Pediatric tracheotomy: The Universitair Ziekenhuis Brussels’ experience

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Key-words. Airway obstruction; pediatric tracheotomy; tracheotomy indications

Abstract. Pediatric tracheotomy: The Universitair Ziekenhuis Brussels’ experience. Objective: To investigate indications, features and outcome of pediatric tracheotomy in our ENT department. Methods: A retrospective chart review of all pediatric patients who underwent tracheotomy between 1992 and 2006 in the Children’s Hospital of the Universitair Ziekenhuis Brussel. The main parameters of the study were age, gender, indications, morbidity and mortality rate, time and success of decannulation. Results: Twenty-nine children younger than 16 years of age, 21 males and 8 females, underwent tracheotomy. Indications for tracheotomy fell into two main groups: chronic diseases requiring ventilation support (55%) and relief of airway obstruction (45%). Tracheotomies were mainly performed in young children, 76% were under 3 years of age. In this age group, upper airway obstruction was the most frequent indication. The complication rate was 36%, and the non-tracheotomy-related mortality rate was 25%. The tracheotomy-related mortality rate was 3.5%. Successful decannulation was possible in 28% after a mean duration of 24 months after surgery. Of the remaining 72% for whom decannulation was not performed, 35% died mainly because of the underlying disease. Those infants failing decannulation (65%) had neurologic disorders. Conclusions: In accord with the literature, where a shift towards very young patients and towards indications related to chronic ventilatory support is observed, in this series tracheotomies were mainly performed for the youngest children. Relief of upper airway obstruction was the most frequent indication. Morbidity and mortality rates among this specific patient population should not be ignored.

Introduction

Tracheotomy was initially developed to relieve acute life-threatening upper airway obstruction, performed only as a procedure of last resort. In the 20th century, the indications for the procedure were expanded to include access for assisted ventilation and pulmonary hygiene. While the major indications have remained unchanged for the last 20 years, several trends can be seen when reviewing the literature.1

In a series from the Children’s Hospital of Philadelphia (CHOP), the relative incidence of tracheotomy decreased as compared with the number of hospital admissions, although the absolute number of tracheotomies remained stable.1,2 The widespread use of antibiotics and the implementation of vaccination programs have caused the relative decrease in the incidence of tracheotomy.3 The development of better, uncuffed intubation materials and appropriate care have rendered endotracheal intubation via the oropharyngeal or nasopharyngeal route an attractive and feasible alternative, even for extended periods. In the CHOP series, prolonged ventilation remained the most common indication for intubation. In addition, this study showed an increase in duration before decannulation, which appears to be due to the increased number of chronically ventilated children.1,2

In order to evaluate the incidence and indications for pediatric tracheotomy in our hospital, we analyzed the medical records of all children undergoing this procedure within the past 15 years.

Material and methods

A retrospective evaluation of the medical records of all children (i.e., younger than 16 years of age) who underwent a tracheotomy in the Universitair Ziekenhuis Brussel, Brussels, Belgium, between June 1992 and October 2006 was performed. Data collection included specific parameters such as age at tracheotomy, gender, indications, morbidity and mortality rate, time and success of decannulation.

Technique of tracheotomy

All tracheotomies were performed under general anaesthesia in the
controlled environment of an operating theatre, according to standard techniques. A horizontal skin incision was made and was deepened until the strap muscles were reached; these were divided in the midline. The area of the tracheal incision was identified in the midline of the second and third or third and fourth tracheal rings. Stay sutures were placed on either site of the planned tracheal incision, approximately 2 mm from the midline. These sutures facilitated introduction of the tube and were left in place until the first tube change. A vertical incision was made in the trachea. Once this incision was made, the anaesthesiologist withdrew the endotracheal tube until the tip was just superior to the tracheostoma. The tube was then inserted into the trachea and the anaesthetic circuit was transferred from the endotracheal tube to the tracheotomy tube.4,5

Percutaneous dilatational tracheotomy is not performed in the pediatric population: the landmarks needed to perform the procedure are often difficult to palpate in children because the trachea is soft and flexible. Furthermore, the airway is small and often very unstable.4 As well, some severe types of upper anatomical airway obstructions preclude the insertion of a fibroscope, which is necessary for the dilatational technique.

