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Fibroscopic-guided percutaneous dilatational tracheostomy in critically ill children: a single center observational study

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Abstract

Background Percutaneous tracheostomy is rarely used in children due to limited experience and safety concerns, in contrast to adult patients where the overwhelming majority of tracheostomies are placed via the percutaneous route. To assess the feasibility of percutaneous dilatational tracheostomy (PDT) using the modified fibroscopic-guided Ciaglia technique, we prospectively recorded and analyzed all PDT procedures performed for persistent failure to wean from mechanical ventilation and inability to protect the airway in our pediatric intensive care unit.

Results From January 2003 to March 2022, 27 children (median age 12, range 5–17, years; median weight 38, range 19.5–80 kg; median PRISM II 10, range 6–11) underwent a PDT for acute encephalitis (10 children), neurovascular disease (5 children), and other indications, using a Shiley cannula ranging from 5.5 to 7 mm internal diameter (ID) after a median length of mechanical ventilation of 13 (range 10–22) days. Early complications included a few minor events, and we did not observe significant peristomal granulation nor infection. Three patients required transient tracheal stenting for suprastomal collapse, and four others developed severe subglottis (1) or substromal tracheal stenosis (3). The overall in-hospital mortality was 27%. Among the long-term survivors, cannulas were removed in 85% of cases after a median length of tracheostomy of 47 (range 31–77) days.

Conclusions PDT is feasible and could be an alternative option to traditional surgical tracheostomy in adolescents and children over the age of 5.

Keywords Tracheostomy, Percutaneous tracheostomy, Children, Pediatric intensive care, Tracheal stenosis

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Background

Percutaneous tracheostomy (PT) has gained a growing interest among intensivists as an airway access technique in adult ICU for the failure of weaning from mechanical ventilation. PT compares favorably to traditional surgical tracheostomy (ST) in terms of safety and easy bedside profile, with the most recent meta-analyses suggesting that PT techniques can be performed faster and reduce stoma infection risk, although are associated with increased technical difficulties when compared with ST [1, 2]. Among PT techniques, percutaneous dilatational tracheostomy (PDT) was associated with the lowest non-life-threatening intraprocedural risks [1]. Moreover, dilatational percutaneous techniques are associated with decreased procedural time and reduced risk of unfavorable scarring in comparison with ST [3, 4]. Unlike adults, PDT has only been reported rarely in children, probably due to limited experience and concerns about safety or feasibility, especially in infants or smaller children [5]. We therefore report our single-institution experience of PDT using the modified Ciaglia technique in 27 consecutive children [6].

Method

This is an analysis of prospectively collected data. Following multi-disciplinary team discussion, all patients older than 4 years requiring an elective tracheostomy for persistent failure to wean from mechanical ventilation and/or inability to protect their airway were eligible. Data was recorded prospectively (institutional electronic database system). The study was approved by the appropriate Institutional Review Board (IRB). The requirement for written informed consent was waived by the IRB. The parents or legal representatives of the children received written information and discussion prior to the procedure that data concerning their child may be analyzed and published. No parents or legal representatives refused consent for data collection and publication.

During the study period, we performed PDT with the modified fibroscopic-guided Ciaglia technique using a single-step dilatation with a hydrophilic curved dilator in accordance with the manufacturer's instructions (Ciaglia Blue Rhino G2 Advanced Percutaneous Tracheostomy Introducer Sets, Cook Medical, Bloomington, IN) [7]. The first procedures at the start of our experience, prioritizing older patients (mainly teens), were performed under the supervision of a skilled senior anesthesiologist (L Martin). Briefly, all the bronchoscopic guided procedures were carried out at the bedside under mechanical ventilation and general anesthesia (sufentanil, propofol, atracurium) by two staff senior intensivists. We used a flexible bronchoscope through the endotracheal tube (Pentax FB 10 V, Montvale, USA, or disposable Ambu aScope 4 BronchoSlim model, Ballerup, DK) to control both the puncture of the second tracheal interspace with the dedicated needle and the dilatation procedure along a specific guide wire. The smaller loading dilatator available in the introducer set (i.e., 19 Fr) allowed the insertion of a 5.5- to 6-mm ID Shiley cannula. This device can be used in patients weighing more than 20 kg and or 5 years old. But beyond technical requirements, this cutoff was partly based on previously published experience and clinician judgment for the feasibility and/or risk of PDT. The decannulation process always followed the recommendations and included laryngeal nasofibroscopy to assess airway permeability at the glottic and subglottic levels and rule out dynamic suprastomal collapse or tracheomalacia [8]. All the nasofibroscopy was performed after a successful capped trial period by an ENT surgeon in PICU in most cases. We prospectively collected all the consecutive patients' baseline characteristics, the immediate and delayed adverse events, and the patient's outcome. Data are presented as medians and interquartile ranges or percentage as appropriate.

