AIRWAY MANAGEMENT IN CRITICAL CARE MEDICINE

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Airway Management in Critical Care Medicine
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1st edition 2013
© 2015 Endo Press GmbH
P.O. Box, 78503 Tuttlingen, Germany
Phone: +49 (0) 74 61/1 45 90
Fax: +49 (0) 74 61/708-529
E-mail: Endopress@t-online.de

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Editions in languages other than English and German are in preparation. For up-to-date information, please contact Endo Press GmbH at the address shown above.

Design and Composing:
Endo Press GmbH, Germany

Printing and Binding:
Straub Druck + Medien AG
Max-Planck-Straße 17, 78713 Schramberg, Germany

07.15.0.5

ISBN 978-3-89756-769-6

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Introduction

The principal reason for admitting a critically ill patient to an intensive care unit (ICU) is respiratory failure. A vast array of techniques and equipment are available in modern critical care medicine for the management of respiratory dysfunction. In recent years, noninvasive ventilation with a face mask or helmet has become an increasingly important ventilatory modality in critical care settings. Nevertheless, some patients with conditions such as acute lung failure (ARDS) will continue to require urgent endotracheal intubation, and a variety of strategies must be available for providing invasive ventilation. Besides ventilation with a face mask or classic endotracheal tube, supraglottic airway devices are also available. These devices are useful for providing short-term ventilation and oxygenation, especially in emergency situations. Examples are the laryngeal mask and laryngeal tube. These devices cannot replace the endotracheal tube in everyday clinical care, however, and serve only as adjuncts until a definitive airway can be established by endotracheal intubation or tracheotomy. The advantages of securing the airway with a cuffed tube include:

- the prevention of gastric insufflation
- relative protection from tracheal aspiration of fluids and solid foreign bodies
- allows for special ventilatory techniques such as high-frequency oscillatory ventilation (HFOV)
- allows for controlled ventilation at high positive pressures (e.g., PEEP)
- allows for selective tracheal or bronchial administration of pharmacologic agents through the indwelling tube
- provides access for bronchoscopy and bronchial lavage
- permits the selective sampling of tracheal secretions for microbiological testing

Endotracheal intubation is usually performed with a laryngoscope and Macintosh blade (Fig. 2). This technique is also called direct laryngoscopy because it affords a direct view of the laryngeal inlet (Fig. 3). But as several authors have pointed out, securing the airway in an ICU is associated with more complications and a higher rate of difficult intubations than in anesthesia. As a result, there have been increasing efforts in recent years to develop devices that can improve visualization of the glottic plane even in patients with a difficult airway. Most of these innovative devices do not require a direct line of sight to visualize the vocal cords, relying instead upon a camera or optical system that displays an eyepiece or monitor image of the laryngeal inlet.
Video-assisted intubation with the C-MAC® video laryngoscope. This technique is often called indirect laryngoscopy, therefore. Available data suggest that indirect laryngoscopy will find growing applications in the everyday practice of critical care. Because complications are especially likely to arise during the airway management of critically ill patients with decreased physiologic reserves, every ICU should stock a number of alternative devices for establishing a secure airway. The specific assortment of devices will depend on local circumstances. No single conventional device is suitable for every conceivable situation that may occur during airway management. Multiple techniques and devices should be on hand for managing any complication that may arise during endotracheal intubation. Experience has shown that it is best to stock devices that can be used for routine applications such as elective general anesthesia. When these devices are used routinely, the practitioners will already have a high degree of expertise when confronted with an emergency situation, since every instrument and device will have its own learning curve. Consequently, intensivists familiar with airway management should be trained in the use of these devices.

It is not practical to stock a variety of airway adjuncts at every patient bed in the ICU. A better solution is to employ rugged airway carts that can be individually outfitted and wheeled quickly to the bedside, delivering all materials and equipment necessary for elective or emergency airway management (Fig. 6).

Video-assisted intubation with the C-MAC® video laryngoscope.

Portable airway cart for in-hospital use.

Video-assisted fiberoptic intubation in the awake patient.
A common procedure in critical care medicine is bronchoscopy for the diagnosis and treatment of conditions such as atelectasis due to retained secretions. Percutaneous dilatational tracheotomy under endoscopic guidance has also become a fairly standard procedure in critical care settings. Thus, a bronchoscope or at least a large-bore intubation endoscope should be available in every ICU where patients are being ventilated. Ideally, this instrument should be kept on the airway cart so that it will be quickly available when needed (Fig. 7). The use of a battery unit and portable light source has proven helpful (Fig. 8). Immediate accessibility is crucial in the management of an unanticipated difficult airway. The optional use of a monitor system is particularly useful in performing a percutaneous dilatational tracheotomy (Fig. 9).
Special Issues in Critical Care Medicine

The Critically Ill Patient

ICU patients are generally very sick and have greatly diminished physiologic reserves. Many of them will require circulatory and respiratory support. Patients in respiratory failure are frequently admitted to the ICU. Once improved past the critical stage, patients are weaned from the ventilator and finally extubated. Some of these patients will have to be reintubated because their general health status does not allow for adequate spontaneous breathing. Intensivists, then, must have a broad knowledge of circulatory and respiratory therapies. Clinical experience and detailed background knowledge are essential to ensure that anesthesia induction and airway management by endotracheal intubation can be successfully accomplished in this complex subset of patients.

The problems of scant respiratory and cardiovascular reserves are often compounded by an associated impairment of consciousness. Since many of these patients are not fasted, they are also susceptible to the aspiration of gastric contents. Due to their critical health status, therapeutic decisions must be made quickly and purposefully to ensure the provision of appropriate care.

This is in contrast to the majority of patients who are treated electively in an operating room setting. These patients are usually well prepared, fasted, and rarely have a life-threatening illness. Anesthesia induction is not urgent in most cases and – unlike the conditions in an ICU – can be performed with optimum staffing, equipment, and working space.

Incidence of Difficult Airways in Critical Care Medicine

In our own study of 140 endotracheal intubations in an anesthesia-led ICU, we documented a 21% incidence of difficult intubation, defined as a Cormack-Lehane grade of III or IV11 (Fig. 10). In 7% of the patients, more than two intubation attempts were necessary to secure the airway. A group of French authors reported a 12% incidence of difficult intubation in ICU patients6. One study in over 3400 patients found a 10.3% incidence of difficult endotracheal intubation in all nonoperating-room intubations, with 3% of patients requiring three or more attempts12. Another study in more than 1000 patients found that more than two intubation attempts were needed13. By contrast, the incidence of difficult intubation in the operating room is only about 5%14. The incidence of difficult airways in prehospital emergency settings is comparable to that in the ICU: 15–19% with a Cormack-Lehane grade of III or IV15, 16. These figures clearly demonstrate that airway management in the ICU is a very demanding task with a high complication rate. For these reasons, intensivists must have comprehensive training and experience that will enable them to manage critically ill patients safely and effectively.

Grade I

The vocal cords are fully visible.

Grade II

Only the arytenoid area and posterior part of the glottic opening are visible.

Grade III

Only the epiglottis is visible.

Grade IV

View is limited to the soft palate (pharyngeal structures cannot be seen).

Definition of the Difficult Airway

Various definitions of a difficult airway have been presented in the literature. According to the guidelines of the German Society of Anesthesiology and Intensive Care Medicine (DGAI), a difficult airway is present when an anesthesiologist of average training experiences difficulty with mask ventilation or tracheal intubation.

Intubation is classified as difficult if successful endotracheal tube placement by conventional laryngoscopy requires more than three attempts or takes longer than 10 minutes. Inability to intubate often presents as a difficult direct laryngoscopy in which the glottic plane cannot be visualized well enough to allow safe placement of the endotracheal tube.

If failed intubation is accompanied by failure of bag-and-mask ventilation, a “cannot ventilate – cannot intubate” situation exists that is acutely life-threatening to the patient. Instead of wasting time with more failed intubation attempts, the intensivist should change to an alternative technique as shown in the Noppens-Piepho Algorithm for Emergency Airway Management (see diagram).

Noppens-Piepho Algorithm for Emergency Airway Management

In-hospital algorithm for the management of an unanticipated difficult airway. Mask ventilation is the starting point because it generally represents the first backup option. The selection of a particular device is based on availability and experience. SP = specialist.
Complications of Endotracheal Intubation in Critical Care Medicine

Various life-threatening complications may arise during endotracheal intubation (see Table 1). In a multicenter study of 250 ICU patients, at least one life-threatening complication was documented in 28% of endotracheal intubations. Severe hypoxia occurred in 26% of these patients, severe hypotension in 25%, and cardiac arrest in 2%. Other complications were cardiac arrhythmias (10%), esophageal intubation (5%), and aspiration (2%). Another study also found a high incidence of potentially life-threatening complications, with severe hypoxia occurring in 19% of the patients, severe hypotension in 10%, esophageal intubation in 7%, and aspiration in 6%. The incidence of cardiac arrest during airway management is significantly higher outside the operating room: 17.2% of the patients in the study suffered cardiac arrest, and severe hypoxia (SaO₂ < 70%) was identified as the cause in most cases. The risk of cardiac arrest was increased in cases where regurgitation, aspiration, esophageal intubation, or bradycardia occurred during intubation.

Table 1 Frequent complications of intubation in the ICU.

- Severe hypoxia (SpO₂ < 80%)
- Severe hypotension
- Cardiac arrest
- Cardiac arrhythmia
- Esophageal intubation
- Aspiration

Training of ICU Physicians in Airway Management

The physician staffing of ICUs varies widely at different institutions. In Germany, it has been found that staffing ICUs with physicians trained in critical care is associated with significantly better patient outcomes. Based on available data on airway management complications in critical care medicine, physicians who work in a critical care setting should receive competent training in airway management. To date, however, this requirement has not been implemented on a broad scale and many doctors who work in ICUs are not adequately trained in airway management. One reason for this may lie in different specialty backgrounds: In Germany, various specialties such as internal medicine, surgery, pediatrics, and anesthesiology are concerned chiefly with the provision of intensive care. Few of these specialties devote much attention to the practice of airway management. This led some authors to conclude that critical airway situations should be handled only by an anesthesiologist, who is an “airway specialist”. Currently, however, there is no scientific evidence to support this requirement. In principle, specialty training in critical care medicine does not ensure proficiency in successful endotracheal intubation. The ability to secure an airway is gained chiefly through clinical experience. Expertise in airway management is based on comprehensive medical and pharmacologic knowledge and on clinical experience with the various methods of establishing an airway. Studies indicate that 50 to 100 endotracheal intubations performed under supervision with a laryngoscope and Macintosh blade are necessary to become fully proficient in this technique.

The practical implementation of an airway management algorithm, a standard protocol for anesthesia induction, and easy access to airway devices and alternatives have proven helpful in reducing serious complications of airway management.

Special Problems in the Intensive Care Unit

Because of space limitations, it is more difficult to establish an airway in the ICU than in the operating room. The patient is surrounded by myriad devices such as the ventilator, monitors, hemofiltration devices, and infusion pumps. Infusion lines and cables may hamper direct access to the head of the ICU bed (Fig. 11). Moreover, special beds (e.g., ICU beds with an integrated air mattress) and devices immobilizing the cervical spine can hamper access to the patient’s head and make it difficult to position the head for intubation. Space constraints may hinder assisting personnel in providing patient care. Often the available space is already occupied by ICU devices, making it a challenge to get the airway cart close to the patient.
In dealing with each of the available devices and adjuncts, the operator must gain enough practice to be able to use the devices immediately, successfully, and safely even in emergency settings.

The airway management guideline of the DGAI describes a four-step process for learning the principles of airway management. These principles are applicable to all techniques and procedures for airway management in critical care medicine (Table 2).

### Equipment for Airway Management

Every ICU should be equipped with a standard airway cart to ensure the rapid availability of necessary airway devices and adjuncts. One survey conducted in the U.S. found that only 75% of the ICUs polled had equipment for endotracheal intubation available in the ICU as a set. Fifty percent of the ICUs reported having a difficult-airway cart or tote bag available within the unit. A survey conducted in Great Britain found that basic equipment for endotracheal intubation (ventilation bag, laryngoscope, laryngeal mask) was available in all of the ICUs. Surprisingly, however, only 32% of the units routinely used capnography for the verification of tube placement after endotracheal intubation. This is unusual when we consider that since 1991, the American Society of Anesthesiologists (ASA) has recommended the measurement of end-tidal CO$_2$ level as a basic monitoring test after anesthesia induction (Fig. 12).

---

**Table 2** Sequence of steps in learning the principles of airway management.

- Learn basic theory.
- Practice basic principles on an airway trainer.
- Perform the technique or procedure in a patient under supervision.
- Perfect the acquired skills. Place an airway in patients with an anticipated difficult airway. Participate in continuing education and training.
The end-tidal CO$_2$ level measured for 60 seconds is a reliable indicator of successful ventilation and thus provides an indirect sign of successful intubation. For years, therefore, capnography has been a recognized standard in anesthesiology, and a capnometer should be available in all settings where patients are intubated. It is noteworthy that current German standards stipulate that rescue vehicles with a physician on board must be equipped with a capnometer for monitoring intubations in prehospital emergency settings.

Endotracheal intubation is the gold standard in critical care medicine for treating an oxygenation deficit that cannot be managed by noninvasive ventilation. The ICU should be equipped with suitable instruments for anesthesia induction, therefore (Fig. 13).

### Table 3 Essential devices for airway management in the ICU.

<table>
<thead>
<tr>
<th>Device</th>
<th>Comments</th>
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<tbody>
<tr>
<td>Ventilation mask</td>
<td>Various sizes should be available (e.g., mask sizes 3, 4, and 5)</td>
</tr>
<tr>
<td>Ventilation bag</td>
<td>Should be available at every patient bed. FiO$_2$ capacity should be &gt; 0.9 (e.g., oxygen reservoir, demand valve)</td>
</tr>
<tr>
<td>Devices for maintaining a patent airway: Guedel tubes, Wendi tubes</td>
<td>Various sizes should be available (e.g., Guedel tube sizes 3, 4, and 5)</td>
</tr>
<tr>
<td>Laryngoscope handle</td>
<td>Regularly check the battery charge</td>
</tr>
<tr>
<td>Laryngoscope blade</td>
<td>Macintosh blades in at least two sizes: No. 3 and No. 4. Straight Miller blades may also be used, depending on in-house protocols</td>
</tr>
<tr>
<td>Suction device</td>
<td>Check for function before every endotracheal intubation</td>
</tr>
<tr>
<td>Suction catheter</td>
<td>Various sizes</td>
</tr>
<tr>
<td>Stylet</td>
<td>Various sizes. Choose the stylet that fits the inner diameter of the endotracheal tube. <em>Gum elastic bougies</em> may also be used</td>
</tr>
<tr>
<td>Capnometer</td>
<td>E.g., a portable capnometer or one integrated into the monitoring system</td>
</tr>
<tr>
<td>Endotracheal tubes</td>
<td>Various sizes (e.g., ID 6.5–9.0 mm) plus a 10-mL inflation syringe</td>
</tr>
<tr>
<td>Pulse oximeter</td>
<td>For monitoring oxygenation during airway management. Due to the delayed fall in oxygen saturation, especially after good preoxygenation, pulse oximetry is not useful for verifying correct endotracheal tube placement</td>
</tr>
</tbody>
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### Table 4 Adjunctive devices for managing a difficult airway.

<table>
<thead>
<tr>
<th>Device</th>
<th>Comments</th>
</tr>
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<tbody>
<tr>
<td>Supraglottic devices: such as the laryngeal mask, intubating laryngeal mask, laryngeal tube, and Combitube</td>
<td>The unit should be equipped with the supraglottic device that is most familiar through clinical use</td>
</tr>
<tr>
<td>Alternative laryngoscopes McCoy blade, video laryngoscope</td>
<td>The use of video laryngoscopy as a standard procedure offers many advantages over conventional direct laryngoscopy (see Video Laryngoscopy in Critical Care Medicine, p. 26)</td>
</tr>
<tr>
<td>Flexible intubation endoscope</td>
<td>Intubation endoscope with a light source (e.g., a battery-powered LED light source)</td>
</tr>
<tr>
<td>Cricothyrotomy set</td>
<td>An instrument set for surgical cricothyrotomy should always be available in addition to a needle cricothyrotomy kit</td>
</tr>
</tbody>
</table>

13 Instrument set for anesthesia induction.
Predictors of a Difficult Airway

If time allows, every endotracheal intubation should be preceded by a review of the patient's records and a comprehensive airway examination. Airway assessment should also precede "urgent intubations" (for respiratory failure that worsens over a period of hours). Generally there is no time available for airway assessment in emergency intubations (for sudden respiratory arrest).

The anesthesia protocol may provide an important clue to an anticipated difficult airway. Especially in surgical patients, the anesthesia protocol will generally yield important information on the airway history. It may document possible complications during airway management such as difficult mask ventilation, difficult intubation, or the use of alternative airway devices.

Airway assessment should always include an evaluation of the mouth, face, teeth, jaw, tongue, neck, and cervical spine (Table 5). This process takes very little time (about 15 seconds) and can prevent potentially serious complications.

