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Tracheostomy in infants: indications and outcomes

Traheostomija kod odojčadi: indikacije i ishodi

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Abstract

Background/Aim. Prolonged ventilation is the most common indication for pediatric tracheostomy. The aim of the study was to determine the indications, possible complications, and outcomes of tracheostomy in infants, as well as the association of patient phenotype with complications following tracheostomy. **Methods.** This retrospective study highlights the main indications, complications, and decannulation rates in tracheostomy pediatric patients treated at the Institute of Mother and Child Health Care of Serbia "Dr. Vukan Čupić", Belgrade, for three years. **Results.** A total of 38 infants were included in our retrospective study, 31 (81%) of whom underwent elective tracheostomy, and 7 (19%) underwent urgent tracheostomy due to acute respiratory distress and difficult intubation. The mean age was 5.4 ± 3.5 months, and the youngest participant was 36 hrs old. The primary indication for elective tracheostomy was prolonged mechanical ventilation in 13 (42%) patients, neuromuscular disorders in 5 (16%), airway obstruction in 10 (32%), craniofacial anomalies in 2 (5%), and pulmonary disease in 1 (3%) patient. Early complications (occurring within the first seven days after tracheostomy) were present in 4 (10.5%) patients, three of whom had air leaks (due to inappropriate cannula selection), whereas wound dehiscence was reported in one patient. Late complications (those occurring more than seven days after tracheostomy) were reported in 4 (10.5%) patients and they were peristomal granulations in three patients and tube obstruction in one patient. There were no deaths associated with tracheostomy, although overall mortality was 21% (8 patents). All of these patients died as a result of their primary diseases. Seventeen (44%) patients were successfully decannulated. **Conclusion.** Most patients required long-term treatment and tracheostomy retention due to the nature of their primary diseases, which coincided with low decannulation rates. Therefore, tracheostomies should preferentially be carried out in specialized pediatric centers with trained medical personnel ensuring adequate health care.

Key words:
infant, newborn; respiration, artificial; serbia; tracheostomy.

Apstrakt

Uvod/Cilj. Produžena ventilacija predstavlja najčešću indikaciju za pedijatrijsku traheostomiju. Cilj rada bio je da se utvrde indikacije, komplikacije i ishod traheostomije kod dece, kao i udruženost fenotipa i komplikacija koje prate traheostomiju. **Metode.** Retrospektivnom studijom procenjene su osnovne indikacije, komplikacije i stope dekanulacije kod dece sa traheostomom, lečene na Institutu za zdravstvenu zaštitu majke i deteta Srbije „Dr Vukan Čupić" u Beogradu, tokom trogodišnjeg perioda. **Rezultati.** Studijom je obuhvaćeno ukupno 38 novorođenčadi, od kojih je njih 31 (81%) bilo podvrgnuto elektivnoj traheostomiji, a 7 (19%) urgentnoj traheostomiji zbog akutnog respiratornog distresa i teške intubacije. Srednja životna starost novorođenčadi bila je 5,4 ± 3,5 meseci, a najmlađe je bilo staro 36 sati. Primarna indikacija za elektivnu traheostomiju bila je produžena mehanička ventilacija kod 13 (42%) bolesnika, neuromuskularni poremećaji kod 5 (16%) bolesnika, opstrukcija disajnih puteva kod 10 (32%), kraniofacijalne anomalije kod 2 (5%) i plućna bolest kod jednog (3%) bolesnika. Rane komplikacije (koje su se javljale tokom prvih sedam dana od traheostomije) bile su prisutne kod 4 (10,5%) bolesnika, od kojih je njih troje imalo curenje vazduha (zbog neodgovarajućeg izbora kanile), a dehiscenciju rane imao je jedan bolesnik. Kasne komplikacije (koje su se pojavile kasnije od sedam dana posle traheostomije) bile su prisutne kod 4 (10,5%) bolesnika i to peristomalna granulacija kod tri bolesnika i opstrukcija tubusa, kod jednog bolesnika. Nije bilo smrtnih ishoda kod bolesnika povezanih sa traheostomijom, mada je ukupan mortalitet bio 21% (8 bolesnika). Svi ovi bolesnici preminuli su usled primarnog oboljenja. Sedamnaest (44,7%) bolesnika je uspešno dekanilisano. **Zaključak.** Za većinu

