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Predictors and Associations of Prolonged Tracheostomy in Pediatric Cardiac Surgical Patients

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Abstract

Objectives: To describe the predictors and associations of prolonged tracheostomy duration in pediatric cardiac surgical patients.

Method: Prospective study. All pediatric patients below 10 years of age who underwent tracheostomy after cardiac surgery from January 2019 to December 2019, were subdivided into short and long groups according to the tracheostomy duration during the intrahospital stay if more than 21 days. Different variables were compared.

Results:1084 pediatric patients who underwent cardiac surgery during study period, 41 (3.7%) received tracheostomy. LT group was associated with univentricular repair (p=0.03) and sepsis (p=0.04), longer days of ventilation (p=0.0005), higher number of extubation trials (p=0.02), higher accidental tracheostomy tube dislodgement (p=0.048), ventilator-associated pneumonia (p=0.013), more days of feed interruption (p=0.0089), higher days of hospital stay (p=0.0001) and intensive care unit stay (p=0.0001). ST was associated with significantly higher anticipated longer duration of ventilation and earlier liberation from the ventilator as an indication for tracheostomy than LT (p=0.02).

Conclusions: Univentricular repair, sepsis, longer mechanical ventilation, longer duration of intensive care unit and hospital stay, a higher number of extubation trials, higher number of accidental tracheostomy tube dislodgement, ventilator-associated pneumonia, higher days of feed interruption were found to be significant associations with a long duration tracheostomy.

Keywords: Prolonged, Tracheostomy, Pediatric, Cardiac surgical patients

Introduction

There has been fabulous advancement and progress in cardiac surgery in infants and children due to growth in perfusion, postoperative care, cardiac anesthesia, and improvements in surgical practices. Respiratory failure following cardiac surgery is associated with increased mortality and resource utilization, requiring prolonged postoperative mechanical ventilation (MV). Many of them have to face its associated morbidities, as well as mortality postoperatively. The improvement in MV protocols and early extubation shortens the intensive care unit (ICU) stay and results in fewer complications and improved outcomes. For those who need prolonged MV, the endotracheal tube is often replaced by a tracheostomy tube for smooth liberation from MV and to improve patient comfort and survival. Tracheostomy is usually performed in children undergoing high-risk complex surgical procedures, and post-surgery cardiac complications, such as severe ventricular

dysfunction, low cardiac output, residual lesions, sepsis, syndromic association, airway issues, etc. [1-4].

Even though tracheostomy is a modality for liberation from MV, studies have found that tracheostomy after cardiac surgery has been associated with poor prognosis in this population, with reported 1-year mortality greater than 60% and survival rates as low as 16% at 5 years [5]. This means that tracheostomy has to be viewed as a complication and measures for reducing the duration of tracheostomy should be taken. Predictors of PMV after pediatric cardiac surgery are investigated in several studies [1-4]. However, there is a dearth of literature describing the predictors and associations of prolonged duration tracheostomy among pediatric cardiac surgical patients. Identification of these parameters in each center can guide clinicians in choosing the best management protocol towards hospital discharge. We thus decided to evaluate the predictors and associations of LT among postoperative pediatric cardiac surgical patients.

Methods

We conducted a prospective study on 1084 children ≤ 10 years of age who underwent cardiac surgery during the study period from January 2019 to December 2019 at a tertiary care institute and were under care at the Cardiac Surgical Intensive Care Unit (CSICU), All India Institute of Medical Sciences, New Delhi, India. A total of 41 of them underwent tracheostomy postoperatively. This study was approved by the Institute Ethics Committee (IECPG-472). Informed consent was taken from the parents of the participants. Those who were tracheostomized before surgery as well as those who did not wish to participate were excluded from the study. The decision to perform a tracheostomy was made by the intensivist and cardiac surgeon together, based on postoperative problems like cardiac complications, including ventricular dysfunction, residual defects, neurological injury, sepsis, airway abnormality, inability to wean from MV, etc. The timing of tracheostomy was based on the hemodynamic stability, the anticipated course in the ICU including morbidities and, after reviewing, various clinical and laboratory parameters. Tracheostomy was considered to be early if performed within 7 days of onset of MV. All the tracheostomies were performed surgically at the bedside in the CSICU. Enteral feeding was interrupted for 6 hours for the procedure. The choice of cuffed or uncuffed tube was based on the standard guidelines as per the age of the patient. Antibiotics were continued as per the unit protocol, based on individual patient profiles. Post-tracheostomy weaning of MV was continued in a stepwise manner. Enteral nutrition was continued through Ryle's tube till the child started accepting orally. Patients were discharged from the intensive care unit to the ward after a mandatory period of 48 hours of unsupported ventilation, minimal secretions, and adequate gas exchange. We preferably try to decannulate our patients in the ICU before discharge.

