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Predicting Factors of Decannulation in Children with Tracheostomy

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PREDICTING FACTORS OF DECANNULATION IN CHILDREN WITH TRACHEOSTOMY

Abstract

Objectives: Our aim was to determine the treatable causes to increase the chance of decannulation success. For this purpose we evaluated the differences between the patients who succesfully decannulated and the patients who still has tracheostomy.

Metods: A retrospective cohort study was conducted based on medical records of all pediatric patients with tracheostomy in a single centre.

Results: Decannulation was successfully achieved in 59 patients (34.5%) of total 171 patients with tracheostomy between the years 2012-2019. Median duration of tracheostomy was 41.5 and 12 months in patients who remained with tracheostomy and decannulated respectively. Neurological disorders were higher in patients remained with tracheostomy, congenital heart disease and airway abnormalities were higher in decannulated patients. Presence of bacterial colonization (3.8-fold), history of invasive respiratory support following tracheostomy (2.9-fold), and having any neurological disorder and/or comorbidity (5.2-fold) were significantly associated lower rates of decannulation.

Almost 33 % of patients had bacterial colonization and colonization rates were higher in patients who needed invasive respiratory support following tracheostomy placement ($p<0.001$), patients with feeding/swallowing problems ($p=0.005$) and neurological disorders(0.002). There was significant correlation between duration of tracheostomy and bacterial colonization rates ($p=0.008$). But after analysing with logistic regression only having a neurological disorder was associated with bacterial colonization (OR= 2.9; 95% Cl: 1.15-7.47 $p=0.024$).

Conclusion: While conducting decanulation assessment, the presence of colonization should be considered. Future prospective researchs are necessary in order to determine the role of chronic colonization on decannulation success.

PREDICTING FACTORS OF DECANNULATION IN CHILDREN WITH TRACHEOSTOMY

INTRODUCTION

Tracheostomy is a surgical procedure that provides artificial airway patency. The indications of tracheostomy have been changed over the past few decades from emergency procedure like trauma or infectious diseases to prolonged mechanical ventilation or underlying neurological and cardiological diseases diseases[1-5].

While the number of patients with tracheostomy remained stable over the years[7], the age at the time of tracheostomy procedure decreased[5,8]. The accompanying chronic conditions are increased and almost 80% of the patients are accompanied by more than one chronic condition, which is associated with longer hospital length of stay, higher hospital charges and higher in-hospital mortality[4]. Increased number of cumulative comorbidities lower the chances of tracheostomy decannulation[9]. Persistent and recurrent lower respiratory infections due to chronic bacterial colonizations are the most common causes of the hospitalizations in the children with tracheostomy[10-15]. Until now there is no study investigating the effect of bacterial colonization on possibility of decannulation.

Decannulation should be planned as early as possible to minimise tracheostomy related complications, to improve the quality of life of the patients and caregivers, as well as to reduce the health care costs[16].

In children, the overall succesfull decannulation rates vary between 24 to 60% [5,8]. Decannulation decision has been made by clinical judgement according to the preliminary assessment in line with the consensus reports and checklist[17-19]. There is no consensus protocol for decannulation practices that changes based on the patient characteristics and conditions of center.

Our aim was to investigate the differences between the patients who succesfully decannulated and the patients who still has trachesotomy in terms of underlying diseases, comorbidities, bacterial colonization and previous need for respiratory support. We also aimed to evaluate the factors associated with decannulation success.

MATERIAL-METHOD

Patients:

We retrospectively reviewed the medical records of patients with tracheostomy at our instution between July 2012 to December 2019. Data including age, gender, underlying disease, presence of comorbidities, bacterial colonization and invasive respiratory support following tracheostomy were obtained from patient's medical records.

While the main causes of tracheostomy are classified as primary disorders, other systemic static problems are defined as comorbidies.

