



Surgical Management Of the Failed Airway: A Guide To Percutaneous Cricothyrotomy



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The first-known mention of an attempted surgical airway, a tracheostomy, was depicted on Egyptian tablets as early as 3,600 BCE. History has condemned the emergent surgical airway when it has failed, but when successful, the physicians who performed it have risen in esteem to become “on a footing with the gods.”

In 100 BCE, the Persian physician Asclepiades described in detail a tracheal incision for improving the airway.¹ Yet most who advocated surgical approaches to the airway, including Asclepiades, were severely criticized. Vicq d'Azyr, a French surgeon and anatomist, first described cricothyrotomy in 1805. Emergent cricothyroidotomy (also known as cricothyrotomy, mini-tracheostomy, and high tracheostomy) became widely acknowledged and accepted in 1976 when Brantigan and Grow confirmed the relative safety of the procedure.² A decade later, the Seldinger technique, a wire-over-needle procedure commonly used for intravascular cannulation, was adapted for use in obtaining both emergent and nonemergent surgical airways.

The 3 procedures that might be considered in an emergency airway setting include needle cricothyrotomy (with or without jet ventilation), surgical cricothyrotomy (traditional 4-step or percutaneous), and tracheostomy. For anesthesiologists and other nonsurgical specialists, learning needle or percutaneous cricothyrotomy may be more suitable than the more complicated surgical alternatives. The complication rate for emergent cricothyrotomy is substantial, ranging from 10% to 40% of cases.³

Emergent cricothyrotomy is not a procedure that is easily practiced for “real-life” situations. For the anesthesiologist, the decision to abandon traditional intubation and supraglottic ventilation methods for a surgical approach is emotionally difficult. The difficulty is compounded when the physician faces an emergent situation with no time for adequate preparation and discussion.

Psychological preparation throughout one’s career, therefore, is the single most important aspect of training for failed airway situations; not surprisingly, it is stressed repeatedly in numerous publications, including the Anesthesia Patient Safety Foundation’s guidance on the topic.⁴ Exposure to the procedure through simulation may improve the chance of success, but given that not all providers have access to simulation centers, for

most clinicians, the first opportunity to perform the procedure will be on a patient who cannot be intubated or ventilated. Simulation may even improve the chance of success when the only instruments available are a pocketknife and ballpoint pen (although this is highly discouraged). Emergent cricothyrotomy remains a high-risk, low-frequency event that is ideally practiced in simulation centers on mannequins and cadavers. All physicians who deal with the airway should attempt to obtain proficiency in at least one surgically invasive method.

Indications

Certain pathologic conditions in oropharyngeal anatomy may predispose a patient to difficult routine airway management. These include infection, trauma, endocrine disorders, foreign bodies, inflammatory conditions, tumors, and certain physiologic anomalies (Table 1). The rate of performed emergent surgical airways in the out-of-hospital setting is 10 times the rate of the in-hospital setting. In the emergency room arena, the rate is about 1% (of all secured airways), and about 0.1% in the operating room or intensive care setting.⁵

The doctrine that supports performing any surgical airway is the following: A surgical airway should be attempted in order to save the life of an obtunded patient who cannot be ventilated by any other means. In other words, the final cannot-intubate, cannot-oxygenate option in all airway management algorithms is the insertion of an endotracheal tube (ETT) via cricothyrotomy.⁴

Once the decision is made to perform an emergent surgical airway, no absolute contraindications remain in adults (Table 2); it is a last-resort, lifesaving measure, as it is presumed that less-invasive methods have been tried in an attempt to ventilate the patient. (The exception being children under the age of 10 years, including neonates, for whom incision through the cricothyroid membrane may cause irreparable damage and for whom needle cricothyrotomy is the method of choice.)

When time is available, the most experienced surgical clinician should always be consulted first. When no experienced surgeon is available and one’s inexperience or fears preclude action, a larger-bore angiocatheter should be placed into the trachea, and attached to a low-pressure oxygen source at 15 L per minute.

