



Pediatric tracheostomy

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Abstract

Objective: To provide an up-to-date review of pediatric tracheostomy, primarily focusing on indications, surgical technique, complications and hospital and home care.

Sources: MEDLINE and PubMed databases were searched using the following keywords: tracheostomy, tracheotomy, children, newborn.

Summary of the findings: Indications for tracheostomy in children are changing. Today the most common indication is prolonged ventilation. The age at the time of the procedure has also changed, with a peak incidence of tracheostomy in patients less than 1 year old. Except under emergency conditions, pediatric tracheostomy should be performed in the operating room with the child intubated. A horizontal skin incision with vertical tracheal incision and no tracheal resection is recommended. Although post-tracheostomy complications are not uncommon, they usually do not need special treatment or surgical procedures. Tracheostomy mortality can occur in up to 40% of pediatric cases, however the tracheostomy-related mortality rate is only 0 to 6%.

Conclusions: The decision to perform a tracheostomy remains complex, and depends on several factors. The procedure is safe and with a low number of complications if carried out at a tertiary hospital by a trained and experienced team.

J Pediatr (Rio J). 2009;85(2):97-103: Tracheostomy, tracheotomy, prolonged intubation, children, newborn.

Introduction

Tracheostomy is the surgical procedure by which a cannula is introduced into the trachea in order to establish direct communication with the external environment. When performed on children, and especially on newborns and infants, the procedure had been associated with greater morbidity and mortality than when performed on adults.¹⁻³ Over the years, the use of tracheostomy with children has changed and, nowadays, more specific indications are followed and more satis-

factory results observed over long-term follow-up.⁴ The objective of this study is to review pediatric tracheostomy.

History

Asclepiades is credited with carrying out the first tracheostomy in Rome in the second century BC.⁵ Antyllus defined the tracheostomy technique once again in the second century AD, emphasizing that the trachea should be opened at the third or fourth rings. Nevertheless, it was only during the 16th century that the Italian physician Antonio M. Brasovola

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Table 1 - Indications for pediatric tracheostomy

	Upper airway obstruction	Pulmonary hygiene, assisted ventilation
Allergic	Angioedema; anaphylactic shock	Asthma
Metabolic	-	Cystic fibrosis; diabetes-induced coma, uremia, etc.; respiratory distress syndrome
Prophylactic	Head and neck surgery; neurosurgery; heart surgery; prolonged intubation	-
Degenerative/idiopathic	Vocal chord paralysis	Central nervous system or neuromuscular deficiency: Guillain-Barré syndrome; polymyositis; myasthenia gravis; botulism; cardiac arrest, respiratory arrest
Sleep disorders	Collapse of pharyngeal musculature; enlarged adenoids/amygdala	-
Congenital	Choanal atresia; macroglossia; cleft palate; Pierre-Robin sequence; laryngomalacia, laryngeal stenosis ; vocal chord paralysis; laryngeal web and cysts; subglottic stenosis; vascular ring; hypoplasia tracheal	Congenital heart failure and cardiac disease; esophageal atresia with tracheoesophageal fistula; pulmonary hypoplasia due to diaphragmatic hernia; craniomaxillofacial surgery
Traumatic	Oral and facial injury; foreign body; burns; laryngeal edema; recurrent laryngeal nerve injury; laryngeal fracture	Head trauma; crushed chest; intrapulmonary hemorrhage; pneumothorax; post-lung transplant care
Toxic	Corrosives	Toxic coma (phenobarbital and others); aspiration syndromes (meconium and others)
Infectious	Epiglottitis; laryngotracheitis ; gingivostomatitis; diphtheria; retropharyngeal abscess; cervical cellulitis; tetanus; rabies	Meningitis; encephalitis; cerebral abscess; pneumonia; bronchiolitis; poliomyelitis; pulmonary aspiration evidence of laryngeal closure
Neoplastic	Tumors of the larynx, trachea, pharynx and tongue: papilloma, hemangioma, lymphangioma and sarcoma	Cerebral and spinal marrow tumor

described successfully performing a tracheostomy on a patient with an abscess of the trachea.⁵ In 1620, Nicholas Habicot described four successful tracheostomies, one of which was carried out on a 14-year-old boy. In 1766, Caron describes a tracheostomy on a seven-year-old child carried out to remove a foreign body. This is considered to be the first successful tracheostomy performed on a patient in the pediatric age group.⁶ Other reports of the procedure being performed successfully on children were to follow, by Andree in 1782 and Chevalier in 1814.⁵

