Emergent surgical cricothyrotomy (cricothyroidotomy)

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INTRODUCTION — Cricothyrotomy (also called cricothyroidotomy) is a procedure that involves placing a tube through an incision in the cricothyroid membrane to establish an airway for oxygenation and ventilation.

The procedure has a controversial past. In 1909, Dr. Chevalier Jackson, a laryngologist at the Jefferson Medical School in Philadelphia, described the surgical techniques and critical considerations related to performing cricothyrotomy, which he called "high tracheostomy" [1]. Before the advent of antibiotics, cricothyrotomy was often performed because of severe infection or an inflammatory process (eg, diphtheria). Dr. Jackson became famous for popularizing the procedure. However, he then began to receive hundreds of referrals for patients who had developed tracheal stenosis following the procedure. After investigating nearly 200 of these cases, he condemned cricothyrotomy in a well-publicized paper [2].

Following this report, cricothyrotomy fell out of favor until the 1970s when two physicians, Brantigan and Grow, reported a series of 655 patients who had undergone elective cricothyrotomy for prolonged mechanical ventilation. They reported a low rate of complications, 6.1 percent overall [3]. Only eight patients (0.01 percent) developed subglottic stenosis, none of whom developed a chronic condition. Consequently, cricothyrotomy, which is generally considered easier to perform than emergent tracheostomy, was revisited and has now become the surgical rescue technique of choice for the failed airway in adults.

Because cricothyrotomy is a rarely performed but potentially life-saving procedure of last resort in the patient with a failed airway, clinicians responsible for airway management must retain familiarity with the necessary equipment and relevant anatomy. While debate continues regarding the merits and risks of various approaches or techniques for performing the procedure, it remains clear that skill acquisition and maintenance are vital. We suggest that emergency clinicians responsible for airway management review the anatomy and practice with the equipment needed for cricothyrotomy several times each year.

Performance of cricothyrotomy in adults is reviewed here. Other aspects of difficult airway management are discussed separately. (See "Rapid sequence intubation in adults" and "The failed airway in adults" and "The difficult airway in adults").

FREQUENCY — Cricothyrotomy is rarely performed, but rates vary among different providers and settings. A five year review at one institution found that cricothyrotomy comprises 1 percent of all intubations in the emergency department (ED) and 10.9 percent of intubations in the prehospital setting [4]. Earlier reports found a cricothyrotomy rate of 1.7 percent for all intubations and a rate of 14.8 percent for all prehospital intubations [5,6].

One study observed a decline in the rate of cricothyrotomies performed on trauma patients over 10 years following the establishment of an emergency medicine residency training program [7]. The cricothyrotomy rate before the residency was 1.8 percent and steadily dropped to 0.2 percent. The authors attributed the decline to several possible causes, including widespread use of rapid-sequence intubation, the presence of supervisory emergency...
medicine faculty 24 hours a day, and diminished concern about performing orotracheal intubation on trauma patients without first ruling out cervical spine injury by radiograph [7].

With ongoing adoption of advanced video laryngoscopy and increasingly effective non-invasive airway rescue techniques, it is likely that the rate of cricothyrotomy will continue to decline. However, while infrequently performed, the procedure continues to be a life-saving intervention and will likely remain the cornerstone of failed airway management for the foreseeable future. (See "Devices for difficult emergency airway management in adults".)

**INDICATIONS** — Cricothyrotomy is indicated when an emergency airway is required and orotracheal or nasotracheal intubation is either unsuccessful or contraindicated. When the clinician cannot intubate and cannot oxygenate (CICO) the patient, the swift establishment of an airway is crucial. Failure to provide oxygen to the brain may lead to anoxic encephalopathy and ultimately death. In a CICO scenario, placement of an extraglottic airway device (eg, laryngeal mask airway) may be attempted as a rescue maneuver or as a bridge to provide ventilation while preparations are made to perform a cricothyrotomy. However, if oxygenation cannot be maintained, cricothyrotomy is required. Management of the difficult and failed airway is discussed separately. (See "The difficult airway in adults" and "The failed airway in adults".)

Conditions associated with a difficult airway that may necessitate cricothyrotomy include massive hemorrhage, profound emesis, trismus, obstructing lesions (eg, tumor, polyp), and a broad array of traumatic and congenital deformities. One study found that of all clinical conditions requiring cricothyrotomy, 32 percent involved facial fractures, 32 percent blood or vomitus in the airway, 7 percent traumatic airway obstruction, and 11 percent failed intubation in the absence of other specified problems [7].