<table>
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<th>Predictors of a difficult airway</th>
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<tr>
<td><strong>Mouth and pharynx</strong></td>
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<tr>
<td>- Limited mouth opening (&lt; 3 cm)</td>
</tr>
<tr>
<td>- Limited range of TMJ motion</td>
</tr>
<tr>
<td>(lower incisors cannot be moved</td>
</tr>
<tr>
<td>anterior to the upper incisors)</td>
</tr>
<tr>
<td>- Dental status: long upper incisors</td>
</tr>
<tr>
<td>(&quot;buck teeth&quot;)</td>
</tr>
<tr>
<td>- High, narrow palate</td>
</tr>
<tr>
<td>(&quot;gothic-arch&quot; palate)</td>
</tr>
<tr>
<td>- Macroglossia (Fig. 14)</td>
</tr>
<tr>
<td>- Uvula not visible with the patient sitting</td>
</tr>
<tr>
<td>and the tongue protruded (Fig. 15)</td>
</tr>
<tr>
<td>- Jaw proportions</td>
</tr>
<tr>
<td>▶ Retrognathia</td>
</tr>
<tr>
<td>▶ Prognathia</td>
</tr>
<tr>
<td>- Upper airway tumors</td>
</tr>
<tr>
<td><strong>Face</strong></td>
</tr>
<tr>
<td>- Congenital anomalies (e.g., trisomy 21, Lenz-Majewski syndrome)</td>
</tr>
<tr>
<td>- Scars</td>
</tr>
<tr>
<td>- Trauma (e.g., midfacial fracture)</td>
</tr>
<tr>
<td>- Edema</td>
</tr>
<tr>
<td><strong>Neck</strong></td>
</tr>
<tr>
<td>- Limited cervical spine motion</td>
</tr>
<tr>
<td>- Pronounced ankylosing spondylitis</td>
</tr>
<tr>
<td>- Large tumors displacing the trachea</td>
</tr>
<tr>
<td>- Prior surgery, scarring</td>
</tr>
<tr>
<td>(e.g., neck dissection)</td>
</tr>
<tr>
<td>- Obesity with a short neck (Fig. 16)</td>
</tr>
</tbody>
</table>

Table 5 Predictors of a difficult airway.

If one or more predictors of difficult intubation is found, the intubation should always be performed by a physician experienced in endotracheal intubation. The procedure of first choice for anticipated difficult intubation is awake flexible fiberoptic intubation (see Flexible Endoscopic Intubation, p. 35). Spontaneous respiration should be maintained in these patients until the endotracheal tube has been placed in the trachea. This procedure, done under topical anesthesia, is successful in a high percentage of cases and can be performed at low risk. Uncooperative patients may be carefully sedated (e.g., with opioids) to facilitate the procedure. The sedative dosage should be low enough to preserve spontaneous breathing.
Securing the Airway

Preoxygenation

Every critically ill patient in the ICU should be adequately preoxygenated before anesthesia induction. Preoxygenation washes nitrogen (approximately 78% content in ambient air) from the lungs and maximizes the functional residual capacity while producing maximum oxygen saturation in the blood.

The patient is preoxygenated by administering 100% oxygen through a ventilation mask placed firmly over the face. When a ventilation bag is used, the oxygen flow should be at least 15 L/min and a reservoir bag should be attached to the circuit to achieve the highest possible oxygen concentration (>90%) (Fig. 17). The reservoir provides for oxygen enrichment in the ventilation bag. After each ventilation the attached reservoir refills the ventilation bag with 100% oxygen.

Another option is ventilation bags that can be connected to a demand system (Fig. 18). This arrangement can deliver a high FiO2 concentration within a short time.

The use of a nasal cannula or oxygen reservoir mask is inadequate for preoxygenation. These systems can provide only oxygen enrichment, so even with high oxygen flow they are very limited in the maximum inspiratory oxygen content that can be achieved (FiO2 = 30–75%, depending on the system used).

The use of a ventilation bag with oxygen delivery (reservoir bag or demand system) is a simple and effective preoxygenation method that can reduce the risk of severe hypoxia during airway placement. Preoxygenation before anesthesia induction should be continued for 3–4 minutes. There appears to be no benefit to extending the preoxygenation period to more than 4 minutes.

Especially in obese patients with an anticipated rapid fall in oxygen saturation, noninvasive ventilation (pressure support: 6 cm H2O, PEEP: 4 cm H2O) during preoxygenation was found to produce a markedly improved oxygen content in the arterial blood. In another study of hypoxic patients requiring intubation, it was found that preoxygenation by noninvasive ventilation led to significantly fewer hypoxic events during intubation compared with conventional preoxygenation. Preoxygenation was performed for 3 minutes using 100% oxygen, pressure support ventilation with a tidal volume of 7–10 mL/kg body weight, and a PEEP of 5 cm H2O. This study also demonstrated a positive effect on oxygenation for up to 5 minutes after endotracheal intubation.

Thus, the recommended preoxygenation method for critically ill patients in respiratory failure is noninvasive ventilation on 100% oxygen, pressure support of at least 6 cm H2O (target = 7–10 mL/kg b.w.), and a PEEP of at least 4 cm H2O for a period of 4 minutes (Fig. 19).
Endotracheal Intubation

The principal indications for endotracheal intubation in critical care medicine include the following:

- Maintaining a patent airway
- Oxygenation
- Controlled ventilation
- Protection from aspiration
- Access for bronchial lavage

As a general rule, critically ill patients are assumed to have a full stomach. Hence, there is always a risk of regurgitation and aspiration during airway management.

To reduce the likelihood of aspiration, rapid sequence induction (RSI*) should always be performed during endotracheal intubation.

* So named because the normal sequence of intubation is shortened and some steps are omitted.

Induction Agents

Hypnotics

The need for hypnotics during anesthesia induction is markedly decreased in critically ill patients who are hemodynamically unstable. Also, it is advisable to use drugs that cause as little cardiovascular suppression as possible (Fig. 20). The use of propofol for emergency intubation is associated with a higher risk of hypotension than etomidate.

On the other hand, induction with etomidate causes adrenocortical suppression and may be harmful for patients in septic shock. For these reasons, ketanest (0.5–1 mg/kg) is being used increasingly as a hypnotic agent for anesthesia induction in hemodynamically unstable patients. Propofol is excellent for anesthesia induction in hemodynamically stable patients.

Neuromuscular Blockade

Neuromuscular blockade is induced with muscle relaxants to improve the intubation conditions and obtain better visualization of the glottic plane. Currently two drugs are available for rapid sequence induction: succinylcholine and rocuronium (Fig. 21). Both agents have a rapid onset at the proper dosage and provide good intubation conditions. Succinylcholine (1–1.5 mg/kg) is a short-acting depolarizing muscle relaxant (approximately 7 minutes) with a rapid onset of action (30–60 seconds). A number of side effects and contraindications have been reported (Table 6). Many of the contraindications relate to critically ill patients in intensive care.

- Hyperkalemia (> 5 mmol/l)
- Burns
- Stroke
- Spinal injuries
- Multiple sclerosis
- Guillain-Barré syndrome
- Degenerative or dystrophic muscle diseases
- Immobilized patient (bed-confined for >3 days)

Rocuronium is a non-depolarizing muscle relaxant. This drug has a rapid onset of action (60–90 seconds) when administered at high dosage (0.9–1.2 mg/kg), although this will also prolong the duration of the neuromuscular blockade (approximately 120 minutes). Sugammadex (16 mg/kg) can completely reverse the effect of rocuronium within 3 minutes (Fig. 22). The effects of succinylcholine and rocuronium were compared in a Cochrane meta-analysis. Both drugs were found to produce equivalent intubation conditions, but succinylcholine was deemed superior based on its short duration of action.
Neuromuscular blockade should be induced for every intubation in ICU because it significantly improves the intubating conditions.

The use of succinylcholine is limited to selected cases due to its many possible side effects. When sugammadex is available, rocuronium (0.9–1.2 mg/kg) should be used routinely for neuromuscular blockade during endotracheal intubation in critical care medicine.

**Opioids**

Opioids are traditionally used for anesthesia induction and the maintenance of sedation. Because tracheal intubation is a very potent stimulus, opioids (e.g., sufentanil at 0.2–0.4 μg/kg) are often administered as adjuncts to anesthesia induction (Fig. 23).

It should always be noted, however, that all drugs (opioids, hypnotics) administered in a sufficiently high dose may cause hemodynamic instability in critically ill patients with a coexisting intravascular volume deficit.

**Positioning the Head**

Before endotracheal intubation, the patient’s head should be placed in the “snifﬁng position” or modiﬁed Jackson position. This is done by placing the head on an approximately 10-cm-high cushion or pillow and hyperextending the neck (Fig. 24). When the head is correctly positioned, direct laryngoscopy can provide the intubator with a straight line of sight past the upper incisors and through the oral cavity to the larynx (Fig. 25).
Orotracheal Intubation

**Direct Laryngoscopy**

Orotracheal intubation under direct vision is the standard procedure used for most patients. The Macintosh blade is most commonly used (Fig. 26). Use of the straight Miller blade (Fig. 27) differs in some respects from the technique with the Macintosh blade.

After positioning, preoxygenation, and pharmacologic anesthesia induction, the next step is to open the mouth with the “crossed fingers” or “scissor” maneuver with the thumb and middle finger of the right hand placed in the right-hand corner of the mouth (Fig. 28). The thumb is placed firmly against the lower teeth while the middle finger pushes upward on the upper teeth. This grip can also be used to gently extend the head. The laryngoscope with attached blade is taken in the left hand, which typically holds the handle at its distal third (Fig. 29). The laryngoscope blade is introduced into the right corner of the opened mouth and is moved into the midline, pushing the tongue to the left (Fig. 30).
At this point the epiglottis, a critical landmark, should come into view. When a curved Macintosh blade is used, the tip of the blade is advanced into the vallecula, or the depression between the base of the tongue and the epiglottis (Fig. 31). Exerting gentle traction along the axis of the laryngoscope handle will lift the epiglottis out of the sight line and bring the glottis into view (Fig. 32). The handle should always be pulled along its axis, never rotated or “levered” as this might cause dental injury (Fig. 33). Next the prepared endotracheal tube is carefully advanced through the glottis under vision. We recommend advancing the tube down the right side of the mouth (retromolar route) so that the vocal cords can be kept in view. In all cases the cuff of the tube must be positioned within the trachea, and ideally the tube tip should be in the middle third of the trachea. The tube is typically inserted to a depth of 21 to 23 cm from the incisor teeth (Fig. 34).
Verification of Tube Placement

After successful orotracheal intubation, the tube cuff is inflated and correct tube placement is verified. Unrecognized esophageal intubation is the most serious complication of endotracheal intubation. Table 7 lists typical reliable and unreliable signs of correct tube placement in the trachea.

<table>
<thead>
<tr>
<th>Unreliable signs</th>
<th>Reliable signs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breath sounds on auscultation of the chest</td>
<td>Capnometry/capnography. This modality cannot detect unilateral bronchial placement or tube tip placement above the glottis</td>
</tr>
<tr>
<td>Absence of ventilation sounds on auscultation of the stomach</td>
<td>Intubation under vision (watching the tip of the tube pass between the vocal cords)</td>
</tr>
<tr>
<td>Rising and falling of the chest during ventilation</td>
<td>Bronchoscopy with positive identification of the trachea (cartilage rings) and carina</td>
</tr>
<tr>
<td>Fogging in the tube</td>
<td>Chest radiography (films are often not available right away; the tip of the tube in adults should be 5 cm above the carina)</td>
</tr>
<tr>
<td>Pulse oximetry (fall of SaO₂ is often delayed with misdirected intubation)</td>
<td>Esophageal detector devices</td>
</tr>
</tbody>
</table>

Table 7 Unreliable and reliable signs of tube placement in the trachea.

Bilateral auscultation of the chest in the axillary line (symmetrical breath sounds?) and auscultation over the epigastrium (no ventilation sounds?) should be performed after every intubation. Auscultation should not be omitted, as it can exclude placement errors such as a unilateral endobronchial position of the tube tip.

Besides the direct visual monitoring of tube insertion, the most reliable sign of endotracheal tube placement is end-tidal CO₂ detection by capnography. This procedure is also explicitly recommended in the international guidelines of the European Resuscitation Council (ERC) after every endotracheal intubation37.

A capnometer allows for continuous, noninvasive monitoring of the carbon dioxide concentration in the expired air. The measured CO₂ level is displayed in relation to the total gas mixture (in volume percent) or as an end-tidal partial pressure (etpCO₂ in mm Hg). While capnography cannot trace the progression of CO₂ values over the respiratory cycle (Fig. 35), it can provide a graphic display of the CO₂ level at the end of each breath (Fig. 36).

The frequency of esophageal reintubation in critical care has a reported range between 1.3% and 9%.6, 12, 32, 38, 39. These figures underscore the need for end-tidal CO₂ monitoring during every intubation in critical care settings. On the other hand, it may be difficult for capnometry to confirm correct endotracheal tube placement in patients who are in cardiac arrest. Due to the scant lung perfusion during chest compressions, only low end-tidal CO₂ levels are measurable in this subset of patients. As a result, it is difficult to distinguish tracheal from esophageal intubation40.
Esophageal detection devices provide a reliable and cost-effective means of verifying tube placement (Fig. 37). The rubber bulb of the device is compressed, connected to the endotracheal tube, and released. The trachea, unlike the muscular esophagus, will not collapse in response to the bulb suction because it is stabilized by cartilage rings. If the tube is endotracheal, the bulb will reinflate; if it is in the esophagus, the bulb will not reinflate because it cannot aspirate air from the collapsing esophagus41. The bulb method is reliable in patients with or without a circulation but may be misleading in morbidly obese patients, in late pregnancy, severe asthma, and in the presence of heavy tracheal secretions. Under these conditions the trachea may also collapse in response to the negative pressure from the bulb42, 43.

At least one reliable sign of endotracheal tube placement should be detected after every endotracheal intubation. If a reliable sign is not found, the sum of the “unreliable” signs should all be consistent with endotracheal placement. If doubt exists, laryngoscopy or bronchoscopy should be repeated so that passage of the tube through the glottis or tracheal structures can be visualized.

Finally it should be noted that end-tidal CO2 detection, endotracheal intubation under vision, and esophageal detection devices are not 100% reliable in verifying tube placement. None of these methods can exclude the possibility of unilateral tube placement in a main bronchus.

Management of Difficult Direct Laryngoscopy

If direct laryngoscopy is difficult or impossible on the first attempt, various measures can be taken to improve visualization and intubation conditions (Table 8). An essential step is an early call for help from a physician experienced in airway management. The presence of an attending anesthesiologist is associated with a decreased overall incidence of complications44. The airway care delivered by an experienced anesthesiologist is distinguished not only by the type of care provided but also by the pharmacology of anesthesia induction.

It should also be emphasized that repeated intubation attempts are associated with higher complication rates. According to a study by Mort, the incidence of severe complications rises sharply when more than two failed intubation attempts are performed45. The incidence of severe hypoxia (SaO2 <80%) is increased by a factor of 14, aspiration by a factor of 4, and cardiac arrest by a factor of 7. The management of these cases should include the early consideration of alternative airway techniques. The goal of airway management in most ICU patients is the placement of an endotracheal tube. But if direct laryngoscopy proves difficult or impossible, the intubator should not cling stubbornly to that procedure. It is better to switch to an alternative technique than risk additional airway trauma.

<table>
<thead>
<tr>
<th>Measures for improving intubation conditions</th>
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<tbody>
<tr>
<td>Place the head in an optimum position</td>
</tr>
<tr>
<td>(“sniffing” or modified Jackson position)</td>
</tr>
<tr>
<td>Manipulate the larynx to align it more closely with the visual axis of the intubator:</td>
</tr>
<tr>
<td>▪ OELM (optimal external laryngeal manipulation)</td>
</tr>
<tr>
<td>▪ BURP (backward upward rightward pressure on the thyroid cartilage)</td>
</tr>
<tr>
<td>Use an alternative introducer (e.g., gum elastic bougie)</td>
</tr>
<tr>
<td>Prebend the tube tip 90° on a stylet</td>
</tr>
<tr>
<td>(“hockey stick” configuration)</td>
</tr>
<tr>
<td>Use a video laryngoscope</td>
</tr>
<tr>
<td>Use alternative intubation blades</td>
</tr>
<tr>
<td>(e.g., McCoy, Henderson blade)</td>
</tr>
</tbody>
</table>

Table 8 Measures that can improve intubation conditions.
The C-MAC® Video Laryngoscope

Advances in digital photographic and video technology in recent years have led to the development of innovative laryngoscopes that differ from conventional devices by eliminating the need for a direct line of sight to the glottis (Fig. 38). Indirect visualization of the glottic plane is accomplished with a small digital camera that is mounted at the distal end of the laryngoscope blade and transmits the image electronically to an LCD video monitor (Fig. 39).

The C-MAC® video laryngoscope has a modular design that can accommodate various reusable stainless-steel blades with an integrated LED light source and camera. Macintosh blade sizes 2, 3, and 4 and Miller blade size 1 are currently available (Fig. 40). The Macintosh blades have been slightly modified for use with the C-MAC®: The blades have a thinner profile (maximum 1.4 cm) and a beveled shoulder. They may be equipped with an optional guide channel for introducing a suction catheter to maintain a clear visual field. The special “dBLADE™” is additionally available for difficult intubations (Fig. 41). Its distal tip has a 40° angulation that is designed to improve visualization of the glottis in anatomically difficult intubations.