Table 1. Indications for Cricothyrotomy

| |
|---------------------------------|
| Upper airway hemorrhage |
| Midfacial fractures |
| Abnormal facial anatomy |
| Acquired |
| Congenital |
| Airway trauma |
| Inhalational or thermal |
| Foreign body |
| Laryngeal disruption |
| Airway edema |
| Mass (tumor, hematoma, abscess) |
| Supraglottitis |

Table 2. Relative Contraindications To Cricothyrotomy

| |
|---|
| Age <10 y undesirable and <5 y should be avoided completely |
| Preexisting laryngeal pathology: epiglottitis, chronic inflammation, cancer |
| Anatomic barriers: stab wounds, hematoma |
| Coagulopathy |

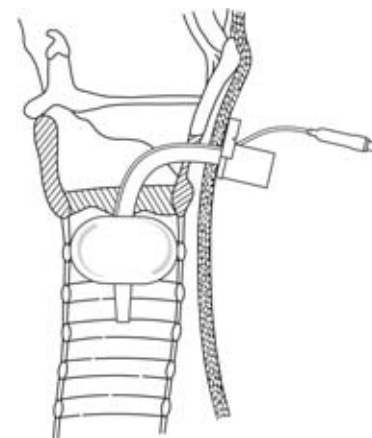
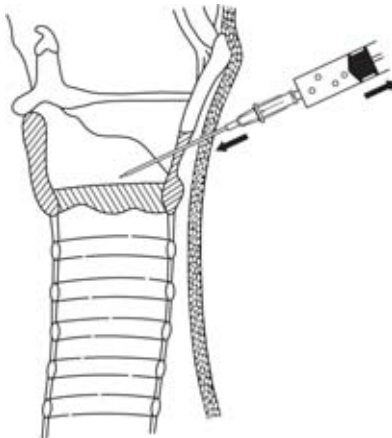


Figure 1. The Melker cricothyrotomy kit.



Figure 2.
The Pertrach kit.



Figure 3.
The QuickTrach kit.



Figure 4. The Portex kit.

Any clinician who performs intubations must know and review the structures of the neck, especially the support structures of the airway (thyroid cartilage, cricoid cartilage, and tracheal rings). The vocal cords are located a short distance (approximately 0.7 cm) above the thyroid notch. An attempt to place a surgical airway here would be harmful, as well as nearly impossible. The cricoid cartilage is a complete cartilaginous ring that can be felt in some individuals. The cricothyroid membrane has a vertical height of 8 to 19 mm and a width of 9 to 19 mm. It is located between the thyroid and cricoid cartilages.⁶ Branches of the thyroid arteries pierce the membrane in its upper third—thus, if possible, cutting the membrane in its lower third is desirable. Identifying the midline of the structure is important, as roughly 30% of the population has large-caliber veins within 1 cm of the midline, whereas only 10% have veins larger than 2 mm

in diameter that cross the midline. In patients for whom the landmarks are difficult to identify, a rule of thumb is that the membrane usually lies 4 fingerbreadths from the sternal notch.

Techniques

The choice of technique for emergency access includes needle cricothyrotomy with high-flow oxygen, surgical cricothyrotomy (open or percutaneous Seldinger technique⁷), and transtracheal jet ventilation. Which method to use ultimately will be dictated by the physician's experience and training with a particular technique. For the purposes of this review, only percutaneous cricothyrotomy using the Seldinger technique will be fully described.

A variety of airway kits is available. These include the Melker (Cook; Figure 1), Pertrach (Pulmodyne; Figure 2), QuickTrach (VBM Medizintechnik; Figure 3), and Portex (Smiths Medical; Figure 4) cricothyrotomy kits. Each of these kits contains detailed instructions for proper use. However, the fundamental approach is essentially the same for all such devices.

- Be sure the cricothyrotomy procedure will effectively bypass an obstruction if present. If the obstruction is within the distal trachea (foreign body, tumor), cricothyrotomy will be pointless.

Table 3. Immediate and Delayed Complications Due to Cricothyrotomy: Elective and Emergent

| Immediate | Delayed |
|---|--------------------------------------|
| Hemorrhage into large neck vessel | Tracheal stenosis/ Tracheomalacia |
| Insertion into wrong tissue space | Bleeding |
| Right mainstem bronchus insertion | Infection/Mediastinitis |
| Esophageal intubation or trauma | Fistulae |
| Laceration of thyroid | Displacement |
| Injury to larynx and/or vocal cords Mediastinal emphysema Hypoxia and death | Scarring |

- Use tools that are provided by the institution and/or the technique that you are most comfortable with. For the Seldinger approach, choose an appropriately sized cannula and determine whether or not it should be cuffed (cuffs allow for better ventilation and should be used whenever possible).

- Assess the adequacy of neck exposure and whether neck extension is permissible. For example, in a morbidly obese patient with difficult landmarks, an open cricothyrotomy approach may be more hazardous than a needle cricothyrotomy. Some percutaneous kits encourage hyperextension of the neck to bring the trachea closer to the surface. This movement may, however, be contraindicated in some patients. If neck extension is not permitted, consider tracheostomy, as some neck extension is necessary to align the head with the long axis of the body before cricothyrotomy.

- An understanding of the relevant anatomy is essential.