**CONTRAINDICATIONS AND PRECAUTIONS**

**Absolute contraindications** — There are no absolute contraindications to emergency cricothyrotomy in adults.

**Relative contraindications** — Possible or known transection of the trachea, laryngotracheal disruption with retraction of the distal trachea into the mediastinum, and fractured larynx are relative contraindications to cricothyrotomy. In such cases, tracheostomy or stabilization of the proximal tracheal segment followed by direct intubation is likely to be the best approach. (See "Initial evaluation and management of penetrating neck injuries: Initial evaluation and management", section on ‘Airway management’.)

Surgical cricothyrotomy is relatively contraindicated in young children for several reasons. The airway of a child is funnel-shaped, with the narrowest part located at the cricoid ring rather than at the vocal cords. This narrowing increases the risk for developing subglottic stenosis following cricothyrotomy.

Some believe that surgical cricothyrotomy can damage the cricoid cartilage of young children. Since the tracheal cartilages are C-shaped, soft, and pliable in a child, the cricoid cartilage is the only circumferential support for the trachea and thus the principal structure maintaining airway patency [8]. A child's airway is smaller in diameter than an adult's and even a small amount of stenosis may cause significant impairment of air flow [9].

The preferred surgical airway technique in a young child is transtracheal ventilation using a 14 gauge needle. The age at which one can safely perform a cricothyrotomy on a child is not well established, and recommendations vary from 5 to 12 years old. (See "The difficult pediatric airway".)

When determining whether to perform a cricothyrotomy, consider not only age, but other variables such as the child's size and physical maturity, state of health, external landmarks of the neck (eg, is the cricothyroid membrane palpable?), clinical findings, and presence of trauma.

Surgical cricothyrotomy is relatively contraindicated in a patient with a bleeding diathesis, but in a life-threatening circumstance the need to establish an airway supersedes this concern.

**PREPARATION**
Fundamental considerations for the clinician — Once a failed airway is recognized and a cricothyrotomy is contemplated, the clinician must address a few fundamental considerations:

- Will a cricothyrotomy effectively bypass the airway obstruction? As an example, if the obstruction is in the distal trachea, performing a cricothyrotomy becomes a critical waste of time that will render any non-invasive ventilation technique ineffective.

- Which cricothyrotomy technique is to be used? In most cases, the emergency clinician should be familiar with the tools available in their institution to perform cricothyrotomy and should have selected and practiced a preferred technique ahead of time.

- Will the patient’s anterior neck anatomy make the procedure particularly difficult or time consuming? If so, then plan accordingly. As an example, a percutaneous guidewire based technique (rather than an open technique) might be more appropriate in a morbidly obese patient with anatomic landmarks that are difficult to appreciate.

A mnemonic for difficult cricothyrotomy is presented in the accompanying table (table 1). Management of the difficult and failed airway is discussed separately. (See "The difficult airway in adults" and "The failed airway in adults".)

Patient counseling and informed consent — The emergent conditions under which this procedure is performed generally preclude the discussion of risks, benefits, and complications with the patient or family.

Materials — Successful performance of a cricothyrotomy depends on familiarity with the necessary equipment. Keep the cricothyrotomy equipment tray simple (picture 1), in contrast to the typical tracheostomy tray, which may contain dozens of instruments. Only a few instruments are required. Practice using the equipment several times a year so it will be familiar during an emergency.

- IV catheter – Be certain that an IV is in place and flushing easily.

- Oxygen – Administer high flow oxygen. In the setting of a failed airway, this will likely be via a bag-valve mask.

- Mechanical ventilator and tubing – Be sure the ventilator is set up and ready for use.

- Yankauer suction catheter, tubing, and canister – Check that all connections are tight and suction is adequate.

- Scalpels – Preferred sizes include numbers 11, 15, and 20 blades. Use the same blade for both the skin incision and the cricothyroid membrane incision.

- Tracheal hook – Handle the tracheal hook carefully when inserting and removing it. The hook’s tip is sharp and can puncture the balloon on the tracheostomy tube causing a leak and necessitating replacement. The tip of the hook can also puncture a glove and skin.

- Tracheal dilator (Trousseau dilator) – The dilator is used to widen the opening through the cricothyroid membrane [10]. Unlike standard scissors or needle drivers, the dilator is opened by squeezing the handles together.

