Tracheostomy Technique

Approach Considerations

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Endoluminal

Intubation may replace or precede tracheostomy and is comparably easy, more rapidly performed, and well tolerated for short periods (generally 1-3 weeks). The intraoperative control provided by an endotracheal tube facilitates tracheostomy. The only reason not to intubate is the inability to do so. Contraindications to intubation include C-spine instability, midface fractures, laryngeal disruption, and obstruction of the laryngotraheal lumen.

Supplements to intubation include the nasal airway trumpet, which provides dramatic relief of airway obstruction caused by soft tissue redundancy, collapse, or enlargement in the nasopharynx. The oral airway prevents the tongue from collapsing against the back wall of the oropharynx. Alert patients do not tolerate the oral airway, and patients obtunded enough to tolerate the oral airway without gagging should probably be intubated. Intubation can be performed orally or nasally, depending on local trauma and the logistics of planned operative intervention.

Emergent Cricothyrotomy

The advantage of performing emergent cricothyrotomy is that the cricothyroid membrane is superficial and readily accessible, with minimal dissection required. The disadvantage is that the cricothyroid membrane is small and adjacent structures (eg, conus elasticus, cricothyroid muscles, central cricothyroid arteries) are jeopardized; moreover, the cannula may not fit. Damage to the cricoid cartilage from the scalpel or pressure necrosis leads to perichondritis and possibly stenosis. The overall complication rate of emergent cricothyrotomy is 32%, which is 5 times that of the procedure under controlled circumstances.

Elective Cricothyrotomy

Cricothyrotomy has enjoyed a renaissance in cardiothoracic surgery. Recent studies have rehabilitated its image and raised questions about its inherent risks (recently 6.1%, which is comparable to the risk of tracheostomy). The advantage claimed by its practitioners is the increased distance between the airway stoma (unsterile) and the supposedly more sterile sternal wound.

With the Seldinger technique (see the video below), a catheter can be threaded into the cricothyroid membrane, and its tiny diameter can be compensated for with a stream of pressurized oxygen, which must be administered cautiously and manually. This is useful in endotracheal procedures (eg, microdebridement) that preclude intubation. The risk of barotrauma and the labor-intensive method of oxygen instillation dictate that this is a short-term intervention.

Surgical cricothyroidotomy Seldinger. Video courtesy of Therese Canares, MD, and Jonathan Valente, MD, Rhode Island Hospital, Brown University.

Emergent Tracheostomy

Emergent tracheostomy should be considered only when the patient is in extremis, which is when a cricothyrotomy should be performed. No conscientious physician should perform any procedure known (even colloquially) as a slash.

Urgent Tracheostomy

Patients in acute respiratory distress may need acute surgical intervention. Urgent tracheostomy can be performed in a controlled environment (eg, operating room) with the patient under local anesthesia. The awake patient contributes to the operative environment both negatively and positively. The patient's anxiety and restless movements challenge the surgeon and the anesthesiologist; however, the patient's vigilance is required to maintain the airway. These patients should be sedated and paralyzed only with extreme caution; better to have an agitated patient with an open airway than a relaxed patient with a complete obstruction. The risk of pneumothorax is increased in a patient with increased work of breathing because the cupulae expand high into the neck with high negative inspiratory pressures.

Elective Tracheostomy

Most elective tracheostomies are performed in patients who are already intubated and who are undergoing a tracheostomy for prolonged intubation. Additionally, patients undergoing extensive head and neck procedures may receive a tracheostomy during the operative procedure to facilitate airway control during convalescence. A smaller population of patients with chronic pulmonary problems (eg, sleep apnea) elects to undergo tracheostomy.

Percutaneous Transtracheal Jet Ventilation

In percutaneous transtracheal jet ventilation (PTJV), a catheter is placed through the skin and into the trachea. This procedure is performed under local anesthesia and, once PTJV is in place, the patient can be oxygenated with jet ventilation maneuvers. This procedure is most commonly used in the management of the difficult airway (supraglottic and glottic obstruction) before the induction of general anesthesia. After surgery, the catheter can be left in place in case the patient needs future
Complications of the procedure include barotraumas, kinking of the catheter, and soft tissue emphysema and pneumothorax.

Gulleth and Spiro reported their experience in 43 consecutive PTJV procedures.\[19\] Only one pneumothorax (a tracheotomy and left chest tube were performed) and one episode of minor subcutaneous emphysema occurred.