Unlike conventional laryngoscopy, video laryngoscopy can “see around the corner” (light blue area).

The glottis is displayed on the 2.4-inch LCD monitor of the C-MAC® PM video laryngoscope.

The C-MAC® PM video laryngoscope, 1: C-MAC® with Macintosh blade sizes 2–4, 2 – 4; and C-MAC® with a Miller blade, 5.

C-MAC® fitted with a dBLADE® for difficult intubation.

External 6.7-inch LCD monitor for the C-MAC® video laryngoscope, displaying the glottis.

The slot on the top of the LCD video monitor accommodates a standard SD memory card.
The camera window is prewarmed by the LED light source to prevent fogging. The color image is transmitted by cable from the camera chip to a 6.7-inch (17-cm) diagonal external video monitor (Fig. 42). The monitor image always shows the tip of the blade, allowing for accurate placement of the blade tip in the vallecula. The C-MAC® video laryngoscope allows still pictures and video sequences to be recorded and stored digitally on an SD memory card (Fig. 43). Both the monitor and the laryngoscope handle have buttons that allow the operator to capture still images and video sequences. The system is powered by a rechargeable lithium ion battery that allows approximately 2 hours of operation. Since the C-MAC® was designed for use under difficult conditions, the casing is made of impact-resistant plastic that protects against dust and splashes.

The C-MAC® Pocket Monitor (PM) that incorporates a 2.4-inch LCD screen (Fig. 44) is a part of the video airway management system that is available as an alternative to the larger monitor. This ultra-portable system is compatible with any KARL STORZ video laryngoscope blade. It can operate for approximately one hour without recharging. The small screen is for live viewing only and cannot capture stills or video.

**Technique of Video Laryngoscopy**

When the C-MAC® video laryngoscope is used with a Macintosh-type blade, intubation employs the same technique as a conventional intubation. The system can be used for conventional direct laryngoscopy as well as video-guided laryngoscopy (Fig. 45). Combining a Macintosh-type blade with a camera at the blade tip makes the system more similar to direct laryngoscopy than other video laryngoscopes. Thus, the C-MAC® video laryngoscope makes it possible to perform conventional intubation under continuous guidance, which is advantageous for training and continuing education. Also, an assistant can monitor the effect of external laryngeal pressure and can actively apply suitable manipulations to help optimize the glottic view (Fig. 46). As a rule, the view of the blade provided by video laryngoscopy is superior to direct visualization with a Macintosh blade. Additionally, the modified shape of the C-MAC® Macintosh blade allows the epiglottis to be carefully lifted on the tip of the blade, analogous to the technique with a straight Miller blade, to obtain a better view of the vocal cords.

When the dBLADE® is used, the intubation technique must be modified to accommodate the unique blade design (Fig. 47). As with most other video laryngoscopes that have an upturned blade tip (e.g., the GlideScope®, McGrath®), the dBLADE® is introduced in the midline for advancement toward the glottis. Analogous to direct laryngoscopy, the intubator...
should always try to identify the epiglottis so that the blade tip position can be assessed. This is done to ensure that the blade tip itself does not encroach upon the glottic inlet.

Due to the upward angulation of the dBLADE® tip, it is important to learn the proper use of the device. Studies with devices having a similar blade shape have shown that 5 to 8 intubations are necessary to become proficient in the use of special blades46–51.

Although the glottic plane can be visualized by video laryngoscopy with a high success rate, problems may arise. Despite an excellent view, it may be difficult to direct the endotracheal tube through the vocal cords. This is true of all systems that do not have an integrated tube guide. With the blade positioned in the oral midline, the tongue may hamper advancement of the tracheal tube (Fig. 48).

In contrast to conventional laryngoscopy, the intubator does not require a straight line of sight from the oral cavity to the vocal cords7. Since it is unnecessary to align the oral, pharyngeal and tracheal axis, the tube must be advanced “around the corner.” Thus, whenever indirect laryngoscopy is performed with a device that does not have an integrated tube guide, endotracheal tube insertion should always be aided by a stylet53–55.

One study found that prebending the endotracheal tube 90° to a “hockey stick” configuration on a malleable stylet allowed for easier endotracheal placement based on the subjective assessment of the users (Fig. 49)53. This result is supported by a study on a simulated airway using the C-MAC® video laryngoscope and Macintosh blade44. When the tube was introduced on a stylet prebent to a 90° angle, the time to endotracheal intubation was shorter in all the simulated scenarios (normal airway, immobilized cervical spine, swollen tongue, and immobilized cervical spine plus a swollen tongue). Especially in scenarios with a very difficult airway (immobilized cervical spine plus a swollen tongue), intubation with the hockey-stick configuration was faster and more successful than intubation without a stylet. A stylet prebent to a hockey-stick shape should definitely be used with all curved blades (including the dBLADE®) to facilitate accurate tube advancement to the glottic plane.

Another alternative is the primary video-laryngoscopic placement of a guide such as a gum elastic bougie or Frova intubating stylet. The tracheal tube is then advanced over the preplaced guide (Fig. 50)56, 57.

Other problems may arise even after the tube has passed through the vocal cords. For example, the extreme prebent configuration of the stylet within the tube can make further tube advancement difficult. This often results from the fact that the tube is pointed toward the anterior part of the larynx (Fig. 51). In this case it may be helpful to advance the tube while simultaneously withdrawing the stylet. Rotating the tube 180° after removing the stylet may also help to advance the tip more deeply7, 53.
Glottic Visualization and Intubation Success with the Video Laryngoscope

One study found that the use of a video laryngoscope with a Macintosh blade improved glottic visualization in 44% of patients compared with direct laryngoscopy (n=300)\(^5\). There were a few cases, however, in which video laryngoscopy gave a poorer view than direct laryngoscopy. Endotracheal intubation with the video laryngoscope was not possible in a total of 4 patients (1.3%). In another study of patients whose glottis could not be visualized by direct laryngoscopy (CL grade III or IV, Fig. 52), the monitor of the video laryngoscope provided an improved glottic view in 84% of the cases\(^5\). The incidence of difficult intubation was reduced from 14% to 3% in this study. The KARL STORZ video laryngoscope was also found to improve glottic visualization in patients with anticipated difficult intubation\(^5\), although this study did not include cases with a CL grade IV view (epiglottis and glottis not visible). The incidence of CL grade III (only the epiglottis is visible) was lower compared with conventional laryngoscopy, and 99% of the patients could be successfully intubated by video laryngoscopy. These data clearly indicate that the use of a video laryngoscope can improve visualization of the glottic plane in most patients. As a result, use of the C-MAC\(^5\) with Macintosh blade can be recommended for every intubation that is performed outside the operating room.

In patients with a simulated difficult airway involving limited cervical spine motion and limited mouth opening due to the placement of a cervical immobilization collar, use of the C-MAC\(^5\) video laryngoscope could significantly improve the view of the glottis (Fig. 53)\(^5\). The vocal cords were visible by direct laryngoscopy in 30% of cases, while use of the C-MAC\(^5\) video laryngoscope with Macintosh blade provided a clear view of the glottis in 86% of the patients. External laryngeal manipulation (BURP maneuver) improved the glottic view in 95% of cases.

In our own study, the C-MAC\(^5\) video laryngoscope with Macintosh blade was used in patients with unanticipated difficult intubation (CL grades III and IV) as an alternative to direct laryngoscopy\(^5\). The C-MAC\(^5\) with Macintosh blade improved visualization of the vocal cords in 94% of the patients. It did not improve the glottic view in 6%. Tracheal intubation was successful in 94% of patients using the C-MAC\(^5\) video laryngoscope. These cases required a maximum of three intubation attempts.
No large clinical studies have yet been done on the use of the curved dBLADE® for difficult airways. In one study of 20 patients with difficult laryngoscopy in which the glottis was not visible (CL grades III and IV), use of the dBLADE® was found to improve visualization in every case (to CL grade I or II)\(^7\). Intubation was successful in 14 patients on the first attempt. The remaining six patients required a maximum of four additional attempts for successful intubation. The high-curvature dBLADE® is particularly intended for use on the unanticipated difficult airway. Studies of video laryngoscopes with a similar blade shape found improved visualization in almost all patients with difficult direct laryngoscopy\(^7,62\). The McGrath® Series 5 and GlideScope® had success rates of 94–95% in cases of failed direct laryngoscopy with a conventional Macintosh blade.

**Video Laryngoscopy in Critical Care Medicine**

Endotracheal intubation is considerably more difficult in critical care settings than in the structured routines of an operating room. Complications during airway management are common. Given these circumstances, it should be assumed that every critically ill patient in ICU who requires endotracheal intubation will have a difficult airway. Previous studies on video laryngoscopy have shown conclusively that the use of a video laryngoscope with a Macintosh-type blade is justified for every intubation in critical care medicine in order to protect patients from potential hazards.

An optimum video laryngoscope must meet the specific requirements of an ICU setting:

- **Rapid accessibility without the complicated assembly of components.**
- **Rugged construction.** Dropping the device, which may well occur in an emergency setting, should not cause significant damage.
- **Easy to use, with a short learning curve.**
- **Flexibility of use.** The device should be usable in a range of patients; various blade sizes and types should be available.
- **A large monitor.** This will allow all members of the intensive care team to observe the intubation and, if necessary, render assistance with minimal communication (e.g., laryngeal manipulation).
- **Fast and effective reprocessing.** The multitude of multidrug-resistant organisms that exist in critical care settings makes it imperative to achieve a thorough decontamination.

Use of the C-MAC® video laryngoscope with a Macintosh video blade in the ICU was able to reduce the incidence of difficult intubation from 20% with direct laryngoscopy to 7% with the C-MAC\(^6,63\). Use of the C-MAC\(^9\) also resulted in more successful intubations on the first attempt (88%) compared with direct laryngoscopy (80%).

**Supraglottic Airway Devices**

Proficiency with alternative techniques of oxygenation and ventilation is of critical importance when endotracheal intubation fails. Supraglottic airway devices have gained an established role as alternative methods for securing a difficult airway in prehospital emergency medicine and anaesthesiology\(^4,33\). To date, supraglottic techniques have been used only sporadically in critical care medicine\(^64\). A British study on the availability of airway equipment in ICUs found that only about 50% of the care units were equipped with supraglottic airway devices\(^26\). The main reason for this is the need to ventilate critically ill patients invasively and for an extended period, which generally can be accomplished only with an endotracheal tube. Moreover, intensivists with no background in anaesthesiology often lack the clinical experience and training necessary to use the devices safely and effectively. On the other hand, intensive training with supraglottic devices and a protocol based on standard guidelines and algorithms will enable practitioners to recognize typical airway problems quickly and institute appropriate measures without delay.

In principle, supraglottic airway devices provide an alternative to face-mask ventilation and endotracheal intubation (Table 9). Because they do not pass through the glottis, the DGAI also refers to them as “pharyngeal airway devices”\(^4\).

<table>
<thead>
<tr>
<th>Supraglottic airway devices</th>
<th>Examples (see Fig. 54)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Classic laryngeal masks</strong></td>
<td><a href="#">Ambu AuraOnce</a></td>
</tr>
<tr>
<td></td>
<td><a href="#">LMA Classic</a></td>
</tr>
<tr>
<td><strong>Laryngeal masks with an esophageal lumen</strong></td>
<td><a href="#">LMA Supreme</a></td>
</tr>
<tr>
<td></td>
<td>[LMA ProSeal(^5)]</td>
</tr>
<tr>
<td></td>
<td>[I-Gel(^6)]</td>
</tr>
<tr>
<td><strong>Laryngeal masks that allow blind endotracheal intubation</strong></td>
<td><a href="#">Fastrach intubating LMA</a></td>
</tr>
<tr>
<td><strong>Devices with an esophageal and oropharyngeal cuff</strong></td>
<td><a href="#">Combitube</a></td>
</tr>
<tr>
<td></td>
<td><a href="#">EasyTube</a></td>
</tr>
<tr>
<td></td>
<td><a href="#">LTS-D laryngeal tube</a></td>
</tr>
</tbody>
</table>

Table 9 Typical supraglottic airway devices.

Even less experienced and novice users can successfully use these devices for ventilation and oxygenation with little training. In one study, 50 subjects with no experience in endotracheal intubation were trained in the use of the LMA Supreme\(^9\) laryngeal mask on an airway manikin\(^66\).
In the next phase the participants inserted the laryngeal mask in anesthetized patients. All 50 subjects were able to place the laryngeal mask successfully, and 86% required only one attempt.

The LTS-D laryngeal tube was successfully inserted by novice users in 74% of anesthetized patients within 45 seconds\(^6\). In another study, first-month anesthesia residents were trained briefly in ProSeal\(^7\) laryngeal mask airway insertion on a manikin and were then able to place the LMA in patients with a higher success rate than conventional laryngoscopic intubation (100% versus 65%) and with a shorter effective airway time (42 s versus 89 s)\(^8\). Similar data were reported for LTS laryngeal tube insertion in an airway manikin: the LTS could be placed faster and with a higher success rate compared to endotracheal intubation\(^9\). In a large study the Combitube could be placed successfully on the first attempt in 82% of cases\(^10\).

In summary, these data indicate that all supraglottic airway techniques are easy to learn. It should be emphasized, however, that training on an airway simulator and on patients is essential before the devices can be used safely and proficiently.

Especially in critical situations involving failed intubation in the ICU, supraglottic airway devices can provide temporary oxygenation and ventilation until a physician experienced in airway management is available. The guidelines of the European Resuscitation Council (ERC) recommend that personnel who lack experience in endotracheal intubation should use a supraglottic airway device as an alternative\(^3\). The Combitube, classic laryngeal mask, laryngeal tube, and I-gel\(^\text{®}\) supraglottic airway are specifically recommended for the ventilation of patients in cardiac arrest. It should be noted, however, that none of the supraglottic devices is a cure-all and none can establish ventilation and oxygenation in every situation.

While many of the supraglottic devices can be placed blindly, they do not allow the airways to be inspected for trauma, bleeding, foreign bodies, or other pathology. As a general rule, all supraglottic techniques are contraindicated in patients who have upper airway pathology that involves severe swelling (e.g., acute inflammatory diseases such as epiglottitis) or large tumors. On the other hand, these contraindications should be considered relative in situations where there have already been multiple failed attempts at endotracheal intubation.

None of the aforementioned devices may be considered a substitute for endotracheal intubation. Instead, supraglottic airway devices should be considered a temporizing measure in critical care settings\(^2\). While it is true that ventilation can often be achieved, a supraglottic airway cannot effectively protect against aspiration. The general aspiration risk during ventilation with a classic laryngeal mask is reported to be 1:5000 in routine anesthesiologic practice\(^7\). The laryngeal mask significantly reduces the risk of aspiration compared with conventional bag-and-mask ventilation\(^11\).

Once oxygenation and ventilation have been established, an individual decision can be made on how best to secure a definitive airway. In principle, this can be accomplished by creating a surgical airway or by flexible endoscopic intubation. An ENT surgeon, for example, can easily perform an elective tracheotomy while a supraglottic device is in place.
The blind insertion of an endotracheal tube through a classic laryngeal mask has a low success rate. It is recommended, therefore, that secondary intubation be performed with a flexible intubation endoscope\(^7\). First, a flexible intubation rod (e.g., Aintree intubating catheter) is positioned within the trachea. Then, the laryngeal mask is removed and the endotracheal tube is introduced over the intubation rod (Fig. 55)\(^7\). When a Mainz adapter is used, ventilation of the patient can be continued during placement of the rod (see also Flexible Endoscopic Intubation).

Once a flexible intubation rod has been placed, the laryngeal mask can be removed and an endotracheal tube can be introduced over the rod.

Laryngeal Masks

**Classic Laryngeal Mask**

Since first described in 1985\(^5\), the laryngeal mask airway has been utilized throughout the world in a variety of anesthetic procedures. According to its inventor, the laryngeal mask is intended to provide a hybrid technique between mask anesthesia and endotracheal anesthesia.

The laryngeal mask has a cuff that seals off the space around the epiglottis from the posterior side, thus enabling the patient to be ventilated without passing a tube through the glottis. The distal tip of the cuff should engage against the upper esophageal sphincter.

With some experience, the user can manually place the laryngeal mask swiftly and without additional aids. As in anesthesia induction before endotracheal intubation, the patient must be anesthetized or deeply unconscious. The ideal head position is the sniffing or modified Jackson position. One way to place a laryngeal mask is to open the patient’s mouth, tilt the head back (Fig. 56), and advance the device along the hard palate into the pharynx. When the tip of the mask engages the upper esophageal sphincter, a definite resistance will be felt, which confirms correct placement.

Many airway algorithms rank the laryngeal mask as an alternative device to be used in cases of failed intubation or difficult face-mask ventilation\(^7\). It should be noted, however, that during the ventilation of a patient with a classic laryngeal mask (e.g., Ambu AuraOnce, LMA Unique), gas leak often occurs at airway pressures of approximately 18–20 cm H\(_2\)O or higher\(^7\). This limits the quality of ventilation that can be achieved in patients with low pulmonary or thoracic compliance.

