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ORIGINAL ARTICLE

Pediatric tracheostomy: ten year experience in an Intensive Care Unit

Traqueostomía en niños: Experiencia de 10 años en una Unidad de Cuidados Intensivos Pediátricos

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What do we know about the subject matter of this study?

Tracheostomy is a common procedure in pediatric intensive care. The indication for prolonged mechanical ventilation (MV) has increased in recent decades.

What does this study contribute to what is already known?

In a referral center in Chile, the indication for tracheostomy is similar to that reported internationally. Children in MV of younger age, with difficult weaning, genopathy, or with special health needs are at higher risk of discharge with tracheostomy and prolonged MV.

Abstract

Pediatric tracheostomy indications have changed over the last 30 years, from acute and transient procedures secondary to airway obstruction to programmed tracheostomies indicated due to the need for chronic use of mechanical ventilation (MV). **Objective:** To describe indications and morbidity associated with pediatric tracheostomies during a ten-year period. **Patients and Methods***:* Descriptive study. Clinical records review of discharged patients (< 15 years old) tracheostomized during their hospital stay between 2005 and 2015. Demographic and clinical variables were evaluated before and after tracheostomy, stay in intensive care unit, age at the time of the tracheostomy, indication of tracheostomy, early complications (< 7 days), late complications (> 7 days), and mortality. **Results***:* 59 children with tracheostomy were analyzed, 36 (59%) tracheostomies were performed in children

Keywords:
Children;
Tracheostomy;
Pediatric Intensive Care Unit;
Chronic Mechanical Ventilation

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under 6 months, and 39 (60%) in males. 23 (39%) had a confirmed or under study genopathy and 25 (42%) had congenital heart disease. The main indications for tracheostomy were 58% secondary to airway disease and 42% due to chronic use of MV. Within the airway disease group, subglottic stenosis, vocal cord paralysis, and tracheobronchomalacia were the principal reasons for indication, and in the group of chronic use of MV, the main causes were bronchopulmonary dysplasia and chronic lung disease. We did not find tracheostomy-related mortality. 89% of the patients were discharged with tracheostomy and 59% with chronic use of MV. The probability of being discharged with a tracheostomy was higher in younger patients while the chronic use of MV at discharge was higher in patients with a greater number of extubation failures before tracheostomy. **Conclusion***:* Tracheostomy is a safe procedure in children, where the predominant causes of indication are airway disease and the need for chronic use of MV. Most children with tracheostomies are discharged with tracheostomy and chronic use of MV. Younger children, those with difficult weaning, confirmed or suspected genopathy, or special health needs are at greater risk of needing tracheostomy and chronic use of MV.

Introduction

It has been reported that between 2.2 to 19% of children hospitalized in pediatric intensive care units who require mechanical ventilation (MV) may require tracheostomy[1]. This percentage is higher in risk groups, such as children with chronic respiratory, cardiological, and neurological conditions, in whom MV is usually for longer periods[2,3].

In the last 30 years, there has been a change in the indication for tracheostomy in pediatrics, from an emergency indication due to obstructive upper airway compromise, to an indication for prolonged use due to congenital airway malformations or prolonged MV dependency. Although prolonged MV is one of the growing reasons for tracheostomy, there is no consensus on its definition. One of the most widely accepted is that proposed by Sauthier M et al[4], who after a systematic review defined prolonged MV in pediatrics as the use of MV ≥ 21 consecutive days for more than 6 hours per day, whether invasive or noninvasive.

Advances in different surgical techniques, pediatric and neonatal intensive care, among other specialties, have allowed greater survival and quality of life for complex patients who can be grouped under the term CYSHCN (Children and Youth with Special Health Care Needs)[5]. Patients with craniofacial or airway malformations, bronchopulmonary dysplasia (BPD), congenital heart disease (CHD), congenital or acquired neuromuscular diseases, among other conditions, may require tracheostomy as a special need that allows them to optimize their development and reduce long-term morbidity[6,7].

