Bronchoscopic-Guided Percutaneous Dilatational Tracheostomy: A Single-Center Experience

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Abstract

Aim: Percutaneous dilatational tracheostomy (PDT) is a common procedure in intensive care units (ICUs) for patients requiring prolonged mechanical ventilation. This study aims to evaluate the outcomes of PDT under fiberoptic bronchoscopy guidance, comparing early versus late tracheostomy timing.

Methods: This retrospective study analyzed 57 patients who underwent PDT with fiberoptic bronchoscopy guidance. Patient demographics, Glasgow Coma Scale (GCS) scores, APACHE II scores, duration of mechanical ventilation, and complications were assessed.

Results: Of the 57 patients, 29.8% underwent early tracheostomy, and 70.2% underwent late tracheostomy. No significant differences were found in terms of age, gender, or GCS and APACHE II scores between the two groups. No significant differences in ICU length of stay, mortality, or weaning from ventilator were observed between the groups. The incidence of minor complications was similar between the two groups.

Conclusions: The study found no significant difference in clinical outcomes between early and late tracheostomy groups. While bronchoscopy enhanced procedural safety, it did not impact complication rates significantly. The timing of PDT should be individualized based on clinical judgment and patient condition. Tracheostomy timing should be tailored to each patient's condition, and larger studies are needed to define optimal timing guidelines.

***Keywords**: Percutaneous dilatational tracheostomy; fiberoptic bronchoscopy; mechanical ventilation; ICU; timing of tracheostomy*

1. Introduction

Percutaneous dilatational tracheostomy (PDT) is a commonly performed surgical procedure in intensive care units (ICUs) for patients receiving prolonged invasive mechanical ventilation. [1,2] Among the various PDT techniques, the percutaneous tracheostomy method described by Griggs and colleagues [3] is widely used, involving tracheal dilation with forceps to place the tracheostomy cannula.

The ability to perform PDT at the patient's bedside without the need for operating room transport, along with its lower complication rates, makes it widely used in ICU patients planned for elective tracheostomy. [4] However, complications can occur during and after the procedure, including bleeding, hypercapnia, hypoxia, subcutaneous emphysema, pneumothorax, sudden death, and esophageal injury. [5] Post-procedure complications may include early and late bleeding, pneumonia, stoma infection, cellulitis, tracheocutaneous fistula, and tracheoesophageal fistula. [5] The use of bronchoscopy during PDT can enhance procedural safety and reduce the incidence of complications both during and after the procedure. [6] Bronchoscopy helps to select appropriate incision site, to prevent posterior tracheal wall puncture and confirm the proper insertion of the cannula. However, it is still controversial to use bronchoscopy routinely when performing PDT. [7]

Bronchoscopy may facilitate PDT particularly in patients with limited neck extension. It was shown that very early (within 3 days) PDT under the guidance of bronchoscopy can be safely performed in anterior cervical spine fixation patients. [8]

Effects of timing of PDT on outcomes have been researched in literature and variable results have been achieved. In a retrospective study comparing very early versus early and late PDT in 255 ICU patients, it was found that very early tracheostomy achieved shorter length of hospital stay and reduced mortality. [9]

Clinical outcomes between trauma patients who underwent early (within 10 days), and late (after 10 days) tracheostomy were compared and early tracheostomy was found to reduce the length of hospital and ICU stay and duration of mechanical ventilation. [10]

Besides, a randomized controlled trial (RCT) showed no significant benefit for early (<10 days of intubation) versus late tracheostomy (>10 days of intubation). Additionally, it was found that only 45% of the cases who underwent to late tracheostomy actually needed it after 10 days. [11]

We aimed to retrospectively evaluate the clinical outcomes and

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complication rates in the patients who underwent early or late PDT performed under fiberoptic bronchoscopy guidance in our clinical practices in this study.

2. Materials and Methods

The study was carried out at the ICUs of Lokman Hekim University Ankara Hospital with a bed capacity of 51. The ethics committee approval was taken from the Lokman Hekim University Ethics Committee (Date: 29/11/2024, No: 2024/275). Data of the patients undergoing PDT in ICUs between January 2021 and October 2024 were obtained from the hospital database and analyzed retrospectively.

From the patient records, age, genders, ICU admission indications, Glasgow Coma Scale (GCS) scores, Acute Physiology and Chronic Health Evaluation-II (APACHE II) scores, duration of invasive mechanical ventilation (IMV) before and after tracheostomy, total duration of IMV, results of blood gas analyze results, early and late complications during and after tracheostomy were recorded.

