Preventing Airway Disasters

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An adverse event involving the patient's airway can be disastrous, rapidly leading to permanent morbidity or death. When considered in retrospect, numerous points where improved decision-making would have mitigated or reversed the situation can often be identified. Although most adverse airway difficulties can be predicted and prevented, truly unexpected problems still occur. The astute clinician must therefore be skilled, not only in recognising the potential for disaster, but also in responding rapidly and appropriately when it strikes.

Many anaesthesiologists admit to having experienced a preventable airway mishap. However, despite general familiarity with published algorithms for airway management, as many as half would not follow these guidelines in an emergency. Many have not undergone specific practical training in rescue techniques such as cricothyroidotomy.[1] Room for improvement exists for practitioners of all levels. Three areas have been identified: accurately predicting difficulty, gaps in theoretical knowledge and technical skills, and the lack of adherence to accepted protocols.[2]

AIRWAY ASSESSMENT AND PREDICTING DIFFICULTY

Most airway difficulty can be predicted, but there is no single test or factor which will reliably alert the clinician in all circumstances. Groups of factors are useful to improve sensitivity and specificity. Core components of airway management are mask ventilation, laryngoscopy/intubation, supraglottic airway use and surgical

Table 1. Factors predicting difficulty in airway management

Factors predicting difficulty in airway management	
Difficult mask ventilation	**Difficult laryngoscopy and/or intubation**
"MOANS"	**"LEMON"**
M – Mask seal poor (e.g. due to beards) O – Obesity and obstructions in the airway A – Extremes of Age N – No teeth S – Snoring and stiff lungs (e.g. airway burns)	L – Look externally E – Evaluate 3-3-2 Rule* M – Mallampati grading O – Obstructions N – Neck mobility reduced or girth increased
Difficult supraglottic airway use	**Difficult surgical airway access**
"RODS"	**"SHORTY"**
R – Restricted mouth opening O – Obstructions D – Deformity of airway anatomy S – Stiff lungs (e.g. bronchospasm)	S – Surgery to the neck (including prior scars) H – Haematoma in the anterior neck O – Obesity R – Radiotherapy to the neck T – Tumours or local trauma Y – Very young patients (<6 years/20 kg)
**3-3-2 Rule: Three fingers mouth opening (inter-incisor distance), 3 fingers thyromental distance, 2 fingers thyrohyoid distance.*	

airway access. Many of the factors predicting difficulty overlap between these areas, making a rapid, targeted clinical assessment practical in all, but the most dire emergency (see Table 1). Special investigations such as plain x-ray, computed tomography (CT), magnetic resonance imaging (MRI) or awake upper airway endoscopy, may be advisable in specific situations.[3,4]

Effective mask ventilation is the most important and yet least emphasised airway skill. Even where intubation is impossible, continued oxygenation and ventilation by face mask will prevent critical hypoxia. Conversely, if failure to oxygenate with a bag-mask is identified, immediate action is essential.

Failure to intubate can be due to difficulty either in laryngoscopy or in passage of the tracheal tube. While either situation can result in disaster, the former has become less common with the regular use of indirect (video or optical) laryngoscopes. Practitioners must be skilled in the use of appropriate bougies and introducers, especially if hyperangulated, non-chanelled video laryngoscopes (VLs) such as the Storz C-MAC D-blade™ or Glidescope™ are used.

The use of supraglottic airways (SGAs, for instance the Laryngeal Mask Airway®) has become very common, both for routine anaesthesia and as a rescue airway where intubation has failed or intubation skills do not exist.[5-9] Indeed, the Classic LMA® has been shown to be an effective rescue device in 94% of "cannot intubate, cannot oxygenate" (CICO) situations,[10] and all modern difficult airway algorithms now advise the use of a supraglottic airway before considering surgical airway access.[11-14] It is essential to recognise patients where the anatomy or pathology prevents their use (see Table 1).

