Tracheostomy

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Introduction

Tracheostomy is one of the oldest known surgical interventions. Although it is a lifesaving method, it bears high complication and lethality rates. It was only at the beginning of the twentieth century, through systematic research by Jackson (1921), that a technique evolved that prevented significant complications.

Fitting a permanent tracheotomy device is still the most common tracheal intervention; however in the meantime, the methods of percutaneous dilatational tracheotomy have increasingly become standard medical practice in intensive care.

Often, endotracheal intubation is preferred instead. Through interdisciplinary assessment, the indication should always be considered carefully with regard to patients with multiple morbidities, who often have extreme respiratory limitations, also taking into account the possibility of early and late complications.

Indications for Tracheotomy

Obstruction of the Upper Airways

Obstruction of the upper airways may be caused by trauma, such as intubation trauma, severe neck and facial burns, or fractures, as well as by abscesses and infections leading to pronounced swelling of the larynx. Furthermore, many benign and malignant neck tumors may cause airway obstruction through applied outside pressure or invasive growth. Other causes are tracheal stenoses of varying etiology, tracheomalacia, foreign bodies, recurrent laryngeal nerve palsies, and the results of allergic reactions.

Alveolar Hypoventilation

Long-term ventilatory assistance might be required in patients with interstitial lung diseases, acute respiratory distress syndrome, chronic obstructive pulmonary disease, or a neurologic muscular disorder (e.g., amyotrophic lateral sclerosis, Duchenne muscular dystrophy), as well as those with a restrictive ventilation disorder caused by chronic thoracic shrinkage or chest wall instability and those with diaphragmatic paralysis.

Excessive Bronchial Secretion Causing Recurring Secretion Retention

Besides those already named, other causes may be bronchiectases, lung abscesses, or mucoviscidosis.

General Preparation for the Procedures

Most patients already are invasively ventilated by an oral or nasal endotracheal tube; some authors prefer the laryngeal mask. The patient is given general anesthesia to prevent movement during the procedure and is placed in the supine position with the neck hyperextended with the aid of a cushion or shoulder roll. Cervical collars are removed while inline stabilization is maintained and the patient's position is secured with sandbags or other positioning aids on either side of the head. Positioning aids are secured with a belt or tape. The appropriate anatomic landmarks of the surgical site are palpated, including the thyroid cartilage, cricoid cartilage, thyroid isthmus, innominate artery, and sternal notch (Miller et al. 1995).

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Surgical Tracheotomy Versus Percutaneous Dilatational Tracheostomy

In the twentieth century, open surgical tracheostomy (ST) was the standard technique for tracheostomy for decades. However, the use of percutaneous dilatational tracheostomy (PDT) has increased during the past 30 years and has become a very common method for placing a tracheostomy in critically ill patients in the intensive care unit (ICU). It is fast, simple, easy to learn, and cost effective (Delaney et al. 2006; Heffner et al. 1986a, b).

The ability to insert a tracheostomy tube with minimal surgical dissection is still the main advantage of PDT compared with open ST. Other advantages are:

- The possibility of performing the procedure in the ICU, not the operating room
- Fewer staff, equipment, and time requirements.
- Less probably of long-term problems, such as scar development, tracheal cutaneous fistula, and tracheal stenosis.

Some studies, however, suggest a higher incidence of short-term but important problems in PDT compared with ST, such as cannula misplacement, loss of airway, or injury to the posterior tracheal wall. Thus, the determination of whether a patient may benefit from PDT compared with ST must be made on an individual basis (Byhahn et al. 2000; Freeman et al. 2000; Melloni et al. 2002).

