Recent developments in the management of the difficult airway

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The difficult airway is so much a challenge mainly for the un-experienced anesthetist, that it deserves a privileged position in the training program of the residents. Enhanced awareness of the importance of thorough preoperative airway assessment as routine practice, implementation of airway management algorithms and the introduction of new airway devices are corner stones for a good outcome. The aim of these steps is to diminish the consequences of encountering a difficult airway, that is, to avoid failed intubation and thus brain failure or other complications of hypoxia. The review highlights recent developments in the management of the difficult airway, by no means intending to substitute clinical teaching or comprehensive airway management courses. Difficult intubation can lead to failure to intubate and if associated to difficult mask ventilation or to the worst nightmare- failed mask ventilation - bare the risk of ending up with unwanted outcomes. Therefore, the authors present the predictors of difficult intubation, introducing the Class zero airways, previously described by the same team. A floppy epiglottis might hamper mask ventilation even to this novel described class of patients. New devices and recommended positions for intubation are updated; ways to assess depth of intubation are exposed. The conclusion states how far we are from ideally managing the difficult airways despite novel technology. The opening to learning, exercising, being prepared with alternatives and providing proper equipment while getting experience are the ways to improve our performances and the patients’ final outcome.

Introduction

During the last three decades, significant progress has been made in the perioperative management of the difficult airway. This period has been marked by 1) a greater awareness of the importance of thorough preoperative airway assessment as routine practice, 2) careful preoperative airway preparation in patients suspected to have a difficult airway, 3) the implementation of airway management algorithms and 4) the introduction of new airway devices. Of these devices, the laryngeal mask airway (LMA) and the fiberoptic bronchoscope (FOB) have made the most impact on modern airway management. Emerging technologies for video-assisted laryngoscopy (VAL) are currently gaining popularity and are likely to similarly impact airway management algorithms in the near future.

The aim of these steps is to avoid the consequences of perioperative airway mishaps. Failed intubation should not lead to brain injury or death and data will be presented to suggest that there has indeed been a decrease in perioperative morbidity and mortality associated with the perioperative management of the difficult airway.

The purpose of this review is to emphasize recent developments in the management of the difficult airway. This review is not intended to be a substitute for clinical teaching or comprehensive airway management courses. There are some important differences in management of the airway in pregnant women and in infants which is beyond the scope of this review, although further reviews will be published on these issues in the near future.

Why is management of the difficult airway still a problem?

Failed intubation still causes brain injury and death. In the ASA closed claims study among general surgical patients, failed airway management was implicated in over 6% of the cases of anesthesia-related severe brain injury or death; this rose to 18% in obstetric patients [1, 2]. These numbers are a concern, as recent years have seen advances in strategies for managing difficult airways. Anesthesia manpower shortages often stretch available resources, so adequate time and manpower may not be allocated for preoperative assessment. Indeed, approximately half of cases of difficult intubations are unpredicted before the induction of anesthesia [3].

Furthermore, the pattern of anesthesia-related morbidity and mortality is continually changing. Even though airway management complications during anesthesia induction are decreasing, they are increasing during emergence from anesthesia, particularly following extubation of the trachea [2]. Finally, the co-morbidities of surgical patients are steadily increasing (including increasing surgery at the extremes of age and body size with the associated increase in risk factors for airway management problems.

Thirty or more years ago, most cases of anesthesia-related mortality and severe brain damage were associated with the aspiration of gastric contents either with or without failure of airway management on intubation. In the last two decades, however, most anesthesia-related mortality has been linked to obesity, to the failure to recognize and adequately manage critical illnesses and to the failure to adopt an
adequate extubation strategy for patients who where already difficult to intubate at the beginning of surgery.

Unfortunately, failure of airway management remains a serious problem and its incidence is far from negligible.

**Incidence of difficult airway**

The incidence of difficult/failed intubation and difficult/failed ventilation [4-10] is summarized in Table I.

