Acta Biomed 2023; Vol. 94, N. 2: e2023103 DOI: 10.23750/abm.v94i2.14243

Estimation of the optimal time needed for weaning of Intensive Care Unit tracheostomized patients on mechanical ventilation. a prospective observational study

Chrisoula Marinaki[1], Theodoros Kapadochos[2], Theodoros Katsoulas[3], Ivan Rubbi[4], Athanasia Liveri[5], Areti Stavropoulou[2], Antonio Bonacaro[6], Dimitrios Papageorgiou[2]

[1]General Hospital of Piraeus "Tzaneio", Athens, Greece; [2]Department of Nursing, University of West Attica, Athens, Greece; [3]Department of Nursing, National and Kapodistrian University of Athens, Athens, Greece; [4]School of Nursing, University of Bologna, Italy; [5]Department of Statistics and Insurance Science, University of Piraeus, Greece; [6]Department of Nursing, University of Suffolk, Ipswich, United Kingdom

Abstract. *Background and aim:* Determining the time that is required for weaning, as well as the factors that influence it can be used for the appropriate planning of patient's medical and nursing care. The aim of this study is to estimate the optimal time an Intensive Care Unit (ICU) patient with tracheostomy needs to wean from mechanical ventilation. *Methods:* This prospective observational study was conducted on 162 patients from two general hospitals in Athens, Greece. A specially designed recording form was created to conduct the study. The Statistical Package for the Social Sciences (SPSS) v.25 for Windows was used to record and analyze the data. The level of statistical significance was set at α=5%. *Results:* Results were found after comparing and associating the demographic and clinical characteristics and medical history of patients with the duration of weaning, the length of post-tracheostomy ICU stay and the time from intubation to tracheostomy. *Conclusions:* According to the results of our study, there are various factors that affect success and duration of weaning. More specifically, there seems to be an association between duration of weaning and age, number of closure attempts, success of closure, time from intubation to tracheostomy, length of the patient's post-tracheostomy ICU stay and diagnosis upon admission. The shorter the duration of weaning, the greater the benefits for the patients themselves, such us avoiding respiratory damage, reduction of mortality and morbidity and preventing of length of patient's ICU stay. (www.actabiomedica.it)

Key words: tracheostomy, mechanical ventilator, ventilator weaning, Intensive Care Units, nursing care

Introduction

The medical and nursing care of a patient with tracheostomy for an effective and timely weaning is of the utmost importance. This should take into consideration various elements, which includes the estimation of the time needed for the weaning of an Intensive Care Unit (ICU) patient with tracheostomy from mechanical ventilation. Additionally, clinical information such as the time estimate for the patient undergoing mechanical ventilation, and for the patient's weaning and the factors that affect it can be utilized for the effective planning of medical and nursing care (1, 2). Apparently, there is very limited literature available nationally and internationally in this regard.

It has been estimated in many studies that the time for the weaning process of patients in the ICU accounts for 40% of their hospitalization. Furthermore, it has been noticed that a considerable number of patients continue receiving mechanical ventilation

without really needing it. This fact is further ascertained by the unexpected extubation of patients, that is when they extubate themselves or when the extubation happens accidentally without the need of reintubation (3). The percentage of reintubation of patients who extubate accidentally is between 31% and 78%, while in scheduled extubation the percentage is 10-20%. This means that the 22-69% of patients keep on receiving mechanical ventilation without being in need of it. This probably occurs because the readiness-to-wean criteria have not been applied properly (3). According to Cosentino et al, 2017, the unexpected extubation is a phenomenon caused by various risks (4). It is very important for the doctors recognize the criteria that could support an extubation. Furthermore, a reduced unexpected extubation could be associated with an increase of the medical professionals and especially of the nursing stuff. In addition, it is very important for medical stuff to provide more supervision to patients who are at risk for unexpected extubation (4).

The reintubation has considerably negative effects on patients' condition, as this complication prolongs the patients' length of stay in the ICU while increasing morbidity, mortality and the chance of being transferred to a rehabilitation center instead being discharged. As a result of all these, the scientific community has expressed a particular interest in the finding appropriate algorithms and assessment tools that lead to the recognition of patients' readiness for weaning but also the prognosis of successful weaning (5).

Patients and methods

This prospective observational study was conducted on 162 patients from two general hospitals (Site A & Site B) in Athens, Greece. Patients' recruitment inclusion and exclusion criteria are presented in Table 1.

Table 1. Patients' recruitment inclusion and exclusion criteria.

