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Conventional Surgical tracheostomy (ST), Dilatational Percutaneous tracheostomy (DPT), critically ill patients.

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Comparison of Percutaneous Dilational Tracheostomy and Surgical Tracheostomy Outcomes and Complications: A Retrospective Study

Abstract

Background: Tracheostomy is an alternate method of airway management that has the potential to alleviate patient discomfort and reduce the amount of work required to maintain the airway.

Objective: to discuss the risks and outcomes associated with surgical tracheostomy (ST) and percutaneous dilatational tracheostomy (PDT).

Methods: The study has employed a retrospective review of medical records. Critically sick patients undertook either ST tracheostomy or PDT. Statistical techniques were applied to analyze results and complications post-tracheostomy.

Results: 106 patients (PDT=66; ST=40) were surveyed. Demographics and comorbidities were similar in both groups. Length of stay in the ICU was significantly shorter in the PDT group (38.2 ± 22.4 days) in comparison to ST (56.1 ± 30.6 days) ($p < 0.001$). Weaning success was higher in the PDT group (68.2%) than ST (55.0%), although not statistically significant ($p = 0.173$). Complication rates were similar between the two groups with no statistically significant differences.

Conclusions: PDT appears to be a safe and efficient alternative to ST, with a notable reduction in ICU stay and a trend toward faster weaning. however, no statistically significant differences were observed in complication rates, successful weaning, or short-term survival.

Given the retrospective single-center design relatively small sample size, non-randomized patient allocation and potential confounding factors, the findings should be interpreted as exploratory and hypothesis-generating rather than definitive comparative evidence. Larger multicenter prospective studies are needed to confirm these findings.

INTRODUCTION

Acute respiratory failure necessitating mechanical ventilation is prevalent in critically ill patients [1], and as our understanding and tools for caring for such patients have evolved, more patients are being kept on mechanical ventilation for extended durations. Prolonged translaryngeal endotracheal intubation, which disables the laryngeal mechanisms and increases the risk of ventilator-associated pneumonia (VAP) due to oropharyngeal contamination of the bronchial tree and lungs, can lead to complications such as sinusitis and damage to the larynx and trachea [2].

Tracheostomy is a remarkably advantageous strategy for regulating the airway, with established high-quality patient results and a low death rate [3]. In the United States, tracheostomies are performed in around 10% of medical institution discharges requiring respiratory support and invasive mechanical ventilation, showing their widespread use among ICU patients [4]. Tracheostomy placement offers several advantages over prolonged endotracheal intubation, including enhanced patient comfort, reduced sedation requirements, lower airway resistance, and easier airway maintenance [5]. Patients with tracheostomies may find engaging in physical therapy and mobility easier. Weaning from mechanical ventilation may be facilitated by a tracheostomy due to reduced airflow resistance and respiratory effort. However, the impact of tracheostomy on these outcomes remains inconclusive. Tracheostomy patients can be more easily ventilated again after mechanical ventilation is removed compared to patients who require immediate re-intubation after extubation [6]. This is because clinicians can use more aggressive methods for mechanical ventilation when compared to patients who require extubation and re-intubation.

There is no standard set of criteria for the selection of tracheostomy patients. Because of this, practice has been shown to vary to decide the best methods for the mechanical ventilation of this group of patients [7]. The tracheostomy may be completed with direct or indirect visual assistance. In a Direct Visual Method, the surgeon dissects the pre-tracheal fascia and inserts the tracheostomy tube under direct view of the trachea. The standard surgical method also has poor aesthetics, and is associated with bleeding and stoma infection (cellulitis). Also, transporting critically ill patients from the ICU to the operating room has an impact on safety and logistics [8].

