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Johannes Zenk, Georgios Fyrmpas, Theodor Zimmermann, Michael Koch, Jannis Constantinidis, Heinrich Iro

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Tracheostomy in young patients: indications and long-term outcome

Johannes Zenk · Georgios Fyrmpas · Theodor Zimmermann · Michael Koch · Jannis Constantinidis · Heinrich Iro

Abstract Diagnostic and treatment modalities have changed substantially over the past years in the field of pediatrics and neonatal medicine. As a result, the indications and outcome after tracheostomy in young patients have evolved. The aim of this study is to present our experience with pediatric tracheostomies and provide an up-to-date review of the literature with special focus on current trends. The complete medical records of 85 children and adolescents (up to age 18) which underwent tracheostomy from January 1990 until March 2008 were reviewed. Telephone interviews were conducted to evaluate the childrens further clinical course. The indications for tracheostomy were upper airway obstruction (27%), craniofacial syndromes (3.5%), long-term mechanical ventilation (22.3%), neurological deficit (25.9%), trauma and sequelae (16.5%) and bilateral vocal cord paralysis (4.7%). The average age of patients at the time of tracheostomy was 4.7 years (range, 2 days–18 years) but there were significant differences between the six indication groups. Children under the age of 7 years comprised 72.9% of all patients. The mean cannulation time was 21.6 months; 50.6% of the patients could be successfully decannulated. Life-threatening complications occurred in 6 patients (7%). The total mortality rate was 18.8%; the tracheostomy related mortality rate was 0%. In the past 30 years, short-term tracheostomy was commonly performed for infectious causes such as epiglottitis. Nowadays, the majority of patients are very young children with severe and chronic diseases. This fact accounts for the relatively low decannulation rates, long cannulation times and high mortality. The tracheostomy related mortality on the other hand, is comparatively low.

Keywords Tracheostomy · Children · Indications · Outcome

J. Zenk (✉) · G. Fyrmpas · M. Koch · H. Iro
Department of Otorhinolaryngology Head and Neck Surgery,
Friederich Alexander University of Erlangen-Nuremberg,
Waldstr. 1, 91054 Erlangen, Germany
e-mail: johannes.zenk@uk-erlangen.de

T. Zimmermann
Department of Pediatrics,
Friederich Alexander University of Erlangen-Nuremberg,
Erlangen, Germany

J. Constantinidis
First Department of Otorhinolaryngology Head and Neck Surgery,
Aristotle University of Thessaloniki, Thessaloníki, Greece

Introduction

Tracheostomy has been described since the Medieval Ages and Johannes Scultetus (1595–1645) quotes tracheostomy in his book "Armamentarium Chirurgicum" as a lifesaving intervention in cases of respiratory distress [1]. Some historical sources, report the origins of tracheostomy as early as 100 BC [2]. However, this procedure became common since approximately the middle of the nineteenth century [1].

Tracheostomy complications include intraoperative and postoperative bleeding, emphysema, air embolism, pneumothorax, mediastinitis, pneumonia, tracheo-esophageal fistula, tracheal stenosis with difficult decannulation, swallowing disorders and granulations [3]. Tracheostomy in children poses additional age specific problems: Speech with a tracheostoma is compromised and depending on the age of the child and duration of cannulation, this may lead to developmental disorders. The risk of tracheal or subglottic stenosis and tracheomalacia are increased. Furthermore,

accidental decannulation is a life-threatening complication which if not timely managed by parents or caregivers, may lead to hypoxic brain damage or death [4]. The elevated airway resistance shortly after the tracheostomy tube is removed may not be tolerated and re-cannulation is then necessary.

The present study deals with tracheostomy in children and adolescents up to the age of 18 years who were treated in our Department from January 1990 to March 2008. The goal of this retrospective analysis is to provide an overview of indications, complications and long-term outcome after tracheostomy in light of the new developments in neonatal medicine.

