Chapter

Management of New Special Devices for Intubation in Difficult Airway Situations

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Abstract

Difficult airway management in critically ill patients has serious implications, as failing to secure a stable airway can lead to a brain injury or even death. Early recognition of a difficult airway can allow the clinician to minimize the potential morbid-mortality. In this chapter, we describe all about the common scenarios that we may tackle when we need to secure a patent airway. It is important to know common definitions about the airway, pre-visualize potential problems and knowing how to be aware of the different pathways on managing and solving the different problems that clinicians may face. It is highlighted to know all the different medical equipment and medication used when an airway is suspected not to be easy to manage or when problems arrive without warning and the practitioner needs to rapidly change the plan on the go. We discuss the current most relevant guidelines and literature about this subject trying to give a practical approach.

Keywords: difficult airway, airway management, ventilation, intubation, airway devices

1. Introduction

One of the most stressful situations that all anesthetists, intensivists and emergency physicians can face is the management of a difficult airway (DA). That stressful situation can turn into a tragedy if the team is not well trained, not ready, and the plans are not well established or known.

The prediction of a DA is essential to anticipate all the strategy that the team has to deploy to successfully manage that situation.

Different guidelines and much literature have been published on this topic in recent years, all these articles try to establish a structured approach and facilitate in the simplest way the different steps to follow in this problematic scenario.

Airway management was considered inappropriate in a high percentage of complaints, including inadequate evaluation, lack of planning for difficult intubation, failure to use the supraglottic airway for rescue, delay in requesting help, and perseveration in failed techniques.

A thoroughly well-designed plan needs to be established and summarized in the airway approach algorithm and foresight all possible situations that may be encountered during the clinical practice of a serious and threatening airway crisis, all of them should be discussed in advance. Awake intubation, intubation after induction of anesthesia, and the "can't intubate, can't oxygenate" (CICO) situation should be planned and well known to all team members.

2. Definition of difficult airway

There is no universal definition of difficult airway in the literature. However, We can define the DA such as some clinical factors that make ventilation of the mask difficult or some anatomical factors that make tracheal intubation difficult for a trained specialist [1]. Difficult airway encompasses the interaction of various circumstances: patient factors, clinical settings, and specialized skills.

Difficult ventilation is the inability of an experienced specialist (intensivist or anesthesiologist) to maintain oxygen saturation above 90% with a 100% FiO2 face mask. We know that with some indirect signs such as absence or inadequate respiratory sound, inadequate chest movement, haemodynamic changes such as hypertension or hypotension, arrhythmias associated with hypoxaemia, cyanosis, etc.

Difficult orotracheal intubation (DOTI) is defined as three or more attempts to perform tracheal intubation or more than ten minutes to perform it. It occurs in 1.5–8% of general anesthesia procedures [2, 3]. The cause of these may be due to difficulty in laryngoscopy: we cannot visualize any portion of the vocal cords, failed intubation: the place of the endotracheal tube is incorrect after multiple attempts, presence of tracheal pathology that prevents correct tracheal intubation.

3. Purposes of the guidelines for difficult airway management

DOTI is a common cause of anesthetic morbidity and mortality, so it is important to anticipate these difficulties before the process. Up to 30% of death from anesthesia could be due to a difficult airway. That is why it is very important to have high prognosis tests to identify difficulties in the airways [4, 5] and make a universal definition to classify the DA and teach the management of this. The main adverse outcomes include brain injuries that can be related to dental damage, trauma to the airways, unnecessary surgical airways or some injuries related to cardiopulmonary arrest, hypoxia, brain injury, or even death. The use of one method and another for the management of the DA, the hierarchy of categories made according to the level of scientific evidence collected will be carried out hereunder.

4. Assessment of the airway

The experienced clinician can anticipate when intubation may be difficult by taking a proper history and complete physical examination. In emergencies, a brief but comprehensive airway assessment is essential to treat patients who require advanced airway management.

4.1 History of the respiratory tract

The physician should take a history of the patient's airway, investigating in detail the medical, surgical, and anesthetic factors that may indicate the presence of a

DA. Many disease states have been associated with DA (**Table 1**). Additionally, lung problems such as asthma, chronic obstructive pulmonary disease (COPD), bronchitis, recent upper respiratory infection, or the presence of pneumonia can affect oxygenation and ventilation. Most patients presenting for emergency procedures are at increased risk of aspiration (**Table 2**) [6].

Congenital	Acquired
Pierre Robin syndrome	Morbid obesity
Treacher-Collins syndrome	Acromegaly
Goldenhar syndrome	Infections involving the airway (Ludwig's angina, epiglottitis, croup, etc.)
Mucopolysaccharidoses	Rheumatoid arthritis
Achondroplasia	Ankylosing spondylitis
Micrognathia	Obstructive sleep apnea
Down syndrome	Tumors involving the airway
Cretinism	Trauma or burns of the face, head, or neck
Beckwith syndrome	Radiation of face or neck

Table 1.
Diseases associated with difficult airway management.

Full stomach – nonfasted, emergency surgery or trauma
Pregnancy after 12 to 20 weeks gestation (gestational age for increased risk is controversial) Symptomatic gastroesophageal reflux
Diabetic or another gastroparesis
Hiatal hernia
Gastric outlet obstruction
Oesophagal pathology
Bowel obstruction
Increased intra-abdominal pressure – ascites, abdominal mass

Table 2.
Conditions that increased risk of aspiration.

