Tracheostomy in Pediatric Intensive Care Unit—A Two Decades of Experience

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Abstract

Aim and objective: To study the profile, indications, related complications, and predictors of decannulation and mortality in patients who underwent tracheostomy in the pediatric intensive care unit (PICU).

Materials and methods: Retrospective analysis of prospectively collected data of tracheostomies was done on patients admitted at PICU. Demographics, primary diagnosis, indication of tracheostomy, and durations of endotracheal intubation, mechanical ventilation, and tracheostomy cannulation were recorded. The indication was recorded in one of the four categories—upper airway obstruction (UAO), central neurological impairment (CNI), prolonged mechanical ventilation, and peripheral neuromuscular disorders).

Results: Two hundred ninety cases were analyzed. UAO (42%) and CNI (48.2%) were main indications in the halves of the study period, respectively. Decannulation was successful in 188 (64.8%) patients. Seventy-seven percentage UAO patients were decannulated successfully [OR (odds ratio); 95% CI (confidence interval), 2.647; 1.182–5.924, $p = 0.018$]. Age <1 year (0.378; 0.187–0.764; $p = 0.007$), nontraumatic, noninfectious central neurological diseases (0.398; 0.186–0.855; $p = 0.018$), and malignancy (0.078; 0.021–0.298; $p < 0.001$), durations of posttracheostomy ventilation (0.937; 0.893–0.983; $p = 0.008$), and stay in the PICU (0.989; 0.979–0.999; $p = 0.029$) were predictors of unsuccessful decannulation. There were 91 (31.4%) deaths. Age <1 year (2.39 (1.13–5.05; $p = 0.02$), malignancy (17.55; 4.10–75.11; $p < 0.001$), durations of posttracheostomy ventilation (1.06; 1.006–1.10; $p = 0.028$), and hospital stay (1.007; 1.0–1.013; $p = 0.043$) were independent predictors of mortality. Indication of UAO favored survivor (0.24; 0.09–0.57; $p < 0.001$).

Conclusion: The indications for tracheostomy in children had changed over the years. Infancy, primary diagnosis, length of posttracheostomy ventilation, and stay in the PICU and hospital were independent predictors of decannulation and mortality.

What This Adds

Similar to developed countries, the age at the time of tracheostomy and indication are changing. Inability to decannulate and mortality were associated with the age of a child at the time of tracheostomy, indication, medical diagnosis, and duration of postprocedure mechanical ventilation and stay in the hospital.

Keywords: Artificial airway, Decannulation, Outcome, Pediatric critical care, Tracheostomy.

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Introduction

Tracheostomy is a lifesaving procedure with potential complications. The indications for tracheostomy have shown a changing trend over the decades. In the 1970s, the inflammatory causes resulting in upper airway obstruction (UAO) were the most common indication for this procedure. Now in the pediatric and neonatal population, tracheostomy is required to relieve an obstructed or unstable airway due to congenital or noninfectious acquired causes, to assist long-term ventilation, or for a tracheobronchial toilet.[1,2] The role of tracheostomy and related outcomes in children has steadily evolved with improving critical care services. Although earlier reviews of the medical literature show pediatric tracheostomy to have two to three times more morbidity and mortality than adults, recent studies suggest that the incumbent risks in children are not as high as once perceived.[3–5] The published data on pediatric tracheostomy is on specific groups of patients, such as burn or trauma victims or neonates.[6,7] There are few epidemiological surveys and research studies on the impact of tracheostomy on morbidity and mortality in children admitted in the pediatric intensive care unit (PICU).[8–14] Our objectives were to study the profile, indications, related complications, and predictors of decannulation and mortality in patients who underwent tracheostomy in the PICU setting of a developing country.

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Methods and Materials

Study Setting, Design, and Data Collection

The study was conducted at a multispecialty teaching hospital with state-of-the-art pediatric critical care services. Clearance from the institutional research and ethics committee was obtained. This was a retrospective analysis of prospectively collected data of tracheostomies done on patients admitted to the PICU from January 2000 to December 2018. Data were recorded in preformed data sheet in the initial years, and later with the availability of internet and computers, it was captured in excel data sheet. Missing parameters, if any, were collected from medical charts. Demographics, primary diagnosis, indication of tracheostomy, and durations of endotracheal intubation, pre- and postcannulation mechanical ventilation, and tracheostomy cannulation were recorded. Length of stay in PICU and hospital were also recorded. The clinical diagnosis was classified according to the primary organ/system involved. Indication was defined as the fundamental reason (separate from primary clinical diagnosis) for tracheostomy placement. Indication was recorded in one of the four categories. Patients with congenital or acquired airway diseases leading to obstructive airways were categorized under UAO. This included isolated or in combination congenital laryngeal, tracheal, and bronchial airway anomalies, craniofacial deformities, facial and airway trauma, and acquired upper airway lesions like subglottic stenosis and corrosive and inhalational injuries. Patients with central neurological impairment (CNI) while on mechanical ventilation required tracheostomy because of their inability to protect the airway, recurrent aspiration and apnea, and for airway toilet. Similarly, patients with peripheral neuromuscular diseases (NMD), peripheral neuropathy, or muscular diseases required tracheostomy for airway toilet, home ventilation, and airway protection. We have assigned the prolonged mechanical ventilation (PMV) category to patients who were on invasive ventilation for sepsis, inflammatory diseases, and cardiopulmonary diseases for ≥14 days.

