

EARLY VERSUS LATE PERCUTANEOUS TRACHEOTOMY IN CRITICALLY ILL PATIENTS: A RETROSPECTIVE SINGLE CENTER OBSERVATIONAL STUDY

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SUMMARY – Despite decades of experience in tracheotomy, there still exists a controversy over its ideal timing. The aim of our study was to compare the impact of early and late percutaneous tracheotomy in terms of their ability to reduce mechanical ventilation duration and length of stay in Intensive Care Unit, as well as the frequency of ventilator-associated pneumonia and mortality rates in tracheotomized patients. This retrospective observational study indicated that early tracheotomy in surgical and neurosurgical patients was associated with a reduced duration of mechanical ventilation and reduced length of stay in Intensive Care Unit, but was unable to reduce the frequency of ventilator-associated pneumonia and mortality. The reason behind the shorter duration of mechanical ventilation and shorter length of stay in Intensive Care Unit in the early tracheotomy arm was shorter duration of mechanical ventilation carried out prior to tracheotomy, while the duration of mechanical ventilation and the length of stay in Intensive Care Unit after tracheotomy were similar in both groups, suggesting that the procedure itself and not its timing influenced the duration of mechanical ventilation and the length of stay in Intensive Care Unit of tracheotomized patients.

Key Words: *Tracheotomy – Methods; Respiration, Artificial; Treatment Outcome; Intensive Care Units; Observational Study*

Introduction

Maintaining patent airway is often of vital importance for successful treatment of intensive care unit (ICU) patients¹. Tracheotomy is a very common procedure performed in ICU patients who require prolonged mechanical ventilation². It has several advantages over prolonged endotracheal intubation, including lower airway resistance, facilitated weaning from mechanical ventilation, improved patient comfort and their ability to communicate, lesser

need for sedation drug administration, possibility of oral feeding and easier nursing care³. Because of its advantages over surgical tracheotomy, percutaneous tracheotomy is performed more frequently^{2,4}. Despite decades of experience in tracheotomy, there still exists a controversy over its ideal timing⁵. Analysis of a large number of studies showed considerable variation in the opinions on optimal tracheotomy timing due to its influence on mechanical ventilation duration, the length of ICU stay, the frequency of ventilator-associated pneumonia (VAP) and mortality rates^{2,6-10}. Some studies showed benefits of early tracheotomy, whereas others failed to do so. The literature also fails to bring any clear consensus about what should be considered early tracheostomy, the timing to be found in various definitions thereby ranging from 2 to even 10 days fol-

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lowing endotracheal intubation and mechanical ventilation initiation or ICU admission¹¹, so that optimal tracheotomy timing remains controversial.

The aim of our study was to compare the impact of early and late tracheotomy in terms of their ability to reduce mechanical ventilation duration and the length of ICU stay, as well as VAP frequency and mortality rates in percutaneously tracheotomized surgical ICU patients.

Patients and Methods

The study was conducted in a 15-bed surgical and neurosurgical ICU of the Department of Anesthesiology and Intensive Care, Sestre milosrdnice University Hospital Centre, Zagreb, Croatia. The study was approved by the Hospital Board of Ethics (E.P. number: 35-1/09). Retrospective data were collected from September 2009 to March 2013. Because of the retrospective and observational design of the study, an informed consent was unnecessary.

Only patients undergoing percutaneous tracheotomy during the study period were eligible for the study. Patients were excluded from the study if they were younger than 18 years, or had previous or emergency tracheotomy.

Study patients were divided into those tracheotomized during the first 7 days following ICU admission ('early tracheotomy') and those tracheotomized 8 or more days after ICU admission ('late tracheotomy'). Percutaneous tracheotomies were performed by the ICU physicians by the patient bedside using the Griggs method. Reasons for performing tracheotomy were respiratory (predicted mechanical ventilation longer than 10 days, weaning difficulties, neuromuscular weakness/the need for more than 10-12 times daily suctioning) or neurological (Glasgow Coma Score lower than 9).

