AIRWAY MANAGEMENT IN THE INTENSIVE CARE UNIT

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SUMMARY – Airway management in the intensive care unit (ICU) is a challenging procedure and is frequently associated with life threatening complications. The incidence of difficult intubations ranges from 10% to 22%, depending on the setting and the patients in need of endotracheal intubation. Multiple attempts are often needed to secure the airway. Despite the high risk for patients in the ICU setting, the equipment for airway management such as capnometry or alternative devices is not always available. The novel technique of video laryngoscopy has been recently introduced into clinical practice in the operating room. First results from larger studies are very promising, suggesting these new devices to be helpful for successful intubation with fewer attempts in difficult intubation scenarios. At the same time, several reports show that successful use of video laryngoscopes in emergency situations need substantial practical training and expertise in airway management. The use of a protocol for airway management has been shown to decrease complications. Parts of this protocol are appropriate staffing, pre-oxygenation and strategies to avoid cardiovascular complications. In conclusion, high practical skill of airway management is needed in critically ill patients. Monitoring such as capnography and alternative equipment for securing the airway is not just mandatory in the operating room but also in the ICU.

Key words: *Intubation; Laryngoscopy; Intensive care medicine; Airway management; Video laryngoscopy; Airway devices; Equipment*

Introduction

Airway management in critically ill patients at locations other than the operating room is challenging and frequently associated with life threatening complications. The incidence of difficult endotracheal intubations is higher in the intensive care unit (ICU) than in the operating room. Depending on the setting and the type of patient who needs endotracheal intubation, difficult intubation ranges from 10% to 22%[1-3]. In a recent report from the United Kingdom, more than 60% of adverse events associated with airway management in the ICU led to death or brain damage[4]. The corresponding incidence in the operating room was 14%. The possible reasons for the high rate of severe complications outside the setting of the operating room include multiple organ failure, advanced age, the use of vasopressors, and low fluid responsiveness[1].

In contrast to the operating room, space is very limited in the ICU. Access to the patient's head is difficult because of the equipment positioned around the bed, such as syringe pumps and hemodialysis machine. Additionally, the position of the patient is often inappropriate and accompanying comorbidities can make laryngoscopy challenging[5].

In most cases, endotracheal intubation is an emergency procedure: in 39% with real urgency, in an additional 48% with a relative urgency[6]. Multiple attempts for endotracheal intubation are often necessary to secure the patient's airway in the ICU setting[3,7]. At the same time, multiple intubation attempts performed outside the operating room are known to increase the

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risk of life threatening complications such as hypoxia (7x), severe hypoxia (14x), regurgitation (7x), aspiration (4x), bradycardia (4x) and cardiac arrest (7x)[8]. Unrecognized esophageal intubation is frequently observed in the ICU and is associated with a high mortality of up to 90%[4,9].

Airway Equipment

Equipment for airway management is not always readily available in the ICU. In a recent study in the United Kingdom, capnography was used in only 32% after intubation; 25% of the evaluated ICUs never use capnography after intubation[10]. At the same time, alternative equipment for airway management is not routinely present at the bedside. Alternative blades such as the McCoy blade were present in 80%, an intubating laryngeal mask in 50% and a laryngeal mask airway in 20% of the ICUs. These numbers show that most ICUs are not ready to treat a "cannot intubate" situation. Fiberoptics was available in 60%, meaning that 40% of the units do not have the option of an awake fiberoptic intubation in case of an expected difficult intubation.

Learning Endotracheal Intubation

Learning the skill of endotracheal intubation under ideal conditions in the operating room is time consuming. A number of 50-60 endotracheal intubations are needed to achieve a success rate of approximately 90% (Fig. 1)[11,12]. So far, no study exists examining the number of intubations needed to master difficult intubations. It is very likely that a much higher number than 60 intubations is required to achieve this goal. First reports indicate that using a video laryngoscope with a Macintosh blade for teaching endotracheal intubation results sooner in a higher success rate and faster intubation compared to traditional laryngoscopy[13].