The decision for tracheostomy was taken by the intensivist, otorhinolaryngologist, and primary pediatrician collectively. Semiemergency tracheostomy was defined as a procedure done as a lifesaving measure after the initiation of advanced airway management. All other tracheostomies were performed as planned elective procedures. All tracheostomies were performed as an open procedure in the operation room under general anesthesia by an otorhinolaryngologist. Postprocedure patients were monitored in the PICU for a week or till the first tube change. The first tube change by the surgeon was done in the PICU on day 7 after ensuring maturity of the tracheostomy track. Complications occurring immediately (intraoperative and within 24 hours), early (<7 days), and late (≥7 days) were recorded.

Patient’s age <1 month, patients with tracheostomy done in the neonatal care unit of our hospital and in other hospitals and now admitted in our unit for critical care for a related or unrelated illness, and patients with incomplete data were excluded from the study.

Home Care, Parent’s Education, and Follow-up

All parents were trained about the routine care of tracheostomy tube and stoma as well as tube change and basic cardiopulmonary resuscitation by the attending intensivist. They were educated about the features of a tube block or displacement and were provided with a written emergency action plan with facilities of immediate help in their vicinity for any life-threatening situation. All patients were sent home with a spare tracheostomy tube, Ambu bag with mask, foot-operated suction machine, and proper size suction catheters. They were advised to change the tube every 10 to 14 days by an otorhinolaryngologist or by themselves if they were confident. The procedure of tube change by parents was witnessed by the educator before discharge.

After discharge, all patients were instructed for follow-up visits at 2–3 month intervals in the outpatient department by a pediatric pulmonologist and otorhinolaryngologist. Tracheostomy care was reemphasized. In case of a missed visit, parents were contacted telephonically or via postal mail to know the well-being of children before or after decannulation. In case of demises, possible cause, place, and date and month of death were noted. In case of no communication from parents, the last follow-up visit was noted to calculate the duration of tracheostomy *in situ*. The last enrolled patient was followed up for 1 year.

Decannulation

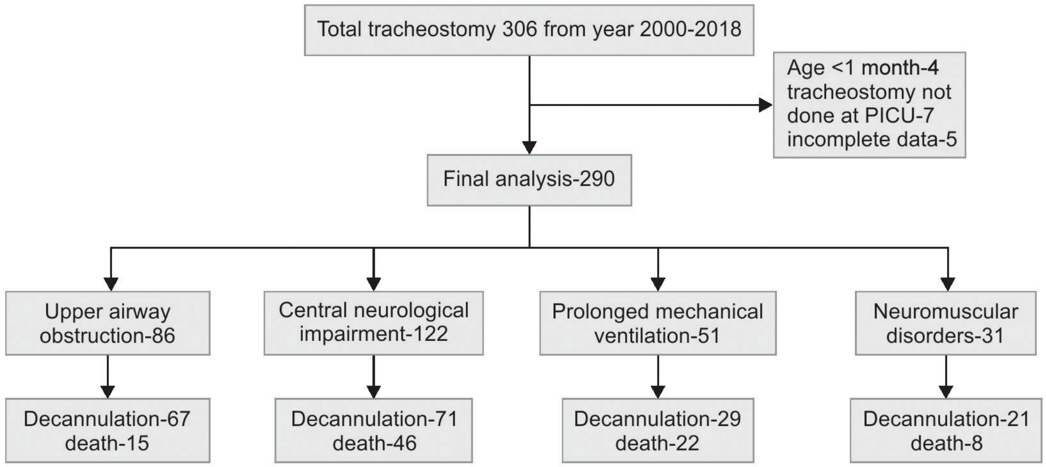
Decision for decannulation was taken in consultation with the otorhinolaryngologist. It was planned when the original indication for tracheostomy had resolved and the child was maintaining oxygen saturation >92% on room air with acceptable work of breathing, had good cough reflex, and was able to handle respiratory secretions and with no evidence of infections in the chest or otherwise. A flexible bronchoscopy was performed prior to decannulation to check the structural and functional suitability of airways.[15] Decannulation was done in the PICU by occluding the tracheostomy tube with an impermeable adhesive tape for 6 hours. Patients were monitored closely for cardiopulmonary instability. After decannulation, patients were monitored for 24 hours in the PICU and for another 24 hours in the ward.