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bolesnika je, zbog prirode njihovih osnovnih oboljenja, bilo potrebno dugotrajno lečenje i retencija traheostomije što se podudaralo sa niskom stopom dekanulacije. Zbog toga bi traheostomije trebalo izvoditi prvenstveno u specijalizovanim centrima sa obučenim medicinskim osobljem, čime se obezbeđuje odgovarajuća zdravstvena zaštita.

Ključne reči:
novorođenče; disanje, veštačko; srbija; traheostomija.

Introduction

Tracheostomy is a potentially lifesaving surgical procedure performed in children for centuries [1]. The first reported surgical airway in adults dates back to Ancient Egypt [2], albeit the first pediatric tracheostomy was performed in 1620 by Nicholas Habicot on a 14-year-old boy who swallowed a bag of pistoles or gold coins to prevent their theft – the bag of coins lodged in the esophagus, compressing the trachea and causing subsequent airway obstruction [3]. Until as recently as the late 1970s, the primary indication for tracheostomy was upper airway obstruction secondary to acute infections such as *epiglottitis* and acute *laryngotracheobronchitis*, or croup [1]. Although the widespread use of antibiotics and the advent of vaccines have led to changes in the primary indications for pediatric tracheostomy in the last thirty years, the incidence of tracheostomy in children has risen due to prolonged survival in intensive care units (ICUs) [4]. Today, the most common indications are chronic respiratory failure with ventilator dependence, congenital or acquired upper airway anomalies, and neurological impairment [4, 5]. More than half of all pediatric tracheostomies are performed in infants, the majority of whom are born preterm with very low birth weights. In this population, mortality rates and health-care costs due to prolonged length of hospital stay (LHS) are higher [6].

Tracheostomy in children, especially in infants, can be more difficult to perform than in adults due to the size of the airway, a soft compliant trachea with greater lateral mobility and proximity of the cupula, and is frequently associated with complications such as deep incisional surgical site infection, scarring and stenosis, recurrent pneumonia, and sudden death. The majority of complications occur in neonates and children with cardiac anomalies and preoperative intraventricular hemorrhage [7].

The aim of this study was to identify the indications, possible complications, and outcomes of tracheostomy in infants, as well as the association of patient phenotype with complications following tracheostomy.

Methods

This retrospective review of medical records of all infants who underwent primary tracheostomy at the Institute of Mother and Child Health Care of Serbia "Dr. Vukan Čupić", Belgrade, Serbia has been implemented between January 1, 2020, and December 31, 2022. A total of 38 patients were identified, 31 of whom underwent elective tracheostomy under endotracheal anesthesia and seven underwent urgent tracheostomy due to acute respiratory distress and difficult intubation. Before tracheostomy, parental permission was obtained for each patient. The study was approved by the Ethics Committee of the Institute (No. 119/2024).

In cases of prolonged intubation, the date of elective tracheostomy was decided upon by pediatricians in the ICU in consultation with otorhinolaryngologists after acquiring parental permission. Data included gender, age, tracheostomy indications, early and late complications, underlying diseases, lower airway pathogens, flexible bronchoscopy findings, culture and sensitivity of tracheal aspirates before tracheostomy, overall LHS, and outcomes. Endotracheal intubation lasting at least four weeks was considered prolonged.

Early complications were defined as complications occurring within the first seven days after tracheostomy. Late complications were those occurring eight or more days after tracheostomy up until decannulation. Potential complications included accidental decannulation, tracheal tube occlusion, infection, pulmonary air-leak syndromes (including subcutaneous emphysema and pneumothorax), bleeding, tracheal or tracheostomy stenosis, and peristomal granulation.

