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### Indications

Anticipated prolonged intubation  
 Upper airway obstruction  
 Radical oropharyngeal or thyroid surgery  
 Significant maxillofacial trauma

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### Preoperative Preparation

Pass an oral or nasal endotracheal tube preoperatively whenever possible

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### Pitfalls and Danger Points

Injury to the cricoid or first tracheal ring during surgery.  
 Inadequate hemostasis.  
 Asphyxia.  
 Injury to the posterior trachea and esophagus may occur during percutaneous tracheostomy.

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### Introduction

Tracheostomy has several benefits over an endotracheal tube. It is a more secure airway and less prone to accidental extubation particularly during transport. A tracheostomy decreases dead space and airway resistance and obviates the need for an endotracheal tube, which if left in place for too long can cause damage to the lips, mouth, and larynx. It facilitates nursing care, specifically airway suctioning and

oral hygiene. Patients with surgical airways are more comfortable than those with endotracheal tubes. They require less sedation; oral nourishment and speech may be possible, and there may be some psychological benefit.

The timing of tracheostomy remains controversial. Many studies have supported early tracheostomy (<7 days) because of less mechanical ventilation, shorter ICU stays, and reduction in pneumonia and mortality. Prolonged intubation (>21 days) increases the chance of subsequent tracheal stenosis. The ideal timing of a tracheostomy is based on individual patient factors, including anticipated improvement or deterioration over time. The current trend is to perform early tracheostomy. Some intensive care units are performing tracheostomies on critical patients by the third hospital day. Tracheostomy should not be performed on patients with advanced ventilator settings such as APRV or with PEEP greater than 10 cm H<sub>2</sub>O. Traditionally, tracheostomy has been performed in the operating room using standard surgical principles. In 1985, Ciaglia et al. described an alternative method in which tracheostomy is performed percutaneously, using a Seldinger approach. Both methods are described below.

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### Operative Strategy

Because most tracheostomy operations are performed with an orotracheal or nasotracheal tube in place, local or general anesthesia may be used. With an indwelling endotracheal tube in place, the risk of anoxia during tracheostomy is virtually eliminated. If for some reason an endotracheal tube is not in place, be certain hemostasis is adequate before opening the trachea. Otherwise, blood may pour into the tracheal stoma, obstructing the airway. Always have an adequate suction apparatus available during tracheostomy. This is one reason a cricothyroidotomy (see Chap. 125) may be a better operation during an emergency situation when an endotracheal tube has not been passed.

If the incision in the trachea is made in the area of the cricoid cartilage or first ring, there is a high risk of subglottic stenosis after the tracheostomy tube has been removed. It should be

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recognized that the opening in the trachea made by the tracheostomy tube heals by cicatrization, incurring the risk of mild narrowing of the trachea at the site of the tracheostomy. If this occurs in the subglottic region, corrective therapy is extremely difficult. For this reason, take every precaution to avoid incising or injuring the cricoid cartilage or first tracheal ring.

A low tracheostomy incision (e.g., at or below the fourth ring) may also entail unnecessary risk for the patient. Pressure exerted by the tip or cuff of the tube may erode into the innominate artery, resulting in massive hemorrhage into the trachea with prompt asphyxiation of the patient. This risk is especially applicable in children, where the innominate artery is relatively close to the tracheostomy site.

Premature dislodgement (before a tract has formed) is a potentially lethal complication. Secure the tube carefully and consider placing a pair of heavy monofilament sutures through the trachea, one on each side, leaving the tails long. These can be used to elevate the trachea into the incision, facilitating tube replacement.

Percutaneous tracheostomy is an attractive alternative to formal surgical tracheostomy. It is more easily performed at the bedside in the critical care unit. This is described at the end of this chapter.

## Documentation Basics

- Indications
- Size and make of tracheostomy

## Operative Technique: Formal Tracheostomy

### Endotracheal Tube

Virtually all patients should have an endotracheal tube in place prior to undergoing tracheostomy.

