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The Difficult Airway: A New Simplified Approach to an Old Complex Problem

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Abstract

Difficult airway situations are a major cause of morbidity, mortality and malpractice claims in anesthetic practice and other critical care settings. Although infrequent, they are serious and complex situations where many variables interact. Among these variables, quick and accurate rescuer decision-making is a major outcome determinant. Emerging evidence, recent advances in technology and development of new devices have provided new tools to deal with the problem, but still, basic underlying principles of management remain. Based on the available evidence and expert consensus, multiple guidelines and algorithms have been published, but they may have limited applicability, contain confusing and ambiguous recommendations or address very specific clinical situations. This narrative review attempts to summarize, organize and consolidate current trends and supported recommendations of the updated guidelines in one practical, concise and unified guide, proposing a simple, intuitive and novel algorithm.

Keywords

Anesthesia, Airway Management, Airway Obstruction, Intubation-Intratracheal, Pulmonary Ventilation, Guideline, Algorithms

1. Introduction

The airway is a tubular structure that leads the air in and out the lungs. After the loss of consciousness or muscle tone, its soft walls can collapse, and due to proximal communication with the digestive tract, it can lead to bronchoaspiration. To allow controlled ventilation the airway must have two characteristics, mentioned in order of priority: the airway must be open (allow air flow with minimum resistance), and it must be sealed (protected against bronchoaspiration and without air leakage). In this paper, we discuss the difficult airway. It occurs when one of these requirements is not met; however, from a traditional and operational point of view, it is better defined as what occurs when controlled ventilation is not achieved due to difficulty with facemask ventilation, tracheal intubation or both.

The incidence of difficult airway varies depending on the population studied and the threshold that is considered, but it generally ranges from 1% - 4% for difficult facemask ventilation (DFMV) and 1% - 5% for difficult tracheal intubation (DTI) [1] [2]. The failure in handling this problem can rapidly lead to significant morbidity and mortality: hypoxia, bronchoaspiration, airway trauma, cardiac complications, permanent brain damage, and death. Although the prevalence is decreasing, airway problems remain a major cause of death and medical malpractice claims directly related to anesthetic practice [3] [4] [5].

This rare but serious problem is often difficult to manage because many factors interact in a complex and rapidly dependent function of time. These include the patient's airway anatomy, comorbidity, the type of surgical procedure, the rescuer's training level and their emotional response to stress, the anesthesia, the availability and functionality of materials and equipment, and the teamwork skills [6] [7].

2. Evidence, Guidelines and Algorithms

In critical situations, with no room for improvisation, there is a need for a strategic plan, or preferably a staggered series of plans if any should fail. Interventions (decisions, maneuvers, and devices) must be supported by medical evidence and must be available and familiar to the rescuer [6] [7] [8] [9].

Difficult airway crises present a challenge for conventional statistical analysis, although recommendations should be supported by well-designed clinical trials, double-blind studies are difficult in this case and randomization becomes less appropriate when the situation being studied is more urgent. For extremely urgent situations, there are usually only reports, case series or expert consensuses. The circumstances in which these studies were conducted are also important. Real situations have more validity than those performed in patients with predictors for difficult airway or simulated situations. The least useful studies include patients with normal airway, corpses, resuscitation mannequins and animal models [8].

Multiple scientific societies of anesthesiology have attempted to gather available evidence, process it in the light of expert consensuses and publish management guidelines, and some have expressed them graphically in the form of algorithms [6] [7] [9]-[31]. However, they may have limited applicability due to their complexity, which is incompatible with the need for quick and accurate decision-making, and ambiguity (mention a series of recommendations without daring to arrange priority), or because they are too specific to a clinical scenario or particular type of patient, raising the need to remember and apply multiple guides according to the situation.

This paper proposes a guide based on existing evidence and the recommendations of guidelines published around the world, trying to organize and prioritize the information in the most effective and simplest way possible (**Figure 1**). It uses a clear, intuitive and almost colloquial terminology to describe situations and prioritize the recommendations in terms of their effectiveness (the ability to achieve the desired outcome), safety (low incidence of adverse effects) and universality (applicable to most patients, operators, institutions, and clinical situations) but clarifying the respective exceptions to the general recommendation. It is especially directed at the management of the patient who is going to be anesthetized and requires intubation, but could apply to other scenarios of the critical patient. The suggestions presented here cannot be considered mandatory, and must be subject to responsible and accredited clinical judgment and individualized according to the patient. Maneuvers and techniques are described only superficially and cannot replace formal theoretical-practical training before being formally implemented.

3. Predicting the Problem

There are clinical findings that correlate statistically with the emergence of difficult facemask ventilation or difficult intubation (predictors of difficult airway). They are primarily anatomical features, symptoms, and findings in the medical history and in selected diagnostic tests [6] [9] [11]. Prospective studies have established the magnitude of this ratio (relative risk), and then a multivariate analysis found the factors that add value to the prediction when combined (independent risk factors). Finally, these findings come together to allow a risk prediction scale that provides a numerical probability value [1] [2]. Difficult airway predictors are outlined in **Table 1**. Prediction scales are not included, but it is assumed that the greater number of predictors match, the greater the risk [9] [11]. There are also predictors for difficult ventilation with supraglottic devices and difficult surgical airways, which should be considered as aggravating risk factors and determinants to consider when deciding the management plan [11].

Predictability is still an inexact science; the scales show good accuracy even with better sensitivity than specificity. They tend to over-predict the problem with false positives (ending in some unnecessarily awake intubations), and they have a low but existing possibility of false negatives (which allows the unexpected appearance of the problem) [11] [22]. The evaluation of predictors and predictability is even more limited in the pediatric population [14] [32] [33].