Alternative procedures, for example glossopexia in patients with the Pierre Robin sequence, was impossible because of comorbidity (such as tracheomalacia).

Results

Twenty-nine children younger than 16 years of age received a tracheotomy between June 1992 and October 2006. All initial clinical records were available for analysis. One patient was lost for follow-up, outcome data were not available for this patient.

Age

The average age of the children at the time of tracheotomy was 1.95 years, with a range from 1 month to 12 years. Children younger than 1 year of age accounted for 62% (18/29) of all tracheotomies and children younger than 3 years of age represented 76% (22/29) of all interventions. The mean age at tracheotomy was higher for children with diseases requiring chronic ventilation support (3.13 years) as compared to children with an upper airway obstruction (0.52 years; Table 1).

Gender

There was a male predominance, with 21 males and 8 females.

Indications

The indications for tracheotomy fell into two main groups (Table 1): 1) Diseases requiring ventilation support (55%; n = 16/29) and 2) Relief of upper airway obstruction (45%; n = 13/29). Cases requiring ventilation support included cerebral trauma (4/16), neuromuscular diseases (7/16), and central respiratory impairment (5/16). Cases of airway obstruction included subglottic stenosis (3/13), craniofacial malformations (3/13), tracheoesophageal cleft (1/13), laryngeal tumours (subglottic hemangioma) (2/13), bilateral congenital vocal cord paralysis (1/13), intubation injury (laceration of unilateral arytenoid mucosa and processus vocalis) in a child with bacterial tracheitis (1/13), and bacterial tracheitis in association with a narrow cricoid (1/13).

Finally, one tracheotomy (1/13) was performed on a premature child with neonatal sepsis, encephalitis and multi-organ failure, who needed prolonged intubation and had to be reanimated twice because of unexplained sudden mucosal swelling of the upper airway and tracheal mucosa.

All tracheotomies were elective, except one emergent tracheotomy in an infant with an extensive subglottic stenosis who was transferred to our hospital with an unstable airway.

Outcome

Decannulation

At the end of the study, successful tube removal was possible in 28% (8/28, one lost for follow up) of all cases within 24 months (mean duration; range 2-95 months). We followed strict criteria before considering a patient for decannulation. Two of these eight decannulations were executed in children whose indication was disease requiring ventilation support; the remaining six were for children whose indication was relief of airway obstruction. Of the remaining 72% (20/28) for whom decannulation was not performed, 35% (7/20) died due to underlying disease. Those patients who were still alive, 65% (13/20), suffered from lasting, incurable muscle weakness (n = 2), Werdnig Hoffmann (n = 3), quadriplegia (n = 3), Ondine’s Curse (n = 2), glossophtosis (n = 2) and bilateral vocal cord paralysis (n = 1). Persistence of a tracheocutaneous fistula after decannulation was seen in one patient (1/8; 12.5%).
Complications

The complication rate was 36% (10/28, one patient lost to follow up). There were no intra-operative complications. Early complications, occurring within the first postoperative week, were diagnosed in five cases. Two children developed a pneumothorax on the first postoperative day; one of these was due to improper ventilation with excessive pressures during transportation from the operation room to the intensive care unit. Early accidental decannulation occurred in two cases. In one of these cases, a false passage was created upon tube replacement. No permanent consequences were observed after proper reinsertion. One patient developed pneumonia within one week of tracheotomy.

Late complications were noted in five cases. Stomal granulation was observed in four patients, and in one patient, we saw the persistence of a tracheocutaneous fistula after decannulation.