- A cuffed tracheostomy tube – Note that tracheostomy tubes vary. A standard tracheostomy tube kit often includes a tube with an inner cannula as well as a solid obturator. Place the obturator in the tracheostomy tube and use it to insert the tube into the trachea. After the tube is placed, remove the obturator and replace it with the inner cannula for air exchange. In an adult a number 4 or 6 cuffed Shiley™ tube is used most often.

Remember that a smaller diameter increases the work of breathing and is more easily obstructed by secretions. However, the cricothyroid membrane averages only 9 mm by 30 mm, so whenever possible the outer diameter of the tube should not exceed 9 mm to avoid damage to surrounding cartilage [11,12].

A number 4 Shiley™ tube with an inner diameter of 5 mm and an outer diameter of 9.4 mm is a good choice for most adults. However, recognize that the outer diameter of the tube is what determines whether the tube fits properly. There is significant product variability even among Shiley™ brand tubes.

- Alternative tube (modified endotracheal tube) – If a tracheostomy tube is not available, use a standard endotracheal tube cut to an appropriate length. To shorten the tube, remove the adaptor and cut just above the take-off of the pilot balloon tubing. Reattach the adaptor to the newly cut end and insert the tube into the trachea, as you would a tracheostomy tube. The tube can be shortened after it is inserted.

Shortening the tube reduces the risk of inadvertent placement in a mainstem bronchus. Eventually, it may be helpful to replace the modified endotracheal tube with a tracheostomy tube, as the design of the tracheostomy tube makes it more stable in the airway.

- 10 mL syringe – Test the balloon on the tracheostomy or endotracheal tube for leaks by injecting 10 mL of air.

- Cloth tie – The cloth tie included with the tracheostomy kit is used to secure the tube by making a circumferential tie around the neck.

**RELEVANT ANATOMY AND IDENTIFICATION OF THE CRICOTHYROID MEMBRANE** — Proper performance of a cricothyrotomy depends upon an understanding of the relevant anatomy and the ability to identify the cricothyroid membrane (CTM). This requires regular practice on the part of clinicians expected to perform the procedure.

One way to improve one's familiarity with the anatomy is to regularly palpate the structures of the anterior neck when examining patients (figure 1 and figure 2 and figure 3 and figure 4). Begin by palpating the laryngeal prominence, which forms the superior edge of the thyroid cartilage. There is often a prominent "V-shaped" notch palpable. It is often more prominent in men [13]. The vocal cords are housed within and protected by the thyroid cartilage. The hyoid bone lies cephalad to the thyroid cartilage. In patients where the thyroid cartilage is not prominent be aware that the hyoid might be mistaken for the thyroid prominence.

Palpate the trachea and note that it is the caudal continuation of the larynx and no longer palpable as it enters the mediastinum. The trachea is comprised in large part by a row of C-shaped cartilaginous rings that are deficient posteriorly where the trachea rests against the anterior esophagus.

Next, identify and palpate the cricoid cartilage, which is a complete cartilaginous ring, shaped like a signet ring, with its widest part found posteriorly. It is located caudal to the thyroid cartilage. The thyroid cartilage, cricoid cartilage, and tracheal rings support and protect the airway.

The boundaries of the cricothyroid membrane (CTM) are the thyroid cartilage superiorly, the cricoid cartilage inferiorly, and the cricothyroideus muscles laterally on both sides. Palpate the CTM. It is located about 2 cm caudal to the laryngeal prominence and can be identified by a slight depression in this area. The anatomical relationship between the thyroid and cricoid cartilages and the CTM is the most important landmark when performing cricothyrotomy.

The cricothyroid arteries are branches of the superior thyroid arteries that course along both sides of the CTM and anastomose in the midline, closer to the superior border of the membrane. Try to avoid these arteries (this can be difficult) when performing a cricothyrotomy by incising the membrane in its inferior third.
Some authors imply that identification of the CTM is relatively straightforward, due to its superficial location in the anterior neck. However, lack of familiarity can make it difficult to find the CTM quickly, particularly in the setting of an airway emergency. Obesity compounds this problem. Misidentification can lead clinicians to make incisions in the thyrohyoid space, which is fraught with potential complications. (See 'Complications' below and "Emergency airway management in the morbidly obese patient").

