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Clinical Outcomes of Early Versus Delayed Tracheostomy Among Intensive Care Unit Patients in Sanandaj, Iran

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ABSTRACT

Background: Tracheostomy is commonly performed in intensive care units to secure the airway of patients requiring prolonged mechanical ventilation. Although the procedure may improve patient comfort and facilitate airway management, it is also associated with potential complications such as bleeding and infection. Optimal timing of tracheostomy remains controversial and is influenced by clinical severity, physician decision-making, patient and family preferences, and institutional resources.

Methods: This study included patients admitted to the intensive care unit of Kowsar Hospital, Sanandaj, Iran, between 2023 and 2024 who required prolonged mechanical ventilation. Participants were categorized into early (≤14 days) and late (>14 days) tracheostomy groups. Primary outcomes included one-month mortality and ventilator-associated pneumonia, while secondary outcomes comprised duration of mechanical ventilation, length of ICU and hospital stay, antibiotic exposure, chest radiographic findings, and arterial blood gas parameters, including pH and PCO_2.

Results: Patients who underwent early tracheostomy experienced significantly shorter hospital stays (25.4 vs. 32.2 days) and required fewer days of antibiotic therapy (7.5 vs. 14.3 days) compared with those in the late tracheostomy group. The total duration of mechanical ventilation was also reduced in the early group. No statistically significant differences were observed between the two groups with respect to one-month mortality or complications such as ventilator-associated pneumonia and fever.

Conclusion: Early tracheostomy was associated with improved clinical efficiency, reflected by reduced hospitalization duration, decreased antibiotic use, and shorter periods of mechanical ventilation, without an increase in mortality or procedure-related complications. These findings suggest that early tracheostomy represents a safe and cost-effective strategy for selected ICU patients requiring long-term ventilatory support.

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Introduction

Tracheostomy is a surgical airway procedure in which a direct opening is created in the trachea to facilitate breathing. In critically ill patients admitted to the intensive care unit (ICU), mechanical ventilation is often required due to conditions such as impaired consciousness or respiratory insufficiency. When prolonged ventilatory support is anticipated, endotracheal intubation is commonly replaced by tracheostomy to reduce airway-related complications. Compared with prolonged endotracheal intubation, tracheostomy may improve patient comfort, decrease airway resistance, allow more effective secretion clearance, and facilitate communication and nutritional support [1-3].

Prolonged presence of an endotracheal tube may result in mucosal injury, ischemia, ulcer formation, and subsequent scarring of the laryngeal and tracheal structures [4-5]. Although tracheostomy can mitigate some of these risks, it is not without potential complications. These include early adverse events such as bleeding, infection, subcutaneous emphysema, and pneumothorax, as well as delayed complications like tracheal stenosis at the stoma or cuff level [6]. Tracheostomy is a well-accepted procedure for critically ill patients admitted to the intensive care unit who require long-term mechanical ventilation.

It is relatively invasive and carries some risks. However, it also has advantages. Physicians should consider the risks and benefits for each patient. However, the ideal time for performing a tracheostomy procedure remains unclear. The timing of tracheostomy depends on many factors, including the severity of the disease, physician judgment, patient and family satisfaction, and hospital resources. For example, in patients with a good prognosis, the physician may have a greater preference for early tracheostomy, which can bias the study and alter the results in favor of one group [7].

The most common indication for the need for tracheostomy in patients admitted to the intensive care unit is the long-term requirement for mechanical ventilation [8]. According to previous studies, it can be concluded that the prognosis of patients admitted to the intensive care unit who require mechanical ventilation can be affected by the type of ventilation.

However, given the differences in the results of various studies and the importance of determining the optimal time to perform tracheostomy, it is necessary to design a comprehensive study that considers the sensitivity of the subject.

Methods

Study design and setting

This retrospective observational study was performed on patients admitted to the intensive care unit of Kowsar Hospital, located in northwest Iran, who underwent tracheostomy between 2023 and 2024.

Participants

The study population consisted of critically ill patients who required tracheostomy following a period of mechanical ventilation. Patients who require mechanical ventilation in the intensive care unit are first intubated, and after a specific period, tracheostomy is performed for them. Based on the interval between endotracheal intubation and tracheostomy placement, patients were categorized into two groups: early tracheostomy (≤14 days) and late tracheostomy (>14 days).

