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Bronchoscopy-Guided Percutaneous versus Conventional Surgical Tracheostomy in a Thoracic Surgery Residency Program: A Prospective Randomized Study

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1. Abstract

1.1. Background

Bronchoscopy-guided percutaneous tracheostomy has become an increasingly adopted alternative to conventional surgical tracheostomy in critically ill patients. However, evidence regarding its incorporation into thoracic surgery residency training programs remains limited.

1.2. Methods

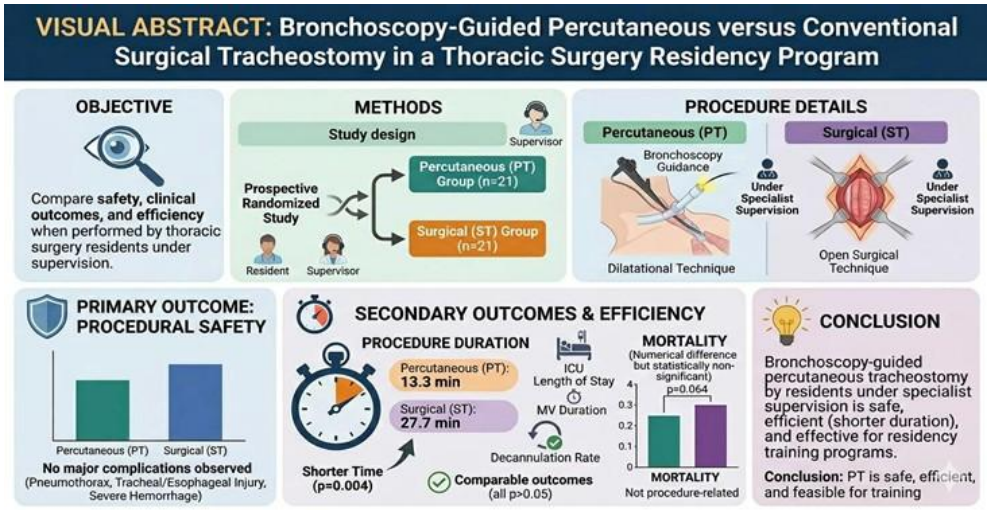
This prospective randomized study compared bronchoscopy-guided percutaneous tracheostomy (PT) and conventional surgical tracheostomy (ST) performed by thoracic surgery residents under specialist supervision in a tertiary university hospital. Forty-two critically ill patients requiring tracheostomy were randomized to PT (n=21) or ST (n=21). The primary outcome was procedural safety. Secondary outcomes included procedure duration, mechanical ventilation duration, intensive care unit (ICU) stay, hospital stay, decannulation, mortality, and procedure-related complications.

1.3. Results

Baseline demographic and clinical characteristics were comparable between groups. Procedure duration was significantly shorter in the PT group compared with the ST group (13.3 vs. 27.7 minutes, p=0.004). No significant differences were observed regarding mechanical ventilation duration, ICU stay, hospital discharge, decannulation, or complication rates (all p>0.05). Mortality was numerically higher in the PT group (14 vs. 8 patients), although this difference was not statistically significant (p=0.064). No major procedure-related complications, including pneumothorax, tracheal injury, esophageal injury, severe hemorrhage, or procedure-related mortality, were observed.

1.4. Conclusions

Bronchoscopy-guided percutaneous tracheostomy performed by thoracic surgery residents under specialist supervision demonstrated safety and clinical outcomes comparable to conventional surgical tracheostomy while significantly reducing procedural duration. These findings support its incorporation into thoracic surgery residency training programs as a safe and efficient bedside airway procedure.



2. Introduction

Tracheostomy is one of the most commonly performed procedures in critically ill patients requiring prolonged mechanical ventilation. Conventional surgical tracheostomy has historically been considered the standard approach for establishing a definitive airway and is routinely performed by thoracic surgeons, general surgeons, head and neck surgeons, otorhinolaryngologist and critical care teams. However, advances in minimally invasive techniques have significantly transformed airway management in intensive care settings [1,2].

Percutaneous tracheostomy has gained widespread acceptance because of its bedside feasibility, reduced tissue dissection, shorter procedural duration, and potential to decrease healthcare resource utilization. The addition of flexible bronchoscopic guidance further enhances procedural safety by providing real-time visualization of needle puncture, guidewire positioning, and tracheostomy tube placement, reducing the risk of airway injury and false passage creation [3,4].

