoxic brain injury by allowing resumption of spontaneous ventilation.[108] In addition, an argument can be made that short-acting NMBAs may not provide sufficient time for a smooth transition to a "Plan B" alternative intubation technique before the return of reflex glottic closure in response to airway instrumentation. Even with rapid reversal of an intermediate-acting non-depolarizing NMBA (e.g., reversal of rocuronium's effects using sugammadex) in a failed oxygenation/CICO situation, case reports suggest that timely resumption of adequate spontaneous ventilation may not be guaranteed.[109,110] With no assurance of a sufficiently early resumption of spontaneous ventilation with either short-acting NMBAs or rapid-reversal agents, the emphasis should not lie with the type of NMBA to use when difficulty is anticipated; rather, it should lie earlier in the decision process when deciding if awake intubation (or induction of general anesthesia with maintenance of spontaneous ventilation) will provide a greater margin of safety.

Cricoid pressure

The use of cricoid pressure remains controversial. Randomized controlled trials on its efficacy are lacking in patients at high risk of regurgitation[111-113] and are unlikely to be forthcoming. Recently, investigators have identified that the esophagus is not completely obstructed by cricoid pressure[114] and that the cricoid cartilage can collapse during the application of pressure, thus failing to compress the esophagus.[115] The maneuver is often performed incorrectly[116]; it may attenuate lower esophageal sphincter tone,[117] hinder face mask ventilation, interfere with placement of and ventilation through SGDs,[118,119] and render laryngoscopy and tracheal intubation more difficult.[120] Furthermore, there are reports that some anesthetists have seen regurgitation despite its application.[121,122] Nevertheless, even if it results in incomplete esophageal occlusion, there is evidence that cricoid pressure still leads to compression of the post-cricoid hypopharynx, constituting at least some degree of physical barrier to the passive regurgitation of alimentary track contents.[123] In addition, there are case reports and series of patients in whom significant regurgitation has occurred upon release of cricoid pressure after successful tracheal intubation.[124,125]

In the NAP4 study, aspiration was the most common cause of anesthesia-related mortality. Analysis of these cases suggests that there was a failure to employ a rapid sequence intubation technique when a significant risk of aspiration existed.[126] As cricoid pressure is likely to have potential benefits,[127] its continued use seems prudent during rapid sequence intubation in the patient at high risk of aspiration (Strong recommendation ***for,*** level of evidence ***C***). However, if difficulty is encountered with face mask ventilation or tracheal intubation, or if SGD insertion is needed, progressive or complete release of cricoid pressure is justified.

Difficult tracheal intubation encountered in the unconscious patient

Difficulty with tracheal intubation will inevitably be encountered in some patients once unconscious. This may be expected, especially when post-induction intubation is elected in the patient with predictors of difficulty, or it may be unanticipated. Appropriate management is addressed in the first article of this two-part series.[13]

Obstructing airway pathology

The patient with significant obstructing airway pathology may be maintaining airway patency only with considerable effort. If time permits, consultation with the attending surgeon and review of recent imaging studies (e.g., CT scans) is advisable prior to airway management. Nasopharyngoscopy may provide useful current information about the extent, location, and nature of obstructing or distorting pathology in the pharynx and larynx.[128] Such an examination may help identify patients in whom an awake technique is appropriate. Awake bronchoscopic intubation may be feasible for oral cavity and pharyngeal pathology, although effective topical airway anesthesia may be difficult to achieve, friable tumours may bleed easily, anatomic landmarks may be obscured by edematous tissues, and bronchoscope manipulation around obstructing lesions can be challenging. Many such patients will have received radiation therapy to the upper airway or neck, rendering tissues friable or less compliant. Bulky lesions of the larynx may accommodate passage of a bronchoscope, although complete airway obstruction by the bronchoscope or the combination of the bronchoscope and tracheal tube may occur. Thus, awake tracheotomy or cricothyrotomy should be strongly considered as a primary technique for significant obstructing airway pathology.

Management of mid- or lower tracheal obstruction remains controversial.[96,129] Rigid bronchoscopy and a skilled operator should be immediately available in case tracheal intubation fails to establish oxygenation.[83,129] Cricothyrotomy or tracheotomy cannot be relied on to rescue a more distal airway obstruction.

