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From Intubation to Tracheostomy: Indications, Techniques, Complications, and Outcomes of Tracheostomy in an Indonesian Pediatric Intensive Care Unit, 2022–2026

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ABSTRACT

Introduction: Tracheostomy is increasingly performed in critically ill children requiring prolonged mechanical ventilation; however, data from settings with a high infectious disease burden and on pediatric bedside percutaneous tracheostomy remain limited. This study described the characteristics, indications, techniques, complications, and outcomes of children undergoing tracheostomy in a pediatric intensive care unit (PICU) in Indonesia.
Methods: This retrospective descriptive study included all PICU patients aged 1 month to 17 years who underwent elective tracheostomy at Bhayangkara Tk. I Pusdokkes Polri Hospital, Jakarta, between January 2022 and March 2026.
Results: Forty-three children were included (mean age 7.8 ± 6.1 years; 58.1% boys); 28 (65.1%) were older than 5 years. The indications were prolonged mechanical ventilation (39; 90.7%) and upper airway obstruction (4; 9.3%). Neurological disease was the underlying cause in 30 cases (69.8%), with tuberculous meningitis being the most frequent diagnosis (9; 20.9%). Bedside percutaneous tracheostomy by intensivists was performed in 38 children (88.4%) and surgical tracheostomy in five (11.6%). The mean ventilation before tracheostomy was 10.2 days (range 1–16), and the mean post-tracheostomy PICU stay was 9.3 days (range 1–30). Complications occurred in seven children (16.3%): minor bleeding, pneumothorax, and laryngeal edema (two each) and subcutaneous emphysema (one), none requiring re-exploration. Twenty children (46.5%) were discharged with tracheostomy. In-hospital mortality was 53.5%, with no procedure-related deaths.
Conclusion: Intensivist bedside percutaneous tracheostomy is feasible with few complications in children with acquired neurological diseases, particularly central nervous system infections. Mortality reflects disease severity rather than the procedure.

Keywords

Tracheostomy, Percutaneous Tracheostomy, Pediatric Intensive Care Unit, Prolonged Mechanical Ventilation, Tuberculous Meningitis

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INTRODUCTION

Tracheostomy is a common procedure in critically ill patients requiring prolonged mechanical ventilation. Compared with prolonged translaryngeal intubation, it facilitates weaning from ventilation, reduces sedation requirements, improves pulmonary toilet and patient comfort, and supports rehabilitation, including speech [1]. Two principal techniques were used. Surgical tracheostomy (ST) creates a stoma under direct vision, usually between the second and fourth tracheal rings, whereas percutaneous tracheostomy (PT) introduces dilators and a cannula over a percutaneously placed guidewire. PT can be performed at the bedside with fewer resources and has become the dominant technique in adult intensive care; however, its use in children remains far less established [2].

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Securing the airway through an incision in the trachea long predates endotracheal intubation. The first pediatric tracheotomy, performed by Caron in 1766 in a 7-year-old child to remove an aspirated bean, was followed by Trousseau's routine use of the procedure for diphtheria and other causes of severe respiratory distress, and the technique and instruments described by Chevalier Jackson in the early 20th century remain largely accepted today [3]. Over recent decades, the indications have shifted substantially. Infectious upper airway obstruction from diphtheria, pertussis, and epiglottitis has almost disappeared with vaccination and improved intubation techniques, and long-term ventilator dependence has overtaken airway obstruction as the leading indication [4,5]. Pediatric tracheostomy indications fall into three broad groups: upper airway obstruction, prolonged mechanical ventilation, and inadequate airway protection or the need for pulmonary toilet. In a systematic review, prolonged ventilation accounted for 26–87% of pediatric tracheostomies, upper airway obstruction for 20–70%, and inadequate airway protection for 25–37% [6]. The indications also vary with age: in neonates and infants, tracheostomy is mainly performed for congenital airway anomalies or prolonged ventilation related to prematurity, whereas acquired conditions such as trauma and infection predominate in older children [7]. The small, soft, and mobile pediatric trachea, the narrow airway lumen, the risk of posterior tracheal wall injury, and the limited availability of pediatric devices make PT more challenging in children than in adults [7]. Evidence in children is limited to observational series. Fiberoptic-guided percutaneous dilatational tracheostomy has been shown to be feasible in children older than 5 years [8]. and a systematic review found that PT carried a risk of complications comparable to that of open surgical tracheostomy in selected children and adolescents [9]. The optimal timing of tracheostomy in the pediatric intensive care unit (PICU) is equally uncertain: observational data suggest that early tracheostomy is associated with shorter ventilation and PICU stay, but randomized evidence is lacking [10].

