Paparella: Volume III: Head and Neck

Section 2: Disorders of the Head and Neck

Part 5: The Larynx, Trachea, and Esophagus

Chapter 37: Tracheostomy

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History

The evolution of tracheostomy can be divided into five stages. The first and longest period (covering roughly 3000 years from 1500 BC to 1500 AD) begins with references to incisions into the "windpipe" in the Ebers Papyrus and the Rig Veda. However, Alexander the Great, Asclepiades, Aretaeus and Galen are all recorded as having used this operation. Between 1546 with the writings of Brassarolo until 1883, the procedure was considered futile and irresponsible and few surgeons had the courage to perform it. The third period starts with Trousseau's report of 200 cases in the therapy of diphtheria in 1833. Tracheostomy became a highly dramatized operation for asphyxia and acute respiratory obstruction. In 1932 Wilson suggested its prophylactic and therapeutic use in poliomyelitis. Tracheostomy was then recommended for a large variety for assorted maladies. This started a tremendous period of enthusiasm.

Indications for Tracheostomy

The indications for tracheostomy can conveniently be divided into three broad groupings: (1) bypass of an obstructed airway, (2) removal of secretions from the distal tracheobronchial tree, and (3) instillation of oxygen into the distal tracheobronchial tree. Table 1 summarizes these indications.

Table 1. Indications for Tracheostomy

Bypass of an Obstructed Upper Airway

Tumors obstructing the upper trachea, larynx, or pharynx
Congenital anomalies causing obstruction to larynx or trachea, for example, web formation, hypoplasia, and so on
Injuries to or fractures of the larynx or trachea
Bilateral vocal cord paralysis
Severe maxillofacial injuries with soft tissue swelling causing upper airway obstruction
Foreign body obstruction to upper airway
Soft tissue swelling causing upper airway obstruction as a result of inflammation of the larynx, trachea, tongue, or pharynx
Burns of the face, neck, or upper airway

Removal of Secretions from the Distal Tracheobronchial Tree

Inadequate cough resulting from thoracic and abdominal surgery
Bronchopneumonia
Vomitus and aspirated gastric contents

Instillation of Oxygen into Distal Tracheobronchial Tree

Chronic obstructive pulmonary disease and alveolar hypoventilation, for example, emphysema, bronchiectasis, asthma
Respiratory depression secondary to drug intoxication or poisoning
Flail chest, fractured ribs, surgical emphysema
Paralysis of chest wall

&&& There are no absolute contraindications to tracheostomy.&

Surgical Technique

In Adults

All tracheostomies should be performed in the operating room. The so-called bedside tracheostomy is mentioned only to be condemned. The lack of adequate lighting, patient positioning, and resuscitative equipment all contribute to a hazardous surgical procedure. With adequate preparation, meticulous surgical technique, and efficient postoperative care, the procedure of tracheostomy is a safe and reliable operation.

The patient should be placed supine on the operating table and the neck moderately extended. Care should be exercised not to overextend the neck, as this may compromise an already narrowed airway. Control of the airway is essential, and supplemental oxygen may be administered by face mask if necessary. Meticulous positioning of the head and neck exactly in the midline is essential to avoid any torsion or rotation of the larynx and major blood vessels. The procedure should be carried out under sterile conditions with surgical field preparations and draping.

If the procedure is to be performed under local anesthesia, the area between the cricoid cartilage and upper tracheal rings is infiltrated with local anesthetic. It is wise to bear in mind that the patient with respiratory obstruction and a raised PCO_2 may be more sensitive to the systemic effects of epinephrine, and thus the amount of this substance should be chosen and injected with caution.

If the procedure is performed under general anesthesia, supplementary infiltration of local anesthetic into the tissues of the neck in the area of the incision is useful for minimizing bleeding.

The controversy regarding the use of a vertical or horizontal skin incision continues. Advocates of the horizontal skin incision cite the fact that this type of incision leaves a less noticeable scar. Those who favor a vertical skin incision state that dissection in the midline is rendered easier by this type of incision and also that there is no lower flap under which secretions tend to accumulate.