In our local setting , the evidence on the reason for tracheostomy indication in intensive care units is limited. In a study carried out by Ríos Deiddan et al. in a tertiary healthcare center in Chile, out of 56 children with tracheostomy in the period 2001-2008, the main indication was airway pathology (70%) and prolonged ventilation (30%)[8]. The objective of this study is to describe the indications for tracheostomy in a highly complex pediatric intensive patient unit (PICU) and the associated morbidity. As a secondary objective, to describe the pre- and post-tracheostomy clinical characteristics in order to explore which factors could be determinant for the best timing of its indication.

Patients and Method

Descriptive, retrospective, case series study. Through electronic records, we collected hospital discharges between 2005 and 2015 of all children under 15 years of age with indication of tracheostomy at the Clinical Hospital of the Pontifical Catholic University of Chile. Those patients who underwent tracheostomy during hospitalization were included in the analysis. Clinical Hospital of the Pontifical Catholic University of Chile is a tertiary center located in an urban area in Santiago, Chile, which is also a national referral center for congenital heart surgery.

The clinical records were analyzed individually, obtaining demographic variables and clinical characterization before and after tracheostomy, stay in the intensive care unit, age at the time of tracheostomy, indication for tracheostomy, early complications (within 7 days after tracheostomy), late complications (more than 7 days after tracheostomy), and mortality.

For the statistical analysis, we used the statistical software Stata 15.1 SE (StataCorp, Texas, USA). Descriptive statistics were performed according to the nature of the variable, and Shapiro Wilks normality test for continuous variables. The exploration of an association between variables was evaluated with univariate regression models according to the nature of the outcome variable. We used logistic regression for

dichotomous variables; Ologit regression for ordinal variables, both with odds ratio (OR) reported; negative binomial regression for discrete variables, with incidence risk ratio (IRR) reported; and simple linear regression for continuous variables, with coefficient β reported. All reported coefficients present 95% confidence interval (95%CI) and p-value.

For the comparison of differences with statistical significance between nominal variables, the Chi-square test was used[2]. A p-value < 0.05 or the crossing of the neutral value by the 95%CI was considered statistically significant. For the exploratory analysis of hospitalization stays and related variables, Kaplan-Meier estimation was used with comparison between curves by Mantel-Cox test, and evaluation of the association by Cox proportional-hazards model reporting Hazard ratio (HR), 95%CI, and p-value.

This study was approved by the Clinical Research Ethics Committee of the Pontifical Catholic University of Chile (Project 16-200).

Results

Of 65 hospital discharges with tracheostomy, 59 patients who underwent tracheostomy during their hospitalization in this center were analyzed. Six patients were excluded since they had tracheostomy at admission. Figure 1 and Table 1 summarize the indication for tracheostomy by group and by specific cause, respectively.

During the period 2005-2015, the number of new tracheostomies has remained stable in our center, performing between 6 to 10 interventions per year. During the period 2005-2009, the indication for tracheostomy due to airway disease was 65% and the prolonged MV group was 35%, and in the period 2010-2015, it was 54% and 46%, respectively. The comparison of both groups of tracheostomy indication did not show significant differences between the periods 2005 to 2009 compared with 2010 to 2015 (p = 0.707).

Figure 2 shows the number of tracheostomies performed by age group. 59% corresponded to children under 6 months of age. 39% were diagnosed with a confirmed genetic syndrome or were under investigation for it. Of these, the most frequently reported complex congenital heart disease was hypoplastic left heart syndrome (HLHS). The median (range) number of days in MV before tracheostomy was 28 days (1-180). 25% of the children had at least one episode of extubation failure. Table 2 summarizes the clinical characteristics before tracheostomy.

Table 3 summarized the clinical characteristics, stay in the PICU, complications, and need for MV and/or tracheostomy at discharge. Of the total number of patients, 53 were discharged with tracheostomy, 23 with home hospitalization, and 24 returned to their referral hospital. Six patients were decannulated and discharged home.

We found no mortality associated with the tracheostomy technique. Six patients died during their stay. The deaths occurred more than 28 days after the tracheostomy was performed and were secondary to complications derived from their underlying diseases. Of this group, five patients underwent tracheostomy due to the need for prolonged MV of cardiopulmonary cause and one patient due to airway disease.

