# Chapter 68 – Tracheostomy

**Karen M. Kost,**
**Eugene N. Myers**

Tracheostomy was first described many centuries ago. Alexander the Great is reported to have “punctured the trachea of a soldier with the point of his sword when he saw a man choking from a bone lodged in his throat” in the fourth century bc.[1,2] The first successful tracheostomy was attributed to Antonio Musa Brasavola, who recorded saving the life of a patient close to death from an “abscess of the windpipe” in 1546. In 1620, Nicholas Habicot of Paris published a 108-page book on tracheostomy, the first work devoted solely to this operation. One of the patients he described was a 14-year-old boy who intentionally swallowed a bag of gold coins to prevent their theft. The bag lodged in his esophagus and produced upper airway obstruction. Habicot performed a tracheostomy to improve the airway and then manipulated the bolus, initiating its esophageal descent. Despite these success stories, tracheostomy remained a marginal procedure viewed with suspicion and fear for several centuries because of very high morbidity and mortality rates. In 1799, when Dr. Elisha Dick recommended tracheostomy for a patient in airway distress, two colleagues vocally opposed him, and on December 14, 1799, George Washington died of acute upper airway obstruction.

Prevailing attitudes toward tracheostomy changed dramatically in the 19th century. The description in 1825 of a lifesaving tracheostomy in a child seems to have singularly had the greatest impact. In that year, Bretonneau saved the life of a 5-year-old girl named Elisabeth de Puysergur who was suffering from diphtheria by performing a tracheostomy. In 1833, Armand Trousseau related, “I have now performed the operation in more than 200 cases and I have the satisfaction of knowing that one-fourth of these operations were successful.”

Cautiously, the indications for tracheostomy expanded and the procedure became more widely accepted. During this time, subjects such as technique, complications, tube morphology, tracheostomy placement, and anesthesia were hotly debated in the medical literature, and there were almost as many views as there were surgeons. Many of the patients who underwent tracheostomy suffered from diphtheria and unfortunately died of the toxic effect of the disease, even though the airway obstruction had been relieved by the procedure. It was to be the work of Chevalier Jackson in 1909 that would earn tracheostomy a solid and permanent place in the surgeon's armamentarium. Jackson standardized the technique and indications for the operation, and demonstrated that with attention to a few key technical points, the morbidity and mortality from the procedure could be dramatically reduced.[3,4] Jackson emphasized the importance of a long incision, avoidance of the cricoid cartilage, routine division of the thyroid isthmus, slow and careful surgery, use of a proper cannula, and meticulous postoperative care. Jackson's teachings were in large part responsible for reducing the mortality of tracheostomy to less than 2% and reducing the incidence of laryngeal stenosis, particularly in children.

Over the years, the indications for tracheostomy have continued to change in parallel with the evolution of medicine. Endotracheal intubation for short-term airway protection and/or ventilation has replaced tracheostomy in treating several conditions. Currently, the majority of tracheostomies are performed in critically ill patients. Other indications include sleep apnea, chronic lung disease, primary alveolar hypoventilation syndrome (Ondine's curse), and conditions requiring home mechanical ventilation.[5,6]

## *PATIENT SELECTION*

The primary objective of a tracheostomy is to secure an artificial airway. Current major indications for tracheostomy include: (1) relief of upper airway obstruction (both acute and chronic), (2) providing a means for assisted mechanical ventilation, and (3) enabling more efficient tracheobronchial toilet. The decision to carry out a tracheostomy is complex, and numerous factors must be considered to ensure that this is the optimal procedure for the individual patient. These factors include the relative advantages and risks of tracheostomy versus alternative methods of providing an artificial airway, the facilities of the institution, the skills of the personnel, the unique features of the patient's airway and respiratory physiology, and the specific disorder or disease process and its likely course.[7]

Patients with upper airway obstruction should be managed initially by endotracheal intubation, when possible, to stabilize the airway and the patient's general condition. Treatment of the condition may permit extubation, rendering tracheostomy unnecessary. Examples include management of acute epiglottitis in children or adults, and angioneurotic edema of the larynx.

Patients with upper airway obstruction, from laryngotracheal trauma or neoplasms of the upper aerodigestive tract, may be stabilized with endotracheal intubation initially but are likely to require conversion to a tracheostomy. Laryngeal papillomatosis and subglottic hemangioma are examples of neoplastic processes in children that may require a tracheostomy (Fig. 68-1).

Click to view full size figure

**Figure 68-1** Large volume papilloma obstructing the airway in a young child.

Patients with chronic upper airway obstruction will require a tracheostomy in the management of their problem. Such conditions affect patients with nasal and craniofacial anomalies, such as Crouzon's disease, large nasal encephalocele, Treacher-Collins syndrome, subglottic stenosis, and laryngeal and subglottic webs. Some patients develop iatrogenic laryngeal or subglottic stenosis from chronic airway management, such as those in the neonatal intensive care unit with respiratory insufficiency who require artificial ventilation.

Patients who require ventilatory assistance, such as those with central nervous system disorders, stroke, drug ingestion, or respiratory failure, should soon undergo conversion from endotracheal intubation to tracheostomy. The fact that prolonged endotracheal intubation of the larynx causes laryngeal stenosis and other laryngeal complications has made tracheostomy useful in such settings.

Patients with chronic obstructive pulmonary disease, adult respiratory distress syndrome, and crush injuries to the chest, who require efficient pulmonary toilet, may also be well managed by tracheostomy.

## *PREOPERATIVE PLANNING*

Every effort should be made to ensure that the patient's condition is optimized before surgery. Coagulopathies should be corrected to an International Normalized Ratio (INR) of less than 1.5, with more than 50,000 functioning platelets. Cessation of aspirin or other nonsteroidal anti-inflammatory medications for 10 days preoperatively is ideal but not absolutely necessary. A cross-match should be obtained if the hemoglobin is less than 10 g.

Patients presenting with stridor require a safe airway first and foremost. In some cases, this may be achieved with endotracheal intubation with or without endoscopic guidance. Situations involving severe facial or laryngeal trauma may make intubation an unsuitable, even dangerous, choice. In these instances, emergency bedside tracheostomy may be a lifesaving measure. An unstable airway is one of the few true emergencies that may lead to death, and its management requires mobilization of the team to stabilize the airway as quickly as possible.

Traditionally, tracheostomy has been performed in the operating room (OR), which is fully equipped with adequate lighting, suction, and assistance. Admitted patients as well as those from the emergency department, are best transferred to the controlled, monitored setting of the OR whenever possible. Intubated adult patients from the intensive care unit (ICU) may undergo tracheostomy safely either at the bedside[8–10] or in the OR[11,12] with comparable complication rates.

If possible, the anesthesia team should be present during tracheostomy, because patients who have a chronic form of respiratory insufficiency with high $CO_2$ levels may lose their respiratory drive following establishment of their airway. Such patients require close monitoring of all vital signs, and in severe cases may also require assisted ventilation and even cardiopulmonary resuscitation.

