Review Article

Tracheal intubation in the ICU: Life saving or life threatening?

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Access this article online

Website: www.ijaweb.org

DOI: 10.4103/0019-5049.89872

Quick response code

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ABSTRACT

Tracheal intubation (TI) is a routine procedure in the intensive care unit (ICU), and is often life saving. However, life-threatening complications occur in a significant proportion of procedures, making TI perhaps one the most common but underappreciated airway emergencies in the ICU. In contrast to the controlled conditions in the operating room (OR), the unstable physiologic state of critically ill patients along with underevaluation of the airways and suboptimal response to pre-oxygenation are the major factors for the high incidence of life-threatening complications like severe hypoxaemia and cardiovascular collapse in the ICU. Studies have shown that strategies planned for TI in the OR can be adapted and extrapolated for use in the ICU. Non-invasive positive-pressure ventilation for pre-oxygenation provides adequate oxygen stores during TI for patients with precarious respiratory pathology. The intubation procedure should include not only airway management but also haemodynamic, gas exchange and neurologic care, which are often crucial in critically ill patients. Hence, there is a necessity for the implementation of an Intubation Bundle during routine airway management in the ICU. Adherence to a plan for difficult airway management incorporating the use of intubation aids and airway rescue devices and strategies is useful.

Key words: Complications, intensive care, intubation bundle strategy, tracheal intubation

INTRODUCTION

Tracheal intubation (TI) is commonly performed in the setting of respiratory failure and shock, and is one of the most commonly performed procedures in the intensive care unit (ICU). It is an essential life-saving intervention; however, complications during airway management in such patients may precipitate a crisis. Hence, professional competence in airway management is required while caring for critically ill patients.

Airway management in the ICU differs significantly from TI carried out for routine surgical procedures in the operating rooms (OR). In the OR, elective intubations are performed on stable patients with good physiological reserve by skilled anaesthesiologists, and TI is associated with very low rates of complications. These observations are in stark contrast to the high occurrence of failed airways and major complications like severe hypoxaemia and cardiac arrest related to airway instrumentation in the ICU.[1-5] TI in the ICU is often performed in a high-pressure environment by junior medical staff, some of whom have had little or no training in airway management. In addition, complications in the critically ill patients are attributable to the compromised physiologic status of the patient, time constraints for evaluation of airway and inefficiency of conventional pre-oxygenation. Furthermore, many of the medications used to facilitate TI have adverse haemodynamic consequences.

MAGNITUDE OF THE PROBLEM

Schwartz and colleagues studied complications during almost 300 emergency TIs in the ICU.[1] The incidence of difficult intubation (DI) was 8%, oesophageal intubation 8%, pulmonary aspiration 4% and the associated mortality rate was 3%. Presence of hypotension during TI was strongly correlated with cardiac arrest. They

How to cite this article: Divatia JV, Khan PU, Myatra SN. Tracheal intubation in the ICU: Life saving or life threatening?. Indian J Anaesth 2011;55:470-5.

also found that more than one attempt was required in more than 25% patients. In a French multicentre ICU survey,[2] 25% of 253 intubations required at least two attempts. The TI difficulty correlated with the time to intubation and enhanced the rate of hypoxaemia. Griesdale *et al*.[3] compared the risk of complications during TI and their association with the skill level of the intubating physician. The overall risk of complications was 39%, with serious complications in 24% of the patients, including severe hypoxaemia (19.1%), severe hypotension (9.6%), oesophageal intubation (7.4%) and frank aspiration (5.9%). Difficult intubation (three or more attempts by an expert) occurred in 6.6%. Using similar definitions, Jaber *et al*.,[4] reported severe complications in 28%, with severe hypoxaemia (25%) and hypotension (26%) as the most common complications. Difficulty in intubation with multiple attempts (>3) were reported in 12%. Intubation for acute respiratory failure and presence of shock were independent risk factors for severe complications, along with ≥3 intubation attempts. More recently, Martin *et al*.,[6] reported the results of 3,423 emergent non-operating room airway management cases (out of which 60% were in the ICU) over a 8-year period. Complications occurred in 4.2%. The incidence of difficult intubation was 10.3%. Among 2,284 intubations performed by residents, independent predictors of the composite complication outcome were three or more intubation attempts, grade III or IV view, general care floor location and emergency department location.