Patients' recruitment inclusion criteria	Patients' recruitment exclusion criteria
Patients aged 18 years or over	Patients under the age of 18
Intubated and had undergone tracheostomy	Discharged or died before tracheostomy

Data collection was performed from September 2019 to September 2021. Researchers developed a specific form in accordance with relevant literature (6). Relevant clinical data were extracted from the patients' health records, anonymised and classified through the above-mentioned form. Prior to the beginning of the study, the patients' relatives were asked to sign an informed-consent form in full accordance with the Department of Human Health Services' policy. Furthermore, Hospitals' Scientific Advisory Boards granted the ethical approval for the research (Ref No 5844/29-3-2018 and 24845/3-5-2020).

The specific form was filled 239 times, but the sample of the study consisted of 162 patients. Sixty two patients was discharged or died before tracheostomy and 15 excluded from the study because of lack of data in their medical records. Patients followed up since their admission to ICU until their discharge from ICU. Furthermore, data collected comprised of demographic and clinical characteristics, such us gender, age, occupation, nationality, chronic conditions, family history, diagnosis upon admission to ICU, prior hospitalizations, smoke, alcohol and BMI. In addition to those, date of patient admission to ICU and date of discharge from the ICU, type of tracheostomy, number of efforts to achieve a tracheostomy stoma closure and success or failure of closure, were recorded. Qualitative variables of this study are gender, nationality, marital status, occupation, education level, chronic conditions, prior hospitalizations, family history, smoke, alcohol, diagnosis upon admission, present disease, type of procedure, success of closure and causes of closure failure. In addition, quantitative variables of this study are age in years, BMI, number of efforts for closure, time from intubation to tracheostomy, duration of weaning and length of stay in ICU after tracheostomy.

Statistical analysis

Tracheostomised patients' medical history, demographic and clinical characteristics were analysed through descriptive statistics.

The quantitative data were presented as mean and standard deviation, while qualitative data presented as rates and absolute values. Kolmogorov-Smirnov test was used for the test of normality (6, 7).

Correlation coefficient Pearson (r) and Correlation coefficient Spearman (ρ) were used for investigating the relationship between the two quantitative variables. T- test and Mann–Whitney U test were used for the difference between of one quantitative and one qualitative variable with two levels. In addition to that, the Anova and the Kruskal–Wallis tests were utilised for the difference between of one quantitative and one qualitative variable with three levels and more. Finally, multiple regression analysis was employed to determine factors that affect a quantitative data.

The Statistical Package for the Social Sciences (SPSS) v.25 for Windows was used to record and analyze the data. The level of statistical significance was set at a=5%.

Results

66,7% (n=108) of the study sample were men and 33,3% (n=54) were women, and the mean age of the participants was 58,36 (±16,56) years old. The rest of the demographic characteristics of the participants are presented in Table 2.

Regarding the medical history of patients, the majority of patients suffered from chronic conditions (n=135, 83,3%) with a high incidence of cardiovascular diseases scoring the highest percentage (n= 84, 51,9%). Table 3 presents the distribution of the sample according to medical history.

In respect to the diagnosis upon admission, the main diagnosis was neurological problems with 29,6% (n=48) followed by head injuries with a percentage of 20,4% (n=33), Covid-19 disease with 19,8% (n=32), respiratory problems with 14,8% (n=24), sepsis – septic shock with a percentage of 5,6% (n=9), cardiovascular problems with 3,7% (n=6) and post-surgical complications with a percentage of 2,5% (n=4). The rest of the clinical characteristics of the patients are recorded in Table 4.

Comparisons and associations between the demographic characteristics of the patients, the duration of weaning, patient's post-tracheostomy ICU length of stay and time from intubation to tracheostomy are presented in Table 5. Patients with Greek nationality seemed to have a longer duration of weaning than patients with a different nationality. Furthermore, private sector employees seemed to have a shorter duration of weaning than patients employed elsewhere. Similarly, patients with a post-graduate degree/ PhD had a shorter duration of weaning than patients who completed primary school only. The age seemed to be associated slightly and positively with the duration of weaning (p<0,05). In addition to that, it was revealed from the comparisons that the participants hospitalized at Site A had a longer length of stay in the ICU after tracheostomy than patients in Site B. Finally, private employees were more rapidly tracheostomised in comparison to freelancers or those who were employed elsewhere.

