Algorithms for difficult airway management: a review

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ABSTRACT

Difficult airway management and maintenance of oxygenation remain the two most challenging tasks for anesthetists, while also being controversial items in terms of clinically based-evidence to support relevant guidelines in the literature. Nevertheless, different expert groups and scientific societies from several countries have published guidelines dedicated to the management of difficult airways. These documents have been demonstrated to be useful in reducing airway management related critical accidents, despite their limited use in litigations and legal issues. The aim of this review is to compare different airway management guidelines published by the United States, United Kingdom, France, Italy, Germany, and Canada while trying to elucidate the main differences, weaknesses, and strengths for identifying critical concepts in the management of difficult airways.

Key words: Guidelines - Intubation - Medical devices.

It is widely recognized that the two most important tasks for anesthetists are the management of a difficult airway and the maintenance of oxygenation. Problems related to difficult airways are known to be the primary cause of life-threatening anesthesia-related accidents,1-3 and are one of the main sources of legal issues in the United Kingdom Defense Societies registries 4 and in the American Society of Anesthesiologists (ASA) closed claims.5 Nevertheless, the real incidence of airway related adverse events remains underestimated 6 and the number of “near accidents” is relatively unknown.7 That is why difficult airway management is one of the most demanding duties for anesthetists, and it provides a continuous challenge in addressing and solving potentially life-threatening problems. However, the question of what to do after a failed intubation in the paralyzed patient is a daily concern. Unfortunately, the different international guidelines do not provide standardized procedures for this or similar situations.

Guidelines for difficult airway management

Before guidelines were made available, the common response during difficult airway management cases was to count on individually acquired experience and skill. Thus, practitioners simply relied on lessons from previous errors with no preplanned protocols applied.

The need for systematically developed recommendations aimed to help anesthetists and patients in difficult airway management situations was clearly felt in the United States in the early 1990’s,8 which lead to the publication of ASA Guidelines for Difficult Airways Management (American Document, AD1993) in 1993,9 and their revision in 2003 (AD2003).10 In 1996, the French Society for Anesthesia and Intensive Care (SFAR) pub-
lished a preliminary document addressing airway management followed by a not yet fully approved revision in 2006 (French Document, FD). In 1998 the Canadian \textsuperscript{11} airway management focus study groups published specific guidelines (Canadian Documents, CD), followed by the 2004 publication of UK\textsuperscript{4} and German \textsuperscript{12} Documents (UKD and GD respectively). In 1998, the Italian Difficult Airways Study Group, on behalf of the Italian Society for Anesthesia and Intensive Care (SIAARTI), published an initial document for adult patients (Italian Document, ID1998)\textsuperscript{13} and a separate pediatric section,\textsuperscript{14} followed by respective revisions in 2005\textsuperscript{15} (ID2005) and 2006.\textsuperscript{16}

The aim of this review is to compare the different airway management guidelines, while trying to highlight the main limitations of the different documents and to provide a summary of the best available options for the management of difficult airways.

The best approach to evaluating these documents is to consider some major topics, and then to compare the various strategies and plans proposed by different guidelines.

Definitions and scientific background

All six of the aforementioned documents are based on the same published literature with the main differences being "guidelines language." These types of differences may be represented by the choice of different terminology to express the strength of a particular recommendation or the lack of sufficient evidence for some statement. Terms such as "supportive, suggestive, or equivocal" have to be compared with "recommended, not recommended, or mandatory", thereby expressing the preference of different study groups to direct the reader's attention towards certain concepts rather than others. However, the main problem of the guidelines for airway management is the lack of evidence to support the majority of clinical decisions and behaviors.

In addition, airway management represents a formidable challenge for statistical analysis. It is often impossible or difficult to perform randomized controlled trials in certain settings, or to normalize some variables such as individual experience or the feedback generated from other colleagues during difficulties.\textsuperscript{17} In addition, there is an important lack of evidence-based medicine, and the standard requisites for clinical data to be included in published papers are difficult to achieve.\textsuperscript{18} For example, consider the impossible task of performing a randomized double-blind controlled trial to compare Seldinger and non-Seldinger techniques for rapid tracheal access.