CHALLENGES IN AIRWAY MANAGEMENT IN THE CRITICALLY ILL

Response to pre-oxygenation

In critically ill patients with oxygen transport limitations (alveolar volume loss and shunt fraction) and suspected time-consuming airway management, maximal pre-oxygenation is strongly indicated to buy adequate amount of time to tolerate apnea. During apnea, the time course of oxyhaemoglobin desaturation to below 85% is only 23 s in a typical critically ill post-operative patient, whereas it is 502 s in a healthy adult. Mort[7] studied pre-oxygenation by bag-valve-mask for 4 min in stable controls undergoing cardiac surgery and unstable critically ill patients. In the controls, PaO_2 increased from 79±12.3 to 403.6±71.8. On the other hand, in ICU patients, the PaO_2 increased from 64.2±3.5 to 86.8±9.5, and there was a <5% change from baseline PaO_2 in 41% of the cases. Furthermore, only 6% had an increase in PaO_2>50 mmHg with pre-oxygenation.

Thus, conventional pre-oxygenation fails to improve PaO_2 adequately to tolerate even a moderately prolonged period of apnea in critically ill patients.

Attempts at tracheal and oesophageal intubation

Mort reported episodes of severe hypoxaemia SpO_2<70% in 28% patients and an incidence of oesophageal intubations as high as 51% in patients requiring three or more attempts at TI.[8] The incidence and severity of complications was significantly lower in patients who required two or fewer attempts at TI. They recommended that the number of attempts at TI should be limited to two in critically ill patients. Mort also showed that every single episode of oesophageal intubation increased the risk of hypoxaemia by 51%, with an 11-fold increase in the risk of hypoxaemia in the subsequent attempts.[9] Hence, endotracheal tube (ETT) placement confirmation with a rapid, reliable and portable technique, e.g. capnography, is essential to rapidly detect oesophageal intubation.[9]

In summary, complications during TI in patients with acute hypoxic respiratory failure along with a hypermetabolic state like severe sepsis and shock who are hypoxic at the time of TI is contemplated are frighteningly common. Patients have a poor response to pre-oxygenation, and emergent airway instrumentation in the hands of inexperienced doctors leads to multiple attempts, creating a difficult airway scenario with one or more oesophageal intubations, frequent episodes of severe hypoxaemia and, consequently, cardiac arrest.

STRATEGIES FOR AIRWAY MANAGEMENT IN THE INTENSIVE CARE UNIT

Being prepared for unforeseen complications during TI is of prime importance in a critically ill patient. Furthermore, conditions for intubation should be as close to ideal as possible in a busy ICU environment. In anaesthesia and pre-hospital practices, specific procedures [i.e., pre-oxygenation, rapid sequence intubation (RSI) using the combined administration of a sedative and muscle relaxant agent, capnography to check the correct tube placement, etc.] are included in guidelines and are recommended to improve intubation safety.[10] Such standardized recommendations are lacking in ICU practice.

SUPERVISION AND EXPERTISE

Jaber *et al*.,[4] evaluated 253 occurrences of TI in 220 patients in seven French ICUs. Endotracheal

intubation (ETI) performed by a junior physician supervised by a senior (i.e., two operators) was identified as a protective factor for the occurrence of complications. Schmidt *et al*.,[5] performed a prospective cohort study, enrolling 322 consecutive patients who required emergent intubation. One hundred and fifteen were intubated with attending anaesthesiologist supervision, whereas 207 where intubated by anaesthesia residents in the absence of an attending anaesthesiologist. There were no differences in demographics, clinical characteristics or illness severity among patients intubated with and without an attending supervision. Supervision by a consultant anaesthesiologist was associated with a significant decrease in complications (6.1% vs. 21.7%; $P<0.0001$). Griesdale *et al*.,[3] were unable to find a difference in the odds of any complication, ICU or hospital mortality by level of expertise of the person performing emergent TI. However, in the study of Martin *et al*.,[6] the overall complication rate was only 4.2% in 3,423 emergency intubations outside the OR. They attributed the low complication rate in their study to the relative increased experience of the first responder. According to their institutional practice, a resident with at least 24 months of perioperative intubation experience is present at each emergent non-operative airway management situation.

These studies suggest that the presence of two operators, one of whom is experienced in airway management, can reduce the incidence of complications during emergent intubations.

ASSESSMENT AND EVALUATION OF THE AIRWAY

Before initiating invasive ventilatory support, the individual should quickly be assessed for (1) the risk for difficult mask ventilation and (2) the risk for DI. Several tests and combinations of tests are available. To mention a few, Malampatti Class (III and IV), thyromental distance <6.5 cm, limited neck mobility, inter-incisor distance <2.5 cm and body mass index >26 are independent predictors of difficult airway in controlled settings. The LEMON (ie, Look externally, Mallampati class, Obstruction, and Neck mobility) airway assessment method may be used to identify the risk of DI in the emergency department. However, in an unpublished study in our ICU, only about 30% of the airways in the emergency setting were evaluated in this fashion.