Comparisons and associations between medical history of the patients, the duration of weaning, length

Table 2. Demographic characteristics of the patients.

	n	%
Gender		
Men	108	66,7%
Women	54	33,3%
Nationality		
Greek	143	88,3%
Other	19	11,7%
Marital status		
Single	20	12,3%
Married	108	66,7%
Divorced	13	8%
Widowed	21	13%
Occupation		
Public Sector employee	17	10,5%
Private Sector employee	41	25,3%
Free- lancer	30	18,5%
Other	74	45,7%
Educational level		
Primary school graduated	30	18,5%
Secondary school graduated	30	18,5%
High school graduated	41	25,3%
College degree	51	31,5%
Postgraduate degree/ PhD	10	6,2%
	M±SD	
Age in years	**58,36±16,56**	

Table 3. Medical History of the patients.

	n	%
Chronic conditions		
Respiratory	45	27,8%
Cardiovascular	84	51,9%
Neurological	33	20,4%
Urological	17	10,5%
Haematological	5	3,1%
Musculoskeletal	11	6,8%
Reproductive	10	6,2%
Diabetes Melitus	46	28,4%
Autoimmune diseases	12	7,4%
Pathological diseases	2	1,2%
Prior hospitalizations		
Yes	93	57,4%
No	69	42,6%
Family History		
Respiratory	32	19,8%
Cardiovascular	61	37,7%
Neurological	42	25,9%
Urological	8	4,9%
Haematological	3	1,9%
Musculoskeletal	1	0,6%
Reproductive	2	1,2%
Diabetes Melitus	48	29,6%
Smoke		
Yes	64	39,5%
No	98	60,5%
Alcohol		
Yes	22	13,6%
No	140	86,4%

of their post-tracheostomy ICU stay and time from intubation to tracheostomy are presented in Table 6. More specifically, patients with chronic conditions appeared to have a longer duration of weaning and a longer time from intubation to tracheostomy than patients with no chronic conditions. Similarly, patients with prior hospitalization had a longer time from intubation to tracheostomy than patients who did not have prior hospitalization. Moreover, patients with a family

Table 4. Clinical characteristics of patients.

	n	%
Diagnosis upon admission		
Neurological problems	48	29,6%
Cardiovascular problems	6	3,7%
Respiratory problems	24	14,8%
Head injuries	33	20,4%
Covid-19	32	19,8%
Post- surgical complications	4	2,5%
Sepsis -Septic shock	9	5,6%
Other	6	3,7%
Present disease		
Respiratory cause	35	21,6%
Neurological cause	22	13,6%
Neurosurgical cause	30	18,5%
Surgical cause	44	27,2%
Cardiovascular cause	7	4,3%
Urological cause	2	1,2%
Pathological cause	39	24,1%
Coma	1	0,6%
Type of procedure		
Surgical	16	9,9%
Percutaneous	146	90,1%
Success of closure		
Yes	124	76,5%
No	38	23,5%
Causes of closure failure		
Neurological cause	16	9,9%
Neurosurgical cause	4	2,5%
Respiratory cause	10	6,2%
Neurological cause/ Respiratory cause	5	3,1%
Neurological cause/ Neurosurgical cause	3	1,9%
	M±SD	
BMI (kg/m^2)	26,75±4,12	
Number of efforts for closure	3,73±2,11	
Time from intubation to tracheostomy (in days)	13,31±4,96	
Duration of weaning	38,86±13,40	
Length of stay in ICU after tracheostomy	25,55±12,78	

Table 5. Comparisons and associations of demographic characteristics of patients.

	Duration of weaning		Length of stay in ICU		Time from intubation after tracheostomy to tracheostomy	
	M±SD	p	M±SD	p	M±SD	p
Hospital						
Site A	40,09±14,74	0,220	27,15± 14,14	**0,048**	12,94±4,99	
Site B	36,78±10,56		22,83±9,57		13,95±4,81	0,400
Gender						
Men	38,72±13,05	0,823	25,03±12,69	0,250	13,69±4,80	
Women	39,15±14,20		26,59±13,03		12,56±5,15	0,127
Nationality						
Greek	39,59±13,51	**0,021**	26,13±13,20	0,093	13,46±4,90	
Other	33,42±11,46		21,21±8,01		12,21±5,22	0,109
Marital status						
Single	35,95±12,23	0,475	25,50±12,71	0,570	10,45±5,68	
Married	38,45±12,77		24,94±12,32		13,52±4,56	0,188
Divorced	42,00±18,53		26,31±16,41		15,69±5,44	
Widowed	41,81±14,16		28,29±13,32		13,52±4,93	
Occupation						
Public Sector employee	42,59±18,34	**0,047**	30,06±17,94	0,429	12,53±3,99	
Private Sector employee	34,73±13,68		23,73±12,28		11,00±4,36	**0,001**
Free-lancer	38,93±9,88		22,57±8,54		16,37±5,59	
Other	40,27±12,89		26,73±12,91		13,54±4,52	
Educational level						
Primary school graduated	43,30±14,58	**0,024**	29,40±13,43	0,126	13,90±4,49	
Secondary school graduated	35,13±9,37		21,80±8,10		13,33±5,80	0,258
High school graduated	39,80±12,62		25,85±13,16		13,95±4,07	
College degree	38,69±14,70		25,75±14,00		12,94±5,34	
Postgraduate degree/ PhD	33,80±13,90		23,00±13,00		10,80±4,39	
	Correlation coefficient	**p**	**Correlation coefficient**	**p**	**Correlation coefficient**	P
Age in years	0,201	**0,010**	0,142	0,071	0,205	**0,009**