As a result, the main concern for all of these documents is that they do not represent a standard of care or a universally accepted and recognized protocol, and that their strict application does not obviate personal responsibility and judgement. On the other hand, the apparent simplicity of the guideline statements and the faith in experts' opinions, which represent the fundamentals of all published airway management guidelines, have led to the widespread dissemination of these documents with the consequence of reduced airway-related critical accidents. The degree of this beneficial effect has been proportional to the relative dispersion and adoption of these guidelines, as clearly demonstrated by the recent publication of the ASA closed claims.\textsuperscript{5}

However, a side effect of such a lack of clinical supporting evidence is the inconsistency among the different documents in expressing the same concepts regarding airway difficulties. Definitions are extremely important, both conceptually and from a practical point of view, as different definitions result in large variations in the reporting of difficult incidences in the literature.\textsuperscript{15, 19} For this reason, the definitions themselves have been thoroughly reviewed and changed during the past fifteen years from the guidelines' initial publication.

When considering definitions for "airway," "ventilation," "laryngoscopy," and "intubation," we discover important differences among the different documents.

The AD1993 guidelines considered difficult ventilation simply as difficult mask ventilation, and recommend "measuring" difficulty using only the peripheral oxygen saturation value as an indicator ($\geq 90\%$). However, this definition only accounted for the available literature of that period and does not consider the use of the laryngeal mask airway (LMA) or other extraglottic devices ([EGD], supraglottic devices [SGD] in American literature), which were poorly publicized at that
time, as alternatives to difficult mask ventilation. We must also remember that the AD1993 was the first document to be published. Thus, despite the need for improvement, the chosen definitions were the first to be used and, as a consequence, the UKD and GD adopted the same definitions though the ID1998 guidelines extended the difficult ventilation concept to difficult LMA ventilation and modified the index of difficulty from arterial desaturation (considered as the final result of a difficult ventilation) to the difficulty/impossibility of delivering an adequate tidal volume (Tv). Other documents published before AD2003 defined difficult ventilation on the basis of a proper facemask sealing or on the difficulty of delivering a correct Tv because of a large air leak or airway resistances (>25 cm H₂O). However, the last review of FD probably included too precise a specification for the lower limit for Tv, which dictated a fixed airway dead space (Vd=3 m³·kg⁻¹) together with the absence of a clear capnographic curve and the use of frequent O₂ flushing.

At the end of the last century, the “difficult ventilation concept” had been largely reconsidered due to the paper by Langeron et al., and widespread acceptance of EGD as an alternative for difficult/impossible ventilation. These advances eventually led to the inclusion in the AD2003 guidelines of the concept of predictive indexes for a difficult mask (BMI >26 kg/m², beard, advanced age, lack of teeth, history of snoring or obstructive sleep apnea syndrome, and increased airway resistance), and EGD ventilation (limited mouth opening, lower airways or laryngeal obstruction, and high pulmonary or abdominal pressures). Nevertheless, these concepts remained poorly outlined in ASA guidelines.

The evolving definition for laryngoscopic difficulty has followed the same path. For example, AD1993 only focused on Cormack-Lehane (CL) grading 3 and 4, thereby restricting the concept of laryngoscopic difficulty to an obstructed view of laryngeal structures.

Subsequently, ID1998 (the first to implement these changes) and CD considered the masking of vocal cords as an indicator for difficult laryngoscopy. Thus, these changes correctly expanded the concept of laryngoscopic difficulty to all partial views of larynx components and introduced the “2B” or “2extreme” grade view, which corresponds to the different levels of posterior arytenoids surface exposure. This variation, together with the specification of “external manipulation” and “best view” concepts, has allowed an increase in “resolution” for difficulty measurement, resulting in a more precise correspondence to real clinical scenarios and the adoption of a six step grading system in ID2005 introduced by Yentis et al.²³

A similar evolution of management protocols can be observed for difficult intubations. In AD1993, difficulty was expressed as the number of attempts (four) and maneuver duration (10 min). FD and ID1998 also implemented these definitions with small differences (5 min for ID1998), whereas the faulty indicator of procedural duration was recognized in later revisions of all documents. Nevertheless, much confusion has arisen regarding the number of attempts or laryngoscopies often represents an important factor in litigations, and their limit should be well defined.