2.1. Tracheostomy Procedure

From 2021 onward, tracheostomy procedures in our ICU have been performed bedside using bronchoscopy guidance, Griggs forceps for dilation, and a modified mini-surgical technique. After obtaining informed consent, pre-procedure evaluations of bleeding parameters and other laboratory tests were performed. If patients were under anticoagulants, appropriate adjustments were done. The PDT equipment was checked, and pre-oxygenation was provided with 100% FiO_2 with mechanical ventilator on a controlled mode. Patients were given adequate analgesia, sedation, and muscle relaxants. The preparation involved positioning the patient with transverse shoulder elevation to achieve head extension. After sterile cleaning of the surgical site and clothing, surgical asepsis was maintained with appropriate protective gear (cap, mask, sterile gown, and gloves) as well. The thyroid cartilage, the first, second, and third cricoid cartilages were marked with a marker. Local anesthesia (2% lidocaine with adrenaline) was applied at the identified site, followed by a vertical 1-1.5 cm incision. Bronchoscopy was used to visualize the trachea for guidance. Following vertical and transverse blunt dissection, mini-surgical exposure of the trachea was achieved. A needle attached to a 3-4 ml saline-filled syringe was inserted into the trachea and its position was verified via bronchoscopy and bubbles seen in the syringe when aspirated simultaneously. A J-tip guidewire was then introduced into the trachea, and dilation was performed using a small dilator followed by Griggs forceps over the guidewire. After ensuring hemostasis, the tracheostomy cannula was lubricated and inserted with the aid of the guidewire. Bronchoscopic visualization confirmed proper cannula placement, and lung ventilation was assessed using a stethoscope and by verifying mechanical ventilator settings. The endotracheal tube was removed, and the tracheostomy cannula was secured and dressed. Patients' admission diagnoses were categorized as neurological (cerebrovascular disease, degenerative and demyelinating diseases), infectious diseases, intracranial lesions, respiratory problems, post-cardiac arrest conditions, trauma, or cardiac-related events. Complications were classified as intra-procedural or post-procedural; intra-procedural complications included hypoxemia, acute bleeding, or death, while post-procedural complications included subcutaneous emphysema, bleeding, pneumothorax, stoma infection, and tracheal stenosis. Bleeding was classified as none, minor (controlled with sponges), moderate (requiring pressure dressing), or massive (requiring operating room intervention).

Table 1

Demographic data and ICU process of the patient groups receiving early and late tracheostomies

Variable	Total (n=57)	Early Tracheostomy (n=17)	Late Tracheostomy (n=40)	p
Male	30	10	20	0.5761
Female	27	7	20	
Age, years median (min;max)	74 (18-96)	60 (22-83)	75 (18-86)	0.3122
Duration from intubation to tracheostomy, days	13 (1-40)	7 (1-10)	19.5 (11-40)	<0.0013
After PDT MV days	13 (1-103)	10 (1-39)	13.5 (2-103)	0.4373
APACHE II	22.32 (±7.515)	22.12 (±6.224)	22.40 (±8.073)	0.8984
GCS	7 (3-15)	10 (3-15)	7 (3-15)	0.1503
Comorbidities of patients				
· Hypertension	32	6	26	0.0381
· Diabetes mellitus	23	7	16	0.5811
· Chronic obstructive pulmonary disease	14	2	12	0.1281
· Asthma	1	0	1	0.7021
· Cardiovascular disease	27	7	20	0.3751
· Malignancy	6	2	4	0.5861
· Chronic renal disease	3	0	3	0.3381
· Cerebrovascular disease	8	1	7	0.2381
Admission diagnoses				
· Neurological	4 (7%)	0 (0%)	4 (10%)	
· Infection	8 (14%)	3 (17.6%)	5 (12.5%)	
· Intracranial lesions	6 (10.5%)	2 (11.8%)	4 (10%)	
· Respiratory	24 (42.1%)	7 (41.2%)	17 (42.5%)	
· Post-CPR	4 (7%)	0 (0%)	4 (10%)	
· Trauma	1 (1.8%)	1 (5.9%)	0 (0%)	
· Cardiac	10 (17.5%)	4 (23.5%)	6 (15%)	