**Understanding the airway problem**

Airway management problem-solving depends on the anatomic or pathophysiologic mechanism of the difficult airway which can be classified as supraglottic, glottic-epiglottic or subglottic mechanisms. Greenland [11, 12] recently described a new model to explain normal and difficult laryngoscopy and tracheal intubation. The interdependence between each laryngoscopy step and an eventual pathological change that might appear at each point is emphasized. The understanding of this complex model may help resolve three important airway issues:

- Finding a reliable airway assessment tool.
- Understanding the mechanisms of successful or failed laryngoscopy and intubation.
- Predicting the use of a specific airway device for a specific problem or scenario.

**Predictors of difficult intubation**

Predicting a difficult airway and proceeding with the correct airway management approach undoubtedly saves lives. Mallampati described a frequently used predictor of difficult intubation, the Mallampati class [13, 14]. However, when used alone, the Mallampati score is a weak predictor for difficult intubation despite the popularity of the test. It also does not make any prediction about the ease or difficulty of mask ventilation. For example, Ezri et al [15, 16] described a “class zero” airway, not included in the Mallampati classes where the epiglottis is visible through direct inspection of the oral cavity (Fig. 1). Although the authors found all those patients to be easy to intubate, the presence of a large, highly situated, floppy epiglottis might hamper mask ventilation in patients who received muscle relaxation.

When compared to the Mallampati classes, another easily applicable test, the “upper lip bite” test, showed significantly higher specificity and accuracy in predicting difficult intubation [17]. With the “upper lip bite” test a class I is considered if the lower incisors biting the upper lip, make the mucosa of the upper lip totally invisible, a class II if the same biting maneuver reveals a partially visible mucosa and a class III if the lower incisors fail to bite the upper lip.

To achieve greater predictive value for difficult intubation, the Mallampati score should be combined with other assessments such as those included in the Wilson score [18] (patient’s weight, neck extension, mouth opening, receding jaw) A recently described modified Mallampati class is Mallampati with extended craniocervical junction [19]. The authors of this article found that a high “Extended Mallampati Score” along with a diagnosis of diabetes mellitus are reliable predictors of difficult laryngoscopy in the morbidly obese patients. This study also supports previous findings that a high patient’s body mass index by itself is not a reliable predictor of difficult laryngoscopy or intubation [20]. Similarly, in a study of 91,332 consecutive patients scheduled for direct laryngoscopy (national anesthesia database in Denmark), Lundstrom et al [21] demonstrated that a high body mass index (BMI) is a poor predictor for difficult or failed tracheal intubation and that a neck circumference (measured at the level of the thyroid cartilage) greater than 40 cm is a better predictor than the BMI. Thus, it seems reasonable that the pattern of fat distribution rather than the BMI per se is important in forecasting a difficult intubation.

A frequently neglected preoperative measurement that may help predict a difficult airway is the mentohyoid distance. Recently, Huh et al [22] have shown that a ratio between mentohyoid distance in full neck extension and that in neutral position may be a good predictor of difficult laryngoscopy if this ratio is less than 1.2.

This ratio reflects mobility of the occipito-atlanto-axial complex and may explain failed laryngoscopy in patients with apparently normal airways. In such cases, optimal vi-
visualization of the glottis might require maximal head extension during laryngoscopy.

**Airway management devices and techniques**

Devices for airway management can be arbitrarily classified into intubation devices (laryngoscopes, tracheal tubes, retrograde intubation kits, light wands, gum elastic bougie, tube exchangers, etc), ventilation devices (facemasks, pharyngeal airways, supraglottic devices, transtracheal needle jet ventilation devices, etc), surgical airways (cricothyrotomy, percutaneous dilatational tracheostomy and formal tracheostomy) and devices serving other purposes such as CO₂ detectors, patient positioning devices, etc. As stated above, this review will focus primarily on recently developed airway devices.

In regard to supraglottic devices, Brimacombe [23] has challenged this terminology and proposed to call them extraglottic devices considering that they may actually be positioned below the level of glottis although still extraglottic (they do not pass the vocal cords). New extraglottic airway devices have been described at a rate of one per year for the last 25 yr, increasing to two per year since the turn of the century. However, it is not clear whether they add significant improvements compared to the laryngeal mask airway.

