

## Tracheostomy among pediatric patients: A review

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### ABSTRACT

Tracheostomy is a surgical procedure which has been performed since ancient time. Tracheostomy is a life-saving surgical procedure done among critically sick patients. Children with airway compromise often require tracheostomy. The indication of the tracheostomy among children ranges from airway obstruction to prolonged mechanical ventilator support. There are numerous research papers published for adult tracheostomy with its indications, operative technique, and complications, but the literature on pediatric tracheostomy is scarce. Advanced technique of pediatric anesthesia and increased awareness for vaccination for serious diseases such as polio, measles, diphtheria, tetanus, and *Haemophilus influenzae* type b (Hib) among children increased the changing indication for tracheostomy from emergency to more elective procedure. Standardization of the procedure, timing, and exact indications is helping to reduce the mortality related to the tracheostomy among the pediatric patients. Here, we attempt to discuss the indications, techniques, selection of the tracheostomy tube complications, and outcome of the tracheostomy among pediatric patients.

**Key words:** *Airway obstruction, Pediatric patients, Prolonged ventilation, Tracheostomy*

Tracheostomy is a surgical procedure which has been performed since ancient time. The first tracheostomy is described by Asclepiades (100 BC) who made an opening of the trachea in a patient with stridor [1]. Paul dEgine documented the first successful tracheostomy in the 16<sup>th</sup> century, whereas in the 19<sup>th</sup> century, Armand Trousseau popularized the tracheostomy as a life-saving procedure during diphtheria epidemic [2]. In the 20<sup>th</sup> century, Chevalier Jackson described a technique of tracheostomy which we are performing today [1]. Tracheostomy is a commonly done for life-saving surgical procedure among critically sick patients. Children with airway compromise often need tracheostomy. It is a challenging surgical procedure among children than adult as it is associated with high morbidity and mortality. The risks of the tracheostomy as an invasive procedure must be weighed against its benefits to the children. The clinician should consider the risk-benefit ratio of pediatric tracheostomy short term as well as long term in relation to the child's morbidities. The risk of complications for tracheostomy is more in pediatric age group [3].

The indications for tracheostomy among pediatric patients have been changed significantly in last few decades. Initially, the upper airway obstruction due to infectious causes was the most common indication for tracheostomy among children [4]. Nowadays, the main reasons for tracheostomy in pediatric patients (Fig. 1) are prolonged ventilation, upper airway obstruction caused by craniofacial malformations, laryngotracheal stenosis, trauma, and neurological disorders associated with hypoventilation [5]. There

are numerous research papers published for adult tracheostomy with its indications, operative technique, and complications, but the literature for pediatric tracheostomy is scarce. There is always need for the standard guidelines for the standard protocols for pediatric tracheostomy. The aim of this review article is to discuss the indications, techniques, and complications of tracheostomy among pediatric age group.

### INDICATIONS

The indications for tracheostomy among children include bypassing an upper airway obstruction, facilitating long-term ventilation, protection from aspiration, prevention of laryngotracheal stenosis (LTS), and help in weaning from a ventilator by reducing ventilatory dead space. In pediatric patients, common requirement for tracheostomy is congenital or acquired airway obstruction, neurological conditions requiring long-term ventilation or pulmonary toilet, bilateral vocal cord paralysis (Fig. 2), and infectious conditions of the upper airway [6]. In difficult airway, where intubation is difficult and often needs tracheostomy for ventilation. These clinical conditions are retropharyngeal abscess, epiglottitis, and post-tonsillectomy hemorrhage, obstructive sleep apnea, crushing injury of the neck, facial burn, and tracheal foreign body.