Surgical airways can be achieved using a needle technique, leading to jet insufflation or retrograde intubation, or by performing either an emergency cricothyroidotomy or formal tracheostomy. Recent evidence and the latest guidelines suggest that in the emergency setting, immediate cricothyroidotomy may be more successful than placing a cannula.[5,6,15] However, this requires effective simulation training and immediately available equipment. Again, it is essential to recognise the patients in which surgical airway access will be difficult or impossible.

If factors predicting difficulty are identified for more than one core component, referral to a setting or centre capable of specialised techniques is advisable. This may include awake flexible endoscopic intubation or awake tracheostomy in the operating theatre.

PLANNING

Any area in which airway management is expected to take place should include basic airway equipment and rescue devices in a variety of appropriate sizes. Routine basic equipment includes face masks, Magill's forceps, oral and nasal airways, rescue airways such as an LMA™, a bag-valve-mask device, appropriate endotracheal tubes and introducers, laryngoscopes with a variety of blades (including a VL or optical laryngoscope [e.g. Airtraq™]), and suction equipment. In cases where airway difficulty is not anticipated, it is appropriate to proceed with routine management, provided equipment for unexpected events is available. This equipment should be stored in a marked airway resource cart or toolbox, and should be checked regularly. In South Africa, lists of suggested equipment and the relevant sources are contained in the Southern African Society of Anaesthesiologists (SASA) Airway Guidelines, which are freely available.[16]

If difficulty is anticipated, a clear set of prioritised plans (Plan A, B, C, etc.) should be formulated based on the airway assessment, and communicated to the team (DAS Guidelines). It may be appropriate to fetch additional equipment (such as a video laryngoscope or surgical airway kit) and place it at the bedside. The plans should emphasise safety and offer 'escape routes', such as waking up the patient or using an alternate device.