### Incision and Exposure

Position the patient with a folded sheet underneath the shoulders so the neck is extended. The superior thyroid notch, cricoid, and suprasternal notch can usually be palpated through the skin. Although some surgeons believe that a horizontal skin incision produces a better scar, the generally preferred incision is a vertical one beginning at the level of the cricoid and continuing in a caudal direction for about 4–5 cm. This incision gives better exposure and access. Carry the incision through the subcutaneous fat and the platysma muscle directly over the midline of the trachea, exposing the sternohyoid muscles. Achieve complete hemostasis with electrocautery and Vicryl sutures. Now elevate the strap muscles and make a

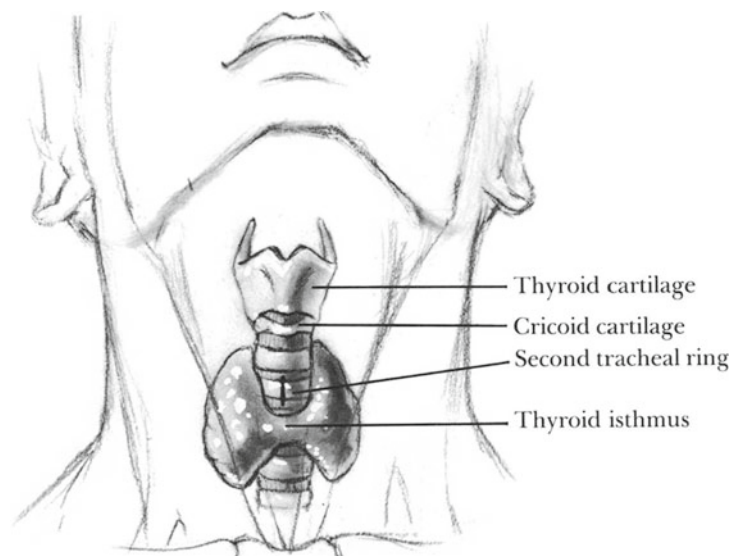


Fig. 126.1

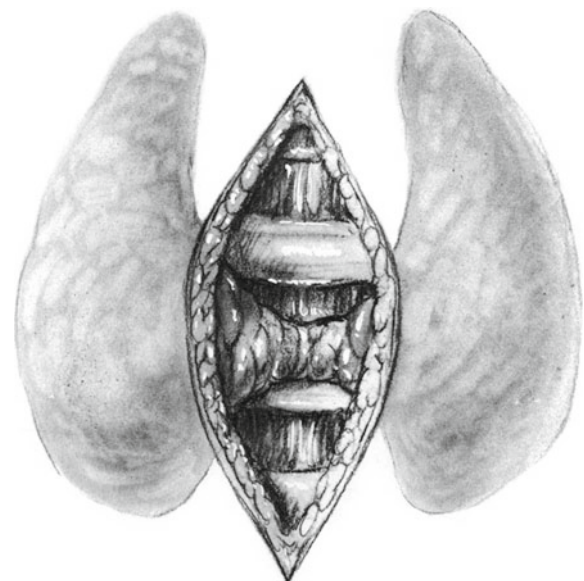
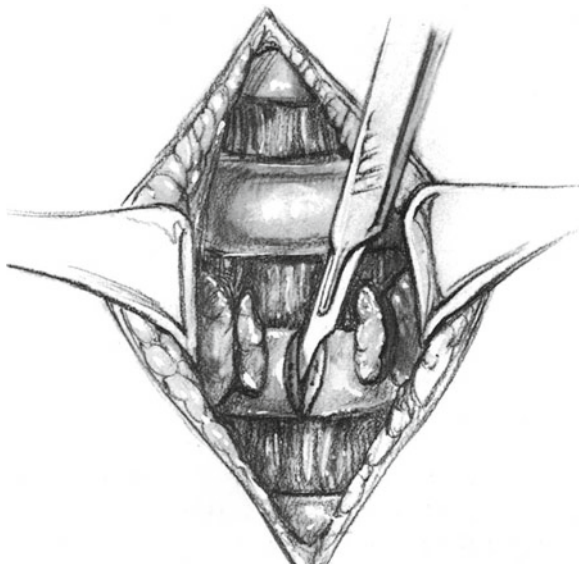


Fig. 126.2

vertical incision down the midline separating these two muscles. Carry the incision down to the upper trachea and expose and divide the capsule of the thyroid gland. Clamp, divide, and ligate all veins in this vicinity. Identify the thyroid isthmus. This bridge of tissue generally lies across the second, third, or fourth tracheal ring (Figs. 126.1 and 126.2).

### Identifying the Tracheal Rings

It is imperative to clearly identify the cricoid cartilage and the first tracheal ring. Preserve these two structures from injury.

