Acute Airway Obstruction Following Intubation: A Clinical Dilemma

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Partial or complete blockage of a newly placed artificial airway, such as an endotracheal tube (ETT) or tracheostomy, by intraluminal or extraluminal sources may present acutely or more innocuously. A slow, progressive narrowing of the lumen may not be recognized until it begins to affect peak inspiratory airway pressure, luminal resistance when passing a suction catheter, or problems with weaning the patient from mechanical ventilation. Clinical signs and symptoms may be absent or nonspecific until substantial or complete obstruction of the lumen occurs. Discrete changes in respiratory parameters resulting from luminal accumulation may remain undetected for a prolonged period, even when changes in the inspiratory and expiratory flow pattern are evident.1-9
Preemptive monitoring with advanced sound technology and periodic inspection of the respiratory parameters may assist the clinician in earlier detection and prompt corrective action. Such intervention may reduce the risk for morbidity and mortality (Figure 1).\textsuperscript{10-14}

Although the accumulation of secretions, blood, and biofilm are common precursors of luminal narrowing, other causes of obstruction include manufacturing defects in the ETT or tracheostomy tube, damage to the tube caused by clinicians or patients, luminal kinking, cuff herniation, encroachment of the tube tip against the tracheobronchial mucosa, bronchospasm or foreign bodies such as dental implants, granulation tissue, teeth, or the misplaced tip of a nasogastric tube.\textsuperscript{15-24} Manual or mechanical ventilation may become difficult or impossible regardless of the location of airway obstruction. Although these challenges may silently disturb the mechanically ventilated patient, surveillance, monitoring, and vigilance may allow for early intervention. Conversely, the obstructive process may be acute and life-threatening, occurring during or immediately following urgent and emergent tracheal intubation of the critically ill patient. Although this airway setback appears to be uncommon, the presence of pulmonary pathology, including pneumonia, retained secretions, pulmonary hemorrhage, and aspiration, may pose a particular risk for this potentially catastrophic airway event. Its incidence in the setting of urgent and emergency tracheal intubation has not been reported. However, its potentially serious consequences justify its review and an offering of therapeutic strategies (Cases 1-3).

The Clinical Dilemma

Emergency tracheal intubation may be required for mechanical support based on respiratory insufficiency over an airway exchange catheter and visualized in the glottis. Initial bag-valve ventilation was easy, with positive capnography. Increased resistance to hand ventilation and a loss of the capnography waveform occurred. The location of the ETT was confirmed by laryngoscopy, with no evidence of kinking or patient biting.

The patient was extubated after clinicians were unable to pass a 14Fr suction catheter distally, coupled with falling oxygen saturations. Successful manual bag-mask ventilation was followed by a single attempt at reintubation with direct visualization of ETT placement within the glottis. Manual ventilation proved difficult, culminating in sudden desaturation and bradycardia that progressed to cardiac arrest. Repeated episodes of inability to ventilate required the ETT to be removed 3 more times followed by uncomplicated reintubation. Saline irrigation through the fifth ETT allowed suction removal of a significant amount of thick secretions. Following the spontaneous return of pulse, cardiopulmonary resuscitation (CPR) was suspended after 12 minutes. However, the patient had sustained severe anoxic brain injury. Examination of each removed ETT revealed obstruction of the distal 6 cm by thick, tenacious secretions.

Case 1

On postoperative day 3 after open heart surgery, a 68-year-old woman with respiratory insufficiency and severe cardiac dysfunction required her ETT to be exchanged for a persistent cuff leak resulting from rupture of the cuff. Documented tracheal secretions were trace. Intubation in the operating room (OR) had been straightforward. Prior to intervention, 100% oxygen (10 minutes), pharmacologic sedation-analgesia, appropriate positioning, and conventional laryngoscopy revealed a Cormack-Lehane grade 2 view, with a visible epiglottis, posterior portion of true and false cords, and the arytenoids. The existing 8.0 ETT was replaced over an airway exchange catheter and visualized in the glottis. Initial bag-valve ventilation was easy, with positive capnography. Increased resistance to hand ventilation and a loss of the capnography waveform occurred. The location of the ETT was confirmed by laryngoscopy, with no evidence of kinking or patient biting.