Patients on mechanical ventilation (MV) who no longer required hospitalization were discharged after their parents or caregivers received adequate home care and ventilation education and underwent tracheostomy tube changes in the hospital every three weeks in an outpatient setting. Patients were decannulated when they no longer required MV once the original indication for tracheostomy was resolved after tube downsizing and a trial of daytime capping (24 hrs for 3–4 consecutive days without respiratory difficulties).

The relationship between patient age and the presence of complications and LHS before tracheostomy was examined as well. For this study, patients were divided into three age categories: 0–3 months, 3–6 months, and 6–12 months.

Surgical technique

Irrespective of whether an urgent or elective tracheostomy was performed, a midline vertical "Y" tracheal incision through the second, third, and fourth tracheal rings was used. Maturation sutures were then used where the edges of the skin incision were sutured to the edges of the tracheal incision using absorbable 4/0 vicryl. Uncuffed either polyvinyl chloride Tracoe or silicone Rusch® tracheostomy tubes were introduced into the tracheal stoma after endotracheal tube withdrawal, and the tracheal cannula flanges were securely tied around the neck using shoestring-style ties. In each patient, a tracheostomy tube of appropriate

dimensions was selected, and its proper position was determined by ventilator parameters and/or chest radiography.

Statistical analysis

Statistical data was determined using the Easy R software program. The Kolmogorov-Smirnov test was used to determine whether variables exhibited normal distribution. Variables with normal distribution were expressed as mean and standard deviation. Categorical data was compared using nonparametric tests – Pearson's Chi-square test and Fisher's exact test. Multivariable logistic regression analyses were used to calculate the odds ratio (OR) and corresponding 95% confidence intervals (CIs) to identify independent factors that may influence disposition. A p-value < 0.05 was considered statistically significant.

Results

The study included 38 infants, 20 (52.6%) male and 18 (47.4%) female. The majority of children, 18 (47.4%), were aged 6–12 months, 7 (18.4%) of them were 3–6 months old, and 13 (34.2%) were 0–3 months old. The mean age was 5.4 ± 3.5 months, and the youngest participant was 36 hrs old. Demographic characteristics are shown in Table 1.

Elective tracheostomy was performed in 31 (81%) infants, and urgent tracheostomy in 7 (19%). The most common indication for urgent tracheostomy involved airway anomaly or underdevelopment, and the mean age was 26.3 ± 16.4 days. There was no statistically significant difference in LHS after tracheostomy between these three groups (p = 1). Almost all of these infants had low or very low birth weights (71.4%), see Table 2.

The average ICU LHS was 44 days (ranging from 1 to 97 days), and the average LHS was 85 days (ranging from 21 to 227 days). An intubation time before tracheostomy of less than 15 days was seen in 9 (29%) patients, an intubation time of 15–30 days was seen in 4 (13%) patients, and 18 (58%) patients had an intubation time of more than 30 days.

Ventilator-associated respiratory failure (chronic respiratory failure with ventilator dependence) was the most common indication for elective tracheostomy seen in 14 (36.8%) patients, most of whom had complex congenital heart disease or neuromuscular disorders. In 41.7% of these patients, extubating was attempted more than twice before tracheostomy. The second most common indication was upper airway obstruction in 11 (28.9%) participants (tracheomalacia in four, subglottic hemangioma in two, lymphangioma in two, bilateral vocal cord paralysis in one, subglottic stenosis in two). Other indications are shown in Figure 1.

The most common pathogen isolated in tracheal aspirates before tracheostomy was *Pseudomonas aeruginosa* in 23.6% of participants, with the highest prevalence (30.8%) in the youngest age category. Chronic colonization of lower airways was associated with prolonged hospital stay (Pearson's Chi-square test, p = 0.03). The most frequent pathogens from tracheal aspirates are shown in Figure 2.