**Fig. 126.3**

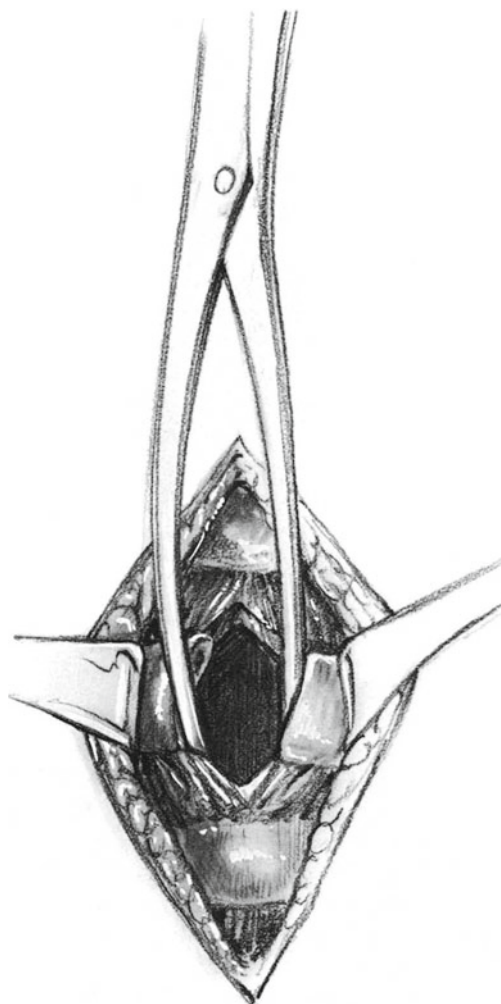
Occasionally it is possible to retract the thyroid isthmus in a cephalad direction to expose the second and third tracheal rings. In most cases, it is necessary to free the thyroid isthmus from the trachea by sliding a right-angle clamp underneath the isthmus and elevating it. Then, divide the isthmus between hemostats and insert suture-ligatures to maintain complete hemostasis. This maneuver clearly reveals the identity of the second and third tracheal rings (Fig. 126.3).

### Checking the Tracheostomy Equipment

For most adults, have a size 8 Shiley cuffed tracheostomy tube with disposable inner cannula open on the field. Ensure that the cuff is functional. Insert the obturator into the tracheostomy and have both pieces lubricated. The inner cannula needs to be easily accessible on your field. If your patient has a very obese neck, you may need to have an extended-length tracheostomy tube available.

### Opening the Trachea

Once you are certain that hemostasis is complete and that your equipment is functional, it is time to place stay sutures into the trachea. Have the anesthesiologist deflate the cuff of the endotracheal tube while you throw your stitch. Using 2-0 Prolene on SH needle, place a lateral suture around the second tracheal ring and leave the tails long. Repeat this for the other lateral edge of the tracheal ring. Air knots may be tied into the stay sutures. These sutures are left long and taped to the chest of the patient. If the tracheostomy is dislodged prematurely, these sutures can be used to lift the trachea. This