Tracheostomy is one of the oldest surgical procedures described in medical literature. At present, tracheostomy is a standard surgical procedure for managing the long-term



Figure 1: Child with tracheostomy tube

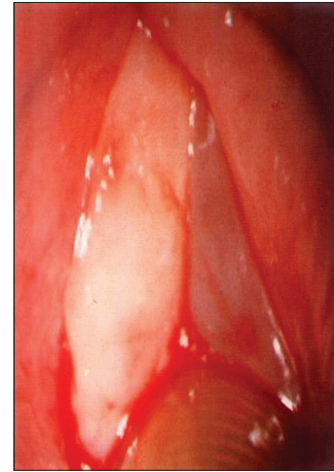


Figure 3: Endoscopic picture showing laryngeal papillomatosis

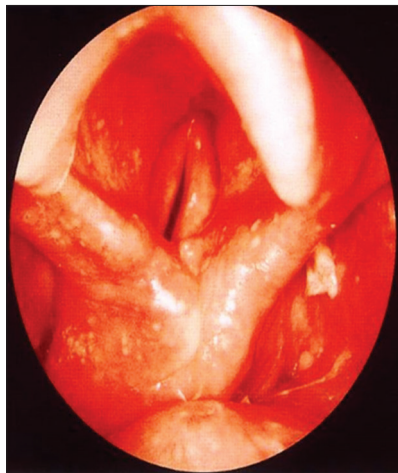


Figure 2: Endoscopic picture showing bilateral abductor paralysis of vocal cords

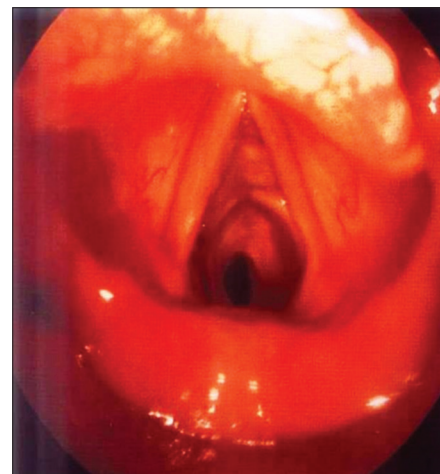


Figure 4: Endoscopic picture showing subglottic stenosis

ventilator-dependent sick patients [7]. Tracheostomy in pediatric patients often done to relieve stridor and is helpful in case of prolonged ventilation in children. The indications for pediatric tracheostomy have been changing over the periods of last four decades. Initially, the infectious conditions such as epiglottitis and laryngotracheobronchitis were common indications for tracheostomy [8]. As the treatment of infectious conditions of the airway is improved, the indications of pediatric tracheostomy changed drastically in the present time. Introducing *Haemophilus influenzae type b* vaccine and improvements at the intensive care units (ICU) have really reduced the number of tracheostomies for infectious diseases of the upper airways over the 1980s and 1990s [3]. Nowadays, pediatric tracheostomy is commonly done for prolonged ventilation, upper airway obstruction, and neurological diseases causing hypotonia [9].

Tracheostomy protects from aspiration by giving access for the tracheobronchial toilet. Tracheostomy prevents stenosis of laryngotracheal area by avoiding long-term intubation. It provides facilitation of weaning from ventilator by eliminating ventilator dead space. Laryngomalacia, recurrent laryngeal papillomatosis (Fig. 3), and LTS (Fig. 4) are common etiology for tracheostomy in children. The management of the laryngomalacia is based on the observation and follow-up in majority of the cases, as often

symptoms disappear by the 2<sup>nd</sup> year of life. In some cases of severe laryngomalacia, it has a bad outcome which needs surgical intervention. There are various surgical interventions available for the treatment of laryngomalacia such as supraglottoplasty, partial resection of the aryepiglottic folds, and epiglottopexy. Few severe cases of laryngomalacia patients do not improve with surgical procedure and need ventilation through tracheostomy.

Recurrent laryngeal papillomatosis is usually seen in children. The treatment of laryngeal papillomatosis is to excise the papillomatous growth from the larynx to keep the airway patent. However, in certain cases, the lesion is highly recurrent and causes airway obstruction and requires tracheostomy. Upper airway obstruction can be seen in certain craniofacial malformations such as Robin's sequence, Treacher Collins syndrome, Beckwith-Wiedemann syndrome, Nager syndrome, and CHARGE (coloboma, heart defects, atresia choanae [also known as choanal atresia], growth retardation, genital abnormalities, and ear abnormalities) association. These craniofacial anomalies with upper airway obstruction often need tracheostomy due to neurological involvement [5]. Children those need prolonged ventilator support for weeks or months need tracheostomy which facilitates pulmonary toilet and reduces the laryngotracheal lesions such as subglottic stenosis and tracheomalacia. Hence,

long-term intubation itself leads to different morbid complications which are one of the most important indications for tracheostomy in children [10].