All tracheostomies were carried out by three surgeons with over 15 years of experience. High-flow oxygen therapy after tracheostomy was utilized in 29 (77%) patients.

Table 1

Demographic data of 38 studied infants

Variable	Values
Gender	
male	20 (52.6)
female	18 (47.4)
Mean age (months)	5.4 ± 3.5
Elective tracheostomy	31 (81)
Urgent tracheostomy	7 (19)
Mean ICU length of stay (days)	44 ± 23
Mean length of ET intubation (days)	28 ± 26.2
Early complications	4 (10.5)
Late complications	4 (10.5)
Mortality	8 (21.1)

ICU – Intensive Care Unit; ET – endotracheal.
All values are given as numbers (percentages) or mean ± standard deviation.

Table 2

Urgent tracheostomies in seven out of a total of 38 analyzed infants

Age (days)	Gender	Body weight (g)	Diagnosis
45	male	1,250	acquired tracheal stenosis
5	female	1,000	congenital tracheal stenosis
35	male	1,900	congenital tracheal stenosis
30	female	2,730	laryngeal membrane
2	male	1,800	hypopharyngeal tumor
37	female	2,300	choanal atresia
30	male	3,030	pertusis

All values are expressed as numbers.

Early complications (≤ 7 days after tracheostomy) were reported in 4 (10.5%) patients. An air leak was reported in three of these patients, each of whom was subsequently managed by tracheostomy tube upsizing (using a larger tube). One case of wound dehiscence was reported, which was treated conservatively using simple wound care, antibiotic coverage, and suture closure. Early complications were more common in the youngest age category (0–3 months) compared to the other age categories. In particular, air leaks were present in 65% of patients in the 0–3 months-old group (Fisher's exact test, $p = 0.01$).

Late complications (> 7 days after tracheostomy) were reported in 4 (10.5%) patients: peristomal granulations were reported in three children, and tracheostomy tube obstruction was reported in one child.

The ICU LHS post-tracheostomy lasted more than one month in 17 (44%) cases, less than one month in 9 (23%) cases, and less than seven days in 12 (33%) cases.

Total LHS lasted more than one month in 33 (87%) cases and less than one month in 5 (13%) cases.

Tracheostomy revision surgery was not reported in any of the 38 patients in this study.

There were no deaths associated with tracheostomy, although the total mortality was 21% (8 patients). These patients succumbed as a direct result of or from sequelae related to their primary diseases, all of them in the ICU, in four patients within 30 days after tracheostomy and in the remaining four cases within a year after tracheostomy. Six of these children had multiple congenital anomalies, and two had neuromuscular disorders. Mortality rates were higher among the youngest patients (73%, $p = 0.04$). Multivariable logistic regression was used to examine which variable predicted mortality the best – prolonged intubation, early complication occurrence, patient age, or emergency tracheostomy. Younger age was the most significant predictor of fatal outcome ($p = 0.03$, OR 0.295, 95% CI 0.032–0.97).

Of the 38 tracheostomized patients, 20 (64%) discharged patients required home MV. Parents received adequate education on home care before discharge, including home ventilation, airway management, suctioning, tracheostomy care, and emergency management. Tracheostomy tube changes were carried out for outpatients every three weeks in the hospital.