Materials and methods

Medical and surgical records of all tracheostomized patients up to the age of 18 years at the Departments of Ear, Nose and Throat and Pediatrics from January 1990 to March 2008, were scrutinized. Parents and older children were invited to participate in a telephone survey regarding the childrens current state of health. The following data were collected and analyzed: date of birth, sex, date of tracheostomy, indication and follow-up data such as date of decannulation, re operation, complications, death and cause of death.

Pediatric tracheostomy at our Department is performed according to the following technique: a horizontal or vertical skin incision is followed by dissection of the strap muscles and ligation of the thyroid isthmus, if necessary. The trachea is entered by a vertical incision including the second and third tracheal rings and a horizontal incision on both ends of the former incision (H shape). The trachea is unfolded like a "trap door" and the walls are fixed with sutures to the skin for facilitating epithelialization and securing the airway during cannula changes. In patients older than 10 years, a piece of cartilage is resected and trachea is entered through a small window.

The emergency tracheostomies were performed in acute life-threatening situations without prior intubation. For the calculation of the average cannulation time, repeat tracheostomies in the same patient were not considered separately; the total number of days with a tracheostoma in situ was taken into account for each individual.

The patients were grouped into six different categories based on their indication for tracheostomy according to Carron et al. [5] (Table 1):

- Group 1: Upper airway obstruction.
- Group 2: Craniofacial syndromes.
- Group 3: Long-term mechanical ventilation (for children, longer than 10 weeks).
- Group 4: Neurological deficit.
- Group 5: Trauma and sequelae.
- Group 6: Bilateral vocal cord paralysis.

Results

From January 1990 to March 2008, a total of 100 patients (<18 years) who underwent tracheostomy were identified. Complete data records could be collected in 85 cases (85%). Two of the 85 tracheostomies were performed as emergency procedures (2.3%); one for treatment of a traumatic tracheal rupture and the second for treatment of an acute retrotonsillar abscess.

The indications for performing tracheostomy in our study were, in order of decreasing frequency: upper airway obstruction (27%), neurological disease (25.9%), long-term mechanical ventilation (22.3%), trauma and its sequelae (16.5%). In contrast, craniofacial syndromes and bilateral vocal cord paralysis constituted a very low percentage.

Table 1 shows that, among the different causes of upper airway obstruction (Group 1), infectious diseases such as epiglottitis or laryngitis very rarely required tracheostomy. Craniofacial syndromes (Group 2) were also rarely represented. The commonest cause which required long-term mechanical ventilation (Group 3) was bronchopulmonary dysplasia, which was associated with premature birth in most cases. Arnold–Chiari syndrome was the leading cause of neurological deficit in Group 4. The majority of patients in Group 5 (trauma and sequelae) had been involved in traffic accidents and had sustained serious head or spinal column injuries for which a tracheostomy was required. One patient in this group suffered a cervical spine fracture with paraplegia as a result of attempted suicide by hanging; a newborn in the same group suffered tetraparesis and apnea due to a very traumatic delivery. Three children with bilateral vocal cord paralysis (Group 6) came from the Tschernobyl area. They had undergone total thyroidectomy after the nuclear plant accident and had both recurrent laryngeal nerves severed. Another child suffered from idiopathic bilateral vocal cord paralysis.

The average age of children and adolescents at the time of tracheostomy was 4.7 years (range, 2 days–18 years). The percentage of patients younger than 7 years was 72.9% (62 of 85). A correlation between age of the patients and indication for tracheostomy was noted. Young patients mostly suffered from upper airway obstruction, neurological deficits or required long-term ventilation, whereas older patients were often involved in trauma. Specifically, Group 1 (upper airway obstruction) exhibited an average age of 2.4 years, whereby 65.2% of the patients in this group were under the age of 1 year. In Group 2 (craniofacial syndromes) on the other hand, the average age was only 3 months. The majority of patients in Group 3 (long-term