Algorithms and cognitive aids

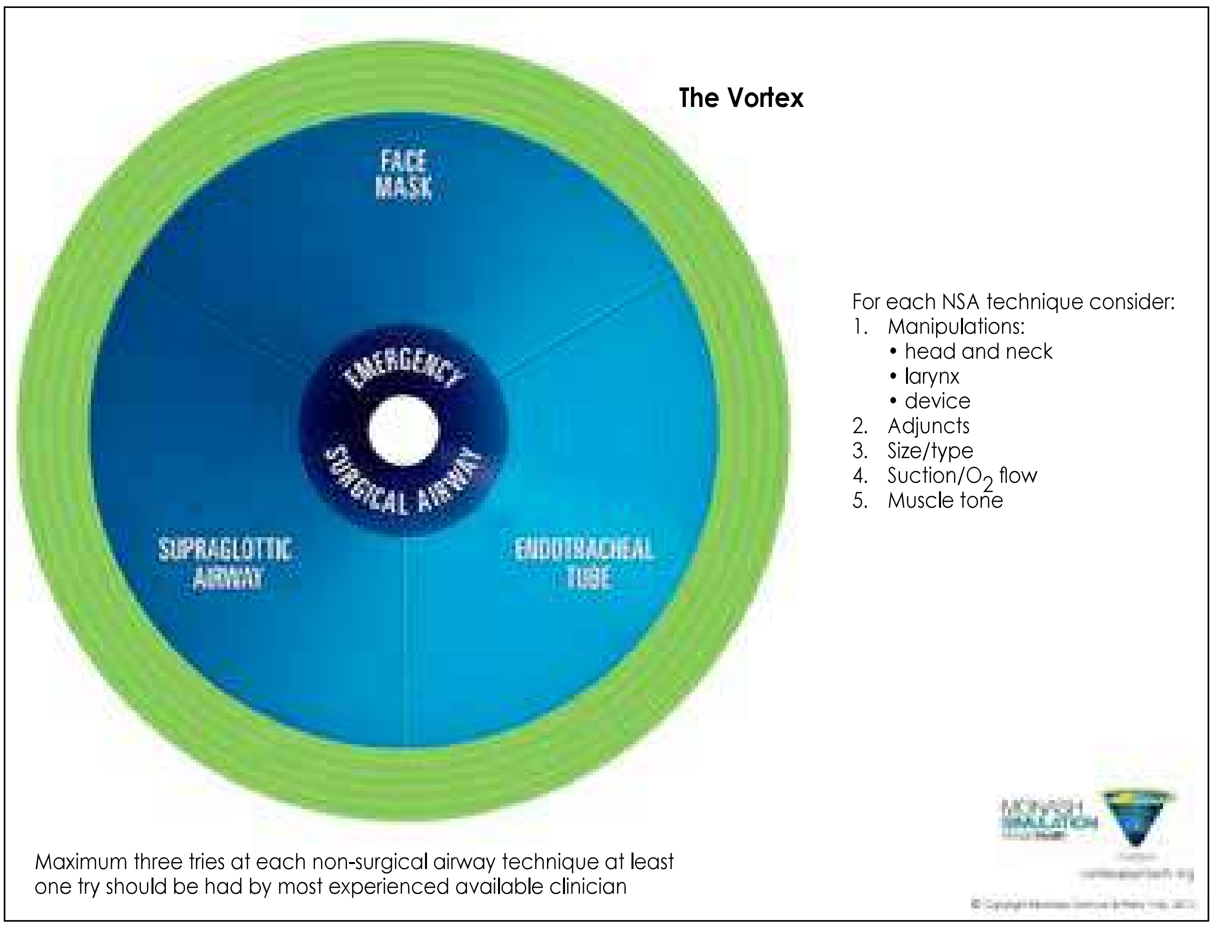
Many national and special interest societies have created airway algorithms for both anticipated and unexpected difficulty.[11-13, 15, 17-19] More recently, specific paediatric and obstetric difficult airway algorithms have been promulgated.[11] While very useful for educational purposes, all but the simplest algorithm is challenging for the clinician to remember and follow during an impending airway disaster.[1,21] To address this, simple cognitive aids and checklists have been proposed. Importantly, these aids should be prominently displayed in areas in which airway management occurs, and should be regularly used in simulation training.[22] An excellent example of a cognitive aid is the Vortex Approach (see Figure 1). A list and open-access links for many of these algorithms and cognitive aids are available online at www.openairway.org.

HIGH RISK INDUCTIONS – POSITIONING AND PRE-OXYGENATION

Careful patient positioning greatly improves intubating conditions and success. Effective positioning can be achieved by ensuring the earlobe and sternal notch are in the same horizontal plane, and the patient's facial access is parallel to the ceiling.[23,24]

Patients with critical illness are at a much greater risk of adverse events during airway management, because of their reduced physiological reserves and increased metabolic demands. This may in turn be caused by lung pathologies, decreased level of consciousness, reduced innate airway protection, reduced oxygen carrying capacity, and decreased respiratory drive as they near the point of decompensation. Recent

Figure 1. The vortex approach



Source: Open access from http://www.vortexapproach.com/Vortex_Approach/Vortex.ht ml attention has focused on strategies to increase effective pre-oxygenation and decrease the likelihood and rate of desaturation.[25]

Pre-oxygenation can be improved with CPAP or assisted ventilation to increase mean airway pressure, using a bag-valve-mask-reservoir (e.g., Ambu® Bag) with a PEEP valve, or by manually assisting ventilation on a circle system. Some centres use non-invasive ventilation (NIV) by face mask; many ICU and anaesthesia ventilators can do this in pressure support mode.[26] Nasal cannula oxygen, especially using high-flow systems, also provides CPAP and pre-oxygenation.[27]

Apnoeic oxygenation (‘ApOx’) can be used where intubation attempts are anticipated to be difficult and/or prolonged.[28] Ideally, it should be achieved with the use of specifically designed high-flow nasal cannula,[29] but normal nasal cannulae at flow rates of 10-15 L/min for short periods are effective and well tolerated.[30,31] This has also been described in paediatric patients at risk of desaturation.[32] A laryngoscope modified to deliver oxygen is also a proposed option.[33]

