Abstract

The procedure of tracheotomy dates back to ancient times. Its use has been adapted in the neonatal and pediatric population over the past half-century. Despite being a life-saving measure, tracheotomy-related mortality rates range from 0.5 to 3.6%, and this procedure is not without significant and sometimes frequent complications. Techniques regarding pediatric tracheotomy vary from surgeon to surgeon and include orientation of skin incision, removal of subcutaneous tissue, orientation of tracheotomy, maturation and stay sutures, as well as postoperative care and surveillance. In this chapter, the authors detail their technique for tracheotomy. Surgical pearls for success are highlighted.

The concept of tracheotomy dates back to the days of ancient Greece. Modern-era tracheotomy began with French physician Armand Trousseau in the mid-1800s treating patients with diphtheria-associated dyspnea [1]. Since that time, techniques and indications have evolved with the vast improvements occurring in pediatric and neonatal intensive care medicine.

Despite being a life-saving measure, tracheotomy-related mortality rates range from 0.5 to 3.6%, and this procedure is not without significant and sometimes frequent complications [2–4]. These can include anything from the catastrophic plugging or decannulation to the benign such as suprastomal granuloma and nuisance bleeding. For this reason, infants and children remain intubated longer than adults in order to avoid these potential issues.

Techniques regarding pediatric tracheotomy vary from surgeon to surgeon and include orientation of skin incision, removal of subcutaneous tissue, orientation of tracheotomy, maturation and stay sutures, as well as postoperative care and surveillance. A recent practice pattern survey of 225 members (75% return rate) of the American Society of Pediatric Otolaryngology found the following predominating trends in pediatric tracheotomy technique: vertical skin incision, routine removal of subcutaneous fat, maturation of the stoma and routine use of stay sutures and tracheostomy tube ties to secure the tracheostomy tube in place [5].

Relevant Anatomy

- The sternal notch, cricoid cartilage and hyoid bone should be identified and marked with a pen prior to starting the procedure.
• As discussed in the anatomy chapter, it is important to note the relationship of the hyoid bone and thyroid cartilage in neonates and infants
  – In this age group, the thyroid cartilage ‘telescopes’ beneath the hyoid bone (see figure 2 of the Laryngeal Development and Anatomy chapter).
  – This relationship is important because the surgeon cannot rely on palpation of the thyroid notch (i.e. adults) as much as the hyoid bone as a relevant anatomic landmark in pediatric neck surgery

**Indications**

There are multiple indications for tracheotomy in the pediatric age group with the two most common being chronic ventilation (53%) and airway obstruction (38%) [3].

**Contraindications**

None.

**Anesthesia Considerations**

• Communication with the anesthesiologist is crucial during this procedure. As seen often in pediatric aerodigestive surgery, exchanging ventilation tubes from one site to another requires careful collaboration between the surgeon and the anesthesiologist, and a discussion of the steps or flow of the case should be done prior to starting the procedure.
• The oxygen concentration should be reduced as much as possible in an effort to decrease the risk of airway fire during the dissection with electrocautery

**Preparation**

• Pediatric tracheotomy should be done over a definitive airway under general anesthesia if at all possible
• Several different size tracheotomy tubes should be available
• A shoulder roll is utilized in order to expose the necessary surgical landmarks
• The surgeon should wear a headlight, and loupe magnification can be helpful

**Procedure**

• A 1- to 2-cm vertical incision is marked out in the midline neck about just inferior to the cricoid
  – Vertical incision is preferred over horizontal due to the ability to extend the incision easily intraoperatively and the lack of redundant skin above and below the tracheostoma allowing recannulation easier
• The wound edges then have the subcutaneous fat removed using electrocautery
• Exposure using small retractors such as a Senn rake or pediatric Ragnell is necessary to keep