Table I shows the main differences among documents for the number of laryngoscopies.

The resulting concept is that number of intubation attempts is variable and should not be considered only as a difficulty marker, but also as a decisional crossroad. Thus, a successful intubation

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<th>Table I.— Number of laryngoscopies allowed in cases of difficulty by the different Airway Management Guidelines.</th>
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after 3 attempts by a novice is of a different difficulty than a successful intubation after 3 attempts by an expert. Similarly, a single attempt by an expert with a CL4 view and a patient awakening decision is different than 4 attempts by a novice with an awakening decision due to difficult ventilation. Moreover, the difficult laryngoscopy concept should account for previously performed laryngoscopic attempts, correct head positioning, external laryngeal manipulation, and should be separate from the intubation difficulty, as the second might occur even with a good laryngeal view (i.e. subglottic stenosis) while the first might not be followed by any intubation attempt (i.e. CL4 and awakening). To summarize, on one hand it is important to consider that the number of laryngoscopic attempts should not be used as a measure of difficulty, while on the other, it is important to highlight the importance of a limited number of attempts because of their consequences on airway morbidity and ventilability.

Several key points might be deducted by the following ID2005 suggestions:
— one to three attempts are the maximum number of suggested laryngoscopies in the presence of a CL grading up to grade CL3. Considering that more than 4 attempts are associated with the development of airway trauma and the worsening of ventilation and that the success rate in the presence of a CL3extreme or CL4 is extremely poor. This point of view regarding laryngoscopy performed under the best conditions should become a decisional crossroads rather than a simple difficulty score. Thus, after the first attempt (the “awareness” one), the second one should be “diagnostic” and should be performed under the best conditions, while the third and fourth attempts should represent two alternate approaches (i.e. blade change or introducer use) to endotracheal tube placement.
— Between any attempt, ventilation should be checked and oxygenation monitored, as deterioration of one or both is the key point to decide for awakening the patient. In addition, LMA positioning or rapid tracheal access should be made available even after a single laryngoscopy.

Role of prediction

Almost all considered guidelines strongly agree on the importance of a patient examination and on airway pre-evaluation, even in emergency conditions. In addition, the association of different tests is required, and there is no indication for the value or performance of a single test. These guidelines highlight the well known concept that almost all airway predictive tests show a lack in sensitivity and specificity, resulting in a significant number of false positives and a low positive predictive value for any single test.

The different documents reveal different preferences for test associations, indicating them as useful (ASA and CD) or mandatory (FD and ID), while only the UKD does not address the problem of prediction parameters.

Interestingly, there is a strong conceptual difference among all the documents. Namely, the AD introduces a large number of “non-reassuring findings” without any numerical value for any parameter, and a similar approach is used in the CD; the UKD does not account for prediction, and the GD remains quite generic. In contrast, ID1998-2005 and the FD are extremely precise both in terms of the type of requested tests and on threshold values distinguishing between difficulty and the absence of difficulty. This is particularly true for ID2005, which considers the importance of maxillary prognathism presence and correction, and of the Mallampati test in both a standard approach and with phonation.

These differences correspond to the choice in ID and FD to divide ab initio airway problems into predicted and unpredicted difficulties, thereby moving the target from intubation to ventilation and oxygenation with consequential strategies suggested according to the degree of predicted (or unpredicted) difficulty.

Finally, the ID2005 is the only set of guidelines recommending registration of preoperative airway evaluation on the anesthesia record. This is designed as a “political choice” aimed to increase the power of guideline-oriented behaviors in case of litigation.

The key point is that predictive tests are fundamentally important. First of all, they are educational tools to develop awareness of airway problems. Despite their limitations, if the test predictions are overweighting, it might not necessarily be a problem in the field of airway management as overestimation of the problem might result in
Much ado about nothing, while underestimation might result in brain damage or death.