Ciaglia et al. [9] proposed the first of many methods generally known as percutaneous dilatational tracheostomy (PDT). This method has gained preference to traditional surgical tracheostomy in many ICUs and trauma centers. PDT involves percutaneous tracheostomy tube placement using a dilatational technique [8], often with the guidance of ultrasonography, blind puncture, or bronchoscopic imaging. PDT offers several advantages over traditional surgical tracheostomy, including less invasiveness, shorter procedural duration, and a lower risk of certain complications. [10]. Moreover, efforts to optimize tracheostomy practice might positively impact on the quality of care given to this group of severely sick patients and the resources used to provide that care. However, the best way to insert tracheostomies in this group has not been determined yet. While there is a lot of information available about the pros, disadvantages, and technical details of tracheostomy procedures, there is not much agreement on the optimal technique to use when dealing with critically sick individuals with acute respiratory failure. This study aims to compare Dilatational percutaneous tracheostomy versus surgical tracheostomy in critically ill patients.

MATERIAL AND METHODS

Study Design:

This is a retrospective, quantitative study design based on the analysis of medical records to compare perioperative outcomes and complications between patients undergoing dilatational percutaneous tracheostomy and those undergoing surgical tracheostomy. The study was conducted at a tertiary hospital in Riyadh, Saudi Arabia, between 2021 to 2024.

Given the observational retrospective nature of the study, patients were not randomly assigned to PDT or ST groups. Selecting appropriate tracheostomy techniques was at the discretion of the clinician. Considering the patient's condition and anatomy, along with the clinician's skills relative to that of their colleagues, formed the basis of the institution. This study aimed to analyze the clinical outcome impacts, but not the causal impact of techniques with respect to their superiority.

This study was designed retrospectively, and consequently, a lot of the clinical details relating to individual procedures was absent from the files. Records were sparse in their detail for the methodology of PDT, specifically if bronchoscopic or ultrasound guidance was used, what dilatation kits were used, or on the management of anticoagulation around the procedure. Additionally, information regarding the tracheostomy tube, the tube's dimensions, the duration of the procedure, and other technical details were either absent or not clear in the records.

Study participants:

This study analyzed data from 106 total patients (66 patients undergoing percutaneous procedures and 40 patients undergoing surgical procedures). Patients included in the study were adults that required Tracheostomy procedures while being in an intensive care unit (ICU). The percutaneous case sample was estimated to create a statistical power of 0.80 ($\alpha = 0.05$), with a target of 34 cases per arm to statistically capture difference on a sample calculated with an assumption of a 11.4% versus 40% rate of complications. [22–25].

Inclusion criteria:

Adult Patients (≥ 18 Years) in Need of Tracheostomy Admitted to the ICU. Patients Receiving Dilational Percutaneous Tracheostomy or Surgical Tracheostomy. Patients with Prolonged Intubation or who Fail to Wean from Mechanical Ventilation

Exclusion Criteria:

Patients with anatomical abnormalities complicating tracheostomy. Patients with a history of prior tracheostomy. Patients whose medical records lacked essential information required for the study.

Procedure

The study was carried out in a tertiary hospital in Riyadh, Saudi Arabia involving the nurses from different departments. The patients were included consecutively from the eligible patients who underwent tracheostomy during the study period. Electronic medical records were used to retrospectively collect data. Demographic data, comorbidities, type of tracheostomy surgery performed, intensive care unit (ICU) length of stay, mechanical ventilation withdrawal and postoperative complications were all extracted. Data were kept securely on university servers, and only available to the research team with strict encryption and monitoring procedures, ensuring confidentiality and integrity.

Sample Size Justification:

The sample size was determined to ensure good representation of both groups of tracheostomy types and was guided by previous reports reporting the different complication rates between the two types of tracheostomy in critically ill patients with similar patient populations in the ICUs and similar observational designs [23–25]. Reported complication rates in these studies ranged approximately from 10% to 40%, depending on the definition of complications and patient characteristics. Using these estimates, a minimum sample size of 34 patients per group was calculated assuming 80% power and a two-sided alpha of 0.05. However, because the present study was retrospective and based on all eligible cases during the study period, the calculation should be interpreted as supportive rather than determinative of enrollment

Data Analysis

Statistical analysis was carried out using the Statistical Package for the Social Sciences (SPSS Inc., Chicago, IL, USA), version 28. Frequency and percentages were obtained for the categorical variables, while mean and standard deviation (SD) were calculated for the scale variables. Qualitative data is described as numbers and percentages and then compared using the Chi-square and Fisher's Exact tests. Post hoc analysis was done using the Bonferroni test. The level of significance was set at $p < 0.05$.