Ventilator-associated pneumonia is defined as a type of nosocomial pneumonia occurring more than 48 hours after intubation and mechanical ventilation¹². The presence of VAP was defined using the simplified Modified Pulmonary Infection Score (CPIS)¹³.

All patients were fed enterally using a nasogastric tube (in most patients starting from day 2 of ICU stay), received systemic stress ulcer prophylaxis (ranitidine or proton pump inhibitors) and were kept in a semi-recumbent position during their ICU stay.

The inter-group comparison was made based on the patient status at ICU admission and during ICU stay, and characteristics of surviving patients.

Statistical analysis

Demographic and clinical data were presented as median and 25th and 75th interquartile range, or number (%). Continuous variables were compared using Student's t-test for independent samples, while categorical variables were compared using χ^2 -test. P values <0.05 were considered statistically significant. Difference in the frequency of VAP between the groups was calculated using Fisher's exact test. All statistical analyses were performed using MedCalc 9.5.1.0 (MedCalc Software, Mariakerke, Belgium).

Results

During the study period, 5,071 adult patients were admitted to our ICU. One hundred and forty-two (2.8%) of these patients underwent percutaneous tracheotomy. Of the 142 percutaneously tracheotomized patients, 78 were early tracheotomized and 64 late tracheotomized. Tracheotomy was performed at a median of 6 (5-6) days after ICU admission in the early tracheotomy group and at a median of 12 (9-16) days after ICU admission in the late tracheotomy group. Table 1 shows the characteristics of VAP patients established at ICU admission. Patient groups did not differ significantly according to age, gender, main reasons for ICU admission and prevalence of the majority of comorbidities, with the exception of chronic obstructive pulmonary disease (COPD). COPD was more prevalent in the late tracheotomy group compared to the early tracheotomy group. The Simplified Acute Physiology Score II (SAPS II) and Acute Physiology and Chronic Health Evaluation II (APACHE II) scores (taken during the first 24 hours following ICU admission) were higher in the early tracheotomy group as compared with the late tracheotomy group. The proportion of the main reasons for ICU admission did not differ between the groups. The most frequent reason for ICU admission in both groups was postoperative care.

Table 2 shows the characteristics of VAP patients observed during ICU stay. In the late tracheotomy group, the main reason for mechanical ventilation

was of respiratory nature, while in patients with early tracheotomy the reason for mechanical ventilation was mainly neurological or the need of sedation. During the study period, antibiotic treatment was more frequently required in the late tracheotomy group, whereas sedation was more often needed in the early tracheotomy group. Duration of mechanical ventilation before tracheotomy was longer in the late tracheotomy group. The early tracheotomy group was subjected to tracheotomy mainly for neurological reasons, whereas in the late tracheotomy group the reasons were mostly of respiratory nature. VAP developed in 60 (42%) patients, 27 (45%) of them with early tracheotomy and 33 (55%) with late tracheotomy ($p=0.060$). There were no between-group differences in the frequency of VAP after tracheotomy. After tracheotomy, six of 78 (8%) patients in the early tracheotomy group

and six of 64 (9%) patients in the late tracheotomy group developed VAP ($p=0.768$).

The overall ICU mortality among percutaneously tracheotomized patients was 29% (41/142). Mortality was not different between two groups (27% *vs.* 31%, $p=0.704$). In the surviving patients, total duration of mechanical ventilation and the number of days in ICU were shorter in the early tracheotomy group compared with the late tracheotomy group. Duration of mechanical ventilation and the number of days in ICU before tracheotomy were shorter in patients with early tracheotomy than in those with late tracheotomy, but after placement of the tracheotomy, both groups were weaned off mechanical ventilation and discharged from the ICU after similar periods. The groups did not differ significantly according to SAPS II at discharge (Table 3).