The principles of performing an emergency cricothyrotomy remain the same in the child (under the age of 10-12 years), with a few caveats: Everything will be smaller, landmarks will be harder to find, and the chance of injuring an adjacent structure is greater. Rather than

an incision, in children a 14- to 16-gauge needle should be inserted through the membrane. Transtracheal ventilation may be attempted. (QuickTrach kits are available for neonates to adults. They contain a needle and do not require an incision for insertion.)

‘Poor Man’s’ Cricothyrotomy With Low-Pressure, High-Flow Oxygen⁸

Occasionally, an emergent cricothyrotomy must be performed, but a prepackaged device cannot be readily located. When only a “nonsafety” angiocatheter and an adapter from a size 7.5 ETT are available, this technique may allow oxygen to reach the patient while a more stable option is considered. Angiocatheters are suitable for attaching syringes for aspiration of air for confirming entry into the trachea, and for attaching the adapter from a 7.5 ETT for high-flow oxygen delivery.

Oxygen can be administered by replacing the 3-mL syringe with a 10-mL syringe. Remove the plunger. Place a 7-mL ETT into the 10-mL plunger, inflate the cuff, and attach the oxygen line to the adapter end of the ETT.

This procedure does not produce a definitive airway and thus may only provide an additional 10 minutes of oxygenation. Furthermore, if an obstruction to exhalation is present, a second angiocatheter to release built-up carbon dioxide may be placed. Urgent surgical consultation is a must. A needle cricothyrotomy is only a temporary airway until a more stable airway—which may include intubation by a more experienced operator, full surgical cricothyrotomy, or regular tracheotomy—may be obtained. Even a small partial airway may be enough to keep a patient alive and avoid hypoxic brain damage until additional help can be mobilized.

Complications

The cricothyroid membrane is superficial and easily accessible with minimal dissection, yet the procedure is not without disadvantages. The cricothyroid membrane is small and surrounded by adjacent structures—including the conus elasticus, cricothyroid muscles, and central cricothyroid arteries—that are easily injured (Table 3). Damage also may occur to the cricoid cartilage from a scalpel, resulting in perichondritis and stenosis. Immediate complications include damage to the thyroid cartilage and vocal cords, subcutaneous emphysema, hemorrhage, extra-tracheal tube placement, pneumothorax, laceration of the esophagus or trachea, and anoxia from prolonged placement time. Delayed complications include infection, fistulae, and damage to the larynx.

Case Study

When the airway must be secured and time is not severely limited, percutaneous cricothyrotomy with the Seldinger technique may be preferable to percutaneous tracheotomy for those unfamiliar with the latter procedure.

In this case, a 60-year-old man who had undergone 3-vessel cardiopulmonary bypass surgery was extubated 2 days postoperatively, but was reintubated without difficulty shortly afterward because of unexplained tachypnea, tachycardia, and agitation. Bacterial pneumonia was diagnosed and he remained hospitalized for an additional 7 days. Following a trial of extubation, he became tachypneic and severely agitated within 30 minutes and required reintubation. A grade 3 view

was seen with direct laryngoscopy following sedation and full paralysis. Despite the use of the GlideScope (Verathon Medical), significant airway edema prevented visualization of the vocal cords. An LMA ProSeal #5 (Teleflex) was inserted and ventilation was possible. Oxygen saturation improved from the mid 80s to low 90s. A decision was made to secure the airway via a surgical approach, and a percutaneous tracheostomy was attempted by the surgical team. However, despite multiple attempts, a false passage was created and ventilation and oxygenation was never achieved. The patient became more difficult to ventilate via the laryngeal mask airway and cardiopulmonary arrest ensued. The patient could not be resuscitated.

Conclusion

An elective cricothyrotomy carries a complication rate of 6%; for an emergent procedure, the rate approaches 40%, more than a 5-fold greater risk. Nonetheless, in the emergent setting, cricothyrotomy may be easier to perform than tracheostomy for many nonsurgical specialists, and a clinician can perform the procedure with few material resources. Prepackaged sterile percutaneous cricothyrotomy kits are available, and familiarity with a particular kit will increase the success of performing the procedure in little time under a great amount of pressure.

Authors' note: As an anesthesia provider (JS), I do not find that fixing the neck from the patient's right side is comfortable as is recommended from the cephalad position. When I teach this procedure, I frequently stand at the patient's left side (I am right-handed) and fix the neck with my nondominant hand, but from the caudal area below the incision. Doing so allows the dominant right hand to perform the initial needlestick into the neck, which is caudally directed. However, if a neck incision is made initially, it may be preferable to stand on the right side.

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