history of neurological problems underwent tracheostomy later than patients with no previous family issues in this area. Finally, none of the factors of the patients' medical history appeared to be related to the length of their post-tracheostomy stay in the ICU.

Comparisons and associations between clinical characteristics of the patients, the duration of weaning, the length of their stay in the ICU after tracheostomy and the time from intubation to tracheostomy are presented in Table 7. More specifically, patients

Table 6. Comparisons and associations of medical history of patients.

	Duration of weaning		Length of stay in ICU		Time from intubation after tracheostomy to tracheostomy	
	M±SD	p	M±SD	p	M±SD	p
Chronic conditions						
Yes	39,78±13,23	**0,013**	25,90±12,66	0,132	13,88±4,68	
No	34,30±13,56		23,81±13,51		10,48±5,30	**0,018**
Chronic conditions						
Respiratory	38,04±10,85	0,849	23,71±10,57	0,477	14,33±4,75	0,123
Cardiovascular	40,24±13,82	0,134	26,39±13,22	0,279	13,85±4,87	0,256
Neurological	44,12±17,30	**0,035**	30,33±16,80	0,066	13,79±4,92	0,081
Urological	40,47±14,59	0,672	26,94±14,18	0,517	13,53±2,65	0,876
Haematological	39,80±8,59	0,571	26,60±8,20	0,447	13,20±2,49	0,861
Musculoskeletal	41,09±19,08	0,912	26,91±18,68	0,847	14,18±5,31	0,356
Reproductive	35,40±10,59	0,374	21,00±9,62	0,323	14,40±3,57	0,484
Diabetes Melitus	38,07±14,09	0,423	23,15±13,38	0,063	14,91±5,23	0,193
Autoimmune diseases	37,42±6,57	0,969	24,50±6,59	0,696	12,92±3,00	0,386
Prior hospitalizations						
Yes	37,90±11,31	0,837	23,76±10,00	0,397	14,14±5,19	**0,038**
No	40,16±15,79		27,96±15,54		12,20±4,37	
Family History						
Respiratory	37,63±10,80	0,557	24,00±11,00	0,387	13,63±3,134	0,921
Cardiovascular	38,59±15,82	0,352	26,07±15,41	0,588	12,52±5,60	0,229
Neurological	38,17±8,96	0,715	22,98±9,37	0,238	15,19±4,36	**0,005**
Urological	40,63±19,23	0,790	29,38±15,76	0,419	11,25±5,06	0,279
Diabetes Melitus	38,77±15,48	0,387	25,81±14,75	0,657	12,96±4,38	0,966
Smoke						
Yes	39,44±13,397	0,342	26,02±12,19	0,366	13,42±5,19	0,585
No	38,49±13,460		25,24±13,21		13,24±4,79	
Alcohol						
Yes	40,05±14,31	0,661	27,68±15,10	0,457	12,36±5,53	0,185
No	38,68±13,30		25,21±12,41		13,46±4,84	
	Correlation coefficient	**p**	**Correlation coefficient**	**p**	**Correlation coefficient**	P
BMI	0.018	0,816	0,018	0,825	-0,015	0,845

with success of closure had a shorter duration of weaning than patients who did not have success of closure. Furthermore, patients with a respiratory problem had a longer duration of weaning than patients with no respiratory problem. On the contrary, patients with a surgical problem showed a shorter duration of weaning than patients who did not have a surgical problem.

The number of closure attempts appeared to be moderately and positively associated with the duration of weaning ($p < 0.05$). Time from intubation to tracheostomy in days is lightly and positively associated with the duration of weaning ($p < 0.05$). Patients' length of post-tracheostomy ICU stay is strongly and positively associated with the duration of weaning ($p < 0.05$).

Table 7. Comparisons and associations of clinical characteristics of patients.