## *SURGICAL TECHNIQUE*

The patient is placed on the operating table with a rolled towel or sheet under the shoulders to extend the neck unless the patient has documented or suspected cervical spine injuries. In such cases, extension of the neck is contraindicated because of the risk of spinal cord compression. Adults with airway obstruction may not be able to tolerate the supine position, and tracheostomy may need to be performed with the patient sitting up at 45 degrees. Patients with severe cervical osteoarthritis, kyphoscoliosis, or other conditions, in whom the neck cannot be hyperextended, present a formidable surgical challenge. The use of local or general anesthesia may be dictated by the circumstances. Patients with a marginal airway and respiratory distress must be managed with local anesthesia alone without sedation to prevent suppressing the respiratory drive. In more elective situations, with a protected airway, either general anesthesia or local anesthesia with intravenous sedation may be appropriate. In children, the procedure is typically carried out under general anesthesia.

Lidocaine (Xylocaine) 1% with 1:100,000 epinephrine is injected into the skin and subcutaneous tissue where the incision will be placed. This maneuver may be helpful regardless of anesthetic technique because of the benefits of local vasoconstriction. The neck, face, upper chest, and shoulders are prepared with a povidone-iodine (Betadine) or other suitable solution, and a drape is placed to allow easy access to the neck and oral cavity.

A transverse incision is made approximately 1 cm above the suprasternal notch or 2 cm below the cricoid cartilage. Sharp dissection is carried through the subcutaneous tissue. Four small rake retractors are used to provide good exposure. The anterior jugular veins should be identified and retracted laterally (Fig. 68-2). It is not necessary to ligate these vessels unless they are inadvertently cut. The strap muscles are split in the midline and retracted laterally (Fig. 68-3A). The thyroid isthmus is visualized and the anterior wall of the trachea identified (see Fig. 68-3B). In adults, the thyroid isthmus can often be retracted superiorly and the trachea entered (see Fig. 68-3C). If the trachea cannot be exposed otherwise, the isthmus is undermined and grasped with right-angled clamps, transected, and then ligated with 2-0 silk or Vicryl suture on a cutting needle. In patients under local anesthesia, it is important to inject additional lidocaine in the paratracheal tissues before opening the trachea to obtain effective anesthesia. Once the trachea is identified, a tracheal hook is placed in the area of the second tracheal ring and held by an assistant to immobilize the trachea in the wound. In infants and children, a vertical incision is made between the second and the third or the third and the fourth tracheal rings without removing any cartilage. Traction sutures are then placed just lateral to the incision (Fig. 68-4).

