Pediatric and Neonatal Tracheostomy

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Introduction

The popularity of tracheostomy has waxed and waned over the centuries. Tracheostomies date back as far as 3100 BC in ancient Egypt. There is documentation of tracheostomies in the Rig Veda of India dating to 2000-3000 BC. There is even a popular story that Alexander the Great performed a tracheostomy with his sword on a wounded soldier on the battlefield in 400 BC. Tracheostomy went out of popularity for quite some time until the resurgence of the procedure in the early 20th Century, especially in the 1940s and 50s when the polio epidemic left thousands of patients unable to breathe without the assistance of a ventilator. At that time, the most common indication for tracheostomy was infectious, most often diphtheria, epiglottitis, and polio [1-3]. These indications have changed over time as vaccination has relieved the infectious burden. As modern Medicine has increased the survivability of pre-term infants, there has been an increase in the incidence of bronchopulmonary dysplasia (BPD) and the need for prolonged ventilation. Lee *et al* report a tenfold increase in the proportion of infants receiving tracheostomies from 1997 to 2005 (0.01% to 0.1%) [4]

The incidence of pediatric and neonatal tracheostomy has been relatively steady, accounting for 4800-5000 cases per year in the United States [2, 5, 6]. In 1997, the mean hospital stay for a tracheostomy admission was approximately 50 days, with an average facility cost of $200,000 or more [6]. As more complicated patients with chronic conditions undergo tracheostomy, these numbers are expected to rise. Infants undergoing tracheostomy have a higher length of stay and higher costs associated with their initial hospitalization. Seventy-two percent of all pediatric tracheostomies are performed at dedicated pediatric facilities [6].

Tracheostomy in children is most common at the extremes of the pediatric range age with approximately 32% being less than 1 years of age, and 33% being 15-18 years of age at the time of tracheostomy [6]. Carron *et al*. noted that between 1988 to 1998, indications for tracheostomy were most commonly neurological disorders, followed by prolonged intubation, and then upper airway obstruction [3]. More recently, the most common indications have changed with prolonged intubation and airway obstruction being most common [7]. In addition, 60% of infants undergoing a tracheostomy have congenital anomalies as their primary diagnosis with prematurity and pulmonary disturbance being the next most common. Older adolescents most commonly undergo tracheostomy for trauma in approximately 80% of cases. Upper airway infection (epiglottitis, croup, bacterial Tracheitis) now only accounts for 1% of tracheostomies annually [6].

As the indications for tracheostomy have changed in children, those with more complex medical conditions are undergoing the procedure. As Zhu *et al*.

notes, up to 80% of pediatric patients have chronic conditions that may affect both surgical and postoperative care and complications [8]. According to Berry *et al*., over the decade from 1997 to 2006, there was a considerable increase in the number of children undergoing a tracheostomy that had neuromuscular impairment, chronic lung disease, congenital heart disease, and prematurity [9, 10]. Due to more complicated children undergoing a tracheostomy , the post-operative care and outpatient burden has shifted. During the 1940s and 50s, the patients could usually be decannulated following the resolution of the infectious agent and the mortality was relatively low. Now with sicker children undergoing a tracheostomy, long term care and outpatient decannulation has taken a more prominent role [9, 10]. It is estimated that in the United States, in the 1990s, home care for a child with a tracheostomy costs approximately $110,000 per year with home care nursing accounting for 60% of that cost [9]. In 2017 dollars, that would equate to $200,000 or almost $17,000 per month.

Complications

Children undergoing a tracheostomy are at higher risk for complication than adults and the younger the patient, the higher the risk. Much of the morbidity and mortality is associated with the underlying comorbidities [11-13]. The overall mortality of children with a tracheostomy is between 13 and 19% [3, 9, 14-16]. It is estimated that 7-8% of children do not survive to discharge during the hospitalization in which the tracheostomy was performed. Higher mortality is seen in patients less than one year of age (10-13 %) as compared to children aged 1-4 years old (1-4 %) [10]. Mortality is higher in children with concurrent cardiac disease or prematurity (13-19 %). Much of the mortality seen is due to the underlying comorbidities [10]. Interestingly, children undergoing a tracheostomy in a pediatric dedicated facility are twice as likely to survive to discharge as compared to those at non-pediatric facilities. In addition, there is a direct correlation with the average volume of tracheostomies performed and the likelihood of survival to discharge. The odds ratio of death during hospitalization was 0.19 for a hospital in the 26th-50th percentile and down to 0.05 for those in the 76th-100th percentile [6].

Complications are split into early and late. Early complications include pneumothorax, accidental decannulation, tracheostomy plugging, bleeding, and death. Late complications include stoma breakdown, granulation tissue, tracheoinnominate fistula, tracheoesophageal fistula, and death. Major complications such as accidental decannulation and death have decreased over the years [2].