Table 1 Indications for tracheostomy

Indication	Number of children (children <7 years)
1. Upper airway obstruction (27%)	23 (20)
Subglottic hemangioma	3
Glottic stenosis	1
Subglottic stenosis	3
Cricoid stenosis	1
Tracheal stenosis	3
Tracheomalacia	4
Lymphangioma	2
Rhabdomyosarcoma	2
Retrotonsillar abscess	1
Epiglottitis	1
Laryngitis	1
Epidermolysis bullosa	1
2. Craniofacial syndromes (3.5%)	3 (3)
Pierre Robin syndrome	2
Goldenhar syndrome	1
3. Long-term mechanical ventilation (22.3%)	19 (19)
Bronchopulmonary dysplasia	11
Metabolic myopathy	4
Thoracic dystrophy	1
Pneumonia	2
Histiocytosis-sepsis	1
4. Neurological deficit (25.9%)	22 (14)
Arnold–Chiari syndrome	5
Hypoxic encephalopathy	2
Brain tumor	2
Intracranial hemorrhage	2
Cerebellar angioma	1
Meningoencephalitis	1
Trisomy 21	1
Werding–Hoffmann syndrome	1
Guillain–Barré syndrome	1
Basilar artery thrombosis	1
Brainstem damage/tumor	3
Botulinum intoxication	1
Epileptic fits-undefined syndrome	1
5. Trauma and sequelae (16.5%)	14 (2)
Head trauma	7
Posttraumatic tetraplegia	6
Tracheal rupture	1
6. Bilateral vocal cord paralysis (4.7%)	4 (4)
Iatrogenic	3
Idiopathic	1

mechanical ventilation) were younger than 1 year (89.5%), with an average of 8.8 months, which seems reasonable in the context of the underlying diseases affecting this group. In Group 4 (neurological deficit), the average age at the time of tracheostomy was 5.8 years. It should be noted, however, that the age of patients in this group did not follow a normal distribution but it was skewed towards the two age extremes: 45.5% of patients were younger than 1 year and 31.8% were 16 years or older. The children and young patients in Group 5 (trauma and sequelae) had an average age of 11.4 years at the time of tracheostomy. Eighty-six percent of the patients were 16 years age or older. This seems reasonable if one considers that young people at this age start to drive and therefore run an increased risk of a trauma from traffic accidents. Group 6 (bilateral vocal cord paralysis) featured an average age of 5.1 years.

At the time of data collection, 69 out of 85 patients were still alive and of these, 46 were successfully decannulated at the first attempt. Eleven patients required a new tracheostomy at later time (13% of all patients; 22.9% of all initially decannulated patients). The reason for repeat tracheostomy was recurring respiratory insufficiency due to inflammatory or mechanical obstruction/stenosis after closure of tracheostoma. Of the 11 patients with repeat tracheostomies, 6 could be successfully decannulated at a later time. The total decannulation rate (successful decannulations/total number of patients) was 50.6% (43 of 85 patients). Twenty-six patients retain their tracheostoma up-to-date. One patient died several years after decannulation. The average cannulation time for all 85 patients was 21.6 months (2 days–17.1 years).

As with age distribution, clear differences between the individual indication groups in terms of decannulation rates were noted: in Group 1 and 5, 60.9 and 71.4% of the patients were successfully decannulated, respectively. In contrast, successful decannulation rates in Group 3 and 4 were markedly lower (26.3 and 45.4%, respectively). In Group 2 (craniofacial syndromes) and Group 6 (bilateral vocal cord paralysis) 0 and 100% of children could be decannulated, but these values should be viewed with caution due to the small number of cases.

The complications of tracheostomy were classified as early or late and life threatening or not (Table 2). If granulations and hypertrophic scar formation are taken into account, 50 of 85 patients (58.8%) experienced a tracheostomy associated complication. Forty out of 50 children with granulations were younger than 7 years (80%). Twenty-seven children and adolescents had only one complication (31.8%) and 23 two or more complications (27%). Of the total 79 documented complications, granulations and hypertrophic scar formation formed the largest proportion as expected, with 51.9 and 11.4%, respectively.

