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Microbiological Findings, Infection Risk Factors and Complications Among Children after Tracheostomy

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Summary

Introduction. Bacterial infection of the respiratory tract is highly common among pediatric patients with tracheostomy, yet there is no wide knowledge about the prevalence of different airway microbes, the incidence of bacterial infection, infection risk factors, and complications.

The aim of the study was to analyze the prevalence of airway microbes, the incidence of bacterial infection, infection risk factors, and complications.

Methods. Retrospective data of officially reported cases were collected from 2018 to 2022 at Riga Children's Clinical University Hospital (RCCUH). Demographic factors, airway microbiological findings, tracheostomy-related complications, underlying conditions, and outcomes for 37 patients were gathered from the hospital's database Andromeda. The data were analyzed using MS Excel. This study received ethical approval from RSU Ethics Committee.

Results. Microbiological analyses were done in 78.3% (n=29) of the cases. Most cultures were obtained from airway aspirate. Altogether 46 different species of microbes were identified. The most frequently identified bacteria were Pseudomonas aeruginosa (in 72.4% of the cases; n=21) and Staphylococcus aureus (65.5%; n=19). Forty-eight percent (n=18) of the patients had respiratory tract infections that required hospitalization. Overall, there were 60 hospitalization episodes of which 51.6% (n=31) were caused by pulmonary bacterial infection, 25.0% (n=15) by non-bacterial infection, and 0.05% (n=3) because of local wound infection. The rest 18.3% (n=11) of hospitalization episodes were due to granulation tissue. The risk factor that showed the greatest significance in the development of bacterial infection was ventilator dependency. Formation of granulation tissue in the airways was found to be the most common complication among pediatric patients with tracheostomy.

Conclusion. This study summarizes the most common pathogens, risk factors, and complications, which should be considered while treating pediatric patients after tracheostomy. The results of this study demonstrate that P. aeruginosa and S. aureus have the highest prevalence among these patients. This research is currently used to develop guidelines for pediatric patients with tracheostomy care in RCCUH.

Keywords: pediatric tracheostomy, respiratory infections, tracheostomy complications.

Introduction

Tracheostomy is one of the most often performed surgical manipulations in critically ill patients. During this procedure, an opening is created in the trachea to ensure optimal ventilation for the patient. The stoma is preserved by inserting a tracheostomy tube. (8,9)

Over the last decade, tracheostomy is performed more often in pediatric patients with chronic illnesses or complicated conditions, due to the improvements in neonatal and pediatric

ICU care. The main indications for this surgery are obstruction of the upper airways due to obtained or congenital anomalies, prolonged ventilator dependency, and irreversible neuromuscular, chronic lung, and heart diseases. (13)

Children after tracheostomy are at an increased risk for tracheopulmonary infections as the tracheostomy tube bypasses the naturally protective nasal and oral airway passages and provides easy entry for bacteria into the lower airway. (1,12) Adverse events following tracheostomy placement in pediatric patients range from mild to life-threatening. Immediate identification of the risk factors and diagnosis of tracheostomy-related infections is essential to avoid severe complications and devastating outcomes. In the pediatric population, the risk of complication development after tracheostomy is around 15-19%. (2,8,13) Other studies have demonstrated an increased mortality rate due to tracheostomy complications in emergencies, severely ill patients, and especially in children. The most common tracheostomy-related cause of death has been reported to be tube obstruction, tube misplacement, and accidental decannulation. (13)

The aim of the study

To analyze the prevalence of airway microbes, the incidence of bacterial infection, infection risk factors, and complications.

Materials and methods

Patients and study design. This retrospective study was conducted using data from January 2018 to December 2022 at Riga Children's Clinical University Hospital (RCCUH). This study received ethical approval from RSU Research Ethics Committee. A total of 37 patients were included in this study. The inclusion criteria were patients aged 0 to 24 years, that have received treatment in Riga Children's Clinical University Hospital from January 2018 to December 2022, and who have the diagnosis "Tracheostomy" (Z93.0). The exclusion criteria were patients older than 24. Among the included patients 23 were male and 14 were female with a median age of 2. Their underlying conditions were categorized as cerebral palsy (CP), congenital central nervous system (CNS) malformation or CNS disorders, upper airway anomalies, neuromuscular disease, cardiovascular anomalies, and CNS infections. The age, sex, underlying disease, hospitalization course, laboratory data, and management of each patient were recorded.