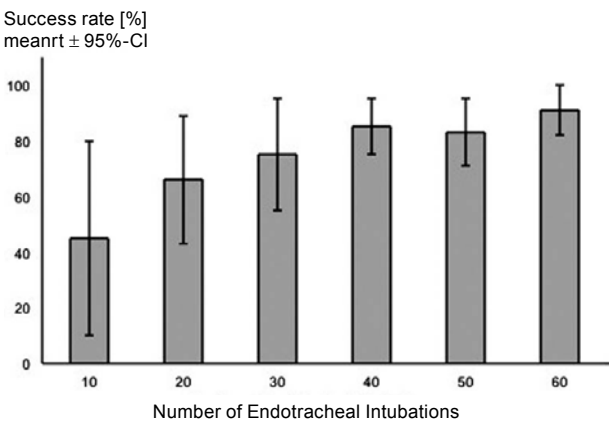

Fig. 1. Learning curve for endotracheal intubation (modified from[12]).

Management Protocol for Endotracheal Intubation

Several interventions have been identified to improve the endotracheal intubation routine. Using noninvasive positive pressure ventilation (NIPPV) for preoxygenation using a pressure support of 8 cm H_2O and a positive end-expiratory pressure of 6 cm H_2O resulted in a faster and prolonged oxygenation[14]. The sheer presence of a senior anesthesiologist during airway management resulted in a significantly reduced incidence of complications (6% *vs.* 22%)[15]. Recently, a strategy for endotracheal intubation in the ICU has been evaluated. The use of an intubation management protocol led to a reduction of intubation related complications[16]. The protocol included several interventions: preoxygenation using NIPPV, fluid loading, presence of two physicians, rapid sequence induction, capnography, early administration of sedation, and early vasopressor use when needed[16]. The interventions were categorized in "pre-intubation", "intubation" and "post-intubation" procedures (Fig. 2). "Pre-intubation" procedures included the presence of two physicians (including one anesthesia specialist), use of fluid loading in the absence of cardiogenic pulmonary edema (500 mL isotonic saline or 250 mL starch) and pre-oxygenation using NIPPV with a FiO_2 of 100%. The pressure support level was set between 5 and 15 cm H_2O to achieve an expiratory tidal volume between 6 and 8 mL/kg. "Intubation" procedures included rapid sequence induction using either etomidate or ketamine, combined with a rapid onset muscle relaxant. "Post-intubation" measures included immediate confirmation of tube placement using capnography. Norepinephrine was used if diastolic pressure was below 35 mm Hg. Long-term sedation and lung protective ventilation was initiated. After implementation of this protocol, intubation related complications were significantly reduced: life-threatening complications 21% *vs.* 34% and mild to moderate complications 9% *vs.* 21%[16].

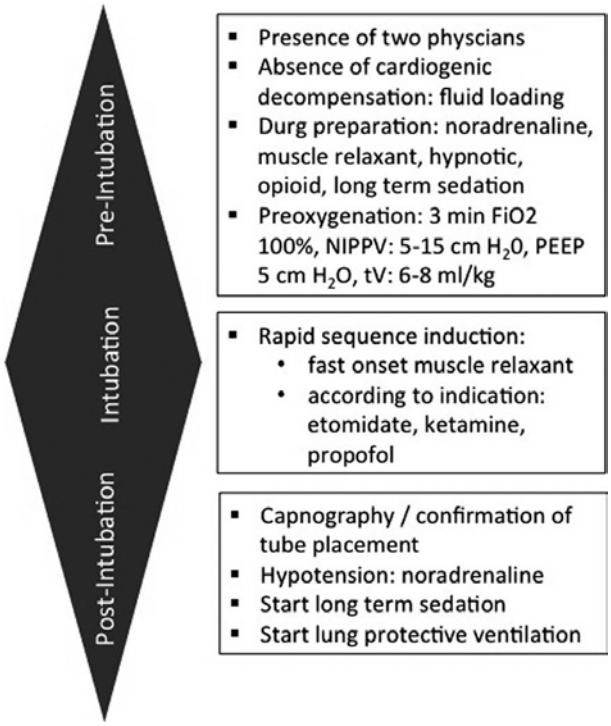

Fig. 2. Protocol for endotracheal intubation in the intensive care unit (modified from[16]).