Statistical Analysis

Patient characteristics were compared and described by appropriate statistics. Data were expressed as means (SD), medians (interquartile range [IQR]), and proportions as appropriate. Mann–Whitney *U*-tests were used to compare continuous variables, and chi-square test was used for categorical variables. Comparisons among various indications were performed using the Kruskal–Wallis test for continuous variables. To identify potential factors associated with decannulation, univariate analyses were performed. A multivariate logistic regression model was used to identify independent risk factors for decannulation. A stepwise approach was used to enter the terms into the model, with a limit of $p < 0.05$. Time-to-event variables were visualized using Kaplan–Meier curves for decannulation and survival. For all tests, a p value <0.05 was considered statistically significant. A statistical analysis was conducted using SPSS version 17.0 (SPSS, Inc., Chicago, Illinois).

Results

Out of 306 tracheostomies performed in the PICU from 2000 to December 2018, 290 cases were analyzed (Flowchart 1). From 2010 to 2018, there were 7,089 admissions in our PICU and, out of which, 2,462 (34.7%) cases received invasive mechanical ventilation. One hundred sixty-four (6.7%) cases underwent tracheostomy for various indications. Out of 290 tracheostomized patients, there were 210 males and the median (IQR) age was 36 (5–96) months. Moreover, 30/36 (83.3%) children with airway-related diseases and 19/22 (86.4%) with cardiopulmonary diseases were <1 year



Flowchart 1: Study diagram

Table 1: Characteristic differences between year 2000–2009 and 2010 –2018

Parameters	*2000–2009 (n = 126)*	*2010–2018 (n = 164)*	*p value*
Age (months)	18 (2,84) [a]	60 (10.7,120)	0.0001
Male	98 (77.8)	112 (68.3)	0.07
Indication			
UAO	53 (42.1) [b]	33 (20.1)	<0.0001
CNI	43 (34.1)	79 (48.2)	0.01
PMV	19 (15.1)	32 (19.5)	0.33
NMD	11 (8.7)	20 (12.2)	0.3
Pretracheostomy ETI	13 (4,21)	11 (7,16)	0.59
Complications			
Immediate	18 (14.2)	26 (15.8)	0.96
Early	14 (11.1)	24 (14.6)	0.91
Late	45 (35.7)	38 (23.1)	0.01
FFB			
Pretracheostomy	86 (82)	63 (38.4)	<0.0001
Posttracheostomy	114 (90.4)	102 (62.2)	<0.0001
Duration of tracheostomy (days)	155 (62,389)	119.5 (54,229.2)	0.007
PICU stay (days)	26.5 (13,47.7)	25 (16,41.2)	0.63
Hospital stay (days)	39 (24,68)	35 (22.7,53)	0.2
Survivor	89 (70.6)	110 (67)	0.42

[a]Median with interquartile range; [b]Number with percentage; UAO, upper airway obstruction; CNI, central neurological impairment; PMV, prolonged mechanical ventilation; NMD, neuromuscular disorder; ETI, endotracheal intubation; FFB, flexible fiberoptic bronchoscopy

of age, while 62.5% of patients with neoplastic diseases were over >5 years of age. Two hundred seventy-four children required pretracheostomy endotracheal intubation and ventilation and the median (IQR) duration of endotracheal intubation prior to tracheostomy was 12 (5–20) days. Table 1 compares patients' characteristics and outcomes from the year 2000 to 2009 and 2010 to 2018.

There were 31 semiemergency tracheostomies. There were 10 cases of subglottic stenosis (6 acquired and 4 congenital), 5 with severe mucositis (Stevens–Johnson syndrome and corrosive ingestion), 4 with severe laryngotracheomalacia, 4 with life-threatening oral or pharyngeal infections, 3 with facial or airway injury, 2 with congenital laryngeal web, and one each of congenital bilateral vocal cord palsy, airway hemangioma, and severe midfacial deformity. Ten cases were not endotracheally intubated while the rest were intubated for a short time (6.5 $\pm$ 3.2 hours) before tracheostomy tube placement.

The most common indication for tracheostomy was CNI followed by UAO (Table 2). The inability to protect the airway and failed extubation were the main reasons for tracheostomy in patients with CNI.

The majority of children had some form of infection or inflammatory disease (Table 3). Central nervous system infections of viral, bacterial, tubercular, and fungal etiology constituted 13.4% of the total cohort.

Tube malposition and bleeding at the operative site were the common immediate complications. Tube malposition was most frequent in patients <1 year of age in the first week of tracheostomy (15/20). Similarly, tube block by a clot or mucus plug was also frequent in infants (11/15). Bleeding was minor and did not require any medical or surgical interventions (Table 4). Lung atelectasis and stomal and tracheal granulation formation were the common complications in the first week and later, respectively. Forty-one infection-related complications occurred in our patients.