Data of the study participants including preoperative, intraoperative, postoperative, peri tracheostomy, and outcome variables were collected and analyzed. The study population was divided into two groups according to the tracheostomy duration during the intrahospital stay: "short" if less than 21 days or "long" if more than 21 days. Different variables were compared between short (ST) and long (LT) tracheostomy. These data were compared between the short-duration (ST) and long-duration (LT) tracheostomy. The outcomes of the study were the predictors of survival, and other associations like the length of hospital stay, intensive care unit stay, sepsis, complications etc.

Definitions

1. High-risk cardiac surgery was defined according to the risk adjustment for congenital heart surgery (RACHS)1 score.

2. Acute kidney injury (AKI) was defined according to the kidney disease improving global outcomes (KDIGO) criteria [6].

3. Central nervous system (CNS) event: Any change in the Glasgow coma scale (GCS) score or any postoperative neurologic disorder (visual, cognitive, motor, or speech) documented and/or neurologic disability severely affecting day-to-day functioning was attributed to a CNS pathology or biochemical changes.

4. Sepsis was defined as per the sepsis 3 definition [7].

5. Hospital-acquired infections (HAI), including catheter-associated urinary tract infection (CAUTI), catheter-related bloodstream infection (CRABSI), ventilator-associated pneumonia (VAP), and surgical site infection (SSI) were defined, according to the Center for Disease Control and Prevention (CDC) definitions [8].

Statistical analysis

Statistical analysis was performed with the use of SPSS version 20 (Stata Corp, 4905, Lake Way Drive, College Station, Texas, 77845, USA). Demographic and clinical variables were described as median (interquartile range [IQR]) and frequencies (%) for categorical variables. Variables were compared using the nonparametric Wilcoxon– Rank sum test for the continuous data and Fisher's exact test for categorical variables. A "p" value <0.05 was considered statistically significant.

Results

During the 1-year study period, 1084 index pediatric cardiac operations were performed on children below 10 years of age. Tracheostomy was performed in 41 (3.7%) of these patients. The median age of 41 tracheostomized children was 1 year. As many as 30 (73%) of these children were males and 11

(27%) were females. Five children were syndromic—two had trisomy 21, one child had thrombocytopenia absent radius (TAR) syndrome, one had Goldenhar syndrome, and one had Vertebral defect, Anal atresia, Cardiac defect, Tracheoesophageal fistula, Renal and Limb abnormality (VACTERL) association. Preoperative variables such as sepsis, MV, previous surgery, chronic lung disease, neuromuscular disease, etc. were assessed among the study population. Details regarding comprehensive cardiac diagnoses, surgical procedures, RACHS1 score, and tracheostomy duration in the study population are elaborated in **Table 1**. Among the 41 children, 23 (56%) belonged to the ST group and 18 (44%) belonged to the LT group.

Patient demography, anthropometric measurements, preoperative & and intraoperative variables, postoperative complications, HAI, postoperative outcome variables and nutrition are compared in **Table 2**. Univentricular physiology was associated significantly with the LT group (p=0.03). The number of accidental tracheostomy tube dislodgement (p=0.048) and number of extubation trials (p-0.02) were significantly higher in the LT. LT group was also associated with significantly higher culture-proven sepsis (p=0.003), ventilator-associated pneumonia rate (p=0.013), ventilator-associated pneumonia before tracheostomy (p=0.008) and higher feed interruption (p=0.009). We also noticed that the indication of tracheostomy being an anticipated prolonged

Table 1. Pediatric cardiac surgery patients who required tracheostomy postoperatively.

S no	Diagnosis	Cardiac surgery	No of patients (%)	Risk Adjustment for Congenital Heart Surgery -1 Score	Number of Short tracheostomy (ST) patients (%)
1	Tetrology of fallot	Total correction	10 (24.3)	2	7 (1.7)
2	Ventricular septal defect	Ventricular septal defect closure	3 (7.3)	2	3 (7.3)
4	Transposition of great arteries	Arterial switch operation	10 (24.3)	4	5 (12.2)
4	Supra cardiac total anomalous pulmonary venous connection	Total anomalous pulmonary venous connection repair	2 (4.8)	2	1 (2.4)
5	Infra cardiac total anomalous pulmonary venous connection	Total anomalous pulmonary venous connection repair	2 (4.8)	4	0 (0)
6	Atrioventricular septal defect	Atrioventricular septal defect repair	6 (14.6)	4	4 (9.8)
7	Pulmonary atresia intact ventricular septum	Pulmonary valvotomy right ventricular outflow tract patch	1 (2.4)	2	0 (0)
8	Idiopathic pulmonary artery hypertension	Potts shunt	2 (4.8)	3	0 (0)
9	Tetrology of fallot pulmonary atresia hypoplastic main and left pulmonary artery	Right modified blalock taussig shunt followed by bidirectional glenn	2 (4.8)	3	0 (0)
10	Ebstein's anomaly	Cone repair	1 (2.4)	5	1 (2.4)
11	Type-3 patent truncus arteriosus	Truncus arteriosus repair	1 (2.4)	5	0 (0)
12	D-transposition of great arteries large inlet ventricular septal defect pulmonary atresia aortopulmonary collaterals post-right modified blalock taussig shunt/bidirectional glenn/ azygous vein ligation post coil	Completion fontan	1 (2.4)	3	0 (0)
13	Partial atrioventricular septal defect patent ductus arteriosus severe pulmonary hypertension	Pulmonary artery band atrial septectomy patent ductus arteriosus ligation	1 (2.4)	3	1 (2.4)
14	Ventricular septal defect mesocardia small right ventricle	Bidirectional glenn ventricular septal defect closure	1 (2.4)	2	1 (2.4)
		TOTAL	41 (100)		23 (56)

