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Tracheostomy in patients with SARS-CoV-2 reduces time on mechanical ventilation but not intensive care unit stay

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ABSTRACT

Cross-sectional study to know if tracheostomy influences the time on mechanical ventilation and reduces the ICU stay in patients with SARS-CoV2. From February 14 to May 31, 2020, 29 patients: 23 men and 6 women, with an average age (SD) of 66.4 years (±6,2) required tracheostomy. The average intensive care unit (ICU) stay was 36 days [31–56.5]. The average days on mechanical ventilation was 28,5 days (±9.7). Mean time to tracheostomy was 15.2 days (±9.5) with an average disconnection time after procedure of 11.3 days (±7.4). The average hospital stay was 55 days [39–79]. A directly proportional relation between the number of days of MV and the number of days from ICU admission until tracheostomy showed a significant value of $p = 0.008$. For each day of delay in tracheostomy, the days of mechanical ventilation were increased by 0.6 days. There was no relation between days to tracheostomy and days to disconnection ($p = 0.092$). PaO_2 / FiO_2 (PAFI) before tracheostomy and Simplified Acute Physiology Score III (SAPS III) at admission presented a statistical relation with mortality, with an OR of 1.683 (95%CI; 0.926–2.351; $p = 0.078$) and an OR of 1.312 (CI95%: 1.011–1.703; $p = 0.034$) respectively. The length of stay in the ICU until the tracheostomy was not related to the risk of death ($p = 0.682$). PEEP and PaO_2/FiO_2 (PAFI) at admission and before tracheostomy and APACHE II, SAPS III and SOFA at admission did not show influence over time on MV. We conclude that the delay in tracheostomy increase the days on mechanical ventilation but does not influence stay or mortality.

1. Introduction

Coronavirus pneumonia was already described in the Severe Acute Respiratory Syndrome (SARS-CoV) in 2003 and in the Middle East Respiratory Syndrome (MERS-CoV) in 2012 [1]. A novel coronavirus, 2019-nCoV, was the causal agent of pneumonia reported in December 2019 in Wuhan, China [2].

The SARS-CoV2 infection spread rapidly to Europe, being diagnosed in Spain for the first time in a critically ill patient in our Centre in February 2020.

Currently we know that 8.3% of patients with SARS-CoV-2 pneumonia require mechanical ventilation (MV) [3] and that the mortality of critically ill patients is between 22% and 62% [4,5].

Tracheostomy is the most frequent surgical procedure performed in COVID-19 patients.

Indication of early or late tracheostomy is still under debate [6] and more in these patients where early tracheostomy increases the risk of infection due to the associated viral load. The median tracheostomy time after the onset of adult respiratory distress syndrome (ARDS) is 14 days [7]. Most studies agree that timing of the tracheostomy does not influence the duration of MV [8]. Early tracheostomy does not prevent ventilator-associated pneumonia (VAP) either [9,10], although it is associated with a lower sedation requirement [11]. Performing an early tracheostomy in a critical patient (before 10 days of MV), seems to reduce the risk of mortality and increase the probability of discharge from the ICU on day 28 [12].

Some hematologic and biochemical markers [13,14], respiratory factors [15] and severity and prognosis scales have been related to the severity of the disease in patients with SARS CoV-2, which may influence the appearance of intraoperative and postoperative complications,

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the time on MV and ultimately mortality.

The objective of the study was to know if performing tracheostomies in COVID-19 patients influences the time on mechanical ventilation and reduces the ICU stay. Analytical and respiratory variables and complications related with the procedure that could influence disconnection were also analyzed.

2. Methods

All patients admitted to ICU with SARS CoV-2 who required a tracheostomy from March 19th to April 30th, 2020 were selected and followed up to 3 months after inclusion of the last patient.

The authors declare that they have complied with the requirements established by the Helsinki Declaration for Human Research of 1974 (last modified in 2000). This study has the approval of the institutional review board and the ethics referral committee.

The inclusion criteria were age >18 years, SARS-CoV-2 diagnosis, MV, indication of tracheotomy and informed consent for tracheotomy authorized by family members.