In 1833, Trousseau reported having saved 50 children with diphtheria by carrying out tracheostomies.⁶ This was the first report in history that also described techniques for postoperative care.⁶ As a result of this satisfactory use of tracheostomy in children with diphtheria, surgical management of airway problems increased in popularity, even in the knowledge that the mortality associated with the procedure remained high. In 1921, Jackson demonstrated a reduction in mortality when tracheostomies were carried out correctly, especially so where

there was also appropriate postoperative care.⁷ This contributed to the history of tracheostomy by reducing complications through emphasis on good surgical technique and on postoperative care, with a consequent increase in tolerance. The next impetus to increased use of the procedure came when Galloway reported using tracheostomy with patients with poliomyelitis.⁸

Indications

Tracheostomy was originally used to relieve acute airway obstruction and was a last-resort measure.⁵ The number of indications for the procedure increased from the twentieth century onwards and it came to be used for treatment or improvement of respiratory care or even to prevent narrowing of the airway.^{9,10} The principal indications for pediatric tracheostomy can be found in Table 1.⁵

While the principal indications for tracheostomy in children have remained the same over the last 20 years, countless tendencies become apparent when descriptions of case

series covering the period are analyzed. Wetmore et al.¹¹ reported that the incidence of tracheostomy has reduced in relation to the number of hospital admissions, although the absolute number of tracheostomies per year has remained unaltered. The same study, in conjunction with another recently-published study,¹² showed that patients are being tracheostomized for longer periods, perhaps because they are children chronically dependent on mechanical ventilation.

Tracheostomy has been recommended for children of all age groups. Nevertheless, it is most frequently performed on children less than 1 year old.¹¹⁻¹⁴ The increase in tracheostomies within this age group has been attributed to increases in the survival of premature newborn infants and those requiring prolonged ventilation.⁴

The decision to perform a tracheostomy on a child is complex and depends on several factors, including the severity of airway obstruction, the difficulty and duration of intubation and the child's subjacent medical condition. All of these factors must be assessed one by one by the pediatrician and surgeon in conjunction and the indication for tracheostomy must be based on the individual conditions of each child.^{5,15}

After the first successful pediatric tracheostomy was completed in 1766, the procedure began to be carried out specifically for children with airway obstruction, to the extent that it was indicated for the management of children with diphtheria, laryngitis and laryngeal edema.⁹ Tracheostomy then came to be indicated in order to facilitate aspiration of secretions from the airways of children intubated for long periods. This particular indication for the procedure was well-described in children with poliomyelitis.¹⁶ Once vaccines began to be used to combat diphtheria (1940) and poliomyelitis (1956), the most important indications for tracheostomy came to be acute inflammatory processes in the larynx, such as laryngotracheobronchitis and acute epiglottitis.¹⁷ From the 1980s onwards, as tracheal tubes and intubation technique improved, together with improvements in the care in intensive care units, intubation came to be the procedure preferred over tracheostomy for these children with inflammatory processes of the airway.⁵

The ever-growing use of tracheal intubation for the management of children with airway problems, with a resultant increase in the survival of these children, led to an increase in the incidence of subglottic stenosis, which then became the most common cause of pediatric tracheostomy. Nevertheless, the constant improvements in surgical techniques for the correction of subglottic stenosis, which came to be treatable without the need for prior tracheostomy, combined with better care of the airways of intubated children, reduced the indications for tracheostomy in children with subglottic stenosis. Currently, the most common indication for pediatric tracheostomy is prolonged intubation;^{5,18,19} followed by intubation for tracheobronchial hygiene and congenital malformations of the airway.⁵