Table 2. Comparison Between Short Duration (ST) and Long Duration (LT) Tracheostomy.

S no	Clinical Variable	Short Duration Tracheostomy (ST) (n=23)	Long Duration Tracheostomy (LT) (n=18)	P value
1	Age, in years, median (IQR)	2 (0.5,5)	0.875 (0.2,2)	0.188
2	Male sex, in number (%)	17 (73.9)	13 (72.2)	0.589
3	Weight in kg, median (IQR)	8.4 (4.8,12.5)	6.4 (3.3,9.6)	0.264
4	Preoperative hospitalization in number of days, median (IQR)	2 (1,5)	5 (1,11)	0.249
5	Chromosomal anomaly, in number (%)	3 (13.0)	2 (11.1)	0.619
6	Difficult airway, in number (%)	5 (21.7)	4 (22.2)	0.630
7	Neuromuscular disorder, in number (%)	0 (0)	1 (5.5)	0.431
8	Chronic lung disease, in number (%)	0 (0)	1 (5.5)	0.431
9	History of immediate preoperative mechanical ventilation, in number (%)	2 (8.6)	3 (16.6)	0.381
10	History of previous cardiac surgery, in number (%)	4 (17.3)	5 (27.7)	0.336
11	Preoperative sepsis, in number (%)	4 (17.3)	6 (33.3)	0.208
12	Cyanotic congenital heart disease, in number (%)	18 (28.2)	15 (83.3)	0.500
13	Univentricular physiology, in number (%)	0 (0)	4 (22.2)	0.030
14	High risk surgery, in number (%)	10 (43.4)	11 (61.1)	0.210
15	Cardiopulmonary bypass time, in minutes, median (IQR)	143 (106,216)	127 (84,171)	0.499
16	Aortic cross clamp time, in minutes, median (IQR)	93 (65,166)	69 (54.5,118)	0.343
17	Postoperative bleeding, in number (%)	6 (26.0)	6 (33.3)	0.434
18	Re-exploration, in number (%)	7 (30.4)	10 (55.5)	0.097
19	Delayed sternal closure, in number (%)	9 (39.1)	6 (33.3)	0.479
20	Post operative ECMO required, in number (%)	1 (4.3)	1 (5.5)	0.691
21	Residual defect in the immediate post operative echo, in number (%)	9 (39.1)	7 (38.8)	0.621
22	Central nervous system event in the form of seizures or low sensorium, in number (%)	5 (21.7)	7 (38.8)	0.197
23	Acute kidney injury, in number (%)	9 (39.1)	7 (38.8)	0.621
24	Unanticipated arrest, in number (%)	6 (26.0)	9 (50)	0.106
25	Accidental tracheostomy tube dislodgement, in number (%)	1 (4.3)	5 (27.7)	0.048
26	Pressure sore, in number (%)	4 (17.3)	8 (44.4)	0.061
27	Sepsis, in number (%)	4 (17.3)	12 (66.6)	0.003
28	Procalcitonin, in ng/ml, median (IQR)	18 (7.5,21.7)	16.1 (1.8,63)	0.695
29	Galactomannan, in ODI, median (IQR)	1 (1,1.7)	1 (0.24,1.2)	0.644
30	Ventilator associated pneumonia, in number (%)	4 (17.3)	10 (55.5)	0.013
31	Ventilator associated pneumonia before tracheostomy, in number (%)	1 (4.3)	7 (38.8)	0.008
32	Ventilator associated pneumonia after tracheostomy, in number (%)	3 (13.0)	6 (33.3)	0.120