The qualitative or quantitative probability value should be integrated with other variables. These variables should consist of clinical circumstances that do not alter the probability of the problem occurring, but if present, make management difficult, increase the tendency to degenerate into serious adverse outcomes, or worsen the morbi-mortality. These could be called *impact aggravating clinical factors*, and are also mentioned in **Table 1**; these include the risk of bronchoaspiration [6] [14] [26] [29], increased desaturation rate and the airway

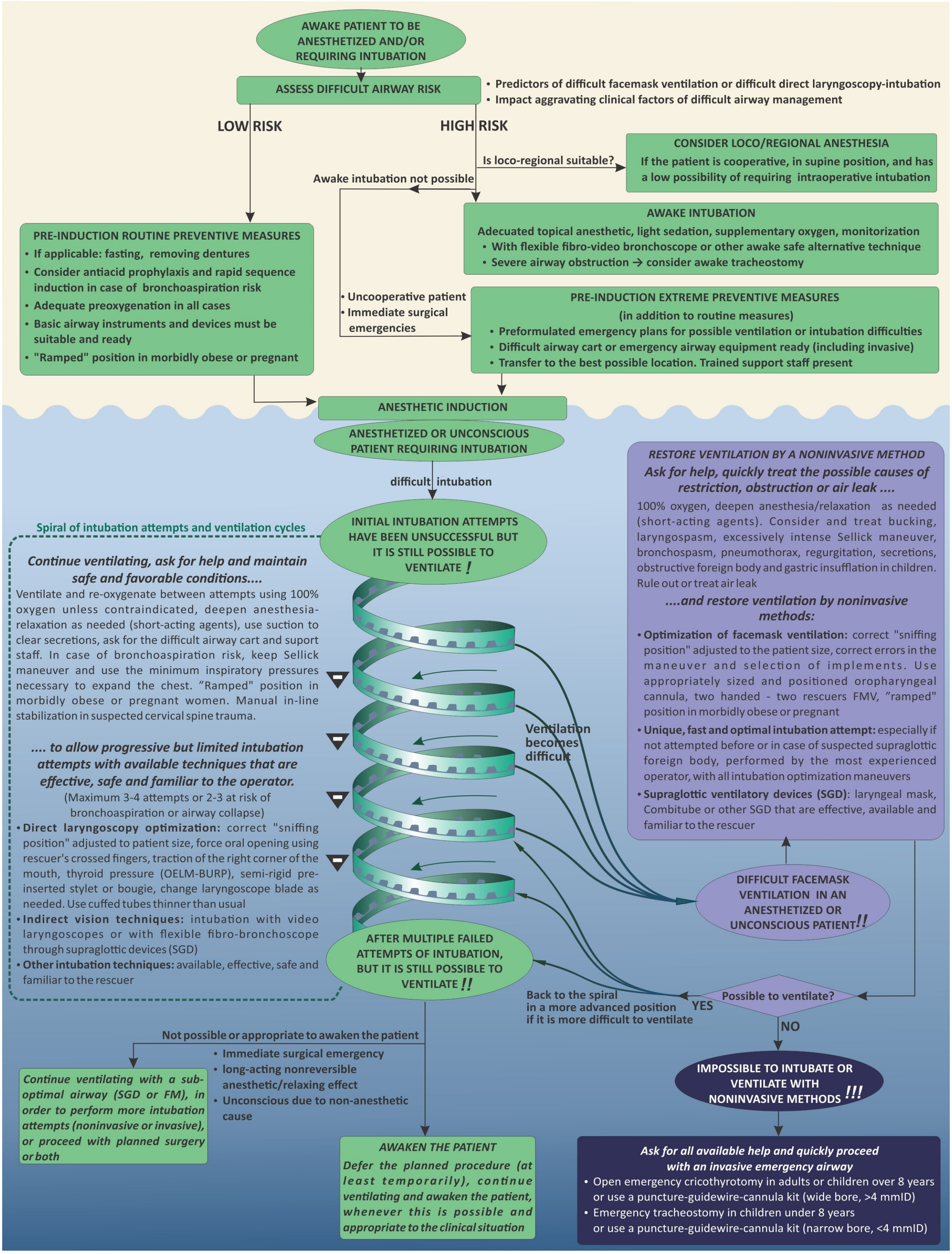

Figure 1. Simple and unified algorithm for difficult airway managment.

Table 1. Predictors and impact aggravating factors of difficult airway management.

Predictors of difficult facemask ventilation:
Beard, lack of teeth, history of snoring or obstructive sleep apnea, higher body mass index or weight, limited mandibular protrusion, decreased thyromental distance, modified Mallampati class 3 or 4, history of neck radiation, older age, male sex.

Predictors of difficult direct laryngoscopy—intubation:
Limited mouth opening, modified Mallampati class 3 or 4, decreased thyromental or sternomental distance, limited mandibular protrusion, narrow dental arch, decreased submandibular compliance (e.g. scarring from surgery, burns, or radiation therapy), limited head and upper neck extension, increased neck circumference, history of difficult tracheal intubation.

Impact aggravating clinical factors of difficult airway management:
- Increased risk of bronchoaspiration, increased desaturation rate, airway tendency to collapse.
- Special populations: children, pregnant, morbidly obese, critical or trauma patients.
- Adverse logistic circumstances: lack of equipment, training, support staff or remote locations.
- Predictors of difficult supraglottic device use or difficult emergency invasive airway (see below).

Predictors of difficult supraglottic device use:
Reduced mouth opening, supra- or extraglottic pathology (e.g., neck radiation, lingual tonsillar hypertrophy), glottic and subglottic pathology, fixed cervical spine flexion deformity, increased body mass index, applied cricoid pressure, poor dentition, rotation of surgical table during the procedure, male sex.

Predictors of difficult emergency invasive airway:
Thick or obese neck, overlying pathology (e.g. tumor, inflammation, induration, radiation), displaced airway, fixed cervical spine flexion deformity, age < 8 years, female sex.