### TECHNIQUES OF PEDIATRIC TRACHEOSTOMY

All the tracheostomies are carried out by senior ear-nose-throat surgeons in our hospital with the presence of anesthetist and a pediatrician in pediatric ICU (PICU) or pediatric emergency. All the tracheostomies among pediatric patients were performed under general anesthesia. Informed consents including death on the table in severe condition were obtained. A standard procedure for tracheostomy was used in all cases. In the first step, the cricoid cartilage and sternal notch are palpated. A horizontal incision is made between the sterna notch and cricoid cartilage which corresponds to the second and third tracheal cartilage rings. Then, skin over this area is infiltrated with adrenaline which minimizes the bleeding during the procedure. A horizontal skin incision is made and once trachea is visible, a vertical incision is made on the trachea. Following the horizontal skin incision, the fat and platysma layers are transected in horizontal plane and retracted inferiorly and superiorly. The strap muscles are retracted laterally for exposing the trachea. The thyroid isthmus may be seen during exposing the trachea. The thyroid isthmus is divided vertically with cautery. Two parallel stay sutures are kept on both sides of the incision of trachea and insertion of the appropriate size of the tracheostomy tube. Stomal maturation sutures are applied from trachea to the skin. Tracheostomy tubes are changed bedside after 3 days of operation. In some cases, vertical skin incision is made for rapid access of the trachea and reduces the risk for vascular injury and excessive bleeding. The vertical incision is not used regularly as it is not cosmetically appealing.

### EMERGENCY TRACHEOSTOMY

In emergency tracheostomy, midline skin incision is made midway between the cricoid cartilage and the suprasternal notch. The incision is deepened through the skin, deep subcutaneous tissue, and strap muscles. It is a relatively avascular field, done in emergency situation. It is simple and quicker technique.

### ELECTIVE TRACHEOSTOMY

Elective tracheostomy is often done in PICU to avoid prolonged ventilation. A horizontal incision is made midway between the cricoid cartilage and suprasternal notch. It is cosmetically better incision for performing tracheostomy. The deep tissues are separated for approaching trachea and making opening at the anterior wall of the trachea.

### PERCUTANEOUS TRACHEOSTOMY

The patients are selected on the basis of apparently normal neck anatomy, no bleeding tendency, and well-palpated cricoid cartilage and upper part of the trachea. The neck is extended as in

conventional tracheostomy. Around 1.5–2 cm transverse incision is made at midway between the cricoid cartilage and sternal notch. A 14G cannula is inserted into the incision site. AJ guide wire is introduced into the trachea through the cannula, and the opening for tracheostomy is dilated sequentially up to 36 FG (12 mm) using specially made plastic dilators. The appropriate size of the tracheostomy tube is then inserted over a small size dilator.

### SELECTION OF TRACHEOSTOMY TUBE

Choosing appropriate tracheostomy tube (Fig. 5) is an important criterion for getting successful procedure. Appropriate tracheostomy tube size prevents the complications in the pediatric patients. The diameter of the tracheostomy tube often corresponds to the age of the patients. The length and curve of the tracheostomy tube are also considered when selecting the tracheostomy tube. The length of the tracheostomy tube is ideally extending at least 2 cm beyond the stoma and tip of the tube and the tip closer than 1–2 cm from the carina [11]. The distal part of the tracheostomy tube should be parallel with the trachea avoiding the butting of anterior-posterior wall of the trachea. Longstanding abutment may lead to granulation and erosion into esophagus or innominate artery causing life-threatening conditions like hemorrhage.

