Management of the airway in intensive care

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Abstract

Airway management in the intensive care unit (ICU) is largely uneventful; there is a higher incidence of airway difficulties, however, than those encountered in the operating suite. Management of the airway in the ICU presents challenges unique to this environment that must be coped with by a multidisciplinary team that may be less experienced in airway management than clinicians in the operating theatre. The risks associated with this situation, we believe, may be ameliorated by planning and forethought. This article outlines some of the specific difficulties faced by clinicians in ICU and attempts to provide some guidance as to how these may be overcome, or at least abated. Drug and equipment choices are discussed. A suggestion for a difficult airway algorithm for use in the ICU is put forward. The timing of tracheostomy is discussed. Finally, the importance of the team and the human factors that are at play are touched upon.

Keywords Endotracheal tube; extubation; intubation; oxygenation; tracheostomy

Royal College of Anaesthetists CPD Matrix: 1C01, 1C02, 2A01, 2C02, 2C05, 3C00

Learning objectives

After reading this article, you should be able to:

- recognize the challenges airway management in the ICU presents to the clinician
- be aware of the equipment that may be on an ICU difficult intubation trolley
- be familiar with a suggested difficult airway algorithm for the ICU
- understand that human factors are a major contributor to success or failure in airway management in the ICU (as elsewhere) and that communication and practice may improve performance of the team

As the case opposite illustrates, airway management in ICU patients has a number of challenges that differ from management in other settings. These issues can be divided into the following categories: patient-related; environment related; and staff related. Box 1 summarizes some of these difficulties.

Patient factors

Patients in intensive care are subject to many factors that make managing their airways prone to problems. They often require exogenous support of various organ functions. The lack of cardiovascular reserve requires extreme care on the part of the intensivist in terms of their choice of airway management techniques, especially regarding induction agents with their attendant possibility of cardiovascular collapse. The indications for intubation in ICU often relate to failure of the respiratory system, meaning that the period of time before dangerously low oxygen

Case history

A morbidly obese 67-year-old woman presents to the emergency department at approximately 15.00 hours with abdominal pain. She is diagnosed with acute pancreatitis. She is hypotensive and requires vasopressors to maintain a mean arterial pressure of greater than 65 mmHg. Her heart rate is 110 beats per minute. Her oxygen saturations are 94% while receiving 10 l/minute of O_2 via a Hudson mask and her respiratory rate is 27 breaths per minute. She is transferred to the ICU for ongoing management.

Despite initially appearing to be stable on a low dose of norepinephrine, in the hours following her admission to the ICU she deteriorates and by 0200 her breathing is increasingly labored, her respiratory rate rises to 38 and her saturations have fallen to 84% despite optimal management. It is decided to intubate her trachea to allow invasive ventilation. The medical staff in this ICU overnight consists of an internal medicine trainee with 1 year of full-time intensive care training to date and a junior resident. The on-call intensivist resides 20 minutes away. A call to the anaesthetic department reveals that the covering anaesthetist is currently busy in the operating theatre and unable to attend for some time. The patient is unable to comply with non-invasive ventilation and is becoming increasingly agitated and hypoxic.

Complicating factors in ICU airway management

- Bag mask ventilation is impaired by: upper airway oedema; increased incidence of obesity; and increased age
- Laryngoscopy may be impaired by: limited preoxygenation; higher incidence of anatomical abnormality; and neck immobility (e.g. in C-spine injury)
- Cricothyroidotomy may be more difficult due to the width of the bed and positioning of the patient
- Extraglottic devices may be more challenging to use, due to increased airway resistance and decreased pulmonary compliance of ICU patients

Box 1

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saturation levels are reached after sedation is commenced is likely to be very limited. As well as limited cardiopulmonary reserve, critically ill patients may have impaired renal, hepatic and/or neurological function, adding other dimensions of complexity. The need to intubate a patient for ventilation in the ICU is rarely predictable, thus making a potentially full stomach (which may be exacerbated by gastroparesis in this patient group) and the attendant risk of aspiration a significant issue. In addition, the indications for intubation in critically ill patients are usually time critical, thus removing the option of delaying until other staff are present or of allowing the patient to recover from the effects of the induction agent and attempting intubation at another time. Finally, ICU patients are more likely to have difficult airways with a higher chance of oedema, cervical spine injury and previous intubation attempts. This necessitates the use of an airway assessment tool such as the MACOCHA score.[1]