2.1. Procedure and data study

The procedures were performed in a purpose-converted operating theatre inside the ICU (Fig. 1). Total Intravenous Anesthesia (TIVA) and deep muscle relaxation were delivered by senior anesthesiologists.

All tracheostomies were performed by an experienced team following the tracheostomy protocol for patients with COVID-19 [16,17,18].

The following variables were collected: sex, age, date of ICU admission, date of tracheostomy, date of the first disconnection of MV, ICU and hospital discharge date, PEEP and PaO2/FiO2 (PAFI) at admission and before tracheostomy, APACHE II, SAPS III and SOFA at admission. 28 days after admission, a cut-off was made in the study to assess patients on MV and mortality.

2.2. Statistical analysis

SPSS 21.0® package for Windows (IBM Corp. Released 2012. IBM SPSS Statistics for Windows, Version 21.0. Armonk, NY: IBM Corp) was used.

Patient characteristics were analyzed using frequencies and percentages for qualitative variables and using means and standard deviation or medians and interquartile ranges for quantitative variables. The comparative of the predictive factors was carried out by means of the Chi-square test with Fisher's corrections for qualitative variables and bivariate analysis by means of paired *t*-test or Wilcoxon test for quantitative variables with confidence intervals of 95% (95% CI). ANCOVA covariance analysis was carried out by correlating the number of days of intubation with the number of days of MV and the number of days from ICU admission until tracheostomy. Statistical results were estimated for those who reported a value of $P < 0.05$.

3. Results

29 patients, 23 men and 6 women, with an average age (SD) of 66.4 years (±6,2) required tracheostomy. The clinical and analytical characteristics, respiratory condition, and severity score of tracheostomized patients are shown in Table 1. Data by patient are shown in Table 2 and represented in Fig. 2.

3.1. Mechanical ventilation

The average delay for tracheostomy was 15.2 days (±9.5) with an average disconnection time after procedure of 11.3 days (±7.4). The average time on MV was 28.5 days (±9.7). The average ICU stay was 36 days [31–56.5]. The average hospital stay was 55 days [39–79]. 28 days immediately after admission 11 patients (37.9%) remained on MV. At the end of the follow-up, 19 patients (34,48%) remained connected.

A directly proportional relation between the number of days of MV and the number of days from ICU admission until tracheostomy showed a significant value of $p = 0.008$. These results indicate that, for each day of delay in tracheostomy, the days of MV were increased by 0.6 days (Fig. 3). There was no relation between days to tracheostomy and days to disconnection ($p = 0.092$). PEEP and PaO2/FiO2 (PAFI) at admission and before tracheostomy and APACHE II, SAPS III and SOFA at admission did not show influence over time on MV.

3.2. Mortality

9 patients (31.3%) died during their stay in the ICU. The median survival of deceased patient was 31 days [IQR 20.5–58.5] These patients were discarded for the calculation of days on MV. The 28-day crude

Fig. 1. Performing surgical tracheostomy in a COVID 19 patient with a Personal Protective Equipment (PPE) in a purpose-converted operating theatre inside the ICU.

Table 1
Clinical characteristics, severity score and respiratory condition of tracheostomized COVID-19 patients.