4.2 Examination of the respiratory tract

The purpose of this evaluation is to detect physical characteristics that may indicate the presence of a DA.

The sight assessment provides very useful information. Obesity, facial hair, thick and short neck, and neck collars are immediately apparent and suggest a possible DA.

Mouth. The jaw opening should be at least 4 centimeters in adults, which is roughly three to four fingers. A mouth opening of fewer than three fingers is considered limited. Patients with temporomandibular joint (TMJ) disease or previous surgery may have a very limited mouth opening or trismus. The movement of the TMJ must allow at least a maximum opening of the mouth of 50 to 60 mm. A small or large jaw can affect vision when intubated. The dentition should be evaluated, paying particular attention to the presence of caps, crowns, implants, veneers, dentures, braces, or loose teeth. The small space between incisors suggests possible DA management [7–9]. The Mallampati classification was first described in 1985 as a test to predict difficult laryngoscopy [10]. The Mallampati classification involves the size of the tongue concerning the oral cavity. The more the tongue obstructs the view of the pharyngeal structure, the more difficult the migration of the device:

Class I: The entire tonsillar pillars, uvula, hard and soft palates are visualized.

Class II: Partial uvula and soft palate are visualized.

Class III: Only the soft palate is visualized.
Class IV: No visualization of any structures beyond the tongue.

Neck range of motion decreases with age, neck arthritis, cervical spine disease, or previous spinal surgery. Patients with restricted neck extension may be more difficult to position optimally for induction of anesthesia and intubation [11]. Airway management must be based on the fact that DA cannot be predicted reliably. This is a particularly important consideration in the intensive care setting [12]. Recognition of patients at particular risk of DA management helps planning and is recommended, even in the most urgent situations. The only validated airway assessment tool in critically ill patients is the MACOCHA score (**Table 3**). A score of ≥3 predicts difficult intubation in critically ill patients. However, to reject difficult intubation with certainty, the main value of the score comes from the negative predictive value of the parameter. It is wise to be prepared for DOTI, even if intubation is ultimately not difficult [13].

Mallampati 3 or 4	5
Obstructive Sleep **A**pnea	2
Cervical-spine movement limited	1
Mouth **O**pening < 3 cm	1
Coma	1
Hypoxemia (<80%)	1
Non-**A**nesthetist intubator	1

Table 3.
MACOCHA score.

5. Basic preparation for difficult airway management

A difficult airway management protocol includes several well-organized strategies to achieve sufficient ventilation and apply various intubation techniques to have the best chance of success and decrease the chance of injury to the patient. Although the airway approach is a challenge for the emergency team, airway management is even more difficult in critically ill patients. Decision-making, interaction within the team, use of resources, and motor skills can all be affected under stress. The goal is to ensure oxygenation in life-threatening and rapidly changing situations that require agile decision making, thereby reducing the number and severity of critical incidents and complications.

5.1 Recommendations for the management of the difficult airway

There should be at least one portable storage unit containing all specialized equipment for managing DA. A variety of standard and alternative airway devices should be readily available, including masks, appropriate sizes and types of laryngoscopes (direct, indirect, flexible), oral and nasal airways, supraglottic airways (SGA), spark plugs and equipment. For the front of the mouth neck access (FONA). Make sure there is at least one additional person who must be immediately available to serve as an assistant in managing DA.

All patients must be pre-oxygenated before induction of general anesthesia. Pre-oxygenation increases oxygen reserve delays the onset of hypoxia and allows more time for laryngoscopy, tracheal intubation, and airway rescue in the event of intubation failure [14]. The duration of apnea without desaturation can also be prolonged by passive oxygenation during the apneic period (apneic oxygenation). This can be achieved by administering up to 15 liters/min of oxygen through nasal cannulas. Nasal administration of oxygen during intubation management has been shown to prolong apnea time in obese patients with a DA [15]. High-flow nasal cannulas (with humidified high-flow oxygen (up to 70 liters/min) have been shown to prolong apnea time, although their ability to improve preoxygenation has not yet been elucidated [16, 17].

5.2 Recommendations for basic DA management

There should be a portable chart unit containing all specialized pieces of equipment for the management DA. The following steps are highly recommended [16]: • Inform the patient (or responsible person, if possible) about the risks and special procedures related to the management of DA. • Make sure there is at least one person available to operate as an assistant. • Pre-oxygenate with a mask before starting DA management. In the uncooperative or pediatric patient may result impossible to achieve. • Actively seek any opportunity to supply supplemental oxygen throughout the DA management. These include the delivery of oxygen via nasal cannulas, mask or LMA, and oxygen supply through any applied device. Airway management is safer when potential problems are identified in advance in case of urgent intubation, allowing planning and reducing the risk of complications [17]. Airway assessment should be performed routinely to identify factors that may cause difficulties with face mask ventilation, SAD insertion, tracheal intubation, or front neck access (FONA). The prediction of DA management is not always completely reliable. Basic management preparation for DA management includes (1) availability of DA management equipment, (2) informing the patient or relatives of a known or suspected DA, (3) assigning a person for help and assistance, (4) mask pre-oxygenation, and (5) supplemental oxygen administration throughout the DA management.