Examples of such recently developed devices are laryngeal tubes with drainage tube, EasyTube, SLIPA, I-gel, etc. The LMAs, have come with ProSeal pediatric sizes, disposable intubating LMAs (Fastrach) and the new, disposable LMA-Supreme (Fig. 2).

The LMA Supreme combines design features promoting easy insertion available with the Fastrach, with the presence of a draining tube available with the ProSeal LMA. It is supplied in three sizes: 3, 4 and 5. Timmermann [24] et al studied the performance of size 4 LMA Supreme in 100 women. They reported easy insertion, optimal laryngeal fit and low airway morbidity.

Positive pressure mask ventilation may be both ineffective and hazardous in obese patients with failed intubation. In such cases, aspiration of gastric contents is an imminent risk. Goldmann et al [25], prospectively studied the process of airway management with the ProSeal LMA in 2114 adult surgical patients (some of whom were morbidly obese). They found a 99% insertion success rate within three attempts and a mean airway leak pressure of 28 cmH₂O. Endotracheal intubation was required in only 3.2% of cases. Ventilation was adequately controlled in 98% of cases. There were 3.3% clinically “relevant” adverse events. 12 patients had some regurgitation that was witnessed through the drain tube, but none had any signs of aspiration. The authors concluded that ProSeal is a valuable ventilation device even in morbidly obese patients with a difficult airway and that the draining tube was useful in preventing the aspiration of gastric contents into the patients’ lungs.

**Video-laryngoscopy**

This relatively new laryngoscopy technique is becoming increasingly popular. It enables an clear view of the larynx, even with anatomically distorted airways. It combines either a standard or nonstandard laryngoscope blade or stylet with a built-in video camera and a view screen. Videolaryngoscopy may increase the success rate of intubation in anesthetized patients with unexpected difficult airways and is also a valuable teaching tool. Videolaryngoscopy may be performed with optic stylets (Shikani, Levitan, Foley, Sen-saScope, etc), C-Trach (video-LMA – Fig. 3), Airtrach (the first completely disposable laryngoscope – Fig. 4) and with the videolaryngoscopes (Glidescope – Fig 5, Storz, McGrath, Pentax Airway Scope, ViewMax Laryngoscope, Airway Cam, Parker TrachView, Weiss Macintosh Laryngoscope, Video camera attachment to True View, Bullard and Uphers Laryngoscopes, etc).

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![Fig. 2. LMA supreme](image1)

![Fig. 3. C-Trach](image2)
The Glidescope has a video camera embedded into a plastic laryngoscope blade, while the blade bends 60 degrees at the mid-line allowing an unobstructed laryngeal view. A Light Emitting Diode (LED) mounted beside the camera provides illumination. A limitation in using the Glidescope is sometimes difficult manipulation of the endotracheal tube through the vocal cords which can typically be overcome by using a dedicated, pre-curved tube stylet. In our experience it is an airway tool that is both easy to use and teach and has a wide clinical utility including in critical care units, delivery suites and emergency departments.

As these novel laryngoscopic techniques are still new, there may not yet be adequate data to judge their role in difficult airway algorithms. Mihai [26] et al performed a meta-analysis of 15 randomized controlled trials and 42 case series and showed no compelling evidence to support the superiority of these tools over direct laryngoscopy. Our opinion is that videolaryngoscopy does have potential to facilitate intubation in difficult airway management and save lives but we await the results of larger ongoing studies.

Positioning of the patient for intubation and mask ventilation
The “sniff” position is widely considered the ideal position for intubation since it bring together the three upper airway axes: the oral pharyngeal and laryngeal, thus, improving the laryngoscopic view. However, in obese patients, this positioning may not be adequate to enable the best possible laryngoscopic view. Head elevation beyond the sniffing position by raising the back and shoulders (“ramped” position – Fig. 6) facilitates alignment of the pharyngeal, laryngeal, and oral axis of the airway during difficult laryngoscopy, especially in obesity. A rule in attaining the ramped position is to keep the patient’s head above his shoulders and to keep the external auditory meatus and the sternal notch in the same horizontal plane [27]. Collins et al [28] found that the “ramped” position improved the laryngeal view when compared to a standard “sniff” position. Rao et al [29] proposed that a “ramped” patient’s position obtained by either changes in the operating table position or by placing blankets or other devices under the patient’s head and shoulders produced similar laryngoscopic views.