Descriptive		
Sex	Male, n (%)	23 (79.3)
	Female, n (%)	6 (20.7)
Age (years), mean (SD)		66.4 (6.2)
Smoker	No, n (%)	27 (93.1)
	Yes, n (%)	2 (6.9)
Height (cms), mean (SD)		172.0 (7.9)
Weight (Kg), mean (SD)		82.4 (9.8)
Reason for admission	Hospitalization, n (%)	23 (79.3)
	Emergencies, n (%)	5 (17.2)
	Transfer, n (%)	1 (3.4)
Pathological antecedents		
Hypertension	n (%)	17 (58.6)
Diabetes Mellitus	n (%)	6 (20.7)
Obesity (BMI>30)	n (%)	8 (27.6)
Cardiopathy	n (%)	5 (17.2)
COPD	n (%)	2 (6.9)
Immunosupression	n (%)	2 (6.9)
Autoimmunity	n (%)	4 (13.8)
Liver disease	n (%)	2 (6.9)
Broncopathy	n (%)	4 (13.8)
Primary hypercoagulability	n (%)	1 (3.4)
Another comorbilities	Lung cancer, n (%)	1 (3.4)
	Corticoids, n (%)	2 (6.9)
Severity scores at admission		
APACHE II score, mean (SD)		13.9 (3.2)
SAPS III score, mean (SD)		55.9 (4.9)
SOFA score, mean (SD)		4.5 (1.8)
Respiratory condition		
PEEP at OTI, mean (SD)		12.4 (2.1)
PEEP at tracheostomy, mean (SD)		9.4 (2.3)
PAFI at OTI, median [IR]		113 [97.5–180.5]
PAFI at tracheostomy, median [IR]		200 [152–240]

BMI = Body Mass Index; ICU = Intensive Care Unit; SOFA = Sequential-related Organ Failure Assessment score; APACHE II = Acute Physiology and Chronic Health Evaluation II; PAFI = ratio of the partial pressure of oxygen in arterial blood (PaO2) to the inspired oxygen fraction (FiO2); OTI = Orotracheal Intubation; IU = International Units; U = Units; SD = Standard Deviation; IR = Interquartile Range.

mortality was 17.2% (5 cases) and 24 patients (82.7%) were still alive. 50% of those who died (10 patients) did so before the 28th. The length of stay in the ICU until the tracheostomy was not related to the risk of death ($p = 0.682$). PaO_2/FiO_2 (PAFI) before tracheostomy and SAPS III score at admission showed influence on mortality with an OR of 1.683 (95% CI; 0.926–2.351; $p = 0.078$) and an OR of 1.312 (CI95%: 1.011–1.703; $p = 0.034$) respectively.

4. Discussion

83 patients of the 1050 hospitalized patients with SARS CoV-2 required intensive care (79%). In our center 29 tracheotomies were performed out of a total of 83 patients with SARS CoV-2 admitted to the ICU (34,94%). This percentage contrasts with that described in another study with a non-COVID critical patient population (8–24%) [6]. This increase in the percentage of tracheostomized patients may be due to the occupation of the ICU by a homogeneous population (100% of patients with bilateral pneumonia) that required prolonged intubation and post-tracheostomy MV.

4.1. Mechanical ventilation

Analyzing the MV time of critically ill patients without coronavirus disease we find studies with a greater number of cases due to the inclusion of non-respiratory patients.

In the 2004 Rumbak study [19] with 122 patients, time on MV ranges from 7.6 to 17.4 days. The duration of MV in patients that received tracheostomy was significantly longer than that in those that did not (21.5 vs 7 days) in the international study of non-COVID patients by Abe et al. [20]. In the 2013 TracMan Randomized Trial [11] with 622 tracheotomies, patients received respiratory support between 13.6 and 15.2 days. In our study, the average time in MV was longer (28.5 days), showing the ventilatory requirements of the patients with SARS CoV-2.

4.2. ICU stay

Terragni et al. [21] in their randomized study with 419 tracheostomized patients reported an ICU stay that ranged from 31 to 32 days. In our study, the average ICU stay was similar, 36 days [31–56.5]. The length of ICU and hospital stay was also longer in the Abe et al. [20] study in patients that received tracheostomy (11 vs 8 days and 24 vs 14 days respectively). Making a cut-off at 28 days after admission to ICU, Terragni et al. [21] reported a successful weaning in 68–77% of the cases. In our COVID-19 tracheostomized patients' cohort, 28 days immediately after ICU admission, we registered a slightly lower value, 62.1%.

The average delay for tracheostomy in our study was 15.2 days, within the range of days recommended by the Spanish Consensus Document on tracheotomy in patients with COVID-19 infection indicating tracheostomy from the 14th day of intubation [22].