APACHE II: Acute physiology and chronic health evaluation-II scores; GCS: Glasgow Coma Scale; MV: Mechanical ventilation; Cardiopulmonary resuscitation CPR; Percutaneous dilatational tracheostomy PDT; 1: Fisher's Exact test; 2: Pearson chi-square test; 3: Mann–Whitney U test; 4: Student's t-test

Table 2

Respiratory parameters of early and late tracheostomy groups on the admission day

Variable	Total (n=57)	Early Tracheostomy (n=17)	Late Tracheostomy (n=40)	p
Admission Day				
· pH	7.38 (6.82-7.56)	7.38 (7.27-7.54)	7.37 (6.82-7.56)	0.5621
· PaCO2, mmHg	41 (21-219)	40 (26.3-81.8)	41.1 (21-219)	0.8621
· PaO2, mmHg	65.8 (21.6-242)	60 (40-169)	71.5 (21.6-242)	0.4221
· PaO2/FiO2	131 (43-484)	120 (80-338)	143 (43-484)	0.4271
Tracheostomy Day				
· pH	7.45 (7.04-7.77)	7.44 (7.12-7.60)	7.47 (7.04-7.77)	0.2711
· PaCO2, mmHg	39 (20-77)	42 (28-60)	37 (20-77)	0.1931
· PaO2, mmHg	94 (41-165)	65 (41-126)	102 (49-165)	0.0091
· PaO2/FiO2	188 (82-330)	130 (82-252)	204 (98-330)	0.0091

FiO2: Fraction of inspired oxygen; PaCO2: Arterial partial pressure of carbon dioxide; PaO2: Arterial partial pressure of oxygen; 1: Mann–Whitney U test

Table 3

Outcomes of critically ill patients receiving early and late tracheostomies

Variable	Total (n=57)	Early Tracheostomy (n=17)	Late Tracheostomy (n=40)	p
Mortality	43 (75.4%)	12 (70.6%)	31 (77.5%)	0.3081
ICU LOS, days	35 (7-153)	35 (13-81)	35 (7-153)	0.8962
Hospital LOS, days	40 (8-153)	42 (13-81)	40 (8-153)	0.8822
Weaning success	14 (24.6%)	5 (29.4%)	8 (22.5%)	0.4053
Discharge	12 (21%)	4 (23.6%)	8 (20%)	0.6421

ICU: Intensive care unit; LOS: Length of stay; 1: Pearson chi-square test; 2: Mann–Whitney U test; 3: Fisher's Exact test

2.2. Statistical Analysis

Statistical analysis was performed using IBM SPSS (Statistical Package for the Social Sciences) version 27.0 program. Shapiro-Wilk test, histogram, and skewness-kurtosis coefficients were used to evaluate normal distribution of the data. For the variables distributed normally the Student's T-test and for parameters that did not have a normal distribution Mann-Whitney U test was used when comparing paired groups. To evaluate Multivariate cross-tabulations Fisher's Exact test or Chi-square test were used. The survival analysis was evaluated using Kaplan-Meier analysis in groups. A p-value of <0.05 was considered statistically significant.

3. Results

3.1. Features of the overall group

A total of 57 patients were included in the study. The median age of the patients was 74 years (range: 18-96), and 30 patients (52.6%) were male. The median number of days on positive pressure mechanical ventilation before the tracheostomy procedure was 13 days (range: 1-40). The median duration of follow-up with tracheostomy was 18 days (range:2-150), the median ICU length of stay was 35 days (range:7-153) and the median hospital length of stay was 40 days (range:8-153). The mean APACHE II score of all patients was 22.32 (±7.515), and the median GCS score was 7 (range: 3-15). Hypertension was the most common comorbidity (56.1%), followed by heart disease in 47.4% of cases, diabetes mellitus in 40.4%, and chronic obstructive pulmonary disease (COPD) in 24.6%. When examining hospital admission diagnoses, 42.1% were respiratory, 17.5% cardiac, 14% infection, 10.5% intracranial lesions, 7% post-CPR, 7% neurological, and 1.8% trauma. There was no statistical difference in terms of admission diagnoses between groups (p=0.368). Demographic data and ICU process of the patients undergoing early and late tracheostomies are shown in **Table 1**.

Of 57 cases, 43 patients (75.4%) died during intensive care follow-up. The overall success rate of weaning from the ventilator was 24.6%.