The mortality rate in this series was 25% (7/28, one lost to follow up). Five deaths could be attributed to the underlying disease, such as septic shock and neurological consequences, rather than to the tracheotomy itself. One death (1/28, 3.5%) was due to tube obstruction after discharge from the hospital. One patient died due to a concurrence of several pathological conditions; however, none of these was related to tracheotomy.

Discussion

Age

Tracheotomies were performed mainly in young children (62% younger than one year of age, 76% younger than three years of age). In the literature, the percentage of tracheotomies in babies younger than one year of age ranges from 30% to 75%, which is comparable to the incidence observed in this study. Anatomy is the main reason why airway obstruction is relatively common in young children: the small diameter of the airway renders it highly vulnerable to even slight edematous or inflammatory changes.

The number of tracheotomized infants younger than one year of age seems to be increasing due to higher survival rates of premature infants and those with severe congenital anomalies, among other reasons.

In a recent review by Trachsel et al., adolescents, especially injury victims with traumatic brain lesions, represent a second important subset of children who require tracheotomies, contributing one third to the total. Palmer et al. showed that 75% of the children requiring tracheotomy following trauma were 17 or 18 years of age. This was not seen in our series, possibly because children older than 16 years are treated in the adult department of our hospital and were not included in our series.

As previously described by Butnaru et al., the mean age was higher for children with diseases requiring assisted ventilation when compared to children with an upper airway obstruction.

Gender

There was a preponderance of males (72%) subjected to tracheotomy, which has also been reported in other series. Ward et al. proposed that this was due to the greater susceptibility of males to acquired conditions requiring tracheotomy. Trachsel et al. hypothesized that it could be related to X-linked inherited diseases and high-risk behavior, leading to greater risk for trauma in males.

In our series, the cause of the male preponderance remains unclear because the congenital diseases of our children were all autosomal recessive and we did not observe a male predominance in tracheotomies following injuries.

Indications

Tracheotomy has a long and colorful history. The first report of a successful tracheotomy in a child dates back to 1620 for the removal of an inhaled gold coin in a 14-year-old boy. During the 19th century, many tracheotomies were performed in children for management of diphtheria, croup, pertussis, laryngitis and laryngeal edema, with significant associated morbidity and mortality rate.

The development of vaccination, introduction of endotracheal intubation and the development of better and safer tube material dramatically reduced the need for tracheotomies in children.

Studies regarding changing trends in pediatric tracheotomy have described a significant proportional decrease in tracheotomies performed for infectious upper airway obstruction from more than 50% in the early 1970s to almost none today. Currently, the procedure is mostly performed for long-term problems, such as prolonged ventilation for patients with neuromuscular diseases. However, improved survival rates in preterm infants, children with congenital malformations and children with pulmonary and neurologic dis-
cases, have broadened the indication for tracheotomy.\textsuperscript{3,15,16} In our series, ventilation support accounted for 55\% of all tracheotomies, similar to observations made in other series.\textsuperscript{3,6,10-12}

**Outcome**

**Decannulation**

Decannulation was carried out successfully in 28\% (8/28, one lost for follow up) of all cases within 24 months (mean duration; range, 2-95 months). Palmer \textit{et al}.\textsuperscript{9} suggested that the duration of tracheotomy had increased, an observation supported by previous investigators.\textsuperscript{1,9} In other series,

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Indications for tracheotomy and patient characteristics</th>
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<tr>
<td><strong>Indications for tracheotomy</strong></td>
<td>N</td>
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<tr>
<td>Upper airway obstruction</td>
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<tr>
<td>Subglottic stenosis</td>
<td>3</td>
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<tr>
<td>Craniofacial syndromes</td>
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<td>Tracheo-esophageal cleft</td>
<td>1</td>
</tr>
<tr>
<td>Laryngeal tumours</td>
<td>2</td>
</tr>
<tr>
<td>Respiratory infections aggravating other obstructive causes</td>
<td>2</td>
</tr>
<tr>
<td>Unknown etiology</td>
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<tr>
<td>Bilateral vocal cord paralysis</td>
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</tr>
<tr>
<td><strong>Ventilation support</strong></td>
<td>16</td>
</tr>
<tr>
<td>Cerebral trauma</td>
<td>4</td>
</tr>
<tr>
<td>Neuromuscular disease</td>
<td>7</td>
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<tr>
<td>Central respiratory impairment</td>
<td>5</td>
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Adapted from Trachsel \textit{et al}.\textsuperscript{10}