Ethical Considerations:

Ethical approval was obtained from the Institutional Review Board (IRB) of King Fahad Medical City, Riyadh Second Health Cluster (IRB No: 24-522). Given the retrospective nature of the study and the use of previously recorded anonymized clinical data, the IRB approved a waiver of informed consent. Throughout the trial, patient privacy and confidentiality were rigorously upheld.

RESULTS

Table 1 presents the demographic characteristics and comorbidities of patients who underwent percutaneous. The average age of patients was 57.9±16.6 years in PDT, whereas for ST, the average age was 60.5±23.2 years (p=0.538). Both groups had clear male dominance; PDT accounted for 63.6% and ST for 52.5% (p=0.258). BMI mols were not significantly different: the mean for PDT was 28.0±6.6 kg/m², and that for ST was 29.1±7.3 kg/m² (p=0.436). Examples of comorbidities are between groups such as hypertension 60.6 % vs. 60.0 %; diabetes 53.0 % vs. 52.5 %; ischemic heart disease 24.2 % vs. 17.5 %; and chronic kidney disease 19.7 % vs. 10.0 % without any significant difference. The demographic parameters and comorbidities related to the groups, Percutaneous Tracheostomy (PDT) and Surgical Tracheostomy (ST), revealed no statistical difference.

Importantly, no statistically significant differences were identified between the two groups regarding baseline demographic characteristics, BMI, or major comorbidities, suggesting reasonable comparability between cohorts despite the absence of randomization.

Table 1.Demographic characteristics and comorbidities between the study groups

Variables		Percutaneous (Total=66)	Surgical (Total=40)	p-value
Age (years)		57.9±16.6	60.5±23.2	^0.538
Gender	Male	42 (63.6%)	21 (52.5%)	#0.258
	Female	24 (36.4%)	19 (47.5%)	
BMI (kg/m2)		28.0±6.6	29.1±7.3	^0.436
Comorbidities	Hypertension	40 (60.6%)	24 (60.0%)	#0.951
	Diabetes mellitus	35 (53.0%)	21 (52.5%)	#0.958
	Ischemic heart disease	16 (24.2%)	7 (17.5%)	#0.414
	Chronic kidney disease	13 (19.7%)	4 (10.0%)	#0.187
	Arrhythmia	10 (15.2%)	5 (12.5%)	#0.704

Data are presented as Mean±SD or number (%). BMI: Body mass index. #Chi square test. ^Independent t-

Table 2 states that there were no statistically significant differences in a unit of admission, APACHE II score, and time from intubation to tracheostomy between the study groups. The ICU and thoracic operators performed the percutaneous technique significantly, while the ENT operators performed the surgical technique significantly.

A comparison of complications between percutaneous tracheostomy (PDT) and surgical tracheostomy shows minimal differences in adverse outcomes (Table 3). Air leaks were noted in a slightly higher proportion concerning PDT than with ST (12.1% vs. 10.0%), with a relative rate of 1.21 (95% CI: 0.39-3.77). In PDT, bleeding was recorded in 9.1% of cases, and in ST, 5.0%; the difference was statistically insignificant (p=0.707). Emphysema incidence was comparable - 3.0% in PDT and 2.5% in ST; one case of pneumothorax was noted in PDT (1.5%), while ST had none. PDT had a slightly higher overall complication rate (19.7%) compared to ST

(17.5%), although this difference was not significant (p=0.779). These data suggest that both procedures are similarly safe, with no firm evidence of differences in any complications.