Drugs to facilitate tracheal intubation, rapid sequence intubation

Cardiovascular collapse frequently occurs within a few minutes following intubation. The additive effects of drug-induced vasodilation and myocardial depression, hypovolaemia, the suppression of the endogenous activation of sympathetic response by the anaesthetic drugs as well as the intrathoracic positive-pressure due to mechanical ventilation are implicated in cardiovascular collapse after intubation in critically ill patients. Fluid loading may prevent severe cardiovascular compromise. Propofol and thiopentone are usually avoided in patients with obvious or potential haemodynamic instability. Ketamine and etomidate are anaesthetic agents widely used in emergency conditions because they have a rapid onset, a short half-life, are well tolerated haemodynamically and improve intubation conditions. Etomidate is an agent suspected to have a negative effect on adrenal function. Considering the need for a cardiostable agent, use of ketamine is advocated in the ICU.[11] Majority of ICU patients are considered to have a full stomach; hence, securing the airway with a rapid sequence intubation seems logical. Succinylcholine has a rapid onset and short duration of muscle relaxation and is recommended for RSI[12,13] when there are no contraindications to its use. The cannot ventilate–cannot intubate situation after the patient has been rendered apneic by a muscle relaxant is a dreaded complication. Inexperienced doctors are often hesitant in prescribing a muscle relaxant to facilitate intubation in the ICU. However, data from a large dataset[6] suggests that the use of muscle relaxants in associated with fewer complications, including in patients with difficult airways. In a prospective multicentre study, Jaber[4] observed fewer complications when muscle relaxants were used to facilitate intubation (22% vs. 37%). In the emergency department, Li *et al*.[13] found a significant decrease in oesophageal intubation when patients received muscle relaxants (3% vs. 18%). However, there are particular subsets of patients with difficult airways, obstructed airways or those at risk of hyperkalaemia with succinylcholine in whom any or particular muscle relaxants can be detrimental and should not be used.

PRE—OXYGENATION AND CONFIRMATION OF TRACHEAL INTUBATION

Pre-oxygenation prior to airway instrumentation is important. Conventional pre-oxygenation may not give adequate response in patients with respiratory failure.

Baillard *et al*.,[14] undertook a randomized controlled trial to determine whether pre-oxygenation prior to TI with the use of non-invasive positive-pressure ventilation (NIPPV) was superior to that performed in the usual manner using a bag-valve mask device for 3 min duration. The application of NIPPV ensured better pulse oximetric saturation (98±2% vs. 93±6%) and higher PaO_2 values during TI (203 vs. 97 mmHg) and up to 5 min into the post-intubation period compared with the conventional pre-oxygenation method. In acute respiratory failure, NIPPV improves oxygenation by delivering high oxygen concentration, by unloading respiratory muscle, by recruiting alveoli and thereby increasing the functional residual capacity in such hypoxaemic patients.

After TI, it is of vital importance to confirm the endotracheal position of the tube. Auscultation and capnography are widely used and strictly recommended in the OR. In particular, capnography has almost 100% sensitivity and specificity in identifying correct endotracheal tube placement and should be considered mandatory to confirm TI in the ICU. Following intubation in cardiac arrest victims, it is recommended that continuous waveform capnography be used not only for confirming TI but also to monitor continuing tracheal placement of the tube.[15] This is especially important during chest compression, when the tube may get dislodged. Others devices that measure carbon dioxide in the exhaled air, like eosophageal detector device, may also be used. A post-intubation chest radiograph must be performed to rule out endobronchial intubation.

AIRWAY MANAGEMENT ALGORITHM IN THE INTENSIVE CARE UNIT

Need and development of algorithm

The acuity and nature of a patient's disease vary depending on the clinical scenario (pre-clinical, emergency department, ICU or OR), which in turn affects the strategic planning of airway management. Assessing a patient's airway prior to performing a potentially difficult TI in the critically ill patient with severe respiratory failure is challenging in the best of circumstances. Hence, a pre-planned strategy is central to managing airway problems.[16,17] Mort performed a retrospective review of 3,035 critically ill patients undergoing emergency airway management over two time periods, 1990–1995 and 1995–2002.[18] He showed that implementation of a protocol requiring the availability of advanced airway equipment and ETT-verifying devices at the bedside resulted in a reduction in cardiac arrest within 5 min of intubation by 50% (from 2.8% to 1.4%).