Tracheostomy procedures will be performed entirely by an anesthesiologist and an intensive care specialist, Dr. Majedi. The inclusion criteria include patients who require tracheostomy due to long-term mechanical ventilation. The exclusion criteria also include patients who do not agree to the tracheostomy procedure. The necessary data for this study were extracted from the archives of Kowsar Hospital, Sanandaj, in 2023-2024.

Sample size

In this study, the files of patients available in the archives of Kowsar Hospital, Sanandaj, who required tracheostomy due to a hospitalization duration of more than 14 days in the intensive care unit and simultaneous mechanical ventilation, were evaluated. According to the information obtained from the respected archive officer, approximately 100 files could be reviewed.

Outcome measures and follow-up

The patient's history, the reason for the loss of consciousness, the need for mechanical ventilation, the level of consciousness upon arrival at the emergency room, and the tests were extracted from the archived files. In addition, the comprehensive information system of Kowsar Hospital was utilized to visualize patients' chests for examining cases such as ventilator-associated pneumonia.

Interventions

In this study, patients hospitalized in the intensive care unit of Kowsar Hospital, Sanandaj, in 2023 and 2024 were examined. These patients required mechanical ventilation due to their condition, and after a specific period, due to complications of long-term intubation, they required tracheostomy. According to the time of conversion of intubation to tracheostomy (before and after 14 days), the patients were divided into two groups: early and late. In these two groups, several factors were examined and compared, including one-month mortality rate, ventilator-associated pneumonia, length of stay in intensive care units and hospital wards, duration of antibiotic use, and other variables such as chest radiograph findings, blood acidity, and exhaled carbon dioxide levels.

Statistical analysis

Statistical analyses were performed using SPSS software version 22. Data distribution was assessed using the Shapiro–Wilk test to evaluate normality prior to further analysis. In comparing the means between multiple levels of variables, post hoc tests were used for pairwise comparisons. The Pearson correlation test was used to assess the relationship between quantitative variables, and the chi-square test was used to determine the relationship between qualitative variables. The chi-square test was used to evaluate the qualitative variables in groups. Additionally, to assess the relationship between quantitative variables within each group, the independent two-sample t-test was employed, adhering to the test's specific assumptions. It is worth noting that the assessment of the relationship between quantitative variables in terms of multi-level variables (i.e., variables with more than two levels) was conducted using one-way analysis of variance.

Results

A total of 77 patients were evaluated, including 32 patients in the early tracheostomy group and 45 patients in the late tracheostomy group. The overall mean age of the study population was 58.6 years, with 55 ± 21.2 in the early group and 62.62 ± 20.7 in the late group. The results of the chi-square test did not show a significant difference between the two groups. Therefore, both groups were homogeneous in terms of the frequency distribution of these variables. The study included 49 men (63.6%) and 28 women (36.4%). There was no statistically significant difference in sex distribution between the two groups. Disease severity was greater in the early tracheostomy group, as reflected by significantly higher APACHE II scores; it was 25 ± 7.7. The results showed that the mean APACHE2 score in the early group was significantly higher than in the late tracheostomy group. Patients in the early tracheostomy group also had lower GCS scores, indicating poorer neurological status at admission (Table1).

Table 1. Comparison of clinical characteristics between early and late tracheostomy groups

Variables	Late tracheostomy (n = 45)	Early tracheostomy (n = 32)
Age (years)	62.62 ± 20.7	55.0 ± 21.2
Time from intubation to tracheostomy (days)	16.09 ± 2.4	7.75 ± 2.5
Total hospital and ICU length of stay in survivors (days)	66.8 ± 30.2	37.8 ± 27.0
APACHE II score	25.0 ± 7.7	29.0 ± 9.3
GCS score	9.8 ± 3.5	8.03± 3.9
Total duration of mechanical ventilation (days)	52.4 ± 29.9	31.5 ± 26.6
Hospital length of stay (days)	57.2 ± 32.2	52.4± 33.4
Duration of antibiotic therapy (days)	14.3 ± 9.2	7.3 ± 7.5

Data are presented as mean ± standard deviation (SD)

The mean time from admission to tracheostomy and time from intubation to tracheostomy were significantly longer in the late tracheostomy group (16.09 ± 2.4) compared to the early tracheostomy group (2.57 ± 7.75). The mean duration of hospital stay was 33.4 ± 25.4 for the early tracheostomy group and 57.2 ± 32.2 for the late tracheostomy group. Patients who underwent early tracheostomy experienced significantly shorter hospital stays compared with those in the late group. The duration of intensive care unit stay was also significantly longer in the late tracheostomy group.