Table 2. Clinical characteristics of tracheostomy between the study groups

Variables		Percutaneous (Total=66)	Surgical (Total=40)	p-value
Unit	General ICU	37 (56.1%)	26 (65.0%)	#0.342
	Cardiovascular ICU	11 (16.7%)	8 (20.0%)	
	Neuro critical care unit	18 (27.3%)	6 (15.0%)	
APACHE II score		25.3±32.4	23.8±32.0	^0.815
The interval between intubation and tracheostomy (days)		21.5±9.9	23.9±9.3	^0.221
Operator	ICU	42 (63.3%)a	0 (0.%)b	#<0.001 *
	ENT	0 (0.%)a	39 (97.5%)b	
	Thoracic	24 (36.4%)a	1 (2.5%)b	

Data are presented as Mean±SD or number (%). ICU: Intensive care unit. ^Independent t-test. #Chi square test. *Significant. Homogenous groups had the same symbol, "a and b," based on the post hoc Bonferroni test.

A comparison of complications in Percutaneous Tracheostomy (PDT) versus Surgical Tracheostomy (ST) shows only slight differences (Figure 2). Air leaks were seen more commonly in PDT at 12.1% than in ST, which was at 10.0%. Bleeding complications were similarly more common in PDT, at 9.1% than in ST, which had a 5.0% incidence. Slightly higher than ST at 2.5%, emphysema was seen at a 3.0% rate in PDT. There were incidences of pneumothorax at 1.5% of PDT cases, while there were no cases in ST. Total complications were seen at 19.7% in PDT patients compared to 17.5% in ST patients. This implies that both methods are comparable to each other in terms of safety, but the complication rates vary only slightly.

Table 3. Complications between the study groups

Complications	Percutaneous (Total=66)	Surgical (Total=40)	p-value	Relative rate (95% CI)
Air leak	8 (12.1%)	4 (10.0%)	§0.999	1.21 (0.39–3.77)
Bleeding	6 (9.1%)	2 (5.0%)	§0.707	1.82 (0.39–8.58)
Emphysema	2 (3.0%)	1 (2.5%)	§0.999	1.21 (0.11–12.94)
Pneumothorax	1 (1.5%)	0 (0.0%)	§0.999	Not applicable
Any complication	13 (19.7%)	7 (17.5%)	#0.779	1.13 (0.49–2.58)

Data are presented as numbers (%) unless mentioned otherwise. §Fisher's Exact test. CI: Confidence Interval.

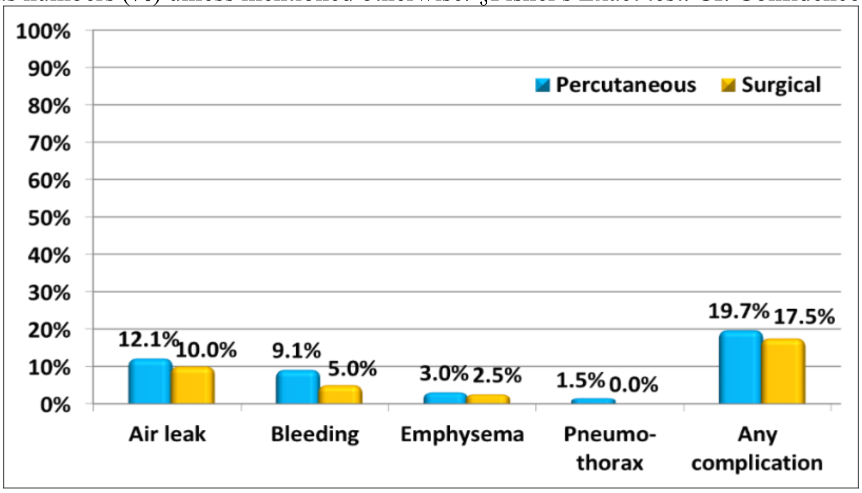

Figure 1. Comparison of complication rates between Percutaneous Tracheostomy (PDT) and Surgical Tracheostomy (ST).