![Fig. 1. Retraction both laterally and pushing down into the wound assists the surgeon in preventing erroneous dissection laterally.](image)
the trachea in constant view during the dissection (fig. 1; online suppl. video 1)
- The strap muscles are divided using electrocautery and the thyroid, if located in the surgical field, is divided with the electrocautery
  - Division of the thyroid prevents it from obstructing the trachea in the event of accidental decannulation
- Using bipolar and peanut sponges, the trachea is brought into view and the cricoid is identified
- 4-0 monofilament, non-absorbable suture is placed paramedian at the level of the second and third tracheal rings and secured with mosquito clamps to act as stay sutures (fig. 2)
  - This suture should span the cartilaginous tracheal ring
  - These are helpful in elevating the trachea out of the wound for the remainder of the case
  - These remain in place until the first tracheostomy tube change on postoperative day 5
- After communication with anesthesia, a vertical tracheotomy is made through the second and third tracheal ring
  - If the second and third ring cannot be positively identified, it is better to make the tracheotomy lower than higher in order to avoid inadvertent damage to the subglottis
- 4-0 monofilament absorbable suture is then used to ‘mature’ the tracheostoma. This stitch is thrown in a vertical half-mattress fashion with two superiorly and two inferiorly (fig. 3).
  - This will make recannulation easier and prevent the creation of a ‘false passage’ in the event of accidental decannulation during the first week after tracheotomy
  - Use of maturation sutures does not increase the incidence of tracheocutaneous fistulas or granulation tissue formation [6]
- The endotracheal tube is then withdrawn by the anesthesiologist and the tracheostomy tube is placed
  - The circuit is switched over and the patient is examined for good chest rise and breath sounds
  - The tracheostomy ties are secured around the neck
  - The stay sutures are knotted and taped to the chest and marked ‘left’ and ‘right’ in case of accidental decannulation

Fig. 2. Stay sutures are placed around the second tracheal ring to help elevate the trachea out of the wound. They will stay in place until the first tracheostomy tube change.

Fig. 3. A view of the matured stoma; note the skin edges are tacked down on to the trachea with little subcutaneous fat in between. This helps to eliminate any potential space and possible false passage in case of accidental decannulation and premature tracheostomy tube change.
• The shoulder roll is removed and a flexible fiber-optic tracheoscopy is performed to ensure there is adequate distance from the tip of the tracheostomy tube to the carina

Postoperative Care
• Postoperative stay in the intensive care unit until the first tracheostomy tube change
• Humidified trach collar is an imperative due to the fact that pediatric tracheostomy tubes do not have an inner cannula and can form obstructive crusts very easily
• The first tracheostomy tube change should be performed by the otolaryngology service. This can be performed at the bedside.
• Subsequent tracheostomy tube changes are recommended every 2 weeks
• Depending on the degree of pre-existing airway obstruction, the following airway adjuncts and equipment should be available at the time of the tracheostomy tube change. Otherwise, the surgeon may opt to change the tube in the operating room.
  – Flexible fiber-optic scope
  – Airway cart with different-sized laryngeal mask airways and endotracheal tubes
  – Head light
  – Tracheotomy tube one size smaller than the current tube
  – Cricoid hook and tracheostomy spreader
• Postoperative tracheostomy tube training for parents and caregivers
  – Must change the tracheostomy tube with the nurses at least three times each
  – Must watch an infant CPR video
• There are no current practice guidelines for interval direct laryngoscopy/bronchoscopy for children with tracheostomy tubes. The author's practice pattern is to routinely look in the operating room every 6 months to survey the airway for significant changes (i.e. suprastomal granuloma).

  – The rate of suprastomal granuloma has been reported to be as high as 72–80% [7, 8]
  – We recommend immediate endoscopic evaluation of pediatric tracheotomies if any of the following symptoms occur:
    – Severe bleeding from the tracheostomy site
    – Lack of phonation
    – Difficult tracheostomy tube change

Pearls
• Palpation through the wound is done consistently throughout the case in order to maintain anatomical orientation. Due to the relatively small anatomy, it is quite easy to get 'off track' and palpation of the cricoid and trachea will help avoid this error.
  – The authors will remove nasogastric and orogastric feeding tubes prior to performing a tracheotomy to decrease the chance of mistaking the esophagus for the trachea during palpation
• Lateral retraction by the assistant is crucial. It is important that they help bring the airway into view with replacement and advancement of the retractors deep into the wound bed.
• Placement of stay sutures serve two purposes:
  – During the procedure, they elevate the trachea out of the wound prior to entering the airway. It is imperative to avoid subglottic injury by incorrect placement of the tracheostomy tube. Placement of these stay sutures gives the airway surgeon better control of the airway in order to correctly identify the surgical landmarks necessary to place the tracheostomy tube correctly.
  – When left in place, taped to the chest, they serve to assist in replacing the tracheostomy tube if accidental decannulation occurs in the immediate postoperative period
• Post-tracheotomy direct laryngoscopy and bronchoscopy are important to confirm good placement of the tracheostomy tube.
References