Children requiring mechanical ventilation are initially managed using tracheal intubation, with the indication of tracheostomy depending on the subjacent disease and the age of the child. Newborn infants usually tolerate intubation for months, with minimal edema or laryngeal inflammation.⁵ For older children and adolescents with irreversible subjacent diseases, and where there is no prospect of extubation, tracheostomy is indicated after 10 to 14 days of intubation. For children in the same age group, but where the primary disease allows for the possibility of extubation, depending on clinical progress, weekly fibrobronchoscopy is recommended after 10 to 14 days of intubation in order to evaluate the condition of the upper airway. Where there is ulceration of mucosa or ischemic abnormalities of the larynx or trachea, caused by the tracheal tube, tracheostomy is recommended.¹⁵

Intubation may be indicated to protect the airways of children if there are problems with clearance of laryngotracheal secretions, but it does not completely prevent aspiration if the larynx is incompetent. Other protective measures include nasogastric feeding or gastrostomy, in order to reduce secretions originating from the deglutition mechanism, and aggressive medical or surgical treatment of gastroesophageal reflux. In certain rare cases in which tracheostomy does not improve chronic aspiration, laryngeal separation should be discussed.²⁰

Tracheostomy cannulae

The ideal tracheostomy cannula should offer a series of characteristics.⁵ The tube should be soft enough to mold itself to the trachea and throat without causing any pressure or discomfort or injury to the skin or mucosa tracheal. However, it should not be so soft that it develops creases or kinks, resulting in its lumen becoming occluded. The tube should be manufactured from a material that causes the minimum tissue reaction possible and should preferably be available in the same sizes and numbering systems as the corresponding tracheal tubes. The ideal cannula should have an external connector to connect a mechanical ventilator and the internal tube should be removable for cleaning. Unfortunately none of the cannulae available in metal or plastic today offer all of these characteristics.¹⁰ Nevertheless, the majority of authors prefer to use plastic cannulae.^{5,21}

It is important to consider diameter and length when choosing the tracheostomy cannula. A cannula with too large a diameter may injure the mucosa or even cause ischemia in the tracheal wall. This can result in ulceration and later fibrotic stenosis of the trachea. For the same reason, tracheostomy cannulae used with children do not have cuffs, due to the risk of ischemic injury and residual stenosis. The diameter of the cannula can generally be estimated from the diameter of the tracheal tube appropriate for the child.⁵

The length of the tracheostomy cannula is also important, especially with newborn infants and small children. A cannula

that is too short may facilitate accidental decannulation or the creation of a false airway; a cannula that is too long may injure a carina or result in selective intubation of one of the bronchi. Sometimes long cannulae are chosen for the treatment of an area of lower tracheal stenosis or tracheobronchomalacia.⁵

Surgical technique

Except in emergency situations, pediatric tracheostomy should be carried out in a surgical environment, under general anesthetic and with the patient intubated. Operating theatres are well-lit and patients can be put in the most appropriate position.⁵ A rigid bronchoscope should be available throughout the procedure, in case there is any need to manipulate and control the airway.

The child is placed in decubitus dorsal, with a roll under the shoulders to stretch the neck. A horizontal incision is preferred in the skin, since it offers better esthetic results. When opening the airway, it is preferable to make a vertical incision at the third and fourth tracheal rings.^{3,5,21,22} Collapses above the tracheostomy and narrowing of the trachea are more often observed after horizontal tracheal incisions, or those in "T" or "H", and also when the tracheal wall undergoes resection.²²⁻²⁴ With children, it is very important that stay sutures are placed in the tracheal wall and these are of fundamental importance if accidental decannulation occurs postoperatively.^{3,21,22} If it proves necessary to replace the tracheostomy cannula these are tractioned upwards allowing the tracheal opening to be brought forward and opened, facilitating cannulation of the trachea.²²