Source: extracted and adapted from Kheterpal *et al.* [1], Shiga *et al.* [2], Frerk *et al.* [6], Mushambi *et al.* [7], Apfelbaum *et al.* [9], Law *et al.* [11], Black *et al.* [14], Mhyre *et al.* [18], Collins *et al.* [47].

tendency to collapse by repeated trauma [11] [29]. Several of these factors often converge in populations that should be considered special: children (especially younger) [14] [15] [34], pregnant [7] [18] [19] [20], morbidly obese [11], critically ill [30] [31] and traumatized patients [27] [28]. The predicted risk of ventilation with supraglottic devices (SGDs) and the difficult surgical access mentioned above are also aggravating factors [11] [29]. Furthermore, logistical and operational circumstances such as lack of adequate equipment or familiarity with equipment, untrained staff, the absence of expert assistance and remote locations must be considered [11].

Finally, precise cutoff points regarding the risk level have not been defined, which separates the possible management options or recommendations to follow and leaves the threshold between high and low risk to clinical interpretation.

4. Low Predicted Risk of Difficult Airway

If the initial assessment suggests a low risk of difficult ventilation with a facemask and a low risk of difficult intubation, it is reasonable to proceed with conventional anesthetic induction. Considering that difficult airway is always a possibility, routine pre-induction preventive measures that reduce the probability of problems, facilitate handling problems or decrease their clinical impact are justified. The preventative measures that are regularly used include fasting in elective cases, removing dentures and oral piercings [7], using antacid prophylaxis and rapid sequence induction in patients at risk of bronchoaspiration [24] [35].

The availability and functionality of equipment for airway management is mandatory before any anesthetic induction. The equipment must be ready, tested and suitable for the size of the patient [9] [25]. Many routine situations can become critical by the absence or inoperability of equipment [4]. Pediatric populations require a wide range of device sizes [14] [17]. Additionally, it is advisable to have a difficult airway cart in all surgical locations, containing additional and specialized equipment to deal with this type of emergency. The difficult airway cart must be able to be quickly moved and should be under regular supervision, in working condition and complete [6] [9] [15] [17] [21]. Some of the devices that the cart should contain will be mentioned in the text.

During apnea, saturation falls at a rate proportional to the metabolic consumption and inversely proportional to the amount of oxygen contained in the functional residual capacity [23] [29]. Evidence shows that both preoxygenation techniques, conventional (3 min of tidal volumes, 100% oxygen) or fast (30 - 60 s, 4 - 8 forced vital capacities, 100% oxygen), significantly increase the oxygen reserve and desaturation time in apnea [9] [12] [11] [36], providing valuable time to maneuver before hypoxia occurs. The conventional method has shown superiority [7] [37]. It is important to seal the mask against the face with light pressure and it has been proposed that the expired oxygen fraction should be greater than 90% as an objective parameter of satisfactory pre-oxygenation [11] [23] [37]. In morbidly obese patients and pregnant women, the "ramped" position (the chest and head in a mildly inclined lift, until horizontal alignment of the external auditory meatus and the suprasternal notch), improves the quality of pre-oxygenation, and also facilitates ventilation and intubation after induction [11] [18] [37].

5. High Predicted Risk of Difficult Airway

When the preliminary assessment predicts a high risk of difficult facemask ventilation or difficult intubation, especially in the presence of aggravating factors, the most universally accepted and supported recommendation is awake intubation [11] [20] [21] [28]. The strategic advantage of this approach is that spontaneous ventilation is maintained during intubation attempts as well as the protection by reflexes against bronchoaspiration. Additionally, if awake intubation fails it could give the opportunity to desist, defer and reconsider the conditions of induction [6] [11] [21]. Other independent indications that could be compatible with this recommendation include pre-surgical patients at very high risk for bronchoaspiration (e.g., gastrointestinal obstruction with abdominal distention and active vomiting) [25] or severe respiratory or cardiovascular compromise. However, there are some situations when awake intubation is inapplicable or risky.

The most accepted awake intubation technique is performed with a flexible fibro-bronchoscope (or flexible video-bronchoscope) [9] [11] [21] [25]. This technique requires the availability, proper functioning, and prior operator training that every anesthesiologist should have. It is essential to obtain the acceptance and cooperation of the patient, supply supplemental oxygen, gradually instill topical local anesthetic in the pharynx, glottis, and proximal trachea, and provide light titrated sedation with short-acting agents, and all this requires patience, skill and time [11] [38]. Given the aforementioned strategic advantages of awake intubation, in the absence of a flexible fibro-bronchoscope, other intubation devices can be considered in the awake and cooperative patient if the operator has the necessary expertise and provides the same care described above [11] [20]. Alternative intubation techniques in the awake patient may include the use of video laryngoscope [11] [20], direct laryngoscopy [9] [11] [20], and in extreme circumstances, retrograde intubation [9] [12] [39] [40] [41].

It is important to note that in elective cases or in non-critical emergencies when logistical situations are unfavorable in terms of equipment, materials, staff support or operator expertise, it is perfectly reasonable to defer the planned procedure and move to a more favorable location within the same institution (e.g. operating room) or refer the patient to another health service as long as the delay and transfer do not confer a greater risk [7] [11] [17] [26].

Patients with clinical signs of acute severe airway obstruction (e.g. obstructive tumor masses, obstructive laryngeal angioedema, severe croup or epiglottitis) are an important exception to awake intubation recommendations. In these cases, awake oral-nasotracheal intubation could increase inflammation or edema and cause airway collapse, resulting in an extremely critical situation [42]. The safest route in these patients is an awake tracheostomy [11] [20], this must be performed by an experienced surgeon with the patient collaboration, ideally in the operating room, and while being monitored in the presence of an anesthesiologist. Furthermore, mild and titled sedation with short-acting agents, oxygen supply, and a judicious infiltration of local anesthetic should be used [11] [20] [43].

The role of local or regional anesthesia in patients at high risk of difficult airway is debated. Certain guidelines consider local and regional anesthesia to be a strategic way to avoid manipulation of the airway [9] [11] [19] [29]. Others warn that if it fails, a hasty intubation in a less controlled situation would be required [8] [20] [21] [26] [44], but there are no comparative studies on the subject. Local and regional anesthesia could be considered in adult collaborating patients facing short procedure in the supine position, with a low possibility of failed regional anesthesia, a low risk of impairment of consciousness, breathing or perfusion, and if necessary, intubation can be performed awake with the patience and time required [11].