Once the incision is made through skin and subcutaneous tissue, it is deepened down to the strap muscles. From this point, dissection is made exactly in the midline using a hemostat. The hemostat advances in a stepwise fashion through the tissues overlying the trachea. Each stepwise purchase of tissue is retracted laterally by the assistant, using a small right-angled retractor. Using this technique, the trachea is approached by blunt dissection exactly in the midline, thus decreasing bleeding; the laterally directing retractors act to stabilize the central position of the trachea. The isthmus of the thyroid gland is often encountered at this stage and can usually be retracted superiorly or inferiorly. If, however, the isthmus is difficult to reposition, it should be sectioned between clamps and the edges suture-ligated. Sharp dissection using a fine-pointed scissors to incise the tissues cleanly may be used as an alternative method to blunt midline dissection. This technique is used with evaluation of the underlying tissues until the trachea is identified.

The pretracheal fat and fascia are now identified and dissected away from the tracheal rings. At this stage, hemostasis should be secured because subsequent bleeding into the incised trachea will stimulate coughing and straining by the patient, complication the insertion of the tracheostomy tube. After securing complete hemostasis, the trachea is immobilized by inserting a tracheostomy hook into the anterior tracheal wall at the level of the first tracheal ring. This hook will facilitates positioning of the tracheal opening for the insertion of the tracheostomy tube.

Using a small-gauge needle, a small amount of local anesthetic is injected into the tracheal lumen after first aspirating back a small amount of air to confirm the position of the needle. The instillation of this anesthetic will make the positioning of the tracheostomy tube less irritating to the tracheal mucosa and thus decrease the attendant cough reflex.

The site of the tracheal incision is now identified. The rings should be carefully studied and the incision made to incorporate the anterior half of either or both of the second and third rings. Using a No. 11 scalpel blade, the intercartilaginous space above and below the rings is incised. This window of tissue is now grasped with either a hemostat or a clamp to prevent its dislodgement into the tracheal lumen, and the remainder of the incision is completed using either a scalpel blade or heavy scissors, depending on the degree of calcification of the tracheal cartilages. The tracheostomy tube is then inserted, the cuff is inflated to prevent aspiration of blood from the tracheal mucosal incision, and the tracheostomy hook is removed. An alternative to excising a window of tracheal wall is the creation of a U-shaped, inferiorly based flap of anterior tracheal wall. This flap is reported to facilitate reintroduction of the tracheostomy if needed.

Prior to introducing the tracheostomy tube, the cuff should be inflated and tested. A low-pressure, high-volume, thin-walled cuff that conforms to the tracheal shape with little pressure on the mucosa is ideal.

The tapes of the tracheostomy tube should be securely tied after flexing the neck. Tying the tapes when the neck is extended often allows the tapes to be bound too loosely around the neck and may allow dislodgement of the tube. As an additional precaution, a heavy suture may be placed through the tracheostomy flange directly into the underlying skin.

These sutures are left in place until the first tracheostomy tube change.

The skin incision may be loosely sutured, but too tight a closure should be avoided, since it may result in entrapment of air beneath the skin of the incision, leading to surgical (subcutaneous) emphysema.

Infants and Small Children

Tracheostomy in infants and small children is generally less technically difficult than one might anticipate at first, provided that meticulous attention is paid to detail, since the soft, pliable infant neck structures facilitate dissection.

Tracheostomy in infants should always be performed after either a bronchoscope or an endotracheal tube has been inserted. The tube or bronchoscope not only provides vital control of the infant airway but also gives some rigidity to the supple trachea, which may otherwise be easily retracted laterally, inadvertently leading to dissection deep to the plane of the trachea and possible laryngeal nerve damage.

Control of the infant airway by tube or bronchoscope also prevents large excursions of the cupulae of the pleura into the neck in respiratory distress and will thus minimize the chances of damage to these structures.