The duration of antibiotic therapy was significantly reduced in the early tracheostomy group was 7.3 ± 7.5 and 14.3 ± 9.2, respectively, indicating that antibiotic use was significantly higher in the late tracheostomy group.

Falls and motor vehicle accidents were the two main mechanisms of trauma in this study. No statistically significant differences were observed between groups regarding pneumonia, fever, or radiographic pulmonary findings, and pulmonary infiltrates on chest radiography, as well as the rate of in-hospital mortality. Of the cases studied, a total of 60 patients survived, comprising 25 patients in the early tracheostomy group and 35 patients in the late tracheostomy group. Among deceased patients, the GCS was significantly lower in the early tracheostomy group (5 ± 2.2) than in the late tracheostomy group (7.6 ± 2.5), and the APACHE II score was significantly lower in the early tracheostomy group (37 ± 4.7) than in the late tracheostomy group (29.4 ± 7.7). The total duration of mechanical ventilation, intensive care unit (ICU) stay, hospital stay, and antibiotic duration was significantly different between the early and late tracheostomy groups. Tracheostomy to separation time, total mechanical ventilation time, hospital stay to tracheostomy, and intubation to tracheostomy time were significantly longer in the late tracheostomy group than in the early group. The mean total mechanical ventilation time was significantly longer in the late tracheostomy group (52.4 ± 29.9) compared to the early group (31.5 ± 26.6). However, the time from tracheostomy to separation was not significantly different between the early and late groups. There was also no significant difference in complications related to prolonged tracheal intubation between the early and late groups after separating the data into two subgroups: survivors and deceased. Also, the mean time from admission to tracheostomy and from intubation to tracheostomy was significantly longer in the early tracheostomy group. However, the difference in tracheostomy to weaning from the ventilator and the total duration of mechanical ventilation between the groups was not significant. Regarding the distribution of gender and mechanism of injury in the early and late groups, it was not observed after dividing into subgroups of deceased patients. The total number of days of antibiotic use in the late tracheostomy group was significantly higher compared to the early tracheostomy group. No significant difference was observed between the studied groups in terms of VBG parameters. The total duration of hospitalization, the number of days of antibiotic use, and VBG parameters were not significantly different between the groups. Among the deceased patients, there was no difference in gender or mechanism of injury between the groups. In terms of complications, leukocytosis was significantly lower in the late group (0%) compared to the early tracheostomy group (42.9%). It is also worth noting that no fever or pneumonia was recorded in the deceased patients. The results also showed that the total number of days of hospitalization and intensive care unit stay in the late tracheostomy group was significantly higher (66.8 ± 30.2) than in the early tracheostomy group (37.8 ± 27).

Discussion

In this study, clinical data of hospitalized trauma patients (either falls or traffic accidents) who were admitted to the intensive care unit of Kowsar Hospital, Sanandaj, were collected and analyzed. This study aimed to evaluate clinical outcomes associated with early versus delayed tracheostomy in critically ill patients. Because extended endotracheal intubation increases the risk of airway injury and infection, the timing of tracheostomy has gained considerable clinical attention [9-11]. Several studies have defined different times for categorizing early and late tracheostomy. However, most studies have defined early tracheostomy as tracheostomy within 5 days of admission and late tracheostomy as more than 10 days after admission to the hospital [12-14]. The mean age of the patients was (58.61 ± 21.5), with 63% male, and the mean GCS was 9.1 ± 3.8. The mean time from admission to tracheostomy was 7.7 days for the early group and 16 days for the late group. Similar to this study, a study by Angel et al. reported a mean time from intubation to tracheostomy of 9 and 19 days for early and late tracheostomy, respectively [15]. In a similar study by Bertini et al., the mean time from intubation to tracheostomy for early tracheostomy was 6 and 17 days [4]. The timing of early and late tracheostomy in different studies ranged from 3 to 14 days, but in most studies, a delay of less than 10 days from intubation to tracheostomy was the main differentiator between early and late tracheostomy [14,16-17].