56 The head is tilted back and the laryngeal mask is inserted along the hard palate into the pharynx.
Laryngeal Masks with an Esophageal Lumen

A recent development is laryngeal masks with a separate lumen that connects directly to the esophagus. This provides access for various actions such as inserting a gastric tube after successful placement of the laryngeal mask. The airway and esophagus can be separately ventilated and drained through the extra lumen. This significantly reduces the risk of aspiration. Three laryngeal masks with an esophageal lumen are currently available:

- The I-gel® is a single-use, uncuffed laryngeal airway made of a gel-like material (Fig. 57). The laryngeal part conforms to the anatomy of the hypopharynx and has a drainage channel that permits the insertion of a thin gastric tube.
- The LMA ProSeal® is a reusable laryngeal mask with an extra lumen for a gastric tube. It has a modified cuff designed to create a better seal than the classic LMA Unique®.
- The LMA Supreme® is a single-use laryngeal mask with an esophageal lumen. It has an anatomical shape designed for easier placement (Fig. 58). Like the ProSeal®, it reportedly creates a better airway seal than the classic laryngeal mask.

In one clinical study, the I-gel® laryngeal mask was successfully placed on the first attempt with a success rate of 78%80. The I-gel® was correctly placed in all anesthetized patients after a maximum of two additional attempts. The airway leak pressure in the I-gel® group was reported to be 27 cm H2O.

In another study the I-gel® laryngeal mask was successfully placed on the first attempt in 83% of cases81. It was correctly placed after 3 attempts in 95% of cases and could not be successfully placed in 5% of the patients. In all, 50% of the I-gel® laryngeal masks produced an airtight seal at a ventilation pressure of 20 cm H2O. No significant difference in airway leak pressures was found between the I-gel® device and the classic laryngeal mask (LMA Unique®): 25 vs. 22 cm H2O82.

The I-gel® laryngeal mask was successfully used for the ventilation of a patient with failed intubation (CL grade III)83. Also, a thin endotracheal tube was passed into the trachea through the laryngeal mask under fiberoptic guidance.

The LMA Supreme® and LMA ProSeal® were correctly placed on the first attempt with a high success rate (92–95%) in anesthetized patients84. The same study found airway leak pressures of 29 cm H2O for the LMA ProSeal® (cuff pressure 45 cm H2O) and 26 cm H2O for the LMA Supreme® (cuff pressure 65 cm H2O). Gastric tube insertion was successful in all cases.

In one case report, the LMA Supreme® laryngeal mask was successfully used for ventilation, oxygenation, and drainage of gastric contents in a critically ill, nonfasted patient with a difficult airway (CL grade III)85. The LMA ProSeal® was also used successfully in two patients with an unanticipated difficult airway as an alternative to endotracheal intubation (airway edema with CL grade III and failed intubation in an obese patient with CL grade III)86.

In principle, the ICU should always be equipped with the type of laryngeal mask with which personnel have had the most clinical experience.

Available data indicate that the LMA Supreme® and ProSeal® allow for higher ventilation pressures and easier placement than the I-gel® laryngeal mask.
Laryngeal Masks for Endotracheal Intubation

The Fastrach intubating laryngeal mask airway (ILMA) is an advanced version of the classic laryngeal mask. The Fastrach is specially designed for endotracheal tube placement and permits a special spiral-wound tube with a soft silicone tip to be passed blindly through the vocal cords (Fig. 59).

One feature that distinguishes the ILMA from a classic laryngeal mask is its shortened, rigid shaft. The shaft, or airway tube, is curved at almost a 90° angle and conforms to the anatomy of the pharynx. Attached to the shaft is a rigid handle (Fig. 60, 1). A small rubber lip, called the epiglottic elevating bar, is automatically raised during endotracheal tube insertion and, when the ILMA is correctly positioned, enables the spiral tube (up to size 8.0 I.D.) to enter the trachea (Fig. 60, 2).

The ILMA is available in sizes 3–5 for patients with a body weight of 30–100 kg. Unlike other laryngeal masks, the ILMA is designed mainly for use in anticipated or unanticipated difficult airway situations.

An important advantage of the ILMA is the ability to carry out a two-step procedure in emergency patients. In the first step the ILMA is placed much like a classic laryngeal mask to oxygenate and ventilate the patient. In the second step the trachea can be intubated via the ILMA if necessary. But if problems arise during advancement of the tracheal tube, the tube can be withdrawn while ventilation of the patient is continued.

Various studies have been published on the successful use of the ILMA. Medical students inexperienced in the use of laryngeal masks were able to place the ILMA faster than a classic laryngeal mask and achieved adequate ventilation with a higher success rate87. Tracheal intubation via the ILMA was successfully completed by 67% of the participants. In another study, inexperienced participants were able to ventilate anesthetized patients faster with an ILMA than by bag-and-mask ventilation (36 s versus 44 s) and with a higher success rate (98% versus 86%)88. Also, endotracheal intubation was successful more often with the ILMA (92%) than with conventional direct laryngoscopy (40%). In patients with a difficult airway, experienced anesthesiologists were able to place the ILMA with an 89% success rate on the first attempt89. Ventilation was accomplished in three attempts or fewer in all patients. The success rate for blind intubation through the ILMA was 97%. The remaining patients were successfully intubated under fiberoptic guidance. In a European multicenter study, blind intubation through the ILMA was accomplished in 96.2% of cases after a maximum of three attempts90.

Successful use of the ILMA has also been documented in patients with known airway access difficulties such as decreased mouth opening, limited cervical spine motion, or an unanticipated difficult airway91.

Airway leak has been described with the ILMA at peak ventilation pressures of 24–27 cm H₂O92, 93. Currently there are no data on the incidence of aspiration with the ILMA compared with endotracheal intubation. In one published case, aspiration occurred during the use of an ILMA in a patient with a previously unknown axial hiatal hernia94.

Use of the ILMA is limited in patients with upper airway abnormalities such as tumors, abscesses, or foreign bodies, because additional airway injury cannot be ruled out in this “blind” intubation technique91.

Owing to its ease of placement in the pharynx, reasonably good airway seal during ventilation, and the added option of semi-blind endotracheal intubation, the ILMA provides an effective alternative for failed intubation cases. Even in this application, however, the ILMA should not be used as an “ad hoc” rescue device for emergencies. It should be used only after adequate training and practice in an unhurried atmosphere.
Devices with an Esophageal and Oropharyngeal Cuff

**Combitube**

The **Combitube** consists of a cuffed, double-lumen tube. One lumen resembles a conventional endotracheal tube with a distal cuff. The other lumen is closed at its distal end, has multiple side openings, and has a proximal cuff at the level of the oropharynx that seals the oronasal airway (Fig. 61). The dual-lumen design allows for ventilation after either esophageal or endotracheal placement.

The **Combitube** is classified as a backup device for use on unanticipated difficult airways and especially in cannot intubate–cannot ventilate scenarios. It can secure the airway and provide rapid oxygenation and ventilation in emergency settings despite difficult anatomy, unfavorable lighting, a confined space, and limited equipment.

The **Combitube** is available in two sizes – 37 F-SA (“small adult”) and 41 – and can be used in patients who are at least 122 cm tall. Whenever possible it should be placed under direct vision with the aid of a laryngoscope to reduce the risk of injury. The **Combitube** can also be placed semi-blindly. This is done by opening the mouth, lifting the lower jaw by the Esmarch maneuver, and passing the **Combitube** into the pharynx. Two markings on the tube shaft indicate the correct insertion depth.

In more than 95% of cases the tip of the blindly inserted **Combitube** will enter the esophagus, and therefore initial ventilation is delivered through the longer, blue lumen following blind insertion. With positive end-tidal CO₂ detection and positive auscultation of the lungs, ventilation is simply continued through that lumen, which has side openings at the level of the larynx. The transparent limb can be used to pass a gastric tube into the esophagus or stomach.

In the event of negative end-tidal CO₂ detection and lung auscultation, ventilation can still be provided through the shorter, transparent lumen without repositioning the **Combitube**. Positive auscultation and CO₂ detection will confirm that the distal end of the tube has entered the trachea.

When placed in the esophagus, the **Combitube** produces an effective airway seal up to a ventilation pressure of approximately 40 cm H₂O. It should be noted, however, that this can be achieved only with a very high pharyngeal cuff pressure greater than 250 cm H₂O. Owing to its tight seal, the **Combitube** can also be used during cardiopulmonary resuscitation without having to interrupt chest compressions for ventilation.

In one study the **Combitube** was successfully placed on the first attempt in 82% of 1594 patients in cardiac arrest. Seven percent of the patients could not be ventilated even with multiple attempts, however. In anesthetized patients, the **Combitube** was successfully placed on the first attempt in 84% of cases. Adequate ventilation could not be achieved in 10% of the patients, even with multiple attempts.

The **Combitube** can secure the airway without manipulation of the cervical spine. The technique can be quickly learned, especially by personnel inexperienced in endotracheal intubation.

Obstruction of the side openings by mucosa can hamper or prevent ventilation. Another limitation is the material used: Because the cuffs contain latex, the **Combitube** cannot be used in patients with a latex allergy. Relative contraindications exist in patients with intact bite or swallowing reflexes. The tube should not be used without laryngoscopic visual guidance in patients with diseases of the esophagus or after the ingestion of caustic substances.
The EasyTube (EzT) was developed for in-hospital and prehospital use in all patients with an anticipated or unanticipated difficult airway. It permits the oxygenation and ventilation of patients who are trapped in wreckage or difficult to reach. It is also recommended in cases where direct laryngoscopy is difficult or impossible due to bleeding or vomiting.

The EzT is a single-use device that combines the basic features of an endotracheal tube with those of a supraglottic airway device. It is available in two sizes, 28 and 41 Ch, and can be used in patients at least 90 cm in height. The principle of the EzT is analogous to that of the Combitube: It is a double-lumen tube that can provide ventilation when placed in either the trachea or the esophagus. The large proximal cuff seals the oropharyngeal and nasopharyngeal airways. The single distal lumen of the tube is equivalent to a standard endotracheal tube with an inner diameter of 7.5 mm (41 Ch) or 5.0 mm (28 Ch) (Fig. 62).

Compared with the Combitube, the esophageal and tracheal lumens of the EzT are shaped much like an endotracheal tube. Even when the distal tip of the tube is positioned in the esophagus, the trachea is still accessible through the second lumen (Fig. 63). The EzT allows the passage of a flexible endoscope into the trachea, permitting an exchange for a definitive endotracheal tube.

After primary direct laryngoscopy and tracheal placement (Fig. 64), the patient is ventilated through the clear-colored lumen. If direct laryngoscopy and endotracheal intubation are not possible, the tip of the EzT can be placed in the esophagus blindly or under visual control with a laryngoscope. In this case the patient can be ventilated through the shorter, blue-colored lumen.

In a study comparing the EzT with direct laryngoscopy in anesthetized patients, the EzT could be placed faster and more easily. The initial placement attempt was successful in 95% of the patients. With both the EzT and endotracheal tube, airway leak occurred at a ventilation pressure of 35 cm H2O. When used in prehospital settings, the EzT achieved a high success rate in the ventilation of difficult airways. In a clinical comparison with the laryngeal tube and LMA ProSeal® laryngeal mask, the EzT was successfully placed on the first attempt in 41% of cases (versus 82% for the laryngeal tube and 68% for the LMA ProSeal®). The EzT had a reported cuff pressure of 320 to 350 mm H2O when inflated with 70–90 mL of air. Cuff leak occurred at ventilation pressures of 18–22 mm H2O in this study.

As with the Combitube, relative contraindications exist in patients with intact bite or swallowing reflexes. Laryngoscopic placement under vision is particularly indicated in patients with diseases of the esophagus or after the ingestion of caustic substances. Due to its rigid construction, upper airway trauma cannot be ruled out during use of the device.
Laryngeal Tube

The laryngeal tube (LT) consists of a single-lumen tube with a larger oropharyngeal cuff and smaller esophageal cuff (Fig. 65). The proximal end of the tube is fitted with a color-coded standard connector. The color of the connector depends on the size of the LT. The distal esophageal end is closed and fitted with a low-pressure cuff. The oropharyngeal cuff seals off the upper airways, allowing respiratory air to flow through the anterior opening toward the blade. Both cuffs are inflated simultaneously with a large syringe after placement. Color markings on the inflation syringe match the color of the LT connector so that even in an emergency, the cuff can be quickly inflated with an air volume appropriate for the size in use (Fig. 66). The reusable LT is made of silicone, and the disposable version is made of polyvinylchloride.

It is recommended that the patient’s head be placed in a modified Jackson position for successful placement of the laryngeal tube. The cuff of the LT should be completely deflated and well lubricated. The mouth is opened, the head is tilted back, and the laryngeal tube is inserted in the midline along the hard palate and into the pharynx until a slight resistance is felt. The middle black line on the tube should be between the upper and lower teeth (Fig. 67). Correct placement is verified by end-tidal CO₂ detection and lung auscultation. The cuff pressure should not exceed a value of 60 cm H₂O.

The LT can be placed with a high initial success rate of 97–100%. Ease of placement is similar to that of a laryngeal mask. The airway leak pressure of the LT is reported to be 2 cm H₂O higher than that of a classic laryngeal mask (laryngeal mask: 18–20 cm H₂O, LT: 20–22 cm H₂O). This difference is probably not relevant in clinical use, however. In a comparative study the LT was placed on the first attempt as successfully as the LMA ProSeal®, although five patients could not be successfully ventilated with the LT. Both devices produced a comparable airway seal. The placement of the LT had to be repeatedly adjusted and optimized, however. The LMA ProSeal® achieved a higher tidal volume than the LT at equal ventilation pressures. In another comparative study, the LT could not be optimally placed in two patients. Again, both devices were found to have comparable airway leak pressures (24 cm H₂O for the LT, 26.5 cm H₂O for the ProSeal®).

Compared with the classic laryngeal mask airway, the LT protects better against aspiration owing to its distal esophageal cuff. To date, no instances of aspiration have been reported during routine use of the LT.

As with the laryngeal mask, an intubation catheter can be passed through the ventilation lumen of the LT under fiberoptic guidance, and an endotracheal tube can be advanced over the catheter into the trachea. The LT permits oxygenation and ventilation in patients with previous failed attempts at endotracheal intubation. The LT was used with a high success rate (97%) after failed prehospital endotracheal intubation. The authors conclude that the LT provides a reliable rescue device when intubation has failed. The LT can also be used as an initial airway in emergency settings by rescuers less experienced with endotracheal intubation.
The LT also provides an alternative to face-mask ventilation. Paramedics working in cardiac arrest situations could successfully insert the LT on the first attempt in 90% of all cases. Ventilation could be performed in 95% of the resuscitations. In another study, ventilation was performed exclusively with an LT during cardiopulmonary resuscitation by rescuers instead of bag-and-mask ventilation. It was found that effective ventilation could be provided after successful placement.

One disadvantage of the LT is the inability to drain the stomach through a gastric tube. Also, a mouth opening of approximately 2.3 cm is required to introduce the shaft into the oral cavity. The cuffs are both large and thin-walled and may tear on sharp teeth, for example, during placement. Relative contraindications to use of the LT exist in patients with intact bite or swallowing reflexes.

**Laryngeal Tube Suction (LTS)**

The LTS is an advanced version of the LT. It has a second lumen that allows for decompression of the esophagus in case of regurgitation and provides access for inserting a gastric tube. The esophageal drainage tube additionally reduces the risk of aspiration.

The LTS has been used repeatedly and successfully in critically ill patients, seriously injured patients, and in the of cardiopulmonary resuscitation.

**Flexible Endoscopic Intubation**

Flexible endoscopy is a widely used technique for endotracheal intubation in both unanticipated and anticipated difficult airways. In a classic flexible endoscope (also called a “fiberscope”), optical fiber bundles extend to the eyepiece for image transmission and toward the distal end for light transmission, accompanied by deflection control elements. Recent developments include endoscopes that employ CMOS (complementary metal oxide semiconductor) sensor technology for imaging, so that the terms “fiberoptic” and “fiberoptic intubation” are no longer applicable to these endoscopes.

Nevertheless, the terms “flexible endoscopic intubation” and “fiberoptic intubation” still refer to the same technology and can be used interchangeably.

Few contraindications exist to flexible endoscopic intubation. They include all airway strictures and stenoses that cannot be crossed with the endoscope and endotracheal tube. Also, vision may be obscured due to blood or secretions. When active bleeding is present, key landmarks generally cannot be identified, resulting in a failed intubation.

In principle, intubation with a flexible endoscope can be performed by either the nasal or oral route. Nasal intubation is technically easier because usually the epiglottis and glottis are more easily visualized after the scope passes through the nasopharynx. The flexible endoscope can be used through either access route (oral or nasal) in the awake or anesthetized patient.
Flexible Endoscopic Intubation in the Awake Patient

Flexible endoscopic intubation of the awake patient is the procedure of first choice for an anticipated difficult airway. Spontaneous breathing is preserved, allowing the patient to remain oxygenated until the endotracheal tube is placed.

The procedure is explained to the patient, and informed consent is obtained. A cooperative patient during intubation is a key factor in completing a successful procedure. Initial topical anesthesia of the airways is indicated to blunt protective reflexes (coughing, gagging) and make the procedure more comfortable for the patient.

The success of this procedure depends greatly on the preparation of the patient and the necessary materials. In contrast to laryngoscopy, accurate positioning of the patient is not strictly necessary, although the upper body of an ICU patient should be elevated to support spontaneous breathing.