The choice of induction medication can modify patient outcome and survival. In a randomized, controlled trial patients received either etomidate or ketamine for intubation[17]. The authors found that intubation conditions were similar in both groups, however, patients receiving etomidate as a single dose presented with adrenal insufficiency. Septic patients showed a trend towards increased mortality. The authors conclude that ketamine should be preferred in patients with sepsis. Etomidate is currently not recommended for use in trauma patients since it is associated with a higher risk of acute respiratory distress syndrome, multi organ failure and a prolonged ICU stay[18].

Video Laryngoscopy in the ICU

Video laryngoscopes seem promising for airway management[19]. Within only five years, several new devices have been introduced into clinical practice. Video laryngoscopes contain a small camera and a light source at the distal third of the blade. The video picture is transferred to a monitor. The major advantage of video laryngoscopes is that the glottis can be visualized indirectly *via* screen without a direct line of view ("look around the corner"). Video laryngoscopes can be subdivided by the way the blade is shaped and the presence of a guiding channel for the endotracheal tube. Some devices use interchangeable blades allowing different shaped blades to be used with the same system. C-MAC® with dBlade, McGrath Series 5® and GlideScope® are examples of devices using a blade with an elevated tip, similar to the McCoy blade with a lifted tip. C-MAC® with Macintosh blade and McGrath MAC® are examples of devices using video blades, which are similarly shaped to traditional Macintosh blades. Airtraq® and AirwayScope® represent the group of devices using a channel to guide the tube during endotracheal intubation. The Airtraq® does not use video technique; an optical system of prisms and lenses is used for indirect visualization of the glottis. Most of the devices have been evaluated in the operating room, with all devices having an improved laryngeal view in normal and difficult airway compared to traditional direct laryngoscopy[19].

However, an improved laryngeal view on a video laryngoscope screen does not always translate into successful tracheal intubation. The camera is placed close to the glottis, which results in a "look around the corner". The tip of the endotracheal tube has to pass a sharp angle to enter the larynx, which increases the risk of contact with the anterior tracheal wall[20]. As a result, the tube cannot be easily advanced into the trachea. This phenomenon has been described with the use of several video laryngoscopes, such as the McGrath Series 5® and the GlideScope® [21,22]. The use of a video laryngoscope with a Macintosh shaped video blade has reduced the problem of tube advancement despite a good glottic view compared to the video laryngoscopes that use a more curved blade[23].

Despite multiple very promising publications showing the superiority of video laryngoscopes, an increasing number of reports exist where video laryngoscopes have similar or even worse success rates than Macintosh laryngoscopy. In a pre-hospital study, the Airtraq® was compared to Macintosh laryngoscopy[24]. Surprisingly, the success rate for intubation with the Airtraq® was 47%, compared to a success rate of 99% using Macintosh laryngoscope. The GlideScope® was compared to direct laryngoscopy outside the operating room[25]. In this study, no overall difference in success

rate between the two methods was shown. The video laryngoscope was only superior when a difficult airway was present. In a study comparing the McGrath Series 5® with Macintosh laryngoscopy, a success rate of 60% *vs.* 100% was found[26]. Most authors of these studies conclude that clinical experience was probably insufficient for successful use of the novel instruments.

Use of a Macintosh shaped video laryngoscope is very similar to traditional laryngoscopy and is sufficient to improve visualization of the glottis and increases intubating success in most cases. Two approaches to visualize the glottis with the use of a Macintosh video laryngoscope blade are available: first, a direct view of the glottis and second, an indirect view by means of a miniature camera on the screen of the monitoring unit.