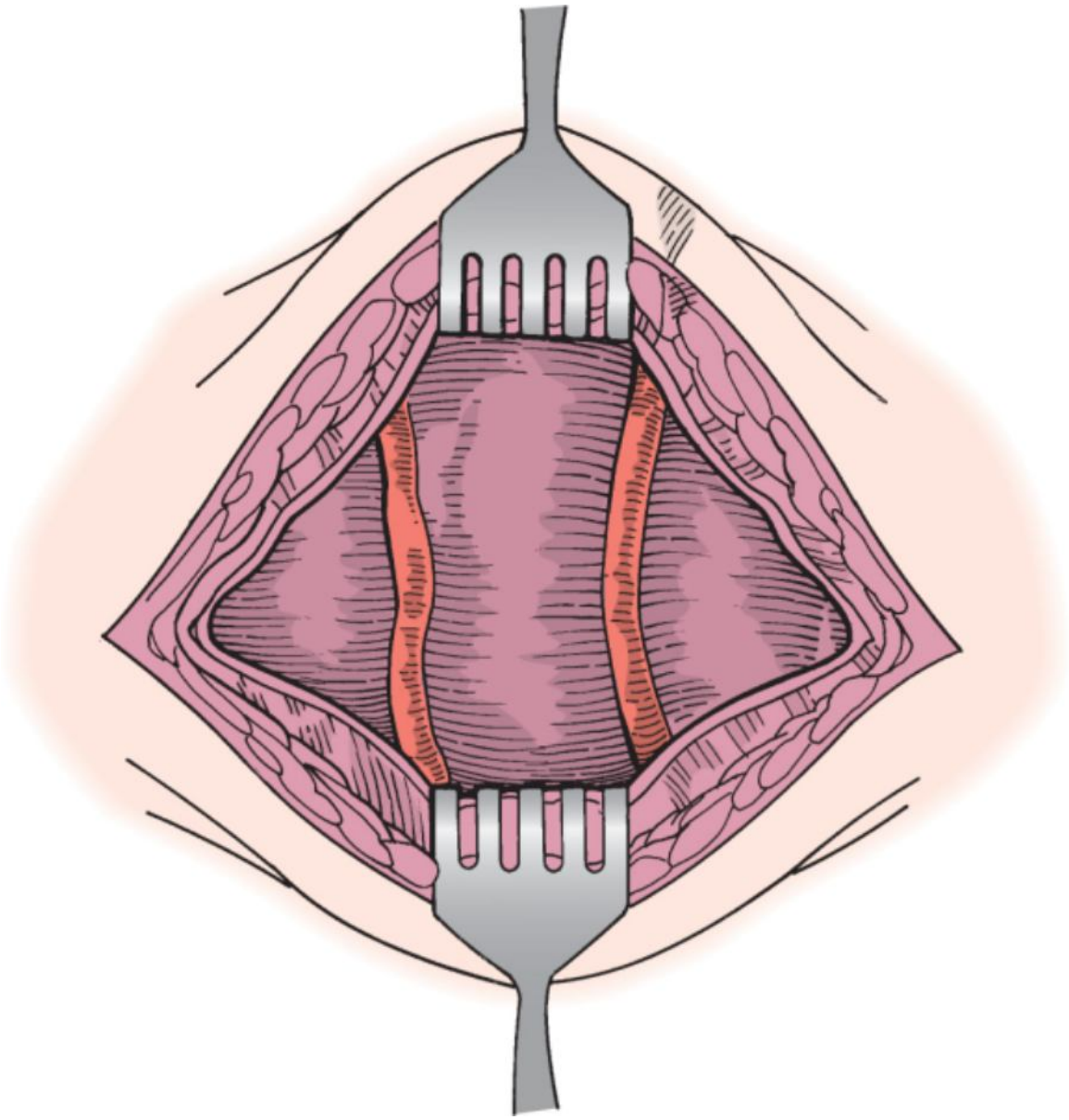

**Figure 68-2** Retractors promote good visualization of the operative field.

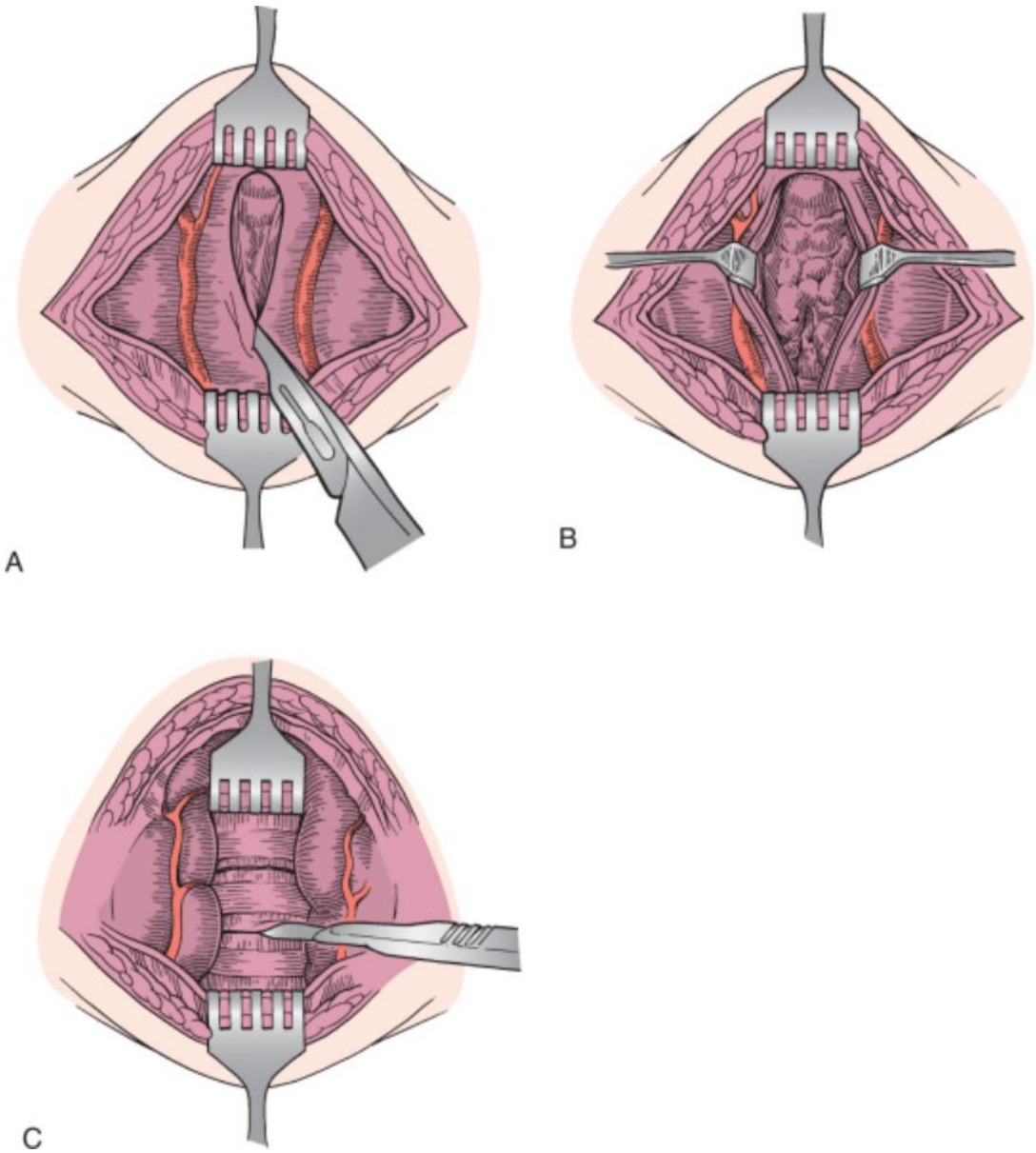


**Figure 68-3** **A,** The strap muscles are split in the midline and retracted laterally. **B,** The trachea and thyroid isthmus are identified. **C,** The trachea is entered through an incision between the second and the third tracheal rings as the thyroid isthmus is retracted superiorly, or divided, as required.

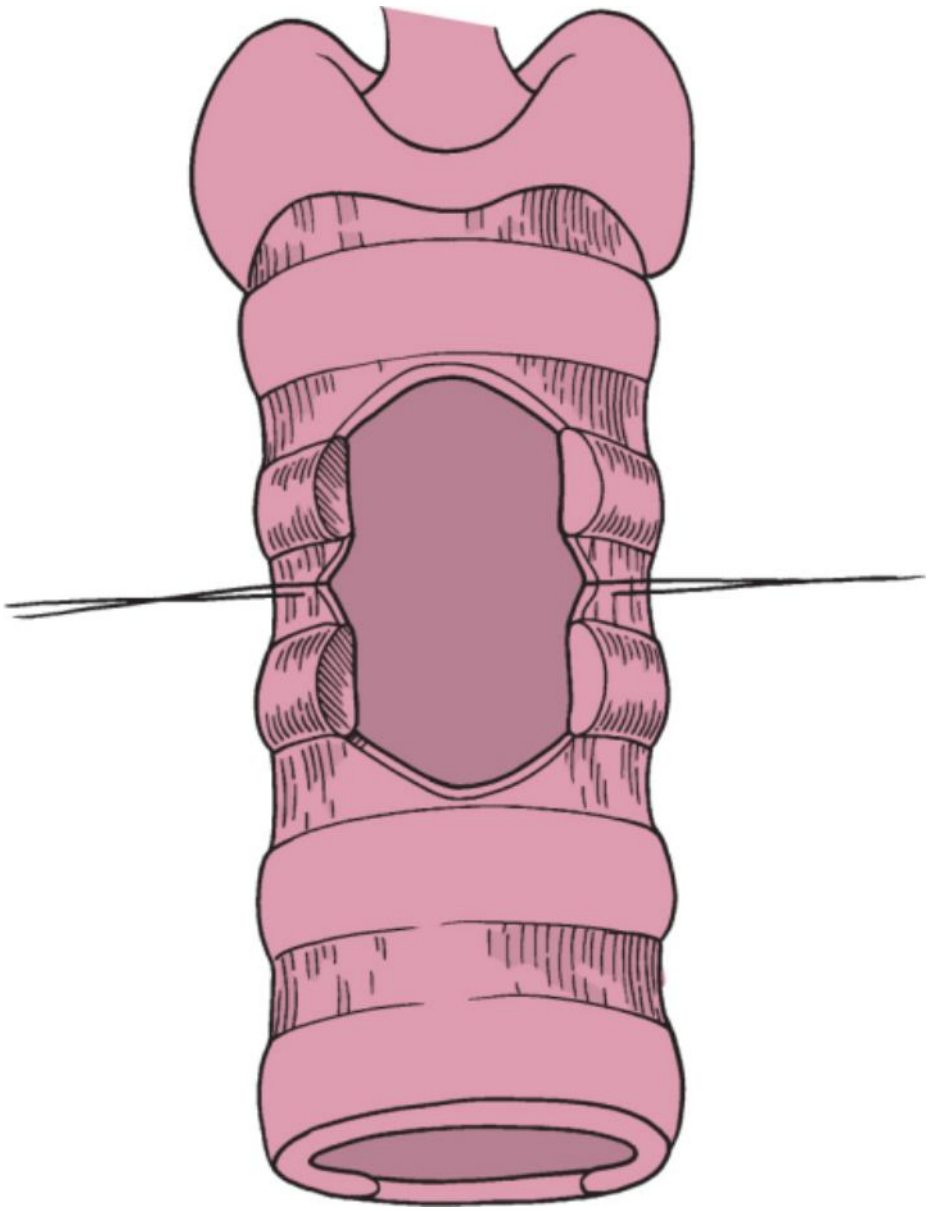

**Figure 68-4** Traction sutures are placed lateral to the stoma in children. No cartilage is removed.

In adults, the anterior portion of the third or fourth tracheal ring removal may facilitate insertion of the tracheostomy tube. In most older patients, the tracheal ring is calcified, and heavy scissors must be used to excise a small portion of the tracheal ring after transverse incisions have been made in the area just above and below the tracheal ring. This maneuver effectively leaves a rectangular window in the trachea (Fig. 68-5). If necessary, the opening may be enlarged by removing additional cartilage with a Kerrison rongeur. Removal of the anterior aspect of the tracheal ring ensures that the cannula is placed in the trachea rather than in a false passage anterior to the trachea.[13]