An important exception in case of anticipated difficult airway is the uncooperative patient (children, and adults with psychiatric disorders, delirium or severe cognitive impairment) or immediate surgical emergencies (severe ongoing bleeding, fetal distress with bradycardia, etc) [7] [11] [16] [28]. In these cases, awake intubation or local-regional anesthesia are inappropriate and it may not be safe to delay the procedure. There is no reliable evidence or unanimous expert opinions for these situations. Some experts recommend proceeding to anesthetic induction while taking extreme preventive measures in addition to those mentioned in section 4, and having several preplanned strategies with prepared equipment and personnel to face difficult ventilation or intubation, including invasive options (e.g. difficult airway cart, surgeon, etc) [9] [11].

For uncooperative patients with signs of acute airway obstruction, attempting intubation or tracheostomy after inducing anesthesia and maintaining spontaneous ventilation (inhaled or intravenous, without relaxation) has been described. This approach, in theory, reduces the risk of airway collapse and avoids apnea periods [9] [11] [16].

6. In an Anesthetized or Unconscious Patient, Initial Intubation Attempts Have Been Unsuccessful but It Is Still Possible to Ventilate

In this potentially serious scenario, the apneic patient needs facemask or SGD ventilation, which is effective. The airway is open but unprotected and requires intubation; however, initial attempts have failed. Complex dissertations in the guidelines for these cases can be summarized in the following recommendation: *continue ventilating, ask for help and maintain safe and favorable conditions to allow progressive but limited intubation attempts using available techniques that are effective, safe and familiar to the operator* [6] [7] [9] [12] [14] [16] [18] [20] [21].

This situation is symbolized by the spiral trace of the algorithm, which attempts to represent effective ventilation cycles alternating with repetitive failed intubation attempts and its relatively slow progression into complications in case of prolongation (see **Figure 1**). There are two risks that are always present in this case [45] [46]. First, the trauma of repeated intubation attempts generates progressive edema and inflammation that can collapse the airway and create an impossible ventilation-intubation situation. This risk is increased in previously small or narrow airways (children, adults with previous obstructive pathology) [8] [16] [17] [45]. Second, there is a progressive risk of bronchoaspiration, particularly in patients with a full stomach (pregnant, acute abdominal emergencies, decreased gastric emptying, airway bleeding …) [7] [12] [27] [28].

Safe and favorable conditions refer to the following: the maintenance of ventilation between failed intubation attempts, usage of 100% of oxygen unless contraindicated (risk of retinopathy in premature newborn or heart diseases when this is counterproductive), usage of the minimum inspiratory pressures necessary to expand the chest, especially in patients with full stomach (e.g. 20 cm H20 in pregnant women), and suction secretions as needed [6] [7] [10] [18]. In case of increased bronchoaspiration risk, a rapid induction sequence is performed [7] [11] [27], avoiding ventilating before intubation and only using ventilation cycles if intubation fails. In these cases, continuous cricoid pressure (Sellick maneuver) is advisable [6] [7] [9] [11] [12] [27] [28]. Excessive cricoid pressure may interfere with ventilation, laryngoscopy, and the tube or SGD advancement, and one should be aware of this possibility and reduce or release pressure as needed [6] [7] [10] [11] [12]. In suspected cervical spine trauma, techniques that minimize neck or head extension are preferred and an assistant must maintain manual in-line stabilization during ventilation and intubation maneuvers [27] [28].

Another favorable condition is anesthetic depth. The effect of initial induction doses disappears quickly and usually additional doses of opioid, intravenous or inhaled anesthetic and, in some cases, muscle relaxant are required. This improves intubating conditions, decreases hemodynamic or respiratory responses and prevents awareness [6] [7] [14] [24]. It is advisable to use short-acting or pharmacologically reversible agents to keep the ability of awakening the patient if intubation attempts fail.

Emphasis is placed on the suggestion that intubation attempts must be *progressive and limited* because repeatedly performing the same failed maneuver is ineffective and involves a cumulative risk [45] [46]. It is crucial to ask for help and to add something at each attempt (maneuvers, devices or operator expertise) to increase the chance of success. Several of these additions are discussed in the following sections (6.1 and 6.2). As for the number of attempts that is considered safe, the guidelines suggest a maximum of 3 or 4 in routine cases [6] [10] [22] and 2 or 3 in cases with a high risk of collapse or bronchoaspiration [7] [12] [15] [17] [44]. If progressive difficulty in maintaining ventilation cycles or regurgitation episode occurs, the operator must limit the number of intubation attempts and precipitate the final decision. If the suggested number of attempts is exceeded, continue with section 7. If at any time ventilation becomes difficult, go to section 8. If intubation is accomplished, proceed to the confirmation and fixation procedure described in section 10.

6.1. Direct Laryngoscopy Optimization

When facing difficulty with direct laryngoscopy and conventional intubation, immediately one should use maneuvers, techniques and devices that optimize direct vision laryngoscopy or tube manipulation and advancement, especially those proven effective, safe and universal. The operator must begin by correcting mistakes in the maneuver or patient position. The correct "sniffing position" that produces the necessary axle alignment for direct vision consists of slight neck flexion and moderate head extension [6]. For this, a low pillow or foam ring under the head can be useful in adults [20] [23] [47], but unnecessary in children over 2 years. In children under 2 years, a roll under the shoulders can be advantageous [14] [34]. Forced oral opening using rescuer crossed fingers facilitates the initial positioning of the laryngoscope, and traction of the right corner of the mouth may increase the field of view of the intubator [47]. The aforementioned "ramped" position improves laryngoscopy in pregnant and morbidly obese patients [15] [30] [31].

Thyroid pressure, denoted with the acronym OELM in American literature and BURP in British literature, consists of antero-posterior pressure on the thyroid cartilage (different from Sellick maneuver) and consistently improves the vision of the glottis during laryngoscopy [6] [7] [10] [12] [14] [15] [16] [34]. Excessive thyroid or cricoid pressure (Sellick) may hinder laryngoscopic vision or tube advancement, especially in children, and the rescuer must be aware of this possibility to reduce or release it as needed [14].