Multiple randomized trials and meta-analyses have demonstrated comparable safety profiles between percutaneous and conventional surgical tracheostomy, with some studies suggesting lower wound infection rates and shorter procedural times with the percutaneous approach[4–9]. Consequently, bronchoscopy-guided percutaneous tracheostomy has become an increasingly important component of airway management in modern intensive care practice [5,6].

Beyond its clinical applications, the growing adoption of bedside minimally invasive procedures has important implications for surgical education. Contemporary thoracic surgery training increasingly requires proficiency not only in conventional operative techniques but also in bronchoscopic procedures, critical care interventions, and multidisciplinary intensive care management. Bronchoscopy-guided percutaneous tracheostomy combines several of these competencies, including airway endoscopy, procedural decision-making, and bedside intervention, making it a potentially valuable educational tool for thoracic surgery residents.

Despite the expanding use of percutaneous tracheostomy, evidence regarding its incorporation into thoracic surgery residency training programs remains limited, particularly in middle-income countries and public healthcare systems. Understanding whether residents can safely perform bronchoscopy-guided percutaneous tracheostomy under specialist supervision is essential for developing modern competency-based training curricula [7-9].

Therefore, this prospective randomized study aimed to compare bronchoscopy-guided percutaneous tracheostomy and conventional surgical tracheostomy when performed by thoracic surgery residents under specialist supervision, evaluating procedural safety, clinical outcomes, and procedural efficiency in critically ill patients.

3. Methods

This prospective randomized study was conducted between february until october 2025, in the intensive care units (ICU) of Hospital das Clínicas, Federal University of Minas Gerais, Brazil, a tertiary academic referral center with an accredited Thoracic Surgery Residency Program.

Adult critically ill patients requiring tracheostomy for prolonged mechanical ventilation or airway management were screened for eligibility. Patients younger than 18 years of age, those with severe cervical infections, uncontrolled coagulopathy, previous tracheal disease, or anatomical contraindications to percutaneous tracheostomy were excluded.

4. Sample Size Calculation

The sample size was estimated based on the institutional annual volume of tracheostomies, with an average of 62 procedures performed per year. Considering a two-sided alpha error of 0.05, a statistical power of 80%, and the feasibility of recruitment during the study period, a minimum sample size of 46 patients was defined. Patients were randomly allocated in a 1:1 ratio, resulting in 23 patients in the bronchoscopy-guided percutaneous tracheostomy group and 23 patients in the conventional surgical tracheostomy group.

All procedures were performed by thoracic surgery residents under direct supervision of board-certified thoracic surgeons. Residents participating in the study had previous experience in bronchoscopy and basic airway procedures as part of their structured residency curriculum.

All patients received standardized sedation and analgesia protocols consisting of fentanyl, midazolam, and neuromuscular blockade according to institutional intensive care unit protocols.

Percutaneous tracheostomies were performed at the bedside under flexible bronchoscopic guidance using the Seldinger dilatational technique. Conventional surgical tracheostomies were performed according to standard open surgical techniques.

5. Outcomes

The primary outcome was procedural safety, assessed through the occurrence of perioperative and postoperative complications.

Secondary outcomes included: Procedure duration, Mechanical ventilation duration after tracheostomy, ICU length of stay, Hospital discharge, Mortality, Decannulation rate, Need for additional specialist consultations, Procedure-related complications.

Procedure duration was defined as the interval between skin incision/puncture and successful tracheostomy tube placement.

Complications included clinically significant bleeding, pneumothorax, tracheal injury, esophageal injury, tracheomalacia, wound infection, and other airway-related adverse events.

6. Statistical Analysis

Continuous variables were expressed as mean ± standard deviation or median (interquartile range), according to data distribution. Categorical variables were presented as absolute numbers and percentages. Comparisons between groups were performed

using Student's t-test or Mann–Whitney U test for continuous variables and Chi-square test or Fisher's exact test for categorical variables, as appropriate. Statistical significance was established at a two-sided p-value <0.05. Statistical analyses were performed using SPSS version XX (IBM Corp., Armonk, NY, USA).

7. Ethical Considerations

The study followed all ethical guidelines, ensuring informed consent for all patients and protecting their identity and preventing data leaks. The work was duly submitted and approved under registration number CAAE: 92142525.7.0000.0444, with favourable opinion number: 8.291.990 by the ethics committee of the Faculty of Medicine of the Federal University of Minas Gerais. Informed consent forms were duly applied to the guardians of the patients involved, in accordance with the study guidelines.

Resident Training Program

The study was conducted within an accredited thoracic surgery residency program. Tracheostomies were performed by first and second year residents in thoracic surgery program under direct supervision of board-certified thoracic surgeons. Residents had prior experience in flexible bronchoscopy and airway management and were progressively exposed to both conventional surgical and bronchoscopy-guided percutaneous tracheostomy techniques as part of their competency-based training. Supervising surgeons remained available throughout all procedures to ensure patient safety and provide technical guidance when required.