In the exploration of associations, we reported that the older the age at tracheostomy, the lower the probability of discharge with tracheostomy (OR 0.99; 95%CI 0.97-0.99; p < 0.005). Figure 3 shows the different tracheostomy indication groups and their age, with no significant difference between them. The time in MV after tracheostomy is greater in children with confirmed or suspected genopathy, HR 0.56 (95% CI, 0.36-0.89; p < 0.005); in the CYSHCN group, HR 0.55 (95% CI, 0.32-0.95; p < 0.005), and in those with a greater number of days on ventilation before tracheostomy, HR 0.98 (95% CI, 0.98-0.99), p < 0.005). On the other hand, the probability of discharge with prolonged MV is higher in those children with greater time on MV after tracheostomy (OR 1.01; 95% CI, 1.00-1.03; p = < 0.005) and those children with a greater number of extubation failures before tracheostomy (OR 5.30; 95% CI, 1.71-16.5; p = < 0.005).

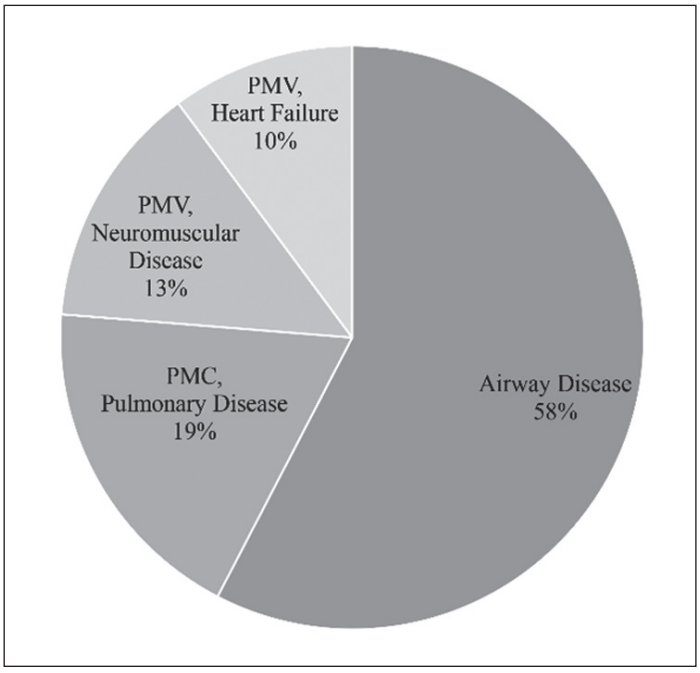

Figure 1. Indications of Tracheostomy. PMV: Prolongued Mechanical Ventilation.

Table 1. Indication of tracheostomy in a cohort of pediatric patients

Subjets, n (%)	59 (100)
Airway desease, n (%)	34 (58)
Subglottic Stenosis	8
Vocal chord paralysis	8
Tracheobronchomalacia	8
Subglottic hemangioma	1
Severe post-extubation laryngitis	1
Subglottic Cysts	1
Macroglossia	1
Choanal atresia	1
Tracheal Stenosis	1
Floor of the mouth tumor	1
Severe micro-retrognathia	1
Lymphoproliferative Syndrome	1
Cervical Neurofibroma	1
Prolongued mechanical ventilation, n (%)	25 (42)
Pulmonary Disease, n (%)	11 (19)
BPD	6
CLD	4
Pulmonary Hypoplasia (CDH)	1
Neuromuscular Disease, n (%)	8 (13)
Diafragmatic paralysis	2
Myotonic Dystrophy	2
Centronuclear Myopathy	1
Menkes Disease	1
Cerebral Palsy	1
Critical illness myopathy	1
Heart Failure, n (%)	6 (10)
Hypoplastic left heart syndrome	3
Truncus Arteriosus	1
d-TGA	1
Tricuspid atresia	1

DPD, Bronchopulmonary Dysplasia; CLD, Chronic Lung Disease; CDH, Congenital diaphragmatic hernia; d-TGA, dextro-Transposition of the great arteries.