During direct laryngoscopy with a partial vision of the glottis (Cormack-Lehane 2 or 3a), intubation guides are useful. The semi-rigid pre-inserted stylet, molding the tube in a "hockey stick shape", improves routing the tube tip [9] [24]. The guide should not exceed the tip of the tube to prevent injuries and a smooth or lubricated guide should be used to allow withdrawal at initial insertion into the glottis. The Eschman introducer, better known as the "gum elastic bougie", is an alternative to the pre-inserted stylet [6] [11] [12] [13] that has shown greater effectiveness [25] [48] [49]. It is a flexible and malleable long guide (60 cm), with an angled atraumatic tip. The Eschman introducer can be inserted into the glottis by direct vision [6] [10] [12] ; then, keeping the laryngoscope in position facilitates sliding the tube, and rotating the tube 90 degrees counterclockwise can facilitate advancement [50].The Eschman introducer also serves to maintain canalization of the trachea when the tube needs to be changed to one that is more appropriate. The original reusable bougie has been shown to be more effective and less traumatic than disposable versions [51], and there are also pediatric variants [15]. Faced with a Cormack 3b or 4, attempts to insert the bougie blindly below the epiglottis were once recommended by looking for signs of intra-tracheal position (e.g. sensation of clicks sliding against tracheal rings) [12], but this is currently considered risky and less effective than indirect viewing methods [6] [7].

There is no evidence suggesting that random changes in the laryngoscope blade improve visualization. Instead, in specific instances of a "distant glottis" or "pendulous or angled epiglottis" that are hiding the glottis, switching to a longer curve blade or to a straight one can be advantageous [10] [25] [34]. Some describe the paraglossal or retromolar approach, which uses a straight blade and a strong right corner mouth traction and could be useful in pediatric macrogosia or micrognatia and in adult intraoral tumors [14] [16] [25] [34]. In case of intubation difficulty, it could be favorable to use smaller tube diameters to avoid failed attempts or unnecessary reintubations [7] [10] [34].

6.2. Other Noninvasive Intubation Methods

Given the risks associated with intubation and the elapsed time, only safe and effective methods should be used in anesthetized or unconscious patients. To date, the effective methods have been determined from comparative studies in predicted or simulated difficult intubations and in a few real situations. In general, there are two techniques considered useful that are both based on indirect vision of the glottis: the use of video laryngoscopes and intubation with flexible fibro-bronchoscope through SGD.

There is increasing supporting evidence for the use of video-laryngoscopes in difficult intubation (e.g. Glydescope, McGrath, Airtrach, King Vision and others) [9] [10] [52] in a variety of patients and clinical scenarios [7] [9] [14] [15] [16] [28], but their use is limited by its high costs. They are fast and easy to use, and tend to be intuitive for the experienced anesthesiologist because the indirect laryngoscopy maneuver is similar to the conventional method while providing better visualization of the glottis. Insertion of the tube, however, requires some facilitative maneuvers and proprioceptive skill. A pre-inserted stylet or a bougie that is not molded into a "hockey stick" shape, but into a uniform curvature that mimics that of the device may be useful [6] [10]. They tend to be resistant to use, are durable, have interchangeable and re-sterilizable blades, and are variable according to the patient size. Whether the evidence favors one of these devices is still debated [10] [53].

Fiberoptic intubation through a SGD is a more laborious, less intuitive technique and requires more assistive devices and prior training. It has the advantage of simultaneously maintaining ventilation, partially protecting against aspiration while intubation attempts are performed, and could reduce the need for cervical extension when this could be harmful [10]. It was initially described for the laryngeal intubation mask airway (ILMA, e.g. Fastrach), which has a specific design for this purpose. Its effectiveness and safety are sustained in real situations of difficult intubation, even with novice operators [12] [19]. ILMA allow ventilation and direct passage of the tube even blindly with reasonable effectiveness (96.7%) [9] [12] [54], which increases with flexible fibro-bronchoscope, pre-inserted into the tube [6] [10] [54]. ILMA are available in sizes 3 and 4, which limits their use to patients over 30 kg [12] [15]. Some recent variants have integrated fibroscopic vision (e.g. CTrach) [55].

Blind intubation through the Classic laryngeal mask airway (LMAc) is discouraged because of many problems related to the internal diameter of its vent tube, length, curvature and angle of incidence [12]. In contrast, the use of LMAc as a conduit for fiberoptic intubation on an anesthetized patient is well established in real situations, and has the advantage of availability, familiarity and a range of sizes that includes the pediatric population. Although it is sometimes possible to slide the tube directly, it is more common to use the sequence LMAc-FO-guide-tube [6] [10] [14]. The flexible bronchoscope is inserted through the LMA until the glottis and the trachea are visualized (an appropriate connector could allow simultaneous ventilation during this maneuver), a guide is advanced to the trachea, and then the bronchoscope and LMA are removed keeping the guide in position, which is used to slide the tube. For adults and older children, a hollow guide is externally pre-inserted to the bronchoscope (e.g. Aintree Intubation Catheter) [6] [11] [12] [56]. For infants and neonates, a long flexible metallic guide-wire with an atraumatic tip is inserted through the working or suction channel of the bronchoscope. In theory, this technique could be used regardless of the size of the patient, but it is more laborious and its excessive flexibility makes the sliding of the tube unpredictable [14] [15] [16] [57].

Other disposable and reusable SGDs also allow intubation with fibrobronchoscopic aid either directly or with the initial use of a guide. Some second-generation SGDs have designs that facilitate this maneuver while maintaining better sealing and protection against aspiration [58] [59]. However, these SGDs have scant evidence in real cases, are limited by their cost and availability, and need to have a range of sizes according to the patient size.