	Duration of weaning		**Length of stay in ICU**		**Time from intubation after tracheostomy to tracheostomy**	
	M±SD	**p**	**M±SD**	**p**	**M±SD**	**p**
Diagnosis upon admission						
Neurological problems	39,35±13,80	0,142	26,35±12,67	0,339	13,00±4,26	
Cardiovascular problems	13,796±11,87		23,33±10,07		12,50±5,09	**0,043**
Respiratory problems	41,71±11,77		26,96±11,89		14,75±5,39	
Head injuries	36,42±14,49		24,76±13,20		11,67±4,89	
Covid- 19	40,41±11,29		25,09±11,62		15,31±4,55	
Post- surgical complications	28,75±5,91		14,50±5,26		14,25±3,59	
Sepsis- Septic shock	39,33±17,28		25,78±15,60		13,56±2,79	
Other	37,83±19,87		29,50±22,39		8,33±8,17	
Present disease						
Respiratory cause	41,26±11,20	**0,047**	27,86±12,16	0,067	13,40±4,14	0,781
Neurological cause	41,73±15,73	0,271	28,18±13,25	0,199	13,55±4,55	0,975
Neurosurgical cause	38,20±13,55	0,677	25,40±12,42	0,637	12,80±4,67	0,236
Surgical cause	35,84±14,40	**0,027**	24,64±14,07	0,261	11,20±5,18	**0,003**
Cardiovascular cause	36,57±11,01	0,545	23,71±9,25	0,876	12,86±4,74	0,725
Pathological cause	41,26±13,01	0,120	26,00±13,07	0,986	15,26±4,69	**0,019**
Type of procedure						
Surgical	38,88±21,07	0,431	30,31±19,75	0,908	8,56±8,91	**0,003**
Percutaneous	38,86±12,39		25,03±11,76		13,84±4,01	
Success of closure						
Yes	36,39±11,24	<**0,001**	23,04±10,26	<**0,001**	13,35±4,43	0,863
No	46,95±16,54		33,74±16,46		13,21±6,37	
	Correlation coefficient	**p**	**Correlation coefficient**	**p**	**Correlation coefficient**	P
Number of efforts for closure	0,645	<**0,001**	0,687	<**0,001**	-0,065	0,408
Time from intubation to tracheostomy (in days)	0,326	<**0,001**	-0,096	0,224		
Length of stay in ICU after tracheostomy	0,866	<**0,001**				

Patients with success of closure had a shorter length of post-tracheostomy ICU stay than patients with no success of closure, and the number of closure attempts seemed to be moderately and positively related to the patients' length of post-tracheostomy stay in the ICU (p <0, 05).

Finally, patients affected by COVID-19 disease underwent tracheostomy after a significantly longer time than patients who had another diagnosis upon admission. In addition, surgical patients were subject to tracheostomy after a shorter period of time than medical patients. Those who underwent surgical tracheostomy appeared to have a shorter time from intubation to tracheostomy than patients who underwent percutaneous tracheostomy.

Multiple regression analysis was deemed appropriate in order to determine if the statistically significant variables can affect the duration of the patients' weaning. Its results are shown in Table 8. Duration of weaning was used as the dependent variable while

Table 8. Multiple regression analysis with dependent variable the duration of weaning.

	B	95% Confidence interval		p
		Upper limit	Lower limit	
Constant	7,984	2,867	13,100	0,002
Number of efforts for closure	4,323	3,644	5,001	<0,001
Time from intubation to tracheostomy	1,107	0,817	1,397	<0,001

Table 9. Multiple regression analysis with dependent variable the length of patients' stay in ICU after tracheostomy.

	B	95% Confidence interval		p
		Upper limit	Lower limit	
Constant	9,545	6,675	12,415	<0,001
Number of efforts for closure	4,285	3,616	4,955	<0,001

nationality, occupation, education level, age, chronic conditions, neurological chronic condition, respiratory present disease, surgical present disease, success of closure, number of closure attempts and time from intubation to tracheostomy were used as independent variables. The model which resulted from the analysis contained the constant ($p < 0.05$), the number of closure attempts ($p < 0.05$) and the time from intubation to tracheostomy ($p < 0.05$). Additionally, independent variables interpret only 54.1% (Adjusted R Square) of the variation of the dependent variable. More specifically, an increase in the number of closure attempts by one unit implies a statistically significant extension in the duration of weaning by 4,323 days on average. Similarly, an increase in time from intubation to tracheostomy by one unit increases statistically significantly the duration of the patients' weaning by 1,107 on average, taking into consideration the number of closure attempts.

The analysis about the length of the patients' post-tracheostomy ICU stay is presented in Table 9 with the length of the post-tracheostomy ICU stay as the dependent variable and the hospital, success of closure and number of closure attempts as the independent variables. The model which resulted from the analysis was the one that contained the constant ($p < 0.05$) and the number of closure attempts ($p < 0.05$). In addition, independent variables interpret only 49.6% (Adjusted R Square) of the variation of the dependent variable. More specifically, an increase in the number of closure attempts by one unit increases statistically significantly the duration of the patients' post-tracheostomy stay in the ICU by 4,285 days on average.