### Percutaneous Versus Open Tracheostomy

In 1969, Toy and Weinstein described a technique of tracheostomy performed percutaneously at the bedside using essentially a Seldinger technique modified with progressive dilation.\[20\]

Its main advantage is that it can be performed at the bedside; therefore, the expense and logistics of transportation and operating room usage are eliminated. These advantages are mitigated because bedside anesthesia is required and recently advocated bronchoscopic visualization adds to the expense and personnel required. Moreover, preparation for the possibility of an emergent open tracheostomy is important.

Its disadvantages stem from the decreased exposure and thus decreased visualization and control. A recent study of 149 critically ill patients found a greater risk of severe (>50%) suprastomal stenosis developing as a late complication of percutaneous dilational tracheostomy versus surgical tracheostomy.\[11\]

The following patients are commonly recognized to be unfavorable candidates:

- Patients with obesity
- Patients with abnormal or poorly palpable midline neck anatomy
- Patients who need emergency airways
- Patients with coagulopathy
- Pediatric patients
- Patients with enlarged thyroids

Kost recently reported on the use of this procedure in 500 consecutive intubated adults in the intensive care unit.\[21\] When this procedure was performed in conjunction with bronchoscopy, the complication rate was acceptably low (9.2%). No serious complications (eg, pneumothorax, pneumomediastinum, death) occurred. The most common complications were oxygen desaturation in 14 patients (defined as a drop, even transient, to less than 90%) and bleeding in 12 patients (when intervention was required to control the bleeding).

### Pulmonary Toilet

For the patient who requires only improved pulmonary toilet, a tracheal fenestration, which is an oval opening, allows the passage of a suction catheter. This catheter, which is covered by an operculum when not in use, allows speech.

### Cricothyrotomy

The patient's neck is extended and stabilized. Palpate for the cricoid cartilage approximately 2-3 cm below the thyroid notch.

A 1-cm horizontal incision is made just above the superior border of the cricoid (this avoids the vessels that run under the inferior border, in the same manner as the intercostal neurovascular bundles) to expose the cricothyroid membrane, which is then punctured in the midline.

The blade must be directed inferiorly to avoid trauma to the true vocal cords. Care is taken not to extend this puncture through the back wall of the larynx and into the esophagus (see the image below).

Parasagittal view through larynx. The asterisk indicates structures at risk during cricothyrotomy.
Insert a blunt instrument (eg, knife handle) into the incision and rotate it perpendicularly to widen the incision to accommodate a small cannula. Later conversion to a tracheostomy is addressed below.

Open Tracheostomy

Tracheostomy is best performed in an operating room with adequate equipment and assistance. Position the unconscious or anesthetized patient supine with the neck extended and the shoulders elevated on a small roll. The awake patient does not tolerate this; therefore, the procedure is performed with the patient in a sitting or semirecumbent position.

Overextension of the neck should be avoided because it further narrows the airway; additionally, overextension can lead to placement of the tracheostomy too low (toward the carina) and too close to the innominate artery (especially in the very mobile pediatric trachea).

Palpate the landmarks (eg, thyroid notch, sternal notch, cricoid cartilage) and mark them with a pen. Plan a 3-cm vertical incision that extends inferiorly from the cricoid cartilage and infiltrate lidocaine (1%) with 1:150,000 parts epinephrine. This is sufficient anesthesia in awake patients and facilitates hemostasis in all patients.

Make the vertical incision. Many advocate the horizontal skin incision, which is made along relaxed skin tension lines and gives better cosmesis. A horizontal incision may trap more secretions. Meticulous hemostasis is important throughout, beginning with the skin edges.

Subcutaneous fat may be removed with electrocautery to aid in exposure and to prevent later fat necrosis. Dissection proceeds through the platysma until the midline raphe between the strap muscles is identified.

Palpate the inferior limit of the field to assess the proximity of the innominate artery. Cauterize or ligate aberrant anterior jugular veins and smaller vessels. Midline dissection is essential for hemostasis and avoidance of paratracheal structures.

The strap muscles are separated and retracted laterally, exposing the pretracheal fascia and the thyroid isthmus. The lateral retraction also serves to stabilize the trachea in the midline.

Although the thyroid isthmus, which typically lies anteriorly over the first 2-3 tracheal rings, may be retracted out of the field, it must often be divided in some cases. A retracted isthmus may be irritated if it rubs against the tracheostomy tube in the postoperative period, causing bleeding. Division is performed sharply or with electrocautery and suture ligature. Elevate the isthmus off the trachea with a hemostat and divide it (see the image below).

Operative view of tracheostomy. The thyroid isthmus is divided with electrocautery.

