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8.1 Introduction

The primary purpose of a cricothyroidotomy is to establish an emergent rescue airway when standard and traditional techniques have failed. Traditional techniques include bag valve mask (BVM), laryngeal mask airway (LMA), laryngoscope, and video assist device. The inability to oxygenate, ventilate, and intubate the patient utilizing standard equipment and techniques is the indication to perform the next step, which is cricothyroidotomy. The ability to perform the procedure is a lifesaving intervention. The procedure is preferred over emergent tracheostomy due to the speed of which it can be performed, ease of landmark identification, and superficial and avascular nature of the cricothyroid membrane [1–3]. The specific technique used will vary depending on the provider comfort level, experience level,

and equipment available. It most commonly performed in the intensive care unit, emergency department, trauma bay, operating room, and the prehospital setting. All providers who are responsible for managing an airway should be familiar with these techniques. Failure to perform this lifesaving intervention will likely lead to severe hypoxemia, respiratory arrest, cardiac arrest, severe anoxic brain injury, and death.

Cricothyroidotomy should not be confused with tracheostomy as they are two different procedures and have different indications. There are non-emergent indications for cricothyroidotomy, but this chapter will focus on the emergent indications for lifesaving airway establishment. Tracheostomy has also been described for emergent airway establishment, but is reserved for severe laryngeal fracture [1, 4].

8.2 Background/History

Cricothyrotomy was described in the medical literature in the mid-1800s. In the early 1900s, Dr. Jackson popularized the technique he referred to as “high tracheostomy”; however, this was thought to contribute to long-term complications such as subglottic stenosis [3]. In the 1970s, Brantigan and Grow revisited Dr. Jackson’s research and found very low incidence of subglottic stenosis. This procedure is recognized as the standard technique for an emergency rescue airway [3].

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8.3 Anatomic Review

Understanding the anatomy of the neck is crucial to successfully performing the procedure and to decrease potential complications. Superiorly, the thyroid cartilage forms the laryngeal prominence on the anterior neck also known as the “Adams apple.” (Fig. 8.1) Inferiorly, the cricoid cartilage forms a firm, complete ring in the anterior neck and it is easily palpable. The cricothyroid membrane is located inferior to the thyroid cartilage and superior to cricoid cartilage. (Fig. 8.2) It is subcutaneous in location and composed of dense fibrous tissue. There are no major vessels, muscle layers, or nerves surrounding this membrane. In an average adult, the membrane can be found in the anterior midline and one third the distance from the angle of the mandible to the sternal notch.

It is important to understand that anatomical variations may exist. Distortion of normal anatomy may occur with obesity or disease processes,



Fig. 8.1 Thyroid Cartilage (Superiorly)



Fig. 8.2 Cricoid Cartilage (Inferiorly)

such as tumors, abscess, trauma, edema, or hematoma [5]. In children, the cricothyroid membrane is more superior and in infants the thyroid cartilage will not be as evident [5].

8.4 Indications

1. Failure/unsuccessful oral or nasal endotracheal intubation
2. Severe facial trauma
3. Laryngospasm
4. Airway obstruction from foreign body
5. Massive emesis/hematemesis/hemorrhage
6. Severe anaphylaxis/angioedema
7. Cannot intubate, cannot ventilate (CICV)

8.5 Contraindications

1. Transtracheal transection
2. Tracheal obstruction
3. Laryngeal fracture
4. Airway establishment – ETT, LMA, King tube

8.6 Relative Contraindications

1. Inability to identify landmarks due to anatomic distortion
2. Age less than 12

8.7 Procedural Types

8.7.1 Needle Cricothyroidotomy

Needle cricothyroidotomy is the procedure where a large bore needle with catheter (12–14 gauge) is placed percutaneously through the skin, subcutaneous tissue, and cricothyroid membrane into the trachea [1, 5]. The patient can then be ventilated through the catheter by either transtracheal or transtracheal jet ventilation. Transtracheal ventilation is oxygenation using a bag valve device with a 100% oxygen source for oxygen delivery or via oxygen tubing

for passive ventilation. Respiratory rate is maintained with an average of 10–12 L/min for adults. Transtracheal jet ventilation is using an oxygen source that produces at least 50 psi of pressure to give high-frequency, low-volume bursts of oxygen delivery [5, 6]. This usually produces adequate oxygenation but leads to carbon dioxide retention and respiratory acidosis [2]. This can be decreased by allowing adequate exhalation time. Needle cricothyroidotomy is only a temporizing measure until a definitive airway can be established [1].