For Shiba et al. [23], tracheostomy in COVID-19 patients should be delayed until the diagnostic test is performed and should be an extremely rare procedure, as disseminated interstitial pneumonia progresses or resolves in a brief period, ignoring the benefits of tracheostomy. The study of Mattioli et al. [24], from April 2020, shows its 2-week experience of 28 tracheostomies in COVID-19 patients and recommend the completion of the tracheostomy between days 7 and 14, which could accelerate the discharge from the ICU. In our study, the tracheostomy timing did not influence ICU stay.

4.3. Mortality

Terragni et al. [21] observed a survival at 28 day ranged from 68 to 74%. In our study, survival at 28 day was greater and 24 patients (82.7%) were still alive. Scales et al. [25], in their retrospective cohort study with 10,927 tracheostomies, concluded that global mortality ranges between 63.9 and 67.2% and that each additional delay of 1 day was associated with increased. In our study, mortality of tracheostomized COVID patients was lower (31,3%) within the defined range in critical patients with COVID-19 (22–62%) [14,15]. From these data it can be inferred that tracheostomized patients were selected from survivors 15 days after admission and that the decision to perform a tracheostomy was reserved for patients with a better prognosis, despite the fact that tracheostomy did not result in a reduction in the time of disconnection as suggested by other authors [26] and that delay in tracheostomy did not influence mortality.

Overall mortality at discharge in the Tracman study [11], with 69% patients with pulmonary disease, was 41% and the mortality of tracheostomized patients ranged between 6.3% and 7.8%. In our study with tracheostomized COVID-19 patients, all with pulmonary involvement, mortality was much higher since 31.3% died during their stay in the ICU.

The strength of the study is that it describes a unique population at a critical time that is unlikely to repeat itself in such an abrupt way which provides a unique insight. It has been possible to quantify the influence of the tracheostomy on the total time of mechanical ventilation and to demonstrate that although the tracheostomy reduces the time on mechanical ventilation, it does not reduce the stay in the ICU. Therefore, according to our criteria, it cannot be considered a procedure to be carried out quickly to reduce the occupation of the ICU. Data collected in this period could be compared with data from a similar non-COVID population in subsequent studies.

Table 2
Database: Respiratory characteristics and chronology of tracheostomized COVID-19 patients. PEEP_int; PEEP_7 day; PAFI_INT; PAFI_7day; PAFI_trach.

N	Sex	Age	PEEPint	PEEP7 day	PEEPtrach	PAFI int	PAFI7 day	PAFItrach	SOFA	APACHE	SAPS III	TRACH DAY	Days on MV	ICU stay (days)	Exitus day
1	M	65	14	16	14	130	250	190	3	16	53	21	42	55	
2	M	77	12	12	12	466	190	133	3	15	57	18		22	22
3	F	67	12	12	10	82	160	220	3	18	62	17	19	33	
4	M	63	12	16	8	71	210	250	2	12	55	18	39	43	
5	M	69	12	12	7	113	189	150	6	13	57	15	21	31	31
6	M	53	16	14	12	53	180	212	7	10	49	15	25	31	
7	M	69	12	8	5	100	210	250	4	14	50	10	12	59	
8	F	70	16	13	12	113	191	280	6	14	59	15		19	19
9	M	72	14	10	8	100	315	256	3	18	58	23	42	86	
10	M	60	14	14	12	181	154	202	3	10	52	20	27	45	
11	M	69	14	12	10	225	200	150	7	16	55	18		22	22
12	F	67	14	13	7	132	128	190	3	14	52	18	30	42	
13	M	57	13	10	10	100	200	250	3	9	49	7	32	39	
14	M	63	12	10	10	101	145	142	4	11	55	7		15	15
15	M	69	12	5	6	100	190	260	3	11	55	8	12	29	
16	F	64	16	10	8	80	100	240	3	11	52	15	24	34	
17	M	61	12	10	7	140	186	160	3	10	55	17	29	32	
18	M	63	12	10	10	156	228	154	6	12	52	16	39	103	
19	F	68	10	10	8	111	180	216	6	12	57	16	23	36	36
20	M	66	12	6	6	200	136	204	3	12	55	9		104	104
21	M	62	15	10	10	95	92	190	4	11	53	21	39	48	
22	M	69	12	11	8	240	194	184	3	13	53	19	24	33	
23	M	74	10	10	10	174	290	200	6	18	57	11	16	19	
24	M	67	10	12	10	195	156	210	5	19	56	11	27	40	
25	M	78	10	12	10	51	215	200	3	14	57	18	26	33	
26	F	75	13	10	12	63	176	100	7	15	62	22	35	57	
27	M	52	12	10	12	208	78	140	7	17	73	19		81	81
28	M	70	12	12	8	150	300	240	7	22	63	17		36	36
29	M	69	6	6	12	180	117	130	8	17	58	6	46	52	