Environmental factors

The environment at the bedside in intensive care can be very crowded. Potentially, a patient's room may contain multiple infusion pumps, a ventilator, a haemofilter, monitors, and even an ECMO circuit. Additionally, ICU beds are often designed with multiple aims in mind, in particular, facilitating transport of the patient with all the above paraphernalia, preventing pressure sores and facilitating nursing care. The design aims may sometimes conflict with the need for easy access to the airway. Other equipment that may be *in situ*, such as air mattresses, orthopaedic frames and cervical collars, may hamper rapid access to the airway in an emergency. Furthermore, cognitive overload is innate to any airway crisis environment and can be mitigated by the use of cognitive aids to improve performance. The Vortex approach is one aid that has gained significant traction, probably due to the fact that it can be applied to any airway management scenario independent of the user or airway device.[2]

Staff factors

Many intensivists are airway management experts in their own right; however, the various pathways to entry to intensive care training (internal medicine, anaesthesia, emergency medicine as well as direct entry, among others) result in varying skill levels and degrees of comfort with airway procedures. It would seem intuitive that increased airway skills ought to lead to better outcomes. Certainly, the presence of a senior clinician with airway skills supervising the procedure has been shown to improve success in emergency intubations.[3,4]

At present, ICUs have widely varying medical staffing models, with very different levels of expertise with airway management even among staff at the same institution. Additionally, the skill level and experience of ICU nurses with assisting at intubation may be significantly less than that of anaesthetic nurses who routinely assist intubation in the operating suite. If resources permit, select an intubation team with clearly designated roles.[1]

Securing the airway

Pre-oxygenation is a highly desirable step in preparing a patient for intubation. The increased reserve may allow for significantly greater time before desaturation occurs. Unfortunately, lung disease and the ability of the patient to tolerate a facemask may decrease the efficacy of preoxygenation in the ICU setting. However, apneic oxygenation significantly reduces hypoxaemia during emergency intubation.[5] We also advise nasal cannula oxygenation as an adjunct to bag-mask pre-oxygenation, despite the effects on mask seal success.[6] It is worth considering delayed sequence induction as an approach to pre-oxygenation in an agitated patient. Note that sitting the patient at 25−30° of elevation may increase the efficacy of pre-oxygenation and may also enhance the view at laryngoscopy.[7]

Drugs

The most common induction method used to secure the airway in the ICU is a modified rapid sequence induction (RSI). The physiological considerations referred to above make the use of the predetermined, weight-based dosing of the standard RSI (based on the doses required for healthy, ambulant members of the population) unwise and even hazardous in ICU patients. The most commonly used drug for induction, propofol, causes direct depression of myocardial function and alters sympathetic output, leading to a fall in arterial tone. This combination of effects commonly results in significant hypotension.

Alternative agents, such as ketamine and etomidate, have been proposed as more suitable for the critically ill patient. Both these agents have disadvantages − ketamine may increase myocardial oxygen demand and etomidate has the well-documented side effect of adrenal suppression. The use of ketamine is becoming increasingly common in patients with cardiac instability. The use of a fast-acting opioid (such as alfentanil or fentanyl) in order to ablate the sympathetic response to laryngoscopy, together with the use of a much lower dose of propofol, is the author's standard technique. Alternatively, awake intubation using a fibreoptic bronchoscope and topicalization of the airway with local anaesthetic may result in a more cardiovascularly stable intubation, provided there is adequate time to prepare for this course and the airway is not soiled with blood or other material that may prevent adequate visualization with the bronchoscope.

Muscle relaxant is commonly given as part of the standard and modified RSI. In the past, the agent usually chosen was suxamethonium due to its rapid onset and offset. Intensive care patients have a higher than normal incidence of contraindications to suxamethonium − its use is to be avoided in patients with burns older than 24 hours, hyperkalemia, neuromuscular disease and prolonged immobility. In these patients, rocuronium may be preferred. This agent has a fast onset but a prolonged action. This prolonged action may be curtailed, however, by the use of the specific reversal agent Sugammadex®, and recent decreases in the cost of this agent make this a natural choice.

As a general rule, the minimum amount of a drug required to optimize intubating conditions and provide patient comfort should be used. The best guide to this outcome is the judgment of an experienced clinician, allowing for the specific circumstances encountered, rather than dogmatic adherence to specific guidelines regarding dosage and drug choice.