Surgical technique is similar to that previously described for adults. It is modified, however, when the trachea itself is identified. Tracheal cartilage is never excised from the anterior tracheal wall as in adults, but a midline vertical incision is made through the second, third, or fourth anterior tracheal rings. A No. 11 scalpel blade is used to incise the anterior tracheal wall, taking special care not to insert the scalpel blade too deeply and thus possibly incise the posterior tracheal wall. 3-0 Nylon sutures may be placed through two or three tracheal rings on either side of the midline incision. These stay sutures should be labeled "left" and "right" on small tape labels attached to the ends of the sutures. Traction on these sutures in the appropriate direction will reopen and reposition the tracheal incision for insertion of the tracheostomy tube if it becomes dislodged in the postoperative period.

Because infants have short, fat necks, dislodgement of the tracheostomy tube is a very real possibility. Every care should be taken in placement and tying of the tracheostomy tapes after flexion of the neck; direct suture of the tube to the skin of the neck is recommended. These sutures and the stay traction sutures are left in place until after the first tracheostomy tube change, usually 3 days postoperatively. After this time, a permanent tract exists and there is little difficulty in subsequent tube reinsertion. As in adults, the skin incision is sutured loosely, if at all, to prevent development of surgical emphysema.

Position of the infant tracheostomy tube is critical, and occasional difficulty may be encountered with a tube that is too long or too sharply angled. In such a case, immediate postoperative anteroposterior and lateral chest radiographs, as well as a lateral soft tissue view of the neck, are required to ascertain tube position and length and to exclude complications such pneumomediastinum or pneumothorax.

Postoperative Tracheostomy Care

The postoperative period is critical in the success of tracheostomy in many patients, especially infants; neonates still die because of inadequate care during this period. Diligent care and attention to detail are vital.

Humidification

Humidification of inspired air is necessary to prevent tracheitis and crusting. Humidification may be provided by a nebulizer and tent or by a collar on the tracheostomy tube opening. If the latter technique is used, prevention of torsion of the tracheostomy tube itself is necessary to prevent tracheal wall irritation and ulceration.

Suction

Suction is required to keep the tube, trachea, and bronchi clear of secretions without causing excessive irritation from nonessential "routine" suctioning. Suction should be exerted for 15 seconds or less after insertion of the catheter into the distal trachea, as longer periods of suction may precipitate hypoxia and cardiac arrest.

Tracheostomy Tube Changes

The introduction of tracheostomy tube made of polymeric silicone (Silastic), polyvinyl chloride, and silicone rubber, which cause little reaction, has all but eliminated the use of metal tubes. These plastic tubes should not be sterilized with ethylene oxide because the plastic has the ability to retain some of the gas for up to 7 days. The slow liberation of toxic byproducts such as ethylene glycol and ethylene chlorhydrin have been shown to cause severe mucosal damage. The frequency of tracheostomy tube changes has been decreased by the use of these tubes. The first change is usually performed at 3 days when an adequate tract has formed.

Prophylactic Antibiotics

The use of antibiotics is indicated only for treatment of pulmonary or other specific infection and only after appropriate culture and sensitivity tests have been performed. There is no value in the use of prophylactic antibiotics for tracheostomy alone.

Complications

Immediate Complications

Hemorrhage

Hemorrhage of some degree is a common postoperative complication. Frequently, patients requiring tracheostomy are hypotensive, and bleeding occurs only when arterial blood pressure is restored or when venous pressure is increased by coughing associated with irritation from the tracheostomy tube. Meticulous hemostasis is thus essential at the termination of the surgical procedure. Any small vessel that is overlooked will almost certainly bleed more freely when intravascular pressures increase postoperatively. Persistent oozing may often be controlled by half-inch gauze packing around the tracheostomy tube. Occasionally the bleeding vessel will have to be identified and ligated in the operating room after removing the tube and securing the airway.

Subcutaneous Emphysema

Some subcutaneous emphysema is often noted postoperatively around the tracheostomy site. Occasionally, extensive emphysema may occur and extend diffusely up to the face and over the chest. This is usually caused by suturing the surgical incision, thereby trapping the air in the subcutaneous tissues. Usually this is a benign finding, although it may be alarming to parents and other observers. Therapy must include immediate removal of all skin sutures. There is a potential for the development of either pneumomediastinum or pneumothorax if the condition is allowed to progress.