3.2. Comparison of the early and late tracheostomy groups

PDT performed within 10 days of intubation was defined as early PDT and PDT performed after more than 10 days of intubation was defined as late PDT according to existing literature. Patients were then divided into two groups; Seventeen (29.8%) of 57 patients were classified in the early group, and 40 patients (70.2%) were classified in the late group. The early and late groups were similar in terms of age and gender, with no statistical difference observed. The median number of days on positive pressure mechanical ventilation before the tracheostomy procedure was 7 days (range: 1-10) in the early group, and 19.5 days (range: 11-40) (p<0.001) in the late group. There was no difference in terms of APACHE II and GCS scores between the early and late groups. Among comorbidities, only hypertension showed a marginally significant difference between groups (p=0.038).

Comparing arterial blood gas values on the first day of admission, early and late tracheostomy groups were found similar. Arterial blood gas values on the tracheostomy day were compared as well; PaO_2 (mmHg) was 65 (range:41-126) in the early tracheostomy group and 102 (range:49-165) in the late tracheostomy group, showing a statistically significant difference (p = 0.0091). PaO_2/FiO_2 ratio was 130 (range:82-252) in the early tracheostomy group and 204 (range:98-330) in the late tracheostomy group, also demonstrating a statistically significant difference (p = 0.009) (**Table 2**).

Complications during the procedure included hypoxemia in 1 patient (1.8%) in the overall group, with 2.5% in the late tracheostomy group. Acute bleeding occurred in 4 patients (7%), with 1 patient (5.9%) in the early tracheostomy group and 3 patients (7.5%) in the late tracheostomy group. Post-procedural

complications included subcutaneous emphysema in 1 patient (1.8%), with 1 patient (5.9%) in the early tracheostomy group and none in the late tracheostomy group. Minor bleeding was observed in 3 patients (5.3%), with none in the early tracheostomy group and 3 patients (7.5%) in the late tracheostomy group. No moderate bleeding, pneumothorax, or tracheal stenosis were observed in any of the groups. Stoma infection occurred in 1 patient (1.8%), with none in the early tracheostomy group and 1 patient (2.5%) in the late tracheostomy group.

Twelve (70.6%) of 17 patients in the early group died in ICUs. while 31 (%77,5) patients died in the late group. The median ICU stay was 35 days (range: 13-81) for the early group and 35,5 days (range: 7-153) for the late group, with no statistically significant difference (p>0.05). The success rate of weaning from the ventilator was slightly higher with an incidence of 29.4% in the early tracheostomy group when compared to late tracheostomy group (22.5%), though the difference was not statistically significant (**Table 3**). A total of 4 (7,0%) patients, 3 of them in early and 1 in late tracheostomy group were decannulated during ICU stay.

Univariate and multivariate regression analysis was performed for variables that may have influenced PTD timing. None of the parameters were found to be an independent influencing factor for timing of PDT. Regression analysis of variables that may influence PDT timing is shown in **Table 4**.

Table 4

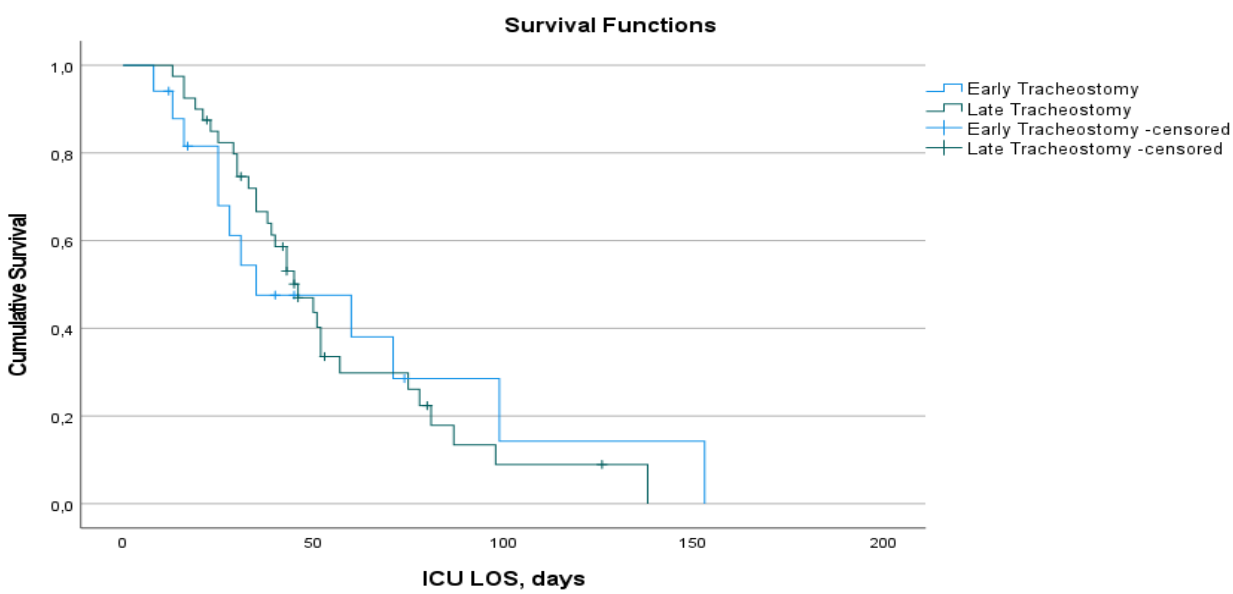
Regression analysis of variables that may influence PDT timing