Discussion

In this series of tracheostomized patients during the period 2005 to 2015, we observed that, as reported in international publications, tracheostomy is mainly performed in the group under 6 months of age and the indication for MV is growing in importance[9-18]. Gergin et al describe that between 1984 and 2014, there has been a change in the indication for tracheostomy in pediatrics, from its indication mainly due to airway disease and craniofacial malformations, to the indication for prolonged MV of cardiopulmonary cause or neuromuscular disease[6]. In our study, we found a similar trend. On the other hand, if we take as a starting point the study by Ríos Deidan C et al. carried out in a tertiary referral center in Chile between 2001 and 2007, we see that 71% of the children were tracheostomized due to airway compromise and 28% due to the need for prolonged MV. In the period analyzed in our study, both groups of indications tended to be similar, reaffirming the above.

The specific indications for tracheostomy due to airway disease observed in the patients analyzed are similar to those reported in the literature. The high number of vocal cord paralysis and subglottic stenosis as the main cause of tracheostomy has been described in congenital heart surgery referral centers. In studies carried out in pediatric hospitals in the United States by Gorantla et al[19] and Khariwala SS et al[20], it is described that in the postoperative period of congenital heart disease, 5% of the operated children present vocal cord dysfunction, 6% bilateral vocal cord paralysis, and 33% subglottic stenosis. In both studies, these conditions were directly related to the need for tracheostomy.

In the patients analyzed, the main cause of prolonged MV requiring tracheostomy was cardiopulmonary

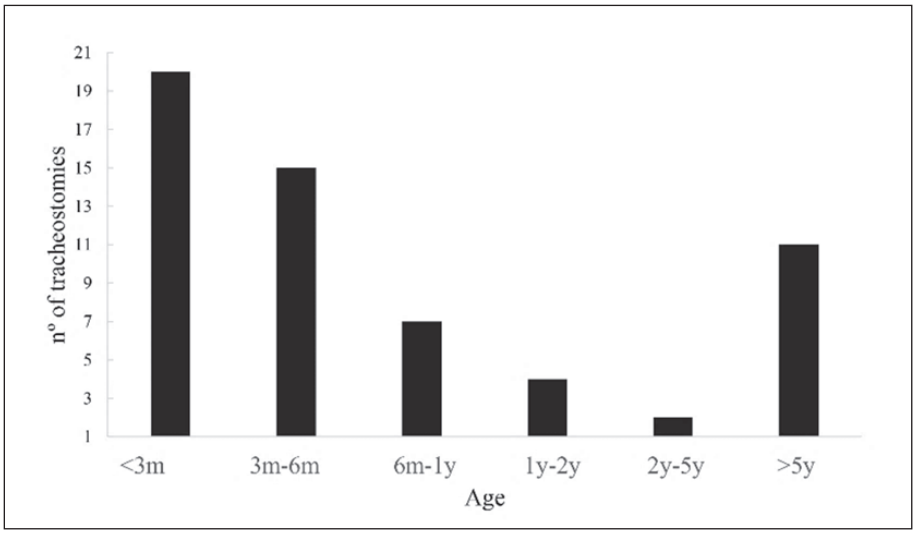

Figure 2. Age ranges at the time of Tracheostomy.

Table 2. Clinical and demographic characteristics before tracheostomy

Subjets, n	59
Age of tracheostomy (months), median (min-max)	4 (0-180)
Male, n (%)	39 (66)
Prematurity, n (%)	20 (34)
Genetic Syndrome, n (%)	23 (39)
Congenital heart disease, n (%)	25 (42)
HLHS	6
Patent Ductus Arteriosus	6
Aortic Coarctation	3
Tetralogy of Fallot	2
Truncus Arteriosus	2
Interauricular communication	2
HRHS	2
Interventricular communication	1
Hypertrophic cardiomyopathy	1
MV, n (%)	45 (76)
Cause of MV	
Airway disease	12
Cardiopulmonary disease	23
Neuromuscular disease	10
Duration of MV, median (min-max)	28 (1-180)
Ventilator associated pneumonia, n (%)	13 (29)
Extubation failure, n (%)	45 (76)
Nº of extubation failure, median (min-max)	1 (1-5)
Airway endoscopy prior to tracheostomy, n (%)	43 (73)

HLHS: Hypoplastic left heart Syndrome; HRHS: Hypoplastic right heart Syndrome; MV, mechanical ventilation.