Infection definitions. Patients with fever and at least one respiratory tract infection symptom/sign were considered to have pneumonia. We classified definite bacterial pneumonia episodes (culture-proven/microbiologically positive) as a WBC<4000 or >12,000/mL, CRP >1 mg/dL, CXR with a pneumonic patch, and positive sputum cultures. Possible bacterial pneumonia episodes were classified as WBC <4000 or >12,000/mL or CRP >1 mg/dL or CXR with a pneumonic patch. Non-bacterial pneumonia episodes were classified as WBC 4000- 12,000/mL, CRP <1 mg/dL, and CXR without a pneumonic patch.

Statistical analyses. The data was collected and analyzed using Microsoft Excel.

Results

All 37 recruited patients had underlying conditions. For 70.0% (n=26) of the patients, tracheostomy was performed during the ages 0 to 6. For 24.0% of the patients, tracheostomy was performed during the ages of 13 to 18. And for the rest, it was performed from the age of 7 to 12 *(Figure 1)*.

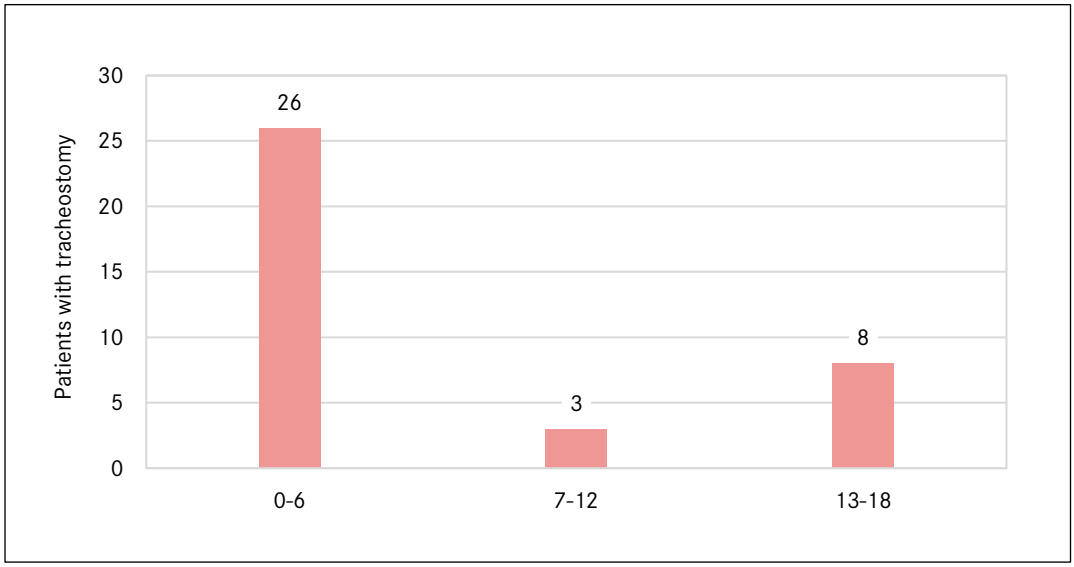

Figure 1. Age in years at which tracheostomy is performed.

The average age for the insertion of a tracheostomy cannula was 5.0 years. In this study, there were 27.0% (n=10) ventilator-dependent patients.

The most common underlying conditions were CNS malformations or disorders for 32.0% (n=12) patients, upper airway anomalies for 30.0% (n=11) patients, neuromuscular disorders for 14.0% (n=5), cerebral palsy for 11.0% (n=4), cardiovascular anomalies for 8.0% (n=3), CNS infection for 3.0% (n=1) and airway infection for 3.0% (n=1) *(Figure 2).*