Suggested strategies in case of difficulties

There are essentially two kinds of approaches to airway difficulties among the six documents. With the limitations that occur with any generalization, we can define a “serial” approach, based on pure consequentiality of events, and a “parallel” approach, based on the unpredicted and predicted difficulties.

These different approaches correspond to the different roles of prediction recognized in the documents. ID and FD are built on prediction, resulting in a focus on ventilation and oxygenation rather than on intubation. The algorithm is then developed based on the events after the main choice of whether or not to make the patient apneic. In contrast, the AD, UKD, GD, and in some respects, the CD, build this algorithm based on the consequences of difficulties, giving less importance (but not misrecognizing) the original distinction between severely predicted and unpredicted difficulties between apnea and spontaneous breathing, and between ventilation/oxygenation and intubation.

This above approach can be highlighted through the five following elements from the aforementioned guidelines: initial responses during unpredicted difficulty, the presence of a difficult airway cart, the role of extraglottic devices, the role of fiberoptic bronchoscope (FOB), and tracheal access.

First line behaviors during an unpredicted difficulty

Among all the guidelines, Macintosh laryngoscopy remains the main approach after an airway difficulty. This is the suggested first laryngoscopy after optimization with sniffing position and external laryngeal manipulation (backward upward rightward pressure [BURP] and introduction of “alternative techniques” indicated in Table II).

The key point is that in cases of unpredicted difficulty (which should be lower for “parallel” rather than for “serial” approaches), the correct sequence should be optimization of head position and of laryngeal manipulation, followed by blade change (McCoy or Miller) and use of a gum elastic bougie or a tracheal introducer (preferably hollow as recommended in FD and ID2005 to allow CO2 detection and oxygenation). A lighted stylet, blind intubation through any EGD, and generally any blind technique should be avoided because of their high failure rate and potential airway trauma with ventilation deterioration. Use of FOB should be avoided in an emergency situation because of technical problems (ventilation, secretions, and bleeding), unless it is employed by experienced users. Finally, it must be emphasized that all these alternative techniques should not be used in cases of CL3 extreme and CL4 views, as all guidelines highlight the high failure rate under these circumstances and suggest patient awakening and planning of a spontaneous breathing technique for elective intubation. In addition, ventilation deterioration should indicate the early use of EGD and, if unsuccessful, the use of tracheal access.

Difficult airway dedicated cart

All documents recommend availability of a dedicated airway cart, but not all of them clearly indicate its level of importance and where it should be located. For example, the AD suggests a large
and expensive cart including some fundamental items (such as FOB) and almost all available airway devices, without any indication of the cart location. On the other hand, the FD, ID, and CD suggest a light cart including a few “familiar and practiced,” but not mandatory devices (including alternatives to a face mask and a tracheal access device), and considers the FOB should be “available upon request”. This is probably a consequence of the “parallel approach” with few instruments listed as mandatory for ventilation/oxygenation with the low number of difficulties left unpredicted, while there is time to organize for a predicted difficulty. At the same time, a “political choice” accounts for the economically unjustified effort necessary to equip a large cart along with experienced users for the different devices. However, it is a compromise to have a light but functional cart everywhere anesthesia is applied (as indicated in the respective guidelines) rather than a single fully equipped one. For this reason, recent commercially available devices and instruments, such as videolaryngoscopes, and new optical and fiberoptic devices were not included among the mandatory devices. This was done based on the limited use of some of these devices or out of the assumption that the superior vision quality and the teaching potentiality of some devices may not always be enough to counteract the generally high economic impact of such instruments.

Interestingly, all documents suggest the airway cart should include some devices for tube position control (ranging from auscultation, capnography, CO₂ detectors, esophageal detector device, and FOB control), therein recognizing the risks of esophageal intubation. In contrast, some debate remains regarding strategies for protected extubation, especially in the latest guidelines. This debate is a result of the recent evidence demonstrating a failed reduction in airway accidents during this phase of anesthesia.¹

The value of extubation-failure predictive tests (cuff leak test) remains uncertain, while use of dedicated devices such as tube exchangers to perform tube exchange or protected extubation (leaving a guide to railroad the endotracheal tube if reintubation is necessary) is more or less strongly recommended among the different documents (particularly FD and ID2005).

