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ABOUT COVER

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The primary aim of *World Journal of Methodology* (*WJM*, *World J Methodol*) is to provide scholars and readers from various fields of methodology with a platform to publish high-quality basic and clinical research articles and communicate their research findings online.

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ORIGINAL ARTICLE

Retrospective Cohort Study

Tracheostomy-related data from an intensive care unit for two consecutive years before the COVID-19 pandemic

Maria Papaioannou, Evdoxia Vagiana, Serafeim-Chrysovalantis Kotoulas, Maria Sileli, Katerina Manika, Alexandros Tsantos, Nikolaos Kapravelos

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Abstract

BACKGROUND

Tracheostomy is commonly used in intensive care unit (ICU) patients who are expected to be on long-term mechanical ventilation or suffer from emergency upper airway obstruction. However, some studies have conflicting findings regarding the optimal technique and its timing and benefits.

AIM

To provide evidence of practice, characteristics, and outcome concerning tracheostomy in an ICU of a tertiary care hospital.

METHODS

This was a retrospective cohort study including adult critical care patients in a single ICU for two consecutive years. Patients' demographic characteristics, severity of illness (APACHE II score), level of consciousness [Glasgow Coma Scale (GCS)], comorbidities, timing and type of tracheostomy procedure performed and outcome were recorded. We defined late as tracheostomy placement after 8 days or no tracheotomy.

RESULTS
Data of 660 patients were analyzed (median age of 60 years), median APACHE II score of 19 and median GCS score of 12 at admission. Tracheostomy was performed in 115 patients, of whom 63 had early and 52 late procedures. Early tracheostomy was mainly executed in case of altered level of consciousness and severe critical illness polyneuromyopathy, however there were no significant statistical results (47.6% *vs* 36.5%, $P = 0.23$) and (23.8% *vs* 19.2%, $P = 0.55$) respectively. Regarding the method selected, early surgical tracheostomy (ST) was conducted in patients with maxillofacial injuries (50.0% *vs* 0.0%, $P = 0.033$), whereas late surgical tracheostomy was selected for patients with goiter (44.4% *vs* 0.0% $P = 0.033$). Patients with early tracheostomy spent significantly fewer days on mechanical ventilation (15.3 ± 8.5 *vs* 22.8 ± 9.6, $P < 0.001$) and in ICU in general (18.8 ± 9.1 *vs* 25.4 ± 11.5, $P < 0.001$). Percutaneous dilatation tracheostomy (PDT) *vs* ST was preferable in older critical care patients in the case of Central Nervous System underlying cause of admission (62.5% *vs* 26.3%, $P = 0.004$). ST was the method of choice in compromised airway (31.6%, *vs* 7.3% $P = 0.008$). A large proportion of patients (88/115) with tracheostomy managed to wean from mechanical ventilation and were transferred out of the ICU (100% *vs* 17.4%, $P < 0.001$).

CONCLUSION
PDT was performed more frequently in our cohort. This technique did not affect mechanical ventilation days, ventilator-associated pneumonia (VAP), ICU length of stay, or survival. No complications were observed in the percutaneous or surgical tracheostomy groups. Patients undergoing early tracheostomy benefited in terms of mechanical ventilation days and ICU length of stay but not of discharge status, presence of VAP, or survival.

Key Words: Tracheostomy; Early tracheostomy; Late tracheostomy; Percutaneous dilatation tracheostomy; Surgical tracheostomy; Weaning; Survival; Mechanical ventilation

Core Tip: Performing a tracheostomy in critical care patients is a common procedure. We analyzed patients who were hospitalized for two consecutive years in an intensive care unit in a tertiary hospital, before the coronavirus disease 2019 pandemic. We recorded our findings in this observational study, associated with the timing and method of tracheostomy, the role of tracheostomy in weaning from the mechanical ventilation and the outcome. Our findings were quite consistent with the review of literature, but need to be confirmed by prospective studies. We hope that this study could contribute to a certain degree to the literature about tracheostomy.

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INTRODUCTION

Tracheostomy is a long-established invasive intervention commonly performed in critically ill patients treated in the intensive care unit (ICU). It is primarily carried out to wean patients who may require prolonged invasive mechanical ventilatory support and in emergency upper airway obstruction[1]. Tracheostomy is a safe procedure when used on an elective basis, which has been shown to have benefits compared to prolonged translaryngeal ventilation. Some advantages include avoiding laryngeal injury, protecting against pulmonary aspiration, facilitating clearance of respiratory secretions, decreasing sedation needs, supporting nursing care, and enhancing patients' comfort and daily living activity[2]. Furthermore, there is increasing evidence that tracheostomy shortens the length of ICU stay and decreases the risk of developing ventilator-associated pneumonia (VAP)[3]. Well-known complications are bleeding, pneumothorax, stomal infection, and tracheal stenosis[4].

Two approaches are feasible: the open surgical tracheostomy (ST) and the bedside percutaneous dilatational tracheostomy (PDT) performed by intensive care physicians[1]. The choice depends on patient risk factors. Both techniques bear advantages as well as early and late complications, with the PDT being preferred mainly due to less procedural time, effort consumption, and costs[5]. Evidence on the optimal timing for tracheostomy is still conflicting. Previous meta-analyses showed no difference in the duration of mechanical ventilation, incidence of VAP, or short-term mortality[6,7]. A recent meta-analysis by Chorath *et al*[8] demonstrated lower VAP rates and shorter durations of mechanical ventilation and ICU stay.

Tracheostomy practices in ICUs vary between countries, even between different regions of the same country. Our study aimed to provide evidence of practices, characteristics, and outcomes concerning tracheostomy in the ICU of a tertiary care hospital.

MATERIALS AND METHODS

The protocol of this retrospective observational study was approved by the scientific council of the General Hospital of Thessaloniki "G. Papanikolaou," reference number 1214, and a relative from each participant gave written informed consent. Participants were all patients admitted to the 2nd Intensive Care Unit of the tertiary General Hospital of Thessaloniki "G. Papanikolaou" between 01/03/2018 and 31/08/2019, with no exclusion criteria. No sample size calculation was performed. Instead, it was decided to include all the patients for two consecutive years to better represent this specific unit's epidemiological data before the coronavirus disease-19 (COVID-19) pandemic. The same group of ICU physicians used the same PDT technique while the same team of surgeons performed the ST.