8. Results

Patients were randomly assigned in a 1:1 ratio to undergo either bronchoscopy-guided percutaneous tracheostomy (PT group) or conventional surgical tracheostomy (ST group). Randomization was performed using sealed opaque envelopes prepared before study initiation. A total of 42 patients were included after 4 patientes were excluded because they did not meet the study's inclusion criteria.: Percutaneous tracheostomy group (PT) with 21 patients and surgical tracheostomy group (ST) with 21 patients

The groups demonstrated homogeneous demographic and clinical characteristics. Mean age was 63.2 years in the percutaneous group and 56.6 years in the surgical group. APACHE II and SOFA scores showed no statistically significant differences. The most frequent underlying diseases were neurological, cardiological, and oncological conditions. The principal indication for tracheostomy was prolonged intubation, followed by failed extubation Table 1.

Clinical outcomes were comparable between groups. No significant differences were observed in ventilatory, ICU, hospital discharge, decannulation, or complication outcomes (all p>0.05). Procedure duration was significantly shorter in the bronchoscopy-guided percutaneous tracheostomy group (13.3 vs. 27.7 minutes, p=0.004). Although mortality was numerically higher in the percutaneous group (14 vs. 8 patients), this difference was not statistically significant (p=0.064). Despite being performed by thoracic surgery residents under specialist supervision, both techniques demonstrated a favourable safety profile Table 2. Procedure-related complications were uncommon in both groups, despite all procedures being performed by thoracic surgery residents under specialist supervision. No major complications, including pneumothorax, tracheal injury, esophageal injury, tracheomalacia, severe hemorrhage, or procedure-related death, were observed. Delayed minor bleeding (>24 hours) occurred only in the conventional surgical tracheostomy group. Overall complication rates were low and did not differ significantly between techniques.

Demographic Characteristics of the Tracheostomized Patients Included in the Study – Hospital das Clínicas, Federal University of Minas Gerais (UFMG), 2025.

Variables	Percutaneous (n = 21)	Conventional (n = 21)	Total (n = 42)	P - value
Age (years)	63,2 (32-84)	56,6 (33-87)	59,9 (32-87)	0,098
Male	9	12	21	0,355
Female	12	9	21	0,355
Hypertension	13	12	25	0,753
Diabetes	4	5	9	1,000
Smoking history	7	7	14	1,000
Alcohol use	3	4	7	1,000
Obesity	2	2	4	1,000
Dyslipidemia	0	3	3	0,232
Hypothyroidism	4	0	4	0,107
Hyperthyroidism	0	1	1	0,311
COPD	2	2	4	1,000
Other comorbidities	17	16	33	1,000

Number of comorbidities	3,52 (0-10)	2,67 (0-6)	3,10 (0-10)	0,412
Emergency admission	19	14	33	0,130
Oncologic disease	6	6	12	1,000
Cardiovascular disease	8	6	14	0,513
Neurological disease	8	9	17	0,753
Previous transplantation	3	2	5	1,000
Immunosuppression	4	5	9	1,000
Coagulopathy	5	6	11	0,726
SOFAq	6,43 (1-14)	7,95 (3-15)	7,19 (1-15)	0,166
APACHE II	19,81 (5-32)	21,57 (10-35)	20,07 (5-35)	0,347

Table 1: Baseline demographic and clinical characteristics of patients randomized to bronchoscopy-guided PT) and ST.

Table 2: Clinical Evolution Aspects of the Tracheostomized Patients Included in the Study – Hospital das Clínicas, Federal University of Minas Gerais (UFMG), 2025.

Variables	Percutaneous	Conventional	Total	P - value
	(n = 21)	(n = 21)	(n = 42)	
Intubation duration (days)	10,4 (0-27)	12,7 (5-21)	11,6 (0-27)	0,212
Transfusion for tracheostomy[1]	4	1	5	0,343
Procedure-related adverse events	6	3	9	0,454
Procedure duration (min)	13,3 (2-45)	27,7 (8-80)	18,0 (2-80)	0,004
Time to ICU discharge after tracheostomy[1] (days)	15,6 (3-61)	16,1 (3-48)	15,9 (3-61)	0,557
Time from tracheostomy to liberation from mechanical ventilation[2] (days)	6,23 (1-23)	7,14 (1-46)	6,7 (1-46)	0,487
Decannulation	15	10	25	0,116
Time to decannulation (days)	33,2 (8-92)	33,3 (12-127)	33,2 (8-127)	0,880
Time to hospital discharge (days)	46,6 (16-98)	46,3 (16-127)	46,4 (16-127)	0,831
Mortality	14	8	22	0,064

Table 2: Clinical outcomes of patients randomized to bronchoscopy-guided PT and conventional ST.