Attention is turned to drying the field. Clean the remaining fascia off of the anterior face of the trachea and warn the anesthesiologist of impending airway entry.

When preparations for transfer of circuitry tubes are complete, deflate the endotracheal tube balloon and enter the trachea. Injection of topical anesthesia can stem the cough reflex of an awake patient. Absolute hemostasis before this point obviates the threat that blood could enter the trachea and exacerbate the cough reflex.

Securing the cricoid with a hook and elevating it superiorly facilitates control of the tracheal entry. Several options for the tracheal stoma are available (see the image below).
Operative view of tracheostomy. These are options for tracheal incision.

For a T-shaped tracheal opening, make a 2-cm incision horizontally through the membrane between the second and third or third and fourth tracheal rings. Use heavy scissors to cut vertically and inferiorly in the midline through the distal 1-2 tracheal rings. With this incision, a silk stay suture can be placed through the tracheal wall on each side and taped to the neck skin on either side. This facilitates tube replacement should it dislodge in the immediate postoperative period. Marking the tape that holds these sutures to the skin with “Do not change or remove” is prudent. These sutures are removed after the first tracheostomy tube change 5-7 days postoperatively.

For a U- or H-shaped tracheal opening, reflect tracheal flaps inferiorly or both inferiorly and superiorly. These can be tacked to skin edges with absorbable sutures to create a semipermanent stoma, or silk stay sutures can be placed in each tracheal flap and taped to the chest and neck skin, facilitating replacement of a displaced tube in postoperative care. This is beneficial in the patient with obesity.

A permanent stoma can be created with skin flaps developed and sutured to a rectangular tracheal opening. Removal of small anterior portions of the tracheal rings is required. This is desirable only in patients who are expected to require secure transluminal access indefinitely (eg, patients with sleep apnea, terminal illnesses). Resecting part of the anterior tracheal wall predisposes the patient to stenosis; thus, this resection is unwise in a temporary tracheostomy.

After the trachea is entered, suction secretions and blood out of the lumen and slowly withdraw the endotracheal tube to a point just proximal to the opening. Replace the lateral retractors into the trachea and insert the previously tested tracheostomy tube.

After the airway is confirmed intact based on carbon dioxide return and bilateral breath sounds, secure the tracheostomy tube to the skin with 4-0 permanent sutures.

Attach a tracheostomy collar with the head flexed to avoid unnecessary slack in the collar.

To avoid the risk of subcutaneous emphysema and subsequent pneumomediastinum, the skin is not closed. Place a sponge soaked with iodine or petrolatum gauze between the skin and the flange for 24 hours to deflect infection and anxiety about minor oozing of the skin edge.

The video below depicts a tracheostomy being performed.

Surgical technique for a tracheostomy. Video courtesy of Ravindra G Elluru, MD, PhD.

**Percutaneous Tracheostomy**

Percutaneous tracheostomy is generally carried out in the intensive care unit on a patient who is intubated and ventilated with continuous monitoring under deep intravenous sedation/analgesia (see the video below).

**Percutaneous Tracheostomy:***

Personnel requirements include the surgeon, someone to manage the sedation/analgesia, someone to manage the ventilator, a bronchoscopist, and an assistant. An airway cart with instruments for an urgent surgical tracheostomy or urgent intubation should be readily available.

The patient is preoxygenated with 100% oxygen, which is continued during the procedure. A shoulder roll is placed to extend the patient’s neck.

A 1.5- to 2.0-cm incision is made through the skin of the neck approximately 2 cm below the palpable cricoid cartilage. Blunt horizontal and vertical dissection with a hemostat is used to carry the dissection down to a pretracheal plane, attempting to
sweep the thyroid isthmus (which should not be enlarged) inferiorly. Finger
dissection is used to palpate the cricoid cartilage and tracheal rings.

A small-caliber, flexible bronchoscope attached to a video camera and monitor is
passed via a swivel adaptor down the endotracheal tube, allowing for ventilation
around the scope. The bronchoscopist withdraws the endotracheal tube and
bronchoscope, after deflating the endotracheal tube cuff, to a subglottic level. Care
should be taken not to completely withdraw the tube from the larynx.

During this maneuver, ventilator settings may have to be modified to accommodate
the air leak or space taken up by the bronchoscope. The surgeon can use the light
from the bronchoscope and digital palpation to guide passage of the needle from
the percutaneous tracheotomy kit through the anterior tracheal wall under direct
bronchoscopic visualization.