Table 10. Multiple regression analysis with dependent variable the time from intubation to tracheostomy.

	B	95% Confidence interval		p
		Upper limit	Lower limit	
Constant	5,909	1,480	10,338	0,009
Type	4,331	2,099	6,563	<0,001
Private sector employee	-1,956	-3,610	-0,302	0,021
Freelancer	2,496	0,706	4,287	0,007
Family History Neurological	1,830	0,312	3,349	0,018
Surgical present disease	-2,557	-4,237	-0,877	0,003
Head injuries	-1,943	-3,524	-0,363	0,016

Table 10 summarizes the results of the multiple regression analysis on the patients' time from intubation to tracheostomy. Time from intubation to tracheostomy was considered as the dependent variable, and profession, age, chronic diseases, previous hospitalizations, family history of neurological problems, diagnosis upon admission, present disease of a surgical cause, present disease of a pathological cause and type of tracheostomy were considered as the independent variables. The model that resulted from the analysis contained the constant ($p < 0.05$), the type of tracheostomy ($p < 0.05$), the occupation ($p < 0.05$), the present disease of a surgical cause ($p < 0.05$) and the head injuries ($p < 0.05$). Independent variables interpret only 26.7% (Adjusted R Square) of the variation of the dependent variable.

Discussion

In the light of the present study results, it is deduced that the weaning process is influenced by various factors. After comparing and associating the patients' demographic, clinical characteristics and medical history, and the duration of weaning, the length of post-tracheostomy ICU stay and the time from intubation to tracheostomy, conflicting results were found with other relevant studies in this area.

Firstly, it was found that neurological patients took a shorter period of time for weaning in comparison to other patients. This result is consistent with a similar study conducted in 2006, where patients with cardiac or neurological problems underwent weaning more quickly than patients who were affected by another condition (8). This might be due to etiology of these diseases. In addition, in the present study, the duration of weaning was generally 38.86 days and the time from intubation to tracheostomy was 13.31 days, while in the other study the average duration of weaning was 5 days with tracheostomy being performed around the patient's 8th admission day in ICU (8).

Generally, diagnosis upon admission in the ICU and the reason for the patient's intubation appear to have an important role in weaning. In the present study, the following results were found:

- Patients with a respiratory condition had a longer duration of weaning than patients with no respiratory problem. On the contrary, patients with a surgical issue showed a shorter duration of weaning than patients who did not have a surgical problem.
- Patients with chronic conditions appeared to have a longer time from intubation to tracheostomy than patients with no chronic conditions.
- Patients with prior hospitalisation had a longer time from intubation to tracheostomy than patients who did not have prior hospitalization.

These findings are aligned with those of another study where patients with no comorbidity who had been intubated and had better respiratory function, were more rapidly tracheotomised and subsequent better chances of successful weaning and survival, regardless of age (9).

According to New York guidelines, the time from intubation to tracheostomy in patients with Covid-19 should consist of 21 days after the development of symptoms, whenever that this is possible. The reason being the healthcare team is less susceptible to getting infected (10). Clinically, tracheostomy in Covid-19 patients is not performed before the 14th day from intubation, as shown in an international literature review (11).

In the present study, age appeared to be moderately associated with the duration of weaning and the time passing from intubation to the patient's tracheostomy. Similarly, in another publication, patient's age was associated with the success of weaning. More specifically, half of the female participants age between 40 to 50 years (12), while in our study they were men (n = 108, 66.7%) and with an average age of 58 years. In fact, despite the older age of patients with prolonged mechanical support reduced the rate of weaning success age was not the dominant factor for that (13).

According to the present study findings, patients with successful of closure experienced a shorter duration of weaning and length of post-tracheostomy ICU stay than patients with unsuccessful. This is supported by a systematic review and meta-analysis showing that among all the patients who were ventilated for more than 14 days, only 50% of them had successful weaning and a mortality rate of 62% in 1 year (14). Moreover, as described in various studies, longer duration of mechanical support is associated with a reduced rate of successful weaning and an increased mortality rate. These findings once again support the present study results. Finally, in another study, the duration of mechanical support was weakly but significantly associated with reduced mortality (15).

With regards to the type of tracheostomy, the majority of the present study participants were subject to percutaneous tracheostomy (n=146, 90,1%). Furthermore, patients who experienced percutaneous tracheostomy waited a longer time from intubation to tracheostomy than patients who received surgical tracheostomy. Percutaneous tracheostomy is the most common type of tracheostomy in hospitals as it

is easier to perform (16). Despite of that, many studies have shown these two procedures are equally delivered (17) With regards to Covid -19 patients, both procedures are suitable if performed in the appropriate circumstances (18).