Decannulation was successful in 188 (64.8%) patients. The minimum duration of tracheostomy was 2 days in a child who died due to tube dislodgement and massive subcutaneous emphysema. The maximum duration of tracheostomy was 9.5 years in an infant with accidental corrosive ingestion and was still alive and attending school till last follow-up. The median duration of tracheostomy was maximal in patients with UAO and 77% were decannulated successfully. The success of decannulation varied with diagnosis—airway-related diseases (75%), infection/inflammatory disorders (71.3%), trauma/injury (82.2%), cardiopulmonary diseases (40.9%), nontraumatic, noninfectious central neurological diseases (47.5%), malignancy (18.8%), craniofacial/genetic diseases (52.9%), neuromuscular diseases (69.6%), and miscellaneous (75%). Two children—one of postliver transplantation and the other of diffuse necrotizing myelitis—died at home after successful decannulation. Age <1 year at the time of tracheostomy, diagnosis of nontraumatic noninfectious central nervous system diseases and malignancy, and prolonged duration of posttracheostomy mechanical ventilation

Table 2: Patient characterization and outcome according to indication of tracheostomy

Variables	*UAO (n =86)*	*CNI (n =122)*	*PMV (n =51)*	*NMD (n =31)*	*p value*
Age (months)	5 (1.5,24)[a]	74 (31,126)	10 (3,60)	96 (48,144)	<0.001
Male	68 (78.2)[b]	88 (72.7)	37 (67.3)	17 (63)	0.33
Duration ETi (days)	2 (1–10)	11 (8.5–15)	24 (16–30)	12 (9–21)	<0.001
Elective trach	56 (65.1)	121 (99.2)	51 (100)	31 (100)	<0.0001
FFB (Pre) No	22 (25.3)	86 (71.7)	17 (30.9)	15 (55.6)	
1	55 (63.2)	32 (26.7)	26 (47.3)	10 (37)	<0.001
≥2	10 (11.5)	2 (1.7)	12 (21.8)	2 (7.4)	
FFB (post) No	13 (14.9)	38 (31.7)	15 (27.3)	7 (25.9)	
1	35 (40.2)	64 (53.3)	27 (49.1)	15 (55.6)	0.001
≥2	39 (44.8)	18 (14.8)	13 (23.7)	5 (18.5)	
Complications					
Immediate	18 (20.7)	13 (10.7)	8 (14.5)	2 (7.4)	0.15
Early	11 (12.8)	9 (7.4)	12 (21.8)	3 (11.1)	0.02
Late	36 (41.3)	24 (19.8)	16 (29)	13 (48)	0.01
LOS PICU (days)	12 (8,25)	25 (18.5,34.5)	50 (41,70)	38 (23,77)	<0.0001
LOS hospital (days)	9 (12,39)	34 (26.5,49.5)	68 (45,83)	43 (31,80)	<0.0001
Days of trach	272 (83,510)	111 (55.5209)	75 (34,165)	154 (87,310)	<0.001
Outcome					
Survivor	71 (82.5)	76 (62.2)	29 (56.8)	23 (74.2)	0.002
Alive w/o tube	66 (76.7)	71 (58.2)	29 (56.8)	20 (64.5)	0.034
Alive with tube	5 (5.8)	5 (4.1)	0	3 (9.6)	—
Died with tube	14 (16.2)	46 (37.7)	22 (43.1)	7 (22.5)	0.001
Died after decannulation	1	0	0	1	—

UAO, upper airway obstruction; CNI, central neurological impairment; PMV, prolonged mechanical ventilation; NMD, neuromuscular disorders; ETI, endotracheal tube intubation; trach, tracheostomy; FFB, flexible fiberoptic bronchoscopy; LOS, length of stay; PICU, pediatric intensive care unit

and PICU stay were unfavorable independent risk factors for successful decannulation. UAO as an indication for tracheostomy was independently associated with decannulation (Table 5). The overall probability of decannulation and for individual indications is shown in Figure 1.

There were 91 (31.4%) deaths in our cohort and the majority were due to underlying diseases. The maximum number of deaths occurred in children with malignancies (75%) followed by cardiopulmonary diseases (59.1%) while only 5 of 36 (13.9%) children with airway-related diseases died (p value <0.0001). There were nine (3.1%) deaths directly related to tracheostomy. Seven children died because of tube block and massive surgical emphysema. Four of these deaths occurred in the hospital within 48 hours of tracheostomy and one died after 6 days of procedure in the hospital. Two children died at home due to accidental extubation and tube block. Two cases developed pneumonia and died at their native place. Age <1 year, malignancy, duration of posttracheostomy ventilation, and total length of hospital stay were independent risk factors for mortality while the indication of UAO was favorable for survival (Table 6). The probability of survival of the whole cohort among different indications was analyzed (Fig. 2). Three patients were lost during follow-up and were censored as alive as they were seen on the last visit.