Most published pediatric series originate from high-income countries and are dominated by infants with congenital airway anomalies, prematurity, and chronic lung disease [6]. In settings with a high burden of infectious disease, the population requiring tracheostomy may differ considerably. Childhood tuberculous meningitis, for example, carries substantial mortality and frequent severe neurological sequelae [11]. including in Indonesian cohorts [12]. and may leave children unable to protect their airway for prolonged periods. This study aimed to describe the characteristics, indications, techniques, complications, and outcomes of children undergoing tracheostomy in a PICU in Indonesia, where bedside PT is performed by intensivists.

METHODS

This retrospective descriptive study was conducted in the PICU of Bhayangkara, Jakarta,Tk Indonesia Hospital Tk. I Pusdokkes Polri Hospital, Jakarta, Indonesia, and is reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines. The electronic medical records of all PICU patients aged 1 month to 17 years who underwent tracheostomy between January 2022 and March 2026 (51 months) were reviewed for this study. This age range corresponds to the patients admitted to and classified by our PICU; neonates younger than 1 month are managed in the neonatal intensive care unit and were therefore excluded from this study. Children who underwent emergency tracheostomy or had incomplete medical records were excluded from the study.

Data were extracted from medical records, operative reports, and clinical notes. Variables included age, sex, primary diagnosis, indication for tracheostomy, technique and operator, duration of mechanical ventilation before tracheostomy, procedural complications, PICU length of stay after tracheostomy, total PICU length of stay, and outcome at hospital discharge (discharge with a tracheostomy or in-hospital death). Patients were categorized into five age groups: 1–12 months, >12–24 months, >2–5 years, >5–10 years, and >10–17 years. Indications were classified as prolonged mechanical ventilation (failure to wean or inadequate airway protection) or upper airway obstruction, and underlying diagnoses were grouped as neurological, respiratory, or other. The indication for and timing of tracheostomy were determined by the attending pediatric intensivist. Tracheostomy was performed either as a bedside percutaneous procedure in the PICU by an intensivist or as a surgical procedure in the operating room under general anesthesia by an otorhinolaryngologist with an anesthesiologist present. The technique was selected according to operator availability and on-call schedules.

Coagulation parameters (partial thromboplastin time and platelet count) were assessed before the procedure, and no patient was receiving therapeutic anticoagulation. Pulse oximetry, electrocardiography, and non-invasive blood pressure were monitored continuously throughout the procedure.

Decannulation was planned jointly and led by the attending physician once the child was hemodynamically stable and required minimal or no supplemental oxygen. The frequency of cannula downsizing depended on the child's age and the type of tracheostomy cannula. Parents and caregivers were involved in tracheostomy care and, before discharge, were trained through demonstration in routine care, including suctioning and cannula changes, and in the use of equipment such as suction catheters, suction machines, and oxygen devices. Data were analyzed using IBM SPSS Statistics version 31.0.2.0 (IBM Corp., Armonk, NY, USA). Categorical variables are presented as numbers and percentages. Continuous variables are presented as mean ± standard deviation (SD), mean (range), or median (range), as appropriate. Because the ST group was very small (n = 5), no statistical comparison between PT and ST was performed, and the results are reported descriptively. The study protocol was approved by the Health Research Ethics Committee of Bhayangkara Tk. I Pusdokkes Polri Hospital, and the requirement for informed consent was waived owing to the retrospective design and the use of anonymized data. The study was conducted in accordance with the Declaration of Helsinki.

RESULTS

A total of 43 children underwent tracheostomy during the study period. The mean age was 7.8 ± 6.1 years (median, 6 years; range, 1 month–17 years). Twenty-eight children (65.1%) were older than 5 years, and nine (20.9%) were younger than 2 years. Twenty-five (58.1%) were boys (Table 1).