However, if granulations and hypertrophic scar formation are excluded from complications on the grounds that they are expected and common sequelae after tracheostomy

Table 2 Complications

Early complications (≤1 week post-op)			Late complications (>1 week post-op)		
Type	*N* (children under 7)	Life-threatening complications[a]	Type	*N* (children under 7)	Life-threatening complications[a]
Accidental decannulation	3 (3)	1	Accidental decannulation	4 (4)	2
Edema of larynx and trachea	2 (1)		Edema of larynx and trachea	2 (1)	
Cannula obstruction	1 (1)		Cannula obstruction	3 (2)	1
Hemorrhage	1 (1)	1	Stenosis	11 (7)	1
			Tracheomalacia	3 (2)	
			Pressure necrosis of the tracheal wall	1 (1)	
Total	7 (6)	2	Total	24 (17)	4
Percentage out of all children	8.2% (7%)	2.3%	Percentage out of all children	28.2% (20%)	4.7%

Some patients suffered from more than one complication. Granulations and hypertrophic scar formation were not included

[a] The number of patients with a life-threatening complication out of the total number of patients who suffered a specific type of complication

in children, serious complications occurred in 31 patients (36.5%) (Table 2). Six patients (7%) suffered from more than one complication. Early complications (within the first postoperative week) were observed in 8.2% of patients; two of these, a hemorrhage and an accidental self-decannulation were life threatening (2.3%). Late complications occurred in 28.2% of all cases; four of these were life threatening (4.7%). The most frequent late complications were stenosis (13%) and accidental decannulation (4.7%).

Sixteen of 85 patients (18.8%) were no longer alive at the time of data collection; the cause of death was unrelated to the tracheostomy. The highest mortality rates were observed in the long-term ventilation group (36.8%), followed by the craniofacial syndromes group (33.3%) and the neurological deficit group (18.2%). The mortality rate for patients with an upper airway obstruction, trauma or bilateral vocal cord paralysis was 13, 7.1 and 0%, respectively. The total mortality rate among children younger than 1 year was 23.4%. In comparison, the total mortality among tracheostomized patients over 16 years was only 5.5%. No patient died during the tracheostomy procedure.

Discussion

Pediatric tracheostomy is rare operation with a reported frequency of 6.6 children per 100,000 "children years". In the USA, tracheostomy is performed in 0.07% of all hospitalized children [6].

The indications for performing a tracheostomy in the present study did not differ from those reported in the literature (Table 1). Depending on the specialization of a center, upper airway obstruction and underlying neurological deficit are the commonest indications [7]. This is also supported by our data. A large number of patients had to be tracheostomized as a result of trauma from serious traffic accidents, mainly in the 16–18 year age group. In comparison to the study of Carron et al. [5], the number of children and young patients tracheostomized after trauma is actually considerably higher (16.5 vs. 7.4%).

A shift in the frequency of tracheostomies performed for acute infectious diseases of the upper respiratory tract is observed worldwide (Table 3). In the present study, only 2 out of 69 patients (2.9%) were tracheostomized due to epiglottitis or laryngitis. Up to the 1980s, these were extremely common and frequent indications for pediatric tracheostomy [8–13]. Studies with data before 1985 show that 11–55% of patients had a tracheostomy for an upper airway infection (Table 3) [9, 10, 12–16]. The current number has fallen to 0–9.1% [3–5, 7, 17–21].

While this indication is receding, two distinctive features also emerged from the analysis of the current literature with regard to successful decannulation and total cannulation time (Table 3): Successful decannulation rate has decreased and retention time of the tracheostoma has more than doubled, from a maximum of 12 months to over 24 months [3–5, 7–9, 22, 23].

Many authors attribute this to the fact that, nowadays, considerably fewer, short-term tracheostomies are performed for acute infections, typically epiglottitis and laryngotracheo bronchitis, than was the case in the 1970s and early 1980s. The overall number of tracheostomies performed in children has also decreased. Advances in neonatal intensive care medicine, which enable severely ill newborns and premature infants to survive longer, have also lead to an increase in the number of severely ill children with long-term tracheostomies.