The first procedural step in awake nasotracheal intubation is to place nose drops into both nostrils (Table 10). Nose drops containing a local anesthetic (e.g., lidocaine 3%) plus a vasoconstrictor (e.g., phenylephrine 0.25%) can desensitize the nasal mucosa and also prevent bleeding during intubation (Fig. 70). The operator should wait approximately 2–5 minutes for the agents to take effect before introducing the endoscope.

Oxygenation during Flexible Endoscopic Intubation

Immediately after the nose drops are administered, oxygen should be insufflated via nasal cannula (approximately 4 L/min) (Fig. 71). With an ICU patient who is hypoxic or at risk for hypoxia, noninvasive ventilation can also be performed during flexible endoscopic intubation.

Table 10 Basic protocol for awake endoscopic intubation.

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
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<tbody>
<tr>
<td>1.</td>
<td>Secure informed consent</td>
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<tr>
<td>2.</td>
<td>Administer nose drops containing a vasoconstrictor and local anesthetic (wait 5 minutes!)</td>
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<tr>
<td>3.</td>
<td>Oxygen administration</td>
</tr>
<tr>
<td>4.</td>
<td>Conscious sedation (e.g., remifentanil at 0.1–0.5 μg/kg/min)</td>
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<tr>
<td>5.</td>
<td>Visualize the glottic plane and apply local anesthetic to the glottis; wait for onset of anesthesia</td>
</tr>
<tr>
<td>6.</td>
<td>Insert the endoscope into the trachea and apply local anesthetic. Retract above the glottic plane, wait for onset of anesthesia</td>
</tr>
<tr>
<td>7.</td>
<td>Reinsert the intubation endoscope into the trachea, and advance the endotracheal tube over the endoscope</td>
</tr>
<tr>
<td>8.</td>
<td>Proceed with general anesthesia</td>
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</table>
A snug-fitting CPAP mask or ventilation mask can be used with a Mainz adapter placed between the mask and ventilation hose (Fig. 72). This adapter allows continuous oxygenation and ventilation to be maintained during endoscopic intubation. The mask can be secured to the face and head with flexible straps (Fig. 72, 9).

Another option is to use an endoscopy face mask (Fig. 73), although this type of mask is difficult to secure to the patient’s head. When an endoscopy mask is used, an assistant should be delegated to hold the mask in place on the patient’s face.

Intubating the patient through a face mask requires a user experienced in endoscopic intubation. The advantage is the ability to ventilate the patient on as much as 100% oxygen during the procedure. Another option is to provide noninvasive positive-pressure ventilation (NPPV) during intubation. Ventilatory parameters of CPAP 4 cm H₂O, PSV 17 cm H₂O, and FiO₂ 1.0 during bronchoscopy in NPPV-ventilated patients have been described as adequate parameters.

**Patient Sedation**

Generally sedation should enable the patient to tolerate the procedure well while still allowing spontaneous breathing. Low doses are sufficient in hypoxic, critically ill patients. Short-acting benzodiazepines (e.g., midazolam 0.03–0.05 mg/kg) combined with opioids (e.g., fentanyl 1–1.5 μg/kg) have been successfully used for sedation, anxiolysis, and analgesia. The use of an opioid also has the side effect of suppressing airway reflexes during endoscopic intubation. Remifentanil administered by infusion pump has also been successfully used for sedation and analgesia during awake endoscopic intubation (0.1–0.5 μg/kg/min). The use of remifentanil was characterized by good patient tolerance with high hemodynamic stability. Ketamine (0.2–0.5 μg/kg) may also be administered instead of an opioid. Ketamine combined with midazolam permits adequate spontaneous breathing without circulatory depression while providing good analgesia and sedation.
Flexible Nasotracheal Endoscopic Intubation

The lens should always be pretreated with an anti-fogging agent before the endoscope is used (Fig. 74). We also recommend applying a lubricant (e.g., silicone oil) to the endoscope shaft (Fig. 75). This is necessary so that the endotracheal tube can be easily advanced over the endoscope shaft following successful placement of the endoscope. Before the endoscope is inserted into the nose, an endotracheal tube with its cuff deflated is loaded onto the endoscope shaft and secured (Fig. 76). Spiral-wound tubes have proven excellent for endoscopic intubation owing to their flexibility, atraumatic tip, and kink resistance in routine anesthesiologic use. The inner diameter of the endotracheal tube should be at least 1.5 mm larger than the outer diameter of the flexible endoscope. At the same time, the inner diameter should not be too large relative to the selected flexible endoscope, as this could lead to problems during tube placement.

Nose drops can be administered for initial topical anesthesia of the nasal mucosa, and the pharynx can be anesthetized with lidocaine spray (Fig. 77). Before the endoscope is inserted, both nostrils are inspected and the larger opening is used for intubation (Fig. 78). As the endoscope is passed into the nostril, the inferior meatus is identified as it will be the route for endoscope insertion (Fig. 79).
The endoscope should never be advanced blindly as this could cause airway bleeding and injuries. A key to successful intubation is the identification of landmarks on the way to the trachea (Table 11). If orientation is lost, the endoscope should be slowly retracted until an anatomic landmark can be positively identified. After the scope has passed through the choana and nasopharynx, the epiglottis is identified as the first key anatomic landmark (3). The tip of the endoscope is now positioned just outside the glottis (landmark) (4). It may be helpful at this point to ask the patient to protrude the tongue and inhale deeply. This maneuver mobilizes the base of the tongue from the posterior pharyngeal wall and often improves visualization of the vocal cords.
The next step is topical anesthesia of the vocal cords: 2 mL of lidocaine 2% is applied to the glottis through the working channel of the flexible endoscope (Fig. 80). We recommend preparing 2 mL of lidocaine 2% with 3 mL of air in a 5-mL syringe. The air in the syringe will push all of the lidocaine solution through the working channel. Two minutes are allowed for the anesthetic to act, then the tip of the endoscope is advanced through the glottis and into the trachea (next landmark). The tracheal lumen is easily identified and distinguished from the esophagus by the presence of tracheal rings (Table 11, 3). Next, a second dose of lidocaine 2% (2 mL, same as for the glottis) is injected through the working channel. Then the tip of the endoscope is pulled back past the glottic plane, and another 2 minutes are allowed for the anesthetic to numb the tracheal mucosa. Now the endoscope is readvanced through the glottis into the trachea and the final landmark, the tracheal bifurcation, is identified (Table 11, 3). The endotracheal tube is then carefully advanced through the nostril, which should be well lubricated. A constant endoscopic view of the bifurcation should be maintained during advancement of the tube. It may be difficult to pass the tube through the glottis. Occasionally the tip of the tube becomes snagged at the level of the arytenoid cartilage. If this occurs it is often helpful to retract the tube slightly, rotate it 90° clockwise, and readvance it over the endoscope126, 127.

With adequate analgesia and sedation, it is usually possible to pass the tube through the nose and into the trachea without difficulty and then proceed with the induction of general anesthesia.

In the final step, the distance from the carina to the tip of the endotracheal tube is measured for an accurate assessment of tube position. Final positioning is done by advancing the endoscope tip to the carina and using two fingers to mark the insertion depth on the instrument shaft (Fig. 81, 3). The instrument is then retracted until the tip of the tube appears in the endoscopic field (Fig. 81, 4). The distance from the carina to the tube tip should be 3–5 cm.

Flexible Orotracheal Endoscopic Intubation

Endoscopic intubation by the oral route is similar to nasotracheal intubation. Initial topical anesthesia of the mucosa can be done with nose drops and by numbing the pharynx with a 4% lidocaine spray (see Fig. 77).

Orotracheal intubation is technically more difficult because the tip of the intubation endoscope must negotiate a 90° angle in the pharynx on its way to the glottis, and the insertion is not guided by a natural anatomic channel as in the nasal approach. A bite block must be used to protect the instrument in case the patient bites down during the intubation (Fig. 82). Also, it is often difficult to visualize the epiglottis in the transoral approach.
It is helpful to have the patient protrude the tongue or apply manual traction to the tongue in order to lift the tongue base from the posterior pharyngeal wall and expose the pharyngeal space. Another option is to place a guide tube to help direct the endoscope through the mouth (Fig. 83).

**Flexible Endoscopic Intubation in the Anesthetized Patient**

Endoscopic intubation of an anesthetized patient requires the presence and help of a second physician experienced in the technique to monitor the patient, render assistance, and ventilate the patient if necessary.

Both nasotracheal and orotracheal endoscopic intubation can be performed in the anesthetized patient. Although topical anesthesia of the mucosa is not strictly necessary in the transnasal approach, it is still a good idea to administer nose drops with a vasoconstrictor in order to prevent bleeding.

Because general anesthesia relaxes muscle tone in the upper airways, the epiglottis often cannot be visualized through the collapsed pharyngeal space. Endoscopic intubation can be performed through an endoscopic face mask or through a ventilation mask fitted with a Mainz universal adapter (Fig. 84) to maintain ventilation and oxygenation during the procedure. Often it is helpful to have an assistant perform an Eschmach maneuver to lift the tongue base away from the posterior pharyngeal wall so that anatomic landmarks can be identified.

Pharyngeal adjuncts such as the Optosafe® tube (Fig. 83) can help to keep the pharyngeal space open while guiding the orotracheal intubation.

**Flexible Endoscopic Intubation of an Unanticipated Difficult Airway**

In many airway algorithms, flexible fiberoptic or endoscopic intubation is presented as an airway management option after failed laryngoscopy. An experienced user can perform orotracheal intubation more rapidly than nasotracheal intubation.

It is important to remember that oxygenation generally takes precedence over endotracheal intubation. Thus, flexible endoscopic intubation after failed laryngoscopy should be performed through a ventilation mask fitted with a Mainz universal adapter (Fig. 84) or through an endoscopy face mask to secure ventilation and oxygenation.
Flexible Endoscopic Intubation Through the Laryngeal Mask

When unexpected difficulties arise during airway management, it is often helpful to place a laryngeal mask or ILMA to secure oxygenation and ventilation (see Supraglottic Airway Devices). With the aid of a Mainz adapter, a tube can be placed endoscopically in the trachea while ventilation is continued. This endoscopic placement of the tube has a higher success rate than a blind technique.\textsuperscript{128–130} The set for the LMA Fastrach device includes a spiral-wound tube that is excellent for endoscopic placement. The connector on the spiral tube can be easily removed after successful intubation to facilitate removal of the laryngeal mask (Fig. 85).

During insertion of the flexible endoscope, the epiglottic elevating bar of the ILMA may hamper advancement of the endoscope tip into the trachea. This can be resolved by passing the endoscope to one side of the obstacle, then advancing it into the trachea. Another option is to pass an endotracheal tube over the endoscope as far as the epiglottic bar, then elevate the bar with the tube so that it no longer blocks the endoscope.

An intubation endoscope can also be passed into the trachea through a classic laryngeal mask, although problems may result from the relatively long, narrow shaft and the tight airway connector of most laryngeal masks. Given these restrictions, often only a relatively small endotracheal tube can be passed through a classic laryngeal mask. Often the laryngeal mask cannot be safely removed when the proximal end of the endotracheal tube is just above the connector and the distal end of the tube is just below the glottis. This problem can be solved by first passing an intubation rod (e.g., Aintree\textsuperscript{\textregistered} catheter) into the trachea endoscopically (see Fig. 55). Once inside the trachea, the long catheter will enable the laryngeal mask to be removed without difficulty. An endotracheal tube can then be introduced over the catheter and its placement confirmed by flexible endoscopy.
Flexible Endoscopically Assisted Percutaneous Dilatational Tracheotomy

The number of percutaneous dilatational tracheotomies (PDTs) has increased markedly in recent years. The visual monitoring of PDT using fiberoptics or a flexible intubation endoscope can prevent life-threatening complications during the procedure.

A video monitor provides optimum guidance for a PDT. It not only guides the procedure itself but also permits the whole team to follow the procedure and give assistance where needed (Fig. 86). The endoscope is passed into the endotracheal tube through a Mainz adapter, for example. The trachea is then inspected and any secretions are suctioned as required. The tracheal cartilage rings should be clearly visible (Fig. 87).

The carina is visualized by bronchoscopy, and the tip of the endoscope is positioned level with the tip of the endotracheal tube, which should project approximately 0.5 cm past the endoscope tip. The edge of the tube should be visible but should not restrict the field of view (Fig. 88).

Now the tube is retracted under bronchoscopic vision to a level just above the glottic plane. The tube can also be slowly retracted under video laryngoscopic guidance. This technique is advantageous in that it reduces the risk of accidental extubation because the tube tip and cuff remain below the glottis (Fig. 89).

After key landmarks have been identified on the anterior side of the neck, the proposed puncture site is transilluminated (Fig. 90). Ideally the puncture site is located between the second and fourth tracheal cartilages. Large blood vessels in the anterior neck can also be located by transillumination.

To prevent bleeding from small cutaneous vessels, a local anesthetic with a vasoconstrictor (e.g., prilocaine 1% plus epinephrine) is injected in the area of the proposed puncture site, which has been marked on the skin.

Next the introducer needle is passed into the trachea under endoscopic control (Fig. 91). The operator can check the...
position of the puncture site by viewing the monitor. For this step the endoscope should be retracted into the endotracheal tube to avoid accidental puncture of the endoscope shaft. Ideally the trachea is punctured in the midline between the 10 and 2 o’clock positions (Fig. 92). If strong resistance is felt as the needle enters the trachea, the puncture site should be checked as this usually means that the needle has struck the endotracheal tube. In the next step, a 1.5- to 2-cm-long skin incision is made at the marked position. The skin tract is then bluntly dissected and predilated with a nasal speculum or Griggs dilating forceps. Next a Seldinger wire is introduced and advanced toward the carina.

Depending on the system, the next step is dilation of the puncture site. The single-dilator technique will be described here as an example. After dilating the tract with a small dilator, a guide catheter is passed into the trachea over the Seldinger wire under endoscopic control (Fig. 93).

This is followed by single-step dilation of the tract with a Blue Rhino® tapered dilator (Fig. 94). This process should be monitored bronchoscopically so that any injuries or excessive compression of the trachea can be promptly recognized and the procedure modified as needed.

After dilation is completed, the tracheostomy tube is introduced into the trachea over the guide catheter under endoscopic vision and the cuff is inflated (Fig. 95). The flexible endoscope is now passed into the trachea through the tracheostomy tube to verify correct endotracheal placement of the tube. It is important to identify the carina so that the tip of the tracheostomy tube can be positioned 3–5 cm above the carina under endoscopic control. Attention should also be given to possible intraluminal bleeding sites.
Endoscopic control offers a number of advantages over blind PDT:

- It provides guidance for the endotracheal tube. If accidental extubation occurs, the tube is easily reinserted into the trachea over the endotracheal endoscope.
- Transillumination can reduce the risk of injury to large blood vessels.
- Visual control of the puncture site within the trachea allows for midline placement of the tracheostomy tube and virtually eliminates the possibility of paramedian placement.
- Dilation is performed under visual control.
- Correct position of the tracheostomy tube can be confirmed after placement.

A meta-analysis found that the complication rate of PDT without endoscopy was 16.8%, compared with a rate of 8.3% when endoscopic control was used.132

The greatest risks associated with endoscopically controlled PDT are hypoxia and hypercapnia. A fall in oxygen saturation during dilatational tracheotomy has a reported incidence of 3%.132 Hypoventilation, hypercapnia, and respiratory acidosis with hemodynamic deterioration have been described as a result of continuous bronchoscopy during PDT with the Ciaglia kit.133, 134 In this study a bronchoscope with a 5.8-mm outer diameter was used in an endotracheal tube with an 8.0-mm inner diameter.

When flexible endoscopes are introduced through the endotracheal tube, vision may be significantly obscured due to secretions. There is also a risk of inadvertent puncture of the endotracheal tube cuff, which would jeopardize oxygenation and ventilation.

The placement of a laryngeal mask for PDT is a possible alternative to an endotracheal tube. A randomized study found that the use of a laryngeal mask was associated with a 33% incidence of complications (inadequate ventilation, loss of airway) versus 9.9% with an endotracheal tube. One limitation of this study is that the male and female laryngeal mask sizes were too small. Contrary to these results, another study found that the use of a laryngeal mask for PDT was associated with a lower incidence of hypercapnia (38.5%) than the use of an endotracheal tube (56.7%). In summary, we may conclude that the use of a LMA can significantly improve ventilation and can positively affect the visualization of anatomic structures in the trachea. On the other hand, the user of the LMA must be thoroughly familiar and proficient with the device in routine clinical use. Data available at present appear insufficient to justify a general recommendation or rejection of this technique.64

Invasive Airway Access in Patients with Failed Oxygenation or Patients with Failed Oxygenation and Ventilation

Invasive airway access is an emergency procedure and a last-resort option for rescuing a patient from severe hypoxia and death. It generally consists of a cricothyrotomy and is performed whenever oxygenation and ventilation cannot be established by other available means such as mask ventilation, supraglottic airway placement, or video laryngoscopy ("cannot intubate-cannot ventilate").

The classic procedure in adults is a surgical cricothyrotomy. Since complications are more frequent with an emergency tracheotomy, a cricothyrotomy is always preferred in emergencies. Often the key anatomic landmarks for a cricothyrotomy can be reliably identified.