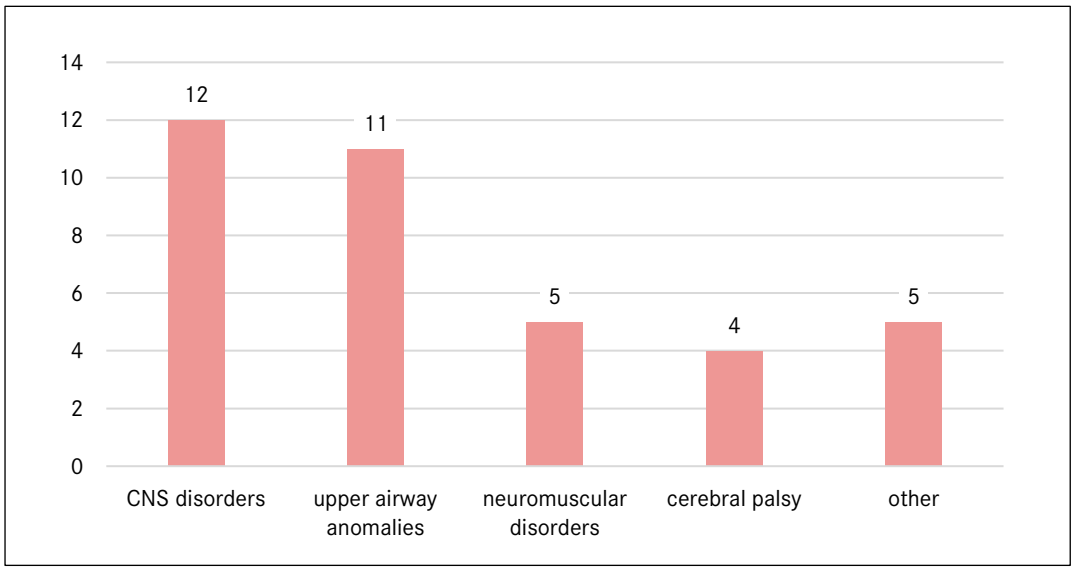

Figure 2. Underlying conditions. *CNS – central nervous system.

Twenty-seven percent of patients (n=10) underwent decannulation. For these patients, the average duration of tracheostomy was 1.4 years. Six patients had tracheostomy cannula for less than a year.

There were four cases of death in this study. For three of these patients with multiple underlying conditions and congenital disorders death occurred due to the worsening of the general condition. The cause of death was determined to be – respiratory failure. For

the fourth patient, the cause of death was also respiratory failure due to aspiration pneumonia, obstruction, and dislocation of the cannula.

Infection episodes. From January 2018 to December 2022 49.0% (n=18) of the patients had respiratory tract infections that required hospitalization. Of these 49.0% (n=18) patients 44.0% (n=8) had one infection episode, 22.0% (n=4) had two infection episodes, 18.0% (n=3) had three infection episodes and the rest (n=3) had four or more infection episodes which required hospitalization.

Altogether there were 60 hospitalization episodes of which 52.0% (n=31) were due to bacterial infection, 25.0% (n=15) were due to non-bacterial infections. 0.5% (n=3) were due to local infections and 18.0% (n=11) were due to a complication – granulation tissue *(Table 1).*

Table 1. Comparison between subjects with respiratory tract infections.

Clinical variables	Bacterial infection n=12	Non-bacterial infection n=7	Local infection n=3	Granulation tissue n=21
Demographic factors				
Median age at tracheostomy (years)	4	3.33	2.30	5.4
Male	11	4	2	14
Female	1	3	1	7
Underlying condition				
Upper airway anomalies	2	2	1	4
Cerebral palsy	0	1	0	1
CNS disorders	6	0	1	10
Heart anomalies	1	0	0	1
Neuromuscular disorders	2	3	1	4
CNS infections	0	0	0	0
Airway infections	1	0	0	1
Comorbidities				
GERD	2	1	0	2
Ventilator dependency	7	1	1	7
Bedridden	5	1	2	7
Outcome				
ICU	6	2	1	13
Death	1	0	0	0

*GERD - Gastroesophageal reflux disease; ICU – Intensive care unit

Seventy-three percent of the patients (n=27) received antibacterial therapy in at least one of the hospitalization episodes. The most commonly used drugs were *Amoxicillinum + Acidum clavulanicum*, for 67.0% (n=12) of the patients, *Azithromycin*, for 61.0% (n=11) of the patients, and *Cefuroxime*, for 56.0% (n=10) of the patients.