The variables that were recorded were the age and the gender of the patients, their Glasgow Coma Scale (GCS)[9] and their acute physiology and chronic health evaluation (APACHE II) and APACHE II predicted death rate (APDR)[10] at admission, their number and category of co-morbidities, their cause of ICU admission and intubation [central nervous system (CNS), cardiovascular system (CVS), respiratory system, sepsis, malignancy, trauma, surgery, metabolic disease compromised airway]. Furthermore, the performance of a tracheostomy, the reason why a tracheostomy was performed (prolonged mechanical ventilation, compromised airway, low level of consciousness, myopathy), the timing of tracheostomy (early *vs* late)[11], the reason for an early tracheostomy (prolonged duration of stay, compromised airway, trauma, neuromuscular disease), the method of the performed tracheostomy (PDT *vs* ST)[12], the reason for a ST (facial trauma, cervical burn, difficult airway, cervical edema, goiter, re-opening), any serious complications during the procedure, the occurrence of VAP, the responsible pathogen for the VAP, isolated by a bronchial secretion culture and variables related with the outcome of the patients, such as where they were transferred after their ICU discharged [ward, another hospital, rehabilitation center, critical care unit (CCU), or intensive coronary care unit (ICCU)], their breathing style at discharge (unassisted or assisted) and more specific their method of breathing (T-piece, speaking valve, tracheostomy closure, continuous positive airway pressure (CPAP), bi-level positive airway pressure, pressure or volume ventilator), their days spent on mechanical ventilation and in ICU and their weaning from mechanical ventilation and survival status.

Analysis was carried out using SPSS Statistics 24.0 software (IBM Corp, Armonk, NY, United States). Continuous variables are presented as a mean ± standard deviation (SD), and categorical variables as number and percentage (*n*, %). Normality tests were performed using the Kolmogorov-Smirnov test to separate parametric from non-parametric variables. Categorical variables were analyzed using the Chi-Square test with Fisher's exact test correction when necessary, whereas continuous variables were analyzed using the Independent Samples *t*-test for parametric variables and the Mann-Whitney *U* test for non-parametric variables. All tests were two-tailed and significance was taken at $P < 0.05$.

RESULTS

Table 1 shows the baseline characteristics of the patients and the comparison between those who were subjected to tracheostomy and those who were not. Patients were subjected more frequently to tracheostomy if their cause of admission was sepsis (3.5% *vs* 0.0%, $P = 0.001$) and trauma (17.4% *vs* 7.2%, $P < 0.001$) and less frequently if they were admitted due to surgery (1.7% *vs* 22.9%, $P < 0.001$). As far as the cause of intubation, CNS pathology, trauma, and compromised airway led to tracheostomy more frequently (47.0% *vs* 25.1%, $P < 0.001$), (13.9% *vs* 3.3%, $P < 0.001$) and (11.3% *vs* 2.6%, $P < 0.001$) respectively, while the opposite was true for surgery (0.0% *vs* 45.1%, $P < 0.001$). GCS at admission was significantly lower in patients with tracheostomy (9.6 ± 4.4 *vs* 12.2 ± 4.4, $P < 0.001$), while patients with tracheostomy spent significantly more days in ICU (21.8 ± 10.7 *vs* 4.0 ± 6.3, $P < 0.001$). Finally, after ICU discharge, patients with tracheostomy were transferred less frequently to a ward (65.2% *vs* 76.9%, $P = 0.009$) and more frequently to another hospital (9.6% *vs* 1.7%, $P < 0.001$) or a rehabilitation center (6.1% *vs* 0.6%, $P < 0.001$).

Regarding the timing of the tracheostomy, patients were subjected less frequently to early tracheostomy when the reason for performing it was prolonged mechanical ventilation (14.3% *vs* 30.8%, $P = 0.033$). If the reason for performing ST was a facial trauma, early tracheostomy was chosen significantly more frequently (50.0% *vs* 0.0%, $P = 0.033$), while the opposite was true if the reason for performing ST was a goiter (0.0% *vs* 44.4%, $P = 0.033$). Patients with early tracheostomy spent significantly fewer days on mechanical ventilation (15.3 ± 8.5 *vs* 22.8 ± 9.6, $P < 0.001$) and in ICU in general (18.8 ± 9.1 *vs* 25.4 ± 11.5, $P < 0.001$) (Table 2).

As far as the method of performing the tracheostomy, patients who were subjected to PDT were significantly older (62.6 ± 14.0 *vs* 47.6 ± 15.0 years, $P < 0.001$) compared to those who were subjected to ST; they also had a significantly lower GCS at admission (9.2 ± 4.3 *vs* 11.7 ± 4.2, $P = 0.025$), significantly higher APACHE II score at admission (19.6 ± 6.4 *vs* 15.7 ± 7.0, $P = 0.020$) and significantly higher number of co-morbidities (1.9 ± 1.5 *vs* 1.2 ± 1.0, $P = 0.044$). PDT was more preferable if the cause of admission was CNS pathology (62.5% *vs* 26.3%, $P = 0.004$) and less preferable if the cause of admission was trauma or surgery (13.5% *vs* 36.8%, $P = 0.022$) and (0.0% *vs* 10.5%, $P = 0.026$) respectively. PDT was chosen more frequently if the cause of intubation was CNS pathology (53.1% *vs* 15.8%, $P = 0.003$), while the opposite was true if the cause of intubation was a compromised airway (7.3% *vs* 31.6%, $P = 0.008$). PDT was also more frequent in cases of cardiovascular co-morbidity (54.2% *vs* 21.1%, $P = 0.008$), a low level of consciousness as a reason for tracheostomy (46.9% *vs* 21.1%, $P = 0.044$) and a prolonged duration for stay as a reason for early tracheostomy (67.9% *vs* 0.0%, $P < 0.001$), while it was less frequent in cases of a compromised airway as a reason for tracheostomy or a reason for early tracheostomy (9.4% *vs* 36.8%, $P = 0.005$) and (5.7% *vs* 50.0%, $P = 0.002$) respectively. Finally, patients with PDT were discharged with CPAP less frequently than those with ST (0.0% *vs* 11.8%, $P = 0.030$) (Table 3).