Pneumomediastinum

Pneumomediastinum may result from air sucked through the wound or from coughing that forces air into the deep tissue planes of the neck and thence into the mediastinum. Pneumomediastinum may produce circulatory embarrassment or rupture into the pleural space, producing simple or tension pneumothorax.

Pneumothorax

In addition to the factors cited as causes of pneumomediastinum, pneumothorax may be caused by injury to the cupulae of the pleura. This injury is more common in children owing to the relatively high position of the pleura in relation to the trachea compared with adults.

Several factors that may be responsible for the pneumothorax include (1) inadvertent incision of high pleural apices, (2) rupture of marginal alveoli with air extension along vascular sheaths into the pneumomediastinum, and (3) increased intrathoracic negative pressure causing dissection of air beneath the pretracheal fascia.

The use of immediate postoperative x-ray films as discussed previously will identify these complications. Pneumomediastinum usually requires no therapy, but pneumothorax may necessitate insertion of chest tubes and an underwater seal.

Tracheoesophageal Fistula

Too deep an incision into the anterior tracheal wall may damage the underlying esophagus and result in a tracheoesophageal fistula. In addition, a tracheoesophageal fistula due to ischemic necrosis from the cuff may occur as a delayed phenomenon.

Recurrent Laryngeal Nerve Damage

Dissection at the time of tracheostomy lateral to the trachea may damage the recurrent laryngeal nerve. Stabilization of the trachea in the midline and prevention of excessive dissection in the paratracheal fascia will prevent this complication.

Aspiration

Aspiration of gastric contents may occur and should be handled immediately with clearance of secretions and therapy to decrease the edema and inflammatory response.

Malpositioned Tube

The hazard of a malpositioned tube may be prevented by the use of stay sutures or the inferiorly based tracheal wall flap. Careful placement and tying of the knot in the tracheostomy tapes after flexion of the neck may also aid in preventing this complication.

Aerophagia

Aerophagia is most often seen infants and young children and may be a cause of persistent dyspnea. It should be treated with nasogastric tube decompression of the swallowed air.

Delayed Complications

Delayed Hemorrhage

Significant morbidity and even mortality is associated with delayed hemorrhage. Significant delayed hemorrhage most often results from erosion of the major vessel by pressure necrosis from the tracheostomy cuff or directly from the tip of the tracheostomy tube. Occasionally, granulation tissue forming at the site of irritation at the tip of the tracheostomy tube or at the inflated cuff may cause a mild degree of delayed bleeding. However, any significant bleeding occurring 4 to 5 days postoperatively must be considered as a "sentinel bleed" due to erosion of a major vessel. The vessel involved is usually an innominate artery that crosses from left to right anterior to the trachea at the superior thoracic inlet with its upper margin lying just beneath the sternum. Thus, a low tracheostomy or hyperextension of the neck at the time of incision are factors that contribute to delayed hemorrhage from a major vessel. If hemorrhage from the trachea is significant, the patient should be transferred to the operating room immediately. Bronchoscopy may reveal the cause to be granulation tissue. If, however, the bleeding is seen to be originating from an area of erosion, an oral or stomal airway should be inserted, with the cuff inflated distal to the site of bleeding. This will secure control of the airway. Finger tamponade through the stoma may be used if needed until definitive repair can be accomplished by median sternotomy with division and oversewing of the eroded arterial vessel. The following steps should be taken to prevent this catastrophe: (1) an adequate skin incision to allow visualization or palpation of a normally situated vessel; (2) avoidance of a low tracheostomy by prevention of hyperextension of the neck, prevention of excessive upward traction of the trachea using the tracheal hook at the time of stabilization of the trachea, and accurate placement of the tracheal incision no lower than the second and third tracheal rings; (3) the use of nonirritating synthetic tubes without pressure cuff, if possible; and (4) constant humidification and sterile technique in the care of the tracheostomy to prevent local infections with the attendant increased risks of mucosal ulceration.

Tracheal Stenosis

Some stenosis is demonstrable at the level of the stoma in every patient. However, stridor occurs only with extreme degrees of stenosis. Stenosis may occur at the site of the tracheostomy and at the level of the cuff; it is caused by the tip of the tube impinging on the trachea. Details of this complication are discussed elsewhere in this book.