Thirteen patients were alive with the tracheostomy tube *in situ* till the last follow-up. Five cases each required tracheostomy for airway protection and severe unresolved upper and lower airway diseases, two children had atlantoaxial dislocation resulting in respiratory and diaphragm paralysis, and one child with myopathy with cardiopulmonary compromise.

Discussion

This study was done at a tertiary-level PICU from 2000 to 2018. Infection/inflammatory diseases were the most common diagnostic category and CNI was the most common indication for tracheostomy tube placement. Younger children required tracheostomy mainly for UAO in the first 10 years as compared to subsequent years. Tube dislodgement and subsequent surgical emphysema were life-threatening complications in the immediate postprocedure period. Although the duration of tracheostomy was the longest in patients with UAO, the proportion of successful decannulation was higher in this group. Diagnosis of neoplastic diseases was associated with poor survival. A higher proportion of patients with CNI and PMV as indications died with the tracheostomy tube *in situ*.

Indications of pediatric tracheostomy are changing over the years. These varied according to the origin of the study and the year of publication. UAO due to infections like epiglottitis had been reported as the most common indication in the early 1970s.[1] Later on, congenital or acquired anatomical narrowing of upper airways became frequent indications.[16-18] In third-world countries, infections are still reported as a common

Table 3: Diagnostic categories of study cohort

Airway-related diseases (36)	*Infection/inflammatory diseases (88)*	*Trauma/injury (45)*
Airway malacia (13)	Acute pneumonia (15)	TBI (25)
TEF (5)	Meningitis/encephalitis (25)	Polytrauma (8)
Congenital SGS (4)	Septicemia (15)	Corrosive ingestion (5)
Acquired SGS (2)	TBM (14)	Drowning (3)
Congenital laryngeal web (3)	SJS (3)	Facial injury (2)
FB aspiration (3)	Hepatitis A (3)	Cervical spine injury (1)
Airway cleft (2)	Retropharyngeal abscess (2)	Burns (1)
Congenital vocal cord palsy (1)	Ludwig's angina (2)	*Neoplasm/malignancy* (16)
Vocal cord dysfunction (1)	Acute myelitis (2)	Solid organ tumor (9)
Obstructive sleep apnea (1)	Collagen vascular disorder (3)	Leukemia/lymphoma (5)
Cystic hygroma (1)	Tropical diseases (4)	LCH (2)
Cardiopulmonary diseases (22)	Craniofacial/genetic anomalies (17)	NM disorders (23)
Chronic lung diseases (11)	Genetic diseases (13)	GBS (17)
Congenital heart disease (6)	Retrognathia (2)	SMA (3)
Cystic fibrosis (2)	Micrognathia (1)	Myopathy (3)
Myocarditis/cardiomyopathy (3)	Macroglossia (1)	
Nontraumatic/noninfectious central neurological diseases (39)		Miscellaneous (4)
Static encephalopathy (16)		Diabetic ketoacidosis (2)
Immune-mediated encephalopathy (5)		Biliary atresia (1)
Superrefractory seizures (5)		Facial hemangioma (1)
Arteriovenous malformation (5)		Atlantoaxial dislocation (3)
Neuroregressive disorders (2)		
Intraventricular bleed (2)		
Spinal dysraphism (1)		

TEF, tracheoesophageal fistula; SGS, subglottic stenosis; FB, foreign body; TBM, tubercular meningitis; SJS, Stevens–Johnson syndrome; TBI, traumatic brain injury; LCH, Langerhans cell histiocytosis; GBS, Guillain–Barre syndrome; SMA, spinomuscular atrophy

Table 4: Tracheostomy complications

Complications	*Immediate*	*Early*	*Late*
Surgical emphysema			
Minor	7	1	0
Major	4	0	0
Tube malposition	12	8	0
Tube block	8	7	3
Accidental decannulation	2	0	3
Bleeding	11	1	0
Lung atelectasis	1	11	1
Stomal infection	0	7	3
Tracheitis	0	1	3
Stomal granulation	0	2	20
Tracheal granuloma	0	0	18
Pneumonia	0	0	27
Suprastomal collapse	0	0	9
Stomal stenosis	0	0	1
Tracheal stenosis	0	0	2
Tracheocutaneous fistula	0	0	3
Tracheomalacia	0	0	1

indication.[19,20] With better airway management and improving critical care, more number of tracheostomies were performed for prolonged ventilation, cardiopulmonary diseases, and neurological impairment.[21-25] Interestingly, we found that UAO obstruction was the most common indication from 2000 to 2009 and CNI was the most frequent indication for tracheostomy from 2010 to 2018. Possible reasons for this change are improved and aggressive in neurocritical care, better airway management, and early surgical interventions with better techniques for congenital airway obstructive lesions. Seventeen (13.5%) patients were tracheostomized for acquired subglottic stenosis in the first 10 years as compared to seven (4.3%) in later years (p value 0.005). This is probably related to the availability of better endotracheal tubes, use of sedation and analgesics in intubated children, improved nursing care, and attempts to extubate early.