Table 1. Patient characteristics at ICU admission

	Early tracheotomy N = 78	Late tracheotomy N = 64	p-value
Age (years)	62 (47-74)	66 (56-78)	0.170
Gender			
Male	52 (67)	46 (72)	0.627
Female	26 (33)	18 (28)	
APACHE II score	16 (13-20)	14 (11-17)	0.038
SAPS II	46 (34-57)	36 (27-48)	0.022
Main reason for ICU admission			
Medical*	4 (5)	3 (5)	0.374
Trauma without surgery	12 (15)	5 (8)	
Surgery	62 (80)	56 (88)	
Comorbidities			
Diabetes mellitus	8 (10)	10 (16)	0.482
Malignant disease	3 (4)	6 (9)	0.318
COPD	2 (3)	10 (16)	0.013
Chronic cardiac disease	10 (13)	17 (27)	0.063
Kidney failure	2 (3)	6 (9)	0.166
Hypertension	27 (35)	29 (45)	0.261
Alcoholism	13 (17)	12 (19)	0.918
Smoking	15 (19)	15 (23)	0.686
Emergency admission	72 (92)	55 (86)	0.340

Results are presented as median (25th-75th interquartile range), or as number (%); VAP = ventilator-associated pneumonia; T = (percutaneous) tracheotomy; SAPS II = Simplified Acute Physiology Score II; APACHE II = Acute Physiology and Chronic Health Evaluation II; COPD = chronic obstructive pulmonary disease; ICU = Intensive Care Unit; *acute respiratory failure, sepsis, state after resuscitation

Table 2. Patient characteristics during ICU stay

	Early tracheotomy N = 78	Late tracheotomy N = 64	p-value
Reason for MV			
Respiratory*	19 (24)	36 (56)	<0.001
Neurological†	27 (35)	13 (20)	
Need for sedation	32 (41)	15 (24)	
Treatment			
Antibiotics	59 (76)	60 (94)	0.007
Glucocorticoids	17 (22)	19 (30)	0.428
Sedation	49 (63)	24 (38)	0.003
Dialysis	2 (3)	3 (5)	0.822
Transfusion	66 (85)	55 (86)	0.987
Number of days on MV before T	5 (3-6)	8 (7-10)	<0.001
Reason for T			
Respiratory#	11 (14)	33 (52)	<0.001
Neurological**	67 (86)	31 (48)	
Frequency of VAP			
VAP before T + after T	27 (35)	33 (52)	0.060
VAP before T	21 (27)	27 (42)	0.074
VAP after T	6 (8)	6 (9)	0.768

Results are presented as median (25th-75th interquartile range), or as number (%). VAP = ventilator-associated pneumonia; T = (percutaneous) tracheotomy; MV = mechanical ventilation; ICU = Intensive Care Unit; *acute respiratory failure, neuromuscular weakness, ARDS; †GCS lower than 9; ‡predicted long MV due to trauma or disease of the lung (>10 days), weaning difficulties, neuromuscular weakness/need for frequent suctioning (>10-12 times daily); §GCS lower than 9; #during first seven days after admission to ICU; **from day eight after admission to ICU

Table 3. Characteristics of surviving patients

	Early tracheotomy N = 78	Late tracheotomy N = 64	p-value
Surviving patients	57 (73)	44 (69)	0.704
Duration of MV (days)			
Before T	5 (3-6)	8 (7-10)	<0.001
After T	1 (1-2)	2 (0-5)	0.071
Total	6 (4-7)	11 (7-14)	0.002
Number of days in ICU			
Before T	6 (5-6)	12 (9-16)	<0.001
After T	8 (5-15)	8 (4-17)	0.164
Total	13 (8-18)	22 (15-34)	<0.001
SAPS II at discharge	28 (20-41)	26 (18-35)	0.252

Results are presented as median (25th-75th interquartile range), or as number (%). VAP = ventilator-associated pneumonia; T = (percutaneous) tracheotomy; MV = mechanical ventilation; ICU = Intensive Care Unit; SAPS II = Simplified Acute Physiology Score II

Discussion

Our study showed that, in surgical patients, early tracheotomy was associated with a reduction in mechanical ventilation duration and length of ICU stays, but had no effect on VAP frequency and mortality rates. In both groups, weaning patients from mechanical ventilation took place at a similar post-tracheotomy time, suggesting that tracheotomy itself and not its timing was a critical factor responsible for the shorter mechanical ventilation and shorter length of ICU stay.