Several studies highlight the potential difficulty of identifying the CTM. In one prospective observational study, anesthesiologists and obstetricians were asked to identify the CTM in 56 women patients, 15 of whom were obese [13]. The CTM was correctly identified in 10 of 41 nonobese patients (20 percent) and 0 of 15 obese patients (0 percent). A similar study involving six patients reported that anesthesiologists correctly identified the CTM 30 percent of the time [14].

Bedside ultrasound has been proposed as a method for identifying the CTM. Ultrasound has been used to guide tracheostomy and the results of several cadaver studies suggest that when used by experienced practitioners it is a rapid and accurate means for identifying the CTM [15,16]. However, clinical studies of ultrasound to identify the CTM for cricothyrotomy have yet to be performed.

PROCEDURE

**Standard precautions** — Use standard precautions to protect against blood and body fluid exposure. This includes gloves, face mask, protective eyewear, gown, and shoe covers. Do not break, bend, or recap needles used in the procedure.

**General considerations** — Place the patient in the supine position on the stretcher. Unless there is a cervical spine injury (known or suspected), extend the patient's neck to help identify the procedural landmarks and to obtain the widest exposure of the cricothyroid membrane. While assembling the equipment for the procedure, ask an assistant (preferably the respiratory therapist) to preoxygenate the patient by administering high-flow oxygen most likely via bag valve mask. Be aware that once the incision is made into the airway bag mask ventilations should be discontinued as this can insufflate the soft tissues of the neck and expel blood into the face of the operator. Either result will complicate the procedure.

**Analgesia and sedation** — Under emergent circumstances there may not be time to administer sedative or analgesic medications. The most important goal is to secure the airway. In the case of respiratory depression or arrest, sedation may make matters worse and is not advised. However, if the patient is agitated and struggling and this behavior is impeding the progress of the procedure, a sedative or analgesic medication can be given to help control the patient.

**Skin preparation** — If time permits, prepare the skin of the anterior neck with an antiseptic solution (eg, povidone-iodine). If the patient is conscious, anesthetize the skin, subcutaneous tissues, and the cricothyroid membrane with a local anesthetic such as 1 percent lidocaine administered through a 27 or 30 gauge needle.

**Monitoring** — Monitor heart rate and rhythm, blood pressure, respiratory rate, and oxygen saturation throughout the procedure. Lower the patient's gown and sheet to observe the rise and fall of the chest with respiration.

**Methods** — Several techniques for cricothyrotomy are in common use. Performance of the Standard, Rapid Four Step, and Seldinger techniques are described here:

**Standard technique**

- **Step 1: Immobilize the larynx and palpate the cricothyroid membrane** (figure 5) – Stand at the patient's right side if you are right-handed, or at the patient's left side if you are left-handed. Immobilize the larynx with the nondominant hand and perform the procedure with the dominant hand.
The procedure is largely tactile, so proper finger position is essential. Place the thumb and long finger of the nondominant hand on either side of the thyroid cartilage to immobilize the larynx. Palpate the laryngeal prominence at the midline of the cephalad rim of the thyroid cartilage with the index finger and then move caudally 1 to 2 cm until a small depression inferior to the thyroid cartilage is encountered. This is the cricothyroid membrane. Palpate the cricoid cartilage which is at the inferior border of the cricothyroid membrane. Maintain manual control and immobilization of the larynx throughout the procedure to preserve the anatomic relationships (ie, don't let go!).

Proper stabilization and continuous palpation of the immobilized larynx serves as the foundation for the procedure, from which all other anatomic relationships are established. While immobilizing the larynx, palpate the cricothyroid membrane and complete the entire procedure by feel. Do not waste time attempting to visualize the cricothyroid membrane.

**Step 2: Incise the skin vertically** (figure 6) – After palpating the cricothyroid membrane, make a midline, vertical incision 3 to 5 cm long through the skin overlying the membrane. The midline skin incision avoids vascular structures located laterally. The vertical orientation allows one to extend the incision superiorly or inferiorly should the initial location be too high or too low or provide inadequate access to the cricothyroid membrane.

**Step 3: Incise the cricothyroid membrane horizontally** (figure 7) – Make a 1 cm horizontal incision in the cricothyroid membrane. Make the incision with care; excessive force can lead to injury of the posterior wall of the trachea. Aim the scalpel in a caudad direction to avoid the vocal cords. The cords, although surrounded by the thyroid cartilage and partially protected, are located only 0.5 to 2 cm above the cricothyroid membrane [9]. While separating the thyroid cartilage from the cricoid cartilage, be careful not to incise or fracture either one.