Equipment

An 'airway trolley' should be maintained in all ICUs with standard airway management equipment arranged in a clear and easily navigable manner. Ideally, this trolley would share a basic layout and contents with similar trolleys in the operating theatre suite and the emergency department at the same institution. This reduces the risk of error for rotating medical and nursing staff from these departments (common in many ICUs) as well as providing ICU staff performing airway management tasks outside the ICU with a higher degree of familiarity with the equipment they may encounter. One approach is to colour-code equipment draws according to an airway management flow chart, grouping items likely to be used together or for a particular situation in the same areas. A suggested list of contents is given in Table 1.

Certain classes of item merit further discussion.

- Laryngeal mask airways (LMAs): LMAs are now endorsed as part of most difficult airway algorithms and have been recommended as a definitive option for management of the airway during cardiac arrest by the Resuscitation Council UK and the Australian Resuscitation Council (ARC). Intubation may be possible through a standard LMA or through an intubating LMA (for example the Fast-Trach® LMA). However, despite this advantage, it may be superior to place a second-generation LMA, such as the LMA supreme® or Proseal®, due to their higher pressure seal allowing for higher pressure ventilation (although there is no evidence regarding their use in patients with lung disease) and central reflux channel reducing the risk of aspiration.
- Laryngoscope: It is advisable to have a selection of blades and at least two handles available for all intubation attempts. Additionally, ensuring a McCoy blade (preferably in both 3 and 4 sizes) is available may enhance success in patients with anterior larynxes or limited neck flexion in particular.
- Videolaryngoscopes: These devices provide an indirect view of the larynx. Undoubtedly, the initial view obtained with a videoscope is likely to be superior to that obtained with a standard laryngoscope; converting this view into successful intubation may be difficult for those not familiar with the devices. Practice with these instruments is essential to familiarize oneself with the different techniques required for indirectly viewed intubation. The wide variety of videolaryngoscopes available on the market is a testament to the popularity of these devices. A recent Cochrane review[8] suggests that videolaryngoscopes have a higher success rate, provide a better laryngeal view, and results in less airway trauma. Certainly the time taken to gain familiarity with the device is much shorter. Another benefit of some videolaryngoscopes is the ability to display to the whole team (including a supervisor) the events unfolding in the airway, making these devices very useful for teaching.
- Endotracheal tubes: Endotracheal tubes used in ICU now routinely have high volume, low-pressure cuffs which have been associated with lower incidence of mucosal trauma and resultant tracheal stenosis.
- Capnographs: Determining that intubation has occurred successfully is of vital importance; the observation of waveform capnography showing 6 breaths is perhaps the gold standard, but allowance must be made for the arrested patient, in whom the CO_2 trace may be diminished. Despite this, the ARC and the Resuscitation Council (UK) recommend the use of waveform capnography to confirm endotracheal placement of a tube during an arrest. A wide variety of portable and non-portable devices are available to provide this function. Many units retain portable units in their emergency response carts or bags while having monitored capnography attached to bedside monitors within the ICU itself. It is worthy of mention that, in the NAP4 review, the Royal College of Anaesthetists noted that the lack of bedside capnography was a contributor in more than 70% ICU airway-related deaths, and identified increasing the use of capnography in the ICU as 'the single change with the greatest potential to prevent deaths such as those reported to NAP4'.[9]

Suggested essential contents for airway trolley

Laryngoscope and blades	Macintosh size 3 and 4 blades McCoy 3 and 4 standard handles x2 short handle Kessel 3 and 4 spare charged battery pack
Videolaryngoscope and bronchoscope	Unit specific videoscope with selection of blades, including difficult blade Fibreoptic bronchoscope — paediatric or intubating sized
Airway devices	endotracheal tubes size 5-9 Guedel airways nasopharyngeal airways LMA classic®s size 3-5 LMA supreme® percutaneous tracheostomy kit (e.g. Melker)
Ventilation devices	self inflating bag with O_2 reservoir and PEEP valve ENK O_2 flow modulator (Manujet jet ventilator)
Other	gum elastic bougies airway exchange catheters portable $EtCO_2$ monitor tracheostomy tape (to secure tubes) transpore tape Scalpel (for scalpel-bougie tube cricothyroidotomy technique)

Table 1

Difficult intubation — a suggested approach

Because difficult intubation is not always predictable, it is important that medical and nursing staff are familiar with a difficult airway algorithm, such as the one described below. It is important for the intubator to remember that the goal of the procedure is to maintain oxygenation and ventilation, not merely to pass the endotracheal tube between the cords. Usually, these two goals are closely aligned, but should difficulty be encountered, then it is vital that recurrent attempts to intubate not prevent other interventions designed to maintain the key goals of oxygenation and CO_2 removal.