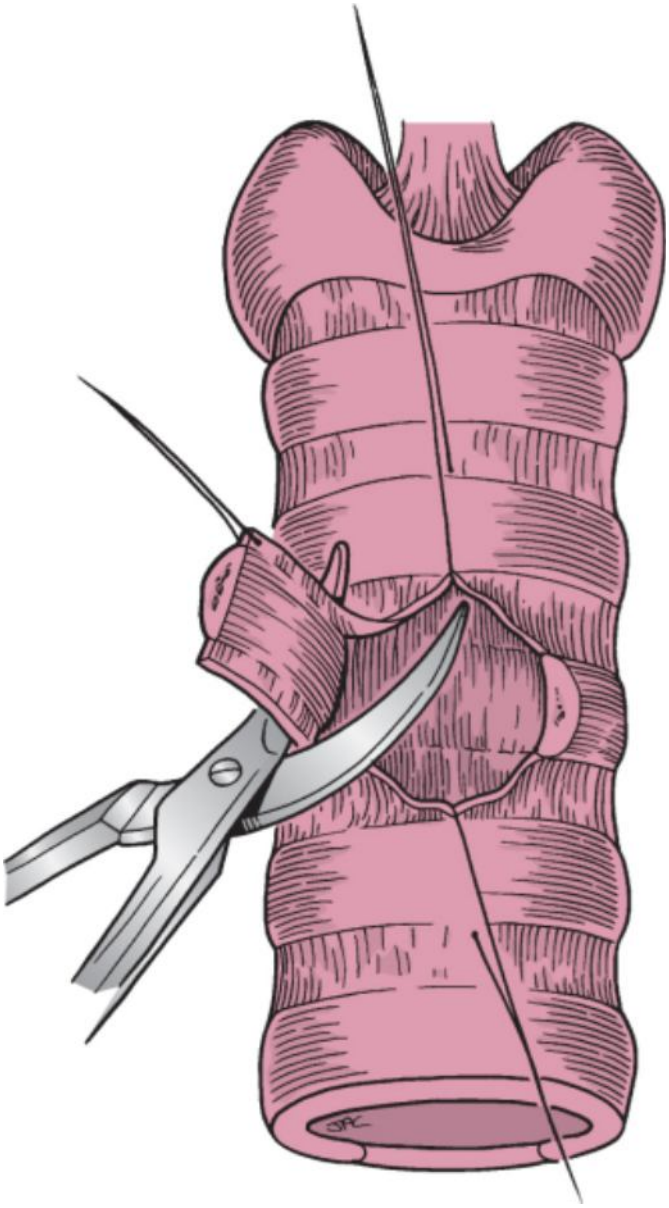

**Figure 68-5** A portion of the tracheal ring is removed to form a window in the trachea.

Traction sutures are inserted to reduce the possibility of creating a false passage in the event that the tracheostomy tube becomes displaced in the immediate postoperative period before a tract has been formed. These are placed in the trachea with a ligature carrier loaded with 2-0 silk (Fig. 68-6). A ligature carrier is easier to manipulate in the depths of the wound than a curved needle. While the tracheal hook retracts the trachea inferiorly, the ligature carrier is passed through the interspace just above the ring superior to the stoma and into the lumen, with care taken not to penetrate the posterior tracheal wall. A small, curved clamp is used to grasp the suture and to stabilize it while the ligature carrier is removed. A similar procedure is carried out inferiorly. Alternatively, traction sutures may also be placed in the lateral tracheal wall. Traction is applied to both sutures to exteriorize the stoma and retract the wound edges. The tracheostomy tube is placed in the tracheal lumen, and the traction sutures are then tied and fixed to the skin of the chest with adhesive tape.

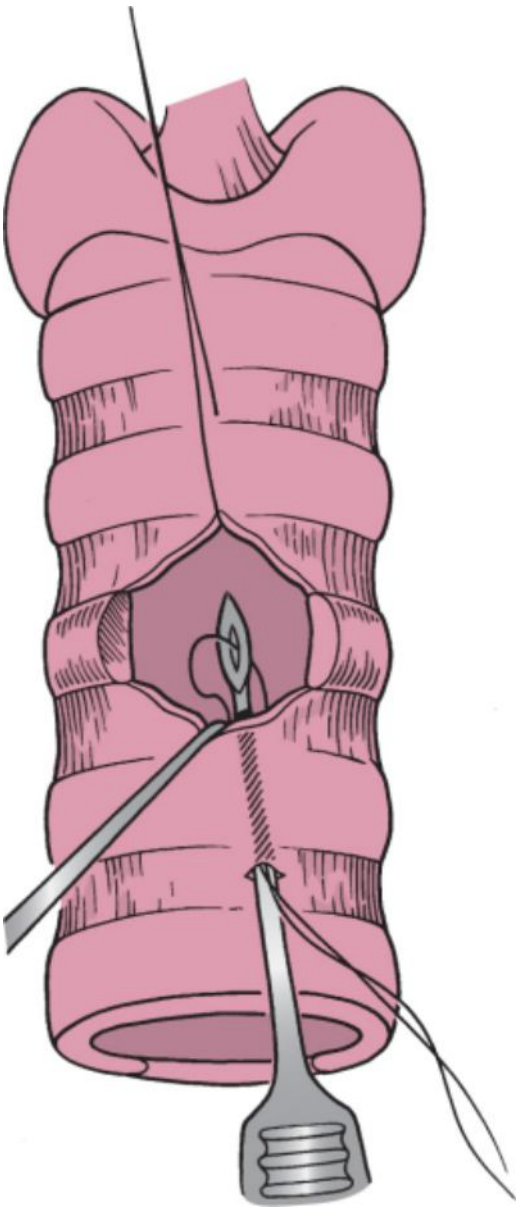

**Figure 68-6** Traction sutures are placed superior and inferior to the stoma in adults.

Once the traction sutures have been satisfactorily placed, the tracheal cannula may be introduced into the stoma. This is begun with the cannula at right angles to the trachea; then, as the cannula is inserted, it is turned so that its axis is parallel to that of the trachea (Fig. 68-7A). This eliminates the difficulty encountered in trying to pass the cannula over the patient's chest. An obturator should always be used while the cannula is inserted. Once the cannula is properly placed in the trachea, the obturator is removed promptly and the inner cannula inserted. Once the tracheostomy tube is in place and adequate ventilation through the tracheostomy tube is assured, the endotracheal tube or bronchoscope used to stabilize the airway may be removed.