6. Difficult airway intubation strategy

A well pre-planned strategy before induction includes several interventions, designed to facilitate intubation in the event of DA. Non-invasive maneuvers targeted at treating DA include [17]: (1) awake intubation, (2) video-assisted laryngoscopy, (3) intubation stylet or tube changers, (4) SGA for ventilation (eg. LMA, laryngeal tube), (5) PEG for intubation (eg. ILMA), (6) rigid laryngoscopy, (7) fibreoptic-guided intubation, and (8) stylets with light or light wands. Following the Difficult Airway Society, we will proceed with a structured detailed plan that consists of several considerations.

6.1 Plan A. Mask ventilation and tracheal intubation

The very essence of Plan A is to maximize the chance of successful intubation on the first attempt or, failing that, limit the number and duration of laryngoscopy attempts to prevent airway injury and progression to a " cannot intubate, cannot oxygenate "(CICO). Patients must be in an optimal position and well pre-oxygenated before the administration of anesthetic medication. The use of neuromuscular blockade facilitates mask ventilation and tracheal intubation. Any attempt at laryngoscopy and tracheal intubation is potentially harmful. A suboptimal attempt is a vain attempt and carries the possibility that success diminishes with each subsequent attempt [18–20]. Repeated attempts at tracheal intubation reduce the likelihood of effective airway rescue with SAD [21]. Current guidelines recommend a maximum of three intubation attempts; a fourth attempt can be done by a more experienced colleague. If unsuccessful, a failed intubation should be stated and proceed to Plan B.

6.2 Plan B. SAD

Maintaining of oxygenation: supraglottic airway device (SAD) insertion is in the guidelines. The emphasis of Plan B is to maintain oxygenation using a SAD. If we succeed in the placement of a SAD, it brings the opportunity to stop and consider whether to wake the patient, try a new attempt at intubation, continue without a tracheal tube, or, in rare cases, proceed to a cricothyroidotomy. If we cannot achieve oxygenation via SAD after a maximum of three attempts, proceed to Plan C.

6.3 Plan C. Awakening or total paralysis

Final attempt at mask ventilation. If effective ventilation has not been established after three attempts at SAD insertion, Plan C proceeds directly. At this stage, several possible scenarios can be developed. During Plans A and B, it will be determined whether mask ventilation was easy, difficult, or impossible, but the situation may have changed if attempts at intubation and SAD placement have traumatized the airway. If mask ventilation results in inadequate oxygenation, the patient should be awakened in all but exceptional circumstances, and this situation will require total antagonism of the neuromuscular block. If oxygenation cannot be maintained using a face-mask, ensuring complete paralysis before critical hypoxia develops and we will have one last chance to rescue the airway without resorting to Plan D. Sugammadex has been used to antagonize neuromuscular block during the situation of CICO, but does not guarantee a patent and manageable upper airway. Residual neuro-depressant medication, airway laceration, or pre-existing upper airway disease may contribute to airway obstruction [17, 21].

6.4 Plan D. Front neck emergency access (FONA)

A CICO situation arises when attempts to manage the airway by tracheal intubation, mask ventilation, and SAD have failed. Hypoxic brain damage and death can occur if the situation is not resolved quickly. NAP4 report provided feedback on a cohort of emergency surgical airway and cannula cricothyroidotomies performed when other methods of securing the airway had failed [22, 23]. The report highlighted several issues, including decision making (delayed progression to cricothyroidotomy), knowledge gaps (not understanding how the available equipment worked), system failures (specific equipment not available), and technical failures (not placing a cannula in the airway). After NAP4, the discussion focused largely on the choice of technique and equipment used when airway rescue failed, but the report also highlighted the importance of human factors (discussed elsewhere) [16, 17]. Regular training in technical and non-technical elements is needed to reinforce and retain skills. Success depends on decision-making, planning, preparation, and skill acquisition, all of which can be developed and refined with repeated practice [24, 25].

FONA consists of surgical airway access employing an emergency cricothyroidotomy. This technique is presented and discussed elsewhere in this book.

7. Different techniques and devices for approaching intubation in DA

7.1 Intubation stylets or tube exchangers

7.1.1 Stylets

We define the classic stylet as a malleable metal wire designed to be inserted into the endotracheal tube to facilitate tracheal placement at the time of intubation with difficult laryngoscopy. Mild mucosal bleeding and a sore throat are complications associated with stylets (**Figure 1**).

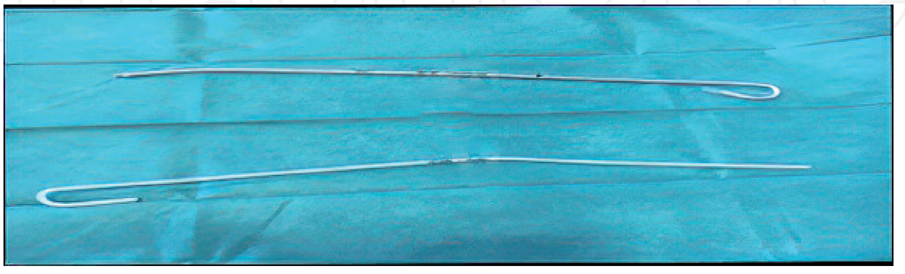

Figure 1.
Classical stylets.