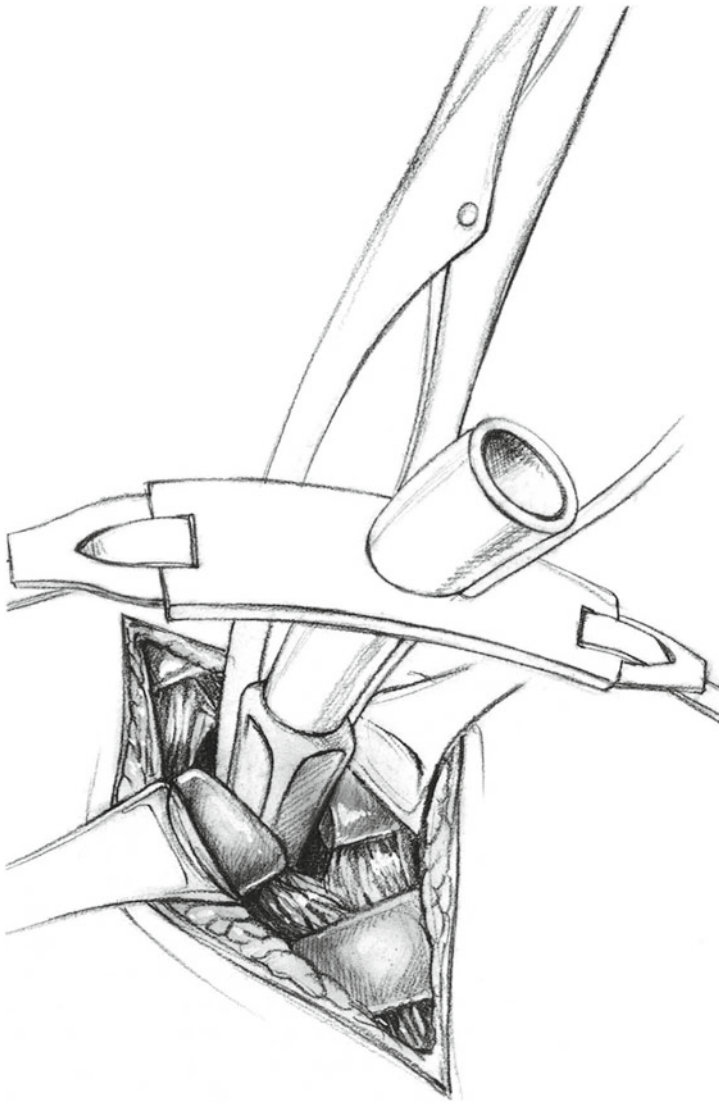
**Fig. 126.4**

greatly facilitates reinsertion. Remove these stay sutures on postoperative day 7.

In some cases, incising only the second ring provides an adequate tracheostomy opening, but generally it is necessary to incise both the second and third rings. Inserting a single hook retractor to elevate the upper portion of the second ring facilitates this procedure. Insert a scalpel with a No. 15 blade to incise the membrane transversely just above the second ring. Then, “T” it by vertically dividing the second ring with the scalpel (Fig. 126.3) and the third ring if necessary. Never divide the first ring or the cricoid cartilage.

### Inserting the Tracheostomy Tube

Retract the edges of the trachea by inserting a hemostat, two small hook retractors, or a Trousseau three-pronged retractor (Fig. 126.4). You will be able to easily see the endotracheal tube. While the anesthesiologist slowly withdraws the endotracheal tube, be ready to insert the lubricated



**Fig. 126.5**

tracheostomy tube with its obturator into the tracheal incision (Fig. 126.5). Quickly remove the obturator and insert the inner cannula into the tracheostomy. Inflate the cuff. The anesthesiologist will hand you the tubing over the ether drape to attach to your tracheostomy. Insert a suction catheter into the tracheostomy tube and aspirate mucus from the bronchial tree if needed.

### Closure

Reapproximate the sternohyoid muscles in the midline with interrupted 3-0 Vicryl sutures. Insert several additional sutures to reapproximate the platysma muscle; then, close the skin loosely with interrupted 4-0 nylon sutures. Suture the tracheostomy neck plate to the skin in two places. Tie the

cotton tapes together at the back of the patient's neck to guarantee fixation of the tracheostomy tube.

## Percutaneous Tracheostomy

Percutaneous dilational tracheostomy was first introduced in the 1950s. The procedure has undergone significant advances. The original method described by Sheldon et al. involved the use of a sharp trochar to gain access to the airway that resulted in several carotid artery and esophageal injuries. The procedure regained popularity in 1985 when Ciaglia et al. developed the serial dilational method by using the Seldinger technique. Commercial kits became available, and then Marelli et al. introduced bronchoscopic guidance in 1990 to facilitate visualization of the tracheostomy site and to verify correct placement of the tracheostomy.

The indications for a percutaneous tracheostomy are the same as for an open tracheostomy with particular attention to some contraindications. Patients needing emergent airway access are not candidates for percutaneous tracheostomy. Patients with obese necks have poor landmarks and are not ideal candidates for the percutaneous approach. In addition, patients with limited neck extension, previous neck surgery (including previous tracheostomy), a large thyroid, or high innominate artery/pulsating vessels near the sternal notch are poor candidates. Percutaneous tracheostomy should not be performed for children under 16 years of age.

The percutaneous approach has a few advantages over the conventional surgical operation. It is simpler, quicker, and less expensive and can be done at bedside without having to move the patient to the operating room. This is a particular attractive option in a critical patient that you suspect could decompensate during transport. Even though an open tracheostomy can theoretically be performed at bedside, most people agree it is better and safer to do in the operating room with experienced operating room personnel, optimal light and instrumentation, greater availability of anesthesiologists, etc. The percutaneous approach is often quicker to do and has lower incidence of postoperative bleeding and infection compared with surgical tracheostomy. Percutaneous tracheostomy is sometimes chosen for patients with a recent median sternotomy. The more cephalad placement of the percutaneous approach is more desirable than an open tracheostomy, keeping tracheal secretions away from the sternotomy incision.