The patient was extubated after clinicians were unable to pass a 14Fr suction catheter distally, coupled with falling oxygen saturations. Successful manual bag-mask ventilation was followed by a single attempt at reintubation with direct visualization of ETT placement within the glottis. Manual ventilation proved difficult, culminating in sudden desaturation and bradycardia that progressed to cardiac arrest. Repeated episodes of inability to ventilate required the ETT to be removed 3 more times followed by uncomplicated reintubation. Saline irrigation through the fifth ETT allowed suction removal of a significant amount of thick secretions. Following the spontaneous return of pulse, cardiopulmonary resuscitation (CPR) was suspended after 12 minutes. However, the patient had sustained severe anoxic brain injury. Examination of each removed ETT revealed obstruction of the distal 6 cm by thick, tenacious secretions.
resulting from inadequate clearing of secretions, poor cough, and shallow respiration, each of which can occur with a variety of pathologies. Previously dormant secretions within the upper and lower airways may be mobilized once intubation is completed and positive pressure ventilation commences. Previously innocuous and unrecognized retained secretions may shift proximally to obstruct the patient’s airway with life-threatening consequences. Thick secretions, debris, or blood clots within the airway may slowly or acutely lead to narrowing or obstruction of the ETT lumen, the tracheobronchial tree, or both. Moreover, during the exchange of an ETT in a patient maintained on elevated positive end-expiratory pressure, the sudden loss of pressure appears to allow proximal movement of retained secretions that had previously been undetected or unreachable by standard suction techniques. Movement of the obstructing material toward the tracheo-carinal region potentially may result in exceedingly difficult or impossible ventilation, thus interrupting oxygen delivery. Partial or complete luminal obstruction may occur.

Determining the precise location of the obstruction may be challenging. Passage of a suction catheter may provide hints of the location of the narrowing. Bronchoscopic evaluation may pinpoint the obstruction and assist with verifying the location of the tube. If the obstructive material is located distal to the ETT, in the trachea, carinal region, or mainstem bronchi, irritation, suctioning, bronchoscopy, or tube exchange may prove insufficient.

Diagnostic Considerations

The airway team must be ready to handle compromised airways through both diagnostic acuity and therapeutic maneuvers. Rapid assessment to narrow the differential diagnosis is unquestionably imperative to isolate the problem (Table 1). Vigilant attempts to identify the location of the obstruction will hasten the deployment of rescue therapies. This is particularly imperative because they differ between in situ ETT obstruction (and its degree) and obstruction distal to the tip of the tube. The increase in resistance or complete inability to ventilate can be categorized most conveniently into conditions involving the ETT/tracheostomy or external to the tube itself (Table 1). A rapid assessment is imperative to identifying the etiologies of the airway compromise and to hasten deployment of corrective measures.

Being aware of the patient’s current and past medical-surgical history and airway management issues may assist in narrowing the differential diagnosis. Immediate access to respiratory care adjuncts, such as saline or mucolytic irrigation, suction catheter access, difficult airway management equipment, as well as flexible fiber-optic bronchoscopy is warranted. Partial or total obstruction of either the artificial airway or tracheobronchial tree or both by inspissated mucus, blood, or tissue may require rapid irrigation and suctioning, either blindly or by fiber-optic assistance or tube replacement.

How Common Is This Problem?

The literature does not specifically comment on this acute airway emergency; thus the incidence of such events is not well defined. Likewise, the incidence of acute airway obstruction of any etiology is unknown. The most devastating consequence of airway

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**Table 1. Differential Diagnosis for Acute Partial or Complete Airway Obstruction**