We can find several commercialized types that differ in curvature and size. There are also specialized stylets available known as endotracheal tube introducers or "rubber elastic plug" which consist of a 50 to 60 cm stylet with the distal tip bent at a 30-degree angle. They are indicated in a grade III Cormack-Lehane view because they allow the physician to direct forward under the epiglottis and through the vocal cords and then a tracheal tube can be inserted over it. Some of them are single-use like **Frova,** whose tip is fenestrated to allow oxygenation. However, Eschmann introducer can be sterilized and reused [26].

Today there are also disposable optical lighted stylets or light wands that incorporate a video or fiber-optic display element at the distal end. The viewing element provides the clinician with an adequate view from outside the mouth with direct laryngoscopy to the region near the glottis. Common examples include; the **Clarus video system**, the **Shikani video system**, the **Bonfires retromolar intubation fibrescope**, and the **Leviton FPS telescope** (**Table 4**) [27, 28]. They are not indicated for use in patients with laryngeal trauma, tumors, and foreign bodies. It is also not indicated for patients with thick necks or limited neck extension.

Instructions for use [28]:

Introduce the ET over the stylet having previously lubricated the inner face of the ET. Choose the desired stylet angle. Using the index finger of the left hand or the laryngoscope, move the tongue to the left and insert the tip of the pencil into the right side of the mouth with the right hand. Try to direct the tip of the stylet towards the midline of the neck trying to pass the glottis. Once the tip of the stylet passes the glottis, we will appreciate light in the midline of the neck by transillumination. We then advance the ETT through the stylet to the trachea.

CLASSICAL	SINGLE USED	REUSED	
SPECIALIZED	LIGHTED	BOUGIE	OPTICAL

Table 4.
Stylets.

7.1.2 Tube exchangers

Airway exchange catheters are long, hollow catheters that allow clinicians to remove and replace tracheal tubes without the need for laryngoscopy (**Figure 2**). These catheters often have connectors for manual and jet ventilation or oxygen insufflation. Cook's Airway Exchange Catheter (CAEC) is one example [26].

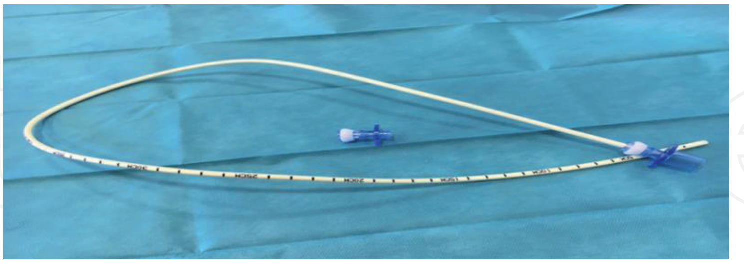

Figure 2.
Cook airway exchange catheter.

7.2 Extraglottic devices for ventilation

Extraglottic airway devices are used to establish an airway for oxygenation and ventilation without entering the trachea. They are important tools that are frequently used in the pre-hospital setting, the emergency department, the operating room, and other settings [26, 29].

These devices are useful in cases of DA management in patients who cannot be intubated or ventilated. Contraindications to the use of extra-glottic airway devices include obstructive airway diseases, traumatized airways, gag reflex, etc.

These types of devices should be used under sedation to reduce pharyngeal spasms/reflexes that can impair ventilation (**Table 5**).

7.2.1 Supraglottic devices

They are laryngeal masks that seal around the glottis and remain superior to the larynx. The laryngeal mask airway (LMA) is a useful supraglottic device added to emergent airway management. Its use is extended by 3 or 4 degrees Cormack-Lehane of laryngoscopic view and Difficult Bag Ventilation Mask (DBVM). This device allows clinicians to provide adequate ventilation in severely hypoxic patients facilitating subsequent treatment. It is very important to correctly fix the LMA as its dislocation is easier compared to endotracheal intubation. However, the LMA does not increase the risk of aspiration if its fixation is ensured.

We can consider LMA as the milestone in the field of supraglottic airway approach. It was first described by Archie Brain in 1983 and has become a commonly accepted device for rescue airway management and is included in the major societal recommendations and DA management algorithms [29].

Supraglottic devices	Retroglottic devices
LMA. (Laryngeal mask airway). ILMA. (Intubating laryngeal mask airway). Air-Q. i-Gel.	Combitube. King LT (King laryngeal tube).

Table 5.
Common extra-glottic devices.

There are multiple types of laryngeal masks, each with specific characteristics. Therefore, the placement of a laryngeal mask (**Figure 3**) is an important tool in adults with a DA, especially in the case of a high anterior larynx, which represents a substantial advance as a rescue device in situations of CICO [29, 30].