According to many recent prospective randomized studies, early tracheotomy seems to reduce the duration of mechanical ventilation and the length of ICU stay^{6,10,14-17}. However, some of the studies failed to confirm this observation¹⁸⁻²⁰. A few recent meta-analyses have also failed to confirm any favorable impact of early tracheotomy on mechanical ventilation duration and length of ICU stay^{3,5}. The reason behind these discrepancies may lie in considerable differences in the definition of early *versus* late tracheotomy offered by various studies, defining early tracheotomy as one performed 2 to even 10 days following endotracheal intubation and mechanical ventilation initiation or ICU admission³. Also, many studies do not clearly state whether total duration of mechanical ventilation or just its post-tracheotomy duration was taken into account. For example, a prospective randomized study that included 419 patients has reported that tracheotomy performed 6 to 8 days following endotracheal intubation was associated with a reduced duration of mechanical ventilation as compared with that performed 8 days following endotracheal intubation. However, the duration of mechanical ventilation calculated within this study frame considered the randomization day as day 1 and took it from there, thereby neglecting the fact that both study groups were randomized at the same time¹⁰. According to our results, early tracheotomy decreases total mechanical ventilation duration and total length of ICU stay, but not the duration of post-procedural mechanical ventilation or the length of post-procedural ICU stay, since no differences in this regard were seen between our study groups. It is only logical that early tracheotomy results in a shorter duration of pre-procedural mechanical ventilation, since the procedure itself was performed

earlier in these patients, but the post-procedural duration of mechanical ventilation was shown to be similar in both groups. In both of our study groups, weaning from mechanical ventilation took place in a similar post-tracheotomy time, suggesting that tracheotomy itself and not its timing was a critical factor accountable for the shorter duration of mechanical ventilation. Our results are in discordance with the results of some observational studies, which have reported that tracheotomies performed earlier may be associated with quicker weaning from mechanical ventilation^{8,21}.

The study also showed that early tracheotomy was more likely to be performed in patients with higher APACHE II and SAPS II scores, showing that this procedure is generally performed in critical patients. However, these patients had similar mortality rates as compared to the late tracheotomy arm, which might lead to a conclusion that early tracheotomy may influence mortality rates in patients with higher APACHE II and SAPS II scores.

Chronic obstructive pulmonary disease was more common in the early as compared to the late tracheotomy group. Respiration-related reasons for the initiation of mechanical ventilation and tracheotomy performance were also more common in the same study group, suggesting that earlier tracheotomy with a possibly shorter duration of mechanical ventilation might be justified in these patients.

According to our results, there were no between-group differences in mortality rates. The effects of early tracheotomy on mortality rates varied across different studies^{3,5}, which might be attributed to differences in the inclusion criteria, definition of early tracheotomy, methods of percutaneous tracheotomy, underlying diseases, severity of illness, comorbidities and individual study quality. Most of the meta-analyses that embraced prospective studies dealing with our study topic, have suggested that early tracheotomy does not significantly reduce mortality rates^{3,5,22,23}. In contrast, one recent meta-analysis found lower overall mortality rates in early tracheotomized patients, but the analysis in question included observational studies only²⁴. In accordance with our results, almost all recent prospective randomized studies indicated that early tracheotomy did not influence mortality rates^{2,10,14-17,20,25}. Only 3 prospective randomized studies showed that patients who had early tracheotomy had lower mortality rates than

those having late tracheotomy^{6,18,19}. However, the beneficial outcomes of early tracheotomy declared by two of these three studies should be interpreted with caution because of the small sample size^{18,19}. The third one, on the other hand, included only critical patients with APACHE II score above 25 and the expected mortality rate of 50%+⁶.