Table 1 Baseline characteristics and comparison between patients who were subjected to tracheostomy and those who were not subjected to tracheostomy, *n* (%)

		Total patients	Patients with tracheostomy	Patients without tracheostomy	*P* value
Gender	Male	375/660 (56.8)	72/115 (62.6)	303/545 (55.6)	0.17
	Female	285/660 (43.2)	43/115 (37.4)	242/545 (44.4)	
Age (yr)		60.2 ± 16.8	60.1 ± 15.2	60.2 ± 17.1	0.97
Cause of admission	CNS	345/660 (52.3)	65/115 (56.5)	280/545 (51.4)	0.32
	CVS	28/660 (4.2)	3/115 (2.6)	25/545 (4.6)	0.45
	RS	56/660 (8.5)	11/115 (9.6)	45/545 (8.3)	0.65
	Sepsis	4/660 (0.6)	4/115 (3.5)	0/545 (0.0)	0.001
	Malignancy	20/660 (3.0)	7/115 (6.1)	13/545 (2.4)	0.06
	Trauma	59/660 (8.9)	20/115 (17.4)	39/545 (7.2)	< 0.001
	Surgery	127/660 (19.2)	2/115 (1.7)	125/545 (22.9)	< 0.001
	Metabolic cause	21/660 (3.2)	3/115 (2.6)	18/545 (3.3)	1.00
Cause of intubation	Not intubated	19/660 (2.9)	0/115 (0.0)	19/545 (3.5)	0.06
	CNS	191/660 (28.9)	54/115 (47.0)	137/545 (25.1)	< 0.001
	CVS	31/660 (4.7)	8/115 (7.0)	23/545 (4.2)	0.21
	RS	42/660 (6.4)	10/115 (8.7)	32/545 (5.9)	0.26
	Trauma	34/660 (5.2)	16/115 (13.9)	18/545 (3.3)	< 0.001
	Metabolic cause	34/660 (5.2)	7/115 (6.1)	27/545 (5.0)	0.62
	Compromised airway	27/660 (4.1)	13/115 (11.3)	14/545 (2.6)	< 0.001
	Sepsis	36/660 (5.5)	7/115 (6.1)	29/545 (5.3)	0.74
	Surgery	246/660 (37.3)	0/115 (0.0)	246/545 (45.1)	< 0.001
GCS (N)		11.8 ± 4.5	9.6 ± 4.4	12.2 ± 4.4	< 0.001
APACHE II (N)		19.2 ± 8.0	19.0 ± 6.7	19.3 ± 8.5	0.65
APDR (%)		35.0 ± 24.5	33.2 ± 20.1	35.7 ± 26.1	0.29
Number of co-morbidities (N)		1.8 ± 1.5	1.75 ± 1.40	1.75 ± 1.49	0.97
Co-morbidity	Cardiovascular	329/660 (49.8)	56/115 (48.7)	273/545 (50.1)	0.79
	Metabolic	273/660 (41.4)	46/115 (40.0)	227/545 (41.7)	0.74
	Respiratory	74/660 (11.2)	13/115 (11.3)	61/545 (11.2)	0.97
	Autoimmune	10/660 (1.5)	3/115 (2.6)	7/545 (1.3)	0.39
	Malignancy	83/660 (12.6)	10/115 (8.7)	73/545 (13.4)	0.17
	Psychiatric	46/660 (7.0)	10/115 (8.7)	36/545 (6.6)	0.42
	Renal	41/660 (6.2)	6/115 (5.2)	35/545 (6.4)	0.63
	Neurological	42/660 (6.4)	9/115 (7.8)	33/545 (6.1)	0.48
	Hematological	19/660 (2.9)	3/115 (2.6)	16/545 (2.9)	1.00
	Urological	26/660 (3.9)	3/115 (2.6)	23/545 (4.2)	0.60
	Infectious	10/660 (1.5)	4/115 (3.5)	6/545 (1.1)	0.08
Days in ICU (N)		7.1 ± 9.9	21.8 ± 10.7	4.0 ± 6.3	< 0.001
Transferred to	Ward	494/660 (74.8)	75/115 (65.2)	419/545 (76.9)	0.009
	Another hospital	20/660 (3.0)	11/115 (9.6)	9/545 (1.7)	< 0.001
	Rehabilitation center	10/660 (1.5)	7/115 (6.1)	3/545 (0.6)	< 0.001

	CCU	6/660 (0.9)	3/115 (2.6)	3/545 (0.6)	0.07
	ICCU	12/660 (1.8)	0/115 (0.0)	12/545 (2.2)	0.24
Survival	Yes	542/660 (82.1)	96/115 (83.5)	446/545 (81.8)	0.68
	No	118/660 (17.9)	19/115 (16.5)	99/545 (18.2)	

N: Number; CNS: Central nervous system; CVS: Cardiovascular system; RS; Respiratory system; GCS; Glasgow coma scale; APACHE: Acute physiology and chronic health evaluation; APDR: APACHE predicted death rate, ICU: Intensive care unit; CCU: Critical care unit; ICCU: Intensive coronary care unit.