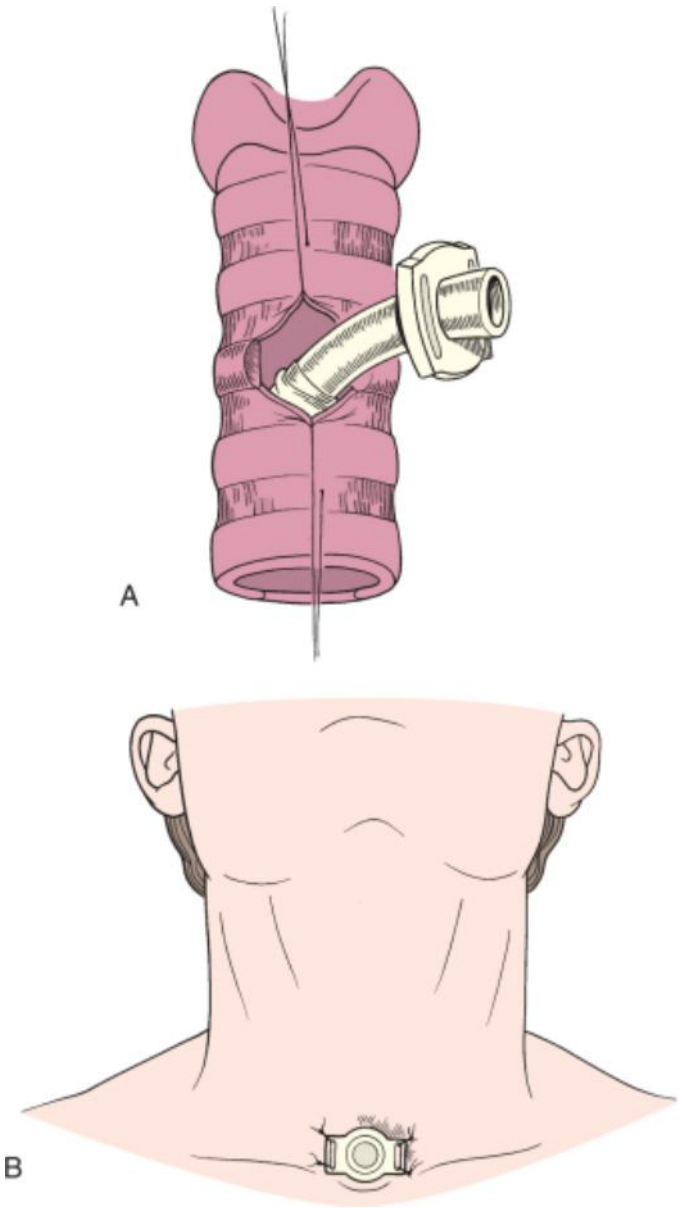


**Figure 68-7** **A,** The tracheostomy tube is inserted into the trachea. **B,** The neck plate of the tracheostomy tube is sutured to the skin. The use of tapes is optional.

The tracheostomy cannula is secured by suturing the neck plate to the skin and by tracheostomy tapes tied securely with a square knot with the neck flexed. Only one fingertip should be admitted between the tape and the patient's neck, and the tapes should be tied over the skin and not over a bulky dressing. When tapes are tied over bulky dressings, the stability of the tracheostomy tube is compromised. This is a major cause of tube displacement in the early postoperative period. In patients undergoing head and neck surgery, the tape is not used if it crosses the cervical flap incision or causes constriction of the blood supply of a regional flap brought up through the neck. In such cases, the tube is sutured to the underlying skin with 2-0 silk sutures (see Fig. 68-7B).

When a tracheostomy is carried out under ideal circumstances, with enough time for vasoconstriction, bleeding is minimal. It is important to secure all bleeding points, with either ligatures or electrocautery, to prevent bleeding postoperatively. Caution should be exercised when using electrocautery close to the trachea because of the risk of airway fire. To reduce the possibility of this catastrophic event, the patient should be ventilated on the lowest possible oxygen concentration, and the trachea should never be entered with electrocautery.

To prevent subcutaneous emphysema, the incision should not be sutured or packed. The wound may be left open or a very light dressing applied.

When the cannula is removed, the wound heals by secondary intention, forming a transverse scar, which is generally less unsightly than the scar left by a vertical incision. When subcutaneous and deeper tissues are properly undermined and retracted, the same amount of working space is obtained through a transverse incision as through a vertical incision.

## POSTOPERATIVE CARE

The choice of the proper tracheostomy tube is important. The purpose of a tracheostomy tube is (1) to provide an airway, (2) to provide for the possibility of artificial positive pressure ventilation if needed, (3) to seal the trachea to reduce aspiration of material from above the tube or in the hypopharynx, and (4) to provide a means of suctioning the tracheobronchial tree.[14] Aspects of tube selection include the shape of the tube and the neck plate. If a cuffed tube is necessary, it should be a low-pressure, high-volume cuff to reduce the possibility of tracheal stenosis. Tubes with an inner cannula provide an added safety dimension in that the inner cannula can be quickly removed in case there is a mucous plug, leaving the outer cannula in situ and the airway protected.

Preoperative planning should also account for any special type of tracheostomy tube reguirements. For instance, obese patients with thick pretracheal soft tissues may require extended-length tubes to decrease the risk of accidental decannulation or tube displacement. Tracheostomy tubes with either proximal or distal extensions are available. Tubes with adjustable flanges and those made of softer, thermolabile materials for anatomically difficult situations are also available. Some patients may benefit from a Passey-Muir valve in the postoperative period. These valves allow the generation of subglottic pressure and therefore facilitate deglutition. The surgeon must therefore be certain that the correct tracheostomy tube is chosen to accommodate these situations.

Postoperative care of the tracheostomy is greatly facilitated through preoperative teaching. This helps allow both children and adults undergoing tracheostomy to adjust to this new way of breathing. Evidence indicates that patients undergoing tracheostomy experience a reduced quality of life.[15] Family counseling is extremely important to support the patient during this time. Highly skilled nursing care is fundamental to the success of this procedure.

In the initial postoperative period, patients are placed in a semi-Fowler position to maximize the ease of coughing and deep breathing, to facilitate suctioning, and to minimize discomfort. Vital signs require frequent monitoring because changes in blood pressure, respiratory rate, or pulse rate may indicate that there is a new or ongoing respiratory problem or that the tube may be plugged or have come out of the trachea. Similarly, agitation, anxiety, and restlessness may all indicate hypoxia. Tracheal suctioning is performed to maintain pulmonary toilet and patency of the tracheostomy tube. Initially, this should be done as aseptically as possible and may be necessary three to four times daily. Either a portable or a wall suction unit may provide the negative pressure needed for suctioning. Patients on mechanical ventilation are at risk for hypoxia and cardiac arrhythmias during suctioning because oxygen-rich air is suctioned and catheters may be too large. This can be prevented by applying suction for up to 12 seconds with a small catheter and ventilating the patient on 100% $O_2$ for at least five breaths before and after suctioning. As an alternative to this open technique, a closed, multiple-use suction catheter contained within a sheath may be used.[16]

Humidification is extremely important to facilitate mucociliary transport of secretions and to prevent crusting, accumulation of secretions, and eventual obstruction of the airway. Humidification is usually delivered through a tracheal mask. The use of a T-tube is avoided because the torque exerted on the tracheostomy tube traumatizes the tissue every time the patient moves.