The cricothyroid membrane is the most superficial part of the airway and is located between the laryngeal prominence and cricoid cartilage (Fig. 96). Typically the membrane is 2.2–3.3 cm wide and 0.9–1 cm high. The principal vessel at this level is the superior thyroid artery, which often runs at the lateral edge of the membrane.
A cricothyrotomy may be necessary in the following typical situations:

- Massive swelling of the hypopharynx or oropharynx (e.g., hereditary angioedema following the use of ACE inhibitors).
- Very severe allergic reactions involving the supraglottic airways.
- Very severe burns or caustic injuries of the face and airways.
- Large tumors or inflammatory masses in the upper airways.

A cricothyrotomy can be performed by one of two principal methods: surgical dissection or needle techniques. Regardless of the method used, extension of the neck will make it easier to perform the cricothyrotomy. It may also be helpful to place a pad beneath the shoulders (e.g., a bed pillow) to support and maintain the extended head position during the procedure (Fig. 97).

An emergency cricothyrotomy should be converted within hours to a surgical tracheotomy, or an orotracheal or nasotracheal airway should be established to prevent serious late sequelae such as tracheal stenosis.

**Surgical Airway**

The operator palpates the larynx and immobilizes it with one hand after locating the thyroid and cricoid cartilages. A longitudinal skin incision is made in the midline, starting over the middle of the thyroid cartilage and ending over the cricoid cartilage (Fig. 98). The larynx and cricothyroid ligament in obese patients can be felt with the scalpel by noting a loss of tissue resistance.

Next the subcutaneous fatty tissue is bluntly spread open with a dissecting scissors or nasal speculum (Fig. 99). A transverse incision is made in the cricothyroid membrane, and that incision is spread open with a nasal or Killian speculum. Next an endotracheal tube with stylet (inside tube diameter = 5.0–6.0 mm) is passed into the trachea. This is easiest when the stylet protrudes slightly past the end of the tube. The nasal speculum is slowly withdrawn during tube insertion to make more room for advancing the tube.

Following successful insertion into the trachea, the cuff of the tube is inflated, the stylet is removed, and correct tube placement is verified by end-tidal CO₂ detection and auscultation.

Potential complications include bleeding and injury to laryngeal structures. Failed attempts at tube placement most commonly result from inadequate surgical access.
**Needle Cricothyrotomy**

Various systems are available for performing a needle cricothyrotomy. They are based either on the Seldinger technique (e.g., Melker Universal Emergency Cricothyrotomy Catheter Set, Cook Medical, Fig. 100) or a one-step dilatation principle (e.g., Portex® Crico Kit, Smiths Medical, Fig. 101; QuickTrach® set, VBM Medical, Fig. 102) 137, 139.

In the Seldinger technique (Melker®), a longitudinal skin incision is made with a scalpel over the cricothyroid membrane, analogous to the surgical airway approach. The skin incision should be approximately 1.5–2 cm long. Next a catheter-over-needle unit with a syringe attached is passed into the trachea while continuous aspiration is applied with the syringe. Ideally the syringe should contain some sterile saline solution: air bubbles rising in the syringe will denote passage into the trachea. After the assembly has been placed, the needle and syringe are removed, leaving the catheter in place. Now a guidewire is advanced down the catheter toward the tracheal bifurcation. The Teflon catheter is removed, and a tracheal tube loaded onto a dilator is passed over the Seldinger wire into the trachea. The Seldinger wire and dilator are withdrawn, and the cuff of the tracheal tube is inflated. This is followed by ventilation with verification of placement by end-tidal CO₂ detection and auscultation.

For one-step dilatation with the Portex Crico Kit (PCK®), the skin is incised and the cricothyroid membrane is punctured with an integral needle/dilator/tracheal tube assembly based on the principle of the Veress needle. As the needle is inserted, the tissue resistance pushes a guide sleeve away from the needle, allowing the sharp steel needle to penetrate the tissue. Entry into the trachea is confirmed by a red indicator ring in the needle hub. The device is advanced until loss of needle resistance occurs and the red indicator ring disappears. The set is now angled approximately 35° caudally and advanced toward the bifurcation. When it reaches the posterior tracheal wall, the increased resistance causes the red indicator ring to reappear. The puncture needle and dilator are now removed, and the tube is advanced into the trachea. The cuff is inflated, ventilation is initiated, and correct placement is verified.

The QuickTrach® set embodies another technique for a one-step dilatational cricothyrotomy (Fig. 102). The cricothyroid membrane is identified by palpation, a small skin incision is made, and the needle with attached syringe is passed into the trachea. A stopper on the puncture needle limits the insertion depth to prevent injury to the posterior tracheal wall and esophagus. After air is aspirated with the attached syringe, the stopper is removed and the tracheal tube is advanced over the puncture needle into the trachea. The cuff is inflated, ventilation is initiated, and correct tube placement is verified (auscultation, capnometry).
Transtracheal Jet Ventilation (TJV)

Another, less invasive method for temporary emergency oxygenation is transtracheal jet ventilation. TJV is considered a temporizing procedure for emergency oxygenation; it cannot provide ventilation. The cricothyroid membrane can be punctured with a special needle (e.g., Ravussin) or with a standard large-bore i.v. catheter (e.g., 14 G) (Fig. 103). After the membrane is identified, the trachea is punctured while continuous aspiration is placed on an attached syringe containing some sterile saline solution. When air bubbles in the syringe confirm entry into the trachea, the syringe and needle are withdrawn and the Teflon catheter is advanced toward the bifurcation. In an emergency, oxygen can be quickly insufflated through the catheter with a simple setup: a high-flow three-way stopcock with 2.5- to 3-mm apertures connected to the catheter hub and an oxygen source. With an oxygen flow rate of 15 L/min, the open port of the stopcock can be intermittently occluded to provide oxygenation and minimal ventilation (Fig. 104).140, 141.

The Manujet III (VBM Medical) is a technically streamlined, manually controllable device for transtracheal jet ventilation (Fig. 105). Ventilation is performed through a supplied Ravussin catheter with extra side openings at the tip to ensure oxygen delivery with the tube in place. The device is connected to a pressurized oxygen source via an ISO adapter. A control knob can set the ventilation pressure to any desired value from 0 to 50 psi, which is indicated on a color-coded pressure gauge. Jet ventilation should always be started at a low ventilation pressure, which is then adjusted to obtain the desired ventilation effect.

When this procedure is used, it must be certain that the expired air can be safely vented through the upper airways to reduce the risk of barotrauma. This limits the use of this technique in patients with large tumors or massive swelling of the upper airways.
**Evaluation of Various Invasive Airway Techniques**

Only a few controlled comparative studies have been done on different techniques of invasive airway management. This is probably due to the fact that most of these procedures are used only in extreme emergency situations. Available studies have been done mostly in animals or cadavers. It is difficult, therefore, to evaluate and compare the relative utility of specific techniques. In a recent study, needle cricothyotomy and surgical cricothyotomy were compared with each other in a porcine larynx model\textsuperscript{142}. The highest success rate was achieved by needle cricothyotomy using the Seldinger technique (100% with the Melker® device), followed by surgical cricothyotomy and the QuickTrach\textsuperscript{®} set (95% each). The Portex Crico Kit\textsuperscript{®} (PCK\textsuperscript{®}) achieved a success rate of 60%. Insertion was fastest with the QuickTrach\textsuperscript{®} (52 s) and surgical approach (59 s) (Melker\textsuperscript{®} set: 94 s, PCK\textsuperscript{®}: 180 s). Another, smaller study compared surgical cricothyrotomy with the Melker\textsuperscript{®} and PCK\textsuperscript{®} sets in a porcine model\textsuperscript{143}. The Melker\textsuperscript{®} set could be correctly placed in all attempts. The surgical technique (55%) and PCK\textsuperscript{®} (30%) were less successful. The different techniques were the same in time to completion (47–63 s). A study in cadavers compared a Seldinger system with surgical cricothyrotomy and found that ventilation was established faster with the Seldinger system with an equally high success rate (88% versus 84%)\textsuperscript{144}. The surgical approach was associated with more frequent injuries, however.

As for transtracheal jet ventilation, the Manujet system (VBM Medical) was tested in a simulated airway without a proximal constriction and delivered a minute volume (MV) of 3.4 L/min using a cannula size of 14 G\textsuperscript{145}. Adequate ventilation was not achieved via a three-way stopcock or with a ventilation bag attached to the cannula. In the presence of a proximal constriction above the puncture site, an MV of 12.5 L/min was achieved with the Manujet and 5.3 L/min with the three-way stopcock. This was another scenario in which a ventilation bag was unable to supply adequate ventilation.

The following three-step process is recommended for learning an invasive airway management technique:

1. Identify a preferred method of invasive airway management
2. Practice the method yearly on an airway simulator.
3. If possible, practice the preferred method on cadavers (with consent!).

The goal of algorithms is to guide and support practitioners in specific clinical situations. A statistical analysis found that implementation of the ASA Airway Guidelines was followed by a decline in serious malpractice claims relating to difficult airway management\textsuperscript{148}.

**Table 12** lists possible preparations and techniques of anesthesia induction in critically ill patients based on current recommendations\textsuperscript{23}. The goal of these practice points is to reduce serious complications such as severe hypoxia and cardiovascular instability.

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**Emergency Algorithm for Airway Management in the ICU**

The level of anesthesiologic care available in an operating room is not easily transferred to a critical care setting. A great many international algorithms and guidelines have been developed, but not all of them do reflect the most recent developments in airway management. Moreover, they often fail to address the specific requirements of critical care medicine\textsuperscript{4, 76}.

**Preparations**

- Confer with the ICU team. (Plan who does what and how).
- Two physicians should be present (one should be experienced in endotracheal intubation).
- Careful volume replacement in patients without left-sided heart failure (e.g., 500 mL complete electrolyte solution, 250 mL colloidal solution).
- Preoxxygenate with 100% O\textsubscript{2} for 3–4 min. With existing oxygen deficit: NPPV with pressure support of 5–15 cm H\textsubscript{2}O, CPAP 5 cm H\textsubscript{2}O (target: tidal volume of 6–8 mL/kg).
- Prepare emergency medications (e.g., catecholamines, atropine).

**Anesthesia induction**

(\textit{rapid sequence induction})

- Propofol (1–2 mg/kg) with an opioid (e.g., sufentanil 0.2–0.4 μg/kg) – or – ketanest 1–2 mg/kg. Ketanest is preferred in hemodynamically unstable patients.
- Neuromuscular blockade: succinylcholine 1–1.5 mg/kg (\textit{caution}: side effects) – or – rocuronium 0.9–1.2 mg/kg. Rocuronium is preferred if sugammadex is available.

**After endotracheal intubation**

- Verification of tube placement: capnometry/capnography, bilateral auscultation of the lungs.
- Catecholamines if mean arterial pressure is < 65 mm Hg; e.g., norepinephrine titrated to response.
- Start sedation (e.g., propofol, sufentanil).
- Start lung-protective ventilation: tidal volume 6 mL per kg ideal body weight.

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Table 12 Preparations for intubation and anesthesia induction in critical care medicine (modified from Jaber et al. 2010\textsuperscript{23}).
An emergency algorithm for airway management in the ICU is also helpful for taking appropriate actions in an emergency situation (Fig. 106). The algorithm shown here is based on existing guidelines and also takes into account new airway management devices (video laryngoscopes) and new pharmacologic agents such as sugammadex for the prompt reversal of rocuronium. The algorithm is intended for use only in patients with an unanticipated difficult airway. If signs of a difficult airway are noted before anesthesia induction (see Predictors), the procedure of choice is flexible endoscopic intubation in the awake, spontaneously breathing patient. Flexible endoscopic intubation can even be performed during noninvasive ventilation with a CPAP mask by using the Mainz universal adapter (see Flexible Endoscopic Intubation in the Awake Patient, p. 35).
Mainz Emergency Algorithm for an Unanticipated Difficult Airway

Adequate Mask Ventilation is Possible

The Mainz Emergency Algorithm starts with mask ventilation because bag-and-mask ventilation is always the first fallback option when problems arise during endotracheal intubation. Even with rapid sequence induction, mask ventilation should always be used for oxygenation if initial endotracheal intubation fails, despite the increased aspiration risk.

If adequate mask ventilation is possible (left side of the algorithm), there is not an immediate threat of hypoxia. There is sufficient time to improve the intubation conditions (e.g., position the head) and, if not already done, place a video laryngoscope for endotracheal intubation. If multiple intubation attempts have failed, it is time to call in a physician experienced in endotracheal intubation. It is important to limit the number of intubation attempts (no more than three) because the risk of severe, life-threatening complications increases with the number of intubation attempts. If laryngoscopic intubation is not successful, it should be asked whether adequate mask ventilation is still possible. If the answer is yes, alternative intubation devices should be tried (Fig. 106). The instruments and devices of first choice are always those with which personnel have had the most clinical experience and are available on the airway cart of the ICU. At this point in the algorithm it must be decided whether endotracheal intubation with an intubation endoscope or a video laryngoscope with an alternative blade is a suitable option. If intubation cannot be achieved with these methods, a supraglottic airway device should be inserted. Afterward an endotracheal tube can be placed through the laryngeal mask with a flexible intubation endoscope, for example (see Flexible Endoscopic Intubation Through the Laryngeal Mask, p. 41). If an airway still cannot be secured at this time, it should be decided whether it is feasible to return the patient to spontaneous breathing and discontinue general anesthesia. Endoscopic intubation, for example, can be reattempted at a later time in the awake, spontaneously breathing patient.

If you reach a point at which oxygenation and ventilation are no longer possible, go to the right side of the algorithm (Fig. 106).

Adequate Mask Ventilation is Not Possible

If the patient cannot be adequately ventilated and oxygenated with a face mask at any time during airway management, a life-threatening emergency exists. Help from an experienced airway manager should be summoned without delay. If endotracheal intubation and mask ventilation are both unsuccessful, a “cannot intubate – cannot ventilate” situation exists. It should be determined whether a return to spontaneous breathing is an option for oxygenation (see Neuromuscular Blockade, p. 16). If the answer is no, only one more intubation attempt should be made to achieve oxygenation and ventilation at this time (Fig. 106). Often the patient is already severely hypoxic at this stage (Fig. 107), so you should turn to the device that is most familiar and offers the best chance of achieving oxygenation. Given the acute life-threatening situation, the placement of an endotracheal tube is no longer a main priority. The only goal at this point is to oxygenate the patient with a supraglottic or alternative device (Fig. 106). If this is successful, the next step is to establish a definitive airway (e.g., a tracheostomy) with expert help. If oxygenation cannot be accomplished with a supraglottic or alternative device, the patient is at an acute risk of death without further action. This situation is marked clinically by severe hypoxia (Fig. 108) and often by initial signs of cardiovascular decompensation. The only remaining option is invasive airway management by cricothyrotomy (see Invasive Airway Access in Patients with Failed Oxygenation and Ventilation, p. 44).
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- Handling oriented towards hygiene
- Reprocessing of the imager: suitable and validated for the following low-temperature reprocessing methods up to bis max. 60 °C: manual/machine cleaning and disinfection, sterilization with E1O gas; High-Level Disinfection (HLD) acc. to US standards
- Compatible with C-MAC® monitor
- Blade can be exchanged within seconds

051113-10* BERCI-KAPLAN C-MAC® S Video Laryngoscope MAC #3, with MACINTOSH laryngoscope blade, size 3, for single use, sterile, package of 10, for use with C-MAC® Monitor 8402 ZX and C-MAC® S Imager 8402 XS

051114-10* Same, size 4

mtp medical technical promotion gmbh,
Take-Off GewerbePark 46, D-78579 Neuhausen ob Eck, Germany
C-MAC® S Video Laryngoscope

051116-10

051116-10*

**C-MAC® S Video Laryngoscope D-BLADE,**
with DÖRGES laryngoscope blade, sterile, package of 10, for use with C-MAC® Monitor 8402 ZX and C-MAC® S Imager 8402 XS

8402 XS

**C-MAC® S Imager,** for C-MAC® Monitor 8402 ZX-1, suitable for manual and mechanical disinfection up to 60 °C and High-Level Disinfection (HLD) acc. to US standards, for use with C-MAC® S-Video Laryngoscopes 051113-10, 051114-10 and 051116-10

* mtp medical technical promotion gmbh,
Take-Off GewerbePark 46, D-78579 Neuhausen ob Eck, Germany
C-MAC® PM – The Pocket Monitor

Special Features:
- Exchange of video laryngoscope within seconds
- Compatible with all C-MAC® video laryngoscopes (D-BLADE, MACINTOSH sizes 2-4, MILLER sizes 0 & 1)
- One hour operating time
- Rechargeable Li-ion battery with capacity control and intelligent power management
- High-resolution 2.4" LED display with 240 x 320 pixels for optimal view
- No additional on/off buttons thanks to the “Open-to-Intubate-Display” (OTI)
- Important for preclinical use: classified for protection class IPX8
- Due to the closed design, the entire pocket monitor unit can be fully immersed in disinfection solution which allows for easy and smooth reprocessing
- Suitable and validated for the following low-temperature reprocessing methods up to max. 60 °C: manual/machine cleaning and disinfection
- Additional standard: RTCA/DO-160F