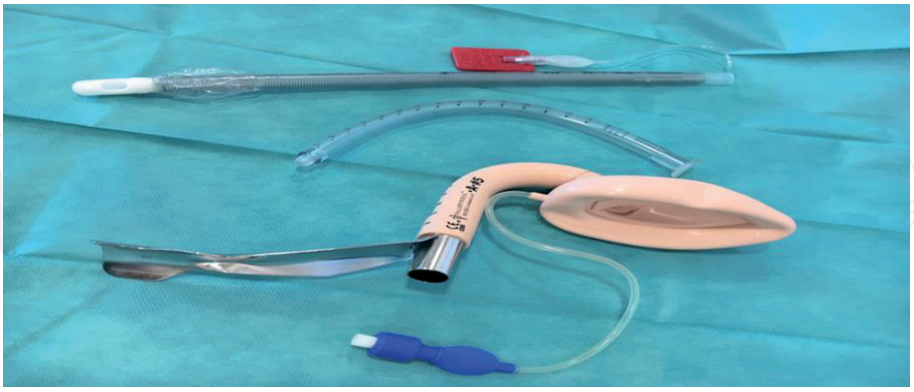

Figure 3.
ILMA (FASTRACH).

7.2.2 Retroglottic devices

They are laryngeal tubes that end in the upper part of the esophagus, posterior to the glottis, and have two balloons, one pharyngeal and the other oesophagal, with ventilation fenestrations in the middle that line up with the glottic opening (**Table 6**).

7.3 Rigid laryngoscopic blades of alternative design and size

The purpose of the laryngoscope is to move the oral anatomical structures out of the laryngoscopist's line of vision to expose the glottic opening. The blade of a laryngoscope consists of a flat element (spatula), a vertical element (flange), and a light source. Straight and curved blades are the most common.

Both the Macintosh (curve) and Miller (straight) blades are available in sizes 0 (neonatal) to 4 (large adult), although we commonly prefer to use the straight blade for infant intubations and curved blades for adults.

7.3.1 Fiber-optic guided intubation (FBO) and awake tracheal intubation (ATI)

Fiber-optic intubation is a technique in which a flexible endoscope with an endotracheal tube loaded along its length is passed through the glottis. The tracheal tube is then pushed out of the endoscope and into the trachea and the endoscope is removed. The nasotracheal route is used frequently and requires the use of nasal vasoconstrictors. A nebulized local anesthetic is delivered to the airways through a mask. Sedation can be given, but ideally, the patient should breathe spontaneously and respond to verbal commands [31].

Curve blade	Straight blade
Macintosh.	Miller.
Adults.	Infants.
Indirectly rising the epiglottis.	Improve lifting of the epiglottis.

Table 6.
Common types of blades.

7.3.1.1 Advantages of FBO-guided intubation

- Avoid the stress of direct laryngoscopy.
- Direct visualization of the vocal cords.
- Short intubation time according to training.
- Less traumatic and less repeated intubation attempts.
- Maximum incidence of success.
- Minimal risk of injury.
- Allows the administration of oxygen through the suction channel.
- Maximum safety in awake patients.
- Definitive control of the ET position.
- Endoscopic study before intubation.
- Possibility of oral or nasal application.
- Possibility of execution in extreme positions [31–33].

Due to all these advantages, intubation with FBO is the cornerstone of DA management as well as its ultimate goal: suspect and identify a DA, perform intubation with the patient awake to avoid unnecessary risks.

Intubation with an awake patient while maintaining spontaneous breathing is the "gold standard" in the treatment of "predicted difficult airway."

Awake fiber-optic intubation is reported to be successful in 88–100% of DA patients. Case reports using other techniques for awake intubation (blind tracheal intubation, intubation through supraglottic devices, optically guided intubation) report not so high odds of success with DA patients [21].

Awake intubation has the following advantages [28, 34]: the patient retains the ability to keep the ventilation and airway patent and the muscle tone that keeps the pharynx clean and preserved; the collaboration of the patient and helps us pass the ET with deep breathing; with good local anesthesia, it facilitates a poor haemodynamic response.

FBOs also have disadvantages [33]: necessary training, skill, patient cooperation, longer execution time, optical fibers are fragile and require rigorous precautions.

The route for tracheal intubation should take into account the patient's anatomy, surgical access, and the tracheal extubation plan. In patients with limited mouth opening, the nasal approach is the only option, while in patients who had nasal surgical interventions, the oral approach should be preferred. No evidence or consensus is found among experts on the superiority of a route if both are feasible. Awake tracheal intubation (ATI) by using video-laryngoscopy has the same success rate and safety as ATI: FBO (98.3% each) [35]. Careful selection of the tracheal tube is critical to the success of any ATI technique. It is advisable to use the tracheal tube with a smaller external diameter, as it can reduce the incidence of injury [36]. A checklist of all the supplies needed should be disposable.

Oxygenation: Desaturation ($SpO_2 \leq 90\%$) with low-flow (< 30 l/min-1) oxygen techniques during ATI ranges between 12% and 16% [37, 38]. When using warmed and humidified high-flow nasal oxygen, desaturation plummets to 0–1.5% [39]. Administration of supplemental oxygen during ATI is highly recommended. It should be commenced on patient arrival before the procedure and continued throughout. High-flow nasal oxygen should be the technique of choice for pre-oxygenation.

Airway topical anesthesia: An effective topicalization with local anesthetics the key point for a successful ATI. The use of topical endonasal vasoconstrictors before nasotracheal intubation is highly recommended. Lidocaine has benefits when compared to other local anesthetic agents due to a safety cardiovascular and systemic reduced toxicity risk profile [16, 17, 21]; perhaps this is the most used local anesthetic drug for ATI. The dose of topical lidocaine should not exceed 9 mg/kg^{-1} lean body weight [40]. Nebulised lidocaine can be used but the absorption is variable. The adequacy of topicalisation should be tested before airway instrumentation, for example, with a soft suction catheter. The use of an antisialogogue is not mandatory and may be associated with undesirable clinical consequences [41].