Table 3: Post-Procedural Complications in the Tracheostomized Patients Included in the Study – Hospital das Clínicas, Federal University of Minas Gerais (UFMG), 2025.

Post-tracheostomy complications	Percutaneous	Conventional	Total	P - value
	(n = 21)	(n = 21)	(n = 42)	
Bleeding >24 hours	0	3	3	0,232
Required specialist consultation[1]	4	4	8	1,000
Number of specialist consultations[1]	1,0 (0,0)	1,75 (0,957)	1,38 (0,744)	0,084
Post-tracheostomy pneumonia[2]	10	6	16	0,204
Bronchoscopy	1	2	3	1,000
Cannula obstruction	1	0	1	1,000
Cannula dislodgement	0	1	1	1,000
Wound infection	1	0	1	1,000

Table 3: Postoperative complications following bronchoscopy-guided PT and conventional ST.

9. Discussion

The present prospective randomized study demonstrated that bronchoscopy-guided percutaneous tracheostomy performed by thoracic surgery residents under specialist supervision is a safe and effective alternative to conventional surgical tracheostomy in critically ill patients. Clinical outcomes, complication rates, ventilatory outcomes, decannulation rates, and hospital discharge were comparable between groups, while the percutaneous technique was associated with a significantly shorter procedural duration.

The most relevant finding of this study was the reduction in procedure time observed in the bronchoscopy-guided percutaneous tracheostomy group. The mean procedural duration was reduced by approximately 50% compared with conventional surgical tracheostomy. This finding is consistent with previous randomized studies and meta-analyses demonstrating greater procedural efficiency of percutaneous techniques. Shorter procedures may reduce sedation exposure, minimize interruption of intensive care unit activities, and improve bedside workflow, particularly in high-volume centers.

Regarding safety, no major procedure-related complications were observed in either group. No cases of pneumothorax, tracheal injury, esophageal injury, tracheomalacia, severe hemorrhage, or procedure-related mortality occurred. Delayed minor bleeding was observed only in the conventional surgical tracheostomy group. These findings are consistent with previous reports demonstrating comparable safety profiles between surgical and percutaneous tracheostomy when appropriate patient selection and technical expertise are present.

Although mortality was numerically higher in the percutaneous tracheostomy group, no death was directly attributable to the procedure itself. All deaths were related to progression of the underlying critical illness. Furthermore, baseline differences not fully captured by measured variables may have influenced outcomes despite randomization. Given the relatively small sample size, the study was not powered to detect differences in mortality, and this finding should therefore be interpreted with caution.

An important contribution of the present study is its educational perspective. Modern thoracic surgery training increasingly extends beyond the operating room and includes bronchoscopy, airway management, and bedside procedures in critically ill patients. Bronchoscopy-guided percutaneous tracheostomy integrates all of these competencies into a single procedure. The favorable safety profile observed in this study suggests that the technique can be incorporated into thoracic surgery residency programs under appropriate supervision without compromising patient safety.

The educational value of the procedure may be particularly relevant in university hospitals and public healthcare systems. The ability to perform tracheostomy at the bedside using minimally invasive techniques may expand resident exposure to airway interventions while simultaneously improving procedural efficiency and reducing the need for operating room resources. In this context, bronchoscopy-guided percutaneous tracheostomy represents not only a therapeutic intervention but also a valuable component of competency-based surgical training.

The limitations of the study were, first, it was conducted at a single institution with a small sample size. Second, the study was not specifically powered to detect differences in mortality or rare complications. Third, long-term outcomes such as tracheal stenosis and quality-of-life measures were not systematically evaluated. Nevertheless, the prospective randomized design and the inclusion of procedures performed by residents under direct specialist supervision provide clinically relevant evidence supporting the safety and feasibility of bronchoscopy-guided percutaneous tracheostomy in thoracic surgery training programs.

10. Conclusion

Bronchoscopy-guided percutaneous tracheostomy performed by thoracic surgery residents under specialist supervision demonstrated safety and clinical outcomes comparable to conventional surgical tracheostomy while significantly reducing procedural duration. The findings support the incorporation of bronchoscopy-guided percutaneous tracheostomy into thoracic surgery residency training programs as a safe and efficient bedside airway procedure.

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