Once you have made the incision in the cricothyroid membrane, keep the tip of the index finger of the nondominant hand in the entry to the incision so as not to lose the opening. Continue to immobilize the larynx firmly, maintaining a triangle formed by the thumb and middle finger on opposite sides of the larynx and the index finger in the incision in the cricothyroid membrane. It is crucial not to let go at this point because there is often significant bleeding that obscures the view of the membrane.

If you are unable to stabilize the larynx because of obesity, edema, trauma, aberrant anatomy, or other reasons, you may wish to leave the scalpel in the incision until you place the tracheal hook in order not to lose the opening. In this case, be careful not to injure the back wall of the trachea with the scalpel.

**Step 4: Insert the tracheal hook** (figure 8) – Place the tracheal hook under the thyroid cartilage and ask an assistant to provide upward traction.

**Step 5: Insert the Trousseau dilator and open it to enlarge the incision vertically** (figure 9) – Squeeze the handles of the dilator to open its jaws. The membrane is naturally wider in the horizontal direction, which makes the vertical direction the hardest to dilate. Overcome the resistance from the thyroid cartilage as it retracts downward and the cricoid cartilage as it retracts upward against the dilator. Leave the dilator in until the tube is placed; the thyroid and cricoid cartilages will spring back into place if the dilator is removed.

**Step 6: Insert the tracheostomy tube** (figure 10) – After dilating the opening, rotate the dilator 90 degrees so that the handles are pointing towards the patient's feet and insert the tube between the jaws of the Trousseau dilator. If the dilator remains in its original horizontal position, its inferior blade will prevent the tube from passing into the trachea. Once past the blades, advance the tube into the trachea. Remove the tracheal
hook and Trousseau dilator. Pay particular attention not to puncture the balloon of the tube when withdrawing the sharp point of the tracheal hook.

- **Step 7: Remove the obturator** (as needed, depending on type of tube used) (figure 11) – This is the solid object with a rounded tip.

- **Step 8: Insert the inner cannula** (as needed, depending on type of tube used) and inflate the balloon (figure 12) - Inflate the cuff of the tube with air from a 10 mL syringe. Inflate the balloon carefully until the balloon indicator is full but not tense; overinflation increases the risk of pressure-related injury to the tracheal mucosa.

- **Step 9: Attach the tracheostomy tube to the mechanical ventilator or a bag valve device** (figure 13) – After confirming proper placement, secure the tube with a circumferential cloth tie around the neck. Use flexible connector tubing to avoid tugging and pressure on the tracheal wall.

**Rapid four step technique** — The rapid four-step technique (RFST) can be done quickly and requires only a number 20 scalpel, hook, and cuffed tracheostomy tube [12]. For this technique, stand at the head of the patient in the same position as when performing endotracheal intubation. Next, perform the following four steps in sequence:

- **Step 1:** Identify the cricothyroid membrane by palpation (figure 5).

- **Step 2:** Make a horizontal stab incision through both skin and cricothyroid membrane with the scalpel (figure 14). The size of the skin incision is approximately 1 to 2 cm.

- **Step 3:** Prior to removal of the scalpel, the hook is placed and directed inferiorly. Caudal traction is used to stabilize the larynx (figure 15). This marks a significant change from the standard method, in which the tracheal hook is placed under the thyroid cartilage. Also in contrast with the Standard technique, this step does not require an assistant to manage the hook.

- **Step 4:** Insert the tracheostomy tube into the trachea (figure 16).

The RFST can be modified by using a tracheal tube introducer (often referred to as a “bougie”). This is done by inserting the introducer through the incision into the trachea following step 3 above and then sliding a tracheal tube over the introducer.

In a small randomized trial performed in anesthetized sheep by inexperienced clinicians, this modified approach increased the speed of performance (median time 67 seconds versus 149 seconds) and was considered easier to perform than the Standard technique [17].

**Seldinger technique** — Cricothyrotomy using a Seldinger technique has been described [18]. Commercial cricothyrotomy kits are available that contain all essential equipment to perform the Seldinger technique. As an example, the Cook® Melker kit includes the following: a 6 mL syringe, an 18 gauge needle with overlying catheter, a guide wire, a tissue dilator, a modified airway catheter (picture 2), and tracheostomy tape. Alternatively, a tracheal tube introducer (ie, “bougie”) can be used to perform the technique, as described above [17]. (See ‘Rapid four step technique’ above.)