Results

From January 2003 to March 2022, 27 children (median age 12, range 5 to 17 years; median weight 38, range 19.5 to 80 kg) admitted to the tertiary pediatric intensive care unit of Bicêtre Medical Center underwent a PDT for failure to wean from mechanical ventilation or to facilitate airway management. Their baseline characteristics are shown in Table 1. None of the PDT procedures failed due to technical issues. Inserted tracheostomy cannula size ranged from 5.5 mm ID in 4 children (aged 5 to 7 years, weighing 19.5 to 22 kg) to 7 mm ID in older children depending both on previous tracheal tube size and weight. No immediate significant adverse events (such as major bleeding or air leak syndrome) and minor adverse events were noted in 5 children (Table 1). During the same period, a surgical tracheostomy was performed on 63 patients (median age 16.5 months, range 1 to 182 months) including 9 patients older than 5 years who presented anatomical problems which ruled out the possibility of percutaneous tracheostomy (small weight, subglottic stenosis or granuloma, tracheomalacia).

Patients and tracheostomy outcomes are detailed in Table 2. We did not observe significant peristomal granulation nor infection. Three patients required transient tracheal stenting for suprastomal collapse with an uneventful outcome. Four others were diagnosed with severe subglottic stenosis (1) or substromal tracheal stenosis (3) including granulation tissue above the tracheostoma level. Of these four children, one child (aged 10 years, admitted for a severe traumatic brain injury) required laser removal of subglottic granulations, followed by a

Table 1 Baseline characteristics at admission

Baseline characteristics, *n* = 27	**Median [IQR] or number (%)**
Age, years	12 [9–14]
Sex—male, *n* (%)	12 (44%)
Weight, kg	36 [31–55]
PRISM II at admission	10 [6–11]
PELOD at day 1	10 [2–11]
Diagnosis on admission, *n*	
Acute encephalitis	10
ARDS	1
Inherited neurometabolic disease	3
Severe trauma injury	2
Tertiary peritonitis	1
Neurovascular diseases	5
Tumor (abdominal, brain)	2
Guillain–Barre syndrome	2
ROHHADNET syndrome	1
Main reason for tracheostomy, *n*	
Weaning failure	13
Inability to protect the airway	14
Anatomical difficulties, *n*	
Short neck	1
Neck edema	1
Obesity	1
MV before tracheostomy, days	13 [10–22]
Immediate minor complications, *n*	
Minor bleeding	2
Transient hypoxemia	1
Tracheal posterior wall puncture	1
Broken tracheal ring	1
PDT procedural duration, min	15 [15–25]

Table 2 Outcome data

Outcome data, *n* = 27	**Median [IQR] or number (%)**
Time between tracheostomy to unassisted breathing in survivors, days[a]	15 [5–25]
PICU length of stay, days	49 [35–67]
Definitive decannulation in survivors, *n*	17 (85%)
Length of tracheostomy in survivors, days[a]	47 [31–77]
PICU mortality, *n*	3 (12%)
Hospital or long-term facility mortality, *n*	4 (15%)
Short-term associated complications, *n*[b]	
Tracheal or subglottis stenosis	4
Tracheal spur (suprastomal collapse)	3

[a] Excluding three long-term ventilator-dependent patients

[b] See the text for the details

Krishaber cannula stenting. She ultimately died from accidental decannulation in a rehabilitation facility. A further child (aged 14 years with brainstem encephalitis secondary to MOG antibodies) needed a successful resection-dilatation procedure for substromal stenosis (diagnosed 3 months after PDT) before decannulation 10 months later. Two further children (aged 13 years with encephalitis and aged 11 years with acute respiratory distress syndrome) underwent a lower tracheal resection under cardiopulmonary bypass after further dilatational procedures failed at 15 and 2 months after PDT for substromal severe tracheal stenosis. Of note, both of these children requiring surgical resection also required an inflated cuff cannula for the inability to control the airway, after a long translaryngeal intubation period.