There are other intubation techniques and devices, but they show inconsistent data regarding their effectiveness, possibly because of the high dependence on operator training. Some studies report good efficacy in highly trained personnel, such as the rigid angulated broncoscope (e.g. Bonfils) [18] [53], the straight rigid bronchoscope in children, or pre-formed rigid light guides for transillumination [9] [25]. However, using these techniques could lead to delays, desaturation or trauma in inexperienced hands [9]. Other techniques are too laborious to be performed in the apneic patient, so some guidelines do not recommend them. These techniques include the flexible fibrobronchoscope used as a single intubation device [21] [22] [25], and retrograde intubation [39]. The current preference is the optical media over the blind methods, discouraging those that also have poor support such as the blind oro-nasotracheal intubation or intubation by blind digital manipulation[17] [22] and blind intubation through conventional laringeal mask [12] [17].

7. After Multiple Failed Attempts of Intubation but It Is Still Possible to Ventilate

In this moderately severe situation, the apneic patient still can be adequately ventilated with a facemask or SGD, but the number of intubation attempts considered safe has been exceeded (see section 6) or all available intubation options have been used. For the anesthetized patient, the most prudent recommendation in the guidelines is to *defer the planned procedure* (*at least temporarily*), *continue ventilating and awaken the patient*, *whenever this is possible and appropriate to the clinical situation*. This includes elective surgical cases and emergencies that are deferrable, at least for several minutes [6] [7] [9] [10] [12] [14].

To awaken the patient, ventilation with FM or SGD is maintained and safety conditions described in section 6 are maintained. Anesthetics must be suspended, and opioids, benzodiazepines, and muscle relaxants are pharmacologically reversed as needed. Then, the quietest awakening possible is carried out [12]. Sugammadex is useful in these situations, at doses up to 16 mg/kg for early pharmacological reversal of deep relaxation states with rocuronium [6] [14]. After the patient is conscious and alert, awake intubation and other options are considered as mentioned in section 5.

The exceptions are situations in which waking the patient is not applicable or appropriate to the clinical situation. This usually occurs for two reasons: it is not possible to awaken the patient in the short term (they are unconscious by a non-anesthetic cause or there are long-acting nonreversible anesthetic-relaxing effects) or it is an immediate surgical emergency that cannot be postponed, not even for minutes. Evidence in this case is weak and is based on case reports or expert opinions. Recommendations from most guidelines can be summarized as follows: *continue ventilating with a sub-optimal airway* (*SGD or FM*), *in order to perform more intubation attempts* (*noninvasive or invasive*) *or proceed with planned surgery or both* [6] [7] [11]. The risks to be considered are the possibility of bronchoaspiration or airway collapse produced by attempts of intubation and the risk by delaying the procedure.

Additional attempts at intubation should be optimized in order to improve upon the previous attempts and have a prepared plan to support ventilation emergencies, including invasive options [6] [10]. Continuing ventilation with a sub-optimal airway to perform a semi-urgent tracheostomy is more appropriate in critical or trauma patients, patients who will require a surgical airway in any case, or those with very high risk of bronchoaspiration [10]. Proceeding with surgery with a sub-optimal airway (usually with SGD) is more justifiable in cases of immediate surgical emergency (severe ongoing bleeding, acute fetal distress, cardiac tamponade, CPR …) [6] [7] [14] [18] [27]. This decision is riskier in patients with full stomach. While there are successful reports about performing surgery using SGD in patients with risk of brochoaspiration (e.g. emergency cesarean section with LMA) [7] [44] [60] [61], there have also been reports of serious complications [60]. Second generation SGD could be considered, especially those that offer greater sealing and airway protection (e.g. ProSeal, LMA Supreme and others) [10] [18] [19] [44] [58] [59] [62] [63]. It is recommended to restrict intraoperative maneuvers that could facilitate regurgitation (e.g. peritoneal insufflation, abdominal pressure, trendelemburg), and to limit ventilation pressure in order to prevent gastric insufflation [7] [10] [25].

8. Difficult Facemask Ventilation in an Anesthetized or Unconscious Patient

Contrary to widespread belief, facemask ventilation (FMV) is not an easy or intuitive maneuver and it requires prior knowledge and training, which unfortunately only a small percentage of physicians or paramedical personnel have [64]. Even the detection of ineffective FMV can be difficult without an established gold standard. In the absence of interference, the fall in pulse oximetry is a reliable but late indicator (30 - 60 sg) of oxygenation. The absence of visible chest expansion is a subjective and sometimes misleading parameter. The presence of capnography is indicative of ventilation, but there may be false negatives when using a facemask, especially with "side stream" systems and high inspiratory flow [65]. It is recommended to consider adequate ventilation only when it is evident by any of the above parameters, otherwise assume their absence, especially in progressive desaturation [1] [9] [66] [67].

When facing an apneic patient, the rescuer may find it difficult to maintain effective ventilation. This may lead to a potentially critical situation because if it is not solved, it will rapidly progress to hypoxia and severe adverse events. This situation can arise immediately after the loss of consciousness or at any time during the spiral of ventilation-intubation cycles described in sections 6 and 7. The primary objective in this case is to restore ventilation by permeabilizing the airway using non-invasive means, sometimes leaving the objective of keeping the airway protected aside.

The summary of recommendations from various guidelines is as follows: *ask for help*, *quickly treat the possible causes of restriction*, *obstruction or air leak and restore ventilation by noninvasive methods* (see sections 8.1, 8.2, 8.3) [6] [7] [9] [10] [16] [17] [18] [20] [21] [68]. It is necessary to clarify that in the absence of ventilation, awakening the patient is not an option because they would suffer significant morbidity and mortality before the return of consciousness and spontaneous ventilation [69].

Obstruction may be due to the simple collapse of soft airway walls in the unconscious patient, but there are other causes that require immediate specific management [66] [70]. Light anesthesia may cause coughing, bucking, thoracic rigidity or laryngospasm. Taking into account that awakening is not an option in this case [69], administering titled anesthetic doses and if necessary, short-acting relaxation is justified [6] [9] [11] [15]. A foreign body, regurgitation, secretions or a Sellick maneuver that is too intense can cause obstruction [6] [9] [11] [15] [66] [70].