Delayed Tracheoesophageal Fistula

Tracheoesophageal fistula occurs occasionally as a late complication of tracheostomy. It is a result of necrosis of the intervening wall between the posterior tracheal wall and the anterior wall of the esophagus. The pathogenesis is felt to be pressure necrosis from the tracheostomy tube cuff or from the tip of a malpositioned tracheostomy tube. An additional factor may be the presence of an indwelling nasogastric tube. This nonyielding tube may play a significant role in the development of the fistula. Aspiration of gastric and esophageal contents through the fistula will inevitably lead to pneumonitis. Repair may be accomplished by open exploration and closure of the fistula, usually with interposition of a rotated muscle flap or dermal graft to buttress the weakened areas.

Dysphagia

Difficulty in swallowing results not from compression of the esophagus by the tube but by inhibition of laryngeal movement or swallowing because of the tracheostomy tube anchoring the trachea to the strap muscles.

Tracheocutaneous Fistula

With long-standing tracheostomy, epithelialization of the tract may occur. This will prevent complete closure of the tracheostomy tract on extubation. It is usually managed simply by excision of the epithelialized tract and closure. A persistent fistula may indicate proximal obstruction, and a laryngoscopy and bronchoscopy should be performed prior to closure. Occasionally a local skin flap and underlying muscle flap may be needed to close this fistula.

Decannulation

Decannulation problems occur typically in infants and young children but only rarely in adults, perhaps because the young children has no airway reserve.

MacLachlan listed the following principles for decannulation in newborns or very young children:

1. Decannulation should be accomplished near or in the operating room with a trained nurse, anesthesiologist, and otolaryngologist present.

2. The child should have been fed 1 to 1.5 hours prior to decannulation.

3. All the necessary equipment for reintubation, both by tracheostomy and orally,

should be readily available.

4. The child should be watched carefully for several hours; frequent checks of vital signs and possibly blood gas determinations should be made.

5. It should be recognized that any difficulty in decannulation requires diagnostic evaluation of the infant to determine the possible factors that make decannulation difficult. Table 2 identifies the factors involved in delayed or difficult decannulation.

Table 2. Factors Involved in Delayed or Difficult Decannulation

Persistence of the condition that originally necessitated the tracheostomy
Anterior tracheal wall dislocation
Granulation tissue around the stoma
Edema of tracheal mucosa
Emotional dependence on tracheostomy
Inability to tolerate upper airway resistance on decannulation
Subglottic stenosis
Tracheomalacia
Incoordination of the laryngeal opening reflux
Impaired development of the larynx as a result of long-standing tracheostomy.&

Cricothyrotomy

Because the morbidity of emergency tracheostomy is several times that incurred when the procedure is done under more controlled circumstances, the procedure of cricothyrotomy increasingly is being advocated as a safer and better alternative.

A basic knowledge of the anatomy of the larynx is essential to understanding the technique of cricothyrotomy and its possible effect on laryngeal function. The external anatomic landmarks are the thyroid and cricoid cartilages. Extending between these two cartilages lies the cricothyroid membrane, with two sets of muscles intimately related to it. The cricothyroid muscle arises anteriorly from the outer surface of the arch of the cricoid cartilage just lateral to the midline and passes superiorly, laterally, and posteriorly to insert on the thyroid cartilage. The action of this muscle is to narrow the space between the cricoid and thyroid cartilages anteriorly, resulting in the lengthening of the vocal cords. The vocalis muscle arises from the inferior portion of the inner surface of the thyroid cartilage at the midline. It passes superiorly and posteriorly and inserts along the length of the vocal cord. Its action is to shorten the vocal cords and to vary the tension along the length of the cords.

Cricothyrotomy basically involves gaining access to the larynx by making incision in the cricothyroid membrane. First, the overlying skin is infiltrated with local anesthetic. The thyroid cartilage is then stabilized with the left hand, and a transverse incision is made through the skin and subcutaneous tissues overlying the cricothyroid membrane. Once the membrane is visualized, a stab incision is made in the midline. It is important to direct the tip of the blade inferiorly to avoid direct trauma to the vocal cords. The thyroid and cricoid cartilages are gently spread apart, and a tube is then inserted and secured into position in the usual manner. Using this technique, an airway may be rapidly secured.