Figure 3.1

(**a**) Surgical technique. Surgery is carried out under sterile conditions in the operating theater. The patient is placed in the supine position with the cervical spine maximally reclined, except in cases of traumatic cervical spine conditions preventing hyperextension in a fixed position. An incision 4–5 cm long is made horizontally, approximately a two-finger width above the jugulum. After cutting through the subcutaneous tissue and platysma, the neck muscles are exposed and divided midline. The two halves of straight neck muscles are pulled aside laterally with retractors. The thyroid isthmus is visible, at least partially. Fundamentally, there are three ways to fit a plastic tracheotomy device (upper, middle and lower tracheotomy). The upper tracheotomy is carried out between the first and second or between the second and third tracheal rings, after the thyroid isthmus is exposed and held aside caudally (*A*). Here, damage to the cricoid cartilage may lead to severe tracheal stenosis. The middle tracheotomy is carried out mostly between the third and fourth tracheal rings; the thyroid isthmus must be resected (*B*). The lower tracheotomy (between the fourth and fifth tracheal rings) requires exposure of the lower thyroid isthmus, often with ligature of the lowest thyroid veins. The thyroid isthmus then is held aside cranially with a retractor or is resected (*C*). In adults, the middle tracheotomy (between the third and fourth cartilage rings), as shown here, is recommended. The upper tracheotomy carries the risk of damage to the cricoid cartilage, possibly leading to severe tracheal stenosis. The lower tracheotomy bears the highest rate of complications because of its proximity to the arterial truncus brachiocephalicus, which might lead to erosive hemorrhage. (**b**) Dividing the thyroid isthmus. The thyroid isthmus is resected midline between the retractors. If a goitre is present, further resectioning must be considered to avoid symptoms of compression and damage to vessels of the lower thyroid (Calhoun et al. 1994; Demmy et al. 2005)

Indications for ST are defined mainly by contraindications to PDT, such as:

- Coagulation abnormalities. Bleeding vessels are controlled more easily under direct vision.
- High levels of ventilatory support, especially for oxygenation (i.e., fraction of inspired oxygen ≥0.7 and positive end-expiratory pressure ≥10 cm H_2O have been suggested).
- Patients with unstable or fragile cervical spines.
- Patients with "unfavorable" neck anatomy. Previous surgery, neck masses, poor neck mobility, or obesity may be more complicated for PDT; however, patients having recent surgical repair of neck injuries might benefit from PDT because of its lower wound infection rate.

One also should keep in mind that there are contraindications to PDT depending on operator and center experience. Additionally, recent work has provided evidence that some contraindications to PDT may need revision. For example, kits that include long dilators and tubes have been designed specifically for morbidly obese patients. These kits, along with ultrasound imaging of the neck, may allow PDT to be performed in certain patients with unfavorable anatomy.

Figure 3.1

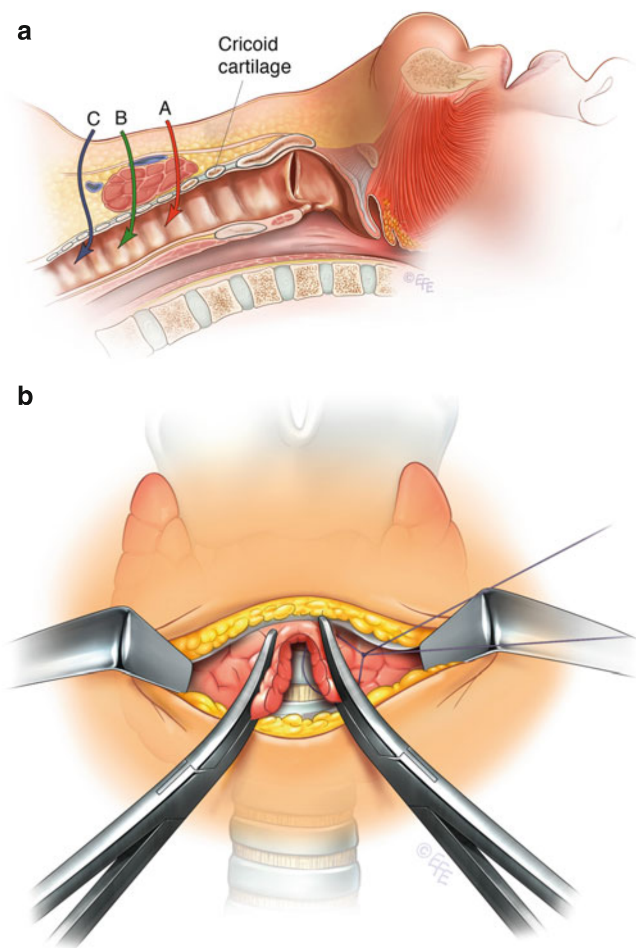


Figure 3.2

(**a**, **b**) View of the exposed trachea, incision line, and flap. Shown is the anterior tracheal wall. Dissection at the lateral tracheal wall is not necessary and may lead to complications such as compromising perfusion of the wall and recurrent nerve palsies. The trachea is incised horizontally between the third and fourth tracheal rings. At this point, care must be taken not to damage the underlying inflated cuff of the endotracheal tube. An inverted U-shaped (Björk) flap is excised from the third cartilage ring. The anterior tracheal wall can be accessed in various ways, and many opinions exist as to which is the best. Possibilities include partial removal of the tracheal cartilage by cutting out a hole, creation of U-shaped flaps cranial and caudally, and star-shaped incisions. We prefer the reversed U-shaped incision by Björk (1960), as shown here