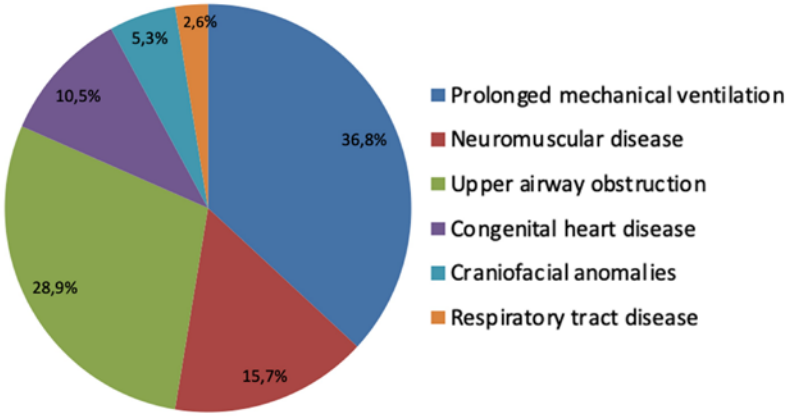

Fig. 1 – Indications for tracheostomy in 38 studied infants.

Fig. 2 – Tracheal aspirate cultures before tracheostomy in analyzed infants.
PA – *Pseudomonas aeruginosa*; SA – *Staphylococcus aureus*; KP – *Klebsiella pneumoniae*; MRSA – methicillin-resistant *Staphylococcus aureus*; G^- – Gram-negative.

Seventeen (44.7%) patients were successfully decannulated. One patient (in whom tracheostomy was carried out because of pertussis) was successfully decannulated within one month. The remaining 16 patients were decannulated 12 months or more after tracheostomy. Three children required tracheocutaneous fistula closure.

Discussion

In our study, the most common indication for tracheostomy in infants was ventilator-associated respiratory failure (or prolonged MV), which is in concordance with other published studies [8, 9]. Although variation exists in terminology and defined criteria for prolonged MV, in our study, an intubation time of a minimum of 28 days was considered prolonged. Upper airway obstruction was the second most common indication in almost 30% of patients, comparable to a study conducted by D'Souza et al. [10]. According to Gumussoy [11], about 80% of children undergoing tracheostomy have comorbidities that can complicate the procedure itself, as well as their postoperative care. In our study, 31 (81%) participants had associated comorbidities. These children often needed their tracheostomies to be retained for months or even years, requiring complex care in centers with expertise, as well as specific home care. Moreover, they spent long periods in the ICU or high dependency units before tracheostomy (44 ± 23 days), less than Dursun and Ozel [12] reported.

In all our infants, tracheostomy was performed using a vertical midline "Y" tracheal incision through the second, third, and fourth tracheal rings. Maturation sutures using absorbable 4/0 vicryl were then used, fixing the edges of the skin incision to the edges of the tracheal incision, allowing a more secure opening that tended to stay open even without the tube *in situ* (allowing ease of access to the airway in case of accidental decannulation) [10]. Some authors advise against the use of horizontal skin and tracheal incisions. One study found a significant correlation between bleeding and the use of horizontal skin incisions and between the incidence of subcutaneous emphysema (an early complication) and stomal infection (a late complication) and horizontal tracheal incisions [11]. Zenk et al. [13] showed good outcomes using a vertical incision between the second and third tracheal rings and a horizontal incision at either end (an "H cut"). A higher incidence of intraoperative bleeding was reported with surgery duration of more than 30 min or with surgeons who had less than five years of experience [11].

Tracheostomy-associated complications can be minor, including wound dehiscence and formation of granulation tissue, or major, including accidental decannulation, bleeding, tube obstruction, and death. Studies show that the frequency of early complications ranges from between 5% and 49%, which agrees with our results [10, 11, 14].

Accidental decannulation, a potentially life-threatening complication, has a reported incidence of approximately 2%, according to literature [12], whereas in our study, no cases were reported. In our study, early complications were reported in 10.5% of patients. There were no major complications. Minor complications occurring within the seven-day postoperative period included an air leak (retrograde flow of air around the tracheostomy tube due to inadequate tube size placement), which was treated by tracheostomy tube upsizing, and one case of wound dehiscence, which was conservatively treated with simple wound care, antibiotic coverage, and suture closure. The moist environment of the tracheostomy and proximity to oral secretions were thought to contribute to chronic skin inflammation around the stoma. In its early stages, wound dehiscence may be recognized by peristomal skin erythema and/or pallor, leading to overt ulceration and dehiscence. No patients developed air leak syndrome (pneumothorax, pneumomediastinum, or subcutaneous emphysema). Early complications were most common in the youngest age category (0–3 months). One author reported a higher incidence of early complications such as intraoperative bleeding with surgery duration of more than 30 min or surgeon experience of less than five years [11]. Some authors recommend early tracheostomy tube changing (up to four days after surgery) to prevent complications [15].