The procedure described here is based upon the Melker kit. Perform the procedure as follows (picture 3):

- **Step 1:** Be certain all equipment is present and functioning. Insert the dilator into the airway catheter. Palpate the cricothyroid membrane with the index finger of the nondominant hand while immobilizing the larynx with the thumb and middle finger (figure 5).
Step 2: Attach the introducer needle to the syringe, and, if time permits, fill it with a small amount of saline or water. Apply a small amount of negative pressure on the syringe and insert the needle carefully into the cricothyroid membrane at a 45 degree angle with the needle oriented caudad (figure 17).

Be careful not to insert it too far as this may damage the posterior wall of the trachea. Watch for the appearance of bubbles in the water, or feel for the free flow of air into the syringe, indicating the needle is in the airway.

Step 3: When bubbles appear, remove the syringe and then remove the needle, leaving the catheter in place, with its distal tip in the trachea. Thread the guidewire through the catheter into the trachea (figure 18). Remove the catheter, sliding it over the guidewire.

Step 4: Make a 1 to 2 cm incision in the skin at the entrance point of the guidewire with a number 15 scalpel blade. The cricothyroid membrane must also be incised at this point.

Step 5: Thread the combined tissue dilator-airway catheter over the guidewire and advance it into the skin incision (figure 19). Following the curve of the dilator, advance the dilator-catheter unit through the subcutaneous soft tissue and into the trachea until the cuff of the catheter is flush against the skin of the neck. A slight twisting motion may be needed.

Step 6: Remove the tissue dilator and guidewire as a unit, leaving the airway catheter in the trachea (figure 20).

Step 7: Secure the airway catheter to the neck with the 'trach tape' provided in the kit or other appropriate means.

Time and ease of completion — The time to completion and ease of performing cricothyrotomy depend upon the surgical technique, patient, setting, and the training and experience of the clinician. Emergency clinicians must be facile with at least one approach.

Studies of cricothyrotomy techniques are limited by the absence of randomized clinical trials. The current literature consists largely of cadaver reports and animal studies and reports disparate findings. Therefore, it is not known which technique is best in which clinical circumstance. The range of findings is suggested by the studies described here.

Observational studies suggest that clinicians can perform cricothyrotomy reasonably quickly using the standard open technique, but that the Rapid Four Step Technique (RFST) may be faster:

- An observational study reported that experienced physicians needed a median of 73 seconds (range 53 to 255 seconds), while inexperienced clinicians required a median of 180 seconds, to complete a cricothyrotomy using the standard technique in unfixed cadavers [19].

- An observational study of 44 paramedic students found that an average of 46 seconds (range 29 to 63 seconds) were needed to complete a standard cricothyrotomy [20].

- Studies performed on preserved human cadavers found that clinicians were 88 percent successful in performing both the standard technique and the RFST, but that the RFST was faster with a mean time of 43.2 seconds compared with 133 seconds for the standard technique [18]. Other cadaver studies have reported the RFST to be faster [21].

Studies comparing cricothyrotomy using open versus the Seldinger technique report conflicting results:
A study of 20 emergency physicians performing cricothyrotomy on 200 human cadavers found that the time to tracheal puncture and first ventilation were significantly faster when cricothyrotomy was performed using the Seldinger technique compared to the open surgical method [18]. Other cadaver studies have found the Seldinger approach to be effective with relatively low complication rates [22,23].

An observational study involving 63 medical students performing cricothyrotomy on human cadavers reported greater success, increased speed, and fewer complications among those using open versus percutaneous techniques [24].

Variations in technique for a given approach may affect performance. A study evaluating variations of percutaneous techniques in a pig trachea model found that a vertical incision preceding the needle placement-guidewire insertion decreased the time needed for completion of the procedure [25].

**COMPLICATIONS** — Complication rates vary widely and depend upon the patient population, the clinical scenario, the clinician’s level of training, and the location of the procedure (eg, emergency department, prehospital). Published reports cite complication rates between 0 and 54 percent [4,5,18,21,26-30]. Emergency surgical cricothyrotomy has a much higher complication rate than elective cricothyrotomy. This is likely because emergency cricothyrotomy is performed on critically ill patients with difficult airways under emergent conditions. In such cases, a higher complication rate is acceptable given the risk of death if the airway cannot be established.