The inability to ventilate may also originate in the lung, chest or abdomen (e.g. bronchospasm, pneumothorax, gastric insufflation in children) [6] [10] [14] [17] [25] [66]. Leakage can also cause ineffective ventilation due to the lack of sealing between the facemask and the patient's face or SGD against the hypopharynx or due to leakage within the circuit or positive pressure device. Small leaks are temporarily tolerable if they allow adequate ventilation; in rare cases of trauma, air can leak from the airway or tracheobronchial tree [66].

8.1. Optimization of Facemask Ventilation

When facing difficulty with FMV, in addition to treating the obstructive and restrictive causes mentioned above, the initial conduct must be to immediately optimize FMV [66] [68]. If desaturation occurs, using 100% oxygen is justified in all cases, and possible errors in the maneuver and selection of implements must be corrected. The "sniffing position" may open the airway by relieving its kinking or collapse. The maneuver should be adjusted to the patient size as previously mentioned [6] [7] [10] [14] [16] [34]. The use of two-handed, two-rescuers FMV can add mandibular protrusion, achieve greater sealing of the mask, reduce rescuer fatigue and finally increase the effectiveness of the ventilation [6] [9] [10] [16] [18] [71] [72]. An appropriately sized oropharyngeal cannula correctly positioned in the anesthetized or unconscious patient can relieve the obstruction. In contrast, improper size may worsen the obstruction and, in a semiconscious patient, may cause cough, bucking or laryngospasm [9] [34]. The "ramped" position should be maintained in pregnant women and morbidly obese patients [6] [7] [18] [19].

8.2. Unique, Fast and Optimal Intubation Attempt

In situations where FMV optimization is ineffective, there may be an optional step that is often overlooked in the guidelines: performing a fast, unique and optimal intubation attempt [14] [66]. If a patient cannot be ventilated with a facemask it does not necessarily mean that they cannot be intubated, although a weak statistical correlation exists between these two circumstances [1]. Observational evidence from a large group of patients in real situations where it was impossible to ventilate the patient using FM (37 cases) showed that 26 patients were intubated on the first attempt and another 10 were intubated with difficulty, whereas only one required surgical access [1] [66]. The ever-present possibility of an inadvertent foreign body causing the obstruction is a consideration that reinforces this behavior and a justification to perform it before considering SGD [14] [15]. The intubation attempt, in this case, must be optimized with all the maneuvers mentioned in section 6.1, and it must be performed by an experienced operator. It is especially recommended when there have been no previous attempts, when there is a great need to seal the airway or when an obstructive foreign body is suspected.

8.3. Supraglottic Ventilatory Devices (SGD)

After the definitive failure of FMV and at least one optimal intubation attempt, the guidelines recommend the fast and effective use of SGD [6] [7] [9] [10] [14] [10], preferring those that have proven effective and safe in real situations. Among these, the laryngeal mask has shown utility in multiple case reports [6] [7] [9] [10] [14] [73] [74]. It is available in most institutions, has a variety of sizes, is familiar to medical personnel, it is simple and intuitive to use and frees the hands of the rescuer; however, it only partially protects against aspiration, and ventilation may be ineffective in cases of deformed airway or of high pressure ventilation requirements [9] [10] [74].

The Combitube is a SGD tested in emergency situations [12] [20] [25] [28] [75] with the advantage of providing better sealing and protection against aspiration; however, it tends to be more traumatic, is less available in institutions and requires previous training to use it. It is available in sizes 37 and 41 Fr, and is limited to patients who are greater than 120 cm in height. [12] [25]. For these reasons, it could be the second choice in this situation.

In recent years, a wide range of SGDs have been developed and marketed, most with little evidence in real situations of impossible FMV, usually extracted from normal patients with simulated or predicted DFMV. They require prior training and have limited availability but could be considered if these obstacles are overcome [16] [20] [58] [59] [62]. The second-generation SGD may have additional advantages in these cases [58] [59] [62].

Given the rapid progression to hypoxia in the absence of ventilation, the use of SGD should be expeditious and effective, always evaluating the return or absence of ventilation. Multiple SGD insertions can also cause inflammation with possible collapse of the airway, so it is advisable to optimize each attempt. In case of difficult insertion, cricoid pressure should be released, the device should be inserted while deflated, and using a partial laryngoscopy could be useful [7] [10]. Faced with difficult SGD ventilation, in addition to treating obstructive or restrictive causes discussed in section 8, controlling the leak by increasing inflation pressure (up to 60 cm H20 in adults) or using a larger size are recommended [7] [10].

If FMV optimization or a SGD restores ventilation, especially after failed intubation, the situation returns to the mentioned spiral of intubation attempts and ventilation cycles (sections 6 and 7) but in a more advanced position if it is more difficult to ventilate. For example, if ventilation is restored but it is difficult to maintain, it is preferable to return the spiral in a position equivalent to that described in section 7, where it may be advisable to awaken the patient or use the other alternatives mentioned in this section [6] [7] [9] [12] [14]. In children, a minimum pulse oximetry limit of 80% without cardiovascular effects has been suggested to be sufficient to maintain transient short term options such as awakening, intubation attempt or surgical airway (but not proceeding with surgery) [14]. If it is impossible to restore ventilation, all noninvasive methods must be declared failed and invasive options should be rapidly initiated.