Tracheostomy complications are classified as early (within the first postoperative week) or late complications and as life-threatening or non-life-threatening complications;

Table 3 Results of prior studies

Authors	Time period of study	No. of children (no. of tracheostomies)	Upper airway infection as indication (%)	Mortality (TRM) (%)	Successful decannulation (%)	Average time to decannulation (months)
Parrilla et al. [22]	1998–2004	38	0	39.2 (0)	31.6	22
Corbett et al. [18]	1995–2004	112 (116)	0	19.8 (1.8)	39.3	12.4
Butnaru et al. [30]	1996–2001	46	0	13 (2.7)	52	20
Leung et al. [31]	1998–2003	65	0	18 (0)	56.6	4.1
Rozsasi et al. [29]	1996–2002	24	0	25 (4)	–	–
Alladi et al. [32]	1991–2003	33	9.1[a]	12.1 (3)	73	8.7
Pereira et al. [19]	1997–2002	55	0	16 (0)	–	–
Hadfield et al. [20]	1993–2001	362	0	–	–	–
Tantinikorn et al. [7]	1991–1995	181 (185)	3.3	13.3 (0.5)	64	12
Kremer et al. [26]	1980–1996	25	8[b]	20 (0)	–	–
Midwinter et al. [23]	1979–1999	143 (148)	0	9.8 (2.7)	60.1	25
Carr et al. [3]	1990–1999	142	–	15 (0.7)	29	25
Klotz et al. [21]	1992–1998	57	0	0[c]	–	–
Carron et al. [5]	1988–1998	197 (204)	0	19 (3.6)	41	23.5
Wetmore et al. [4]	1981–1992	373	1	22 (0.5)	61	25.5
Palmer et al. [11]	1975–1989	281 (286)	2.5[d]	18.2	–	–
Ward et al. [15]	1980–1990	103	11/1.8[e]	36 (3)	38.5	11
Simma et al. [33]	1979–1989	108	0	7.4 (0)	78.7	40.5
Waki et al. [34]	1986–1991	126	–	35 (2.3)	53.6	–
Benjamin et al. [16]	1978–1987	73	16.4	8	73.1	10.9
Prescott et al. [12]	1980–1985	293	55	8.5 (1.7)	98	<12[f]
Arcand and Granger [8]	1976–1986	144	3	21 (1)	–	–
Crysdale et al. [9]	1976–1985	319	14	15 (<1)	85	11
Line et al. [10]	1979–1985	153	29	22 (3)	78	2
Wetmore et al. [13]	1971–1980	420	11	26 (2)	72	6
Rodgers et al. [35]	1967–1976	108	–	44 (6.5)	73.3	–
Hawkins et al. [14]	1970–1975	73	23	27 (5.5)	59	2

TRM tracheostomy related mortality, (–) indicates that data were not available

[a] High prevalence of infectious diseases

[b] No distinction between upper and lower tract infections

[c] Follow-up 48 h

[d] Comprises upper and lower respiratory tract infection

[e] Prevalence in two time periods

[f] 92% decannulated in less than 12 months

thus, better illustrating the tracheostomy specific morbidity [3, 7]. The overall complication rate of 58.8% in our study (including suprastomal granulations and hypertrophic scar formation) is somewhat higher in comparison to that found in the study by Carron et al. [5] or other studies [4, 13]. The determination of the complication rate, however, depends on the type of problems defined as complications. Also, in older studies, a high proportion of tracheostomies were performed for epiglottitis. Since these tracheostomies often remain only for a few days, i.e., until the upper airway edema diminishes, there were considerably fewer complications resulting from long cannulation. Tucker and Silberman [24], in their study from 1945 to 1970, defined any tracheostomy which was not closed within 1 month as delayed decannulation and designated this as a complication. In this study, suprastomal granulations, which occur very frequently after long retention of a tracheostoma, amounted alone to 51.2% of all complications. The complication rate without granulations and hypertrophic scar formation was 37.6%, i.e., only half as high. Complications such as wound infection or pneumomediastinum are very rare nowadays due the fact that operative techniques and intensive care have improved considerably. The training and education programs for parents with tracheostomized

children have been intensified over the last 30 years, so that the rate of inadvertent self-decannulation has also declined [4].