Variables	Univariate binary logistic regression				Multivariate binary logistic regression			
	p	Exp(B)	95% C.I.for EXP(B) Lower	Upper	p	Exp(B)	95% C.I.for EXP(B) Lower	Upper
Age	0.021	1.040	1.006	1.075	0.114	1.030	0.993	1.069
GCS (≥8, <8)	0.151	2.337	0.733	7.451				
APACHE II	0.896	1.005	0.931	1.085				
Hypertension	0.043	3.405	1.038	11.171	0.301	0.488	0.125	1.903
Diabetes Mellitus	0.934	1.050	0.331	3.331				
Chronic obstructive pulmonary disease	0.159	0.311	0.061	1.577				
Asthma	1	0	0					
Heart failure	0.542	0.700	0.222	2.206				
Malignancy	0.843	1.200	0.198	7.267				
Chronic renal disease	0.999	0	0					
Cerebrovascular disease	0.272	0.295	0.033	2.603				

APACHE II: Acute physiology and chronic health evaluation-II scores; GCS: Glasgow Coma Scale;

Figure 1

Comparison of Survival Rates in Early and Late Tracheostomy Patients Using Kaplan–Meier (P-log-rank: 0.860).



Kaplan–Meier analysis for survival was performed. Hazard ratio was found to be 0,892 (CI; 0,449-1,771) reflecting a 10,8% lower mortality rate in early PDT group but was not statistically significant (p = 0.744). Kaplan-Meier survival analysis for early and late tracheostomy patients is presented in **Figure 1**. The median survival time was 35 days for the early tracheostomy group and 46 days for the late tracheostomy group. The difference was not statistically significant (P-log-rank = 0.860).

4. Discussion

The clinical outcomes of early and late tracheostomy in ICU patients undergoing PDT were evaluated in this study.

In our study, no statistically significant difference was found between the early and late groups regarding total length of stay in the ICU. In a randomized controlled trial (RCT) involving stroke patients monitored in the intensive care unit, patients were grouped into early (1-3 days) and standard (7-14 days) tracheostomy timing groups; length of ICU stay was found similar between the groups, but mortality was lower in the early group compared to the standard group. [12] A meta-analysis identified a lower mortality rate in the early tracheostomy group (<10 days) compared to the late tracheostomy group as well. [13] It was found in a publication investigating 127,475 tracheostomy patients' data obtained from The National Inpatient Survey found that early tracheostomy reduces mortality, medical care at home, length of stay in the ICU, and overall hospital costs. [14]

No statistically significant difference was found in mortality between the early and late tracheostomy groups in our study. The success rate of weaning from the ventilator was slightly higher in the early tracheostomy group when compared to late tracheostomy group but was not statistically significant.

In a recent publication comparing surgical tracheostomy and PDT, PDT resulted in significantly decreased long-term follow up, delayed decannulation and increased complications. They concluded that protocols of PDT in the ICU need to be refined. [15]

We could not evaluate the long-term complication rates because of the inability to reach the long-term follow-up records of the patients but we have observed a relatively low complication rate with PDT in our study.

In the literature the incidence of complications during PDT varies for each complication; for pneumothorax 0-4 %, for sub-cutaneous emphysema 0-4 %, for stomal infection 0-10 %, for hypoxia 0-25 %.