9. Impossible to Intubate or Ventilate with Noninvasive Methods

In the extremely life-threatening event that it is impossible to intubate or ventilate with a facemask or SGD despite the maximum effort, a rapid drop in tissue oxygenation will occur, which progresses inexorably to serious complications or death within minutes. In this case, awakening the patient is not an option and there is an immediate need to restore oxygenation, and the use of invasive methods of intubation or at least ventilation are mandatory. These methods must be quickly achievable, acceptably safe and have proven effectiveness in urgent situations. The recommendation, in this case, would be to *ask for all available help and quickly proceed with an invasive emergency airway. An open cricothyrotomy should be used in patients over* 8 *years and a tracheostomy* (*by an expert*) *should be used in children under* 8 *years* (*vs. puncture-wire-cannula kit in* *both groups*) [6] [7] [9] [10] [12] [14]. Ideally, at least two highly trained rescuers should face this situation in a complementary and coordinated manner. One of them makes continuous attempts to achieve at least minimum ventilation by noninvasive methods while the other proceeds with an invasive method. The patient is placed in a pronounced sniffing position that facilitates both maneuvers, and rapid aseptic techniques are performed before proceeding with the incision or puncture [6]. If hemodynamic effects of hypoxia appear (e.g. bradycardia), they must be treated in order to at least delay cardiac arrest. If this occurs, cardiac compressions and other resuscitation maneuvers are started, without interfering with the priority airway access.

The aim is to insert a tube or cannula through the antero-medial cervical route. These should preferably be cuffed to ensure sealing and airway protection and the diameter must be sufficient to allow proper inhalation and full expiration. When thin, uncuffed cannulas are inserted (narrower in comparison to tracheal size), inhalation will require high pressure and flow (usually jet ventilation) to compensate for high resistance and leakage. Exhalation occurs by passive retrograde leakage into the pharynx and not out through the cannula. The latter method is less effective, does not provide protection against bronchoaspiration, and is contraindicated in complete upper airway obstruction because it would produce progressive insufflation with severe respiratory and hemodynamic effects [5].

9.1. Invasive Methods in Adults and Children Older than 8 Years

Contrary to widespread belief, tracheostomy is not the method of choice in this case because it is a laborious, time-consuming technique, and because it can lead to serious complications when performed under stress. Tracheostomy should be discouraged unless performed by a trained surgeon [12] [22] [23]. According to the guidelines, open emergency cricothyrotomy (also called surgical) is the most accepted method [6] [7] [9] [10] [44] [76]. This method involves making an incision in the more superficial and avascular point of the airway (the cricothyroid membrane) to be channeled with a tracheostomy cannula or an endotracheal tube, which are both ideally cuffed. It is best to use tubes that have a slightly thinner diameter than those used via orotracheal (e.g., 6 mm ID in an adult), but are sufficient to allow efficient re-oxygenation with protected airway. The simplified "four step" technique has been described, which could be effective in urgent situations, even by an inexperienced rescuer [6] [12] [76]. This route is a medium-term solution and must be changed to another intubation method within hours or a few days in less urgent and more controlled conditions.

Another alternative in these age groups, although less supported, is the use of cricothyroidotomy kits specially designed for performing the sequence: puncture-guidewire-cannula (wide bore, ID greater than 4 mm). After an initial puncture of the cricothyroid membrane, air suction confirms the intratracheal position and an atraumatic tip guidewire is advanced. The hole is then dilated to slide a cannula, and some of them are cuffed to provide protection and sealing [6] [10] [12] [20] [21] [24]. Uncuffed cannulas could require high flow and pressure or jet ventilation.

In this age group, puncture methods with narrow cannulas (thinner than 4 mm ID) are discouraged because of the high resistance and excessive leakage that does not allow for effective re-oxygenation. This includes improvised techniques using intravenous cannulas, which are very susceptible to kinking and displacement, are ineffective in re-oxygenation, cause unreasonable delay, and can even complicate an adequate surgical access by air entrapment or soft tissue insufflation [7] [10] [77].

9.2. Invasive Methods in Children under 8 Years

In children under 8 years, evidence is merely based on case reports, simulated situations or animal models. In this population, the cricothyroid membrane is hidden under the jaw and is usually too narrow to allow open cricothyrotomy and the passage of a suitable tube. This can also lead to an unacceptably high risk of severe laryngeal trauma with sequelae. The recommended option is rapid tracheostomy by a highly trained pediatric surgeon [12] [14] [15] [78].

The other, less supported option includes specially designed pediatric kits for cricothyro/tracheotomy to use the sequence puncture-guidewire-cannula (narrow bore, thinner than 4 mm ID), which are usually uncuffed, but kink-resistant [12] [14] [78]. Some experts believe that the use of an intravenous cannula (14 - 16 G sizes) could be transiently effective in this population because, despite the high resistance and leakage, lower volumes are needed to maintain oxygenation. It is a more hazardous technique and entails the risk of kinking and soft tissue insufflation [10] [14] [78]. In the latter two methods, the thinner the cannula relative to the trachea, the more jet ventilation is needed, and will be a more short-term solution, providing only a few minutes for oxygenation to wake the patient, attempt intubation or perform tracheostomy.

10. Intubation Confirmation and Fixation

When intubation has been achieved, it is mandatory to confirm the intratracheal tube position. Errors or delays in recognizing esophageal intubation are a cause of morbi-mortality [6] [9] [10] [12]. Clinical parameters such as auscultation or the self-inflating bulb test can be useful, but they are susceptible to failure [6] [14]. Sustained capnographic tracing is indicative of intubation and the absence has a low possibility of a false negative (monitor malfunction, cardiac arrest, severe bronchospasm or tube obstruction) [6] [7] [10] [21]. A direct or indirect laryngoscopic view of the tube through the glottis or bronchoscopic vision of tracheal rings through the tube, are other reliable parameters. If intubation is not evident by reliable parameters, it is best to assume that it was unsuccessful and then return to facemask or SGD ventilation and try intubation again.

It is mandatory to rule out selective endobronchial intubation, which is more common in children, guided by auscultation or fiberoptic vision through the tube [6] [14]. It is important to adjust the cuff pressure to prevent leak or bronchoaspiration, but without compromising the circulation of the tracheal mucosa. The tube must be fixed properly to avoid extubation or inadvertent changes in depth, especially in patients who are to be transported. Tube replacements are safer with an exchanger guide (or bougie) and a partial laryngoscopy [11] [17] [21].

If difficulty arises when ventilating an intubated patient, it is necessary to rule out causes of tube or circuit obstruction (secretions, foreign body, bend or bitten tube) or leakage (connections or cuff) in addition to obstructive or restrictive alterations of the patient [54].

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