**ROLE OF EXTRAGLOTTIC DEVICES**

One of the troubling facets of guideline reporting involves the large and continuous production of new airway devices on the market. Undoubtedly, these devices have changed airway practices and have elevated the threshold of difficult ventilation. However, significant concerns remain regarding their efficacy (not all EGDs are the same), the skills required for their proper use, and in their recognized limits (mouth opening, laryngeal/sublaryngeal stenosis, and a full stomach). All documents adopt the EGD in their algorithms and airway carts, with some important differences. For example, the AD allows all EGDs to be located on the airway cart, while the FD, GD, and UKD are strongly oriented towards LMA and intubating LMA for both ventilation and advanced visualized (including FOB) or blind intubation attempts. The ID maintains a distinction between “LMA and other devices”, leaving the operators the complete freedom to choose between the different commercially available devices on one hand, but recognizing that LMA is still the most widely recommended and the most extensively supported device for clinical practice in the literature. The key point is that whenever necessary, the user should be confident with the technique and its limitations (which means daily use in the clinical routine practice). Furthermore, the practitioner should never forget the concept of minimum interincisor distance to introduce any EGD as a crossroads to choose between an awake intubation technique, and the unsolved, though largely debated problems of a full stomach, rapid sequence induction, and cricoid pressure application.

**ROLE OF FIBEROPTIC BRONCHOSCOPE**

FOB is universally recognized by guidelines as the gold standard to predict severe difficulty with awake, sedated, or anesthetized patients and for tube position control. The main limits for FOB involve the purchasing and maintenance costs, risks of rupture, and skills development. The AD suggests that the FOB be present on the airway cart and indicates FOB intubation among second line strategies in case of failed intubation during unpredicted difficulty. Similarly, the GD, UKD,
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and CD (only if performed by experts) suggest the same use for FOB, while the ID and FD exclude (and suggest not to use) the FOB in an emergency or in the case of failed intubation. In addition, they do not designate it as a mandatory device on the airway cart. Once more, this is the difference between the “serial” and the “parallel” approach, and the consequence of recognizing the value of preoperative evaluation of airway management difficulties.

Definitely, FOB might be extremely useful in experienced hands if combined with dedicated airways allowing ventilation during maneuvers or with EGD (actually with the maneuvers allowing its use) during unpredicted difficulties. However, its use should be discouraged in cases of emergency, especially if combined with worsening ventilation. Perhaps, this is why it is not considered among the mandatory devices as stated by the FD, CD, and ID.

**TRACHEAL ACCESS**

This is the common final goal in all the reviewed documents (all include a tracheal access kit among the mandatory devices) in case of ventilation/oxygenation failure via face mask or extraglottic devices, or as the result of useless and unsuccessful repeated laryngoscopic attempts in case of unfavorable CL grading views. The only differences among documents are related to the procedure choice. Regarding this, there is a preference for surgical cricothyroidotomy (AD and UKD) for a generic transtracheal airway (GD and CD) or for percutaneous Seldinger-guided techniques (ID and FD), with no clear evidence for the optimal performance of one technique over another. Interestingly, the AD remains the only set of guidelines considering emergency tracheotomy, which is correctly considered by all other documents as a procedure that is too risky, inappropriate, and time consuming. This is true especially if the technique is compared with surgical cricothyroidotomy, which can be quickly and easily performed with a small styletted cuffed endotracheal tube, a scalpel, and a blunt dissection instrument.

Furthermore, transtracheal catheterization also allows for oxygenation, but cannot be considered a technique for ventilation, while the Seldinger-guided large-size cannula technique might also allow the performance of a surgery in the case of an undeferrable emergency. Interestingly, only the CD and ID2005 emphasize that, though rare, rapid tracheal access should be an anesthetist’s core skill, even taking into account potential litigations. Thus, a great deal of work has to be done to improve the teaching and performance of these techniques.

**Training and documentation**

Documentation for difficult airway management is considered extremely important for different reasons. For example, documentation can serve as a powerful instrument for legal issues, both in the defensive and the offensive sense, as there is a tendency among experts to regard the chart as a metaphor for the care provided. However, an illegible, scantily completed chart infers that the care was likely substandard and inattentive, and a poor chart is one factor that may result in an expert opinion leading to the critical evaluation of the practitioner.