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ETT: Intrinsic</strong></td>
<td>Endotracheal Tube (ETT) luminal kinking, ETT tip kinking</td>
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<tr>
<td></td>
<td>Cuff herniation occluding distal ETT tip</td>
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<tr>
<td></td>
<td>ETT tip-Murphy eye angulated against tracheal/bronchial wall</td>
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<tr>
<td></td>
<td>Impingement/compression of armored ETT (without recoil)</td>
</tr>
<tr>
<td></td>
<td>Luminal secretions, blood clots, particulate matter</td>
</tr>
<tr>
<td></td>
<td>ETT manufacturing defect, damage</td>
</tr>
<tr>
<td><strong>ETT: Extrinsic</strong></td>
<td>Light anesthesia, bucking, coughing, straining</td>
</tr>
<tr>
<td></td>
<td>Severe bronchospasm</td>
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<tr>
<td></td>
<td>Bronchial intubation</td>
</tr>
<tr>
<td></td>
<td>Patient biting, jaw clenching</td>
</tr>
<tr>
<td></td>
<td>Subglottic-tracheal stenosis, web, synechiae</td>
</tr>
<tr>
<td></td>
<td>Tracheobronchial tree foreign body (e.g., tooth, NGT, stent displacement)</td>
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<tr>
<td></td>
<td>Tracheal compression-collapse (e.g., mass effect, tracheomalacia)</td>
</tr>
<tr>
<td></td>
<td>Tracheobronchial injury (e.g., bronchial tear)</td>
</tr>
<tr>
<td></td>
<td>Secretions, blood clots, particulate matter distal to ETT</td>
</tr>
<tr>
<td></td>
<td>Granulation tissue (e.g., prior injury, tracheostomy)</td>
</tr>
<tr>
<td></td>
<td>ETT misplacement (e.g., pyriform sinus, esophagus, supraglottic location)</td>
</tr>
<tr>
<td></td>
<td>Severe chest wall-lung stiffness, reduced compliance</td>
</tr>
<tr>
<td><strong>Miscellaneous</strong></td>
<td>Malfunction of manual bag assembly, anesthesia circuit</td>
</tr>
<tr>
<td></td>
<td>Occluded/defective disposable ETCO₂ detector, HME device</td>
</tr>
</tbody>
</table>

ETCO₂, end tidal CO₂; ETT, endotracheal tube; NGT, nasogastric tube; HME, heat moisture exchange
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obstruction, hypoxia-driven cardiac arrest, was noted in a recent review to be rare (5 arrests in more than 3,000 emergently intubated patients outside the OR, 0.2%).

The author reviewed his own airway database, comprising more than 3,100 patients—approximately 2,200 intubations and 900 ETT exchanges—who underwent primary tracheal intubation under urgent or emergent circumstances or ETT exchange outside the OR over a 15-year period. The number of patients who experienced any degree of airway obstruction during the procedure is unknown. However, the proportion of those who experienced life-threatening consequences from such an event was approximately 1.6% (51 cases). Mild to moderate obstruction occurs regularly in the critically ill population, but typically resolves quickly with basic interventions (suctioning, irrigation) without apparent significant sequelae.

**Risk Factors**

The etiology of airway obstruction that resulted in serious consequences had a recognizable theme: unrecognized and recognized retained pulmonary secretions. Generally speaking, affected patients had experienced trauma to the chest wall with pulmonary contusions and hemorrhage; had aspirated particulate matter; had bronchopneumonia; and were debilitated with a poor cough and limited ability to clear secretions. Although most patients easily qualify in more than one category, the distribution is based on the principal pulmonary pathology at the time of the airway intervention; thus, the variety of clinical situations included pulmonary trauma/contusion/hemoptysis (n=11; Figure 2), bronchopneumonia (n=12), aspiration (n=8), retained secretions with poor pulmonary toilet and cough (n=10), tracheal stenosis/scarring/granulations (n=3), tension pneumothorax with pneumonia (n=1), bilateral pneumothoraces with hemorrhage (n=1), eroding bronchial malignancy (n=1), tracheomalacia/collapse (n=2), a displaced tracheal stent with granulation tissue (n=1), and occluding tracheal tumor mass (n=1; Figure 3).

**Pattern of Clinical Presentation**

The clinical signs and symptoms of acute airway obstruction will vary, but the problem may have a distinct presentation: Following tracheal intubation, ventilation may immediately be difficult (increased resistance) or impossible; ventilation efforts, which initially may not meet with much resistance, become challenging. Although narrowing or obstruction leads to a “difficult-to-ventilate” situation, the primary concern is not CO₂ exchange but the reduction, interruption, or cessation of oxygen delivery to the patient (Figure 4).