Primary disorders that cause tracheostomy were classified as, neurologic disorders (ND), congenital heart diseases (CHD), chronic pulmonary diseases (CPD), airway abnormalities, metabolic/genetic disorders and other causes. ND group was involved mostly cerebral palsy, spinal muscular atrophy (SMA Type 1 and 2), neuromuscular disorders, refractory epilepsy, central neurvous system trauma and cancer.

Comorbidities were classified as, neurological, cardiological and feeding and swallowing problems. Neurological comorbidities were concomitant problems including minor static disabilities and controlled epilepsy except than the primary neurologic disorder. Cardiological comorbidies were included hemodynamic stable structural defects as VSD (ventricular septal defect), ASD (atrial septal defect), MVP (mitral valve prolapses).

Feeding status of the patients (Tube feeding or oral feeding) and presence of feeding/swallowing problems, (which was defined as abnormal swallowing study or respiratory symptom such associated with feeding) were also obtained from patients' medical records.

Tracheal aspirate cultures were obtained every three months during routine clinical visits regardless of any clinical signs of infection or any time with presence of respiratory infections at our clinic. Bacterial colonization was defined as the presence of the same microorganism (< 100.000

colonies per ml) in more than 3 consecutive cultures of tracheal aspirate without any infection (Lepainteur, Morar). We included the results of trach aspirates in the last year before decannulation in decannulated patients. In patients with remained tracheostomy dependency we evaluated the cultures of last one year before December 2019 by the end of the study period.

Required surgical procedures before decannulation, post decannulation complications, need for respiratory support following tracheostomy and decannulation failure were also recorded. Decannulation failure was defined as an invasive airway need within 48-96 hours following planned decannulation attempt[20].

Tracheostomy decannulation protocol:

Patients who do not need respiratory support more than 16 hours a day, have no recent history of aspiration, can control their airway secretions and have an effective cough reflex were considered candidate for decannulation. Patients with a neurologic disease who can use cough assist successfully were also included to decannulation protocols.

Before decannulation decision, first step was to evaluate airway anatomy and patency by flexible bronchoscopy. Airway pathologies requiring surgical correction were treated before decannulation.

Tracheostomy tube was downsized to a smaller diameter and capped for a 24-48 hours according to patients' clinical condition. Decannulation was performed in children who was stable during tube capping period who has adequate airway patency, stable night/day time oxygen saturation, normal blood gase results and absance of any sign of infection. Patient was monitored in the intensive care unit or pediatric ward for at least 48 hours according to patient's clinical status. Oxygen supplementation and chest physiotherapy were applied if necessary.

Statistical Analysis

The IBM SPSS Statistics (version 22.0 IBM Corp., Armonk, NY) software program was used to analyze the data. Categorical variables are presented as numbers (n) or percentages (%). Continuous variables are shown as medians with 25 and 75 percentages. For comparisons; chi-square test, Mann

Whitney u test and logistic regression analysis were used as appropriate. Odds Ratio (OR) were estimated using logistic regression. A p-value < 0.05 was considered significant.

Ethical Approval

The study was approved by the Ethical Committee of Medipol University Medical Faculty (Number: 10840098-604.01.01).

RESULTS

Clinical Demographics and Indications

Between July 2012 to December 2019, we evaluated 171 tracheostomized patients (54% male). Median age of all the patients was 66 (42-93) months. Neurological disorders (49%), congenital heart diseases (17,5%) and airway abnormalities (11,7%) were the most common primary disorders. Decannulation was successfully achieved in 59 patients (34.5%). Median age of the patients who remained with tracheostomy and decannulated were 66 and 67 months, respectively.

Eightytwo (48%) of the patients needed invasive respiratory support following tracheostomy. Fiftynine of the 112 tracheostomy patients and 23 of the 59 decanulated patients needed invasive respiratory support following tracheostomy (Table 1). Seven patients (3 patients with congenital central hypoventilation, 3 patients with SMA, and 1 patient with severe airway malasia) required non-invasive ventilation following decannulation. Sixteen of the 23 patients detached from ventilator before decannulation during follow-up period.