Table 1. Demographic and clinical characteristics of children undergoing tracheostomy (n = 43)

Characteristic	Value
Age, mean ± SD, years	7.8 ± 6.1
Age, median (range)	6 years (1 month–17 years)
Age group, n (%)	
1–12 months	7 (16.3)
>12–24 months	2 (4.7)
>2–5 years	6 (14.0)
>5–10 years	14 (32.6)
>10–17 years	14 (32.6)
Sex, female / male, n (%)	18 (41.9) / 25 (58.1)
Ventilation before tracheostomy, mean (range), days	10.2 (1–16)
PICU stay after tracheostomy, mean (range), days	9.3 (1–30)

PICU, pediatric intensive care unit; SD, standard deviation.

The most common indication was prolonged mechanical ventilation (39 children; 90.7%), followed by upper airway obstruction (4; 9.3%). Neurological disease was the underlying condition in 30 children (69.8%). Central nervous system infection accounted for 16 cases (37.2%), and tuberculous meningitis was the most frequent single diagnosis (9; 20.9%). Respiratory disease was the underlying condition in eight children (18.6%), and tuberculosis at any site was present in 11 children (25.6%). Upper airway obstruction was caused by laryngomalacia (two), subglottic stenosis (one), and airway injury from facial burns (one) (Table 2). Most tracheostomies were bedside percutaneous procedures in the PICU (38; 88.4%), and five (11.6%) were surgical tracheostomies in the operating room. The mean duration of mechanical ventilation before tracheostomy was 10.2 days (range, 1–16 days). According to the clinical records, sedation requirements decreased substantially within 72 hours of tracheostomy in all patients. Complications occurred in seven children (16.3%): minor bleeding (two; 4.7%), pneumothorax (two; 4.7%), laryngeal edema (two; 4.7%), and subcutaneous emphysema (one; 2.3%) (Table 3). Both bleeding events were superficial, and no complication required surgical re-exploration.

The mean PICU length of stay after tracheostomy was 9.3 days (range, 1–30 days), and the mean total PICU length of stay was 18.9 days. Twenty children (46.5%) were discharged with a tracheostomy cannula, and 23 (53.5%) died in hospital. No death was directly attributable to the tracheostomy procedure (Table 4).

Table 2. Indications for tracheostomy and underlying diagnoses (n = 43)

Indication / diagnosis	n (%)
Prolonged mechanical ventilation	39 (90.7)
Neurological disorders	30 (69.8)
Tuberculous meningitis	9 (20.9)
Viral meningitis	6 (14.0)
Brain tumor	5 (11.6)
Traumatic brain injury	4 (9.3)
Cerebral palsy	2 (4.7)
Epilepsy	2 (4.7)
Bacterial meningitis	1 (2.3)
Arteriovenous malformation	1 (2.3)
Respiratory disorders	8 (18.6)
Pneumonia with ARDS	4 (9.3)
Pulmonary tuberculosis	2 (4.7)
Chronic lung disease (BPD)	2 (4.7)
Other	1 (2.3)
Tetanus	1 (2.3)
Upper airway obstruction	4 (9.3)
Congenital	3 (7.0)
Laryngomalacia	2 (4.7)
Subglottic stenosis	1 (2.3)
Acquired	1 (2.3)
Airway injury from facial burns	1 (2.3)

Note: Percentages were calculated for the entire cohort (n = 43). ARDS, acute respiratory distress syndrome; BPD, bronchopulmonary dysplasia.

Table 3. Complications of tracheostomy (n = 43)

Complication	n (%)
Minor bleeding	2 (4.7)
Pneumothorax	2 (4.7)
Laryngeal edema	2 (4.7)
Subcutaneous emphysema	1 (2.3)
Total children with complications	7 (16.3)

Table 4. Technique, timing, and outcomes (n = 43)

Variable	Value
Bedside percutaneous tracheostomy (intensivist), n (%)	38 (88.4)
Surgical tracheostomy in the operating room (otorhinolaryngologist), n (%)	5 (11.6)
Ventilation before tracheostomy, mean (range), days	10.2 (1–16)
PICU stay after tracheostomy, mean (range), days	9.3 (1–30)
Total PICU stay, mean, days	18.9
Discharged with tracheostomy, n (%)	20 (46.5)
In-hospital death, n (%)	23 (53.5)
Procedure-related death, n (%)	0 (0)

PICU, pediatric intensive care unit.