Advantages: Can be rapidly inserted with minimal and easily accessible equipment

Disadvantages: Not a definitive airway, will need additional intervention [1]

Special considerations: Preferred method in children less than 12 years of age [4]

8.8 Procedure

8.8.1 Instruments Required

1. Chlorhexidine or any type of sterile prep
2. 3–10 cc syringe half filled with saline or sterile water
3. Over the needle IV catheter, 12–14 gauge
4. Bag valve device with 100% oxygen source

8.8.2 Patient Preparation

In an emergent airway situation, rapid yet thoroughly clean the anterior neck with chlorhexidine. If time permits, drape out the neck from the chin to the sternal notch so anatomic structures and landmarks are easily identifiable.

8.8.3 Identification of Landmarks

Palpate the thyroid and cricoid cartilage. The cricothyroid membrane is located between these two landmarks.

8.8.4 Procedure

1. After patient preparation and landmark identification, have an assistant rapidly passing equipment. (Fig. 8.3)
2. Attach fluid-filled syringe to the needle.
3. Preferably using your nondominant hand, locate the cricothyroid membrane with your index finger. Stabilize the larynx between your middle finger and thumb with one hand to prevent it from moving.
4. With the other hand, insert needle attached to a syringe at the location marked previously by your index finger. (Fig. 8.4) Do this in a caudal direction bevel up at approximately 45 degree angle. While aspirating, slowly go through the subcutaneous, through the cricothyroid membrane, and into the trachea. (Fig. 8.5)

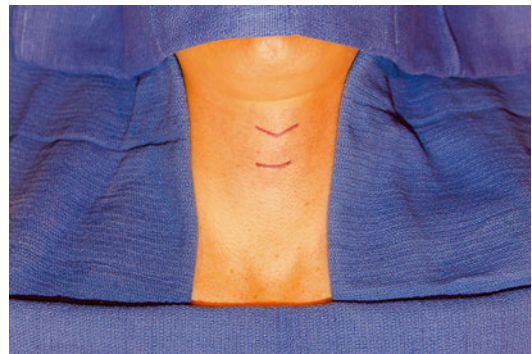


Fig. 8.3 Superior marking defines thyroid cartilage and inferior marking is the cricoid cartilage

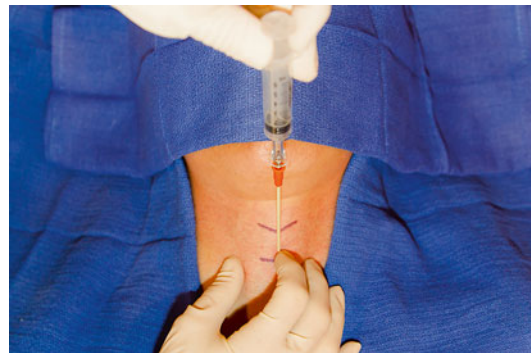


Fig. 8.4 Slowly aspirate as you advance the needle through the cricothyroid membrane

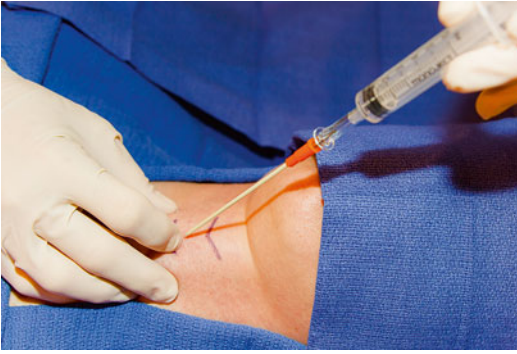


Fig. 8.5 Slowly aspirate as you advance the needle through the cricothyroid membrane