Figure 3.3

Suturing the flap. After the subcutaneous tissue has been mobilized cranial and caudal to the incision edge, the caudally directed flap is knotted together with the edge of the inferior skin incision at the midline. Absorbable sutures (e.g., polydioxaneone 4.0) should be applied using a simple interrupted button technique, taking care to turn the incision edges inward to create an indentation for best medical care of the tracheotomy

Figure 3.2

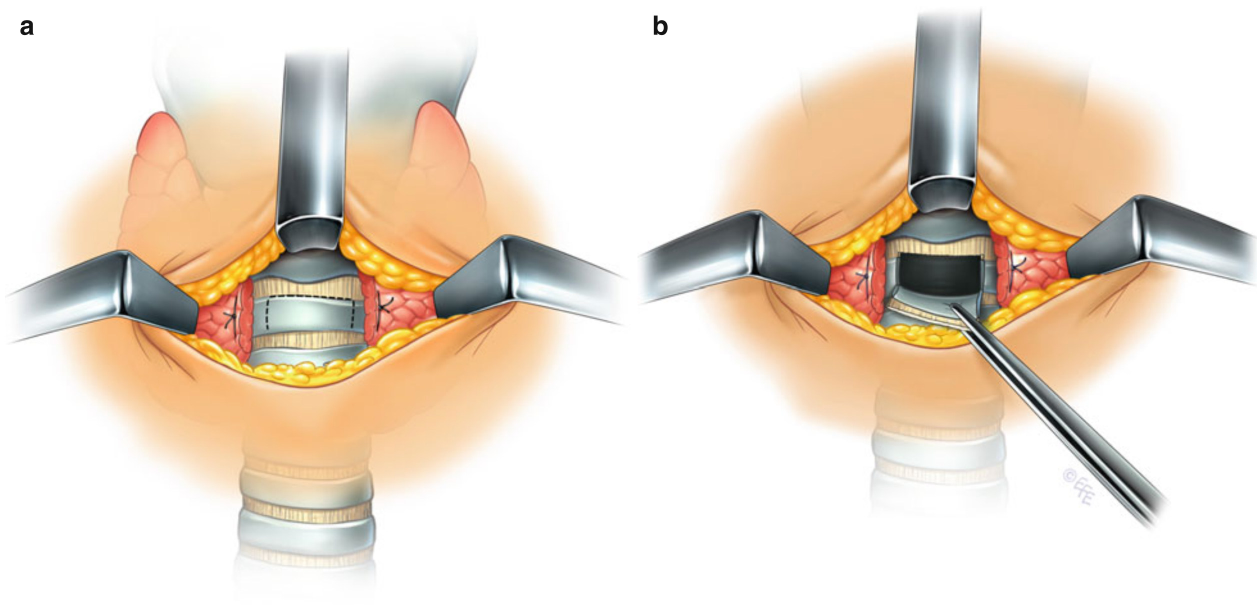


Figure 3.3

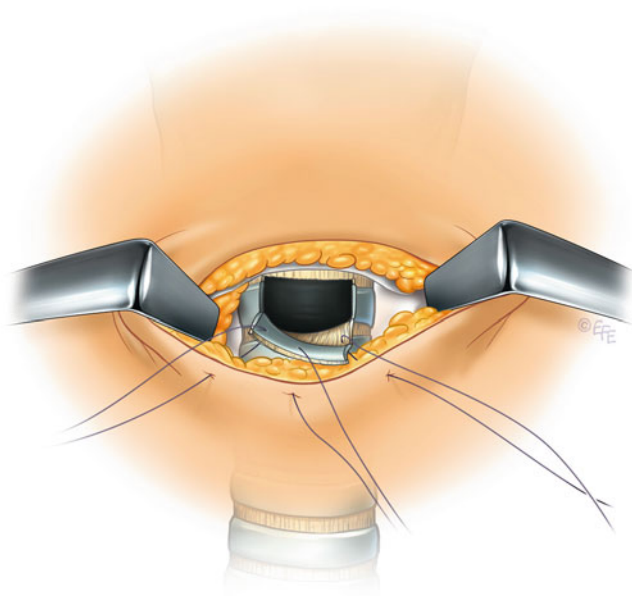


Figure 3.4

Tracheotomy accomplished. In agreement with the anesthesiologist, the endotracheal tube is slowly retracted, the appropriate tracheal cannula is fixed, and the operability of ventilation is checked