Cricoid pressure remains a contentious topic with the recent IRIS study[10] demonstrating that pulmonary aspiration is not reduced with cricoid pressure during RSI. It was, however, shown to give poorer laryngoscopic views. It remains unclear whether this finding can be extrapolated to non-OR RSIs. After three unsuccessful attempts at intubation (implementing a change after each attempt), the proceduralist should stop and attempt to oxygenate the patient with bag and mask ventilation or a second generation supraglottic airway device, while preparing the front of neck airway (FONA) set. The likelihood of bag mask ventilation success can be augmented with a two-person technique or the use of adjuncts. (Although use of adjuncts have not been properly studies in the ICU population.) If oxygenation is not possible at this point then a 'can't intubate, can't oxygenate' scenario has occurred, and the proceduralist should proceed directly to a cricothyroidotomy (scalpel technique is preferred, as there is a higher rate of failure and complications with transtracheal jet ventilation via a narrow-bore cannula identified by the NAP4 study). A flow chart illustrating this system is provided in Figure 1.

All members of the team, including medical and nursing staff should be aware of the plan for intubation, as well as the back-up plans should things fail at any point.

Extubation

Extubation planning is a routine part of intensive care. Historically, this has been done using a combination of clinical criteria and objective parameters, but the appropriateness of the timing can be extremely difficult to judge. Guidelines utilizing up to 66 parameters have been published in an attempt to improve the prediction of successful extubation.[11] Despite such efforts, reintubation is a relatively common occurrence and has been associated with increased morbidity.[12,13] In difficult airway patients extubation should be considered a 'trial' with potential requirement for re-intubation.[14]

As a guide, patients should be alert and ventilating spontaneously with low pressure support and PEEP (e.g. 5 cmH_2O and 10 cmH_2O, respectively) and a low FiO_2 (e.g. less than 0.4). Other factors, such as the haemodynamic stability of the patient and their degree of mental clarity, must also be taken into account. Additionally, the time of day, fasting status of the patient, quantity of respiratory secretions, and staffing levels and experience should be considered before extubation is attempted. The initial reason for intubation should also be re-examined as well,