Inhalational induction with obstructing airway pathology

Inhalational induction has been used successfully in the setting of obstructing airway pathology. Nevertheless, apneic spells, hypoxemia, and hypercarbia can occur with this approach.[96] Episodes of complete airway obstruction can also occur, following which the patient may not rapidly awaken as hypoxemia worsens.[76] The use of inhalational induction in this context is controversial, with limited supporting evidence and varying expert opinion. Although the number of occasions during the study period in which the technique was used successfully is not known, the NAP4 data reveal serious episodes of failure.[76] If awake bronchoscopic intubation or awake tracheotomy is not considered feasible in the presence of predicted difficult tracheal intubation due to obstructing airway pathology, a weak recommendation can be made for the cautious use of inhalational induction (Weak recommendation ***for,*** level of evidence ***C***). Nevertheless, if complete obstruction occurs when using inhalational induction in this setting, an exit strategy other than awakening the patient must be in place to rescue the airway.[76]

The "double setup airway intervention"

A "double setup airway intervention" refers to the immediate availability of equipment and personnel capable of performing a surgical airway in the event that oxygenation fails for any reason during attempted tracheal intubation. Elements of the double setup include identification and marking of the cricothyroid membrane location, (sometimes with application of disinfectant solution to the neck and infiltration of local anesthetic into the overlying skin), ensuring cricothyrotomy equipment is in the room, and designation of an appropriately skilled individual to perform the procedure. In experienced hands, ultrasound may be helpful to identify the cricothyroid membrane, but there is no evidence to support its use in an emergency.

It should be emphasized that rapid cricothyrotomy is unlikely to succeed and cannot be regarded a prudent rescue option if access to the cricothyroid membrane is likely to be very difficult (e.g., in a patient with a very thick neck, previous neck radiation, or overlying tumour or inflammation). This situation may mandate awake tracheotomy under local anesthesia as the preferred primary technique, performed by a surgeon under controlled conditions.

A double setup airway intervention should be prepared whenever the clinician considers a significant possibility of encountering a failed oxygenation situation during attempted awake or post-induction airway management (Strong recommendation ***for***, level of evidence ***C***).

The morbidly obese patient

NAP4 reported a fourfold increase in major airway events in the morbidly obese population.[130] Variously defined as a body mass index (BMI) > 35 or $40\ \text{kg}\cdot\text{m}^{-2}$, morbid obesity can portend difficulty with most aspects of airway management. Even below this level, a BMI > 26 or $30\ \text{kg}\cdot\text{m}^{-2}$ is an independent predictor of difficult face mask ventilation.[40,42-44] Other conditions frequently accompanying morbid obesity, such as a thick neck, history of snoring or obstructive sleep apnea, are similarly associated with difficult face mask ventilation.[40-44] Studies are contradictory on whether morbid obesity or its coexisting anatomic or pathophysiologic features are predictive of difficult direct laryngoscopy; although again, a thick neck does appear to portend difficulty.[35,131-137] Appropriate positioning with "ramping" of the patient to align the external auditory meatus horizontally with the sternum will aid direct laryngoscopy.[87,138,139] Increased BMI is a predictor of SGD failure,[53] and landmark identification and execution can be challenging for cricothyrotomy (e.g., with a thick neck, standard tracheotomy or cricothyrotomy cannulae may fail to reach the trachea).[130] Additionally, physiologic factors, such as rapid oxygen desaturation and increased risk of aspiration, must be considered. Thus, an especially careful airway evaluation is warranted in the morbidly obese patient. When difficult laryngoscopy or intubation is anticipated, given the potential for difficulty with fallback oxygenation options and the potentially short safe apnea time, an awake approach may be safest. Management of the severely obese patient has recently been reviewed in more detail elsewhere.[140]

Tracheal extubation in the patient with a difficult airway

Numerous reports emphasize the risks associated with extubation and subsequent loss of the airway.[11,141-143] Such events account for a significant proportion of adverse respiratory outcomes and are sometimes catastrophic. While there has been a decrease in adverse respiratory events associated with tracheal intubation, the same has not been observed for extubation.[74] Many of these outcomes can be avoided with proper planning and recognition of risk.[144-147] Patients are at particular risk during emergence from anesthesia, relocation to a recovery area, and discontinuation of full monitoring. In the recovery area, recognition and correction of a deteriorating airway can potentially be delayed. Recovering patients may be under the influence of medications that depress their respiratory drive, reduce muscular power, and diminish their protective reflexes. Critically ill patients are at further risk because of limited physiologic reserves.

In contrast to tracheal intubation, extubation is almost always elective, and therefore careful planning is possible. This should include identification of patients at risk of failed tracheal extubation, and those with anatomic features that place them at higher risk of difficult re-intubation should this prove necessary.[146,147] Examples include but are not limited to patients with a reduced functional residual capacity, increased work of breathing, reduced minute ventilation, increased dead space, swelling in or around the airway, a previously difficult airway, or an airway where accessibility is challenged.