Figure 1. weaning succeeded more often in patients with PDT 68.2% than with ST at 55.0%, but p=0.173 indicates no statistically significant difference between the two groups (Table 4). The relative rate 1.24 (95% CI: 0.90–1.72) demonstrated a trend towards PDT but with insufficient statistical confidence. At 30 days, survival was similar in both PDT (81.8%) and ST (82.5%), and a p-value of 0.929 confirms no significant difference between the two groups. The relative rate 0.99 (95% CI: 0.83–1.19) favors this conclusion. PDT patients demonstrated a significantly shorter ICU stay

of 38.2 ± 22.4 days as opposed to ST with 56.1 ± 30.6 days, p-value <0.001 indicating statistical significance, with the mean difference being -18.0 ± 5.2 days, which suggests an absolute reduction in ICU burden with PDT.

Table 4. Clinical outcomes within 30 days between the study groups

Clinical outcomes	Percutaneous (Total=66)	Surgical (Total=40)	p-value	Relative rate / Mean±SE (95% CI)
Successful weaning	45 (68.2%)	22 (55.0%)	#0.173	1.24 (0.90–1.72)
Survival	54 (81.8%)	33 (82.5%)	#0.929	0.99 (0.83–1.19)
Length of ICU stay following tracheostomy (days)	38.2±22.4	56.1±30.6	^<0.001*	-18.0±5.2 -28.2–-7.7

Data are presented as numbers (%) unless mentioned otherwise. §Fisher's Exact test. ^Independent t-test. CI: Confidence Interval. SE: Standard error.

Success in weaning patients within the first thirty days would present a far better figure in the percutaneous tracheostomy (PDT) group (68.2%) than that reported for the surgical tracheostomy (ST) group (55.0%). Although numerically higher weaning success was observed in the PDT group, the difference did not reach statistical significance. Survival rates were not different for either of the two techniques, with PDT at 81.8% and ST at 82.5%. This indicates that short-term survival is the same with both approaches. The time spent in the ICU was substantially shorter for the PDT group (38.2 days) than for the ST group (56.1 days), indicating that other factors in addition to the technique of the tracheostomy may have contributed to the difference in the amount of time spent in the ICU.

DISCUSSION

Current research aims to compare these treatments (PDT and ST) with respect to their complications, Length of stay in the ICU, and duration of mechanical ventilation weaning in a group of patients with a critical illness. The findings provide guidance to the strengths and weaknesses of either approach and are consistent with the findings of previous studies on tracheostomy use in critical care settings [29].

Because of the observational retrospective design of this study, the results should be interpreted in the context of this study. However, demographic and clinical data at baseline (APACHE II score and major comorbidities) were similar between the two groups, thereby supporting the validity of the comparisons made. Moreover, the study is conducted in the actual clinical setting of the ICU in a tertiary-care center, making clinical relevance and relevance of the observations made from the study. In addition, the study reflects actual clinical practice in the ICU in a tertiary care center, allowing clinically relevant observations of the outcomes of tracheostomy performed in the setting of critical illness.

The technique of tracheostomy placement, such as with imaging guidance, choice of equipment, anticoagulation management, and tracheostomy tube design, can affect the success of the procedure and its complications. These variables would not be measured systematically in the current study, so it is not possible to determine how they affected the observed outcomes.

Regarding Complications and Safety Profile, very few complications, such as air leaks, bleeding, emphysema, and pneumothorax, were noted in either PDT or ST groups without any statistically significant difference or differences among groups in these complications. The current findings are, therefore, consistent with previous studies [30], which have shown similarity in complications experienced between PDT and ST. A meta-analysis series by Iftikhar et al. indicated that all the tracheostomy techniques examined had rates of complication within the same range, emphasizing the safety of PDT for critically ill patients [13]. On the contrary, Ülkümen et al. found fewer total complications in PDT, particularly a lower incidence of pneumothorax and accidental decannulation-trial, and these results contrast slightly with the current studies [14]. Such discrepancies in incidence have indeed been attributed to the different types of ability of the operator and the procedural protocol practiced in various institutions [14].