Several reviews are available on routine and difficult airway management in the ICU.[19,20] The American Society of Anesthesiologists (ASA) task force algorithm for difficult airway has its applicability in OR patients.[10] Difficult airway management in the ICU should take into account the complexity of this setting. Availability of expertise and equipment is varied at different times of the day and night. In the critically ill patient, postponement of TI or use of a supraglottic device for the long term are not viable options. Combes *et al*. developed a very specific algorithm for unanticipated difficult airway management in the pre-hospital emergency setting.[21] The initial step was use of the gum elastic bougie, followed by intubating laryngeal mask airway (LMA) (ILMA). In cases of difficult ventilation with hypoxia, ILMA was to be used first. Definitive airway with cricothyroidotomy was the ultimate rescue in case of ILMA failure. They successfully managed all unanticipated difficult airways using their simple algorithm. However, the incidence of serious complications like severe hypoxaemia (26%) and cardiac arrest (6%) were high. Martin *et al*.,[6] documented a difficult intubation rate of 10.3% in their large clinical dataset of 3,423 emergent non-operative intubations. Muscle relaxation was used in 68% of difficult intubations. Rescue by laryngeal mask airways were used successfully in 10 patients and failed in two patients. Bougie-guided intubation was the definitive airway management technique in 52% of difficult intubations. Nine patients had a surgical airway.

Thus, the algorithm in the ICU may have to give greater importance to intubating aids and the definitive surgical airway as an early option. The laryngeal mask should be viewed as a rescue approach to solve a cannot-ventilate/cannot-intubate scenario. The intubating LMA and other intubating options can still be used as potential intermediates to overcome crises. Modification and extrapolation of the algorithm in the ICU needs initiative and development. Maintaining oxygenation and reversing hypoxaemia has to be the main goal during airway management.[22] Incorporation of supraglottic device early for oxygenation and definitive airway followed by surgical or percutanous tracheostomy in airway management in critically ill patients needs future prospective studies.[23,24] Acquiring knowledge and expertise and adherence

to defined strategies and algorithms can resolve most problems in airway management in the ICU.

Intubation "care bundle" management

Jaber *et al*.,[25] evaluated for the first time an intubation management protocol. They proposed an Intubation Bundle along the lines of the severe sepsis bundles[26,27] and the ventilator bundle.[28] Bundles are a group of "therapies" built around best evidence-based guidelines, which, when implemented together, give greater benefit in terms of outcome than the individual therapeutic interventions.[29] Care bundles have been proposed based on the holistic principle that the whole is greater than the sum of its parts. Bundles remove individual preferences and idiosyncrasies that account for variations in practice by constructing the elements into packages that must be followed for every patient every single time. The goal is to perform all indicated tasks 100% of the time.

Securing the airway not only includes TI but also stability of the cardiovascular system, gas exchange and the neurological status, which has prime importance in critically ill patients. By standardizing care, clinicians ensure that all necessary procedures and therapies are carried out in a timely manner, especially in emergent situations, leading to improved outcomes. The proposed ICU intubation management protocol includes 10 bundle elements.

The 10 Intubation Bundle components are:

Pre-intubation

1. Presence of two operators
2. Fluid loading (isotonic saline 500 ml or starch 250 ml) in absence of cardiogenic pulmonary oedema
3. Preparation of long-term sedation
4. Pre-oxygenation for 3 min with NIPPV in case of acute respiratory failure (FiO_2 100%, pressure support ventilation level between 5 and 15 cm H_2O to obtain an expiratory tidal volume between 6 and 8 ml/kg and PEEP of 5 cm H_2O)

During intubation

5. Rapid sequence induction: Etomidate 0.2–0.3 mg/kg or ketamine 1.5–3 mg/kg combined with succinylcholine 1–1.5 mg/kg in absence of allergy, hyperkalaemia, severe acidosis, acute or chronic neuromuscular disease, burn patient for more than 48 h and spinal cord trauma
6. Sellick maneuver

Post-intubation

7. Immediate confirmation of tube placement by capnography
8. Norepinephrine if diastolic blood pressure remains low
9. Initiate long-term sedation
10. Initial "protective ventilation": Tidal volume 6–8 ml/kg of ideal body weight, PEEP 5 cm H_2O and respiratory rate between 10 and 20 cycles/min, FiO_2 100%, plateau pressure <30 cm H_2O

In a recent study,[25] adherence to the bundle resulted in significantly lower (21% vs. 34%) life-threatening complications (severe hypoxaemia, severe hypotension or cardiac arrest) and mild to moderate complications (9% vs. 21%,) compared with the conventional strategy.

CONCLUSION

TI can be an acute airway emergency in itself. Unstable haemodynamics and failing oxygenation during emergency intubations can be life-threatening. Delaying securing airway or awaking the patient is not an option in case of difficulty in the ICU. Intubation failure or predicted difficulty should lead to alternatives such as NIPPV or tracheostomy. TI performed or supervised by experienced doctors is associated with fewer complications. Familiarity with rescue airway techniques is helpful. Developing standardized evidence-based protocols is the need of the hour for airway management in the ICU environment. Hence, implementation of an intubation care bundle along with a pre-planned approach to difficult airway is essential for safe TI in the ICU.

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Source of Support: Nil, **Conflict of Interest:** None declared