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Review Article

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Pediatric tracheostomy: a review

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ABSTRACT

Tracheostomy is a life shaving surgery done in critically sick patients. Pediatric tracheostomy is a surgical procedure performed since ancient times. Performing tracheostomy in the pediatric age group is often challenging because of its association with morbidity and mortality. The indications for pediatric tracheostomy have been changed significantly in the last few decades. In pediatric patients, the common indications for tracheostomy are prolonged ventilation and upper airway obstruction. Advanced methods in pediatric anesthesia and increased awareness for vaccination for serious infections like measles, mumps, diphtheria, tetanus, and hemophilus influenza type b (Hib) among pediatric age increased the changing indications for performing tracheostomy from emergency to more elective one. There are numerous research papers available in medical literature for adult tracheostomy with its indications, surgical techniques, and complications, but literature for pediatric tracheostomy is scarce. This is always a requirement for standard guidelines for standard protocols for pediatric tracheostomy. Proper standardization of pediatric tracheostomy, timing, and appropriate indications are helpful to reduce the complications and mortality related to pediatric tracheostomy. Here, this review article is attempting to discuss the indications, preoperative evaluation, surgical techniques, complications, and post-operative care of the pediatric tracheostomy.

Keywords: Pediatric tracheostomy, Upper airway obstruction, Prolonged ventilation

INTRODUCTION

Tracheostomy is a surgical procedure where a tube or cannula is introduced into the trachea to establish direct communication with the outside environment.[1] When tracheostomy is performed in pediatric patients, especially on newborns and infants, this procedure has been associated with higher morbidity and mortality in comparison to adult age.[2] Pediatric tracheostomy is one of the oldest surgical procedures and performed commonly in past for acute upper airway obstruction caused by infections like diphtheria or epiglottitis.[3] As time progresses, the indications and incidences of pediatric tracheostomy have undergone a substantial shift.[4] After the development of vaccines against *Corynebacterium diphtheria* and *Haemophilus influenza*, the number of emergency pediatric tracheostomy has reduced dramatically.[5] Although a decrease in emergency pediatric tracheostomies, the incidence of tracheostomy in the pediatric age group has not fallen; instead, it has increased especially at a tertiary care hospital.[6] This has mainly been attributed to the increased survival of pediatric patients in the intensive care unit (ICU).[7] As a result, the pediatric tracheostomy is currently a common surgical procedure in children with prolonged ventilatory support, congenital or acquired upper airway anomalies, and neurological disorders.[4] There are several advantages of pediatric tracheostomy such as it needs less sedation of patients, easier breathing, improved long term laryngeal function, less requirement of mechanical ventilation, lower risk of ventilator-associated pneumonia, early discharge of the patient from pediatric intensive care unit (PICU) and improved oral hygiene.[8] The objective of this review article is to discuss the indications, preoperative evaluation, surgical technique, complications, and postoperative care in pediatric tracheostomy.

LITERATURE SEARCH

Literature review of the pediatric tracheostomy was done from the database of Pub Med, Medline, Scopus, and Google scholar search with the use of the terms tracheostomy, pediatric age group, indications of pediatric tracheostomy, postoperative care, and complications of pediatric tracheostomy. We reviewed different current articles published in national and international journals. All the articles were read and analyzed, with relevant data being extracted. A flowchart of the selected articles is in Figure 1. This manuscript reviews the details of pediatric tracheostomy with its indications, preoperative evaluation, the surgical technique of pediatric tracheostomy, selection of appropriate tracheostomy tube, postoperative care, and complication. This review article surely makes a baseline from where further prospective studies can be designed for the pediatric tracheostomy which can help to standardize the pediatric tracheostomy and minimize its complications.

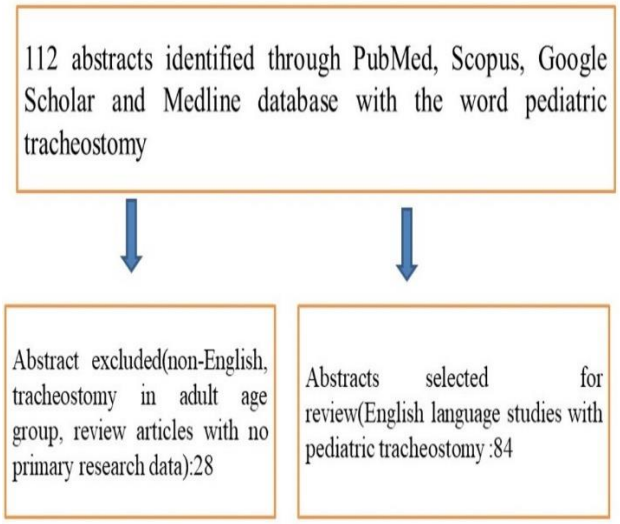

Figure 1: A flowchart of methods for literature search.