As far as survival, it was less frequent if the case of admission was CVS pathology, malignant or metabolic disease (2.4% *vs* 12.7%, $P < 0.001$), (1.9% *vs* 8.5%, $P = 0.001$) and (2.0% *vs* 8.5%, $P = 0.001$) respectively, while it was more frequent if the cause of admission was trauma or surgery (10.3% *vs* 2.5%, $P = 0.007$) and (21.2% *vs* 10.2%, $P = 0.006$) respectively. If the patients were not intubated or were intubated due to surgery, they were more likely to survive (3.5% *vs* 0.0%, $P = 0.033$) and (45.2% *vs* 0.9%, $P < 0.001$) respectively, while they were less likely to survive if they were intubated due to CNS, CVS, metabolic, or septic pathology (26.6% *vs* 39.8%, $P = 0.004$), (2.6% *vs* 14.4%, $P < 0.001$), (4.2% *vs* 9.3%, $P = 0.036$) and (2.0% *vs* 21.2%, $P < 0.001$) respectively. The patients who survived presented with a higher GCS (12.6 ± 4.0 *vs* 7.9 ± 4.8, $P < 0.001$), a lower APACHE II score (16.9 ± 7.0 *vs* 25.1 ± 7.3, $P < 0.001$) and a lower number of co-morbidities (1.7 ± 1.5 *vs* 2.1 ± 1.5, $P = 0.005$). Patients were also less likely to survive if they presented with a cardiovascular or a hematological co-morbidity (48.0% *vs* 58.5%, $P = 0.039$) and (2.0% *vs* 6.8%, $P = 0.011$) respectively, while survivors spent less days in ICU compared to non-survivors (6.7 ± 9.9 *vs* 8.9 ± 9.8, $P = 0.028$) (Table 4).

DISCUSSION

Performing tracheostomy in critical care patients in the ICU is a common procedure in the ICU. An interesting finding of this research is that successful weaning from mechanical ventilation was possible in the majority of the patients, as 88 out of 115 patients who underwent tracheostomy managed to be weaned from the ventilator.

Lim *et al*[13] found that weaning parameters measured before and after tracheostomy in difficult-to-wean patients differed significantly. In particular, after tracheostomy, maximum inspiratory pressure, maximum expiratory pressure, and tidal volume significantly increased, whereas rapid shallow breathing index and airway resistance significantly decreased due to the contrast in length and shape between the endotracheal and tracheostomy of tubes, the biofilm formation in the endotracheal tubes and the improved comfort of the patients after tracheostomy.

With regard to the timing of performing a tracheostomy, early tracheostomy was defined as intervention no more than 8 d after initiation of mechanical ventilation. We defined late as tracheostomy placement after 8 d of intubation[8]. It is interesting that the early conversion from an endotracheal tube to tracheostomy had, as a result, a shorter duration of mechanical ventilation in comparison with patients who underwent late tracheostomy with a statistically significant difference. This finding is consistent with a systematic review and meta-analysis of Griffiths *et al*[14] that show that performing a tracheostomy at an earlier stage than is currently practiced may shorten the duration of artificial ventilation and length of stay in intensive care.

As stated by Dochi *et al*[15], who investigated the effect of the timing of tracheostomy in patients who required prolonged mechanical ventilation using two methods: the early *vs* late tracheostomy, for patients requiring ventilation, performing tracheostomy within ten days of admission was independently associated with shortened duration of mechanical ventilation.

General indications for tracheostomy placement include acute respiratory failure with the expected need for prolonged mechanical ventilation, inability to wean from mechanical ventilation, upper airway obstruction, difficult airway, and copious secretions[16].

In our study, CNS pathology combined with low GCS, surgical trauma with subsequent prolonged mechanical ventilation, and compromised airway, mainly due to cranio-maxillofacial injury, led to tracheostomy more frequently than other causes.

A study by Ahmadinegad and co-workers[17] showed that the GCS of patients with severe head injuries on day five following ICU admission might be used for decision-making regarding the time of tracheostomy. A Tracheostomy should be carried out on day five following ICU admission if the GCS is ≤ 8, but it can be delayed if the GCS on the 5th day is > 9.

In the present study, the actual cause for performing an early tracheostomy was a cranio-maxillofacial injury in polytrauma patients and surgical conditions – malignant or not - of the oral cavity, maxillofacial area, and neck. This finding is consistent with the study of Chandrashekar *et al*[18], who described tracheostomy in ICU as an important and safe procedure if prolonged endotracheal intubation is advised for varying underlying causes.

A PDT is usually selected as a method of choice in critical care patients in a particular study. According to a review by Khaja *et al*[19], PDT is a bedside procedure that is safe to perform, has less procedural time, has low cost, and does not need operating schedule time. Also, complications like bleeding and infection are minimal with a percutaneous tracheostomy.

Our study did not observe a statistically significant difference between the two well-known methods of conducting a tracheostomy, namely, the PDT and the open ST approach. de Kleijn *et al*[20] stated that the rate of short- and long-term complications, including tracheal stenosis, is equal in PDT and ST and that PDT is a safe alternative for ST in selected

Table 2 Baseline characteristics of the patients who were subjected to tracheostomy and comparison between those who were subjected to early tracheostomy and those who were subjected to late tracheostomy, *n* (%)