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**Case 2**

A 38-year-old victim of a motor vehicle accident sustained bilateral pulmonary contusions, multiple rib fractures, long bone fractures, and a bronchopneumonia. His support included mechanical ventilation (FiO₂, 45%; 8 cm H₂O PEEP [positive end-expiratory pressure]; IMV [intermittent mandatory ventilation] 8/min). A cuff leak developed during day 4 in the intensive care unit (ICU), requiring replacement of the ETT. Suction requirements for thin, yellow secretions were documented every 2 hours. The patient was preoxygenated with 100% oxygen for 10 minutes and positioned appropriately. Direct laryngoscopy revealed a Cormack-Lehane grade 1 view. Upon extubation of the trachea, the laryngeal structures collapsed. The esophagus was intubated but this was recognized immediately and the ETT was removed. Reintubation of the trachea proceeded without difficulty. Manual ventilation initially was easy, but an abrupt increase in resistance to manual bag ventilation rapidly culminated in desaturation and a bradycardic-hypoxia arrest. CPR commenced, and the nonkinked ETT was visualized within the glottis. It was replaced without incident, but repetitive obstruction of the tube lumen led to high resistance with manual ventilation. The tube was replaced 5 times, the result of ongoing difficulty with manual ventilation over a 30-minute period. Suctioning of the tube proved unproductive, yet a marked improvement in manual hand ventilation occurred at 30 minutes; a spontaneous pulse was regained; and CPR was suspended. The patient suffered severe anoxic brain injury. Unfortunately, examination of the ETTS was neither reported nor recorded.

Figure 2. Thickened secretion-blood concretion removed from distal airway of a trauma patient with fiber-optic bronchoscope.
COMPLICATIONS OF OBSTRUCTION

The life-threatening events that accompany severe partial or complete obstruction of the airway are numerous. Table 2 outlines the baseline rate of hypoxemia typically seen in patients undergoing emergency intubation and exchange of an ETT as a reference point. Oxygen desaturation occurred in 4 of every 5 cases, with the majority experiencing an SpO2 less than 60%. Bradycardia, a response to severe hypoxemia, was common, as was the need for vasoactive agents to combat the slowing heart rate, hypotension, or cardiac arrest. Cardiac arrest requiring CPR typically was the response to the hypoxia-bradycardia event, although one case was related to a tension pneumothorax. Irrigation and suction of the artificial airway was attempted in the vast majority of patients; whereas others had the occluded ETT replaced. The need to replace the ETT more than once as a result of repeated accumulation of blood clots, particulate matter, or thick, tenacious secretions was relatively common. Bronchoscopy was not an option for diagnosis of complete luminal obstruction because corrective measures were immediately deployed. Bronchoscopy as a diagnostic/therapeutic modality was frequent, however, more so during ETT exchange in the ICU, where the equipment was readily accessible.

Planning and Preparedness

Awareness that this potential airway catastrophe is more likely in select patients may improve clinical prowess and hasten the recognition of clinical clues for

Table 2. Complications of Acute ETT Obstruction

<table>
<thead>
<tr>
<th></th>
<th>Emergency Intubation, % (n=36)</th>
<th>ETT Exchange, % (n=15)</th>
<th>Total Complications, % (N=51)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypoxemia (baseline rate)</td>
<td>20</td>
<td>13</td>
<td>35.2</td>
</tr>
<tr>
<td>SpO2 &lt;80%</td>
<td>36 (13)</td>
<td>33 (5)</td>
<td>45.0</td>
</tr>
<tr>
<td>SpO2 &lt;60%</td>
<td>42 (15)</td>
<td>53 (8)</td>
<td>40.3</td>
</tr>
<tr>
<td>Total desaturation cases</td>
<td>78 (28)</td>
<td>87 (13)</td>
<td>81.0</td>
</tr>
<tr>
<td>Bradycardia</td>
<td>39 (14)</td>
<td>40 (6)</td>
<td>35.2</td>
</tr>
<tr>
<td>Vasoactive agents</td>
<td>67 (24)</td>
<td>87 (13)</td>
<td>77.5</td>
</tr>
<tr>
<td>CPR-chest compressions</td>
<td>25 (9)</td>
<td>27 (4)</td>
<td>25.4</td>
</tr>
<tr>
<td>ETT irrigation/suction</td>
<td>81 (29)</td>
<td>86 (13)</td>
<td>85.2</td>
</tr>
<tr>
<td>ETT exchange (1-5 times)</td>
<td>36 (13)</td>
<td>27 (4)</td>
<td>33.3</td>
</tr>
<tr>
<td>Bronchoscopy</td>
<td>31 (11)</td>
<td>60 (9)</td>
<td>35.2</td>
</tr>
</tbody>
</table>