If the curvature is not suitable, the polyvinyl chloride tracheostomy tube must be replaced with silicon tubes which will readily confront the airway shape. Cuffed tracheostomy is not usually needed in pediatric patients. Children requiring ventilation with high pressure or high risk for aspiration need cuffed tracheostomy tube [12]. Prolonged period inflated cuff may lead to the formation of tracheal granulation and stenosis. During deflating the cuff, there is chance of aspiration. To reduce the chance of aspiration, suctioning should be done before and after deflation. Parents should keep one spare tracheostomy tube at home along with suction catheter, humidifier, and portable suction machine for keeping the tracheostomy tube patent. Tracheostomy tube change should be done weekly; however, it depends on the patient and may need more frequent change. Child may require regular visit to outpatient clinic for healthy tracheostomy site and patent tube. Early tracheostomies may be



Figure 5: Pediatric tracheostomy tube

preferred than late tracheostomies, and it should be done before 10 days when anticipating prolonged ventilation (>21 days) [13].

## TRACHEOSTOMY CARE IN PICU

Proper tracheostomy care at PICU is an important step to prevent complications. Before handling tracheostomy tube, caregiver should wash his/her hands and put on gloves for preventing infections. Surrounding of the stoma should be cleaned with normal saline regularly along with cleaning of tube flanges. The tie fixed to the tracheostomy should be changed to new one regularly. Keeping gauze between the skin and flanges helps to prevent infections and protects from leakage of the secretions from the tracheobronchial tree. Caregivers should check skin around the tracheostomy area every day for signs of infection.

## COMPLICATIONS

Tracheostomy among pediatric patients has several complications including impact on his/her family. These complications are more in low birth weight baby or child with <1 year [14]. Before tracheostomy, clinician should consider its short- and long-term presence and systemic complications, developmental outcome, and its impact on the family. The critical period in tracheostomy is the initial period after procedure. During this period, it is often difficult to recannulate the tracheostomy tube after accidental displacement as stoma or tract is not well formed where the risk of insertion of the tube into a false tract instead of going into trachea. Other immediate post-operative complications are subcutaneous emphysema or even pneumothorax, post-operative bleeding. Rate of these complications in early age like infants is higher [15]. Post-operative bleeding is sometimes seen during early period after tracheostomy.

The late complications include infections at the stomal area which give rise to foul smelling, irritations, and erythema which need topical or systemic antibiotics. Longstanding infections may cause tracheitis which is diagnosed on the basis of clinical illness or respiratory deterioration. Sometimes, granulation is formed at the stoma site which may cause bleeding. Granuloma at the stoma looks like a friable growth and ranges in color from yellow to pink. Granuloma at the stoma is treated with antibacterial dressing or steroid ointment applied over it. Bleeding from or around the tracheostomy site may occur due to repeated suction injury or after tracheostomy tube change where reinsertion of the tube needs some manipulation. Some cases may need silver nitrate cautery in granulation tissue at the stoma area becomes fibrotic and behaves as keloid which may excised surgically. Sometimes, the granuloma is excised surgically. Repeated trauma by the tip of the tracheostomy tube or cuff area leads to granulation formation. This granulation leads to fibrosis and subglottic stenosis.

The most common and dangerous complication of children with prolonged orotracheal intubation is subglottic stenosis. Ulcerations usually occur at the subglottic site after prolonged intubation, which leads to fibrous scar tissue formation and causes stenosis [16]. The clinical presentations of the subglottic stenosis are directly related to the degree of stenosis of the subglottic area.

Grade I subglottic stenosis is usually asymptomatic, but symptoms are aggravated during upper airway infections. Grade II, III, and IV are more severe variety, need urgent tracheostomy where patients present with air hunger, dyspnea, and biphasic stridor. Neurological and neuromuscular diseases of the children such as spinal muscular atrophy type I, congenital myasthenic syndrome, and myotubular myopathy may lead to compromise of the airway and infant may unable to clear the secretions or failure of the respiratory pump and require longer ventilatory support [17]. Tracheostomy in children is more challenging than the one done in adults, because of the smaller, more pliable trachea and limited extension of the operating site.