The complication evaluation was confined to some recognized short-term incidents. Important problems not properly captured were unintentional decannulation, stomal infection, tracheal stenosis, and long-term airway dysfunction. Thus, the results are indicative of some short-term problems and not the overall safety profile of PDT and ST.

The lack of statistically significant differences in complication rates should be interpreted cautiously. The study was powered using complication rates derived from prior literature, which were substantially higher than those observed in the present cohort. As a result, the study may have been underpowered to detect clinically meaningful differences, particularly for uncommon complications such as pneumothorax, emphysema, and major bleeding. Therefore, the absence of statistical significance should not be interpreted as evidence of equivalent safety between PDT and ST.

Regarding Length of ICU Stay, PDT patients had a remarkably shorter ICU stay than ST patients (38.2 ± 22.4 days vs. 56.1 ± 30.6 days, $p < 0.001$). In a recent study, Lim et al. found that PDT procedures had reduced treatment times and fewer complications in the post-procedure period for critically ill neurosurgical patients [16]. In a similar study, Suzuki et al. illustrated that PDT treatment was associated with early recovery and fewer postoperative problems. It is probably the fact that PDT can be done at bedside and requires no transport to the OR that contributes to these results [15].

Although PDT was associated with a shorter ICU stay in the present cohort, this finding should not be interpreted as evidence of procedural superiority. Given the non-randomized allocation process, differences in patient selection, anatomical suitability, operator expertise, and institutional practice patterns may have contributed to the observed outcomes.

Regarding Weaning from Mechanical Ventilation, While the difference between the PDT group (68.2%) and the ST group (55.0%) in the VAC 3-month weaning outcome was not considered to reach significance, its clinical relevance is plausible because PDT is associated with faster weaning from mechanical ventilation. Based on their findings, Freeman & Morris recommend that patients may be more comfortable after tracheostomy placement, and therefore be able to be liberated from ventilatory support earlier in the care, particularly when less invasive approaches are being utilized, such as PDT [6]. In favor of that, Angel et al. and Gupta et al. suggest that PDT provides improved ventilatory outcomes and earlier rehab for patients in the ICU. In some cases, though, individual patient factors like comorbidities and sedation needs will determine the success of weaning [21, 25].

Nonspecific standards for successful weaning were established and were not based on a fixed period of ventilator independence. Success of weaning was defined by available clinical documentation and not by a predetermined period of ventilator independence. Thus, caution should be exercised when comparing the results of this study with other studies that have applied other weaning criteria. A further potential source of confounding is the operator's specialty. In our institute, the major part of PDT was done by the ICU physicians and thoracic surgeons, while the ST was almost exclusively done by the ENT surgeons. The actual differences in operator training, experience with procedures, selection criteria for patients, time of tracheostomy, peri-operative management, and postoperative care pathways may also have played a role in the outcomes, separate from the technique of the tracheostomy itself. Hence, the present comparison is based on actual application processes and should not be viewed as a one-off evaluation of the procedural effects [26].

Clinical Implications

The results of the current study indicate that PDT and ST had similarly broad similarity with respect to short-term results in this institutional population. Given the observational approach and lack of control over confounding factors, the results of the study should not be taken as a conclusive endorsement of the one technique over the other. This is in line with the literature, which indicates that PDT reduces length of stay (LOS) in the intensive care unit (ICU) and accelerates the recovery process without impacting the rate of complications. The choice of the most appropriate tracheostomy technique, however, is still heavily reliant on the experience of the operator, standardization of procedure and patient selection. Long-term outcome data of functional recovery after PDT and ST should be included in future studies [30-31].