Once the decision to perform a percutaneous tracheostomy has been made, the surgeon must have good lighting available in the intensive care, a video bronchoscopy tower, a physician present for maintenance of the patient's airway and skilled at performing bronchoscopy, a respiratory therapist, the intensive care nurse, a local anesthetic, sedation and analgesia, and a

commercially available kit (Ciaglia Blue Rhino Percutaneous Tracheostomy Introducer Kit; Cook Critical Care, Bloomington, IN). Have a formal tracheostomy set immediately available for emergencies. Routine use of bronchoscopic guidance has been suggested by the kit manufacturers and by many authors. Although there are some surgeons that will attempt this procedure without use of bronchoscopy, bronchoscopic guidance for an additional level of safety and confidence is recommended.

## Positioning and Setup

Pull the bed away from the wall to allow the bronchoscopist to be at the head of the bed. Usually the respiratory therapist needs to be at the patient's left to help manage the ventilator and help with the video tower. The surgeon will be at the patient's right. Deep sedation will require an analgesic, an anxiolytic, and a paralytic. One option is to bolus the patient with 50 µg of fentanyl and 5 mg midazolam, followed by rocuronium (1 mg/kg). Silicone spray for the bronchoscope and a bite block are useful. Place the patient's ventilator on 100% FiO<sub>2</sub>, and set it to a volume-controlled mode for the duration of the procedure. The patient's monitor with telemetry, pulse oximetry, and blood pressures needs to be clearly visible.

With the patient in the supine position, place a folded sheet underneath the shoulders so the neck is mildly hyperextended. Nasogastric tubes are removed because they restrict posterior displacement of the tracheal wall during the insertion of the dilating catheter, predisposing the tracheal wall to damage. Palpate the superior thyroid notch, cricoid, and suprasternal notch. Prep the patient's entire neck with chlorhexidine. After a bite block is inserted and the bronchoscope is sprayed with silicone, it can be inserted into the endotracheal tube.

## Procedure

Using a skin marker, trace out the cricoid cartilage and sternal notch. Open the kit and inject the skin with 1% lidocaine with epinephrine. Make a 4 cm vertical incision that starts just below the cricoid cartilage and ends about two fingerbreadths above the sternal notch. Bluntly dissect with a hemostat down to the pretracheal fascia. The trachea needs to be visualized, and its cartilage rings need to be palpable. The endotracheal tube needs to be deflated and slowly withdrawn until the cuff is palpable at the level of the cricoid cartilage, which is approximately 16 cm at the lips in an adult. Both the bronchoscopist and the surgeon can look at the video tower and with use of the light reflex can determine the best site for the introducer needle. Insert the needle with its attached cannula and syringe in the midline trachea between the first and second ring or between the third and

fourth ring. This should be done under direct bronchoscopic vision. Watching the monitor, you should completely see the needle enter the trachea. Avoid sticking the posterior tracheal wall at all cost. Withdraw the needle, leaving the cannula inside the trachea.