Meticulous local wound care is of paramount importance. The tracheostomy site should be cleaned as often as necessary with normal saline or hydrogen peroxide to prevent breakdown of the skin and the progression from wound colonization to infection. Initially, this should be three or four times daily. The twill tapes that hold the tracheostomy tube in place should be changed as necessary. The skin under the tracheostomy neck plate should be kept dry with a thin nonadherent dressing such as Telfa to prevent maceration. It takes at least 48 to 72 hours for a tract to form around the tracheostomy tube. Accordingly, the surgeon should avoid changing the tube until adhesions form between the overlying soft tissues and the trachea. Accidental decannulation in the early postoperative period is more dangerous because the tissues collapse, sealing off the airway. Changing the tracheostomy tube requires some finesse, and early on it is not necessary unless the patient is to be changed from a cuffed to an uncuffed tube or if the cuff fails. Tube replacement in the first 48 hours requires:

- Optimal patient positioning
- Assistance
- Adequate light
- Tracheal hook
- Suction

In addition, the use of a tracheostomy tube exchanger may be extremely useful. The exchanger is a long semiflexible tube with a central lumen through which ventilation is possible. The exchanger is inserted into the tracheostomy tube, which is then removed and replaced with the new tube. The exchanger “guides” the new tracheostomy tube into the trachea. If for any reason the new tracheostomy is difficult to replace, ventilation may be temporarily continued through the exchanger.

The inner cannula must be removed frequently and cleaned to make sure that mucus obstruction does not occur.

Decannulation in adults can be safely accomplished by following a few simple steps. Indirect or flexible endoscopy should be used to ensure that the upper airway is adequate and the larynx is competent. The tube may then be downsized and plugged during waking hours. The patient must be instructed to remove the plug in the event of dyspnea or shortness of breath. If the patient tolerates the plug for 24 hours, the cannula can be removed and the stoma covered with a light dressing and occlusive tape. The period of plugging allows for adequate evaluation of airway adequacy. It also affords time for laryngeal adductor reflexes to be activated. If the plug is not tolerated further, the nature of the obstruction must be investigated.

Children should undergo endoscopy before decannulation. Often a granuloma in the stomal site is found; removing the granulomas enhances successful decannulation. If the airway is adequate, the patient can be decannulated.

## *COMPLICATIONS*

Complications of tracheostomy may be divided into intraoperative, immediate postoperative, and late postoperative complications. Most complications of tracheostomy can be prevented or minimized by providing optimal conditions, which include adequate light, suction, and assistance. For admitted patients or airway emergencies, the surgery is best done in the controlled setting of the OR. For those patients in respiratory distress, the airway should be secured whenever possible by insertion of an endotracheal tube before proceeding to the OR. For adult intubated ICU patients, the procedure may also be safely performed at the bedside, as long as adequate light, suction, and assistance are available.

### Intraoperative Complications

#### *Hemorrhage*

Hemorrhage may be related to the patient ingesting anticoagulants, aspirin, or nonsteroidal anti-inflammatory agents. These may contribute to excessive bleeding during the procedure and in the immediate postoperative period. Patients with coagulation disorders, such as hemophilia, leukemia, or liver disease, may also have excessive bleeding. Every effort should be made to correct these problems preoperatively unless the situation is emergent, in which case correction may be undertaken during the procedure. The surgeon must be absolutely meticulous in controlling the bleeding.

Bleeding during tracheostomy may be minimized by careful attention to the details of the procedure. When using local anesthesia, the procedure should not be begun until adequate vasoconstriction has been achieved. Bleeding is usually minimized by staying in the midline with the dissection, being cautious to dissect layer by layer, and maintaining adequate light and assistance with retraction of the soft tissues. Bleeding from transection of the anterior jugular vein, the thyroid isthmus, and a high innominate artery are all possible and should be dealt with appropriately by identifying, ligating, or cauterizing the offending vessel. Injury to the innominate artery may require repair and the expertise of a vascular surgeon. Introduction of the tracheal cannula may cause a paroxysm of coughing, and bleeding may occur at that time. Appropriate retraction, suction, and lighting will facilitate identification and ligation of the involved vessel. Packing should be avoided because extravasation of air through the packing during coughing predisposes to subcutaneous emphysema.

#### *Intraoperative Tracheoesophageal Fistula*

Intraoperative tracheoesophageal fistula has been reported when the tracheal wall has been injured inadvertently, usually during an “urgent” tracheostomy with over penetration of the trachea itself. If this is recognized at the time, it may be necessary to open the neck once the airway has been established and individually close the wounds in the trachea and the esophagus.

#### *Pneumothorax*

Pneumothorax is most likely to occur in a patient suffering from air hunger. It may also be due to direct puncturing of the pleura by the surgeon. This latter situation is most common in children, in whom the apex of the lung protrudes into the lower neck and is more vulnerable to injury. Pneumothorax may also occur when the tracheostomy tube is inserted between the anterior wall of the trachea and the soft tissues of the anterior mediastinum, creating a “false passage” (Fig. 68-8). This condition is much less likely to occur if the cannula is inserted with adequate exposure, retraction, and the use of traction sutures.

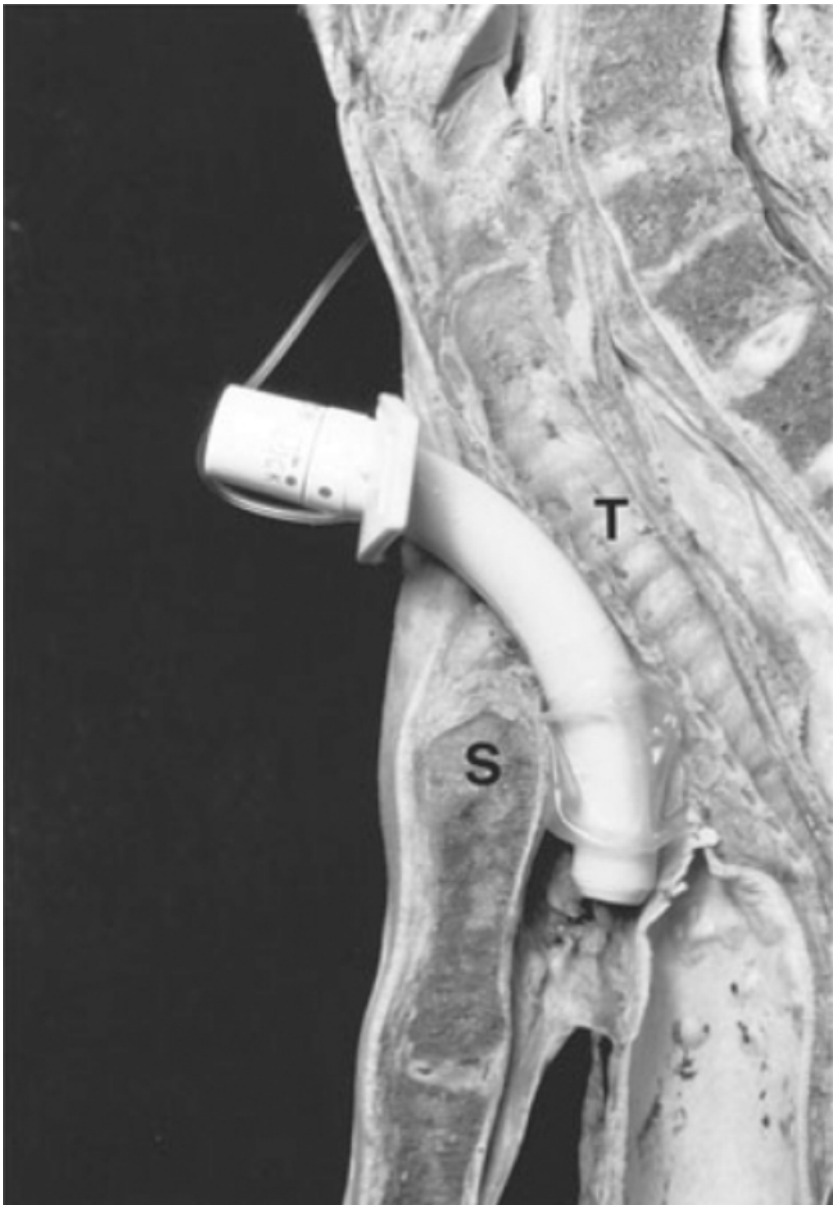


**Figure 68-8** Mechanism of false passage between the sternum (S) and the trachea (T).
*(From Myers EN, Stool SE, Johnson JT: Complications in tracheostomy. In Myers EN, Stool SE, Johnson JT [eds]: Tracheostomy. New York, Churchill Livingstone, 1985, p 150.)*