HISTORY

The first tracheostomy was performed by Asclepiades in Rome in the second century BC.[9] Antyllus documented the techniques for tracheostomy once again in the second century AD and highlighted that the trachea should be opened at the third or fourth tracheal rings.[9] Italian physician Antonia M Brasovala successfully performed a tracheostomy on a patient with an abscess of the trachea in the 16th century.[9] Nicholas Habicot described four successful tracheostomies, one of them was done on a 14-year-old boy.[10] In 1766, Caron performed a tracheostomy on a 7-year-old child for removing a foreign body and this was the first successful tracheostomy in a pediatric age group.[10] Other two reports were showing successful tracheostomy in children such as Andre in 1782 and Chevalier in 1814.[9]

INDICATIONS OF PEDIATRIC TRACHEOSTOMY

In the last three decades, the indications for pediatric tracheostomy have been seen as gross change. In the past, the common indications were acute inflammatory airway obstruction like acute epiglottitis or diphtheria.[11] After the development of vaccines against *Corynebacterium diphtheria* and *Haemophilus influenza* as well as initiation of modern neonatal intensive care units have served to minimize the infection-based indications for tracheostomy.[12] Currently, upper airway obstruction due to laryngotracheal anomalies and prolonged ventilation are common indications of pediatric tracheostomy (Figure 2).[13,14] Tracheostomy prevents aspiration by providing access to the tracheobronchial toilet.[15] It also prevents laryngotracheal stenosis by avoiding prolonged intubation.[16] Tracheostomy facilitates weaning from ventilator by avoiding ventilator dead space.[17] Laryngomalacia, recurrent laryngeal papillomatosis, and laryngotracheal stenosis are common indications for tracheostomy in the pediatric age group.[18] Because of improvements in diagnosis and treatment, the survival rates of pediatric patients with different chronic diseases have improved and these children are properly managed in intensive care units with help of endotracheal intubation for a long period. So, prolonged intubation remains the important indication that requires tracheostomy.[19] The most common indications for prolonged intubations are cardiopulmonary diseases, neurological disorders, upper airway obstruction, and craniofacial anomalies.[20] Certain clinical conditions with difficult airway result in difficult intubation and require tracheostomy for ventilation and these clinical conditions include retropharyngeal abscess, epiglottitis, post-tonsillectomy hemorrhage, obstructive sleep apnea, crushing injury of the neck and tracheal foreign body.[21] Tracheostomy is a part of palliative treatment in pediatric patients with chronic diseases which enables patients to spend more time with their families and allows them to stay more comfortably.[22]

Figure 2: A child with tracheostomy for prolonged ventilation.

PREOPERATIVE EVALUATION OF THE PEDIATRIC TRACHEOSTOMY

A detailed pre-operative evaluation of the child is needed to confirm the appropriate decision to perform a tracheostomy. The overall medical condition of the child and thorough examination of the airway from the nasal cavity to the distal bronchi should be done preoperatively.[23] The exact site of obstruction in the airway must be identified before planning for tracheostomy. The tracheostomy should bypass the obstruction. During neck examination, inability to palpate the airway landmarks, presence of scars due to the past history of neck and chest surgery, and palpation of arterial pulsation above the sternal notch are features of potential hazards that may be encountered during the surgery.[24] The cardiopulmonary status of the child should be assessed by appropriate medical experts to confirm the patient as medically fit for anesthetic and surgical challenges. Moreover, a medical evaluation may help anticipate post-operative complications such as pulmonary edema or loss of respiratory drive in chronically hyperbaric patients.

SURGICAL TECHNIQUE

The surgical checklist should be made before performing the pediatric tracheostomy as in any other surgical procedure. Different sizes of tracheostomy tubes should be available and should be checked before performing tracheostomy in a pediatric patient. Detailed intraoperative airway management should be planned with anesthesia and nursing teams. During performing pediatric tracheostomy, there should be ongoing communication between the surgeon and anesthetist for ensuring to control the airway. The child should be placed in a supine position by a rolled towel keeping under the shoulders for maintaining the neck in extension. The anterior surface of the neck should be palpated by the surgeon to locate the cricoid cartilage, thyroid cartilage, and suprasternal notch.[25] The surgeon should also palpate for prominent vascular pulsations which suggest a high riding innominate artery. The surgical site should be prepared and draped with a sterile towel. A horizontal incision is made midway between the sternal notch and cricoid cartilage. This location usually corresponds to the second and third tracheal rings. Then subcutaneous infiltration is done with local anesthetic with adrenaline which minimizes the intraoperative bleeding.[26] Once horizontal incision is made, the deeper fat and platysma layers are transected in horizontal plane retracted superiorly and inferiorly. Then strap muscles are retracted laterally to expose the anterior wall of the trachea. Once the tracheal is exposed, the cricoid is pulled superiorly with help of a cricoid hook which stabilizes the laryngotracheal complex. The retention sutures may be placed bilaterally before making a tracheal incision. The incision on the trachea is made horizontally or vertically as per the surgeon's preference between second and third tracheal rings. Superior incision above the second tracheal rings should be avoided as it may result in subglottic stenosis in the future.[27] The tracheal dilator is used to dilate the tracheal incision and help to visualize the tracheal lumen. The tracheostomy tube with obturator is then inserted into the tracheal lumen and there should not be any resistance during insertion. Once the tracheostomy is inserted, the obturator is removed. Then inner cannula is inserted if the inner canal is present. The cuff of the tracheostomy tube is inflated and the ventilator connection is established and carbon dioxide tracing is obtained on the capnography.