DISCUSSION

In this 51-month retrospective series of 43 children, tracheostomy was performed predominantly for prolonged mechanical ventilation in older children with acquired neurological diseases, most often central nervous system infection. Nearly nine in ten procedures were bedside PTs performed by intensivists. Complications were infrequent and minor, with no procedure-related deaths; however, in-hospital mortality was high, reflecting the severity of the underlying diseases.

Prolonged mechanical ventilation was the indication in 90.7% of our patients, at the upper end of the 26–87% range reported in a systematic review, in which upper airway obstruction accounted for 20–70% of pediatric tracheostomies [6]. Our cohort also differed in terms of age and disease profiles. Almost two-thirds of the children were older than 5 years, and only nine were younger than 2 years, whereas series from high-income countries are dominated by infants with congenital airway anomalies, prematurity, and chronic lung disease [1]. This is consistent with the age pattern described in a recent narrative review, in which acquired conditions such as trauma and infection predominated among older children, and with Italian national data on 2,572 pediatric tracheostomies, which were performed mostly in the first year of life or adolescence [7]. Upper airway obstruction was uncommon in our cohort (9.3%). Neurological diseases accounted for 69.8% of cases, and central nervous system infections alone accounted for more than one-third of these cases. Tuberculous meningitis was the most frequent single diagnosis (20.9%), and tuberculosis at any site was present in one-quarter of patients, reflecting the high burden of tuberculosis in our population cohort. Childhood tuberculous meningitis carries a high risk of death and disability. A meta-analysis reported a pooled mortality of 19.3%, with neurological sequelae in more than half of survivors [11]. An Indonesian cohort of 283 children reported an overall case fatality rate of 22.8% and severe neurological sequelae in 36.3% of survivors who completed treatment [12]. Children with depressed consciousness and poor airway-protective reflexes after severe brain infection, tumors, or trauma often cannot be extubated safely, and tracheostomy becomes the route to a stable, long-term airway.

The optimal timing of tracheostomy in the PICU remains controversial. In a meta-analysis of eight retrospective cohort studies, early tracheostomy was associated with lower mortality, fewer days of mechanical ventilation, and shorter PICU and hospital stays [10]. A second systematic review found that tracheostomy within 14 days of ventilation reduced the duration of ventilation by approximately 18 days, PICU stay by 14.7 days, and hospital stay by 31.4 days, and reduced the risk of ventilator-associated pneumonia (relative risk 0.56), although in-hospital mortality did not differ [6]. All of this evidence is derived from observational studies with heterogeneous definitions of "early" and a risk of selection bias, and no pediatric randomized trial exists [6,10]. In our cohort, the mean duration of ventilation before tracheostomy was 10.2 days, which falls within most definitions of early tracheostomy, although the range was large. The substantial reduction in sedation within 72 hours supports the comfort benefit of transitioning to tracheostomy. In children with severe acquired brain injuries, such as advanced tuberculous meningitis, the need for long-term airway support can often be anticipated early. An earlier structured decision regarding tracheostomy in such patients, accompanied by goals-of-care discussions with families, may shorten ventilation and PICU stay and warrants prospective evaluation. Surgical tracheostomy remains the standard technique in children, and PT is used less frequently than in adults [2]. The available pediatric evidence is limited but encouraging. In a series of 27 children aged 5–17 years, fiberoptic-guided percutaneous dilatational tracheostomy had no technical failures, and minor adverse events occurred in five children (18.5%); however, significant tracheal or subglottic stenosis subsequently developed in four (14.8%), and three (11.1%) required transient tracheal stenting [8]. A systematic review of 21 studies, including 143 children aged 2 days to 17 years, found a complication risk comparable to that of open surgical tracheostomy. Approximately one-third of procedures were performed at the bedside in the ICU, the mean procedure time was 13.8 minutes, and the mean interval from intubation to tracheostomy was 8.9 days, close to the 10.2 days in our cohort [9]. The authors recommended reserving PT for selected children, particularly adolescents with readily palpable landmarks, with endoscopic guidance, and a surgeon able to convert to an open procedure [9].