Complications

Children suffer two to three times more tracheostomy morbidity and mortality than adults.^{4,15,25,26} The number of complications is even higher during the neonatal period, particularly among preterms, and tracheostomy is considered a high-risk procedure in this age group.³ This can in part be explained by the smaller tubes used with these children and also by the diseases involved, in particular bronchopulmonary dysplasia.³

The incidence of acute tracheostomy complications varies from 5 to 49%^{10,15,25,27-30} and includes bleeding, pneumothorax, pneumomediastinum, emphysema subcutaneous, accidental decannulation, obstructed cannulae, tracheal laceration, tracheoesophageal fistula, infection of the surgical wound and cervical abscess. Later complications are described in 24 to 100% of children^{10,19,25,27-30} and include granulation tissue, bleeding, infection, pneumothorax, tracheal stenosis, tracheomalacia, fusion of the vocal cords and tracheoesophageal fistula.

It has been proven that tracheostomy complications are reduced when the procedure is carried out in tertiary hospitals and by surgeons trained to manage airway obstruction in children.² Specific training for the health professionals who

care for these children also reduces the incidence of complications, as does teaching relatives and members of the community who care for these children about care and resuscitation maneuvers.¹³ Up to 40% of children with tracheostomies may die, while mortality directly related to the tracheostomy varies from 0 to 6%.¹⁵

Care of the tracheostomy

Inspired air should preferably be warm and humid in order to avoid discomfort, thickening of secretions and risk of obstruction of the tracheostomy cannula by a secretion plug.⁵ The weather can also alter the viscosity of secretions, as can heating during the winter and air-conditioning during the summer, drying out the air and making more frequent humidification necessary.³¹

Since the cough reflex is lost in tracheostomized children, the secretions must be aspirated artificially using an aseptic and minimally traumatic method, aiming to reduce the possibility of internal injuries to the trachea.³² Secretions should be aspirated at least twice a day³¹ or more frequently if there are great quantities of secretions that cannot be expelled by coughing. During aspiration, the probe is introduced with the vacuum switched off and the tip is guided to around 0.5 cm below the distal tip of the cannula. The vacuum is then activated and the probe removed gently using rotating movements.³¹

Communication via speech is lost, and can be compensated for in older children using signs or with writing for children who have already learnt to read and write.⁵ A speaking valve can be used with children if the tracheostomy cannula does not exceed two thirds of the tracheal diameter, if clinical status is stable, secretions are not too thick and they have a certain ability to vocalize with occlusion of the tube.³¹

After tracheostomy the respiratory system becomes more susceptible to contamination and foreign body aspiration. It is important to change aspiration probes frequently and employ aseptic techniques when handling the tracheostomy in order to reduce the possibility of infection.³³ Care should be taken with foreign objects at the tracheostomy orifice, since the presence of an open orifice in the trachea makes children more susceptible to aspiration of foreign bodies into the airway.

In general, children can be fed soon after the tracheostomy is carried out, as long as they are fully awake and have recovered from the anesthetic. However, some children may lose certain laryngeal reflexes and suffer occasional minor aspirations.⁵

The frequency with which the tracheostomy cannula should be changed depends on the age of the child, the quantity of secretions and the type of cannula which is being used. In general, plastic cannulae should be changed, on average, after 4-6 months of use, or before they present some degree of obstruction.³¹ When children with tracheostomies are

allowed home, it is important that their parents have two cannulae available for emergency changes: one of the same caliber as that in place and another of the next size down.

The tracheostomy cannula ties should be changed daily or whenever they become soiled or wet.³¹ During the change, one person should secure the cannula in place while another removes the old ties and replaces them.

It is not possible to remove the tracheostomy from all children, to the extent that some will have to be sent home with the cannula. The child's parents will have to acquire all the equipment necessary (portable aspirator, gloves, sterile aspiration probes, oxygen source, manual respirator and saline solution) and will also need to be trained how to care for the tracheostomy and how to detect complications and must learn emergency techniques. The nursing team have a fundamental role to play in providing guidance and in facilitating contact between parents and the hospital and medical team. It is important to point out that children must not be released before their parents have learnt all the procedures for day-to-day and emergency care of the tracheostomized child nor before the equipment has been installed and is functioning at the patient's home.