In a comparison of the use of the traditional Macintosh laryngoscope *vs.* the use of a video laryngoscope (C-MAC®) in patients with difficult laryngoscopy during a scheduled surgical procedure, the use of the C-MAC improved the glottic view in 94% of patients (49/52)[20]. In the operating room, use of the C-MAC in patients with a predicted difficult airway improved optical access to the glottis compared to direct laryngoscopy using a Macintosh laryngoscope and resulted in more successful intubations at first attempt[27].

In a prospective study of 247 consecutive patients over a two-year period, the use of the C-MAC® with Macintosh shaped blade improved visualization of the glottis during airway management in the ICU[2]. In patients with at least one predictor for a difficult airway, not only glottic view but also success rate of endotracheal intubation at first attempt was higher (79%) in the C-MAC group compared to Macintosh laryngoscopy (56%) (Fig. 3).

To the opinion of the author, use of a video laryngoscope with an elevated tip is reserved for the experienced user with a high expertise in airway management. Use of a video laryngoscope does not replace clinical experience and expertise in anatomy, physiology and pharmacology of airway management. Most of the studies have been published by airway management experts, making it difficult to translate the results into daily ICU routine.

Laryngeal Mask Airway in the ICU

Use of a laryngeal mask airway as an alternative device for ventilation and oxygenation after failed endotracheal intubation is generally accepted[28]. Extraglottic airway devices do not seem to have a place in the ICU because long-term ventilation with a laryngeal mask is not an alternative for an endotracheal tube. Additionally, intensivists without a background in anesthesiology do not have practical experience with the device. Nevertheless, laryngeal masks seem to gain popularity for several indications in the ICU[29].

Percutaneous dilatational tracheostomy is a common procedure in the ICU. Visual control using a

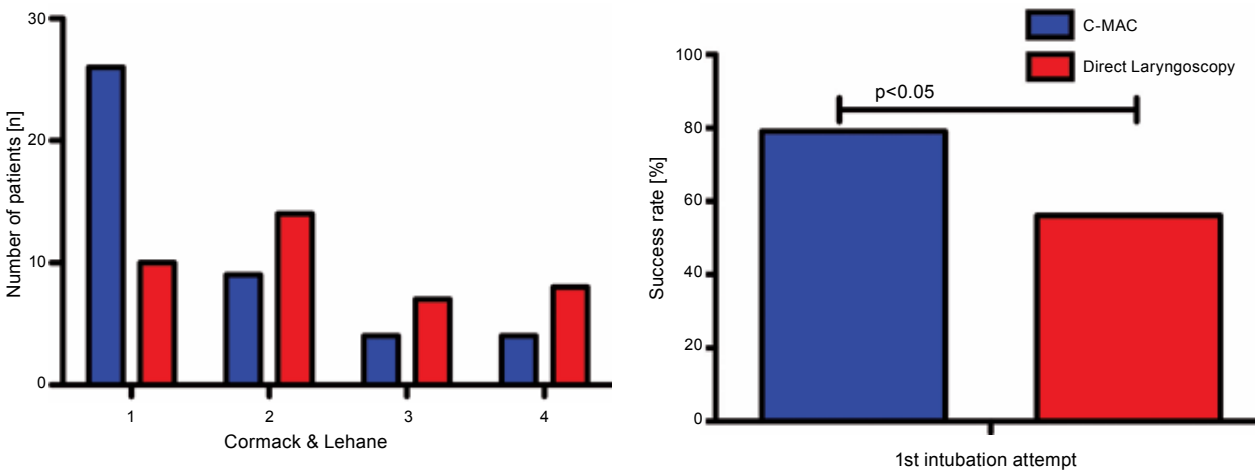

Fig. 3. Glottic visualization and first time intubation success using the C-MAC® in intensive care unit patients with at least one predictor for a difficult airway.

bronchoscope during the procedure is strongly recommended to avoid potential injuries of the posterior tracheal wall and the esophagus[30]. During the procedure, the risk of hypoventilation and hypoxia is present because of the bronchoscope significantly occluding the endotracheal tube. Laryngeal mask airways provide a larger inner diameter than an endotracheal tube; e.g., an average laryngeal mask size 5 has an inner diameter of 12.5 mm, compared to an endotracheal tube with an inner diameter of 8 mm. Use of a laryngeal mask airway for bronchoscopy during percutaneous dilatational tracheostomy resulted in a reduced incidence of complications compared to endotracheal tube[29]. Ventilation and oxygenation was improved during the procedure and duration was shorter when a laryngeal mask was used[31,32].