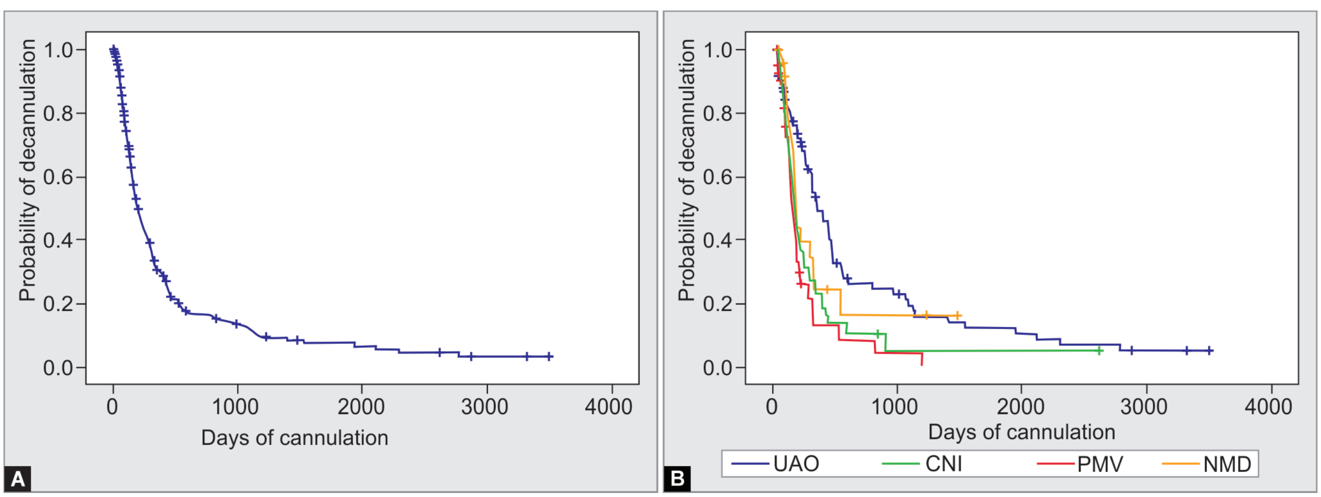
It seems that the average age at the time of tracheostomy in different studies depended on the most frequent indication.[25] Younger age-group was reported in studies in which UAO, craniofacial anomalies, and cardiac diseases were predominant indications[4,18] while older age >3 years was observed in studies when neurological impairment was the cause in the majority of children.[23,24] A similar observation was present in our study and by Lin et al.[24]

The primary diagnosis of patients and indications for tracheostomy are often different and we have reported the same

Table 5: Analysis of predictors of decannulation

	Univariate analysis			Multivariate analysis	
Variables	No decannulation (n = 102)	Decannulation (n = 188)	p value	Odds ratio (95% CI)	p value
Age<1 year	42 (41.2) [a]	55 (29.3)	0.04	0.378 (0.187–0.764)	0.007
Indications					
UAO	19 (18.6)	67 (35.6)	0.004	2.647 (1.182–5.924)	0.018
CNI	48 (47)	74 (39.3)	0.17		
PV	22 (21.5)	29 (15.4)	0.19		
NMD	10 (9.8)	21 (11.1)	0.73		
Diagnosis					
Trauma	8 (7.8)	37 (19.7)	0.007		
CP disease	13 (12.7)	9 (4.8)	0.01		
CNS disease	20 (19.6)	19 (10)	0.01	0.398 (0.186–0.855)	0.018
Malignancy	13 (12.7)	3 (1.6)	0.0001	0.078 (0.021–0.298)	<0.001
Days on MV					
Pretrach	12.5 (8.7,20.2)[b]	11 (4,17.7)	0.02		
Posttrach	10 (4,22)	5 (2,12)	<0.0001	0.937 (0.893–0.983)	0.008
Length of stay (days)					
PICU					
Pretrach	13.4 (9,22)	11.8 (4.6,18.2)	0.02		
Posttrach	13.5 (8,28)	10 (7,20)	0.02	0.989 (0.979–0.999)	0.029
Total	31 (19,50)	24 (13,40)	0.002		
Hospital					
Posttrach	19.5 (12,34.5)	22 (13,40)	0.48		
Total	36.5 (24.7,61.2)	37 (21,56.5)	0.32		
Outcome					
Trach (days)	67 (25.7,216.2)	157 (85.5,317.5)	<0.001		
Survivor	13 (12.7)	186 (98.9)	<0.0001		