Figure 3.4

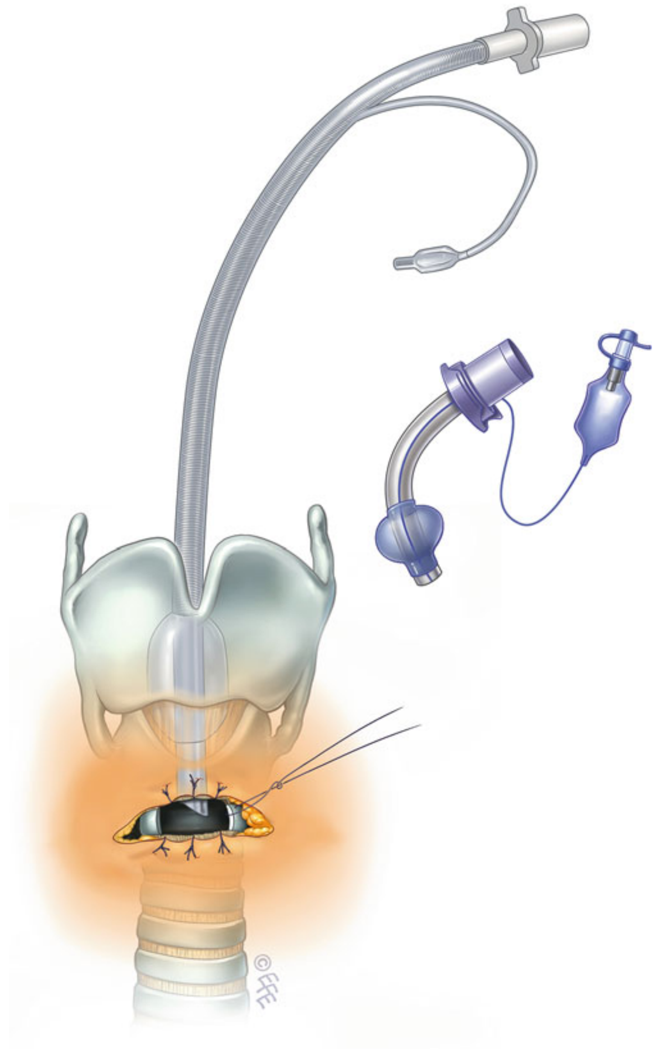


Figure 3.5

Tracheal penetration with a 17-gauge needle. After the patient is appropriately sedated, monitored, and positioned, and the landmarks are identified and marked, the neck is disinfected and draped in a sterile fashion, and the skin is infiltrated with a local anesthetic containing a vasoconstrictor. The incision typically is located halfway between the cricoid cartilage and sternal notch. As a rule, a vertical 2- to 2.5-cm incision or the smallest incision large enough to smoothly accommodate the operator's index fingertip is necessary. The subcutaneous fat and pretracheal muscles are bluntly dissected with a mosquito clamp, with any small bleeding controlled by compression. The dissection is kept in the avascular midline plane to minimize bleeding. A bronchoscope is inserted through the endotracheal tube, and the tip of the tube is withdrawn under bronchoscopic control to a point superior to the intended level of the tracheostomy (typically between the second and third tracheal rings). The trachea is then palpated, and a 17-gauge sheathed introducer needle is inserted into it. Correct placement is confirmed by aspirating bubbles of air into a fluid-filled syringe attached to the needle and by bronchoscopic visualization of the needle entering the trachea (Bardell 2005)

Figure 3.6

Placement of a J guidewire through the sheath. The needle and syringe are withdrawn, leaving the sheath in place. The J guidewire is introduced through the sheath (Seldinger technique), and placement into the trachea is confirmed by bronchoscopy. The sheath is removed and the guidewire left in place