		Whole of the patients	Patients with early tracheostomy	Patients with late tracheostomy	*P* value
Gender	Male	72/115 (62.6)	40/63 (63.5)	32/52 (61.5)	0.83
	Female	43/115 (37.4)	23/63 (36.5)	20/52 (38.5)	
Age (yr)		60.1 ± 15.2	60.1 ± 14.3	60.2 ± 16.4	0.95
Cause of admission	CNS	65/115 (56.5)	38/63 (60.3)	27/52 (51.9)	0.37
	CVS	3/115 (2.6)	1/63 (1.6)	2/52 (3.9)	0.59
	RS	11/115 (9.6)	8/63 (12.7)	3/52 (5.8)	0.34
	Sepsis	4/115 (3.5)	1/63 (1.6)	3/52 (5.8)	0.33
	Malignancy	7/115 (6.1)	2/63 (3.2)	5/52 (9.6)	0.24
	Trauma	20/115 (17.4)	10/63 (15.9)	10/52 (19.2)	0.64
	Surgery	2/115 (1.7)	2/63 (3.2)	0/52 (0.0)	0.50
	Metabolic	3/115 (2.6)	1/63 (1.6)	2/52 (3.9)	0.59
Cause of intubation	CNS	54/115 (47.0)	32/63 (50.8)	22/52 (42.3)	0.36
	CVS	8/115 (7.0)	5/63 (7.9)	3/52 (5.8)	0.73
	RS	10/115 (8.7)	7/63 (11.1)	3/52 (5.8)	0.51
	Trauma	16/115 (13.9)	8/63 (12.7)	8/52 (15.4)	0.68
	Metabolic	7/115 (6.1)	2/63 (3.2)	5/52 (9.6)	0.24
	Compromised airway	13/115 (11.3)	7/63 (11.1)	6/52 (11.5)	0.94
	Sepsis	7/115 (6.1)	2/63 (3.2)	5/52 (9.6)	0.24
	Surgery	0/115 (0.0)	0/63 (0.0)	0/52 (0.0)	N/A
GCS (N)		9.6 ± 4.4	9.3 ± 4.1	10.1 ± 4.6	0.33
APACHE II (N)		19.0 ± 6.7	18.3 ± 6.4	19.8 ± 7.0	0.25
APDR (%)		33.2 ± 20.1	31.7 ± 18.7	35.0 ± 21.7	0.38
Number of co-morbidities (N)		1.75 ± 1.40	1.75 ± 1.33	1.75 ± 1.49	0.99
Co-morbidity	Cardiovascular	56/115 (48.7)	34/63 (54.0)	22/52 (42.3)	0.21
	Metabolic	46/115 (40.0)	22/63 (34.9)	24/52 (46.2)	0.22
	Respiratory	13/115 (11.3)	7/63 (11.1)	6/52 (11.5)	0.94
	Autoimmune	3/115 (2.6)	2/63 (3.2)	1/52 (1.9)	1.00
	Malignancy	10/115 (8.7)	6/63 (9.5)	4/52 (7.7)	1.00
	Psychiatric	10/115 (8.7)	6/63 (9.5)	4/52 (7.7)	1.00
	Renal	6/115 (5.2)	4/63 (6.4)	2/52 (3.9)	0.69
	Neurological	9/115 (7.8)	7/63 (11.1)	2/52 (3.9)	0.18
	Hematological	3/115 (2.6)	1/63 (1.6)	2/52 (3.9)	0.59
	Urological	3/115 (2.6)	1/63 (1.6)	2/52 (3.9)	0.59
	Infectious	4/115 (3.5)	3/63 (4.8)	1/52 (1.9)	0.63
Reason for tracheostomy	Prolonged mechanical ventilation	25/115 (21.7)	9/63 (14.3)	16/52 (30.8)	0.033
	Compromised Airway	16/115 (13.9)	9/63 (14.3)	7/52 (13.5)	0.90
	Low level of consciousness	49/115 (42.6)	30/63 (47.6)	19/52 (36.5)	0.23

	Myopathy	25/115 (21.7)	15/63 (23.8)	10/52 (19.2)	0.55
Method of tracheostomy	PDT	96/115 (83.5)	53/63 (84.1)	43/52 (82.7)	0.84
	ST	19/115 (16.5)	10/63 (15.9)	9/52 (17.3)	
Reason for ST	Facial trauma	5/19 (26.3)	5/10 (50.0)	0/9 (0.0)	0.033
	Cervical burn	1/19 (5.3)	0/10 (0.0)	1/9 (11.1)	0.47
	Difficult airway	6/19 (31.6)	3/10 (30.0)	3/9 (33.3)	1.00
	Cervical edema	1/19 (5.3)	1/10 (10.0)	0/9 (0.0)	1.00
	Goiter	4/19 (21.1)	0/10 (0.0)	4/9 (44.4)	0.033
	Re-opening	2/19 (10.5)	1/10 (10.0)	1/9 (11.1)	1.00
Complications		0/115 (0.0)	0/63 (0.0)	0/52 (0.0)	n/a
VAP		31/115 (27.0)	17/63 (27.0)	14/52 (26.9)	0.99
Pathogen isolated	None	11/47 (23.4)	7/24 (29.2)	4/23 (17.4)	0.34
	Candida albicans	1/47 (2.1)	1/24 (4.2)	0/23 (0.0)	1.00
	Klebsiella pneumoniae	4/47 (8.5)	2/24 (8.3)	2/23 (8.7)	1.00
	Acinetobacter baumanii	15/47 (31.9)	7/24 (29.2)	8/23 (34.8)	0.68
	Pseudomonas aeruginosa	10/47 (21.3)	4/24 (16.7)	6/23 (26.1)	0.49
	Staphylococcus aureus	1/47 (2.1)	0/24 (0.0)	1/23 (4.4)	0.49
	Proteus mirabilis	2/47 (4.3)	0/24 (0.0)	2/23 (8.7)	0.23
	Escherichia coli	1/47 (2.1)	1/24 (4.2)	0/23 (0.0)	1.00
	Enterococcus faecium	1/47 (2.1)	1/24 (4.2)	0/23 (0.0)	1.00
	Hemophilus influenzae	1/47 (2.1)	1/24 (4.2)	0/23 (0.0)	1.00
Days in ICU (N)		21.8 ± 10.7	18.8 ± 9.1	25.4 ± 11.5	0.001
Transferred to	Ward	75/115 (65.2)	39/63 (61.9)	36/52 (69.2)	0.41
	Another hospital	11/115 (9.6)	8/63 (12.7)	3/52 (5.8)	0.34
	Rehabilitation center	7/115 (6.1)	3/63 (4.8)	4/52 (7.7)	0.70
	CCU	3/115 (2.6)	3/63 (4.8)	0/52 (0.0)	0.25
	ICCU	0/115 (0.0)	0/63 (0.0)	0/52 (0.0)	N/A
Condition at discharge	T-piece	82/115 (71.3)	43/53 (81.1)	39/43 (90.7)	0.19
	Speaking valve	1/115 (0.9)	1/53 (1.9)	0/43 (0.0)	0.45
	Tracheostomy closure	5/115 (4.3)	4/53 (7.6)	1/43 (2.3)	0.38
	CPAP	2/115 (1.7)	2/53 (3.8)	0/43 (0.0)	0.50
	BiPAP	1/115 (0.9)	1/53 (1.9)	0/43 (0.0)	1.00
	Pressure ventilator	3/115 (2.6)	2/53 (3.8)	1/43 (2.3)	1.00
	Volume ventilator	2/115 (1.7)	1/53 (1.9)	1/43 (2.3)	1.00
Breathing at discharge	Unassisted	88/115 (76.5)	47/53 (88.7)	41/43 (95.3)	0.29
	Assisted	8/115 (7.0)	6/53 (11.3)	2/43 (4.7)	
Weaning from mechanical ventilation		87/115 (75.7)	48/60 (80.0)	39/50 (78.0)	0.80
Days on mechanical ventilation (N)		18.6 ± 9.7	15.3 ± 8.5	22.8 ± 9.6	< 0.001
Survival	Yes	96/115 (83.5)	53/63 (84.1)	43/52 (82.7)	0.84
	No	19/115 (16.5)	10/63 (15.9)	9/52 (17.3)	