[a]Represents frequency and percentage in parentheses; [b]Median with interquartile range; UAO, upper airway obstruction; CNI, central neurological impairment; PV, prolonged ventilation; NMD, neuromuscular disorders; CP, cardiopulmonary; CNS, central nervous system diseases due to nontraumatic noninfective causes; MV, mechanical ventilation; trach, tracheostomy



Figs 1A and B: Kaplan–Meier curves. Probability of decannulation with estimated mean ± standard error (SE) and 95% CI for whole study cohort (495.4 ± 61.9; 374– 616.7) and for different indications. UAO upper airway obstruction (704.3 ± 110.5; 487.7–920.9), CNI central neurological impairment (374.8 ± 93.8; 163.9–531.7), PMV prolonged mechanical ventilation (236.9 ± 51.3; 136.3–337.6), NMD neuromuscular disorders (412.6 ± 112.2; 192.6–632.6)

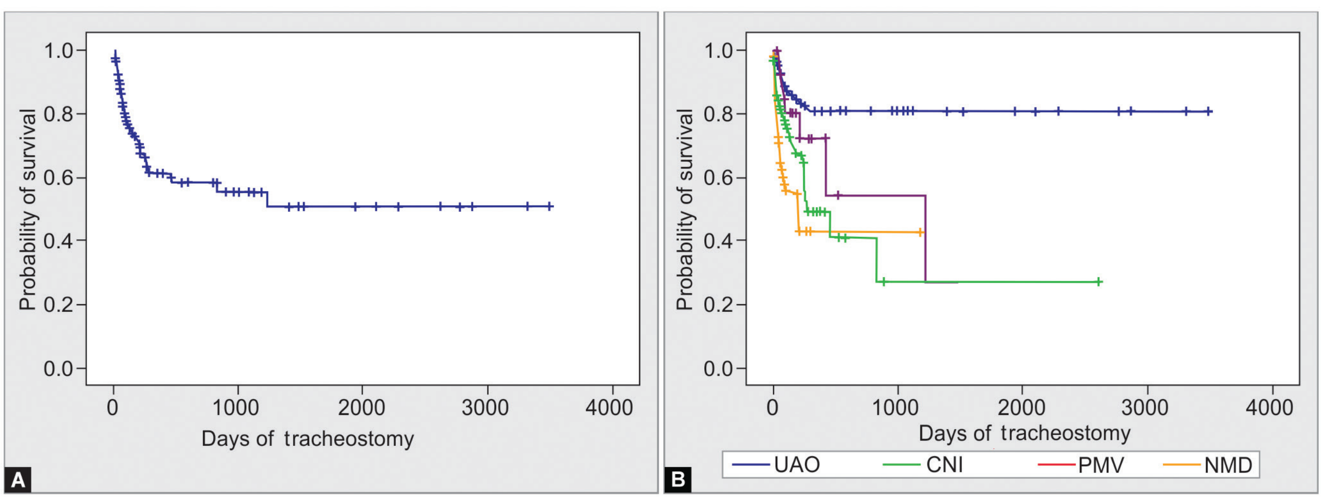
way. Both have an association with the final outcome. McPherson et al. reported that the presence of an oncology process was associated with poor survival and unsuccessful decannulation.[10] In the present study, diagnosis of cardiopulmonary diseases, nontraumatic noninfective central neurological diseases, and neoplasm/malignancy were associated with poor outcomes.

The overall complication rate was 61% in our series. There were 45 immediate, 38 early, and 94 late complications. Thirty-

Table 6: Analysis of predictors of mortality

	Univariate analysis			Multivariate analysis	
Variables	*Survivor (n = 199)*	*Nonsurvivor (n = 91)*	*p value*	*OR (95% CI)*	*p value*
Age <1 year	59 (29.6) [a]	38 (41.8)	0.04	2.39 (1.13–5.05)	0.02
Indication					
UAO	71 (35.6)	15 (16.4)	0.0009	0.24 (0.09–0.57)	<0.001
CNI	76 (38.2)	46 (50.5)	0.05		
PMV	29 (14.6)	22 (24.1)	0.05		
NMD	23 (11.5)	8 (8.8)	0.49		
Diagnosis					
Airway disease	31 (15.6)	5 (5.5)	0.015		
Trauma	39 (19.6)	6 (6.6)	0.004		
CP disease	9 (4.5)	13 (14.3)	0.003		
Malignancy	3 (1.5)	13 (14.3)	<0.0001	17.55 (4.10–75.11)	<0.001
Days on MV					
Pretrach	10 (3,17) [b]	14 (9,21)	0.001		
Posttrach	5 (2,12)	12 (5,26)	<0.001	1.06 (1.006–1.10)	0.028
LOS (days)					
PICU					
Pretrach	12.2 (5.1,19.2)	14.3 (8.8,23)	0.022		
Posttrach	10 (7,20)	14 (9,23)	0.002		
Total	24 (12,40)	33 (20,51)	<0.001		
Hospital					
Posttrach	22 (13,34)	21 (13,35)	0.71		
Total	36 (21,55)	42 (26,62)	0.035	1.007 (1.0–1.013)	0.043