In a prospective randomized study comparing conventional and semi-surgical PDT it was found that the incidence of hypoxemia, intraoperative bleeding, pneumomediastinum, pneumothorax, subcutaneous emphysema and stoma infection was 0% during semi surgical PDT. They found an incidence of 1,3% for postoperative bleeding and loss of airway. They have concluded that semi-surgical PDT is associated with lower complication rates when compared to conventional PDT. [16]

We have observed hypoxemia in 1.8%, acute bleeding in 7%, subcutaneous emphysema in 1.8%, minor bleeding in 5.3% and stoma infection in 1.8% of the overall population. Moderate bleeding, pneumothorax, or tracheal stenosis were not observed in any of the patients in our study. Though our complication rates were similar with the existing literature and relatively low probably because of semi surgical PDT technique, comparison of the early and late PDT in terms of complications may not be powerful due to relatively smal sample size.

Fiberoptic bronchoscopy facilitates better visualization of airway structures, potentially reducing injuries and enhancing procedure safety during tracheostomy. While its use may minimize complications, retrospective analyses demonstrated that bronchoscopy did not affect complication rates significantly. [17,18] One study reported no difference in complication rates between patients who underwent PDT with and without bronchoscopy. However, comparing these groups was challenging as patients undergoing bronchoscopy often presented with technically more complex situations. [17] Similarly, another retrospective review found no impact of bronchoscopy on the complication rates. [18] In a study of PDT performed using the Griggs technique without guidance of a bronchoscopy, complication and mortality rates were reported as 8.6% and 0.6% respectively, concluding that PDT without guidance of a bronchoscopy is safe. [19] Other studies have reported lower complication rates; one indicated a 3.5% complication rate, while another reported a 0.17% mortality rate. [20,21] Despite limited data supporting its use, bronchoscopy during PDT remains common practice. A survey by Kluge et al. [22] demonstrated that 98% of ICUs in Germany routinely use bronchoscopy during PDT. The incidence of complications was relatively low in our study; the complication rate during the PDT procedure was found to be 7.8%, and in the post-procedure period, it was 8.9%.

In a multicenter randomized controlled trial conducted across 70 general ICUs and 2 cardiothoracic ICUs in the United Kingdom between 2004 and 2011, 91.9% of patients in the early tracheostomy group underwent the procedure as planned, whereas only 45.5% of patients in the late group required tracheostomy. Many late group patients were weaned off mechanical ventilation without needing tracheostomy. This study documented the limited capability of the physicians to predict which cases will need prolonged ventilatory support. These findings highlight that individual clinical conditions should guide tracheostomy timing and emphasize the importance of a patient-centered approach. [23]

Findings of our study suggest that tracheostomy timing does not significantly impact mortality. The decision between early and late tracheostomy is complex and requires a dual approach: first, predicting which cases will need longer duration of mechanical ventilation, and second, determining the optimal timing for tracheostomy. If the prediction of prolonged ventilation needs is inaccurate, an early tracheostomy strategy may lead to redundant procedures for some patients, while a late strategy may expose others to unnecessarily prolonged endotracheal intubation.

4.1. Study Limitations

One of the major limitations of this study is its retrospective design. The lack of randomization when enrolling the patients into early and late groups is also a weak point because the decision to perform early or late tracheostomy was given upon the clinicians' opinion or permission of the patients' relatives. The severity of the disease or survival expectancy of the patient could have affected the clinicians 'decision on timing of PDT and these issues may have resulted in a selection bias. Another weak point of the study is its relatively small sample size which could have led to a type II error and failure to detect a true difference. Lastly, the lack of knowledge regarding long-term outcomes is another limitation.

5. Conclusion

As a conclusion, the timing of percutaneous tracheostomy and performing it either under guidance of fiberoptic bronchoscopy or not should be tailored to the patient's overall clinical condition and individual needs. Although the timing of tracheostomy appears to be determined by the physician's clinical intuition and experience, it is essential to prioritize a patient-centered, individualized approach and clearer tracheostomy timing algorithms should be de-

veloped through larger-scaled and randomized controlled prospective clinical trials.

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Statement of ethics

Ethical approval was obtained from the Lokman Hekim University Ethics Committee (Date: 29/11/2024, No: 2024/275) and the study was conducted by the principles of the Declaration of Helsinki. Informed consent forms were obtained from all patients and control subjects.

Source of Finance

The authors declare that they have received no financial support for this study.

Conflict of interest statement

The authors declare that they have no conflict of interest.

Availability of data and materials

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

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