Median duration of tracheostomy was 41.5 (25-66.5) and 12 (5-20) months in patients who remained with tracheostomy and decannulated respectively. At decannulation 24 % of patients were under 1 year old while 55% of them were under two years old.

While neurological disorders, invasive respiratory support following tracheostomy, bacterial colonization were higher in patients remained with tracheostomy, congenital heart disease and airway abnormalities were higher in decannulated patients (Table 1).

Bronchoscopic Findings

Bronchoscopic evaluation were performed before decannulation in 59 patients and 15 patients (25%) had normal bronchoscopic findings. Also fifteen (25%) of the patients have more than one abnormal bronchoscopic findings. Abnormal bronchoscopic findings at 44 patients were listed at Table 2. Patients with subglottic hemangiomas were treated medically before decannulation. Granulation tissue was required surgical excision in 6 patients. Six patients with grade 3 subglottic stenosis according to Cotton Myer scoring system, underwent laser surgery before decannulation. Three

patients with supraglottic collaps (2 patients with SMA type 1, one patient with SMA 2) and one patient with severe tracheomalasia reqired NIV after decannulation. Also another 3 patients with congenital central hypoventilation syndrome were decannulated with NIV and one of these patients had mild granulation tissue and two of them were normal in the bronchoscopic evaluation.

Risk Factors for Affecting Decannulation

Bacterial colonization was present in 56 (33%) patients. *Pseudomonas aeruginosa* (60 %) and *Staphylococcus aureus* (13%) were the most commonly identified pathogens. Bacterial colonization was significantly higher in patients remained with tracheostomy ($p < 0.001$), underlying neurological disorder ($p=0.002$), who required invasive respiratory support after tracheostomy placement ($p<0.001$) and patients with feeding and swallowing problems ($p=0.005$). There was significant correlation between duration of tracheostomy and bacterial colonization rates ($p=0.008$). Tracheostomy duration was 70 months and 52 months respectively, in colonized and noncolonized patients. Having a neurological disorder was an independent risk factor of colonization after the analysis with logistic regression (Table 3).

Logistic regression analysis revealed affecting factors related with decannulation; presence of bacterial colonization (3.8-fold), history of invasive respiratory support following tracheostomy (2.9-fold) and having any neurological disorder and/or comorbidity (5.2-fold) were significantly associated lower rates of decannulation. Having a neurological disorder was also an independent risk factor of bacterial colonization (Table 4).

Decannulation Failure, Complications and Mortality

Three patients required tracheostomy placement in 24-72 hours following decannulation. Two of these three patients couldn’t tolerated decannulation due to congenital heart disease and hemodynamic instability. Second decannulation attempt after 6 months was successful in the other patient who had traumatic brain injury and improvement after rehabilitation period. Consequently, 2 patients (3,3 %) were accepted as decannulation failure in our study.

No complication was found in 42 (71 %) of the 59 patients following decannulation. Atelectasis,

pneumonia and stridor were the most common complications (Table 5).

Eighteen patients (11%) were died during study period because of underlying medical conditions before decannulation. No decannulated patient died during study period.

DISCUSSION

Decannulation under safe circumstances, should be considered in all patients with tracheostomy as soon as possible when the initial indication is no longer exists. Determination of the criterias that predict successful decannulation is important in order protect patients and their families from unnecessary risks and false expectations. Only few studies evaluated clinical factors affecting decannulation success rate in patients with tracheostomy. In these studies, there are big variations in terms of sample size and underlying conditions[21-24].

For the first time in the literature, our study showed that colonization effects decannulation rates.

Indications

Indications of tracheostomy may vary according to the specialization of centre and patient population. Most frequent tracheostomy indications were ND (49%) and CHD (18%) in our study. The indications of pediatric tracheostomy are shifting to dependency of prolonged ventilation in last 30 years[8,25] and the most frequent indications are neurological (% 39-51) and cardiological diseases (% 21-34) in large pediatric series[5,6].