Table 3. Clinical outcomes after tracheostomy

Early complications (< 7 days), n (%)	13 (22)
Tracheitis	11
Peristomal granuloma	1
Subcutaneous emphysema	1
Late complications (> 7 days), n (%)	18 (30)
Peristomal granuloma	8
Tracheitis	9
Accidental decannulation	1
28-day mortality, n	0
PICU Long of stay (days), mean (± SD)	60 (± 58)
Tracheostomy at discharge , n (%)	53 (89)
Mechanical Ventilation at discharge, n (%)	35 (59)

PICU, Pediatric intensive care unit.

disease, with BPD as the main indication. Up to 6.9% of the need for tracheostomy has been described in premature newborns under 1000 grams, with BPD as the main indication, and a mean of 112 days on MV before tracheostomy[21]. In cases in which heart failure was the main cause for indicating MV, we found that HLHS was the most frequent congenital heart disease. Up to 2.7% of children who have undergone congenital heart surgery present difficulties when suspending MV and may require tracheostomy, and one of the most frequently associated heart diseases was HLHS. The need for tracheostomy in this group of patients is usually accompanied by genetic anomalies, tracheal and esophageal

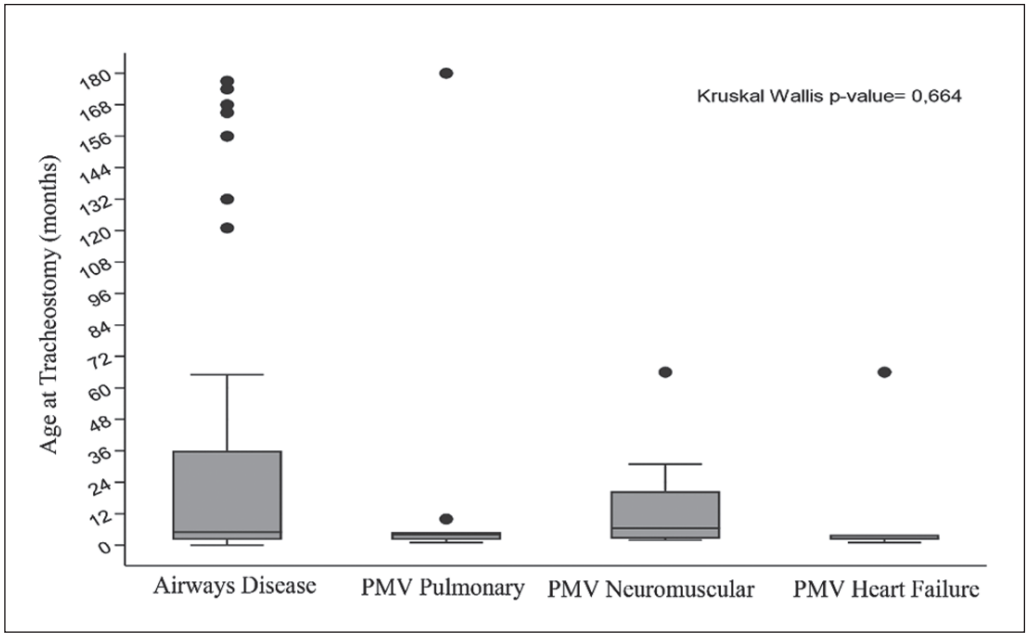

Figure 3. Age at the time of Tracheostomy by groups of indictaions. PMC: Prolongued Mechanical Ventilation.

anomalies, laryngomalacia, diaphragm alterations, and consequences of surgery such as vocal cord paralysis or prolonged extracorporeal circulation[22,23].

Defining when a tracheostomy should be performed in children in the pediatric and neonatal intensive care who fail to discontinue MV still remains controversial. In adults, it has been described in different systematic reviews that early tracheostomy (less than 7 to 14 days of MV) could have benefits in reducing the number of days of ICU stay, MV-associated pneumonia, and mortality[24,25]. In pediatrics, a systematic review by AMM Abdelaal et al[26] concludes that its early performance (less than 14 days of MV) would reduce MV time, ICU stays, and hospitalization days, with a tendency to lower mortality, however, they presented a low level of evidence. In our series, the mean number of days on MV before tracheostomy was high (28 days). In a multicenter study by Wakeham MK et al[27], of 11,466 children admitted to the ICU, they reported a median of 14 days on MV before tracheostomy with a range of 5 to 25 days. In that study, the independent predictors of tracheostomy were age less than 12 months, 2 or more reintubations, cardiopulmonary disease, and longer MV days, which is consistent with our findings.