CPR, cardiopulmonary resuscitation; ETT, endotracheal tube
improving diagnostic efficiency. The airway management team will not only require clinical prowess, judgment, and astute diagnostic skills, but also a variety of equipment and airway management adjuncts. Diagnostic decisions often will drive therapeutic interventions to clear the obstruction. The rapid deterioration that may occur with obstruction suggests that technologies capable of predicting or detecting luminal narrowing before it reaches a dangerous threshold are warranted. These technologies, however, may be more applicable to patients with an indwelling ETT or a tracheostomy rather than the newly intubated patient (Figure 5).

Table 3 outlines equipment that should be customized to the needs and skill levels of the airway team. One caveat to remember is that access to multiple sizes of ETTs and tracheostomies is imperative when repeated obstruction necessitates the replacement of the artificial airway. Flexible bronchoscopy is an extremely valuable diagnostic and therapeutic adjunct for this clinical scenario. Access to such equipment, coupled with the skill and experience in its use, is paramount to its success. Access to a pulmonary consultant with advanced training is an alternative in complicated cases.

Case 3

A 34-year-old woman in her 33rd week of pregnancy was suffering from hypoxic respiratory failure resulting from trilobar viral pneumonia. She was placed on non-rebreather support with 100% oxygen. Due to the severity of hypoxia (maximum \( \text{SpO}_2 \), 93%) coupled with frequent hypoxia-induced fetal decelerations, the patient was moved to the obstetric OR for tracheal intubation and possible cesarean delivery. She had obvious cyanotic lips and nail beds, as well as retractions with exaggerated vital signs (heart rate 128 beats per minute, blood pressure 155/83 mm Hg, respiratory rate 40 breaths per minute, and 2- to 3-word phonation). The airway exam revealed a Mallampati class 1 airway, full range of cervical and temporomandibular joint motion, a thyromental distance of 6 cm, and an extremely poor cough effort. She received 10 minutes of 100% oxygen through the anesthesia circuit with a tight-fitting face mask, and had continuous capnographic evidence of ventilation (maximum \( \text{SpO}_2 \), ~95%). The patient was simultaneously prepped and draped for an emergency cesarean delivery, if required. A difficult airway cart and a trauma surgeon for surgical airway access were at hand.

A rapid-sequence induction with cricoid pressure proceeded with continued low-pressure (<12 cm H\(_2\)O) ventilation with 100% oxygen. A 20-second period of rapid desaturation to 81% occurred with view of the cords. Tracheal intubation was successful; however, manual bagging commenced with high levels of resistance. A normal end-tidal CO\(_2\) trace was noted, yet saturations plummeted to 61% over the next 30 seconds. The ETT was visualized within the glottis, and a 14 Fr suction catheter was passed easily to its full length without improvement. The obstetric team proceeded with the emergency delivery. The patient’s \( \text{SpO}_2 \) declined to the mid-50s, as did her heart rate. IV epinephrine was administered to combat possible bronchospasm and to provide hemodynamic support.

Rhonchorous noises were auscultated from the chest. Irrigation of the ETT with normal saline removed significant amounts of tenacious, yellow-brown secretions, and resistance to manual ventilation eased. The \( \text{SpO}_2 \) reached a nadir of 46% before rising gradually to 82% over a 2-minute period. Bronchoscopy revealed the ETT to be at adequate depth, but thick, purulent secretions were occluding both mainstem bronchi. Vigorous irrigation removed the secretions and was followed by markedly improved compliance and oxygen saturation. Cesarean delivery was uneventful, and the mother remained intubated for 48 hours; she and her baby were discharged without complications.