Late complications are mostly associated with postoperative wound care. In our study, 7.9% of patients developed tracheal-peristomal granulations, which is at a lower rate than reported by several other studies, with incidences of between 24% and 100% [14]. Medical care largely depends on the medical staff's support and ability to care for the surgical airway. Fear of accidental decannulation can lead to hesitation in manipulating cannulas, inadequate peristomal skin inspection, and wound care. This can lead to tracheostomy tube obstruction and the need for urgent tube replacement. Caregivers should be adequately trained in tracheal aspiration, surgical airway management, and tracheostomy tube manipulation in case of accidental decannulation and basic cardiopulmonary resuscitation. Proper caregiver training can help reduce mortality and the incidence of complications. Zenk et al. [13] reported a high tracheal stenosis rate (13%) in children with multiple diseases because of prolonged tracheostomy and frequent infection occurrence.

Overall tracheostomy-associated mortality has been steadily declining the past 30 years and is largely dependent on comorbidities. Relative mortality after tracheostomy is approximately 16% [16, 17]. Dursun and Ozel [12] reported a mortality rate of 59%. The highest mortality was recorded in children with neuromuscular diseases. Primary disease progression was the leading cause of death in children with tracheostomy in our study, which is comparable to other published studies [17]. There were no tracheostomy-associated deaths in our study; however, the overall mortality was 21%, and younger age was found to be an independent risk factor. These patients died as a result of their primary diseases, all of them in the ICU; four patients died within 30 days after tracheostomy, and the remaining four patients within a year after tracheostomy. Six of these children had multiple congenital anomalies, and two had neuromuscular diseases.

After recovery, 64% of patients were discharged from the hospital needing home MV. Parents received adequate

education on home ventilation before discharge. Adequate parent education may reduce tracheostomy-associated mortality. Patients underwent tracheostomy tube changes in the hospital every three weeks in an outpatient setting.

A shift in indications for tracheostomy coinciding with improvements in standards of pediatric intensive care facilities has highlighted two important outcome measures: length of tracheostomy retention and successful decannulation. Successful decannulation rates have decreased, whereas lengths of tracheostomy retention have more than doubled, with maximum figures ranging from 12 months to 24 months and above (decannulation was achieved in 22.5% of cases in the three years) [18, 19]. Decannulation depends primarily on comorbidities and secondarily on postoperative complications. Patients with neuromuscular diseases are rarely decannulated. Zenk et al. [13] reported patients with neuromuscular diseases retaining their tracheostomies the longest (17.1 years). In our study, 17 (44.7%) patients underwent successful decannulation. In all cases, tracheostomies were performed as temporary airway accompanying surgical procedures relieving upper airway anomalies or underdevelopment.

Conclusion

Tracheostomy in infants is a relatively safe procedure. The most common indication for tracheostomy is prolonged intubation and/or ventilator-associated respiratory failure. Only minor resolvable complications were reported in our study. There were no deaths associated with tracheostomy. The majority of patients had severe primary diseases that required multidisciplinary treatment over many years and longer tracheostomy retention periods, resulting in low decannulation rates. Therefore, tracheostomies should be carried out in specialized pediatric centers with experienced medical personnel where parents can receive adequate education on home care.

Conflict of interest

The authors of this paper certify that they have no affiliations with or involvement in any organization or entity with any financial or non-financial interest in the subject matter or materials discussed in this manuscript.

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