In the present study, patients with Greek nationality seemed to have a longer duration of weaning than patients with a different nationality. This result is particularly controversial because the sample was not representative. Similarly, private sector employees seemed to have a shorter duration of weaning than patients employed elsewhere. This result is also, controversial and maybe the association is due to the occupational hazard. Finally, patients with a post-graduate degree/ PhD had a shorter duration of weaning than patients who completed primary school only. This result is particularly controversial and maybe the association is because people with a post-graduate degree/ PhD take care themselves more than people who completed primary school.

Conclusions

In conclusion, weaning of a patient with tracheostomy is undoubtedly one of the most important processes in an ICU. There are various factors that may affect its success and the length of patients' waiting time between intubation and weaning. In the present study, there seems to be a correlation between duration of weaning and age, chronic conditions, number of closure attempts, success of closure, time from intubation to tracheostomy, length of the patient's post-tracheostomy ICU stay and present disease.. More specifically, patients with chronic conditions appeared to have a longer duration of weaning than patients with no chronic conditions. Furthermore, patients with success of closure had a shorter duration of weaning than patients who did not have success of closure. In addition, patients with a respiratory problem had a longer duration of weaning than patients with no respiratory problem. On the contrary, patients with a surgical problem showed a shorter duration of weaning than patients who did not have a surgical problem. Moreover, the age, number of closure attempts and time from intubation to tracheostomy in days appeared to be positively associated with the duration of weaning.

In the end, I must emphasize that patients' length of post-tracheostomy ICU stay is strongly and positively associated with the duration of weaning. Furthermore, the shorter the duration of weaning, the greater the benefits for the patients themselves are, such us avoiding respiratory damage, reduction of mortality and morbidity and preventing of length of patient's ICU stay. In this way, we conclude that the optimal time an ICU patient with tracheostomy needs to wean from mechanical ventilation is the shorter we can attempt. The implementation of a weaning program for mechanically ventilated patients could be proposed as a corrective measure and improve quality of care. The educational program specifically designed for doctors and nurses may be personalized and suits the needs of each patient.

Finally, this study presents limitations. Firstly, the sample size is limited, and participants were recruited in two ICUs only despite the availability of several public and private highly specialized hospitals in Athens. Furthermore, the research team encountered lack of data in some of medical records, which could have negatively impacted the quality of data collection and subsequent analysis. In that way, fifteen patients were excluded from the study (19, 20).

Acknowledgements: The authors would like to thank all the ICU staff of two hospitals for their contribution in our study.

Ethic Committee: Research Ethics Committee, University of West Attica, 2020, protocol number 88615/04-11-2020.

Conflict of Interest: Each author declares that he or she has no commercial associations (e.g. consultancies, stock ownership, equity interest, patent/licensing arrangement etc.) that might pose a conflict of interest in connection with the submitted article.

Authors' Contribution: CM and DP designed the study and established the model of the study. DP had the supervision of the study. TKap, TKats, AS, AB, IR and DP reviewed and edited the manuscript. Data collection was performed by CM and statistical analysis was performed by AL. All authors approved the final version of submitted manuscript.