To what extent the technique of tracheostomy (approach and cartilage resection or preservation) influences the formation of suprastomal granulations and tracheal stenosis is still under debate. It could be that granulations are the consequence of the continuous pressure exerted by the tracheostomy tube on the trachea. Some degree of tracheal stenosis and suprastomal collapse is common after pediatric tracheostomy and on certain occasions this may lead to decannulation difficulties. Continuous pressure exerted on the anterior wall of the trachea by the tracheostomy tube and local inflammation, have been proposed as major precipitating factors [25, 26]. Evidence from an animal model shows that the type of tracheotomy incision plays a role in the development of tracheal stenosis [27]. The vertical incision seems to be advantageous over the horizontal H-shape incision or the Bjork flap [27], and this is further supported by clinical evidence [26, 28]. The creation of a small tracheal window in young children may jeopardize the stability of the anterior tracheal wall [26]. Other investigators found no difference between the several types of tracheal approach [29]. In very young children, we advocate a surgical technique which incorporates (a) division of the thyroid isthmus as this maneuver releases excessive pressure of the tube on the trachea [26] (b) a vertical incision, which is not high enough to injure the cricoid cartilage, combined with two small horizontal limbs in order to facilitate placement of stay sutures to the skin. The high rate of tracheal stenosis (13%) observed in our study may be attributed to the childrens severe comorbidities and long cannulation time which probably predisposes to frequent infections around the stoma. Complications occur more often in young children with medical comorbid conditions independent of the surgical technique adopted [19].

An important step in the management of children who will need a tracheostomy is the preoperative counseling of their parents. A detailed description of life-threatening complications (hemorrhage, self-decannulation, tube displacement and obstruction, tracheal stenosis) and other common complications (suprastomal granulations, stomal stenosis, decannulation difficulties) is an essential part of management.

The overall mortality after tracheostomy has remained fairly constant over the last 30 years and ranges between 7.4 and 44% [3–5, 7–10, 12–19, 26, 29–34]. The mortality rates in studies of pediatric tracheostomy, reflect the frequency and the severity of the underlying diseases which ultimately necessitated the tracheostomy placement. Tracheostomy related mortality is considerably lower, ranging from 0 to 6.5% [3–5, 7–11, 13–15, 17–19, 23, 26, 29, 30, 32–35]. Lewis et al. [6] found that mortality depends on the number of operations performed, the number of tracheostomized children who are treated at the hospital and the specialization of the hospital. The mortality is reduced significantly if many tracheostomies are performed in a single department and this department is integrated in a pediatric hospital. This is due to the greater expertise of the medical and nursing staff at such center [6]. The interdisciplinary care of children in our tertiary referral center has resulted in no tracheostomy related deaths, confirming the above assertion.

The average cannulation time and the rate of successful decannulation depend primarily on the underlying disease, and secondarily, on the complications that develop in the postoperative period. Our decannulation rate of 50.6% lies within the range reported in other large studies (29–98%) [3–5, 7, 9, 10, 12–18, 22, 23, 30–35]. When planning pediatric tracheostomy, it is important to anticipate possible difficulty with decannulation and that additional operations may be required. Patients with specific underlying diseases (e.g., neurological disorders) are very unlikely to be decannulated. In our study, the longest period with a tracheostoma in place was observed in a patient with neurological disease (17.1 years).

Conclusions

Pediatric tracheostomy is rarely performed nowadays, but nonetheless remains a vital procedure for specific conditions. The decision to perform a pediatric tracheostomy should be tailored to the individual situation and in view of alternative options it should be avoided [36]. In the past 30 years, indications for tracheostomy have changed considerably. Whereas short-term tracheostomies for infectious diseases (e.g., epiglottitis) were the rule, the majority of cases today comprise very young, seriously ill children. This is reflected in the relatively low decannulation rate, the increased cannulation time and the high overall mortality rate. Tracheostomy related mortality, however, is comparatively low. The high standards of home care required for such children pose a serious problem. The burden imposed on patients families is high and only partially alleviated by modern cardiopulmonary monitoring devices. The best results after pediatric tracheostomy are achieved if treatment is delivered in centers with well trained personnel and parents receive appropriate home care training.

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