Figure 3.5

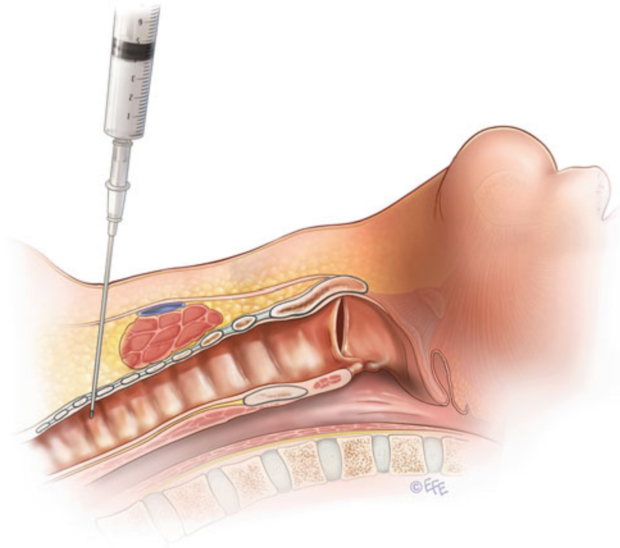


Figure 3.6

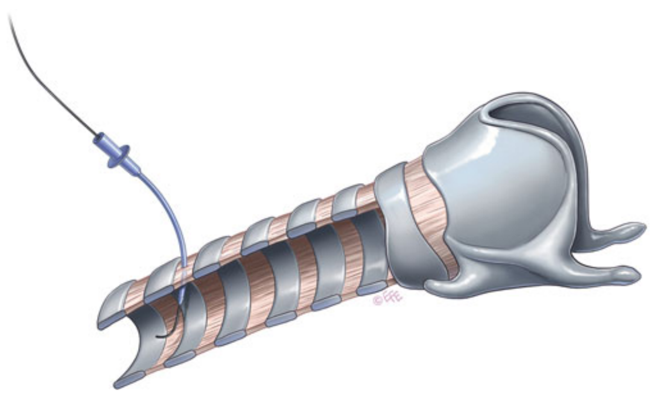


Figure 3.7

Tracheal dilation accomplished with Blue Rhino dilator. Next, a short 14 F dilator is introduced over the guidewire to create a pathway and then withdrawn. The Blue Rhino dilator is moisturized with saline, fed over a guiding catheter, and subsequently advanced over the guidewire into the trachea. Correct placement is confirmed bronchoscopically (Byhahn et al. 2000)

Figure 3.8

Placement of the tracheostomy tube (preloaded on a dilator) into the trachea. The dilator is removed, and the guiding catheter and guidewire are left in place. Next, the tracheostomy tube, preloaded on a dilator, is advanced as a unit into the trachea over the guiding catheter and guidewire under bronchoscopic guidance. Finally, the guiding catheter, guidewire, and guiding dilator are withdrawn, leaving the tracheostomy tube in place. Without removing the endotracheal tube, the ventilator circuit is connected to the tracheostomy tube and the respiration measurements (tidal volume, end-tidal carbon dioxide, oxygen saturation) are confirmed. The bronchoscope is then inserted through the tracheostomy tube to confirm good positioning by visualizing the carina and to rule out bleeding. The endotracheal tube is then removed. After suction of the trachea and bronchi, the bronchoscope is removed and the tracheostomy tube secured to the skin with sutures and tracheostomy tape around the neck

Figure 3.7

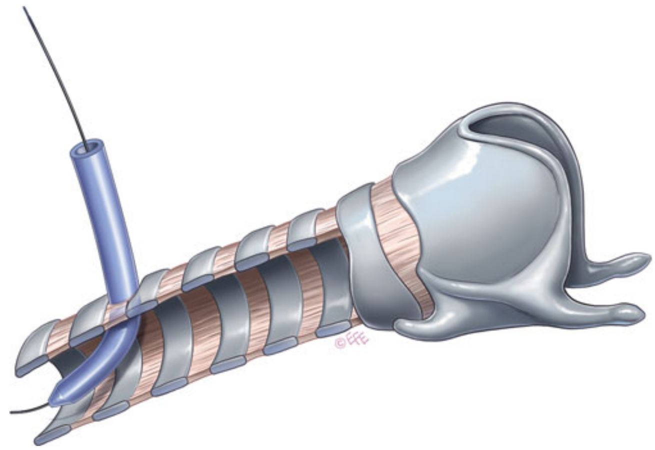
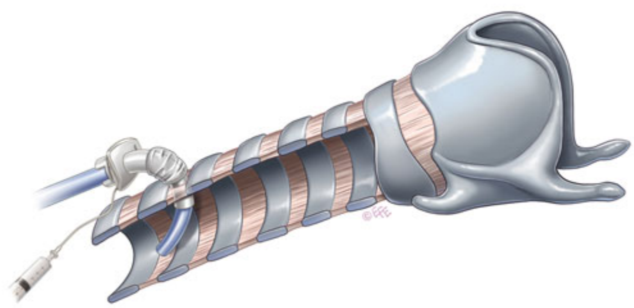


Figure 3.8



Conclusion

The surgical plastic tracheotomy method presented here is indicated when mechanical ventilation and/or immediate access to the airways are required for a longer duration. For a shorter period of required assisted ventilation, a dilatational tracheotomy usually is preferable, as long as no contraindications apply (Demmy et al. 2005).