Microorganisms. Microbiological testing was performed in 78.0% (n=29) of the patients. Cultures from tracheostomy wound were taken in 22.0% (n=8) of the cases, from tracheostomy cannula in 27.0% (n=10) of the cases, and cultures from aspirate were taken in 68.0% (n=25) of the cases. For two patients cultures were taken from all three locations. Altogether microorganisms were isolated 182 times and there were 46 different species found from which 0.07% (n=3) were fungi, 33.0% (n=15) were Gram-positive bacteria and 61.0% (n=28) were Gram-negative bacteria. The most frequently isolated bacteria were *Pseudomonas aeruginosa* (n=21; 72.4%), *Staphylococcus aureus* (n=19; 65.5%), *Stenotrophomonas (Xanto.) maltophilia* (n=13;

44.8%), *Klebsiella spp.* (n=12; 41.3%), *Corynebacterium spp.* (n=11; 37.9%), *Enterobacter cloacae* (n=9; 31.0%) *(Figure 3).*

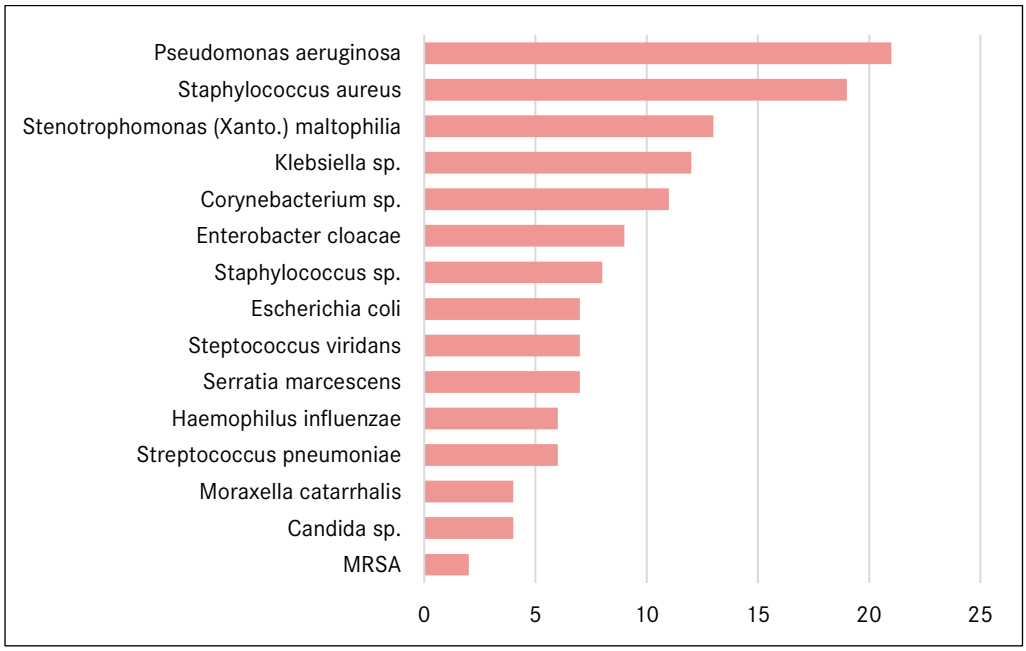

Figure 3. Microbiological findings in children with tracheostomy-related respiratory infections. MRSA - methicillin-resistant Staphylococcus aureus.

Infection risks. In other research done around the world ventilator dependent, gastroesophageal reflux disease (GERD) and bedridden patients with tracheostomy are proven to be at the highest risk for the development of pulmonary bacterial infection. (12) These factors proved their significance also in this study - forty-four percent (n=7) of ventilator-dependent patients, 38.0% (n=5) of bedridden patients and 20.0% (n=2) of GERD patients developed pulmonary bacterial infections.

Discussion

Our data suggests that prolonged tracheostomy use is related to an increased risk of bacterial pneumonia. It is also described previously that long-term tracheostomy tube may lead to irritation of the tracheal mucosa, further increasing the risk for infection. (5) These children are at an increased risk for tracheopulmonary infections as the tracheostomy tube bypasses the naturally protective nasal and oral airway passages and provides an open portal of entry for bacteria into the lower airway. (3,7)

P. aeruginosa was the most common microbe isolated from the patients in our study. This is consistent with other studies that showed a predominance of Gram-negative organisms in this patient population. (3,5,6,11,12) *S. aureus* was the second most common microbe isolated, though methicillin-resistant *S. aureus* was isolated less than in other research. (4,12) When choosing empiric antibiotic therapy for symptoms of respiratory infection in this population, coverage for *P. aeruginosa* and *S. aureus* may be considered as the initial treatment which can be modified after culture results become available.

Currently, there are no unanimous guidelines for diagnosing and treating respiratory infections in children after tracheostomy. As well as there is no unified opinion among experts about which symptoms indicate bacterial respiratory infection in this population. (2,4,9) Our study

showed that it is difficult to differentiate between bacterial and non-bacterial pneumonia episodes and, therefore, antibiotics overuse is difficult to avoid.