Discussion

We report our experience of bedside PDT in 27 patients and suggest that it could be an alternative to traditional surgical tracheostomy in teens and children over the age of 5 years. Tracheostomy remains an unusual procedure in PICU, estimated at less than 2% of children admitted to UK and Canadian PICUs [9, 10]. Moreover, only 19% of intensivists in Canada declared performing PDT in children older than 5 years [9]. The published data with PDT in children is sparse and limited to small case series with various approaches including Ciaglia, Griggs, or Fantoni translaryngeal techniques [5, 11–13]. In our unit, PDT with the Ciaglia technique represents 29% of the overall tracheostomy performed during the study period. Toursarkissian et al. first reported 11 PDTs performed in children aged 10 to 20 years with the Ciaglia technique without complications [11]. Scott et al. later reported two adolescents between 11 and 16 years of age who underwent Ciaglia PDT but further developed major tracheal stenosis or granulomas above the tracheostoma [5]. The Ciaglia approach has raised some safety concerns because due to the narrow and pliable trachea of children, there is thus a theoretical risk of airway collapse and/or inadvertent posterior wall puncture. Some authors therefore promoted Griggs' translaryngeal technique. Using this technique, Gollu et al. performed 45 consecutives procedures in infants or children under rigid bronchoscopy in the operating room with an uneventful outcome, suggesting a good safety profile as previously reported by Fantoni et al. [12, 14]. Rossetti et al. recently reported a two-step safety approach in 9 children using the Melker emergency cricothyrotomy kit under flexible fibroscopic control before a Griggs dilatational step before final cannula insertion [15].

We did not observe any immediate complications of PDT using the Ciaglia technique. Furthermore, animal models comparing PDT and ST suggest a short-term healing benefit in favor of PDT [16]. The prevalence of significant tracheal stenosis and granuloma seen after children following ST is low, at 2 to 4.8% [17, 18]. Reliable data after PDT remains scarce in children; however, in large adult series, the prevalence of symptomatic severe tracheal stenosis (defined as more than 50% narrowing) ranges from 2 to 4% whereas moderate stenosis (more than 10% tracheal narrowing) affects 26 to 40% of the decannulated survivors [19, 20]. A large retrospective study including 1656 adult patients and comparing these two methods do not support the role of PDT as an independent risk factor for posttracheotomy tracheal stenosis in multivariate analysis [21]. Therefore, the incidence of 4/27 cases of severe tracheal or subglottic stenosis that we observed raises the question of the imputability of the percutaneous technique in these complications. The causal relationship between PDT and these adverse events remains speculative given that none of them occurred at the stoma level and may also have been related to prolonged translaryngeal intubation and/or cuff pressure lesion. Laryngotracheoscopy examination prior to PDT may be useful in identifying these cases. Indeed, the case selection for PDT makes inferences on the relative risk of short and long-term complications following PDT versus ST difficult to infer. We also speculate that maintaining expertise in the use of PDT in children may be challenging given the rarity of this procedure in the field.

Conclusion

PDT using the modified fibroscopic-guided Ciaglia technique is an option for traditional ST in adolescents and children older than 5 years. Our data highlight the need for careful airway examination prior to PDT, and debate remains regarding the optimal PDT method. Long-term comparative data, including case selection criteria, may be of use to define future avenues for aiding the weaning of children from mechanical ventilation.

Abbreviations

ARDS	Acute respiratory distress syndrome
ID	Inner diameter
PT	Percutaneous tracheostomy
PICU	Pediatric intensive care unit
PDT	Percutaneous dilatational tracheostomy
PELOD	Pediatric logistic organ dysfunction score
PRISM	Pediatric risk score of mortality score
ST	Surgical tracheostomy

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Authors' contributions
PD conceived the idea, wrote the initial draft of the manuscript, and performed most of the PDT procedures. JM provided useful inputs by performing most of the PDT procedures. MJC provided useful inputs to revise the manuscript substantially. LM provided inputs and supervision in the first PDT procedures. BM provided useful inputs to acquire the data. TB provided useful inputs and performed laryngotracheoscopy as well as management of complications. LM provided useful thoughts and inputs to revise the manuscript substantially. PT provided useful inputs to revise the manuscript substantially. The authors read and approved the final manuscript.

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Availability of data and materials
The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate
The study was approved by the appropriate Institutional Review Board (IRB). The requirement for written informed consent was waived by the IRB.

Consent for publication
Not applicable.

Competing interests
The authors declare that they have no competing interests.

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