Major complications after surgical tracheotomy occur in 1–2 % of cases, minor complications in 6–10 %. Typical early complications are:

- Hemorrhage and secondary hemorrhage with coagulation disorders
- Damage to the posterior tracheal wall
- Tube dislocation, tube malposition
- Wound infection, mediastinitis
- Hypoxemia, hypercapnia
- Pneumothorax
- Recurrent nerve palsy
- Aspiration

Although several studies tried to assess which method of PDT is best, no clear advantage has been demonstrated among methods. Physicians should use the technique with which they feel most comfortable given their training. Many centers use predominantly the Ciaglia Blue Rhino (Cook Critical Care, Bloomington, IL) technique, reserving the translaryngeal method for specific clinical situations, such as patients with an obese neck, a high risk of bleeding, or an unstable cervical spine. Advantages of the single-dilator technique include fewer manipulations in the airway, a lower risk of bleeding/aerosolization of secretions, and quicker stoma dilatation with a lower risk of hypoxia/hypercarbia (Cabrini et al. 2012; Reilly et al. 1997).

Complications of tracheostomy may be classified as immediate, early, or late (Arola 1981; Miller et al. 1995):

- Immediate
  – Anesthetic awareness
  – Bleeding
  – Airway obstruction due to blood clot
  – Dislodgement of the tracheal tube
  – Puncture of the tracheal tube cuff
  – Needle damage to the fiberoptic bronchoscope
  – Damage to the trachea
  – Damage to the esophagus
  – Pneumothorax/pneumomediastinum
  – False passage of the tracheostomy tube
  – Hypoxia
  – Hypercapnia
  – Increased intracranial pressure
- Early
  – Collapsed lung
  – Tension pneumothorax
  – Subcutaneous emphysema
  – Tracheoesophageal fistula
  – Dislodgement of the tracheostomy tube
- Late
  – Minor bleeding erosion into small local vessels
  – Major bleeding (e.g., erosion into the innominate artery/vein)
  – Local stomal infection (Andrews 1971; 1973; Grillo et al. 1971; Pearson et al. 1971)
  – Subglottic/tracheal stenosis
  – Persistent tracheocutaneous fistula
  – Permanent voice changes
  – Difficulty in swallowing
  – Scarring and tethering of the trachea

Suprastomal tracheal ring fracture is a common finding in percutaneous techniques, reported in up to 50 % of cases. It may induce local tissue granulation and possibly formation of stenosis and tracheomalacia. However, the incidence of subglottic tracheal stenosis following suprastomal ring fractures is not known.

The typical late complication is the formation of a scarred tracheal stenosis, which is caused by pressure and erosion by the angled tracheal cannula in the area of the tracheotomy. Another common cause is pressure-induced necrosis and subsequent repair, with the formation of scar tissue from high cuff pressures. Postintubation trauma may lead to clinically relevant tracheal stenoses in up to 14 % of cases. Tracheal stenosis may occur at either side of the stoma, at the level of the cuff, or at the tip of the tube. The main cause of the stenosis appears to be mucosal ischemia. In 1 % of all cases, pressure necroses and leverage may lead to erosion hemorrhage from the truncus brachiocephalicus, which may be life threatening. An oozing hemorrhage may preempt the actual hemorrhage over days and months. Treatment must be initiated immediately; otherwise, this complication usually is fatal. Possible causes include pressure necrosis from a high cuff pressure, tracheal wall trauma and perforation from a malpositioned tube tip, a low tracheal incision, and prolonged tracheostomy. Post-tracheostomy bleeding occurring from 3 days to 6 weeks after insertion is caused mainly by a tracheoinnominate artery fistula.

Pressure necroses at the posterior tracheal wall also may lead to esophageal fistulae (Jacobs 1978). In rare cases, fistulae may occur in the mediastinum, the pleura, and even the pericardium.

Most meta-analyses suggest that percutaneous tracheostomy reduces the overall incidence of clinically relevant bleeding, wound infection, and procedural mortality. Percutaneous tracheostomy also gives a better cosmetic result following decannulation.

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