Sedation:

ATI may be safe and effective even performed in the absence of sedation [42, 43]. Its use during ATI can reduce patient anxiety and discomfort and increase procedural tolerance. In certain patient populations, the risk of over-sedation is particularly hazardous, thus an independent practitioner delivering sedation is strongly recommended. Based on our experience, we can recommend the use of minimal sedation. Two drugs, remifentanil and dexmedetomidine have been associated with high levels of patient satisfaction and low risk of over-sedation and airway obstruction. Complications are reduced when using capnography.

7.3.1.2 Indications and contraindications for FBO-guided intubation

- Suspicion of difficult airway management.
- Knowledge of the difficult airway.
- Risk of aspiration.
- Teaching, learning or consolidation of experiences.
- Unstable cervical spine injury or I. vertebrobasilar.
- Patients with recent voice disorders, stridor, goiter, tracheal stenosis, flexed and fixed neck, use of accessory muscles to breathe, need to sit up to breathe.
- High risk of dental damage.
- Morbid obesity.
- Contraindication to anesthesia or muscle relaxants.
- Improve the safety of airway procedures, such as endotracheal tube changes and percutaneous tracheostomy [33, 34, 44].

7.3.1.3 Contraindications to FBO-guided intubation

- Non-collaboration of the patient.
- Children.
- Allergy to local anesthetics.
- Rejection of the technique.
- Lack of experience or insufficient time.

- ○ Blood or discharge.
- ○ Major fractures.
- ○ Fungal tumors in the larynx.
- ○ Coagulation disorders.
- ○ Full stomach with risk of aspiration.
- ○ Emergencies [33, 34, 44].

7.3.1.4 Complications of FBO-guided intubation

- ○ Hypoxemia.
- ○ Laryngospasm and bronchospasm.
- ○ Haemodynamic disorders and arrhythmias.
- ○ Esophageal intubation.
- ○ Sore throat.
- ○ Tissue trauma.
- ○ Regurgitation or vomiting. Aspiration.
- ○ Stridor or oedema of the glottis.
- ○ Esophageal perforation.
- ○ Gastric distension. Rupture of the stomach.
- ○ Bleeding, epistaxis.
- ○ Eye trauma.
- ○ Pulmonary barotrauma.
- ○ Arrhythmias: bradycardia due to nasal stimulation (naso-cardial reflex) or stimulation of the region of the recurrent and superior laryngeal nerve.
- ○ Haemodynamic disorders: hypertension or hypotension is justified by a diminished stimulus.
- ○ Barotrauma: in the narrow upper respiratory tract.
- ○ Esophageal intubation.
- ○ Regurgitation and vomiting.
- ○ Gastric distension: stomach rupture [45].

8. Confirmation of tracheal intubation

Confirmation of the correct position of the endotracheal tube (ET) is mandatory for all patients during initial intubation. There are several methods [27, 31, 32]:

- Direct visualization of ET passing between the vocal cords.

- Auscultation of respiratory sounds in six areas: apex, bases, trachea and epigastrium.
- Measurement of expired CO2 by capnography.
- Use of self-inflating esophageal detectors.

The most reliable methods are direct visualization of ET placement in the trachea (by direct laryngoscopy or fiber-optic bronchoscopy) and measurement of expired CO2 by capnography. Even if the tracheal tube is observed to pass through the vocal cords and its position is verified by chest expansion and auscultation during positive pressure ventilation, staff should obtain additional confirmation of the location of the tracheal tube in three ways: capnography, a CO2 wave at the end of the exhalation, or with an esophageal sensing device [27, 31].

Capnography measures and displays exhaled CO2 throughout the respiratory cycle. A persistent waveform with ventilation should be observed: during expiration, the capnography does not initially read CO2, but as the anatomical dead space is exhaled, there is an increase in exhaled CO2 to a plateau, which falls to 0% with the start of inspiration. The presence of exhaled CO2 confirms the placement of the endotracheal tube. However, capnography can produce false positives and false negatives. If gastric insufflation has occurred by mask ventilation or after ingestion of carbonated fluids, capnography may produce a false positive after esophageal intubation. In cardiac arrest, states of low cardiac output, and extremely low pulmonary blood flow, a false negative can occur [31, 32].

Esophageal sensing devices aid in detecting the location of the ET based on the anatomical difference between the trachea (a firm spine) and the esophagus (a folding spine). A self-inflating bulb is in ET after placement. Air must collapse the esophagus, while the trachea must remain permeable.

Other imprecise methods include visualization of condensed water vapor in ET, chest wall movement, and Cheney test.

Cheney test: A spark plug or catheter-like device is passed distally into the trachea. The purpose of this test is to detect the impact of the tip in the carinal or bronchial lumen. Generally, the advancement of a spark plug to a depth of 30 to 35 cm can allow appreciation of blockage of distal structures compared to unrestricted advancement if the ET is in the esophagus [27, 31].