Patient positioning: against manual in-line stabilization?
Manual in-line stabilization (MILS) is considered a mandatory for safe intubation of patients with suspected cervical spine injury. In a recent study, Santoni et al [30] have challenged this by showing in a study performed on a cadaveric model that MILS not only increased the rate of failed intubation but also caused a worsening of the cervical spine subluxation. This is attributed to the fact that MILS doubled the force that must be applied during laryngoscopy. The authors propose that under these circumstances, if...
time permits, awake fiberoptic intubation is recommended and if there is no time, intubation with a fiberoptic stylet may be a reasonable choice.

**Depth of insertion of endotracheal tubes**

Many methods have been described to ensure a correct depth of the endotracheal tube and to avoid accidental endobronchial intubation (too deep) or accidental extubation (too superficial). However, all these methods may sometimes fail.

Evron et al. [31] proposed that this failure of the classical methods is caused by anthropomorphic differences between the patients (some have long necks, others short necks). The authors found that a formula based on topographic measurements to be very reliable in establishing the correct depth of endotracheal tube insertion. Fig. 7 shows the correct depth in cm may be calculated by adding two distances: the distance from the right oral commissure to the right mandibular angle plus the distance between the right mandibular angle to the mid-manubrial line. Irrespective of the method chosen, confirmation of tube placement by auscultation is mandatory and may be supplemented by chest X-ray or fiberoptic bronchoscopy if warranted.

**Oral vs. nasal fiberoptic intubation?**

The authors opinion is that in most cases, oral fiberoptic intubation is preferred to nasal fiberoptic intubation since is less traumatic, better tolerated by an awake patient and does not carry the risk of sinusitis if the tube will be kept in place for a longer period of time. The risks of epistaxis (which may both further complicate the airway and obstruct visualization through a FOB) are greater in obstetric (particularly preeclamptic) patients and in coagulopathies.

**Management approaches to difficult airway**

Some airway experts [32] tend to use a minimal number of devices such as the intubating laryngeal mask and the gum-elastic bougie, while the others’ approach is more complex and mostly based on algorithms [33]. Airway management algorithms are very helpful, provided they are simple and scenario-oriented. A detailed presentation of airway management algorithms is beyond the scope of this review.

**Difficult extubation**

Airway management related morbidity and mortality is increasing during and following extubation. The patient with a difficult intubation still poses a problem at the end of surgery and, if reintubation is necessary, it may be even more difficult than the original procedure.

Various techniques of extubation in previously difficult-to-intubate patients have been described [34] including extubation with the aid of a fiberoptic bronchoscope, extubation over a ventilating tube exchanger (such as the Cook airway exchanger catheter), replacement of the endotracheal tube with an LMA, etc.

**Sugammadex**

Sugammadex, is a new antidote of non-depolarizing muscular blocking agents. A recent Cochrane report [35] summarizing 18 randomized controlled trials demonstrated its safety and efficacy. It has a potentially crucial role in managing patients who have received non-depolarizing muscle relaxation (either rocuronium or vecuronium) and who cannot be intubated or ventilated. Although approved for use in Europe, so far it has not been approved by the FDA in the USA.

**Airway management tips**

- If you suspect an airway difficulty, believe it will be difficult.
- Never give muscle relaxants before you are sure you can ventilate the lungs.
- Remember the two/three hand-bag ventilation technique.
- Keep track of time during attempted intubation.
- If you believe the patient needs tracheostomy, do not delay its performing it until the patient’s heart arrests!
- Have a low threshold to call for an ENT surgeon.

**Conclusions**

This short introduction into the complex topic of difficult airway management tried to emphasize that we are far from being able to cope with all the difficulties. So, how could we perform better?

Learning and getting experience, having appropriate equipment and knowing how to use it, learning and practicing surgical airways and always being prepared with alternatives (using simple algorithms) will enable us to further reduce the morbidity and mortality attributable to airway management difficulties.
References