In our study, 88.4% of tracheostomies were bedside PTs performed by intensivists, with no procedure-related deaths and no need for re-exploration. Because 65.1% of our patients were older than 5 years, this age profile likely contributed to the feasibility of the percutaneous approach. Bedside PT also avoids transporting unstable, intubated children to the operating room; in a multicenter prospective study, adverse events occurred in 9.6% of intrahospital transports of critically ill patients [13]. At our center, the main challenge with ST is scheduling delay due to operating room availability and the priority given to emergency cases. Bedside PT removes this logistical barrier, and following a change in local protocol, some PTs can now be performed on

the same day as the consultation. Because PT does not require operating room time, it is also likely to be less costly. However, the interval from consultation to procedure and the costs were not measured systematically in this series, and these advantages require quantification. Complications occurred in 16.3% of our patients. All occurred early, and none required re-exploration. This rate lies within the 5–46.9% range of early and late complications reported in pediatric series [6]. Air-leak complications (pneumothorax and subcutaneous emphysema) occurred in three patients (7.0%), higher than the 2.1% rate of pneumothorax reported in pooled pediatric PT data [9]. suggesting that posterior wall injury or paratracheal placement may have occurred in some procedures. The two cases of laryngeal edema may reflect the preceding period of translaryngeal intubation rather than the tracheostomy itself. Our study captured only early in-hospital complications. Late complications, including granulation tissue, cannula obstruction, accidental decannulation, stomal problems, and tracheal stenosis, frequently arise after discharge; they occurred in more than half of the children in a recent PICU cohort with extended follow-up [14]. and stenosis after PT in particular requires long-term surveillance [8].

Most tracheostomy complications arise from a limited number of mechanisms: bleeding and air leak during insertion, loss of the airway before the stoma tract has matured, cannula obstruction by secretions, pressure injury to the skin and trachea, and inadequate care after discharge. Each can be addressed by specific measures along the perioperative pathway (Table 5). For PT, bronchoscopic guidance allows the operator to visualize the needle, guidewire, and dilator entry into the trachea. In a meta-analysis of seven randomized trials (639 patients), bronchoscopic guidance reduced bleeding (relative risk 0.57), cannula malposition (0.17), and posterior tracheal wall injury (0.08), and increased first-attempt success (1.33) without prolonging the procedure [15]. Pre-procedural ultrasound identifies the midline, tracheal rings, thyroid isthmus, and overlying vessels; in a meta-analysis of 11 randomized trials (1,035 patients), ultrasound guidance reduced overall complications (relative risk 0.56) and bleeding (0.44) and increased first-attempt success (1.23) [16]. These trials were conducted in adults, but the same principles apply to children. Given the air-leak complications observed in our series, routine bronchoscopic and ultrasound guidance for bedside PT, a standardized procedural checklist, and post-procedure chest radiography are practical targets for our unit.

Table 5. Mechanisms of tracheostomy complications and preventive measures

Phase	Complication and mechanism	Preventive measure
Before the procedure	Bleeding from coagulopathy; unplanned or rushed procedure	Assess coagulation and platelets; multidisciplinary decision on indication and timing; family counseling [17]
Insertion (percutaneous)	Posterior wall injury, false passage, pneumothorax, subcutaneous emphysema, bleeding	Bronchoscopic guidance [15]; pre-procedural ultrasound [16]; patient selection by age and anatomy [8,9]; post-procedure chest radiograph
Insertion (surgical)	Loss of airway if the cannula dislodges before the stoma matures	Bilateral stay sutures and maturation sutures in all cases [17]
Cannula selection	Tracheal injury from an ill-fitting cannula or cuff pressure	Careful choice of size and type; cuffless cannulas generally preferred in children [7]
Early postoperative	Cannula obstruction by dried secretions	Humidification; suctioning when secretions are seen or heard or obstruction is suspected [18]
Early postoperative	Accidental decannulation and failed reinsertion	Secure ties; spare cannulas (same and smaller size), suction, and bag at the bedside; first change on days 5–7 [18]
Ward and ICU care	Pressure injury to the stoma and neck	Skin assessment every shift; foam dressing beneath flanges; extended-type cannulas [19]
Discharge and home	Obstruction or decannulation at home; late granulation or stenosis	Caregiver competency assessment [18]; emergency go-bag and structured decannulation follow-up [20]

ICU: intensive care unit.