Ideally the puncture should be made between the second and third tracheal rings.
High placement of the tracheotomy in the immediate subcricoid position is
associated with fracture of the cricoid cartilage and subglottic stenosis and should
be avoided.

The wire guide is then inserted, the tract is dilated per the kit instructions, and the
tracheostomy tube is inserted over a special introducer that is then withdrawn. The
endotracheal tube and bronchoscope are withdrawn from the mouth, and the
tracheostomy tube is sutured into position and secured with a tracheostomy tube
tie. It is essential that the surgeon be intimately familiar and trained in the nuances
of the specific kit being used.

**Conversion of Cricothyrotomy to Tracheostomy**

Cricothyrotomy is accepted only as an emergent procedure used for ease of
performance in the field.

Brantigan and Grow published data on a large series of elective cricothyrotomies
with a 6.1% complication rate, which is comparable to that for traditional
tracheostomies. This research has raised the question of whether to convert
cricothyrotomies to tracheostomies and whether to perform elective
cricothyrotomies instead of tracheostomies. This study is limited because one third
of the patients died before discharge and therefore were not included in the follow-
up documentation.

**The Patient with Obesity**

In particular, the patient with obesity and obstructive sleep apnea poses a
challenge. The apnea can be corrected with a tracheostomy. Until the acceptance
of uvulopalatopharyngoplasty and the availability of continuous positive airway
pressure, tracheostomy was the standard treatment. Yet the same obesity that
impairs ventilation also challenges the surgeon during the operation and the
nursing staff during postoperative care.

Techniques have been developed to facilitate the creation of and maintenance of
the permanent airway (see the image below).

Operative view of tracheostomy. These are special techniques in the patient with obesity.

Skin flaps are raised and subcutaneous fat is removed. Skin flaps are then sutured
circumferentially to corresponding tracheal flaps to create a permanent stoma.

Intraoperatively, taping the chest down and the chin up may help. The reverse
Trendelenburg position recruits the help of gravity.

**The Pediatric Patient**

Infants and children have relatively short necks and are at high risk of tube
displacement. This risk makes the operation and the postoperative course much more perilous.

Use of a rigid bronchoscope or endotracheal tube in place to define the location of the trachea should be considered because paratracheal dissection is not uncommon. In particular, the infant's pleural spaces extend far superiority into the paratracheal spaces and can easily be injured. Thus, postoperative chest radiography is necessary in infants and children.

Tracheal stay sutures can be placed bilaterally in the incised tracheal wall and, when clearly identified, can be taped to the neck. In the event of displacement, these sutures can pull the trachea up into the field and facilitate replacement. Even today, long-term tracheostomy in an infant carries a mortality rate of 20%. Thus, judicious performance of these procedures and the use of every precaution are imperative.

Performance of tracheotomy on a child is similar to the procedure on an adult. For children, however, a simple vertical incision in the trachea is best. The incision is made in the second and third tracheal rings. Excision of any anterior tracheal wall or the use of a Björk flap traditionally has been avoided in operations on children. A starplasty tracheotomy technique, which creates a matured permanent tracheostoma, has been recommended because of the increased safety and prevention of tracheotomy-related complications it affords in infants. Subsequent closure of the fistulas has been possible.

If at all possible, tracheotomy on children is performed only with a secured airway either from intubation with an endotracheal tube or over a ventilating bronchoscope. As in the treatment of adults, emergency tracheotomy is avoided if possible. The smaller diameter, shorter length, greater deformability, and limited stability of the infantile trachea and the greater mobility of the soft tissues of the neck in a child call for special techniques.

During tracheotomy on a child, it is wise to place two sutures, one on either side of the vertical incision in the trachea, to serve as guides if the tracheostomy tube accidentally comes out of the trachea. If such a technique is used, it is essential that the personnel taking care of the child in the hospital be trained in the proper use of these guide sutures. In a panic, it is easy to pull the sutures out. With gentle pulling on the sutures, the trachea can be elevated into the wound and the incision in the trachea can be slightly open to assist reinsertion of the tube. A small 4-0 or 5-0 nonabsorbable monofilament suture usually is used. It is removed at the first tracheostomy tube change 3 or 4 days after tracheotomy.

Polyvinyl chloride or polymeric silicone tubes tend to collect fewer secretions than do metal tubes. The plastic tubes, however, have no inner cannula and are prone to accidental decannulation owing to intrinsic malleability, which allows the tip to come out of the trachea while the body of the tube remains in the neck wound. Pediatric tracheostomy tubes usually have no cuff.
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