N: Number; CNS: Central nervous system; CVS: Cardiovascular system; RS: Respiratory system; GCS: Glasgow coma scale; APACHE: Acute physiology and chronic health evaluation; APDR: APACHE predicted death rate; VAP: Ventilator associated pneumonia; ICU: Intensive care unit; CCU: Critical care unit; ICCU: Intensive coronary care unit; CPAP: Continuous positive airway pressure; BiPAP: Bi-level positive airway pressure; PDT: Percutaneous

dilatation tracheostomy; ST: Surgical tracheostomy.

Table 3 Comparison between the patients who were subjected to percutaneous tracheostomy and those who were subjected to surgical tracheostomy, *n* (%)

		Patients with PDT	Patients with ST	*P* value
Gender	Male	59/96 (61.5)	13/19 (68.4)	0.57
	Female	37/96 (38.5)	6/19 (31.6)	
Age (years)		62.6 ± 14.0	47.6 ± 15.0	< 0.001
Cause of admission	CNS	60/96 (62.5)	5/19 (26.3)	0.004
	CVS	3/96 (3.1)	0/19 (0.0)	1.00
	RS	9/96 (9.4)	2/19 (10.5)	1.00
	Sepsis	3/96 (3.1)	1/19 (5.3)	0.52
	Malignancy	6/96 (6.3)	1/19 (5.3)	1.00
	Trauma	13/96 (13.5)	7/19 (36.8)	0.022
	Surgery	0/96 (0.0)	2/19 (10.5)	0.026
	Metabolic	2/96 (2.1)	1/19 (5.3)	0.42
Cause of intubation	CNS	51/96 (53.1)	3/19 (15.8)	0.003
	CVS	7/96 (7.3)	1/19 (5.3)	1.00
	RS	8/96 (8.3)	2/19 (10.5)	0.67
	Trauma	12/96 (12.5)	4/19 (21.1)	0.30
	Metabolic	6/96 (6.3)	1/19 (5.3)	1.00
	Compromised airway	7/96 (7.3)	6/19 (31.6)	0.008
	Sepsis	5/96 (5.2)	2/19 (10.5)	0.33
	Surgery	0/96 (0.0)	0/19 (0.0)	N/A
GCS (N)		9.2 ± 4.3	11.7 ± 4.2	0.025
APACHE II (N)		19.6 ± 6.4	15.7 ± 7.0	0.020
APDR (%)		35.1 ± 20.3	23.6 ± 16.0	0.022
Number of co-morbidities (N)		1.9 ± 1.5	1.2 ± 1.0	0.044
Co-morbidity	Cardiovascular	52/96 (54.2)	4/19 (21.1)	0.008
	Metabolic	37/96 (38.5)	9/19 (47.4)	0.47
	Respiratory	10/96 (10.4)	3/19 (15.8)	0.45
	Autoimmune	3/96 (3.1)	0/19 (0.0)	1.00
	Malignancy	10/96 (10.4)	0/19 (0.0)	0.21
	Psychiatric	9/96 (9.4)	1/19 (5.3)	1.00
	Renal	6/96 (6.3)	0/19 (0.0)	0.59
	Neurological	8/96 (8.3)	1/19 (5.3)	1.00
	Hematological	3/96 (3.1)	0/19 (0.0)	1.00
	Urological	3/96 (3.1)	0/19 (0.0)	1.00
	Infectious	4/96 (4.2)	0/19 (0.0)	1.00
Reason for tracheostomy	Prolonged mechanical ventilation	22/96 (22.9)	3/19 (15.8)	0.76
	Compromised airway	9/96 (9.4)	7/19 (36.8)	0.005
	Low level of	45/96 (46.9)	4/19 (21.1)	0.044

	consciousness			
	Myopathy	20/96 (20.8)	5/19 (26.3)	0.56
Timing of tracheostomy	Early	53/96 (55.2)	10/19 (52.6)	1.00
	Late	43/96 (44.8)	9/19 (47.4)	
Reason for early tracheostomy	Prolonged duration of stay	36/53 (67.9)	0/10 (0.0)	< 0.001
	Compromised airway	3/53 (5.7)	5/10 (50.0)	0.002
	Trauma	10/53 (18.9)	3/10 (30.0)	0.42
	Neuromuscular disease	4/53 (7.6)	2/10 (20.0)	0.24
Complications		0/96 (0.0)	0/19 (0.0)	N/A
VAP		25/96 (26.0)	6/19 (31.6)	0.62
Pathogen isolated	None	9/39 (23.1)	2/8 (25.0)	1.00
	Candida albicans	1/39 (2.6)	0/8 (0.0)	1.00
	Klebsiella pneumoniae	3/39 (7.7)	1/8 (12.5)	0.54
	Acinetobacter baumanii	13/39 (33.3)	2/8 (25.0)	1.00
	Pseudomonas aeruginosa	8/39 (20.5)	2/8 (25.0)	1.00
	Staphylococcus aureus	1/39 (2.6)	0/8 (0.0)	1.00
	Proteus mirabilis	1/39 (2.6)	1/8 (12.5)	0.32
	Escherichia coli	1/39 (2.6)	0/8 (0.0)	1.00
	Enterococcus faecium	1/39 (2.6)	0/8 (0.0)	1.00
	Hemophilus influenzae	1/39 (2.6)	0/8 (0.0)	1.00
Days in ICU (N)		22.0 ± 10.9	20.7 ± 9.8	0.64
Transferred to	Ward	65/96 (67.7)	10/19 (52.6)	0.29
	Another hospital	8/96 (8.3)	3/19 (15.8)	0.39
	Rehabilitation center	5/96 (5.2)	2/19 (10.5)	0.33
	CCU	1/96 (1.0)	2/19 (10.5)	0.07
	ICCU	0/96 (0.0)	0/19 (0.0)	N/A
Condition at discharge	T-piece	68/79 (86.1)	14/17 (82.4)	0.71
	Speaking valve	0/79 (0.0)	1/17 (5.9)	0.18
	Tracheostomy closure	5/79 (6.3)	0/17 (0.0)	0.58
	CPAP	0/79 (0.0)	2/17 (11.8)	0.030
	BiPAP	1/79 (1.3)	0/17 (0.0)	1.00
	Pressure ventilator	3/79 (3.8)	0/17 (0.0)	1.00
	Volume ventilator	2/79 (2.5)	0/17 (0.0)	1.00
Breathing at discharge	Unassisted	73/79 (92.4)	15/17 (88.2)	0.63
	Assisted	6/79 (7.6)	2/17 (11.8)	
Weaning from mechanical ventilation		70/91 (76.9)	17/19 (89.5)	0.35
Days on mechanical ventilation (N)		18.9 ± 9.7	17.6 ± 10.0	0.60
Survival	Yes	79/96 (82.3)	17/19 (89.5)	0.74
	No	17/96 (17.7)	2/19 (10.5)	