Obtaining an airway in an emergency

There are not many people who practice emergency tracheostomy of children since it is associated with increased risk of airway perforation, bleeding and difficulty in defining anatomic structures.⁵ A child with respiratory failure who needs ventilator life support can initially be ventilated using an anesthetic bag-mask system.³⁴ This technique is safer than tracheal intubation and equally effective, if performed correctly and used for a short period of time.³⁵ It is very important that the airway be opened by mildly extending the neck and that the mask be perfectly fitted to the child's face to avoid air leaks.³⁴ Tracheal intubation should be carried out as soon as a trained and experienced person and all of the necessary equipment are available.³⁶

In cases where tracheal intubation is not possible due to a lack of technical ability or a difficult airway, one alternative is to use a laryngeal mask. These are just as effective as tracheal intubation, but should only be used by trained personnel.³⁷

Another alternative for these patients is tracheal intubation using a fibroscope, where the endoscopic device is used as a guide for introduction of the endotracheal tube. Intubation with fibroscopy can be carried out with all age groups and offers the advantages of being able to assess the airway before intubation and of avoiding intubation of the esophagus or one of the bronchi in addition to confirming the position of the tube within the trachea.³⁸ It is contraindicated when there are excessive quantities of blood or secretions that compromise visibility and in children with whom bag-mask ventilation is

not possible, meaning that oxygenation could not be maintained during the procedure.³⁸

When there is a need for a surgical intervention to obtain an airway in a child, the preferred technique is to perform a cricothyroidotomy.^{5,39} The cricothyroid membrane can be opened by incision or puncture. Because of the risk of injuring vital structures in the neck, incisions should only be performed by physicians with surgical training. A puncture can be carried out by any physician who has been trained in pediatric resuscitation.³⁹ While there is still debate about the true possibilities of ventilating through a large caliber needle after puncture of the cricothyroid membrane for resuscitation, this is the procedure recommended by the American Heart Association Pediatric Advanced Life Support course.³⁹ To perform the procedure, the child is placed in decubitus dorsal, with a roll under the shoulders. The cricothyroid membrane is located beneath the final portion of the thyroid cartilage and the initial portion of the cricoid cartilage and is punctured with a large caliber catheter (abocath® numbers 14, 16 or 18), at the midline, in the caudal direction at a 30° angle. The catheter is connected to a syringe at negative pressure during puncture. Once the cricothyroid membrane has been passed and the airway gained, the needle is removed and the plastic part of the catheter is extended distally. The catheter should preferably be connected to a transtracheal jet ventilation system.³⁸ Cricothyroidotomy by puncture with jet ventilation is faster, simpler and causes less bleeding than surgical cricothyroidotomy. Nevertheless it is a provisional measure and should only be used until a definitive airway is secured.³⁸

Removal of the tracheostomy cannula

Removal of a pediatric tracheostomy is a difficult procedure and should only be attempted after the primary disease that indicated the procedure has been resolved.⁵ The attempt at decannulation should be preceded by fibrobronchoscopy in order to rule out obstructive diseases (laryngeal or subglottic stenosis, granulomas, tracheal collapse above the tracheostomy, and others) which prevent the cannula from being removed. If present, obstructions should be dealt with before removing the tracheostomy cannula. After the cannula is removed, the child must remain in hospital under observation for a minimum of 24 hours.

Conclusions

It can be observed that over recent years several changes have occurred to the tracheostomies performed on children. The age group of the patients operated has changed, with tracheostomy most often carried out on children less than 1 year old. The indications for the procedure have also changed over the last 30 years and it is currently most often used with children on prolonged intubation, followed by children who need better tracheobronchial clearance and those with obstructive malformations of the airways. Pediatric tracheostomy is safe and, when performed in a tertiary hospital environment by

surgeons trained in pediatric airway management, it is associated with minor complications that do not usually require additional surgical intervention.

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