In a selected group of neurosurgical and cardiovascular patients, hemodynamic stability during weaning and tube removal is advantageous in the ICU. Blood pressure peaks as well as increased abdominal pressure because of coughing might result in hyperperfusion, hematoma and wound dehiscence. Use of a laryngeal mask airway has been shown to reduce hemodynamic changes, hypoxia, intracranial pressure and coughing in patients in the operating room[29]. In a recent study, the endotracheal tube was replaced by a ProSeal® laryngeal mask in surgical patients before receiving postoperative care in the ICU[33]. Cardiovascular parameters (heart rate, blood pressure) were more stable in the laryngeal mask group compared to endotracheal tube. The authors did not find any adverse events when the ProSeal® was used.

Conclusion

Airway management in the ICU is challenging and can be potentially life threatening for the patient. The presence of airway equipment including alternative airway management devices and the use of capnography after each endotracheal intubation are mandatory in the ICU. Use of an intubation protocol helps further reduce severe complications associated with securing the airway. The protocol should include at least the presence of two physicians, use of NIPPV pre-oxygenation, fluid loading and the presence of drugs for sedation, muscle relaxation and cardiovascular support. Video laryngoscopy has been shown to improve glottic view and first attempt intubation success. It is very likely that patients with a potentially difficult airway do profit most from the use of a video laryngoscope for intubation. The development of practical skills for video laryngoscopy is mandatory for successful use. Laryngeal mask airways are not just alternative devices after failed endotracheal intubation but might also play a new role in percutaneous dilatational tracheostomy and postoperative care.

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Sažetak

ZBRINJAVANJE DIŠNOG PUTA U JEDINICI INTENZIVNOG LIJEČENJA

R. R. Noppens

Zbrinjavanje dišnog puta u jedinici intenzivnog liječenja (JIL) je izazovan postupak i često se povezuje sa životno opasnim komplikacijama. Incidencija otežane intubacije varira od 10% do 22%, ovisno o uvjetima i bolesnicima kojima je potrebna endotrahealna intubacija. Obično je potrebno više pokušaja kako bi se osigurao dišni put. Unatoč visokom riziku za bolesnika u okruženju JIL oprema za osiguravanje dišnih putova kao što su kapnometrija i alternativna pomagala često nije dostupna. Nova tehnika video laringoskopije je nedavno uvedena u kliničku praksu u operacijskoj dvorani. Prvi rezultati većih studija su vrlo obećavajući, jer pokazuju da su ti novi uređaji korisni za uspješnu intubaciju s manje pokušaja kod otežane inubacije. Istodobno je nekoliko izvješća pokazalo da uspješna uporaba video laringoskopa u hitnim situacijama zahtijeva stalnu praktičnu uvježbanost i stručnost u osiguranju dišnog puta. Primjena protokola za zbrinjavanje dišnih putova je smanjila komplikacije. Dio ovoga protokola čine odgovorajuće osoblje, pred-oksigenacija i strategije za izbjegavanje kardiovaskularnih komplikacija. Ukratko, kod bolesnika u JIL potrebna je visoka praktična vještina zbrinjavanja dišnog puta. Praćenje kao što je kapnografija i alternativna pomagala za osiguravanje dišnog puta nisu obvezna samo u operacijskoj dvorani, nego i u JIL.

Ključne riječi: *Intubacija; Laringoskopija; Intenzivno liječenje; Zbrinjavanje dišnog puta; Video laringoskopija; Uređaji za osiguravanje dišnog puta; Oprema*