N: Number; CNS: Central nervous system; CVS: Cardiovascular system; RS: Respiratory system; GCS: Glasgow coma scale; APACHE: Acute physiology and chronic health evaluation; APDR: APACHE predicted death rate; VAP: Ventilator associated pneumonia; ICU: Intensive care unit; CCU: Critical care unit; ICCU: Intensive coronary care unit; CPAP: Continuous positive airway pressure; BiPAP: Bi-level positive airway pressure; PDT: Percutaneous dilatation tracheostomy; ST: Surgical tracheostomy.

Table 4 Comparison between the patients who survived and those who did not survived, *n* (%)

		Survived	Did not survived	*P* value
Gender	Male	302/542 (55.7)	73/118 (61.9)	0.22
	Female	240/542 (44.3)	45/118 (38.1)	
Age (yr)		59.8 ± 16.7	62.2 ± 17.4	0.16
Cause of admission	CNS	288/542 (53.1)	57/118 (48.3)	0.36
	CVS	13/542 (2.4)	15/118 (12.7)	< 0.001
	RS	45/542 (8.3)	11/118 (9.3)	0.72
	Sepsis	4/542 (0.7)	0/118 (0.0)	1.00
	Malignancy	10/542 (1.9)	10/118 (8.5)	0.001
	Trauma	56/542 (10.3)	3/118 (2.5)	0.007
	Surgery	115/542 (21.2)	12/118 (10.2)	0.006
	Metabolic	11/542 (2.0)	10/118 (8.5)	0.001
Cause of intubation	Not intubated	19/542 (3.5)	0/118 (0.0)	0.033
	CNS	144/542 (26.6)	47/118 (39.8)	0.004
	CVS	14/542 (2.6)	17/118 (14.4)	< 0.001
	RS	33/542 (6.1)	9/118 (7.6)	0.54
	Trauma	30/542 (5.5)	4/118 (3.4)	0.34
	Metabolic	23/542 (4.2)	11/118 (9.3)	0.036
	Compromised airway	23/542 (4.2)	4/118 (3.4)	0.80
	Sepsis	11/542 (2.0)	25/118 (21.2)	< 0.001
	Surgery	245/542 (45.2)	1/118 (0.9)	< 0.001
GCS (N)		12.6 ± 4.0	7.9 ± 4.8	< 0.001
APACHE II (N)		16.9 ± 7.0	25.1 ± 7.3	< 0.001
APDR (%)		27.4 ± 20.6	54.4 ± 23.0	< 0.001
Number of co-morbidities (N)		1.7 ± 1.5	2.1 ± 1.5	0.005
Co-morbidity	Cardiovascular	260/542 (48.0)	69/118 (58.5)	0.039
	Metabolic	217/542 (40.0)	56/118 (47.5)	0.14
	Respiratory	56/542 (10.3)	18/118 (15.3)	0.13
	Autoimmune	8/542 (1.5)	2/118 (1.7)	0.70
	Malignancy	68/542 (12.6)	15/118 (12.7)	0.96
	Psychiatric	36/542 (6.6)	10/118 (8.5)	0.48
	Renal	31/542 (5.7)	10/118 (8.5)	0.26
	Neurological	34/542 (6.3)	8/118 (6.8)	0.84
	Hematological	11/542 (2.0)	8/118 (6.8)	0.011
	Urological	23/542 (4.2)	3/118 (2.5)	0.60
	Infectious	9/542 (1.7)	1/118 (0.9)	1.00
Tracheostomy	No	446/542 (82.3)	99/118 (83.9)	0.79
	Yes	96/542 (17.7)	19/118 (16.1)	
Reason for tracheostomy	Prolonged mechanical ventilation	22/96 (22.9)	3/19 (15.8)	0.76
	Compromised airway	13/96 (13.5)	3/19 (15.8)	0.73
	Low level of consciousness	41/96 (42.7)	8/19 (42.1)	0.96