Children are at higher risk for tracheostomy bleeding, inadvertent decannulation, and death [14, 17]. Complications rates with tracheostomy are high and vary from 36-60% [18]. The risk of major morbidity and mortality from pediatric tracheostomy has been decreasing over time and the risk of minor wound breakdown and granulation tissue accounts for most of these complications [2]. As previously noted, younger patients are not only at a higher risk of mortality, those under 2 years of age are also at higher risk of complications. Mahida *et al* in analyzing the National Surgical Quality Improvement Program (NSQIP), for children under 2 years of age undergoing tracheostomies report a 24% risk of major complication within 30 days of tracheostomy tube placement. Pneumonia occurred in

8% of patients, post-operative sepsis in 6 %, and death in 6%. Predictive factors for complications included younger age, presence of intraventricular hemorrhage (IVH), and concurrent cardiac disease [18].

Current Trends

Many institutions across the world have developed multidisciplinary teams to care for these incredibly complex children. These teams often consist of doctors, nurses, advanced practitioners, speech therapists, and other allied health providers. Most often pulmonary and otolaryngology providers are intricately involved in these teams. Some literature supports decreased complications, shorter length of stay, and improved patient outcomes with the use of these multidisciplinary teams [19].

Controversies

Surgical technique

Optimal surgical technique for neonatal and pediatric tracheostomy has long been debated. The utilization of tracheal maturation sutures, tracheal flaps (Bjork) stay sutures, suturing tracheostomy tubes to the skin, varying types of tracheostomy ties, and use of sedation seem to be largely institution specific. No strong evidence is present for one technique over others when comparing accidental decannulation and other major and minor complications. Day of tracheostomy tube exchange also varies from 3-10 days. Tracheostomy tube change is utilized to assure that an adequate tracheocutaneous fistula tract has formed.

Percutaneous tracheostomies

Percutaneous dilation tracheostomy (PDT) has widely been used in critically ill adults since Ciaglia *et al* introduced it in 1985. Its use in children has largely been avoided due to anatomical considerations and potential complications. Toursarkissian *et al* published a series in 1994 of 11 patients undergoing PDT aged 10-20 years with limited morbidity and mortality [20]. Not much has been published since then and the practice has largely gone out of favor.

Optimal timing

Earlier tracheostomy has been shown, in adults, to result in shorter ICU length of stay, less need for mechanical ventilation, and unaffected mortality [21]. In the children this has not been well elucidated. Cheng *et al* studied early versus late tracheostomy for premature infants and noted no change in time to weaning off mechanical ventilation or time to decannulation[21]. They note that earlier tracheostomy did not change the likelihood of needing airway reconstructive surgery. Although some literature anecdotally supports tracheostomy when 2-3 weeks of intubation is expected, Alibrahim *et al* simply states: "**in pediatric patients, there is no clear and specific time indicated for moving the patient from an artificial trans-laryngeal airway to tracheostomy**" [11].

Airway surveillance

There is no standardization for when and if surveillance airway evaluations should be performed. A survey of 75 pediatric otolaryngologists showed that 38% will perform airway surveillance only as needed, 25% perform evaluations every 12 months, 24% every 6 months, and 9% will perform airway surveillance every 3 months in patients under 2 years of age [22]. Most commonly surveillance

airway evaluations occur if there are clinical issues (bleeding, obstruction, inability to cap or use a one way speaking valve) or just prior to decannulation [23]. Gergin *et al* found airway lesions in 55% of children undergoing surveillance airway evaluation. In this series, 48% were symptomatic and 33.3% underwent intervention,most often for tracheal granulomas [23]. Whether routine surveillance airway evaluation is indicated or advised remains unknown.

Decannulation

Decannulation protocols are highly variable, often institution, patient and age specific. Protocols have had variable time periods for capping, the role of capped sleep studies, standard swallowing evaluation (FEES versus VFSS/MBS), capping in the hospital on a pulse oximeter, optimal time between airway evaluation and decannulation, and outpatient versus inpatient decannulation. Decannulation rates range from 35-75%. As expected, successful decannulation is much more likely in trauma patients than those with neurological or cardiac disease [9]. Many institutions have enacted decannulation standardization protocols for their patients, however, these continue to be institution specific and not widely adopted.

Summary

Overall the indications for tracheostomy have changed over the last half century with many more performed for prolonged ventilation, upper airway obstruction, and neurological disorders. Very few children undergo tracheostomy for upper airway infections. Children that undergo tracheostomy are likely to have a multitude of comorbidities leading to longer hospitalizations and higher costs both as inpatients and outpatients. Recent focuses on multidisciplinary teams seek to improve patient level outcomes, overall costs, and patient safety and quality. Debate still remains as to the optimal surgical technique, timing of tracheostomy, airway surveillance, and decannulation protocols.

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