9. DA extubation strategy: Recommendations for extubation

There is not a sufficient basis to evaluate the benefits of an extubation strategy for DA. For the DA management guidelines, an extubation strategy is considered a logical extension of the intubation strategy.

The extubation strategy will depend on the surgery or situation that led to ICU hospitalization, in addition to the patient's condition and the skill of the physician.

The recommended strategy for extubation of the DA, according to the literature, includes:

- The relative merit of extubation awake versus extubation under the effects of sedation.
- Various situations can harm ventilation after the extubation of the patient.
- An airway management plan should be implemented if the patient cannot maintain adequate ventilation after extubation.
- Short-term use of a device that can serve as a guide for accelerated re- intubation.

This type of device can be a stylet (intubation plug) or a conduit. Intubation stylets or spark plugs are generally inserted through the lumen of the tracheal tube and into the trachea before removing the tracheal tube; they can be used to provide a temporary means of oxygenation and ventilation. The tubes are inserted through the mouth and can be used for supraglottic ventilation and intubation. The intubating laryngeal mask airway and the laryngeal mask airway are examples of conduits.

10. Other considerations in DA management

10.1 Human factors

Human factors (HF) issues have been considered to have contributed to adverse outcomes in 40% of the instances reported to the National Audit Project (NAP4) [22, 23]; however, HF influences in every instance. It has been identified as latent threats (poor communication, poor training and fragile teamwork, deficiencies in equipment, and inadequate systems and protocols) predisposing to loss of situation awareness and subsequent poor decision-making that lead to final errors. Developing guidelines and a professional willingness to follow them are not enough to avoid serious complications of airway management during the procedure. During a crisis, it is common to receive more information than can be processed. An information overload impairs decision-making and can make clinicians 'lose sight of the big picture. It is of huge importance for the team to stop and think to help reduce this risk. For any plan to work well in an emergency, it must be known to all members of the team and should be rehearsed. For rare events, such as CICO, this rehearsal can be achieved with simulation training [17, 21].

10.2 Rapid sequence induction (RSI)

Intubation of the trachea with a cuffed tube offers the greatest protection against aspiration. Suxamethonium is the U.K. and other European countries the neuromuscular blocking agent of choice due to its rapid onset that allows early intubation without the need for bag-mask-ventilation (BMV). Suxamethonium has been compared with rocuronium for RSI, and both are very similar in properties [46]. The ability to antagonize the effect of rocuronium with sugammadex may be a great advantage. Sugammadex can be used as a part of the failed intubation plan, (the correct dose is 16 mg kg − 1.) Cricoid pressure can be applied to protect the airway from gastric content aspiration during the period between the loss of consciousness and placement of the tube (BURP). This is a standard maneuver of an RSI in many countries. Gentle mask ventilation after BURP and before tracheal intubation prolongs the time to desaturation. In case of initial attempts at laryngoscopy are difficult during RSI, cricoid pressure should be released. This should be done only under vision with the laryngoscope and suction available; in the event of gastric regurgitation cricoid pressure should be immediately reapplied [16, 17, 21].

10.3 Position

Adequate patient positioning maximizes the chance of successful laryngoscopy and tracheal intubation. The best position for direct laryngoscopy with a Macintosh-style blade is performed with the neck flexed and the head extended at the atlanto-occipital joint; the classic 'sniffing' position [21]. In the obese patient, the 'ramped' position must be used to ensure horizontal alignment of the external auditory meatus and the suprasternal notch because this improves the view during direct laryngoscopy [47, 48]. This position improves airway patency and respiratory mechanics, facilitating passive oxygenation during apnoea [49]. All patients must be pre-oxygenated before the induction of general anesthesia. De-nitrogenation can be achieved with an appropriate flow of 100% oxygen into the breathing system while maintaining a total face-mask seal [17, 21]. Preoxygenation increases the oxygen reserve delays the onset of hypoxia and allows more time for laryngoscopy, tracheal intubation, and airway rescue in case of a failed intubation. In healthy adults, the duration of apnoea without desaturation (defined as the interval between the onset of apnoea and the time peripheral capillary oxygen saturation reaches a value of ≤90%) is limited to 1–2 min whilst breathing room air but can be extended to up 8 min when using pre-oxygenation. The duration of apnoea without desaturation can also be prolonged by passive oxygenation during the apnoeic period, delivering up to 15 liters min − 1 of oxygen through nasal cannulae. Nasal Oxygenation During Efforts Of Securing A Tube (NODESAT) has been shown to extend the apnoea time in obese patients and patients with DA. Transnasal humidified high-flow oxygen (up to 70 liters min − 1) via nasal cannulae has been shown to extend the apnoea time.

10.4 Choice of induction agent

The induction agent should be selected according to the clinical condition of the patient. Propofol, the most commonly used induction agent in the UK, suppresses laryngeal reflexes and provides better conditions for airway management than other agents. The National Audit Project of the Royal College of Anesthetists highlighted the relationship between DA management and awareness [22, 23]. Several other agents are used depending on the clinical status, these are Midazolam, Ketamine, Etomidate, etc. It is important to ensure that the patient is anesthetized during repeated attempts at intubation. Neuromuscular block (NMB) if intubation is difficult, further attempts should not proceed without full neuromuscular block. NMB abolishes laryngeal reflexes, improves chest compliance, and facilitates face-mask ventilation. A complete NMB should be used if any difficulty is encountered with airway management. Rocuronium has a rapid onset and can be antagonized immediately with sugammadex, but the incidence of anaphylaxis may be higher than with other types of non-depolarizing NMB agents. Mask ventilation with 100% oxygen should begin as soon as possible after the induction of anesthesia. If some difficulty is encountered, the airway position should be optimized and airway maneuvers such as a chin lift or jaw thrust should be ensured.