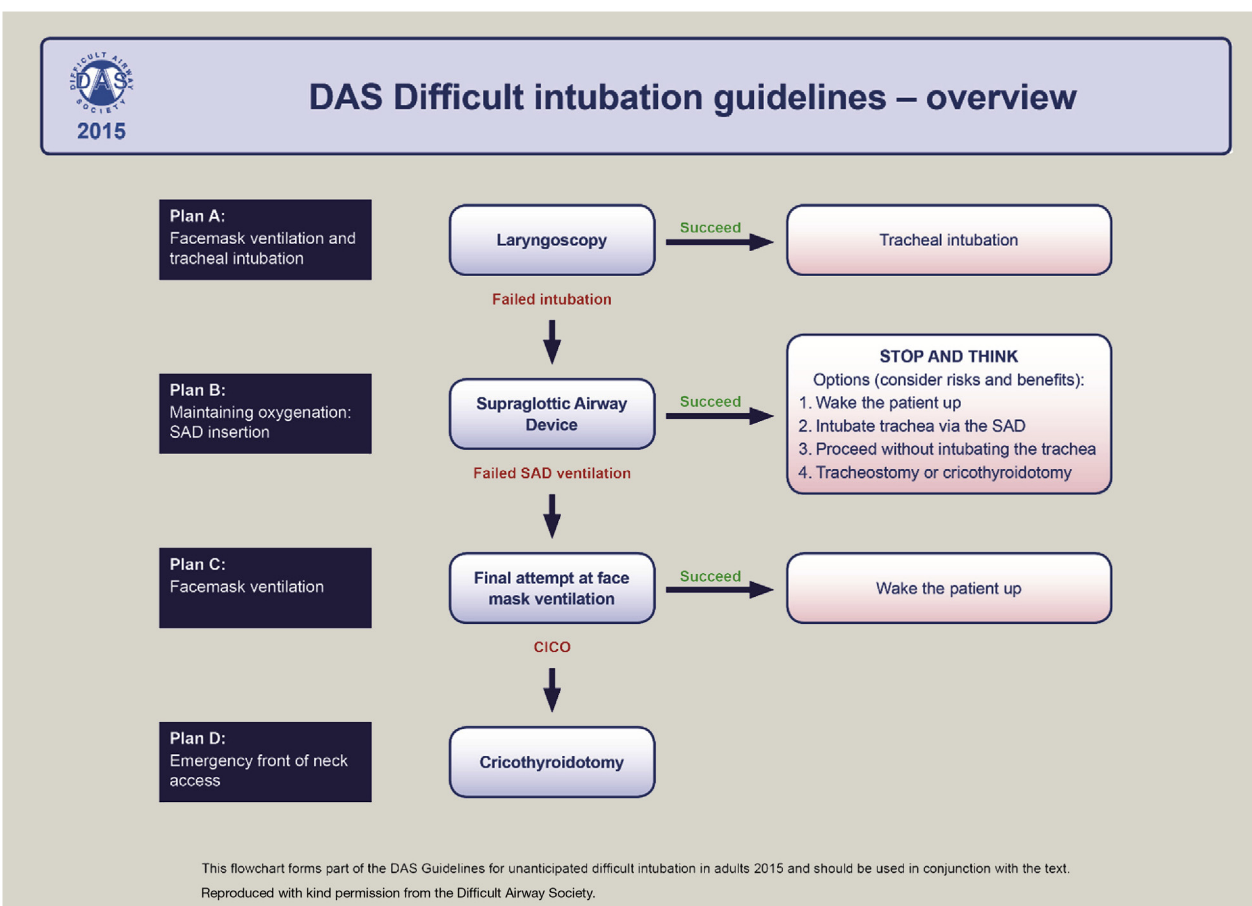

Figure 1

as this may reveal additional pitfalls, for example, in a patient with vocal cord paralysis who is otherwise doing well.

Some extubations may be considered particularly high risk, either because the risk associated with re-intubation is high, or there is a high likelihood of needing reintubation, or both. High-risk extubations include: patients with a history of difficult intubation; those with airway complications (airway oedema, compression or injury); and patients with clinical conditions associated with difficult intubation or ventilation (e.g., morbid obesity, cervical surgery and prolonged intubation). In such cases, a staged extubation may be considered as a way of improving success should reintubation be necessary. This technique involves introducing a hollow tube exchange catheter into the airway prior to extubation and retaining this device until it is clear that extubation has been successful. The use of this technique has been associated with a fivefold increase in the success of first attempts at reintubation.[15] Patients tolerate these devices surprisingly well.[16] As an extension of this technique, Cook Medical produces a staged extubation kit consisting of a reintubation catheter and a coated guide wire. The wire is placed in the airway prior to extubation and may be better tolerated than an airway exchange catheter. The catheter may be railroaded over the guide wire in the event of deterioration requiring re-intubation. Only limited studies have been done that suggests a superiority of the two-staged system.[17]

Tube exchange

Endotracheal tubes may require repositioning or replacement for a number of reasons: occlusion with secretions; cuff leak; inappropriate tube for long-term ventilation (e.g. wire-reinforced tube); incorrect position of tube. Airway changes may occur during prolonged intubation, such as oedema, and the conditions in the ICU discussed above may reduce the success of laryngoscopy compared to previous views in theatre. Therefore, the use of an airway exchange catheter such as the Aintree catheter or a bougie is strongly recommended, even in patients whose airways have previously been documented as not difficult.

Tracheostomy

Tracheostomy is performed when intubation is likely to be prolonged. It reduces the need for sedation and was highly preferable to significant duration of intubation with the rigid endotracheal tubes used in the 1960's. The development of more modern, pliable endotracheal tubes has led to patients tolerating orotracheal intubation for longer periods. Practices around tracheostomy vary widely from unit to unit.[18,19]

Currently, the decision of when to perform a tracheostomy is one of professional judgement, although there is some evidence that early tracheostomy may be associated with better outcomes.[5]

The decision of whether to perform the tracheostomy in ICU or to refer the patient to theatre is dependent on local expertise. Contraindications for percutaneous tracheostomy include: difficult anatomy (fewer than two rings palpable below the cricoid cartilage); presence of vascular structures overlying the trachea (screened for with ultrasound); unstable C spine; raised ICPs, coagulopathy; and significant haemodynamic instability.

Human factors

Many airway catastrophes are potentially avoidable with hindsight; the failure of individuals and teams to react to changing situations as they evolve is a common thread in stories of airway disasters and near misses. Ensuring that all members of the medical and nursing teams are aware of their roles from the outset is a prime responsibility of the clinician taking charge. Also, it is important that, in a deteriorating situation, all staff feel empowered to point out deviations from the plan agreed upon. Regular simulation may assist in achieving these goals. ◆

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