Complications. In this study, 73.0% (n=27) of the patients experienced tracheostomy-related complications. Adverse-related tracheostomy events can be divided into those occurring "early" (including the perioperative and immediate postoperative period) and "delayed". It is important to recognize and address them to prevent devastating outcomes. (13)

Early complications include pneumothorax, pneumomediastinum, or subcutaneous emphysema, hemorrhage, pulmonary edema, respiratory arrest, injury caused by tube placement, accidental decannulation, and mucus plugging. These complications are most frequently caused by technical difficulties during surgery. A chest x-ray should always be performed when the child returns to the ICU after tracheostomy to check the status of the chest. (13) In this study 16.0% (n=6) of the patients experienced accidental decannulation, three patients experienced mucus plugging and one patient had respiratory arrest.

Late complications also include mucus plugging, hemorrhage, and accidental decannulation, as well as the development of granulation tissue, tracheocutaneous fistula, suprastomal granuloma, suprastomal collapse, subglottic stenosis, and many others. (13) In this research the most common complication was the development of granulation tissue, in 57.0% (n=21) of the patients. Peristomal granulation tissue may develop secondary to the friction and movement of the tracheostomy tube or chronic inflammation. It usually responds well to local wound care and more frequent tracheostomy tube and dressing changes. (7,13) Stenosis of the trachea was also a frequent complication, it developed in 16.0% (n=6) of the patients. Fourteen percent (n=5) of the patients experienced aspiration. Other late complications were recorded in 3 or fewer patients *(Figure 4).*

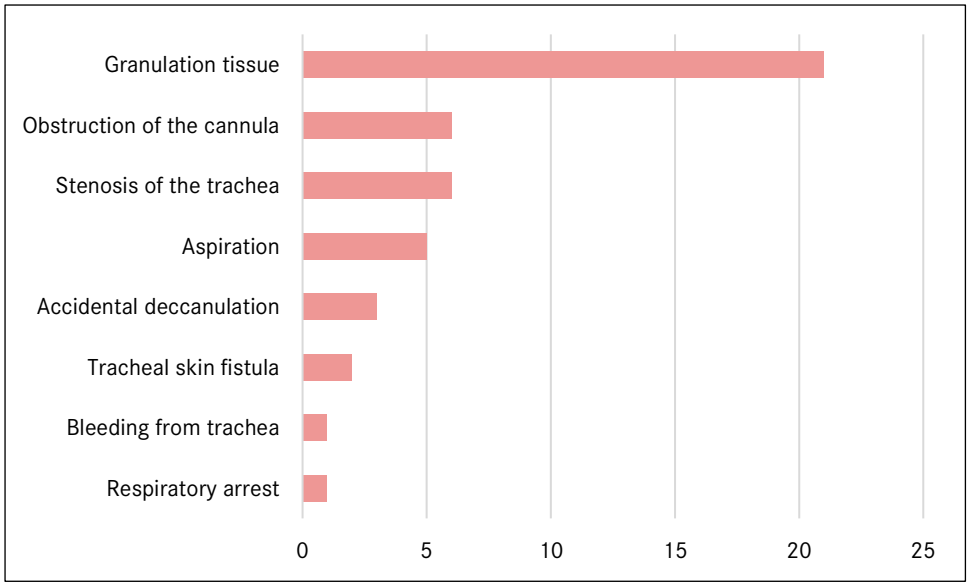

Figure 4. Tracheostomy complications.

Conclusions

There are several limitations to our study. First, as in all retrospective studies, missing data from medical records is inevitable. Second, we had flexible inclusion criteria for possible bacterial pneumonia episodes to prevent overlooking possible bacterial infections. Third, as our study only recruited patients who were admitted to the hospital, we may have missed infections that did not require hospitalization. Fourth, our sample size was not sufficiently large due to the relatively

limited number of children with tracheostomy in Latvia, and it only reflects experiences from a single medical center. However, the characteristics of respiratory tract infections in children with tracheostomy can still be deduced from our data.

In conclusion, this study summarizes the most common pathogens, risk factors, and complications, which should be considered while treating pediatric patients after tracheostomy. The results of this study demonstrate that *P. aeruginosa* and *S. aureus* have the highest prevalence among pediatric patients with tracheostomy. Bacterial and non-bacterial pneumonia are difficult to differentiate clinically which may lead to unnecessary antibiotics use among clinicians.

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