Planning for extubation begins with ensuring optimal conditions, including adequate oxygenation and minute ventilation and intact protective reflexes, and excluding probable causes of airway obstruction. The patient should be hemodynamically stable and normothermic. Recovery from any administered neuromuscular blocking agents should be confirmed with a nerve stimulator, and reversal agents should be given when indicated. Tracheal extubation of at-risk patients requires expert judgement to ensure that appropriate circumstances and resources are in place to provide continuous post-extubation oxygenation. Premature extubation during emergence is more likely to be associated with complications such as breath-holding, aspiration, laryngospasm, and hypoxemia.

If tracheal intubation had been very difficult or circumstances now suggest that it would be so, short-term maintenance of tracheal access using an airway exchange catheter[148] is recommended (Strong recommendation ***for***, level of evidence ***C***). Airway exchange catheters can also be used to exchange defective or inappropriate tracheal tubes. When used to retain tracheal access after extubation, the airway exchange catheter should not be removed prematurely, as re-intubation of an at-risk airway is much more likely to be associated with an adverse outcome after the device has been removed.[144] When properly positioned above the carina and secured, smaller gauge (e.g., 11- or 14-French) airway exchange catheters are generally well tolerated and permit spontaneous ventilation, coughing, and talking. Generally, supplemental oxygen should be applied by face mask or nasal cannulae. Although the hollow lumen of airway exchange catheters can be used for oxygen insufflation[149] and has been used for jet ventilation, fatal barotrauma has been reported with both modalities.[150,151] When to remove an airway exchange catheter after extubation is the subject of much debate and should be individualized to the patient's respiratory reserve, potential for difficult re-intubation, and anticipated clinical course. In the intensive care setting, the majority of patients requiring tracheal re-intubation undergo the procedure within two to ten hours after extubation.[144]

If tracheal re-intubation is required over an airway exchange catheter, success can be enhanced by using a laryngoscope to retract the tongue. Use of a video laryngoscope for this purpose holds the advantage of also allowing indirect visualization of tube passage and facilitating corrective maneuvers for any tube impingement on laryngeal structures.[145] In addition, prior passage of an intermediate catheter (e.g., the Aintree catheter [Cook Medical, Bloomington, IN, USA]) over a smaller gauge airway exchange catheter may facilitate subsequent passage of the tracheal tube through the adult larynx by reducing the size discrepancy between the outer diameter of the catheter and the inner diameter of the tracheal tube.[152]

Summary of recommendations

Strong recommendation *for*, level of evidence B

1. All patients with anticipated difficult tracheal intubation and planned post-induction intubation should be pre-oxygenated with 100% oxygen for three minutes of tidal volume breathing, eight vital capacity breaths over 60 sec, or until F_EO_2 exceeds 90%.

Strong recommendation *for*, level of evidence C

1. A complete airway evaluation should be performed in every patient requiring airway management to assess for potential difficulty with tracheal intubation, face mask ventilation, SGD use, and surgical airway.
2. When deciding if post-induction intubation can be safely undertaken, consideration must be given to face mask ventilation, SGD or surgical airway rescue, and other patient or contextual issues (e.g., safe apnea time, aspiration risk, availability of additional skilled help, presence of obstructing airway pathology, or clinician experience) as well as to anticipated success of tracheal intubation.
3. Proceeding with post-induction tracheal intubation in the cooperative elective surgical patient with an anticipated difficult airway should only occur with an estimated margin of safety equivalent to that of an awake intubation.
4. In most situations, significant predicted difficulty with both tracheal intubation and face mask or SGD ventilation should be taken as a strong signal to consider awake intubation, particularly in the cooperative elective surgical patient.
5. Clinicians with responsibility for difficult airway management should be competent in performing awake tracheal intubation.
6. Prior to proceeding with a post-induction tracheal intubation in the patient with known or suspected difficult intubation, the clinician should prepare equipment for both primary ("Plan A") and alternative ("Plan B") intubation approaches. In addition, an exit strategy for failed intubation should be clear in the clinician's mind.
7. As cricoid pressure does have potential benefits and the consequences of aspiration are significant, its use is recommended during rapid sequence intubation in the patient at high risk of aspiration.
8. During attempted airway management by awake or post-induction approaches, whenever the clinician suspects a significant possibility of encountering a failed oxygenation "cannot intubate, cannot oxygenate" situation, a "double setup airway intervention" should be prepared.
9. If tracheal intubation had been very difficult or circumstances now suggest it would be difficult, short-term maintenance of tracheal access using an airway exchange catheter is recommended upon extubation.

Weak recommendation *for*, level of evidence C

1. Cautious use of inhalational induction can be considered in the presence of a difficult airway or obstructing airway pathology if awake options for tracheal intubation are impractical.

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