Bronchoscopic Findings

Almost in all studies bronchoscopic evaluation is recommended before decannulation for avoiding complications after decannulation and reducing decannulation failure[17,18,26]. In our study, airway granulation tissue was the most common bronchoscopic finding which was detected 39% of bronchoscopic evaluation. The incidence of airway granulation tissue in patients with tracheostomy ranges from 50 to 80% and also granulation tissue is the most common pre-decannulation bronchoscopic finding up to 51% in literature[27,28]. There was no correlation between duration of tracheostomy and existence of grannulation.

Risk Factors Affecting Decannulation

Studies suggested some predictive factors for decannulation, including age at time of tracheostomy, neurologic disease, and anatomic airway disease[29-31]. In our study, 59 patients (34.5 %) were decannulated and the median duration of tracheostomy at decannulation was 22 months. Our results

are consistent with the literature in which decannulation rates are ranging between 24 -60 % [5,6,8]. Seventy percent of our patients were less than 1 year of age at the time of tracheostomy placement and were 22 months of age at the time of decannulation, which are also consistent with literature rates[5,8]. Presence of genetic abnormalities, GERD, dysphagia, irregular respiratory pattern (breath holding spells), false expectations of the parents, and the absence of a multidisciplinary team follow-up were the main factors for decannulation failure[21,22,24].

Our study suggest that bacterial colonization affect the decannulation success in addition to neurological disorders and invasive ventilation requirement following tracheostomy placement.

Bacterial Colonization

Bacterial colonization is a common problem in patients with tracheostomy. In our study almost 33 % of patients had bacterial colonization and the most frequent identified pathogen was *Pseudomonas aeruginosa* (60 %) in accordance with previous studies[23,32-34]. Natural protective effect of the upper airways is eliminated in patients with tracheostomy. Additionally, altered anatomy and recurrent aspiration of airway secretion may lead to chronic colonization and subsequent infections[13,35]. In patients with tracheostomy persistent detection of *Pseudomonas aeruginosa* in tracheal aspirate cultures is known to increase the risk of pulmonary exacerbations[11] and associated with worse clinical outcomes, increase the number of hospitalizations and length of stay in intensive care unit[12].

Our study shows that presence of a feeding and swallowing disorders, respiratory support requirement following tracheostomy placement, concomitant neurological disorders and duration of tracheostomy were the main factors for bacterial colonization. Aspiration of the gastric contents, upper airway secretions and food into airways may cause airway inflammation, facilitate the colonization of the airways with pathogenic bacterias which may lead to lower respiratory tract infections and bronchiectasis[33-36]. Also feeding dysfunction decreased the odds of a successful first decannulation attempt (5.5-fold) and cause decannulation failure[21,37].

Colonization rates were also higher in patients who needed invasive respiratory support following tracheostomy placement and patients with feeding/swallowing problems ($p<0.001$ and $p=0.005$).

In a recent unpublished study conducted at our center, revealed that the nebulized antibiotic treatment reduced the number of hospitalizations, length of stay in the intensive care unit and the bacterial load in the tracheal aspirate cultures in patients with tracheostomy who has persistent bacterial colonization [38]. In line with previous studies, the most common underlying disease in children with tracheostomy were also neurological disorders in our study and colonization rates with pathologic microorganisms were more common this group of patients (65%) [5,6,23,32-34]. Neurological disorders were independent risk factor of colonization regardless of tracheostomy duration (2.93 fold). Bacterial colonization rate was associated with the longer duration of tracheostomy, median duration of tracheostomy was 70 and 52 months in colonized and non-colonized patients respectively. Pozzi et al evaluated the respiratory colonization rates among 65 pediatric tracheostomized patients after acute brain injury in a long-term rehabilitation center. Their study revealed that these patients had high colonisation rates in which Pseudomonas aeruginosa and Staphylococcus aureus were the most commonly identified microorganisims. Of the 23% and 26 % of the patients colonized with one and more additional microorganisms respectively during rehabilitation period [23].