Similar to that reported by McCrory MC et al[1] in their series of tracheostomized children, we found that the probability of discharge with tracheostomy is higher in younger children, and the probability of discharge with MV is greater in those patients who presented a higher number of extubation failures, days on MV before tracheostomy, younger age, confirmed genopathy or under study, and categorized as CYSHCN. Since the evidence is not yet categorical in defining the best time for tracheostomy[26], we believe that it is useful to consider these predictors of the need for tracheostomy and MV at discharge when making this decision.

We did not find mortality related to direct complications of tracheostomy. The literature reports mortality related to the technique between 0.7 to 3.6%[28-32]. JL Funamura et al[31] during a follow-up of 517 tracheostomized children between 1984 and 2015, found overall mortality of 16%. Of this group, 5.9% of cases died during the same hospital stay in which the tracheostomy was performed. A 0.6% mortality rate was related to a tracheostomy care complication such as cannula obstruction or displacement. The authors point out that comorbidities influence mortality, and the group with indication for tracheostomy due to MV of cardiopulmonary cause (BPD and CHD) is the group at the highest mortality risk, which coincides with the cases of death found in our study.

22% of the patients presented some early complication, with tracheitis as the main one, followed by one case of granuloma and one case of subcutaneous emphysema. 30% presented late complications, mainly tracheitis, granulomas, and accidental decannulation. The literature describes a rate of 18 to 56% of complications during hospital stay, mainly pneumothorax, pneumomediastinum, granulomas, infections, and accidental decannulation[11,32]. We found only one case of accidental decannulation, which could be due to underreporting.

Our decannulation rate during hospitalization was 10%. The rate of decannulation during the same hospitalization as the tracheostomy is variable in the different published series. It is described between 35-75% depending on the indication, and it is performed early in cases of trauma and later in the prolonged MV group[33]. In our study, the main causes of tracheostomy were subglottic stenosis and the need for prolonged MV. The first group may require surgical interventions before attempting decannulation, and in those patients requiring MV, rehabilitation and growth time are required to suspend MV and consider decannulation.

One of the main strengths of this study is that it shows a10-year experience in performing tracheostomies in a tertiary center with referral of cardiac surgery patients in Chile. We could observe that the need for tracheostomy due to airway disease is similar to the need for prolonged MV. On the other hand, we have characterized a group of children who would be at greater risk of leaving the hospital with the need for tracheostomy and MV, which allows us to hypothesize on who would benefit from a more opportune performance of tracheostomy.

Our study has limitations, mainly due to its retrospective nature, there may be an underreporting of complications related to tracheostomy. On the other hand, our follow-up lasted until patients were discharged or transferred to their referral centers, which limits the evaluation of long-term prognostic follow-up variables.

Conclusions

Compared with previous national reports, the indication for tracheostomy due to the need for prolonged ventilation has increased, which is similar to what is described in international series. The need for tracheostomy due to airway disesase remains as the main indication for tracheostomy in children, and the indication for prolonged use of MV is also important. Younger children, with a greater number of extubation failures, confirmed or suspected genopathy, or with special health needs are at greater risk of needing tracheostomy and prolonged MV. These factors should

be considered for a timely decision to perform a tracheostomy. It is important to systematize the follow-up of tracheostomized children for better reporting of complications and associated morbidity.

Ethical Responsibilities

Human Beings and animals protection: Disclosure the authors state that the procedures were followed according to the Declaration of Helsinki and the World Medical Association regarding human experimentation developed for the medical community.

Data confidentiality: The authors state that they have followed the protocols of their Center and Local regulations on the publication of patient data.

Rights to privacy and informed consent: This study was approved by the respective Research Ethics Committee, which, according to the study's characteristics, has accepted the non-use of Informed Consent.

Conflicts of Interest

Authors declare no conflict of interest regarding the present study.

Financial Disclosure

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