“Delayed Sequence Intubation” (DSI) is a strategy for the patient who is delirious or combative due to the effects of the presenting medical condition and/or hypoxia, and is therefore challenging to pre-oxygenate. A dissociative dose of ketamine (0.1-0.2 mg/kg) is used to optimise patient compliance without causing apnoea, and therefore improves pre-oxygenation. It can be thought of as a procedural sedation, where the procedure in question is adequate pre-oxygenation. While the utility is obvious to anaesthesiologists familiar with the use of ketamine in critically ill patients, the evidence is still limited to one prospective but observational trial which showed improved oxygenation without complication.[34]

USING NEWER TOOLS

A rapid increase in the variety of airway equipment has occurred over the last decade. Particular areas of expansion have been in the fields of video laryngoscopes and supraglottic airways. Especially in difficult airways, VLs are effective in improving laryngoscopic view during intubation, and improve first-pass success rates, but require training and familiarity with the particular device and the use of a suitable introducer.

SGAs are critical for airway rescue in failed intubation, and can facilitate subsequent intubation either by using either a flexible endoscope, a video device built into the SGA, or a blind technique. It is appropriate to use a second generation SGA (allowing placement of a gastric tube) as a rescue airway, although for blind intubation, the Fastrach ILMA remains the gold standard.

Clinicians should be trained and practise with the devices available in their facility during routine airway management to guarantee effective use in an emergency. Competency with a device in each class is more important than availability of a wide range of devices.

CONFIRMATION, MONITORING AND PREVENTING AIRWAY DISPLACEMENT

While pulse oximetry is an important standard of care, the only method of confirmation and continuous monitoring of endotracheal tube placement suitable to all situations is waveform end-tidal capnography (E_tCO_2). A square capnography waveform demonstrates a patent airway and effective alveolar ventilation, and the E_tCO_2 value can be monitored to ensure adequate ventilation. It also provides an early warning of ventilator failure, tube obstruction, tube dislodgement, etc. Routine use of capnography in all areas in which patients are ventilated should be mandatory.

Careful securing of endotracheal tubes and care during patient movement is important to prevent accidental extubation. The ETT should always be disconnected during movement and protected during transportation. A patient is much more likely to tolerate a brief cessation in ventilation than an unplanned extubation.

Table 2. DOPES mnemonic for sudden difficulty in ventilation

Common causes of sudden failure of mechanical ventilation
"Dopes"
D – Dislodged/displaced endotracheal tube; check ETT is still secured and in trachea
O – Obstruction; check for secretions, clots, mucous, blocked filters, ETT or circuit kinks, and so on
P – Pneumothorax; confirm bilateral air entry and decompress tension if required
E – Equipment failure; check gas and electricity supply, valves and connections
S – Stomach distension; decompress with a nasogastric tube if necessary

TROUBLESHOOTING PROBLEMS IN VENTILATION

The "DOPES" mnemonic is useful to rapidly identify the cause of sudden difficulty or failure in mechanical ventilation (see Table 2). A self-inflating bag-mask device, alternate oxygen source and basic airway equipment should be immediately available in every room where mechanical ventilation is provided.

PLANNED EXTUBATION

Although the initial (intubation) phase of airway management receives the most attention and study, it is now recognised that airway disasters are equally common during emergence from anaesthesia and/or extubation.[5] Fortunately, algorithms to assist in the identification and management of patients at risk during extubation are freely available.[35] Patients should always be extubated in areas with adequate equipment and suitably qualified staff for reintubation and management of airway emergencies.

SUMMARY

Despite continued and rapid development of equipment and strategies for airway management, airway disasters still occur and can result in severe consequences. Preparation, anticipation of difficulty, selection of suitable initial and rescue plans, and training in the use of the available equipment is essential to prevent poor outcomes. Practised skill, good communication, and the use of cognitive aids will further enable the practitioner to provide excellent care.

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