This is the first study in literature which shows that the presence of colonization reduces the odds of decannulation rate by 3.8-fold.

Invasive Ventilation Requirement Following Tracheostomy

Almost half of our patients (48%) required invasive ventilation following tracheostomy placement which was associated with lower decannulation rates (2.9 folds). In literature the need for respiratory support in patients with tracheostomy were 33-44 % and there was no correlation between the duration of respiratory support via tracheostomy and decannulation rate[5,39,40]. Our high

rate of ventilator dependent patient at discharge was related to the high rate of patients with neurological disorders ($p<0.001$). Even in patients with underlying neurological disorders and / or ventilation dependency, decannulation could be done with NIV.

Neurological Problems

As reported in previous studies, the most common underlying disorder in children with tracheostomy was neurological disorders as in our study[5,6]. Studies have found that neurologic diseases were associated with the inability to decannulate successfully [39,41]. In our study, patients with underlying neurological disorders or presence of a concomitant neurological comorbidities in addition to primary disease was associated with lower decannulation rates which was 25 %.

Noninvasive Ventilation need After Decannulation

In previous studies NIV was used immediately following decannulation as a weaning tool (elective NIV) or in children who develops obstructive symptoms following decannulation (rescue NIV) [29,42]. Decannulation with NIV rates vary between 4-30 % [29,42]. Majorty of patients requiring NIV following decannulation are patients with airway problems, congenital central hypoventilation syndrome and neurologic disordes [43]. In our study 7 of 59 (12%) decannulated patients need NIV after decanulation. Six of these patients had ND and one patient had severe tracheomalacia.

NIV was used for the increase of success rate in patients with upper airway obstruction during decannanulation [42], but there is no study reporting the need for NIV during decannulation of patients with ND. An explanation of the need for NIV in our study may be the tendency to upper airway obstruction due to hypotonia.

None of our patients decannulated with NIV required invasive ventilation during follow-up and one patient with tracheomalacia could be independent from NIV.

Decannulation Failure, Complications and Mortality

In our study only 2 (3.3%) patients required tracheostomy replacement in 24-72 hours following de-cannulation due to decompansation of underlying cardiologic disease.

Decannulation failure rates vary according to the decannulation protocols [26,44]. At Wirtz et al's decannulation and observation protocol without any capping or downsizing which they evaluate patient's airway under sedation with spontaneous breathing, decannulation failure rate was % 6. Decannulation failure rates were between 0-13% in studies with capped PSG protocol [44].

While signs of upper airway obstruction were prominent in the first 4 hours following decanulation, problems related to retention of secretions were more common after 24 hours [20]. To our knowledge, there is no study reporting the early complications after decannulation that not cause decannulation failure. Our complication rate was 29% and the most frequent complication was stridor that resolved within few hours.

Children with tracheostomy have higher mortality rates which may be related with underlying disease (12.5-20 %) and preventible complications of tracheostomy (1-3.2%) itself [5,8,39]. In our study 18 patients (11%) died, mortality was related to the underlying condition for all of these patients and none of our decannulated patients died during study period.

Limitations

The retrospective design based on medical records was the limitation of our study. Second limitation, we did not evaluate the patients with PSG before decannulation. But inpatient sleep monitorization that involve sleep and awake oxygen monitorization, morning blood gase analysis for detecting nocturnal hypoventilation were performed to all patients.

CONCLUSION

In order to prevent tracheostomy related morbidity and mortality, decannulation, under safe circumstances, should be considered in all patients with tracheostomy as soon as possible. The lack of evidence-based decannulation guidelines make difficult to predict decannulation success. In our study, we showed for the first time in the literature that the presence of chronic colonization affects decannulation rates, as well as neurological disorders and the need for respiratory support after tracheostomy. While conducting decanulation assessment, the presence of colonization should be investigated and necessary measures should be taken. Future prospective researchs are necessary in order to develop evidence based decannulation guidelines and determine the role of chronic colonization on decannulation success.

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