The morbidity and mortality for pediatric tracheostomy are around 2–3 times more than in adult patients [18]. However, few reports reported similar complications in children and adult [19]. Complications are higher among pediatric patients those undergone tracheostomies [20]. The complications in pediatric patients are varied from 5% to 49% [21]. The complications are higher in children, which may be due to younger age, prolonged requirement for tracheostomy, comorbid pathology, and smaller size airway [22]. In tracheostomy patients, airflow does not occur or less air flow through nose and nasopharynx, leading to chronic physiologic nasal congestion. There may be hypertrophy of lymphoid tissue at the nasopharynx, oropharynx, and hypopharynx. Children with tracheostomy tube are at risk of eustachian tube dysfunction due to reduced nasal airflow and absence of physiologic opening of the tube at the time of swallowing. This may lead to increased chance of serous otitis media and hearing loss.

Tracheostomy has some indirect side effects on the gastrointestinal system. There is increased chance of gastroesophageal reflux due to prolonged bed rest by the majority of tracheostomized children and exposure to non-physiologic feeding patterns. Gastroesophageal reflux can be exacerbated by constipation mainly seen in infants and children with tracheostomies, particularly those have limited ability to perform a Valsalva maneuver [23]. Tracheostomy in children may negatively affect oral feeding, likely due to alteration in the mechanics of swallowing with relative tethering of the larynx, altered sensation in the larynx and pharynx. As there is shifting of airflow from nose to tracheostomy tube, causing change in the mechanics needed to initiate a swallowing. There are also changes occurred in olfaction and perception of food in tracheostomized children. One study showed 80% incidence of dysphagia among tracheostomized infants and toddler [24]. Feeding delay among tracheostomy patients requires occupational therapy and swallowing therapy. However, many children with tracheostomy tube need feeding tubes.

Subglottic stenosis or acquired LTS is a common indication for tracheostomy, particularly in children who have needed prolonged orotracheal endotracheal intubation. LTS can also occur by tracheostomy tube by creating inflammation and irritation of laryngotracheal airway. Some children of LTS can be treated by balloon dilation. LTS often needs laryngotracheal reconstruction before decannulation. Prolonged tracheostomy for ventilator support may lead to tracheomalacia, which may again require

prolonged tracheostomy. Tracheal stenosis in case of prolonged tracheostomy, there are many controversy regarding etiology. There has been documented that underweight newborns and larger size tracheostomy tube may lead to tracheal stenosis [25].

Prolonged use of a tracheostomy tube may cause the stoma to reduce into a non-functional size, though it may not close completely which may lead to the formation of trachea-cutaneous fistula. Some authors believe that technique for tracheostomy which is used may be a cause for trachea-cutaneous fistula [12]. One example for technique like starplasty where stoma is attached to the skin using sutures for reducing pneumothorax and accidental decannulation, it may need intervention to correct the trachea-cutaneous fistula [26]. Standardization of the tracheostomy technique and proper post-tracheostomy care help to improve the quality of the patient care, decrease the unnecessary laryngotracheal procedure, and reduce the economic burden of tracheostomy among pediatric patients.

Percutaneous tracheostomy is an important option in adult patients and easily performed in bedside, whereas it is highly controversial in pediatric patients [27]. The complications, mortality, and cardiorespiratory arrest are higher than classical technique in children [27]. Post-operative care of tracheostomy is a combined task of physician, nurse, and patient attendant. Post-operative care includes regular suctioning and humidification with the help of wet gauze. Restricted mobility of the patients and their parents due to tracheostomy tube may lead to distress among parents and also their children. Social stigma and embarrassing aspects of tracheostomy may lead to psychosocial problems.

## CONCLUSION

Tracheostomy in pediatric patients is often indicated for prolonged ventilation and airway obstruction. Advanced pediatric anesthetic technique like laryngeal mask airway (LMA) in case of difficult airway among children is being used to avoid tracheostomy and is making the role of tracheostomy from emergency life savior to more elective surgical procedure. Proper timing and indications of pediatric tracheostomy improve the morbidity and mortality of the pediatric tracheostomy. Complications of pediatric tracheostomy are uncommon but potentially serious which need specialized care by multidisciplinary team with define patient care protocol.

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