Controversy rages over the relative advantages and disadvantages of cricothyrotomy and the immediate and long-term safety of this procedure. The clear advantage of cricothyrotomy is the rapidity with which it can be accomplished because it is technically simpler and the anatomy involved is less variable. This is obviously important in the management of trauma patients. A clear disadvantage is the increased likelihood of direct trauma to the larynx. Assessment of the true morbidity associated with cricothyrotomy is made difficult by the fact that few studies have addressed this problem because the procedure had been held in disrepute until very recently. This negative attitude was largely due to the writing of Chevalier Jackson, who reported on 100 cases of chronic laryngeal stenosis and attributed 93 per cent of them to a high tracheostomy involving the cricoid cartilage. Therefore, he recommended that if a high tracheostomy was done, it should be converted to a standard tracheostomy as soon as possible. He so strongly advised against anything that might predispose to cricoid damage that the technique of cricothyrotomy fell into disuse.

Obviously, it is almost impossible to avoid traumatizing the cricoid cartilage to some degree during this procedure because of the narrow space between the cricoid and thyroid cartilages. Even if direct trauma were avoided, the possibility of pressure necrosis of the cricoid cartilage caused by the tracheostomy tube has stimulated most authors to recommend early revision to standard tracheostomy. In striking contrast to this viewpoint, Brantigan and Grow recommend the use of cricothyrotomy as an elective procedure in lieu of tracheostomy and without subsequent revision. This controversial opinion is based upon their vast experience of cricothyrotomies (655 cases), 73 per cent of which were performed in the operating room and 27 per cent of which were bedside procedures. The average duration of intubation was 7 days. They reported a complication rate of only 6.1 per cent, including ten early postoperative bleeding episodes and eight obstructive problems. However, it should be noted that approximately one third of the patients did not survive long enough to leave the hospital and, as a consequence, were lost to long-term follow-up. Other more subtle complications include the adverse effect on laryngeal function by traumatizing the cricothyroid and vocalis muscles. The exact incidence of such changes and the effect on vocal quality after this procedure remain undetermined.

Permanent Tracheostomy

Occasionally the need for a long-term tracheostomy may arise. The most common indications include a stenosed or incompetent larynx, chronic obstructive airway disease, and obstructive sleep apnea.

Although the tracheostomy cannula placed in the routine manner, as already described, may suffice as a long-term tracheostomy, the indwelling cannula may result in granulation formation, ulceration, crusting, and the potential for delayed tracheal stenosis. Special "speaking valves" are required to permit the patient to phonate. In addition, the patient and relatives frequently find the management of the cannula arduous and unpleasant. For this reason, every effort has been made to develop an alternate technique that will maintain a wide, stable stoma without dependency on a cannula. At present, no ideal foolproof technique exists, but many different techniques have been described. They essentially consist of raising laterally based skin flaps, debulking the underlying adipose tissue, and then suturing the skin to the walls of the created tracheal stoma. This may be augmented by superiorly and inferiorly based tracheal flaps. An indwelling cannula is discouraged.

These techniques do not always give a predictable result, with tracheal stenosis being a constant source of anxiety. In addition, some patients and physicians feel uncomfortable without the reassuring presence of a stent within the stoma. In an attempt to overcome this problem, Montgomery introduced a vulcanized silicone cannula that is inserted after creating a stoma with a special appliance. This cannula, theoretically, results in minimal tissue reaction and also reduces the amount of intratracheal irritation because of minimal contact of the tube within the trachea. In addition, the outer flange secures the tube against the skin, thereby diminishing the need for circumcervical tape and sutures. An extra long version is available for sleep apnea patients, and these patients can keep the tube opened during the night and plugged during the day.

Although satisfactory in most cases, the incidence of granulation formation is higher than originally perceived and can be quite troublesome. In addition, the tube may become dislodged during coughing spells and has even been reported to have been inhaled into the trachea.