Notes: 1. Thoraco-laryngo-pelvic dysplasia; 2. Oculo-auriculo-vertebral syndrome, hemifacial microsomia; 3. Characterized by micrognathia, glossoptosis, and cleft palate; 4. Genetic disorder characterized by craniosynostosis, nasal stenosis, protrusion of the eyes, leucocornea, atresia external ear canals, small mandible, high arched palate, and additional canines; 5. Non-random association of birth defects. Features are vertebral anomalies, anal atresia, tracheo-esophageal fistula, esophageal atresia, renal anomalies. Presence of at least three of the seven defects are required for diagnosis; 6. Medical condition in which blood vessels and/or lymph vessels fail to form properly; 7. Autosomal recessive muscle disease characterized by weakness due to loss of motor neurons of the spinal cord and brainstem.
decannulation rates range from 40% to 64%. In one series, decannulation in neonates on a newborn intensive care unit was accomplished early in life in two-thirds of the surviving infants. Those infants failing decannulation had severe underlying pulmonary or neurologic disorders. In a study by French performed on 480 patients between three and six years of age, showed a decannulation rate of 40%; most procedures were performed for pulmonary hygiene (60%) and upper-airway obstructions (40%). Tantinikorn et al. reported a decannulation rate of 64.1%. Airway obstruction was his leading indication (59.6%) for the procedure. One possible explanation for our somewhat lower decannulation rate lies in a higher proportion of children with serious neurological problems in our sample.

Criteria for considering decannulation included 1) not ventilator-dependent or requiring oxygen, 2) able to handle own secretions, 3) able to audibly speak or cry with the tube in place and plugged, 4) no evidence of aspiration and 5) infrequent episodes of aspiration and suprastomal collapse. This phenomenon occurred in one of our children and corrective surgery was required.

In one child with subglottic stenosis associated with hemivertebrae, decannulation was only possible after laryngofissure and posterior cricoid split.

In the literature, the incidence of tracheocutaneous fistula after removing the tube ranges from 11% to 40%. Only one patient developed post decannulation tracheocutaneous fistula in our series (1/8; 12.5%). Suprastomal granulation tissue and suprastomal collapse are also problems that could preclude successful decannulation. This phenomenon occurred in one of our children and corrective surgery was required.

Complications
In children, tracheotomy is a procedure associated with significant morbidity and mortality. The 36% complication rate observed in this series is comparable to rates from other reports (range, 19-47%). Non-tracheotomy-related mortality rates, i.e., due to underlying diseases, range from 14% to 36% in other series, which is also comparable to our findings.

The tracheotomy-related mortality rate found in this study (3.5%; one patient with tube obstruction outside the hospital) agrees with previously reported rates of 0.5% to 3.6%. The main causes of tracheotomy-related mortality in the literature were accidental decannulation and tube blockage.

Higher complication rates were seen when tracheotomy had to be performed for mechanical ventilation and pulmonary disease, in emergent circumstances, in children with a history of prematurity, and in children weighing less than 2000 g at the time of the intervention.

Conclusion
The application of tracheotomy in airway management has changed over time. Currently, few children are tracheotomized for acute airway emergencies; instead, there is a tendency toward tracheotomizing children with chronic conditions requiring ventilation support. The associated complication rate is not negligible, although problems can often be attributed to co-morbid conditions and not to the tracheotomy itself.

References
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