10.5 Choice of laryngoscope

The choice of laryngoscope greatly influences the reaching a successful tracheal intubation. Video-laryngoscopes (VAL) offer an improved view when compared with traditional direct laryngoscopy and are currently the first choice or default device for many anesthetists, intensivists and emergency practitioners. Meta-analyses of RCTs comparing both types of laringoscopes in patients with predicted DA report better results with VAL but no differences in time to intubation, airway trauma, gum/lip trauma, dental trauma, or sore throat has been reported.

Airtraq is employed regularly daily in our environment even by our colleagues' Anesthesia on many patients with excellent results. We have a very good experience with this device in cases of DA. Airtraq has a lot of endorsing literature showing better results than the traditional Macintosh and Miller laryngoscopy, as well as with other VAL, reporting excellent intubation rates, less cardiac and haemodynamic alterations, better results in obese patients, a better curve of learning for novice personnel, and very good results when combined with fiber-optic bronchoscope intubation [50–52]. Regular practice is required to ensure that the improved view translates reliably into successful tracheal intubation. All intensivists, anesthetists and emergency practitioners should be trained to use VAL, and have immediate access to, a video-laryngoscope [16–21]. There are available several other interesting models of VAL as **GlideScope Video Laryngoscope, C-Mac Video Laryngoscope, Pentax Airway Scope, McGrath Video Laryngoscope, AirTraq Optical Laryngoscope, King Vision Laryngoscope**, etc. (**Figure 4**).

10.6 Tube selection

Endotracheal tubes should be selected according to the nature of the surgical procedure, age and body weight, but their size, composition material, length, etc. can influence the ease of intubation. A smaller tube usually is easier to be inserted because of a better view of the laryngeal inlet during the passage of the tube between the cords. Smaller tubes are less likely to cause trauma [53]. 'Hold-up' at the arytenoids is a feature of the left-facing bevel of most tracheal tubes and can occur whilst railroading larger tubes over a bougie, stylet, or fibrescope [54]. This problem can be solved by rotating the tube anticlockwise to change the orientation of the bevel (**Figure 5**).

Figure 4.
Different laryngoscopes. From left to right: Traditional Macintosh, McGrath Videolaryngoscope and Airtraq Videolaryngospe.

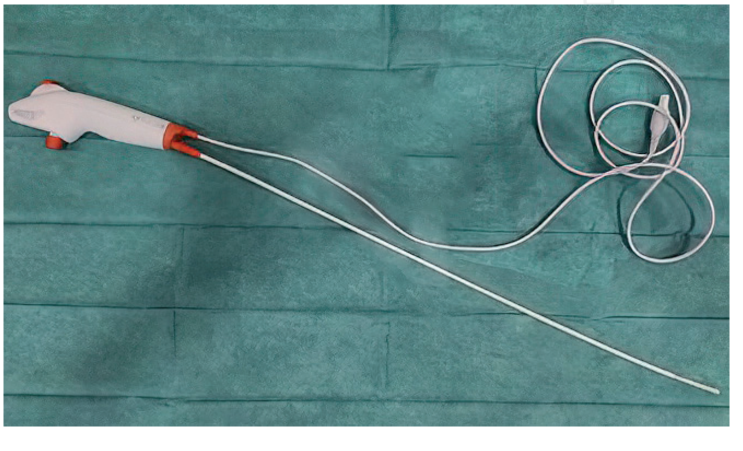

Figure 5.
Single-use fiberoptic bronchoscope.

10.7 Special situations such as Covid-19 pandemia

Managing the airway in Covid-19 pandemia have led intensivists to a point of maximum risk of exposition to the virus due to aerosols and high proximity to the patient's airway. It has been endorsed by many studies and many medical scientific societies the safety use of all personal protective equipment throughout the intubation process. It is also advised to avoid BMV if possible and when the situation allows to pre-oxygenate with a high-flow non-rebreathing mask or high-flow humidified nasal cannulae, then using RSI with a hypnotic drug and rapid depolarizing NBA. Small endotracheal tubes are not recommended due to the predicted long period of mechanical intubation and frequent plugs of mucous that interfere with the patient's adequate ventilation and oxygenation.

11. Conclusions

Intubation, the approach to a DA and the management of the different aspects of the human airway is an intrinsic domain that is supposed to be mastered by the anesthesiologist, the intensivist and the emergency physician, since all of them can face any difficult situation and life-threatening situation involving the airway.

It is also of utmost importance to have an experienced and rehearsed team, as well as a revised and well-equipped mobile chart with all the necessary material to successfully face any potentially threatening situation related to airway management. Knowing and practising under a well-coordinated guide or protocol is the best way to overcome any potential airway life-threatening situation.

We have updated and compiled relevant information on how to manage a DA crisis knowing the best available possibilities to prevail in such problematic situations.

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