For surgical tracheostomy, the International Pediatric Otolaryngology Group recommends stay sutures in all cases, allowing the trachea to be lifted into view if the cannula is dislodged before the stoma tract heals [17]. After the procedure, the American Academy of Otolaryngology–Head and Neck Surgery consensus statement recommends humidification in the early postoperative period and in ventilated children, suctioning

when secretions are seen or heard or obstruction is suspected, complete replacement equipment at the bedside, and a first cannula change 5–7 days after the surgical tracheostomy [18]. Cuffless cannulas are generally preferred in children to reduce the risk of tracheal injuries [7]. A quality-improvement bundle of scheduled skin and device assessment, foam dressings beneath the cannula flanges, and extended-type cannulas reduced tracheostomy-related pressure ulcers from 8.1% to 0.3% [19]. Before discharge, all caregivers should demonstrate competence in tracheostomy care [18]. supported by an emergency go-bag and structured family education [20]. as provided in our unit through a demonstration. The in-hospital mortality rate in our cohort was 53.5%, which is considerably higher than that in most pediatric series. In a recent Chinese cohort of 234 children who underwent tracheostomy in the PICU, only seven of 48 deaths occurred in the hospital [14]. No death in our series was procedure-related, whereas tracheostomy-related mortality in the literature ranges from 0.6% to 14.4%, mainly due to massive bleeding and cannula obstruction [6]. Therefore, the high overall mortality is best explained by the severity of the underlying diseases, namely central nervous system infection, including tuberculosis, brain tumors, traumatic brain injury, and acute respiratory distress syndrome, in older children with acquired critical illness, rather than by tracheostomy. For many of these children, tracheostomy marked a transition to long-term care rather than recovery, underscoring the importance of honest prognostic discussions and early palliative care involvement in children with a poor neurological prognosis.

Twenty children (46.5%) were discharged with a tracheostomy. Death after discharge remains a concern: in the Chinese cohort, 41 of 48 deaths occurred after hospital discharge [14]. Decannulation is also less frequently successful in children with neurological impairment [6]. Structured caregiver training, as provided in our unit before discharge, and organized follow-up are therefore essential, and future reports from our center should include decannulation rates and post-discharge survival. This study has several limitations. First, it was a single-center retrospective study without randomization or blinding, and the choice of technique depended on operator availability rather than predefined criteria. Second, the sample was small, and the ST group comprised only five patients, precluding statistical comparison of the two techniques. Third, children who underwent emergency tracheostomy or had incomplete records were excluded, which may have introduced selection bias. Fourth, illness severity scores (such as the Pediatric Index of Mortality or Pediatric Risk of Mortality), the Glasgow Coma Scale, technique by age group, and detailed causes of death were not analyzed. Finally, only early in-hospital outcomes were recorded; data on late complications, decannulation, home ventilation, hospital length of stay, consultation-to-procedure time, and costs were not available.

CONCLUSION

In our PICU, tracheostomy was performed for prolonged ventilation in children with neurological diseases, tuberculous meningitis, and nervous system infections. Bedside PT by intensivists was feasible, with complications but no procedure-related deaths; in-hospital mortality reflected the severity. Early identification, timing, PT/ST selection, caregiver training, and follow-up may improve outcomes.

DECLARATIONS

None

CONSENT FOR PUBLICATION

The Authors agree to be published in the Journal of Society Medicine.

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COMPETING INTERESTS

The authors declare no conflicts of interest in this case report.

AUTHORS' CONTRIBUTIONS

All authors have read and approved the final version of the manuscript and agree to be held accountable for all aspects of the work presented.

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