Bleeding occurs early and is not usually severe. If bleeding does occur it can usually be controlled by packing the site with gauze [21].

Other early complications include [4,5,26,28]:

- Laceration of the thyroid cartilage, cricoid cartilage, or tracheal rings
- Perforation of the posterior trachea
- Unintentional tracheostomy
- Passage of the tube into an extratracheal location (ie, false tract)
- Infection

Performance of the Rapid Four Step Technique (RFST) involves lifting the cricoid cartilage, instead of the thyroid cartilage, with the tracheal hook. The cricoid cartilage is vulnerable to injury with this technique because the tracheal hook is placed under the anterior portion where it is weakest and thinnest [19]. However, a cadaver based study reported that the cricoid ring was able to tolerate the degree of manipulation required for intubation without cartilage fracture [31].

In one study comparing complications of the RFST and the standard technique, the same overall rate of complications (38 percent) was observed for both, but the incidence of major complications (eg, complete transection of the cricoid cartilage, posterior tracheal or esophageal perforation) was 6 percent higher for the RFST [21]. Other researchers studied complications rates when both techniques were performed on cadavers [32]. They observed no complications with the standard technique but a 16.7 percent complication rate with the RFST. Four of these injuries were to the cricoid cartilage. The remaining complication was a ruptured cuff, which may be attributable to the caudal placement of the tracheal hook beside the cuff, and highlights the importance of removing the hook carefully or using a blunt hook for the RFST.

Long-term complications include subglottic stenosis and voice changes. Subglottic stenosis has been associated with prolonged intubation, underlying laryngeal disease, and younger age [33].

There is limited data regarding the safety of cricothyrotomy in patients with known or suspected cervical spine injury. A study using a cadaver model of an unstable injury at the level of the fifth cervical vertebra observed 1 to 2 mm of anterior-posterior (AP) displacement and less than 1 mm of axial compression by fluoroscopy during the
performance of a standard open cricothyrotomy [34]. The amount of movement considered safe is undetermined, making interpretation of these results difficult. Studies report a low risk of neurologic deterioration with less than 3 mm of AP displacement [35-38]. No case of neurologic deterioration or exacerbation of injury has been reported following cricothyrotomy in trauma patients.

FOLLOW-UP CARE — Appropriate ventilator settings are made for the patient. Adequate sedation and analgesia should be provided as needed. Follow-up care for the tracheostomy tube is provided by the admitting service in consultation with surgery or otolaryngology as the case dictates. (See "Mechanical ventilation of adults in the emergency department".)

SUMMARY AND RECOMMENDATIONS

- Emergency cricothyrotomy (or cricothyroidotomy) is a rarely performed but potentially life-saving procedure of last resort in the patient with a failed airway. We suggest that emergency clinicians responsible for airway management review the anatomy, choose a preferred technique, and practice with the equipment needed for cricothyrotomy several times per year.

- Cricothyrotomy is indicated when an emergency airway is required and orotracheal or nasotracheal intubation is either unsuccessful or contraindicated. Relative contraindications include complete transection of the trachea and laryngotracheal disruption with retraction of the distal trachea into the mediastinum. (See 'Indications' above and 'Contraindications and precautions' above.)

- The equipment necessary for cricothyrotomy is described in the text. The cricothyrotomy equipment tray should be kept simple (picture 1). (See 'Materials' above.)

- Emergent cricothyrotomy is largely a tactile procedure; the field can become bloody following the initial incision, obscuring the view of any landmarks. Clinicians must be familiar with the relevant anatomy (figure 1 and figure 2). (See 'Relevant anatomy and identification of the cricothyroid membrane' above.)

- Three primary methods for performing emergent cricothyrotomy have been described: Standard, Rapid Four Step, and Seldinger. Each is described in the text. No one method has been proven to be superior. Clinicians should choose at least one method in which to become proficient. (See 'Procedure' above.)

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REFERENCES


The SMART© mnemonic for difficult cricothyrotomy

| Surgery (recent or remote) |  
| Mass (hematoma, abscess, or other mass) |  
| Access or Anatomy (obesity, poor landmarks, or otherwise poor access) |  
| Radiation (or other tissue deformity or scarring) |  
| Tumor (including intrinsic airway tumor) |  

© The Difficult Airway Course©: Emergency.