5. Once air is aspirated, stop advancing the needle. Fully advance the catheter into the trachea and remove the needle and syringe.
6. Attach a connector or adapter from a #7 endotracheal tube (ETT) directly to the catheter.
7. Attach this connector to a bag valve assist device with 100% oxygen source.
8. Ventilate the patient using respiratory rate of 5–8 per minute, and allow for long passive exhalation of carbon dioxide. This will help prevent respiratory acidosis and barotrauma.
9. If a jet insufflator is available, deliver small bursts with low volume and high-frequency oxygenation. Allow for adequate exhalation to prevent barotrauma.
10. Secure the catheter in place to prevent kinking or displacement.
11. This is only a temporizing measure and the patient will need a definitive airway.

8.8.5 Potential Complications

Perforated esophagus
 Subcutaneous emphysema
 Subcutaneous placement of needle/catheter
 Inability to pass catheter
 Kinking of catheter
 Pneumomediastinum/barotrauma/pneumothorax
 Bleeding
 Infection

8.8.6 Procedural Pearls

Be sure to slowly advance the needle, and as soon as air is continuously aspirated, stop advancement. This avoids puncturing the back wall of trachea and potential injury to the esophagus. In addition, the advancement of the catheter can be tricky. Kinking of the catheter is a common complication that will prevent one from ventilating the patient [5]. Once the catheter is in place, hold it at all times and secure it quickly to prevent dislodgment.

8.9 Surgical Cricothyroidotomy

Surgical cricothyroidotomy is a surgical incision through the cricothyroid membrane to gain direct access into the trachea. Placement of a tracheostomy tube or endotracheal tube through the cricothyroid membrane is done so under direct visualization. Surgical cricothyroidotomy is preferred over emergent tracheostomy secondary to decreased vascularity of the cricothyroid membrane, subcutaneous location, and easily identifiable landmarks for placement [1–3].

Advantages: It is definitive airway control unlike needle cricothyroidotomy.

Disadvantages: Requires comfort and skill utilizing a scalpel.

Special considerations: Contraindicated in children less than 12 years of age due to their soft membranous cartilage and ring integrity [6].

8.10 Traditional Procedure

8.10.1 Instruments Required

1. Chlorhexidine or any sterile prep
2. Scalpel
3. Kelly clamp, +/- Trousseau dilator
4. Trach hook (if available)
5. ETT or tracheostomy tube, #5–#7
6. 5–10 cc air-filled syringe
7. 2–0 suture

8.10.2 Patient Preparation

In an emergent airway situation, rapid yet thoroughly clean the anterior neck with chlorhexidine. If time permits, drape out the anterior neck from the chin to the sternal notch so the anatomic structures and landmarks are easily identifiable.

8.10.3 Identification of Landmarks

Palpate the anterior thyroid cartilage superiorly and the firm, complete ring of the cricoid cartilage inferiorly. The membrane in between is the cricothyroid membrane.

8.10.4 Actual Procedure

1. If you are right handed, stand on the patient's right side and immobilize the larynx with thumb and middle finger of your left hand.
2. Find the cricothyroid membrane with your left index finger while continuing to immobilize. (Fig. 8.2)
3. With the scalpel, make a vertical incision 3 centimeters in length over the membrane staying in the midline of the anterior neck. (Fig. 8.6) Next, make a 1 centimeter transverse incision through the cricothyroid membrane. (Fig. 8.7)

4. If a trach hook is available, place it under the thyroid cartilage and ask an assistant to pull upward and cephalad.
5. Insert a Kelly clamp, mosquito, or Trousseau dilator into the trachea and gently widen the opening. (Fig. 8.8)
6. Insert the tracheostomy tube or endotracheal tube in a caudal fashion. (Fig. 8.9)
7. Inflate the pilot balloon. If using a tracheostomy tube, insert the inner cannula.
8. Attach tube to a bag valve device with an oxygen source and ventilate the patient with 100% oxygen.
9. Once patient is being adequately ventilated, secure the ETT or tracheostomy tube to prevent dislodgment.