SELECTION OF APPROPRIATE TRACHEOSTOMY TUBE

The selection of an appropriate tracheostomy tube is an important step for getting a successful procedure. The appropriate size of the tracheostomy tube avoids complications in pediatric patients. The diameter of the tracheostomy tube usually corresponds to the age of the children. The length and curve of the tracheostomy tube are also considered during the selection of the tracheostomy tube. The length of the tracheostomy tube is ideally extended at least 2 cm beyond the stoma and the tip of the tracheostomy tube should be closer than 1 to 2 cm from the carina.[28] The distal end of the tracheostomy tube should be parallel to the trachea for avoiding butting to the tracheal walls. Abutment of the tracheostomy tube with the tracheal wall for a prolonged duration may cause the formation of granulation and erosion into the esophagus or innominate artery resulting in life-threatening situations such as hemorrhage. If the curvature of the tracheostomy tube is not suitable, the polyvinyl chloride tube should be replaced with silicon tubes which will easily confront the airway shape. A tracheostomy tube with a cuff is not required always. Pediatric patients requiring ventilation with high pressure or a high chance of aspiration require cuffed tracheostomy tube.[29] If the inflated cuff of the tracheostomy tube stays for a long period, it may result in the formation of tracheal granulation and stenosis. There is a chance of aspiration during deflating the cuff of the tracheostomy tube. To prevent the chance of aspiration, suction should be done before and after deflation.

POST-TRACHEOSTOMY CARE

The care of the tracheostomy tube starts in the immediate post-operative period. A team of medical, nursing, and respiratory therapy persons is needed for appropriate postoperative tracheostomy care. The need for the humidification, suctioning of the tracheostomy tube (frequency, depth of suctioning), an algorithm for managing accidental decannulation of the tracheostomy tube and reinsertion of the tube with sutures require clearly outlined. Inspired air through tracheostomy should be warm and humid for avoiding discomfort thickening of secretions and chance of tracheostomy tube blockage by a secretion plug.[9] The outside weather may alter the viscosity of the secretions as cause heating

during the winter and air-conditioning in summer, drying out the air and so frequent humidification required.[30] As the cough reflex of the patients is lost after tracheostomy, the secretions must be cleared artificially with an aseptic and minimal traumatic method, aiming to decrease the possibility of internal injuries of the trachea.[31] Secretions coming through the tracheostomy tube should be aspirated at least twice daily or more frequently if there are great quantities of secretions that cannot be expelled by coughing.[32] During suctioning, the suction probe is introduced with vacuum switched off and the tip is guided to around 0.5cm below the distal end of the tracheostomy tube. Then the vacuum is activated and the probe is removed gently in rotating movements.[32] To reduce aspiration, suctioning must be done before and after deflation of the cuff of the tracheostomy tube. Caregivers must keep one spare tracheostomy tube at home along with a suction catheter, humidified, and portable suction machine for getting a patent tracheostomy tube. The change of tracheostomy tube should be done weekly; however, it depends on the patient's condition and may require frequent change. Pediatric patients with tracheostomy tubes should do regular visits to the outpatient clinic for getting a healthy tracheostomy tube site and patent tracheostomy tube. Early tracheostomy is better than late tracheostomy and it should be done before ten days when anticipating prolonged ventilation (>21 days).[33] After tracheostomy, a child lost communication via speech. Communication can be compensated in older children with help of signs or with writing for children who have already learned to write and read.[9] A speaking valve may be used in children if the tracheostomy tube does not exceed two-thirds of the diameter of the trachea, has stable clinical status, secretions are not thick, and can vocalize with occlusion of the tracheostomy tube.[32] Care must be taken with foreign objects at the tracheostomy orifice, as the presence of an open tracheostomy tube orifice makes children more vulnerable for aspiration of foreign bodies entering into the airway. It is important to change the suction tube/cannula frequently and employ aseptic techniques when handling the tracheostomy for minimizing the possibility of infection.[34] When a pediatric patient with a tracheostomy tube is allowed to stay at home, their caregivers or parents must keep two tracheostomy tubes for emergency changes: one of the same calibers as that in place and another one of the next sizes down. The tracheostomy tube ties should be changed daily or whenever wet or soiled.[32] During changing the ties, one person should secure the tracheostomy tube in place while another removes the old ties and replace them.