At the same time, clear and exhaustive documentation suggests a standard of quality for doctors and hospitals, and also provides a guarantee for patients’ safety in case of future needs for anesthesia and difficult airway management.

All the examined guidelines, in different ways, report the importance of complete documentation although the ID2005 is the only one of these considering it to be mandatory, not only because of ethical considerations, but also because of a general lack in correct documentation as reported in the literature.

In addition, the AD2003 also suggests details for correct documentation (difficulty and technique description and communication options such as letters or bracelets for patients) and emphasizes the absence of literature-based evidence for the advantages of informing patients. Similarly, the CD suggests a letter be given to the patient according to a precise model, while the FD only suggests patients being informed in cases where difficulties are experienced. No particular notes for documentation are reported in the other guidelines.

Training and the need for the development of specific skills and knowledge among anesthetists is expressed differently among the different docu-
ments. For example, the FD expresses the need for skills development and algorithm adhesion, without further specifications regarding how to pursue it. The CD highlights the lack of knowledge about different endoscopic instruments as an alternative to the conventional laryngoscope. The GD and UKD do emphasize the need for preplanned alternatives in cases of difficulty, but they do not suggest teaching strategies. The ID2005 dedicates a paragraph to skill development and to the importance of specific goals during the formal training period with the identification of core skills and suggestions for teaching options (principally, the role of simulation). In fact, systematic reviews of strategies for changing professional behavior show that relatively passive methods of disseminating and implementing guidelines rarely lead to effective changes. This observation raises the concern that in order to maximize the likelihood of a clinical guideline being used, we need coherent dissemination and implementation strategies. The most important of these strategies is the teaching of these techniques in postgraduate schools and the availability of hands-on experiences in both simulation and clinical practice.

Conclusions

In summary, although the guidelines on airway management possess limitations and require better implementation, they play a key role in both practitioner and patient safety. They are important because they have directed the health community's attention to the “airways problem”, and because, according to available data, they seem to have really changed anesthetists’ practices with important effects on patient outcome and survival, though they have not completely abolished critical accidents.

These guidelines have in some way introduced a “culture of prediction”, thereby breaking up the “cannot intubate fear.” They have encouraged health care practitioners to “call for help,” and have subsequently prompted clinicians to plan a practical response model in case of airway difficulties.

Moreover, the guidelines have encouraged anesthetists to establish a difficult airway cart, thereby making a larger number of clinicians familiar with previously “elite” techniques, such as awake intubation. In addition, the guidelines have probably abolished the mythological images of certain procedures such as early tracheal access.

Finally, the GL highlighted the problem of learning and training in a field that must be considered central to the practice of anesthesia. Clearly, a large range of skills need to be acquired by anesthetists in training, and GL may be considered a kind of template for educational purposes. It is notable that several papers have been written to address this topic and more realistic and sophisticated mannequins are being developed on the “long wave” of GL.

After comparing all available documents, it is difficult (yet not necessary) to identify the optimal guidelines. We concede that some guidelines will be more easily adopted because they are obvious choices and require few mandatory devices, and they contain options that will allow for their virtually effortless introduction into daily practice.

The more algorithms are made to be simple and non-restrictive, the more easily they are received and correctly applied, especially when considering the following mandatory points:

- importance of prediction;
- need of a preplanned high safety/low trauma strategy;
- importance of oxygenation/ventilation rather than intubation;
- familiarity with instruments and techniques;
- correct role of devices and techniques (i.e. awake fiberoptic intubation mandatory for elective severe predicted difficulty);
- skill development and maintenance.

Considering that there is no clear scientifically-based evidence to support any of the proposed guidelines, and accepting that most of the documents examined are constructed from experts’ opinions and experiences, the ideal document is probably the one that best conforms to a single operator’s experience, and to a single center’s availability of devices and instruments. Meanwhile, any algorithm or guideline must be optimized and, independent of this choice, the best options always include consideration of the patient’s safety and good sense.
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