Graphic 67468 Version 5.0
Cricothyroidotomy equipment

**Equipment**

A. Scalpel-No. 11 blade  
B. Trousseau dilator  
C. Tracheal hook  
D. 10-cc syringe  
E. Tracheostomy tube  
  (No. 4 or 6 Shiley, cuffed)  
F. Obturator  
G. Inner cannula  
H. Circumferential tie  
I. Bag-valve-mask and ventilator tubing


Graphic 62233 Version 3.0
Anatomic landmarks for emergency cricothyrotomy

Understanding of the local anatomy is critical to the performance of cricothyrotomy. The laryngeal prominence forms the superior edge of the thyroid cartilage, where there is often a prominent, palpable “V-shaped” notch. The vocal cords are housed within and protected by the thyroid cartilage. The hyoid bone lies cephalad to the thyroid cartilage and in patients where the thyroid cartilage is not prominent it can be mistaken for the thyroid prominence. The cricoid cartilage is a complete cartilaginous ring located caudal to the thyroid cartilage. The cricothyroid membrane lies between the thyroid and cricoid cartilages.

Graphic 86138 Version 2.0
Anatomy of the cricothyroid membrane

* The cricothyroid muscle is bilateral and depicted on one side for illustrative purposes.

Graphic 82088 Version 4.0
Lateral cross-sectional view of the head and neck

The epiglottis is located at the base of the tongue and projects cephalad, well above the level of the vocal cords. The epiglottis is attached to the hyoid bone through the hyoepiglottic ligament. The esophagus is a potential space beginning behind the cricoid cartilage and extending caudal behind the trachea.


Graphic 54025 Version 2.0
Emergent surgical cricothyrotomy (cricothyroidotomy)

Anterior neck anatomy dissection


Graphic 86096 Version 3.0
Standard cricothyrotomy step one

Immobilize the larynx and palpate the cricothyroid membrane with the index finger of the non-dominant hand.


Graphic 69793 Version 3.0
Standard cricothyrotomy step two

Make a midline vertical skin incision, 3-5 cm in length.


Graphic 82644 Version 2.0
Standard cricothyrotomy step three

Incise the cricothyroid membrane transversely.


Graphic 71670 Version 2.0
Standard cricothyrotomy step four

Insert the tracheal hook and ask an assistant to provide upward traction.


Graphic 79117 Version 2.0
Standard cricothyrotomy step five

Insert the Trousseau dilator and open to expand the incision vertically.


Graphic 68235 Version 2.0
Standard cricothyrotomy step six

A) Rotate the dilator 90 degrees. B) Insert the tracheostomy tube, and advance the tube into the trachea.


Graphic 58528 Version 2.0
Standard cricothyrotomy step seven

Remove the obturator.


Graphic 78841 Version 2.0
Standard cricothyrotomy step eight

Replace the inner cannula and inflate the cuff.


Graphic 55500 Version 2.0
Standard cricothyrotomy step nine

Attach ventilator tubing, confirm proper placement, and secure the tube with a circumferential tie around the patient's neck.


Graphic 57056 Version 2.0
Rapid four-step cricothyrotomy technique: Step 2

Make a horizontal stab incision through both skin and cricothyroid membrane with the scalpel.

Graphic 72479 Version 3.0
Rapid four-step cricothyrotomy technique: Step 3

Stabilize the larynx by placing the tracheal hook under the cricoid cartilage.

Graphic 63765 Version 3.0
Rapid four-step cricothyrotomy technique: Step 4

Insert the tracheostomy tube into the trachea.

Graphic 70976 Version 3.0
Melker cricothyrotomy catheter

A cricothyrotomy catheter is pictured above.

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Graphic 75579 Version 3.0
Seldinger technique for cricothyroidotomy


Graphic 52511 Version 8.0
Apply a small amount of negative pressure on the syringe and insert the needle carefully into the cricothyroid membrane at a 45 degree angle with the needle oriented caudad.

Graphic 75433 Version 3.0
Seldinger cricothyrotomy technique: Step 3

Thread the guidewire through the catheter into the trachea. Remove the catheter, sliding it over the guidewire.

Graphic 62706 Version 4.0
Thread the combined tissue dilator-airway catheter over the guidewire and advance it, following the curve of the dilator, through the subcutaneous soft tissue and into the trachea until the cuff of the catheter is flush against the skin of the neck.
Seldinger cricothyrotomy technique: Step 6

Remove the tissue dilator and guidewire as a unit, leaving the airway catheter in the trachea.

Graphic 58139 Version 3.0

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