It is not always possible to remove the tracheostomy tube from the children, so some will have to be sent home with the tube. The parents or the caregivers of the children should acquire all the equipment required such as a portable aspirator, gloves, sterile suction catheters, oxygen source, manual aspirator, and saline solution. The parents/caregivers should be trained to care for tracheostomy and how to find out complications and must learn the emergencies. The nursing team should provide guidance and facilitate the contact between parents and hospital and the medical team. The children with tracheostomy tube must not be discharged from the hospital before their parents have learned all the steps for day-to-day and emergency care of the tracheostomized child nor before the equipment have been kept and functioning at the parent's home.

DECANNULATION PROTOCOL

Before doing decannulation, the patient must be assessed to find out the initial reason for performing tracheostomy has resolved.[35] Airway examination should be done to rule out some lesions which prevent decannulation such as vocal fold paralysis, stomal granulation, supra-stomal collapse, distal tracheal granulation, and tracheomalacia.[36] In the case of long-standing tracheostomy, the stoma may become epithelized. In these cases, there is a higher chance of developing trachea-cutaneous fistula after the decannulation. Decannulation and stomal closure with sutures are not suggested as this may cause infection and result in subcutaneous emphysema. When planning for decannulation of the tracheostomy tube, the common protocol starts with gradual downsizing of the tube for promoting gradual closure of the stoma and training the patient to breathe around the tracheostomy tube. If the patient tolerates, then the tube is corked and tolerated without oxygen, the decannulation should be done after 24 hours. If successfully the tracheostomy tube is removed, the stoma area is covered with an occlusive dressing for promoting closure. Patient monitoring should be done for closure of the stoma. If the stoma is not closed, the patient will be discharged if with stable breathing, and follow-up should be done in an outpatient clinic setting.

COMPLICATIONS

There are several complications of tracheostomy in the pediatric age group. The complications associated with pediatric tracheostomy are more among low-birth-weight babies or children less than 1 year of age.[37] The critical period following tracheostomy is the initial period after the surgical procedure. During the initial period following tracheostomy, it is often difficult to re-cannulate the tube after accidental displacement of the tube as stoma or tract is not formed well where the chance of insertion of the tube into a false tract instead into the trachea. The complications of pediatric tracheostomy include hemorrhage, subcutaneous emphysema, pneumothorax, pneumomediastinum, accidental decannulation, intratracheal mucus plug, occlusion of the tracheostomy tube with the thick mucus secretion, granulations around the tracheostomy, and infections like tracheitis.[38] The immediate post-operative complications are subcutaneous emphysema or even pneumothorax and bleeding. The chance of complications at an early age like an infant is

higher.[39] The late complications of pediatric tracheostomy are infections at the stomal area which give foul-smelling, irritations, and erythema which require topical or systemic antibiotics. Infections for a longer period at the stomal area may cause tracheitis which is detected based on clinical illness or respiratory deterioration. Sometimes the granulation at the stoma cause bleeding. Granuloma at the stoma looks like a friable appearance and ranges in color from pink to yellow. Repeated suctioning may cause injury and bleeding from the tracheostomy tube. Some patients may need silver nitrate cautery in the granulation at the stomal region. Sometimes the granulations at the stomal region are surgically excised. Repeated injury by the tip of the tracheostomy tube or cuff area results in granulation formation. This granulation results in fibrosis and subglottic stenosis.

Although the number of pediatric tracheostomies has been increased, death from tracheostomy is uncommon.[8] One study with 420 pediatric tracheostomies showed 28% of mortality.[40] In pediatric tracheostomy, the case mortality is declining as there were 2 instances out of 57 pediatric tracheostomies and 2 out of 122 pediatric tracheostomies.[41,42] The risks of death are not completely eradicated even with contemporary surveillance protocols like cardiac and oxygen monitoring.

CONCLUSION

Pediatric tracheostomy is commonly performed for prolonged ventilation and airway obstruction. The indications for pediatric tracheostomy are changing. The indications for pediatric tracheostomy have changed over the last three decades and are currently mostly performed for children with prolonged intubation followed by those who need better trachea-bronchial clearance and with obstructive airway malformation. The decision for performing tracheostomy remains complex and it depends on several factors. However, there are chances of associated morbidity and mortality associated with a pediatric tracheostomy. So, a pediatric tracheostomy can be safely carried out by a multidisciplinary team at a specialized center.

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