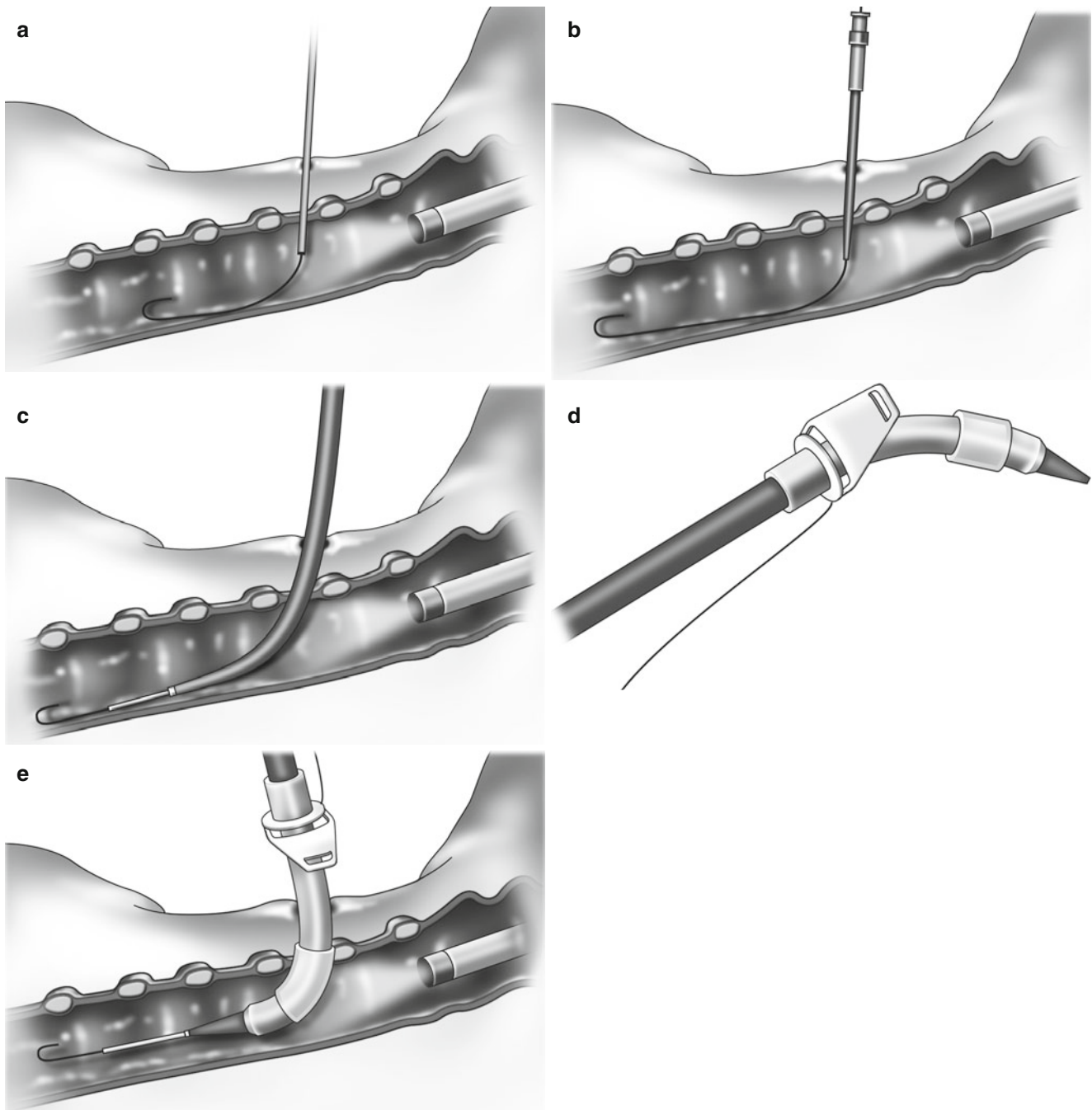
Insert the J-tipped guidewire through the cannula into the trachea toward the carina (Fig. 126.6a). The cannula is then removed leaving the J-tipped guidewire in place. A 14 Fr, 4.5-cm dilator is passed over the wire to dilate the access site (Fig. 126.6b). Some compression of the tracheal wall is expected. Under direct vision, dilate the trachea using the tracheostomy dilator with its preloaded white guiding catheter (Fig. 126.6c). Take care to keep the distal tip of the tracheostomy dilator against the safety ridge of the white guiding catheter. The slippery hydrophilic coating of the tracheostomy dilator allows for smooth dilation. Dilate the stoma up to the skin-level guide on the dilator (38 F) but not past this mark. Next, locate the appropriate size tracheostomy loading dilator. With the 28 F loading dilator inserted into the cuffed tracheostomy tube (Fig. 126.6d) (26 F loading dilator for a size 6 tracheostomy), insert both as a unit into the tracheal lumen under direct visualization (Fig. 126.6e). Remove the J-tipped guidewire, white guiding catheter, and loading dilator. Inflate the cuff, insert the inner cannula, and reattach the ventilator to the patient. The endotracheal tube may now be removed. The bronchoscope can be passed through the new tracheostomy toward the carina for one final look and cleaning. Suture the tracheostomy neck plate to the skin in two places with 3-0 nylon sutures. Tie the cotton tapes together at the back of the patient's neck to guarantee fixation of the tracheostomy tube. A chest x-ray is not routinely required.

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## Postoperative Care

Humidified air is necessary to prevent crusting of secretions and eventual obstruction of the tracheostomy tube. Use lightweight swivel connectors to attach the tracheostomy tube to the ventilator to avoid unnecessary pressure on the trachea at the stoma.