### *Pneumomediastinum*

Pneumomediastinum is most common in children and is usually noted on routine chest radiographs. This complication may be due to excessive dissection of the paratracheal soft tissues or when the patient is struggling to breathe against an obstructed airway. Excessive coughing that forces air from the open tracheostomy into the deeper planes of the neck may also result in pneumomediastinum. Patients with pneumomediastinum are generally asymptomatic, and no therapy is required.

Cardiopulmonary arrest may occur in patients who have had chronic air hunger and elevated $CO_2$ levels. The anesthesia team should be alerted to this possibility in the event that cardiopulmonary resuscitation is necessary. Sudden relief of chronic upper airway obstruction may also result in congestive heart failure due to extravasation of fluid into alveoli in response to reduction of obstruction-induced positive end-expiratory pressure.

### *Fire*

Fire during tracheostomy is rare and may be a catastrophic event. External burns may result from the use of electrocautery shortly after prepping the skin with alcohol-containing solutions. This is of particular concern in hirsute patients, in whom body hair interferes with the drying of the solution. Therefore, every effort should be made to ensure that the operative field is completely dry before electrocautery use, or the solutions should be avoided when possible.

Fire may also occur when using electrocautery in the presence of high concentrations of oxygen, whether delivered by mask (as in local procedures) or via the endotracheal tube under general anesthesia. Oxygen concentrations should be kept at a minimum safe concentration for the patient, and cautery should never be used to enter the airway. In the unfortunate instance of an airway fire, the immediate response includes turning off the oxygen, changing the endotracheal tube, and the use of water in the field, followed by bronchoscopy to assess the extent of injury, medical treatment with antibiotics and steroids, and observation in the ICU. The best treatment consists of instituting all measures necessary to prevent such events.

## Immediate Postoperative Complications

### *Tube Obstruction*

Tube obstruction may be caused by thick mucus or blood clots. This complication is potentially fatal. These may be prevented by attentive nursing care, proper humidification, and frequent suctioning. The use of a tracheostomy tube with an inner cannula that allows regular inspection, cleansing, and suctioning is critical. If for some reason the obstructed tube cannot be cleared, it should be removed and replaced.

### *Displaced Tracheostomy Tube*

Displacement of the tracheostomy tube may occur at any time and is potentially fatal. This complication is most dangerous in the immediate postoperative period before a tract has formed in the soft tissues around the tracheostomy tube. Patient factors that may predispose to displacement of the tube include obesity, excessive coughing, and agitation. Physical factors include incorrect placement of the opening into the trachea, creating a false passage (see Fig. 68-8), loosening of the tapes as a result of resolution of subcutaneous emphysema, inadequately tied tracheostomy tapes, and use of bulky dressings. Such situations are largely preventable by suturing the neck plate to the skin surrounding the tracheostoma.

Displacement of the tracheostomy tube should be suspected when a patient with a fresh tracheostomy develops respiratory distress or is suddenly able to speak. Management of this displacement may be facilitated by traction sutures. When the complication is recognized, the traction sutures should be pulled gently and then returned to a position parallel with the patient's neck. This will retract the skin and bring the stoma into the wound. The tracheostomy tube is then inserted and adequate ventilation verified. If this procedure fails or in a patient with known difficult anatomy, it may be best to reintubate the patient and find the tracheostomy tract once the airway is secured. Identifying the stoma with suction tubing and inserting the tracheostomy tube into the trachea is an alternative method of restoring the airway.

### *Postoperative Hemorrhage*

Postoperative bleeding may occur when the vasoconstriction from the epinephrine wears off or if vessels that were injured during surgery were not ligated. Treatment requires identification and ligation of vessels. For “oozing,” use of a hemostatic packing such as Surgicel may be helpful. Coagulopathies should be identified and corrected. If there is significant bleeding, the patient should be returned to the OR, the wound explored, and hemostasis achieved. Packing an actively bleeding tracheostomy site is contraindicated because of the potential for subcutaneous emphysema.

### *Wound Infection*

The tracheal wound is colonized within 24 to 48 hours by many species of organisms, including *Pseudomonas* and *Escherichia coli,* as well as gram-positive cocci.[13] It is not possible to prevent colonization. Tracheostomy tubes are also colonized by bacteria such as *Staphylococcus epidermidis,* which are imbedded in biofilm. The longer the tube is in place, the heavier the load of biofilm. This biofilm functions as a “coat of armor” of sorts, effectively protecting bacteria from local and/or systemic antibiotics. A true infection of the tracheal stoma is uncommon. Antibiotics may simply select for colonization by a resistant organism. Regular tracheostomy tube changes every 2 weeks for admitted patients may decrease the incidence of granulation tissue and biofilm formation.[16,17]

The fundamental principle is meticulous hygiene with suctioning, cleansing, dressing and tie changes, and tube changes when necessary to remove crusts and necrotic debris, thereby reducing bacterial load. Traction sutures should be removed after the first tube change. True infection with surrounding cellulitis is unusual and should be treated with organism-specific antibiotics and aggressive local wound care with débridement.

Tracheobronchitis may be due to underlying disease or aspiration, or both. Treatment is with suctioning, vigorous pulmonary exercise (blow bottles, cupping and clapping, ambulation), and judicious administration of antibiotics.

Rarely, necrotizing stomal infections may occur, with substantial loss of soft tissue down to and including the tracheal wall. Further progression of the process may result in carotid artery exposure, with its attendant risks.

Management includes aggressive wound débridement and cleaning with antiseptic dressings as well as culture-guided antibiotics. Rarely, local flaps may be necessary to provide soft tissue coverage to vital structures.[16]

### *Subcutaneous Emphysema*

Air may be forced into the subcutaneous tissues during or shortly after tracheostomy. Factors predisposing to this complication include excessive coughing, use of an uncuffed tracheostomy tube, tight suturing of the wound or tracheostomy tube, and packing of the wound. Emphysema is usually mild and may be diagnosed by palpating crepitus in the tissues of the neck, chest, or face. Subcutaneous emphysema is generally prevented by using a cuffed tracheostomy tube and not packing the wound. If the condition is severe, the wound should be opened and any packing removed. Otherwise, no treatment is necessary because the air is slowly absorbed from the tissues.