33	Catheter related blood stream infection, in number (%)	1 (4.3)	2 (11.1)	0.407
34	Catheter associated urinary tract infection, in number (%)	1 (4.3)	1 (5.5)	0.691
35	Superficial tracheostomy site infection, in number (%)	2 (8.6)	6 (33.3)	0.057
36	Surgical site infection, in number (%)	1 (4.3)	3 (16.6)	0.216
37	Antibiotic escalation, in number (%)	10 (43.0)	14 (77.6)	0.132
38	Antifungal therapy, in number (%)	7 (30.4)	8 (44.4)	0.132
39	Nil per oral, in number of days, median (IQR)	2 (1,3)	3 (2,3)	0.051
40	Total parenteral nutrition, in number of days, median (IQR)	1.5 (0,4)	2.5 (0,15)	0.509
41	Feed interruption, in number of days, median (IQR)	2.5 (1,4)	9 (3,15)	0.009
42	Indication for tracheostomy being anticipated prolonged ventilation and easy weaning from ventilator, in number (%)	8 (34.6)	1 (5.5)	0.028
43	Postoperative day of tracheostomy, median (IQR)	8.5 (7,14)	11 (7,18)	0.330
44	Days of ventilation, median (IQR)	16 (15,24)	52 (24,66)	0.0005
45	No of trials of extubation, median (IQR)	1 (0,1)	2 (1,2)	0.022
46	Intensive care unit stays, in number of days, median (IQR)	20 (15,28)	54 (36,82)	0.0001
47	Hospital stays, in number of days, median (IQR)	34 (20,44)	64 (50,90)	0.0001
48	Late tracheostomy complications, in number (%)	5 (21.7)	8 (44.4)	0.113
49	Death, in number (%)	7 (30.4)	5 (27.7)	0.566
IQR: Interquartile Range				

MV and for easy weaning from the ventilator was associated with the ST group (p=0.02). Number of days of MV (p=0.0005), intensive care unit stay (p=0.0001) and hospital stay (p=0.0001) were significantly higher in the LT group.

Discussion

This prospective study determined the predictors and associations of LT. During our literature search, we couldn't find any study which has studied the associations of prolonged tracheostomy duration following pediatric cardiac surgery. However, we could find similar observations to our findings made by investigators on prolonged MV following pediatric cardiac surgery.

The MV median was 22 days for our study population. In our study, the LT group had a significantly higher number of MV days. The incidence of prolonged MV in young children after congenital heart surgery was 10% - 19% [9], and in the adult population after cardiovascular surgery was 3% - 22% [10]. The incidence of PMV in Shi *et al.* [11] and Szekely *et al.* [12] were 35.4% and 25% respectively, and in the study by Polito *et al.* [13] 11% of pediatric patients undergoing cardiac surgery remained intubated for more than seven days. This is the reason why many centers opt for an elective tracheostomy after cardiac surgery anticipating a prolonged MV. In our study, we also found that the indication of tracheostomy being an anticipated prolonged MV and for easy weaning from the ventilator was associated with the ST group. We can also observe that the number of extubation trials before tracheostomy in the ST group was significantly lower than in the LT group.

We observed that there was a significant association between sepsis and ventilator-associated pneumonia with LT. Similar observations were made by Tabib A *et al.* [14] and Shi *et al.* [11]. These studies also noted that low cardiac output, fluid imbalance, age, weight, pulmonary hypertension before surgery, heart failure, respiratory complications, renal failure accompanied by delayed sternal closure, vaso-inotropic score and numbers of inotropes were significant associations. Our study couldn't demonstrate significant differences in these variables. We also noted that univariate physiology, accidental tracheostomy tube dislodgement, feed interruptions, intensive care unit, and hospital stays were significantly higher in the LT group.

Study limitations

The observational nature of this study precluded us from drawing any causality between the duration of tracheostomy and perioperative risk factors and other morbidities. Furthermore, we did not perform a formal cost analysis, but reductions in the intensive care unit and hospital stay were always associated with considerable cost savings and resource optimization. The study considered different age

groups altogether (neonate to 10 years). It was better to perform a subgroup analysis. The number of patients who underwent tracheostomy is low when compared with other studies which may limit the generalizability of the findings. Multicenter studies with a larger sample size can increase the statistical power and generalizability of the findings. Another important lacuna of this study was that we did not evaluate the intermediate and long-term associations. We compared the duration of tracheostomy following the hospital admission for cardiac surgery with different clinical variables.

Conclusion

Our study demonstrated that univentricular physiology, sepsis, and ventilator-associated pneumonia were predictors of long-duration tracheostomy among the postoperative pediatric cardiac surgical children who have undergone tracheostomy. LT was associated with significantly higher accidental tracheostomy tube dislodgement, extubation trials, feed interruption, days of MV, intensive care unit and hospital stay.

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