One of the key findings was a marked reduction in total mechanical ventilation duration among patients undergoing early tracheostomy. In a study by Angel et al. on COVID-19 patients, the total time on mechanical ventilation was significantly shorter in the early group by 15 days compared to the late group [9]. In a similar study by Jurado et al., the total time on mechanical ventilation was also significantly shorter (18 in ET and 22.3 in LT) [18]. In a meta-analysis of COVID-19 patients by Chang et al., including 12 studies with 2222 patients, the mean total mechanical ventilation time was reported to be 20.49 in the early group and 28.94 in the late group [19].

Prediction models evaluated in a retrospective study by Takkawa et al. have shown that length of stay in critically ill patients is associated with increased mortality, both in the hospital and in the ICU, regardless of the severity of trauma or underlying disease [20]. The results of this study showed that early tracheostomy was linked to substantially shorter ICU and hospital stays (p=0.001), with an ICU length of stay of 32.75 in ET and 55.69 in LT and a hospital stay of 33.4 in ET and 57.24 in LT, with an average of 23 days less in the hospital for patients who underwent early tracheostomy. In a cross-sectional study by Hong et al., conducted on 160 patients with brain injury who underwent craniectomy, the length of stay in the intensive care unit was reported to be significantly shorter in the early tracheostomy group, similar to this study [21]. In a study by Khalili et al., conducted on brain injury patients in Shiraz, the early group compared with the late group had a significant reduction in hospital length (38.6 vs. 46.4 days) and intensive care unit stay. Significantly, in the early tracheostomy group, similar to this study [21]. In the study by Khalili et al. conducted on brain injury patients in Shiraz, the early group was associated with a significantly reduced duration of hospital stay (38.6 vs. 46.4 days) and intensive care unit stay (26.7 vs. 34.9 days) compared to the late group [22], which is similar to our study. Prolonged periods of hospitalization can potentially lead to adverse outcomes, one of which is drug overuse, which is a significant issue. Studies have shown that extended antibiotic exposure is known to contribute to antimicrobial resistance and adverse drug effects but can also increase drug-related side effects and hospitalization costs [23-24]. Therefore, dose adjustment or conversion of empirical multidrug antibiotic therapy to a single antibiotic based on culture results is crucial. The mean total antibiotic days in this study were significantly lower in the early group compared with the late group (7.34 in the early group vs. 14.38 in the late group), which is approximately half the number of days of antibiotic prescription in the early group. It is important to note that this was despite no significant difference in mortality or morbidity between the early and late groups. Critically ill patients, and particularly trauma patients, are also susceptible to respiratory infections such as ventilator-associated pneumonia [25-26]. In this study, rates of pneumonia and other infectious complications did not differ significantly between groups, fever, leukocytosis, and pulmonary infiltration on chest radiographs. Buderka et al. evaluated patients with brain injury and reported that the incidence of pneumonia did not differ between those who underwent primary tracheostomy and those managed with prolonged endotracheal intubation [27]. Similarly, Khalili et al. demonstrated no significant difference in the occurrence of ventilator-associated pneumonia when comparing early versus late intervention groups [22].

Several prediction models exist to assess the clinical status and mortality of patients. One of the most widely used models is the APACHE score. This model has been used in various studies to predict mortality in critically ill patients [28]. In our research, the GCS at the time of admission to the emergency department was significantly lower in the early group than in the late group (8.03 ± 3.9 compared with 9.8 ± 3.5). A low GCS (score below 8) has been one of the primary indications for endotracheal intubation [29], and the decision to perform early tracheostomy in the early group can be justified by considering this factor. APACHE-2 was also significantly higher in the early group (29 ± 9.3 for early vs. 25 ± 7.7 for late), indicating a worse clinical status in the early group at the time of admission to the emergency department.

In a study by Pinheiro et al., comparing the effects of early and late tracheostomy in 28 traumatic brain injury (TBI) patients, there was no significant difference between the early and late groups in terms of GCS (5.4 ± 1.7 in early vs. 5.5 ± 1.7 in late) and APACHE score of 26.8 vs. 28.6 [30]. In another study by Boderka et al., comparing SAPS, there was no significant difference between the early and long-term intubation groups [27].