Limitations

This study has several limitations that should be considered. It was carried out in one tertiary hospital and therefore, may not be generalizable. It also has the disadvantage of being retrospective, and may be subject to selection bias and incomplete data, potentially influencing the accuracy of the results. In addition, procedural information was not always available such as bronchoscopic or ultrasound guidance for PDT, specific dilatational techniques and/or kits, anticoagulation management strategies, location of the procedure, tracheostomy tube characteristics, and other procedural information. These factors could affect the risk of complications and clinical outcomes and thus serve as additional unmeasured confounders. Further limitations of the strength of causal inference and external generalizability are introduced by the relative small sample size and absence of comprehensive adjustment for confounders. Furthermore, a priori sample size estimation was carried out, but the assumptions were that the difference between the groups was larger than the difference observed. The study therefore might not have been sufficiently powered to show small differences in outcomes, particularly for rare complications. These large confidence intervals reduce the precision of the estimates of effect and make it impossible to draw any firm conclusions on comparative safety. Successful weaning was not prescribed in terms of a standard protocol or a number of days of ventilator independence, and this may reduce the comparability of this study to others and provide variability in outcome classification.

The choice of the technique for tracheostomy was strongly correlated with the operator's specialty, which was a large source of confounding. The study did not separate the effects of PDT from the effects of the operator, decision making, timing of the procedure, or post procedures care. This restriction also prevents the distinction of outcome differences as a consequence of the technique of tracheostomy.

CONCLUSION

This was a retrospective single-center study of the short-term outcomes and complications of PDT versus ST in the critically ill patient. No statistically significant differences were found in complication rates, but as there were small numbers and low rates of events, the results should not be interpreted as evidence of equal safety. In the PDT group, the number of days in the intensive care unit was shorter, while there was no difference in complications between the two groups, successful weaning to tracheostomy or to non-tracheostomy ventilation, or survival at 30 days. The observational design, non-randomized allocation of treatment and the risk for selection bias do not allow to draw a conclusion on the superiority of either technique, although PDT was associated with a shorter stay in the intensive care unit (ICU). The results are thus exploratory and hypothesis generating, and not to be interpreted as definitive comparative evidence. Complications were not much different, but the small number of complications and absence of long-term follow-up do not allow for detailed safety comparisons. Moreover, it is not possible to conclude from the study design whether this is a result of the technique of the tracheostomy or due to variations in patient characteristics, clinical management and institutional practices. Therefore results in this study should be viewed as observations and hypotheses about procedural improvement and not as proof of the superiority of that process.

Future Research Directions

Future research should investigate the following research areas to further enhance tracheostomy practices:

1.Multicentric study and randomized trial: Multicentric prospective studies with randomized controlled design increase the validity of the application in all healthcare systems.

2.Future work needs to be directed at long term adverse events (e.g. tracheostomy related airway obstruction, quality of life) for a model after tracheostomy.

3.Impact of Operator Expertise: Examining the differences in complication rates and efficiency of procedures between different operators (surgeons vs intensivists) can help improve future training.

4.Cost-Effectiveness Analysis: Consideration of the economic cost of PDT compared to ST, including the use of hospital resources, surgical cost, and cost of postoperative care can be part of a health policy decision-making.

5.New Technologies with Tracheostomy Procedures: The role of robotic assistance or AI-guided imaging in conjunction with real-time ultrasound navigation is under study and could improve accuracy, safety, and patient outcome.

6.Patient-Centered Outcomes: Evaluating patients' self-reported satisfaction with comfort and success in rehabilitation post-procedure would enable a more holistic evaluation of PDT and ST.

7.Future multicenter prospective randomized studies with larger sample sizes, standardized operator protocols, comprehensive adjustment for confounding variables, and extended long-term follow-up are required to establish more definitive comparative evidence regarding PDT and ST outcomes.

Data availably statement

The data that supports the findings of this study are available from the corresponding author, FA. upon request. These data were obtained from a hospital and contain sensitive patient information; therefore, they are not publicly available due to privacy and confidentiality restrictions.

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Declaration of Competing Interests

The authors have no known competing financial or personal interests.

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