Fig. 8.7 Photo depicts simulated cricoid membrane incision



Fig. 8.6 Vertical incision through the skin



Fig. 8.8 Photo depicts simulated dilation with Kelly clamp



Fig. 8.9 Photo depicts direction of tracheostomy or endotracheal tube insertion

8.10.5 Potential Complications

Bleeding

Subcutaneous emphysema

Placement of endotracheal tube/tracheostomy in subcutaneous tissue

Pneumomediastinum/barotrauma/pneumothorax

Infection

8.10.6 Procedural Pearls

One must be cautious when inserting the tracheostomy tube or ETT into the airway to avoid injury to the balloon. The debate regarding conversion of a surgical cricothyroidotomy to a tracheostomy is ongoing. Literature exists to support both the ability to safely keep the surgical cricothyroidotomy in place and to convert to tracheostomy and avoid long-term complications such as tracheal stenosis.

8.11 Rapid Four-Step Surgical Cricothyroidotomy

Indications, contraindications, potential complications, patient preparation, and landmarks are unchanged from traditional surgical cricothyroidotomy.

8.11.1 Procedure [7]

1. Prep the patient and locate landmarks as previously described.

2. Immobilize the larynx with the thumb and middle finger of your nondominant hand. Identify the cricothyroid membrane with your index finger.
3. With your dominant hand, make a transverse stab incision with a #11 scalpel through the skin and cricothyroid membrane.
4. Insert a trach hook inferiorly in this procedure, under the cricoid cartilage (opposite the traditional procedure), and gently pull in a caudal direction.
5. Insert tracheostomy tube or ETT into the opening and in a caudal direction.

8.12 Percutaneous and Dilator Cricothyroidotomy Kits

Percutaneous dilator kits are commercially available from a variety of vendors. Two main types include a one-step dilator system and the other utilizes a Seldinger technique.

Advantages: Commercial kits have all the necessary equipment to complete the procedure.

Disadvantages: Kit may not be readily available or easy to find by staff.

8.13 Procedure

8.13.1 Patient Preparation

In an emergent airway situation, rapid and thoroughly clean the anterior neck with chlorhexidine. Drape out the neck so anatomic structures and landmarks are easily identifiable.

8.13.2 Identification of Landmarks

Palpate the thyroid and cricoid cartilage. The cricothyroid membrane is between these two landmarks.

8.13.3 Actual Procedure

This procedure will vary depending on commercial kit utilized by the institution. Commercial kits

have quick picture instructions and more detailed instructions.

8.13.4 Potential Complications

Perforated esophagus
 Subcutaneous emphysema
 Subcutaneous placement of needle
 Inability to pass wire into trachea
 Placement of endotracheal tube/tracheostomy tube in subcutaneous tissue
 Pneumomediastinum/barotrauma/pneumothorax
 Bleeding
 Infection

8.13.5 Procedural Pearl

During an airway emergency is not the time to familiarize yourself with the location of the kit or the assembly and technique used in your commercial kit [6]. It is important to review the location and the instructions several times throughout the year.

8.14 Summary

When traditional airway management techniques are failing, cricothyroidotomy will be the lifesaving intervention to establish an airway. This

procedure is a rescue airway to either buy time (needle cricothyroidotomy) or to establish a definitive airway (surgical cricothyroidotomy). The specific type of procedure will depend on the primary operator's comfort level and experience. Although this procedure is performed infrequently, it is a vital tool for lifesaving intervention in a true airway emergency. All providers managing an airway should understand and be ready to perform this rescue intervention.

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