If the tracheostomy tube must be changed within the first one or two postoperative weeks, be certain to have instruments available for instant endotracheal intubation or emergency cricothyroidotomy if difficulty is encountered when reinserting a tracheostomy tube. Remember, the track between the skin and the tracheal stoma is not established for a variable number of days after the operation. After premature decannulation, the tracheal stoma typically retracts deep into the neck, where it is extremely difficult to find. This procedure must not be performed by the inexperienced.



**Fig. 126.6**

When it is necessary to change the tracheostomy tube, first place the patient in a recumbent position with a sheet or sandbag underneath the shoulders. This maneuver extends the head and neck, bringing the tracheal stoma closer to the skin incision. Only with the patient in this position and with good light and suction at hand should the old tracheostomy tube be removed and replaced. Never attempt this maneuver during the first two postoperative weeks with the patient in a sitting position.

## Complications

Hemorrhage following tracheostomy may occur as a result of failing to ligate the bleeding points in the wound. The problem manifests as bleeding around the tracheostomy tube. A far more serious type of hemorrhage may occur late in the postoperative period if the tip of the tracheostomy tube or the balloon cuff erodes through the anterior wall of the trachea into the innominate artery. This is a life-threatening

complication manifested by arterial bleeding into the trachea. Emergency management of this condition depends on temporarily controlling the bleeding by inflating the balloon cuff. If inflating the cuff around the tracheostomy tube does not promptly control the bleeding, remove it and immediately insert an orotracheal tube. Secure immediate control of the bleeding by passing an index finger into the tracheostomy stoma and occluding the bleeding site against the underside of the sternum. Sometimes inflating the cuff of the orotracheal tube is sufficient to control the bleeding temporarily. Emergency resection of the innominate artery with suture of both ends may be necessary for definitive repair of the fistula, with resection also of the damaged trachea in some cases. Subcutaneous emphysema may be avoided if the tissues are not sutured too snugly against the tracheostomy tube. There may be some air leakage between the trachea and the tracheostomy tube. If this air has access to the outside, subcutaneous emphysema does not occur.

The role of bronchoscopic guidance in increasing the safety of percutaneous tracheostomy is somewhat controversial. Some think that having a bronchoscope in the endotracheal tube during the procedure can increase the chances of airway complication, but most feel that it actually lowers the chance of a serious operative complication such as posterior tracheal wall injuries, paratracheal placement, or pneumomediastinum. Percutaneous tracheostomy seems to have a lower incidence of peristomal bleeding and postoperative infection compared to surgical tracheostomy, presumably because the stoma fits more snugly around the tracheostomy tube. This lack of dead space serves to both tamponade bleeding and to impede infection. There have been more tracheal ring fractures that occur with the dilating portion of the percutaneous approach. While performing a tracheostomy, loss of a secure airway is a possibility. This can occur by inadvertently withdrawing the endotracheal tube too far or with unsuccessful placement of the tracheostomy tube. If this occurs, the safest maneuver is to reintubate the patient with an endotracheal tube and abort the procedure.

Late sequelae of tracheostomy include symptomatic tracheal stenosis and tracheoinnominate artery fistula. Based on available information, there is no advantage of either technique in preventing these adverse outcomes. Stenosis may occur sometime after the tracheostomy tube has been removed. The stenosis may be at the tracheal stoma or in the area of the trachea occluded by the balloon cuff. Making the incision in

the trachea as small as possible may minimize strictures at the stoma level. Constrictions lower in the trachea have been virtually eliminated by large-volume, low-pressure balloon cuffs. If a patient who had a prior tracheostomy ever develops signs of an upper airway obstruction (stridor, wheezing, shortness of breath), a stricture of the trachea should be strongly suspected. A lateral radiograph of the neck can disclose an upper tracheal stricture, and an oblique chest radiograph should identify lower tracheal lesions. Computed tomography or magnetic resonance imaging provides better imaging details. Tracheal resection and anastomosis may be necessary for serious strictures. A granuloma may be resected through a bronchoscope utilizing the laser in some cases.

Wound infection, pneumothorax (rare), and accidental displacement of the tracheostomy tube may also occur. In conclusion, open surgical tracheostomy and percutaneous tracheostomy are both safe and effective approaches to providing a definitive airway in the critically ill.

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## Further Reading

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