The overall 1-month mortality rate in this study was 22.5%, which was 21.9% in the early group and 22.2% in the late group, which was not statistically significant, indicating that early tracheostomy did not affect mortality compared with late tracheostomy despite a significant difference in GCS and APACHE scores in the early and late groups. In the study by Buderka et al., no difference in mortality was observed between early tracheostomy and long-term intubation [27]. A meta-analysis conducted by Chang et al., which included 2,222 patients with COVID-19 from 12 studies and assessed both 10-day and 14-day intervals between intubation and tracheostomy, demonstrated that early tracheostomy was not associated with increased mortality, despite greater baseline disease severity (32.9% in the early group versus 33.1% in the late group). In contrast, Dunham et al. reported higher mortality rates following early tracheostomy in patients with traumatic brain injury. In their analysis, findings from a randomized clinical trial were combined with data from two earlier trials and subsequently expanded through a meta-analysis of five retrospective studies involving a total of 3,356 patients, which continued to show an increased mortality risk associated with early tracheostomy [31].

However, a separate meta-analysis including 5,106 patients with traumatic brain injury found no significant difference in mortality between early and late tracheostomy groups [32]. More broadly, previous research examining prognostic indicators has consistently shown that a GCS score of ≤8 and an APACHE II score exceeding 27.5 are associated with higher mortality among critically ill patients [33-34]. In the present study, although patients in the early tracheostomy group exhibited more severe clinical conditions based on these thresholds, no statistically significant difference in overall mortality was observed between the two groups. Taken together, available evidence suggests that tracheostomy timing has limited influence on mortality outcomes in critically ill populations.

Analysis of tracheostomy timing demonstrated that, among surviving patients, early tracheostomy was associated with a shorter overall duration of mechanical ventilation. Evaluation of neurological and physiological severity scores revealed that deceased patients in the early tracheostomy group had lower GCS values compared with those in the late group, whereas no significant differences in GCS or APACHE II scores were observed among survivors.

In surviving patients, those who underwent late tracheostomy experienced prolonged hospital admission, longer ICU stays, and extended antibiotic therapy; however, these differences were not observed among non-survivors. Among deceased patients, late tracheostomy was more frequently accompanied by leukocytosis and radiographic evidence of pulmonary infiltrates. Conversely, leukocytosis was more prevalent among surviving patients who received early tracheostomy.

Overall, these findings indicate that early tracheostomy in surviving patients is associated with reduced length of hospitalization, decreased antibiotic exposure, shorter duration of mechanical ventilation, and a lower burden of complications. Consistent with these results, a randomized clinical trial by Dunham et al. involving 24 patients with traumatic brain injury—none of whom died during follow-up—reported no significant differences between early and late tracheostomy groups in the incidence of ventilator-associated pneumonia, duration of mechanical ventilation, or mortality rates [34].

Limitations

Deficiencies in records and data collection. To minimize this problem, patient records and histories were reviewed and collected according to the codes registered for the patients and by category.

Conclusion

Early tracheostomy was associated with reduced mechanical ventilation duration and shorter ICU and hospital stays and lower antibiotic use compared with late tracheostomy. Although the timing of tracheostomy did not affect pulmonary complications when considering surviving and deceased patients, late tracheostomy was associated with leukocytosis and more pathological findings on chest radiographs in surviving patients. Survival outcomes were not influenced by the timing of tracheostomy in these patients. Consequently, compared with late tracheostomy, early tracheostomy may lessen treatment burden, including antibiotic exposure, without increasing complications or affecting ultimate mortality. Considering this, in critically ill patients who are candidates for intubation, these findings support early tracheostomy as a safe and resource-efficient intervention in appropriately selected patients.

Suggestions for future research

Future investigations should be designed as large-scale prospective studies to further validate the findings of this research. In addition, the impact of early tracheostomy on patients' post-discharge quality of life warrants further evaluation. Future studies should also account for potential confounding factors, such as disease severity, through the use of validated clinical scoring systems. Moreover, comparative analyses of the cost-effectiveness of early versus late tracheostomy across different healthcare systems are recommended.

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Ethical consideration

All ethical considerations are outlined in the ethics code IR.MUC.REC.1401.269 has been observed in the Ethics Committee of Kurdistan University of Medical Sciences. In necessary cases, full consent has been obtained from the companions or patients. The patients' data, including their personal information, were not recorded in the patient checklist, and the use of this information will be solely for research purposes.

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