8401 XDK
C-MAC® Pocket Monitor, Set, unit with LCD monitor and power supply for all C-MAC® laryngoscopes, screen size 2.4", monitor movable via two rotation axis, rechargeable Li-Ion batteries, 1 h operation time, 2 h charging time, power management with capacity indicator: switches off automatically after 10 min, protection class IPX8, additional standard: RTCA/DO-160F, validated for up to a max. of 60 °C, manual/mechanical cleaning and disinfection, for use with C-MAC® video laryngoscopes including:
Protection Cap

8401 XDL
Charging Unit, for C-MAC® Pocket Monitor 8401 XD, with fix integrated power supply and adaptor for EU, UK and USA, power supply 110 – 240 VAC, 50/60 Hz, suitable for wipe disinfection
FIVE – Flexible Intubation Video Endoscope for C-MAC®

Special Features:
- Compatible with C-MAC® monitor and C-HUB®
- Compact design
- Ergonomically designed handle
- Lightweight at 385 g
- High image resolution
- Video imaging in 4:3 format
- Possible to exchange components within seconds

- Integrated LED light source
- Suitable and validated for the following low-temperature reprocessing methods up to max. 60 °C: manual/machine cleaning and disinfection, sterilization with Sterrad® (100S, NX, 100NX) and ETO gas; High-Level Disinfection (HLD) acc. to US standards

Flexible Intubation Video Endoscope 5.5 x 65,
CMOS technology, with suction valve, for use with C-MAC® Monitor 8402 ZX and C-HUB® 202901 01
Deflection up/down: 140°/140°
Direction of view: 0°
Angle of view: 85°
Working length: 65 cm
Total length: 93 cm
Working channel inner diameter: 2.3 mm
Distal tip outer diameter: 5.5 mm
Accessories
Flexible Intubation Video Endoscopes

Accessories included in delivery:

- **29100** Plug, for Luer-Lock connector for cleaning, **black**, **autoclavable**, package of 10
- **11301 CD1** Irrigation Adaptor, for machine cleaning, reusable, for Flexible Intubation Video Endoscope 11301 BNX
- **11301 CE1** Suction Valve, for single use, package of 20, for use with Flexible Intubation Video Endoscope 11301 BNX
- **10309** Bronchoscope Insertion Tube, size 4, with integrated mouthpiece, for single use, sterile, insertion length 85 mm, made from EVA, package of 10
- **10310** Bronchoscope Insertion Tube, size 2, with integrated mouthpiece, for single use, sterile, insertion length 65 mm, made from EVA, package of 10
- **11301 CFX** Tube Holder, for use with Flexible Intubation Video Endoscope 11301 BNX
- **27677 FV** Case
- **11025 E** Pressure Compensation Cap, for ventilation during gas sterilization
- **13242 XL** Leakage Tester, with bulb and manometer
- **27651 B** Cleaning Brush, flexible, round, outer diameter 3 mm, for working channel diameter 1.8 – 2.6 mm, length 100 cm
- **8401 YZ** Protection Cap, for the C-MAC® video laryngoscope and electronic module, to protect plug contact during reprocessing, cap is reusable
**Accessories**

**Flexible Intubation Video Endoscopes**

**Optional Accessories:**

- **11001 KL** Biopsy Forceps, flexible, spoon-shaped, round, double action jaws, diameter 1.8 mm, working length 120 cm
- **11002 KS** Grasping Forceps, flexible, alligator jaws, double action jaws, diameter 1.8 mm, working length 120 cm
- **11301 CA** Leaflet Valve, for single use, package of 20
- **11301 CB1** Suction Valve, reusable, for use with Flexible Intubation Video Endoscope 11301 BNX
- **39405 AS** Plastic Container for Flexible Endoscopes, specially suited for gas and hydrogen peroxide (Sterrad®) sterilization and storage, for use with one flexible endoscope, external dimensions (w x d x h): 550 x 260 x 90 mm
- **11301 BM** Adaptor, for leakage test, for Belimed washer-disinfectors
- **11301 FF2** Adaptor for MIELE Cleaning Machines, with safety valve, for automatic leakage test of flexible KARL STORZ endoscopes
- **11301 GG2** Adaptor, for cleaning and disinfecting the irrigation and working channels of flexible endoscopes, for MIELE-ETD washer-disinfectors
- **11301 HH** Adaptor for BHT Cleaning Machines, for automatic leakage test of flexible KARL STORZ endoscopes
- **11301 KK2** Adaptor, for working channel of flexible endoscopes, for MIELE-ETD 03 washer/disinfectors
  
  Please note: Adaptors 11301 FF2 and 11301 GG2 have to be ordered separately!

- **6927691** Adaptor for Two-Way Stopcock, LUER-Lock, with O₂ tube connection
- **600007** LUER-Lock Tube Connector, male, tube diameter 6 mm
Accessories
C-MAC® Video Laryngoscope

8401 YA  **Stand**, for C-MAC® monitor, height 120 cm, rollable with five feet and antistatic castors, crossbar 25 cm x diameter 25 mm, for positioning the monitor, with tray for laryngoscopes, dimensions (w x d x h): 30 x 20 x 10 cm

8401 YAA  **Crossbar**, for Stand 8401 YA, 50 cm x diameter 25 mm, or positioning C-MAC® Monitors 8401 ZX and 8402 ZX with VESA 75 Quick Clip 8401 YCA

8401 YAB  **Same**, 70 cm x diameter 25 mm

8401 YB  **Clamp**, VESA 75 standard, for fixation of C-MAC® monitor to round profile with diameter 20 – 43 mm and square profile with diameter 16 – 27 mm, for use with Monitors 8401 ZX/8402 ZX
Accessories
C-MAC® Video Laryngoscope

8402 YD*  Protective Bag, blue, for C-MAC® system, made of water-resistant and sturdy material, washable, separate compartments for the monitor and two C-MAC® video laryngoscopes with electronic module

8402 YD-1*  Same, red
8402 YD-2*  Same, orange
8402 YD-3*  Same, NATO-olive

809125  MAGILL Forceps, modified by BOEDEKER, length 25 cm, suitable for endoscopic foreign body removal, for use with video laryngoscopes size 2 – 4

NEW 809120  MAGILL Forceps, for children, modified by BOEDEKER, length 20 cm, for use with video laryngoscopes size 1 and 2

39501 LC2  Wire Tray for Cleaning, Sterilization and Storage for two C-MAC® and D-BLADE video laryngoscope blades incl. electronic module, with holder for fixing and sealing electrical connections, external dimensions (w x d x h): 260 x 120 x 170 mm

8401 YZ  Protection Cap, for the C-MAC® video laryngoscope and electronic module, to protect plug contact during reprocessing, cap is reusable

* Crash test carried out by Furtwangen University of Applied Sciences (Germany): C-MAC® system in a protective bag dropped from a height of 5 – 9 meters showed no noteworthy damage.

Please note: The instruments displayed are not included in the sterilization and storage tray.
C-CAM® and C-HUB®

Nothing could be easier!

C-CAM® transforms the C-MAC® video laryngoscope into an all-round system unit for complete airway management. The C-MAC® monitor is at the core of all imaging systems. C-CAM® is a high-grade CMOS camera with VGA resolution which can be connected to all KARL STORZ endoscopes with eyepieces. Illumination is ensured through the Power-LED battery light sources. Consequently, this is the first battery-powered video system to guarantee high-quality documentation. KARL STORZ has once again proven that high quality and mobility are not mutually exclusive.

The C-HUB® is the interface for computer and/ or monitor connectivity. The signal from the front end is transmitted directly to a computer or monitor with the aid of the C-HUB®. The enhanced output can be directly linked to any computer via a USB/S-VHS connection. Thanks to the safety offered by galvanic isolation in the C-HUB®, medical products can now be connected to non-medical products (e.g. computer/monitor).

C-HUB® is the perfect signal converter from C-MAC®/C-CAM® to USB or S-Video.
C-CAM® and C-HUB®

20290132  C-CAM® Camera Head, 8-pin, one-chip CMOS camera head, resolution 640 x 480, focal length f = 20 mm, compatible with C-HUB® 20290101 and C-MAC® 8402 ZX

20290131  C-CAM® Camera Head, 6-pin, one-chip CMOS camera head, resolution 640 x 480, focal length f = 20 mm, compatible with C-MAC® 8401 ZX

20290101  C-HUB® Camera Control Unit, for use with C-CAM® 20290132, Electronic Module 8402 X or compatible CMOS video endoscopes, Interfaces: USB 2.0, S-Video output (NTSC), power socket including:

- C-HUB® Power Supply
- S-Video (Y/C) Connecting Cable
- USB Connecting Cable
Intubation Fiberscopes
Eyepiece Versions

KARL STORZ provides the instruments you need to meet the special challenges of patients who cannot be intubated with conventional methods. Nasopharyngeal awake intubation is regarded as the gold standard of difficult airway management. We offer solutions for any challenge!

Our versatile intubation fiberscopes can be used in all clinical settings whether in intensive care units or emergency rooms as well as for patients with anticipated difficult airways during induction. The various sheath diameters enable you to select the ideal instrument for your patient and allow a swift reaction thanks to the compact, flexible LED light sources.

Special Features:
- Sheath stiffness adapted to anesthesiological requirements
- Suitable for both fiber optic intubation and bronchoscopy
- Patented sheath surface special treatment requires only minimal lubrication and provides optimal tube insertion
- Developed for use in the OR, ICU, ER
- Even safer tube introduction due to video-assisted control on the monitor
- Tube position of ETT, LMA, DLT can be verified
- Video-assisted monitoring for percutaneous tracheostomy
- Adaptable for foreign body removal or bronchial lavage
- Various outer diameters: 2.8; 3.7; 5.2 mm
- Diameter of working channel ranging from 1.2 to 2.3 mm
- Extremely bright, white light due to the LED light source with rechargeable Li-Ion batteries
- Intubation fiberscope can be directly connected to the C-MAC® monitor with the mobile camera head C-CAM®
- Suitable and validated for the following low-temperature reprocessing methods up to a max. of 60 °C: manual/mechanical cleaning and disinfection, sterilization with Steris® AMSCO VPRO 1, Sterrad® (50S, 100S, 200S, NX, 100NX) and EtO gas; High-Level Disinfection (HLD) acc. to US standards

Intubation Fiberscopes – eyepiece version, with optional LED battery light source
**Intubation Fiberscopes**

**Eyepiece Versions**

**2.8 x 65 Intubation Fiberscope with optimized imaging**

Intubation Fiberscope 11301 AA1 is ideal for use in neonatology due to its small outer diameter of 2.8 mm. This fiberscope is the only one of its size that has a working channel with 1.2 mm.

Intubation Fiberscope 11301 AA1 features a connector for suction valves for single or multiple use.

The special sheath surface combined with increased stiffness improves the gliding properties of the ETT over standard intubation fiberscopes.

The use of a mobile LED light source enables independent work under optimal lighting conditions.

**Benefits:**

- Effective suction possible via the 1.2 mm working channel
- Suitable for use with endotracheal tubes as of 3.5 mm
- Increased stiffness and smoother passage of the ETT
- Ready for immediate use and easy to clean and reprocess
- Optimized for use with mobile light sources
- Intubation fiberscope can be connected to the C-MAC® monitor via the mobile C-CAM® camera head
- Practical tube fixation via special adaptor

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**11301 AA1 Intubation Fiberscope 2.8 x 65,**

Deflection up/down: 140°/140°
Direction of view: 0°
Angle of view: 90°
Working length: 65 cm
Working channel inner diameter: 1.2 mm
Distal tip outer diameter: 2.8 mm
Intubation Fiberscopes
Eyepiece Versions

3.7 x 65 Intubation Fiberscope with optimized imaging
The 3.7 x 65 intubation fiberscope is a universal working instrument as it provides gold standard intubation for both adult and pediatric patients. Due to its small diameter, it is an excellent tool for the placement of double lumen tubes. Using a mobile LED light source and C-CAM®, the intubation fiberscope can be directly connected to the C-MAC® monitor for a monitor-assisted intubation solution that is both mobile and flexible – also suitable for electronic documentation.

Benefits:
- Effective suction possible via 1.5 mm working channel
- Suitable for use with endotracheal tubes as of 4 mm
- Increased stiffness and smoother passage of the ETT
- Practical tube fixation via special adaptor
- Ready for immediate use and easy to clean and reprocess
- Optimized for use with mobile light sources
- Intubation fiberscope can be connected to the C-MAC® monitor via the mobile C-CAM® camera head

11302 BD2 Intubation Fiberscope 3.7 x 65,
Deflection up/down: 140°/140°
Direction of view: 0°
Angle of view: 90°
Working length: 65 cm
Working channel inner diameter: 1.5 mm
Distal tip outer diameter: 3.7 mm
Intubation Fiberscopes
Eyepiece Versions

5.2 x 65 Intubation Fiberscope with optimized imaging

The 5.2 x 65 intubation fiberscope creates an ideal balance between image size, working channel size and fiber optics. Effective suction is possible via the 2.3 mm working channel. The fiberscope is also suitable for removing foreign bodies or for bronchial lavage in the intensive care unit. Using a mobile LED light source and C-CAM®, the intubation fiberscope can be directly connected to the C-MAC® monitor for a monitor-assisted intubation solution that is both mobile and flexible – also for electronic documentation.

Benefits:
- Effective suction possible via the large 2.3 mm working channel
- Suitable for use with endotracheal tubes as of 5.5 mm
- Increased stiffness and smoother passage of the endotracheal tube
- Practical tube fixation via special adaptor
- Ready for immediate use and easy to clean and reprocess
- Optimized for use with mobile light sources
- Intubation fiberscope can be connected to the C-MAC® monitor via the mobile C-CAM® camera head

11301 BN1

<table>
<thead>
<tr>
<th>Intubation Fiberscope 5.2 x 65,</th>
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<tbody>
<tr>
<td>Deflection up/down:</td>
<td>140°/140°</td>
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<tr>
<td>Direction of view:</td>
<td>0°</td>
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<td>Angle of view:</td>
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<td>Working length:</td>
<td>65 cm</td>
</tr>
<tr>
<td>Working channel inner diameter:</td>
<td>2.3 mm</td>
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<tr>
<td>Distal tip outer diameter:</td>
<td>5.2 mm</td>
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## Intubation Fiberscopes

### Eyepiece Versions

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<tr>
<th>Order No.</th>
<th>Intubation Fiberscopes</th>
<th>Eyepiece</th>
<th>Deflection up/down</th>
<th>Direction of view</th>
<th>Angle of view</th>
<th>Working length</th>
<th>Total length</th>
<th>Working channel inner diameter</th>
<th>Distal tip outer diameter</th>
<th>Recommended ETT diameter as of*</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.8 x 65</td>
<td>11301 AA1</td>
<td></td>
<td>0°</td>
<td>90°</td>
<td>65 cm</td>
<td>98 cm</td>
<td>1.2 mm</td>
<td>2.8 mm</td>
<td>3.5 mm</td>
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<td>3.7 x 65</td>
<td>11302 BD2</td>
<td></td>
<td>0°</td>
<td>90°</td>
<td>65 cm</td>
<td>93 cm</td>
<td>1.5 mm</td>
<td>3.7 mm</td>
<td>4.5 mm</td>
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<td>5.2 x 65</td>
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<td>0°</td>
<td>110°</td>
<td>65 cm</td>
<td>93 cm</td>
<td>2.3 mm</td>
<td>5.2 mm</td>
<td>5.5 mm</td>
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</tbody>
</table>

### Accessories included in delivery:

- **Case**
- **Pressure Compensation Cap**, for ventilation during gas sterilization
- **Leakage Tester**, with bulb and manometer
- **LIPP Tube Holder**, for intubation fiberscopes
- **Cleaning Brush**, flexible, long, for working channel diameter 1.2 mm, working length 150 cm
- **Cleaning Brush**, flexible, round, outer diameter 3 mm, for working channel diameter 1.8 – 2.6 mm, length 100 cm
- **Plug**, for LUER-Lock connector for cleaning, black, autoclavable, package of 10
- **Irrigation Adaptor**, for machine cleaning, reusable, for fiberscopes
- **Suction Valve**, for single use, package of 20
- **Bronchoscope Insertion Tube**, size 4, with integrated mouthpiece, for single use, sterile, insertion length 85 mm, made from EVA, package of 10
- **Same**, size 2, insertion length 65 mm
### Intubation Fiberscopes

**Eyepiece Versions**

<table>
<thead>
<tr>
<th>Accessories (included in delivery)</th>
<th>Add. Accessories</th>
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<tbody>
<tr>
<td>Case</td>
<td>Pressure Compensation Cap</td>
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<tr>
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</tr>
<tr>
<td>27677 A</td>
<td>11025 E</td>
</tr>
<tr>
<td>27677 A</td>
<td>11025 E</td>
</tr>
<tr>
<td>27677 A</td>
<td>11025 E</td>
</tr>
</tbody>
</table>

**Optional Accessories:**

- **Biopsy Forceps**, flexible, oval, double action jaws, diameter 1 mm, length 110 cm
- **Grasping Forceps**, flexible, double action jaws, diameter 1 mm, length 110 cm, for flexible bronchoscopes
- **Biopsy Forceps**, flexible, spoon-shaped, round, double action jaws, diameter 1.8 mm, working length 120 cm
- **Grasping Forceps**, flexible, alligator jaws, double action jaws, diameter 1.8 mm, working length 120 cm