	Myopathy	20/96 (20.8)	5/19 (26.3)	0.56
Timing of tracheostomy	Early	53/96 (55.2)	10/19 (52.6)	0.84
	Late	43/96 (44.8)	9/19 (47.4)	
Reason for early tracheostomy	Prolonged duration of stay	31/53 (58.5)	5/10 (50.0)	0.73
	Compromised airway	7/53 (13.2)	1/10 (10.0)	0.78
	Trauma	10/53 (18.9)	3/10 (30.0)	0.42
	Neuromuscular disease	5/53 (9.4)	1/10 (10.0)	1.00
Method of tracheostomy	PDT	79/96 (82.3)	17/19 (89.5)	0.74
	ST	17/96 (17.7)	2/19 (10.5)	
Reason for ST	Facial trauma	4/17 (23.5)	1/2 (50.0)	0.47
	Cervical burn	0/17 (0.0)	1/2 (50.0)	0.11
	Difficult airway	6/17 (35.3)	0/2 (0.0)	1.00
	Cervical edema	1/17 (5.9)	0/2 (0.0)	1.00
	Goiter	4/17 (23.5)	0/2 (0.0)	1.00
	Re-opening	2/17 (11.8)	0/2 (0.0)	1.00
Complications [N/T, (%)]		0/96 (0.0)	0/19 (0.0)	n/a
VAP		25/96 (26.0)	6/19 (31.6)	0.62
Pathogen isolated	None	8/40 (20.0)	3/7 (42.9)	0.33
	Candida albicans	1/40 (2.5)	0/7 (0.0)	1.00
	Klebsiella pneumoniae	4/40 (10.0)	0/7 (0.0)	1.00
	Acinetobacter baumanii	12/40 (30.0)	3/7 (42.9)	0.66
	Pseudomonas aeruginosa	9/40 (22.5)	1/7 (14.3)	1.00
	Staphylococcus aureus	1/40 (2.5)	0/7 (0.0)	1.00
	Proteus mirabilis	2/40 (5.0)	0/7 (0.0)	1.00
	Escherichia coli	1/40 (2.5)	0/7 (0.0)	1.00
	Enterococcus faecium	1/40 (2.5)	0/7 (0.0)	1.00
	Hemophilus influenzae	1/40 (2.5)	0/7 (0.0)	1.00
Days in ICU (N)		6.7 ± 9.9	8.9 ± 9.8	0.028

N: Number; CNS: Central nervous system; CVS: Cardiovascular system; RS: Respiratory system; GCS: Glasgow coma scale; APACHE: Acute physiology and chronic health evaluation; APDR: APACHE predicted death rate; VAP: Ventilator associated pneumonia; ICU: Intensive care unit; PDT: Percutaneous tracheostomy; ST: Surgical tracheostomy.

patients.

It is worth mentioning that critical care patients with tracheostomy at a younger age are weaned more easily from mechanical ventilation than older patients due to fewer or no co-morbidities, good physical condition, and a better response to the treatment administered. Apart from this, APDR (Adjusted Predicted Death Rate) in our study was lower in the patients with tracheostomy weaned of artificial ventilation, being a prognostic factor of outcome in this group of patients. In addition, the patients who survived presented with a higher GCS, a lower APACHE II score, and a lower number of co-morbidities.

The Length of stay in the ICU in patients with tracheostomy tubes was significantly longer than patients with an endotracheal tube, and most patients weaned were transferred from ICU either to a ward or to a rehabilitation center. Concerning the outcome of patients, a higher proportion of patients who were subjected to tracheostomy survived during their treatment in the ICU, unlike patients with no tracheostomy, who showed a higher mortality rate.

In a retrospective study of Combes *et al*[21], tracheostomy performed in the ICU for long-term mechanically ventilated patients was associated with lower ICU and in-hospital mortality rates even after carefully controlling for ICU admission and day-3 clinical and physiologic differences between tracheostomized and non-tracheostomized patients.

Prolonged mechanical ventilation, longer ICU length of stay, and higher mortality were observed in patients who developed VAP, even in patients with a tracheostomy cannula. Although this finding did not reach statistical significance, it is known that an endotracheal tube is by far the most important risk factor. Host factors such as the severity of the underlying disease, previous surgery, and antibiotic exposure have all been implicated as risk factors for

the development of VAP[22]. The earlier a tracheostomy is performed, the more the risk factors mentioned above can be avoided. Furthermore, when a patient with a tracheostomy tube is weaned from mechanical ventilation and discharged from the ICU, it could be a reasonable strategy for reducing the incidence of VAP.

Consistent with Szakmany *et al*' systematic review and meta-analysis, early tracheostomy does not help to reduce the length of ICU stay or incidence of VAP[6].

A meta-analysis by Griffiths *et al*[14] compared early tracheostomy with either late tracheostomy or prolonged endotracheal intubation. Early tracheostomy (within seven days of invasive mechanical ventilation) did not significantly reduce the risk of VAP or mortality but reduced the number of days on the ventilator and ICU stay.

According to Gadani *et al*[23], the incidence is directly proportional to the duration of mechanical ventilation, and re-intubation is a strong risk factor for the development of VAP. Therefore, the duration of ventilation has to be reduced to get rid of morbidity and mortality associated with mechanical ventilation, which can be achieved by administering a proper weaning protocol and titrating sedation regimens as per the needs of the patients.

Our study has several limitations. First of all, it was performed at a single ICU center with a small sample size and a non-randomized study design (not blinded) because the decision on the timing of the tracheostomy was judged according to the attending physician's opinion and the patient's clinical status. The current study depended on data that were entered into a clinical database and not collected for research, as a result some data would inevitably be missing. Also, certain variables that have the potential to impact the outcome may not have been recorded *etc*[24]. It is often difficult to identify appropriate study and control groups in retrospective studies[25]. Another limitation was the difficulty of accessibility to patients' medical records. Finally, the study did not evaluate long-term outcomes, such as after ICU and hospital discharge and post-decannulation.

CONCLUSION

In the present study, the early tracheostomy cannula aided in the successful weaning of the critical care patient from mechanical ventilation and the subsequent reduction of ICU length of stay. Also, the appearance or absence of VAP seems to affect the time of the patient's stay in the ICU and the outcome, although it was not associated with a lower mortality rate. The PDT is the most common technique in this study compared with the ST method. In terms of survival, it appears to be more affected by factors such as the patient's age, the cause of admission, the cause of intubation, the comorbidities and GCS scale values, the Apache II score, the predicted mortality rate APDR and less than the tracheostomy itself. It seems that early and percutaneous dilatation tracheostomy is more preferable in ICU patients, compared to late and surgical one, however, more studies are needed to indicate which patients require prolonged ventilation support and investigate the clinical benefits of tracheostomy.

FOOTNOTES

Author contributions: Papaioannou M and Vagiana E designed research; Vagiana E performed research; Manika K, Tsantos A, and Kapravelos N contributed new reagents or analytic tools; Kotoulas SC analyzed data; Papaioannou M, Sileli M, and Kotoulas SC wrote the paper; All authors contributed to the study, read and approved the final manuscript.

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