## Late Postoperative Complications

Granulation tissue is considered to be a late complication or sequela of tracheostomy, variably reported as occurring in 3% to 80% of cases.[17] It is also commonly seen in children, especially those in whom a fenestrated tube has been used. The clinical importance of granulation tissue lies in its ability to bleed, complicate tracheostomy tube changes, delay attempts at decannulation, and completely obstruct the tracheostomy tube with potentially catastrophic results. Factors believed to favor formation of granulation tissue include bacterial infection, gastroesophageal reflux, suture material, and powder from surgical gloves. Although a number of topical treatments such as steroid creams, antibiotic ointments, and silver nitrate have been suggested, larger amounts of granulation tissue, particularly when obstructive, may require surgical excision, with or without the use of the laser.

The prolonged presence of the same indwelling tracheostomy tube, which is a foreign body, elicits an inflammatory tissue response favoring the growth of granulation tissue, increased secretions, and bacterial colonization with biofilm production.[16] Regular tube changes, on a schedule of every 2 to 3 weeks, have been shown to dramatically reduce the incidence of this problem.[17]

Late tracheoesophageal fistula is rare and may result from an overinflated or improperly fitted cuff or malpositioned tracheostomy cannula pushed to the posterior wall of the trachea against an indwelling nasogastric tube. Also, if the posterior wall of the trachea was unknowingly penetrated during surgery, infection may cause a tracheoesophageal fistula. In this case, the neck must be opened, the esophagus and the posterior wall of the trachea must be closed individually, and soft tissue, such as muscle, must be interposed in the defect. More commonly, however, the passage of food through the tracheostomy is a manifestation of aspiration rather than of a tracheoesophageal fistula. This can be confirmed on modified barium swallow.

Rupture of the innominate artery usually occurs within the first 3 weeks after tracheostomy and may be fatal. This complication may occur in patients of any age and may be due to one of the following: (1) placing the tracheostomy low in the neck, below the third tracheal ring where the inferior concave surface of the cannula may erode the artery (Fig. 68-9A), (2) an aberrant course of the innominate artery such that it crosses the trachea at an abnormally high level, (3) use of an excessively long or curved tube, the tip of which may erode the trachea and the vessel wall deep to it (see Fig. 68-9B), (4) over hyperextending the neck during the tracheostomy procedure, (5) prolonged pressure on the tracheal wall by an inflated cuff, and (6) tracheal infection.[13]

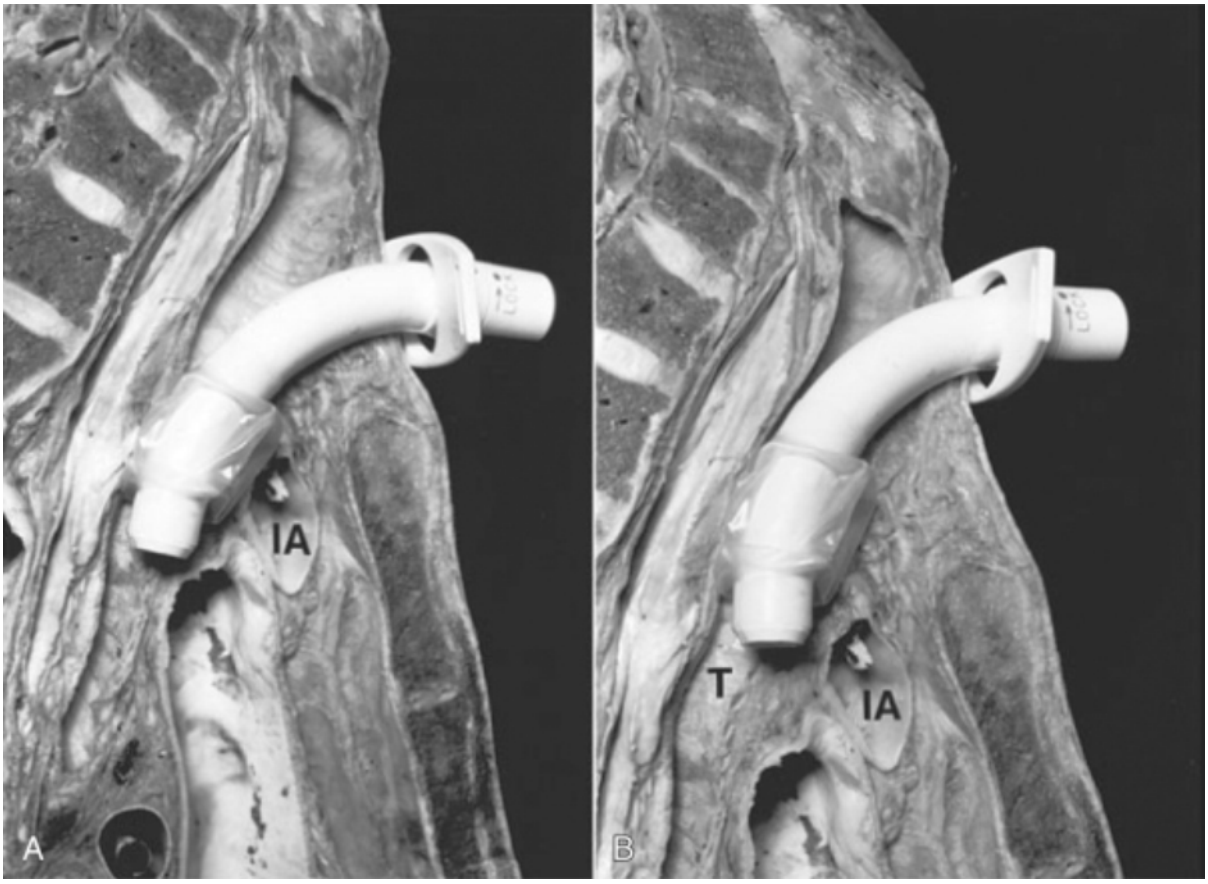


**Figure 68-9** **A,** Mechanism of erosion of the innominate artery (IA) by pressure from the concave surface of the tracheostomy cannula. **B,** Pressure of the tip of the tracheostomy cannula on the anterior tracheal wall (T) causes erosion into the innominate artery (IA).
*(From Myers EN, Stool SE, Johnson JT: Complications in tracheostomy. In Myers EN, Stool SE, Johnson JT [eds]: Tracheostomy. New York, Churchill Livingstone, 1985, p 167.)*

Rupture of the innominate artery is usually heralded by a "sentinel bleed," which may stop and be followed a few days later by a catastrophic hemorrhage. The patient coughs up bright red blood from the tracheostomy tube. If this sign is recognized, the cuff of the tracheostomy tube should immediately be overinflated and suprasternal pressure applied in an attempt to control the hemorrhage. These maneuvers generally control the bleeding at least temporarily. Transfusion is likely to be required, and blood should be sent for typing and cross-matching immediately. Thoracotomy and ligation of the innominate artery may be necessary as a lifesaving maneuver.

Tracheal stenosis and tracheomalacia are late complications. Steps toward decreasing the occurrence of these sequelae include: (1) proper placement of the tracheostomy tube between the first and third tracheal rings, (2) use of the smallest possible tube size, (3) minimizing cuff inflation pressures, and (4) minimizing cuff inflation times.

Tracheocutaneous fistula, depressed scar, and laryngotracheal stenosis are discussed in Chapters 45 and 51.