[a]Represents frequency and percentage in parentheses; [b]Median with interquartile range; UAO, upper airway obstruction; CNI, central neurological impairment; PV, prolonged ventilation; NMD, neuromuscular disorders; CP, cardiopulmonary; MV, mechanical ventilation; trach, tracheostomy; LOS, length of stay



Figs 2A and B: Kaplan–Meier curves. Survival probability with estimate mean ± SE and 95% CI for overall cohort (1903.6 ± 170; 1570.3–2236.9) and for different indications. UAO upper airway obstruction (2803.3 ± 162.5; 2484.6–3121.7), CNI central neurological impairment (888.8 ± 245.1; 408.4–1369.2), PMV prolonged mechanical ventilation (551.5 ± 99.5; 356.3–746.6), NMD neuromuscular disorders (841 ± 184; 480.3–1201.7). UAO vs CNI *p* value <0.0001, UAO vs PMV *p* value <0.0001, PMD vs NMD *p* value 0.02

two children had multiple complications at different time periods. The complication rate is higher and varies in different studies on pediatric tracheostomies (18–80%) as compared to that in adults.[5,18-21] The most dreaded immediate or early complications before the first tube change were tube block, accidental tube removal, and major surgical emphysema. There were five deaths before the first tube change in the present study. The incidence of posttracheostomy subcutaneous emphysema is between 10 and 17% in children.[26] Perez et al. reported acute life-threatening tracheostomy occlusion and accidental decannulation in 29.3 and 15.2%, respectively, and infection as late complications.[27]

Stomal and tracheal granulations constituted 40.4% of late complications in our study. Tracheal granuloma was diagnosed bronchoscopically. Not all suprastomal granulomas required intervention but were a concern at the time of decannulation. The incidence of granulomata varies from 12.5 to 56% in different studies.[4,5,16]

Overall decannulation rate was 64.8% in our study and none of our patients required recannulation. The reported decannulation rate in children varied from 23 to 70%.[2,4,18,27] Similar to our study, Zank et al. reported a higher rate of successful decannulation in UAO and trauma cases.[22] On the contrary, Canning et al. reported UAO as high risk for unsuccessful decannulation.[28] Other predictors for unsuccessful decannulation include age at the time of tracheostomy, neurological diseases particularly congenital disorders, anatomic airway diseases, failure to thrive, and cardiopulmonary diseases.[10,18,29] Such wide variation in decannulation rate is related to patient population characteristics, differences in the categorization of indications, and variable follow-up periods.

In the present study, disease-related mortality was 28.3% and tracheostomy-related mortality was 3.1%. Previous studies have reported wide variation in overall mortality from 2.9 to 59% and tracheostomy-related mortality from 0 to 4.2%.[6,9,30,31] A significant decrease in morbidity and mortality over decades has been reported in an extensive review of the literature.[32] We did not observe a similar change over two decades. In our study, more children with cardiopulmonary diseases, nontraumatic noninfective central nervous system diseases, and malignancy died with tracheostomy *in situ*. A similar observation was reported in previous studies.[10,16]

Our study has some limitations and strengths. This is a single-center study so results may not be applicable to other PICU population outcomes, especially in developed countries. A significant limitation relates to the lack of causes of death, particularly in those who died at home. We have not studied the details of readmission after tracheostomy, the number of failures before successful decannulation, quality of life, nutritional status of cases, resource utilization at the hospital, and burden on parents and family while taking care of a tracheostomized child. These are very important aspects that need more studies in the future. Extensive support is also required at home, playschool, and school to optimize a child's developmental outcome. Unfortunately, in resource-limited countries, it is impossible to provide home visits by trained nurses and social workers. So, children have to visit our hospital or some other health facilities for even minor problems and are totally dependent on parents and caregivers. The major strength of our study is the prospectively collected data with a large number of cases admitted in the PICU over two decades. Every effort was made to follow patients and communicate with parents through postal mail or telephonically and this was reflected in the outcome results.

Conclusion

Indications for tracheostomy in children had changed in resource-limited countries. Decannulation and mortality were determined by the age of the patient at the time of tracheostomy, primary medical condition, and length of posttracheostomy ventilation and stay in the PICU and hospital. In the future, prospective studies are required on the timing of tracheostomy in children admitted to the PICU and its effects on morbidity and mortality and quality of life after discharge from the hospital.

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