References

1. Blackwood B, Alderdice F, Burns KE, Cardwell CR, Lavery G, O'Halloran P. Protocolized versus non-protocolized weaning for reducing the duration of mechanical ventilation in critically ill adult patients. Cochrane Database Syst Rev, 2010 May 12;(5):CD006904. doi: 10.1002/14651858.CD006904.pub2.
2. Esteban A, Anzueto A, Frutos F, et al. Characteristics and outcomes in adult patients receiving mechanical ventilation: a 28-day international study. JAMA, 2002 Jan 16;287(3):345-55. doi: 10.1001/jama.287.3.345.
3. Thille AW, Cortes- Puch I, Esteban A. Weaning from the ventilator and extubation in ICU. Curr opin crit care, 2013;19(1):57-64. doi: 10.1097/MCC.0b013e32835c5095.
4. Cosentino C, Fama M, Foa C, et al. Unplanned extubations in Intensive Care Unit: evidences for risk factors. A literature review. Acta Biomed, 2017 88(Suppl 5): 55-65.
5. Tobin M. Principles and Practice of Mechanical Ventilation, Third Edition McGraw-Hill Companies; 2006. p. 1353- 1372.
6. Yazici B, Yolacan S. A comparison of various tests of normality. J Stat Comput Simul, 2007 Feb;77(2): 175- 183. doi: 10.1080/10629360600678310.
7. Razali NM, Wah YB. Power comparisons of Shapiro- Wilk, Kolmogorov- Smirnov, Lilliefors and Anderson- Darling tests. Journal of Statistical Modeling and Analytics, 2011 Jan;2(1): 21-33.
8. van der Lely AJ, Veelo DP, Dongelmans DA, Korevaar JC, Vroom MB, Schultz MJ. Time to wean after tracheotomy differs among subgroups of critically ill patients: Retrospective Analysis in a Mixed Medical/Surgical Intensive Care Unit. Respir Care, 2006 Dec;51(12):1408 –1415.
9. Quiñones-Ossa GA, Durango-Espinosa YA, Padilla-Zambrano H, et al. Current Status of Indications, Timing, Management, Complications, and Outcomes of Tracheostomy in Traumatic Brain Injury Patients. J Neurosci Rural Pract, 2020 Apr;11(2):222-229. doi: 10.1055/s-0040-1709971.
10. Miles B, Schiff B, Ganly I, et al. Tracheostomy during SARS-CoV-2 pandemic: Recommendations from the New York Head and Neck Society. Head neck, 2020 Jun;42(6):1282- 1290. doi: 10.1002/hed.26166. Epub 2020 Apr 20.
11. Takhar A, Walker A, Tricklebank S, et al. Recommendation of a practical guideline for safe tracheostomy during the Covid – 19 pandemic. Eur Arch Otorhinolaryngol, 2020 Aug;277(8): 2173- 2184. doi: 10.1007/s00405-020-05993-x. Epub 2020 Apr 21.
12. Attia AAE, Abdullatif DA, AbdElGhany SMD. Factors affecting weaning of mechanically ventilated patients. Egyptian journal of health care, 2022 Jun;13(2): 82-97. doi: 10.21608/EJHC.2022.228536.
13. Dermot Frengley J, Sansone GR, Shakya K, Kaner RJ. Prolonged mechanical ventilation in 540 seriously ill older adults: effects of increasing age on clinical outcomes and survival. J Am Geriatr Soc, 2014 Jan;62(1):1-9. doi: 10.1111/jgs.12597. Epub 2014 Jan 9.
14. Damuth E, Mitchell JA, Bartock JL, Roberts BW, Trzeciak S. Long- term survival of critically ill patients treated with prolonged mechanical ventilation: a systemic review and metanalysis. Lancet Respir Med, 2015 Jul;3(7):544-53. doi: 10.1016/S2213-2600(15)00150-2. Epub 2015 May 20.
15. Penuelas O, Frutos- Vivar F, Fernandez C, et al. Characteristics and outcomes of ventilated patients according to time to liberation from mechanical ventilation. Am J Respir Crit Care Med, 2011 Aug 15;184(4):430-437. doi: 10.1164/rccm.201011-1887OC.
16. Freeman BD. Tracheostomy update: when and how. Crit Care Clin. 2017 Apr;33(2): 311–322. doi: 10.1016/j.ccc.2016.12.007.
17. Klotz R, Probst P, Deininger M, et al. Percutaneous versus surgical strategy for tracheostomy: a systematic review and meta-analysis of perioperative and postoperative complications. Langenbecks Arch Surg, 2018 Mar;403(2):137-149. doi: 10.1007/s00423-017-1648-8. Epub 2017 Dec 27.
18. Long SM, Chern A, Feit NZ, et al. Percutaneous and open tracheostomy in patients with COVID-19: comparison and outcomes of an institutional series in New York City. Ann Surg, 2021 Mar 1;273(3):403-409. doi: 10.1097/SLA.0000000000004428.
19. McCredie VA, Alali AS, Scales DC, et al. Effect of early versus late tracheostomy or prolonged intubation in critically ill patients with acute brain injury: a systematic review and meta-analysis. Neurocrit Care, 2017 Feb 26(1):14–25. doi: 10.1007/s12028-016-0297-z.
20. McGrath BA, Brenner MJ, Warrillow SJ, et al. Tracheostomy in the COVID- 19 era: global and multidisciplinary guidance. Lancet Respir Med, 2020 Jul;8(7):717-725. doi: 10.1016/S2213-2600(20)30230-7. Epub 2020 May 15.

Correspondence:
Received: 7 February 2023
Accepted: 13 March 2023
Chrisoula Marinaki, MSc, PhD (c)
ICU Nurse, General Hospital of Piraeus "Tzaneio"
Address: 10 Ionos Dragoumi, 18757 Athens, Greece
Phone: 00306949418972
E-mail: xmarinakh@yahoo.gr
ORCID: 0000-0003-2668-8133