The impact of early tracheotomy on VAP frequency is not clear. By reducing breathing efforts, preventing micro-aspiration of oral secretions and improving lung mechanics, early tracheotomy may facilitate weaning from mechanical ventilation, thereby reducing the time at risk of developing VAP¹⁰. Early tracheotomy may also result in greater patient comfort and sedation drug avoidance associated with prolonged mechanical ventilation duration as the main risk factor for VAP development³. In our ICU patients, early tracheotomy reduced the relative risk of post-tracheotomy VAP by 28% (relative risk 0.82, 95% confidence interval 0.27-2.4). Namely, in 142 percutaneously tracheotomized patients, post-tracheotomy VAP developed in six of 78 (8%) early tracheotomized patients and in six of 64 (9%) late tracheotomized patients, but the risk reduction did not reach statistical significance ($p=0.768$). In some recent studies, early tracheotomy was associated with lower VAP incidence, but, of note, the cumulative, not the post-tracheotomy VAP incidence, was taken into account^{6,15-17,26}. Our results pertaining to the VAP frequency are in accordance with the study by Clech *et al.*, who also took only VAPs occurring after tracheotomy into account²⁷. Some other trials that set VAP as their endpoint obtained similar results too^{2,10,19,25}. According to many studies, antibiotic treatment and sedation are the risk factors facilitating VAP development²⁶. In our study, the early tracheotomy arm was represented by less frequent antibiotic and more frequent sedation drug administration, but the VAP frequency established in both of our study groups remained the same.

Our study had several limitations. It was conducted retrospectively at a single ICU centre. Another limitation was the heterogeneity of our study patients and a low number of those subjected to percutaneous tracheotomy.

In conclusion, the present study indicated that early tracheotomy was associated with a reduced duration of mechanical ventilation and reduced length

of ICU stay, but was unable to reduce VAP frequency and ICU mortality. The reason behind the shorter duration of mechanical ventilation and shorter length of ICU stay in the early tracheotomy arm was the shorter duration of mechanical ventilation carried out prior to tracheotomy, while the duration of mechanical ventilation and the length of ICU stay after tracheotomy were similar in both groups, suggesting that the procedure itself and not its timing influenced the duration of mechanical ventilation and the length of ICU stay of tracheotomized patients.

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Sažetak

USPOREDBA RANE I KASNE PERKUTANE TRAHEOTOMIJE U KRITIČNO BOLESNIH:
RETROSPEKTIVNA OPSERVACIJSKA STUDIJA U JEDNOM CENTRU*T. Magdić Turković, A. Lukić i M. Perić*

Traheotomija je vrlo čest postupak koji se izvodi kod bolesnika koji zahtijevaju produženu mehaničku ventilaciju. Unatoč desetljećima iskustva u izvođenju traheotomije još uvijek postoje dileme o idealnom vremenu izvođenja. Cilj ovoga istraživanja je bio usporedba rane i kasne traheotomije s obzirom na njihov utjecaj na trajanje mehaničke ventilacije i duljinu boravka u Jedinici intenzivnog liječenja, kao i na učestalost pojave ventilacijske pneumonije i smrtnost među traheotomiranim bolesnicima. Istraživanje je provedeno u 15-krevetnoj Jedinici intenzivnog liječenja Odjela za anesteziologiju, reanimatologiju i intenzivno liječenje u Kliničkom bolničkom centru "Sestre milosrdnice", Zagreb, Hrvatska. Podaci su skupljani retrospektivno od rujna 2009. do ožujka 2013. godine. U istraživanje su bili uključeni samo bolesnici perkutano traheotomirani tijekom navedenog razdoblja. Rezultati ovoga istraživanja ukazuju na to da rana traheotomija skraćuje trajanje mehaničke ventilacije i duljinu boravka u Jedinici intenzivnog liječenja, dok na učestalost ventilacijske pneumonije i smrtnost nema utjecaja. Razlog kraćeg trajanja mehaničke ventilacije i kraćeg boravka u Jedinici intenzivnog liječenja je kraće trajanje mehaničke ventilacije prije izvođenja traheotomije, dok je trajanje mehaničke ventilacije nakon traheotomije bilo slično u obje skupine, što upućuje na zaključak da sam postupak traheotomije, a ne vrijeme izvođenja utječe na trajanje mehaničke ventilacije i duljinu boravka u Jedinici intenzivnog liječenja.

Ključne riječi: *Traheotomija-metode; Respiracija, umjetna; Ishod liječenja; Jedinice intenzivnog liječenja; Opservacijska studija*