**Figure 5.** View from bronchoscope of a nearly occluded ETT lumen due to viscous, sticky secretion.

Vigorous irrigation and suctioning was successful but was associated with several episodes of desaturation and was time-consuming.
distal structures. However, they serve no useful purpose for suctioning or manipulation of the physical obstructing material. For therapeutic utility, the diameter of the bronchoscope will dictate its suction capabilities and the ability for potentially removing the offending obstruction (Table 4). The mere presence of a suction channel may not provide clinically useful suction capabilities for combating thick, glue-like secretions, blood clots, or particulate matter. Hence, the pulmonary-based models (~6 mm outer diameter) are preferable to the smaller caliber anesthesia-based flexible bronchoscopes (~2.2-4.1 mm outer diameter; Figure 6). Also, removal of luminal secretions may be time-consuming; hence, electrically powered bronchoscopes are preferred over battery-powered models. In cases of extreme occlusion of the distal airway, the rigid bronchoscope is an effective option in skilled hands. For removal of sizable obstructing material, once grasped by suction or forceps, the flexible or rigid bronchoscope may need to be removed from the artificial airway, thus necessitating extubation. Therefore, advanced airway devices may be lifesaving.

Therapeutic Interventions

If increased resistance is experienced immediately following intubation, a rapid assessment of the problem may generate a straightforward resolution: For example, if the patient is biting down, deepening the level of sedation and analgesia and placing an oral airway may correct the obstruction. If secretions are the cause of the obstruction, immediately passing a suction catheter can locate the blockage and facilitate its removal.
Vigorous saline irrigation of the ETT may loosen the sticky obstructive material and improve its removal. If this fails to resolve the partial obstruction, but oxygenation continues to be life-sustaining, deploying bronchoscopy or a luminal cleansing device (LCD) may be indicated. The LCD allows the passage of an inflatable balloon assembly that gently removes the material from the lumen (Figure 7). However, this device is inappropriate if the blood and inspissated secretions reside in the tracheobronchial tree.\(^{25-28}\) It is helpful to incorporate the LCD after visualizing with bronchoscopy to confirm its need.

If poor oxygenation is not an immediate threat and bronchoscopy or the LCD fail to clear the narrowing, exchanging the artificial airway is an alternative. An airway-exchange catheter combined with video laryngoscopy is the recommended technique for exchanging an ETT. If the patient is unable to be ventilated manually, a decision to remove the ETT must be made immediately. If the previous intubation was performed easily, extubation of the trachea and reintubation should be relatively straightforward. However, if difficulty was previously encountered, removal of the occluded tube should be performed over an airway catheter to retain access to the airway and facilitate reintubation. In the critically ill patient, past performance of easy airway management procedures certainly do not accurately predict future success; thus difficult airway equipment should be at the bedside. Bronchoscopy may be helpful for diagnostic purposes, but removal of inspissated mucus and blood may be challenging, time-consuming, or impossible.

The inability to ventilate (and thus oxygenate) almost always requires the artificial airway to be removed and replaced. If acted on immediately in a patient with sufficient oxygen reserves, irrigation and suctioning may relieve the obstruction. However, the inability to deliver oxygen may lead to rapid desaturation and hemodynamic instability, thus prompting removal and replacement of the airway. Thus, many clinicians regard removal rather than an airway exchange catheter to maintain continuous access to the airway to be an absolute requisite for patient safety. Although it should not be condoned as a safe recommendation, the passage of the airway catheter may clear the luminal obstruction. However, clearing the lumen may push the obstructive material into the distal airway. Thus, this exchange procedure may be lifesaving, but it also may create further obstructions. Follow-up bronchoscopy to observe and expedite the removal of the offending material is recommended.

### Conclusion

Although the incidence of airway obstruction associated with tracheal intubation is unknown, this complication can cause catastrophic deprivation of oxygen and hemodynamic deterioration. Rapid assessment and quick deployment of rescue therapies can be lifesaving. Advanced skills and accessory difficult airway management equipment are imperative for improving patient safety.

### References