*Please note that the accuracy of the ETT diameter may vary depending on the manufacturer's quality.*
BONFILS Retromolar Intubation Endoscopes
Eyepiece Versions

The expert instrument for multiple applications in airway management combines technical sophistication with utmost reliability

Unexpected difficult airways are always a challenge in airway management. With the BONFILS intubation endoscope and its versatile intubation techniques, this situation can be brought back to a controlled status. The endotracheal tube is guided into the trachea under direct vision and the possibility of simultaneous application of oxygen provides more safety. Moreover, KARL STORZ offers a solution to meet the most stringent hygiene requirements – the autoclavable SILVER LINE.
Airway Management in Critical Care Medicine

BONFILS Retromolar Intubation Endoscopes
Eyepiece Versions

Special Features:

- SILVER LINE – autoclavable
- Particularly suitable for the unexpected difficult airway
- Use in the case of minimal mouth opening (> 1 cm) possible
- Introduction of the tube under visualization: What you see is what you get!
- Continuous O₂ flow via tube adaptor between tube and instrument
- One-person intubation possible

- Connect and intubate – thanks to the mobile LED “Power of Light” light source
- Quick and easy cleaning
- Suitable and validated for the following low-temperature reprocessing methods up to bis max. 60 °C: manual/machine cleaning and disinfection, sterilization with Steris® AMSCO VPRO 1, Sterrad® (50S, 100S, 200S, NX, 100NX) and EtO gas; High-Level Disinfection (HLD) acc. to US standards
- Recommended for video-assisted intubation with C-CAM® to C-MAC® monitor

BONFILS Retromolar Intubation Endoscope, outer diameter 3.5 mm, for ETT 4 – 5.5 mm, usable sheath length 35 cm, distal bending 40°, with movable eyepiece, including Tube Holder 10332 BA for tube fixation and O₂ application

NEW 10331 B2K
BONFILS Retromolar Intubation Endoscope, autoclavable, outer diameter 5 mm, for ETT > 5.5 mm, usable sheath length 40 cm, distal bending 40°, with movable eyepiece, with Tube Holder 10331 BA for tube fixation and O₂ application

10332 B1
BONFILS Retromolar Intubation Endoscope, outer diameter 3.5 mm, for ETT 4 – 5.5 mm, usable sheath length 35 cm, distal bending 40°, with movable eyepiece, including Tube Holder 10332 BA for tube fixation and O₂ application

10330 B1
BONFILS Retromolar Intubation Endoscope, outer diameter 5 mm, for ETT > 5.5 mm, usable sheath length 40 cm, distal bending 40°, working channel diameter 1.2 mm, including Tube Holder 10331 BA for tube fixation and O₂ application
### BONFILS Retromolar Intubation Endoscopes

#### Eyepiece Versions

<table>
<thead>
<tr>
<th>Intubation Endoscopes</th>
<th>Order No.</th>
<th>Distal bending</th>
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<td>BONFILS 3.5 x 35</td>
<td>10332 B1</td>
<td></td>
</tr>
<tr>
<td>BONFILS 5 x 40</td>
<td>10330 B1</td>
<td></td>
</tr>
<tr>
<td>BONFILS 5 x 40</td>
<td>10331 B2K</td>
<td></td>
</tr>
</tbody>
</table>

**Accessories included in delivery:**

- **Case**, internal dimensions (w x d x h): 490 x 290 x 85 mm
- **Plastic Case**, without inserts, internal dimensions (w x d x h): 480 x 285 x 80 mm
- **Tube Holder for ETT**, with O₂ application connection, inner diameter 3.5 mm
- **Tube Holder**, inner diameter 5 mm
- **Cleaning Brush**, for Intubation Endoscope 10330 B1
BONFILS Retromolar Intubation Endoscopes
Eyepiece Versions

<table>
<thead>
<tr>
<th>Angle of view</th>
<th>Working length</th>
<th>Total length</th>
<th>Working channel diameter</th>
<th>Distal tip outer diameter</th>
<th>Recommended ETT diameter as of</th>
<th>Case</th>
<th>Tube Holder</th>
<th>Cleaning Brush</th>
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<tr>
<td>90°</td>
<td>35 cm</td>
<td>52 cm</td>
<td>–</td>
<td>3.5 mm</td>
<td>4 mm</td>
<td>27677 BM</td>
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<tr>
<td>110°</td>
<td>40 cm</td>
<td>52 cm</td>
<td>1.2 mm</td>
<td>5 mm</td>
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<td>10331 BA</td>
<td>27651 AE</td>
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<td>110°</td>
<td>40 cm</td>
<td>54 cm</td>
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<td>5 mm</td>
<td>5.5 mm</td>
<td>27677 BM</td>
<td>10331 BA</td>
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</tr>
</tbody>
</table>

Optional Accessories:

- **39501 F**
  - Wire Tray for Cleaning, Sterilization and Storage of one rigid BONFILS endoscope, including holder for light post adaptors, silicone telescope holders and lid, external dimensions (w x d x h): 570 x 80 x 52 mm

*Please note that the accuracy of the ETT diameter may vary depending on the manufacturer's quality.*
LIPP/GOLECKI Airway Management Set
Basic Set

Recommended Set for Difficult and Standard Intubation

11300 B3 LIPP/GOLECKI Airway Management Set, for the difficult airway including:

- **Intubation Fiberscope**, 3.7 mm x 65 cm
- **BONFILS Retromolar Intubation Endoscope**, 5 x 40, autoclavable
- **Battery Light Source LED for Endoscopes**
- **Mask Adaption “MAINZ Adaptor”**, blue, package of 5
- **Laryngeal Tube**, size 4
- **Laryngeal Tube**, size 3
- **Spiral Tube**, size 6, for single use
- **Bronchoscope Insertion Tube**, size 4
- **Laryngeal Mask**, standard, reusable, size 1
- **Laryngeal Mask**, standard, reusable, size 2
- **Laryngeal Mask**, standard, reusable, size 4
- **Intubation Laryngeal Mask**, reusable, size 3
- **Intubation Laryngeal Mask**, reusable, size 4
- **Laryngeal Mask Tube**, diameter 7 mm
- **Laryngeal Mask Tube**, diameter 7.5 mm
- **LMA Tube Stabilizer**
- **MAGILL Forceps**, length 25 cm
- **Scalpel**, for single use, package of 10
- **COTTLE Nasal Speculum**, blade length 55 mm, length 13 cm
- **DÖRGES Emergency Laryngoscope Blade**, cold light, universal size
- **Handle Sleeve**, ISO 7376
- **Battery Insert**, with 2 Batteries 121306 S and Xenon Lamp 8546 XA
- **Case**
Intubation Set -C22-, ULM Model

Basic Set

- Intubation Set -C22-, ULM model
- BOEDEKER-DÖRGES C-MAC® Video Laryngoscope, MAC #3
- BOEDEKER-DÖRGES C-MAC® Video Laryngoscope, MAC #4
- C-MAC® Video Laryngoscope D-BLADE
- C-MAC® Pocket Monitor Set
- Charging Unit, for C-MAC® pocket monitor
- Protective Cap
- Handle Sleeve, ISO 7376
- DÖRGES Emergency Laryngoscope Blade, cold light
- Battery Insert Set LED, with cap
- Bag for Intubation Set -C22-, ULM model
- MAGILL Forceps, modified by BOEDEKER

Bag for Ulm Intubation Set -C22-, made of water-resistant and sturdy material, washable, including two compartments with several holding facilities for C-MAC® video laryngoscope blades with C-MAC® pocket monitor and conventional laryngoscopes, for use with C-MAC® Pocket Monitor 8401 XD, C-MAC® video laryngoscopes and conventional laryngoscopes
Emergency Tracheobronchoscopy Set
Basic Set

Recommended Set for Difficult and Standard Intubation

10330 F

Emergency Tracheoscope Set
including:
Emergency Bronchoscope, size 6, length 30 cm
Emergency Tracheoscope, size 9, length 25 cm
Emergency Tracheoscope, size 7, length 20 cm
Emergency Tracheoscope, size 5, length 20 cm
FLUVOG Adaptor

Adaptor for Ventilation
DÖRGES Emergency Laryngoscope Blade, cold light, universal size
2x Handle Sleeve, ISO 7376
2x Battery Insert, with 2 Batteries 121306 S and Xenon Lamp 8546 XA
Xenon Lamp, package of 6

Forceps, for peanuts and soft foreign bodies

Forceps, alligator, for hard foreign bodies
MAGILL Forceps, length 20 cm
MAGILL Forceps, length 25 cm
YOUNG Tongue Seizing Forceps

Suction Tube, diameter 3 mm, length 35 cm
Suction Tube, diameter 4 mm, length 35 cm
Suction Tube, diameter 5.5 mm, length 35 cm

Case
Battery Light Source LED BRITE LITE
Accessories for Intubation Fiberscopes and Endoscopes

Special Features:
- Battery light source with extremely high light intensity >100 lm / > 150 klx
- Available as battery and rechargeable version
- Absolute white light due to LED technology
- Special light focus allows optimal light adjustment at the endoscope connector
- LED provides up to 50,000 hours lifetime
- Burning time of 120 min
- Waterproof, fully immersible for cleaning and disinfection (11301 D1/D3)

11301 D1/D3/DE/DF
Battery Light Source LED for Endoscopes, with fine screw thread, brightness > 100 lm / > 150 klx, burning time > 120 min, weight approx. 150 g, waterproof and fully immersible for manual cleaning and disinfection, with 2 Photo Batteries 121306 P

11301 D3
Same, with coarse thread

121306 P
Photo Battery, lithium, 3 V, CR 123 A

11301 DE
Battery Light Source LED for Endoscopes, rechargeable, with click connection, brightness > 110 lm / >150 klx, color temperature 5500 K, lithium-ion batteries, charging time 60 min, burning time at 100% brightness 40 min, weight approx. 150 g ready for use, suitable for wipe disinfection

11301 DF
Same, with fast screw thread

11301 DG
Charging Unit, for 11301 DE/11301 DF, for two LED battery light sources, with fixed integrated power supply and adaptor for EU, UK, USA and Australia, power supply 110 – 240 VAC, 50/60 Hz, suitable for wipe disinfection

11301 DH
Holder, for Charging Units 11301 DG, 8546 LE and 8401 XDL
MACINTOSH Laryngoscope Blades  
Cold Light, with Replaceable Fiber Optic Light Carrier  

**Special Features:**  
- **KARL STORZ** blades and handles meet the highest cleaning and hygienic standards  
- Chromium-plating gives the laryngoscope blades a compact, smooth surface; edges are rounded, thus preventing the formation of microcracks, fissure or sharp edges which can harbour germs  
- Handles are not knurled (problematic concerning hygiene), instead have an ergonomic shape and smooth surface.  
- Handles can be supplied with LED “BRITE LITE” power system with > 50,000 lux and Li-Ion rechargeable batteries.  
- The KARL STORZ laryngoscope blades are the only such products currently commercially available that are autoclavable and show no noticeable reduction in light intensity, even after several hundred cleaning cycles**.  
- The Xenon lamps in the fiberoptic light carriers generate a neutral white light which is 30 – 40% brighter than standard halogen light.  
- Laryngoscopy blades and handles comply with the ISO 7376 standard.  
- On request, additional markings can be etched on the laryngoscope/handle free-of-charge (such as, e.g., “1-83-2/Case“ or „Christoph 77/Rucksack“)

**McL BUCC, HM de GAST, J VELDHUIS, LH HASSING, A MEULEMANS, A KAMMEYER:**  
The effect of mechanical cleaning and thermal disinfection on light intensity provided by fibreoptic Macintosh laryngoscopes.  

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>8546</td>
<td>MACINTOSH Laryngoscope Blade,</td>
<td></td>
</tr>
<tr>
<td>8546 A</td>
<td>Same, size 5</td>
<td></td>
</tr>
<tr>
<td>8546 LD</td>
<td>Same, size 4</td>
<td></td>
</tr>
<tr>
<td>8541 AA</td>
<td>Same, size 5</td>
<td></td>
</tr>
<tr>
<td>8541 A</td>
<td>Same, size 4</td>
<td></td>
</tr>
<tr>
<td>8541 B</td>
<td>Same, size 3</td>
<td></td>
</tr>
<tr>
<td>8541 C</td>
<td>Same, size 2</td>
<td></td>
</tr>
<tr>
<td>8541 D</td>
<td>Same, size 1</td>
<td></td>
</tr>
<tr>
<td>8541 E</td>
<td>Same, size 0</td>
<td></td>
</tr>
</tbody>
</table>

MILLER Laryngoscope Blades  
Cold Light, Fiber Optic Light Carrier Incorporated  

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>8537 A</td>
<td>MILLER Laryngoscope Blade,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Same, size 4</td>
<td></td>
</tr>
<tr>
<td>8537 B</td>
<td>Same, size 3</td>
<td></td>
</tr>
<tr>
<td>8537 C</td>
<td>Same, size 2</td>
<td></td>
</tr>
<tr>
<td>8537 D</td>
<td>Same, size 1</td>
<td></td>
</tr>
<tr>
<td>8537 E</td>
<td>Same, size 0</td>
<td></td>
</tr>
</tbody>
</table>
Handles with LED Light Source
for Cold Light Laryngoscope Blades

Special Features:
- Rechargeable lithium-ion batteries
- Extremely bright LED of more than 50 lm/ > 100 klx
- Absolute white light due to LED technology (5500 K)
- Small handle with photo battery

<table>
<thead>
<tr>
<th>Handle</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>8546</td>
<td>Handle Sleeve, ISO 7376, autoclavable, length 12 cm, for use with Battery Inserts 8546 A, 8546 LD, 8549 LD and cold light laryngoscopes</td>
</tr>
<tr>
<td>8546 LD1</td>
<td>Battery Insert, rechargeable, length 12 cm, for Handle Sleeve 8546, with high-power LED, 56 lm/ &gt; 100 klx, lithium-ion battery insert, burning time at 100% brightness 240 min, charging via Inductive Charging Unit 8546 LE</td>
</tr>
<tr>
<td>8549 LDX</td>
<td>Battery Insert Set LED, length 12 cm, for Handle Sleeve 8546 and cold light laryngoscopes, with high-power LED, &gt; 56 lm/ &gt;100 klx, burning time at 100% brightness &gt; 120 min including: Battery Insert, high-power LED 2x Battery, Mignon-Cell, LR 06, 1.5 V Cap</td>
</tr>
<tr>
<td>8548</td>
<td>Handle Sleeve, ISO 7376, length 6 cm, autoclavable, for use with Battery Insert Set 8548 LDX</td>
</tr>
<tr>
<td>8548 LDX1</td>
<td>Battery Insert Set, length 6 cm, for Handle Sleeve 8548, with high-power LED, &gt; 56 lm/ &gt; 100 klx, burning time at 100% brightness &gt; 120 min including: Battery Insert, high-power LED Photo Battery, CR 123 A Cap</td>
</tr>
</tbody>
</table>
Handles with Xenon Light Source
for Cold Light Laryngoscope Blades

8546
Handle Sleeve, ISO 7376, autoclavable, length 12 cm, for use with Battery Inserts 8546 A, 8546 LD, 8549 LD and cold light laryngoscopes

8546 A
Battery Insert, length 12 cm, with 2 Batteries 121306 S and Xenon Lamp 8546 XA

121306 S
Batteries, Baby-Cell, LR 14, for Battery Inserts 8544 A and 8546 A, package of 2

8546 XC
Xenon Lamp, 2.5 V, for Battery Inserts 8546 A, 8547 A and 8547 B, package of 6

Especially suitable for use with blades sizes 0 and 1

8547
Handle Sleeve, ISO 7376, length 12 cm, autoclavable, for use with Battery Inserts 8547 A and 8547 B

8547 A
Battery Insert, length 12 cm, including 2 Batteries 121306 KS and Xenon Lamp 8546 XA

121306 KS
Batteries, Mignon-Cell, LR 06, 2 Batteries 121306 K, for Battery Inserts 8545 A, 8547 A and Battery Insert Set High-Power LED 8549 LD

8547 B
Rechargeable Battery Insert, length 12 cm, for Handle Sleeve 8547, with Xenon Lamp 8546 XA, charging via Inductive Charging Unit 8546 LE

8546 XC
Xenon Lamp, 2.5 V, for Battery Inserts 8546 A, 8547 A and 8547 B, package of 6
Inductive Battery Charger
for rechargeable Laryngoscope Handles

Special features:
- No open contacts
- No corrosion and contact problems
- No voltage peaks
- Batteries can be charged with or without handle sleeve, sterile packaging
- For use with LED handles
- Compatible with previous models

8546 LE

8546 LE  Inductive Charging Unit, for two battery inserts (8546 LD, 8544 B, 8545 B, 8547 B), with fully integrated mains adaptor and power adaptor for EU, UK, USA and Australia, power supply 110 – 240 VAC, 50/60 Hz, suitable for wipe disinfection

8546 R  Reduction Sleeve, for Battery Inserts 8545 B and 8547 B, only

11301 DH  Holder, for Charging Units 11301 DG and 8546 LE
with the compliments of
KARL STORZ — ENDOSKOPE