PEEP = Positive end-expiratory pressure; PEEP int: PEEP at intubation, PEEP 7 day: PEEP at 7th day, PEEP Trach: PEEP at tracheostomy, PAFI = ratio of the partial pressure of oxygen in arterial blood (PaO2) to the inspired oxygen fraction (FiO2); PAFI int: PAFI at intubation, PAFI 7 day: PAFI at 7th day, PAFI trach: PAFI before tracheostomy, SOFA = Sequential-related Organ Failure Assessment score; APACHE II = Acute Physiology and Chronic Health Evaluation II; SAPS III = Acute Physiology Score III at admision; TRACH DAY = tracheostomy day, DAYS IN MV = Days on mechanical ventilation, ICU STAY (days) = Intensive Care Unit stay (days).

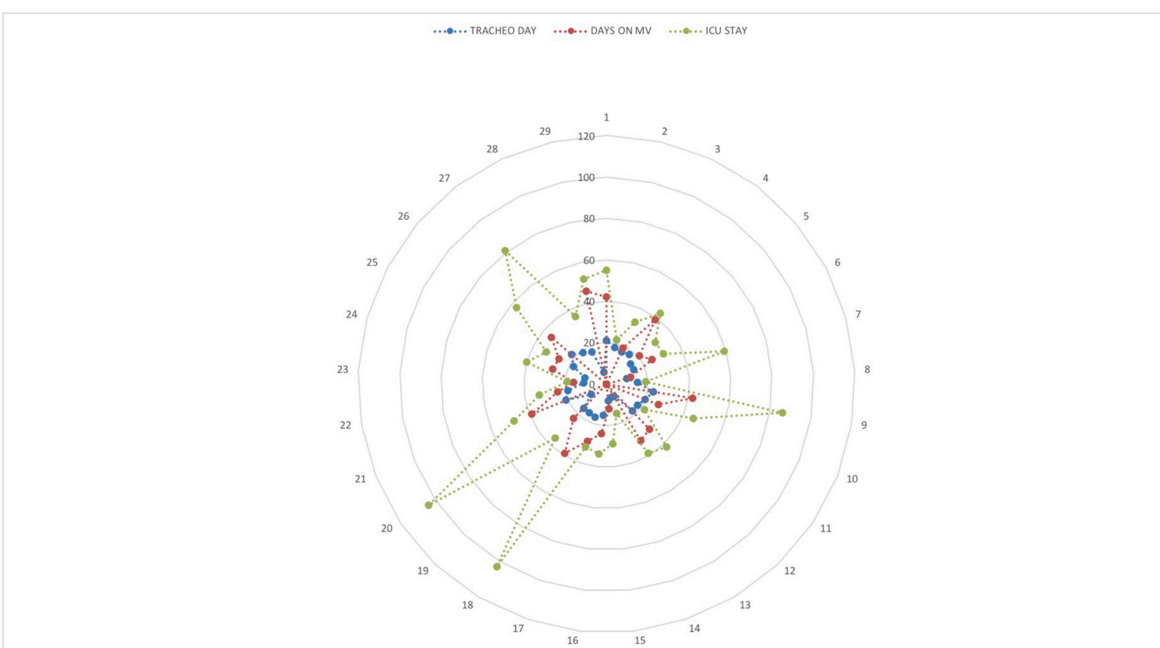

Fig. 2. Graphic representation of the delay in performing the tracheostomy (blue), days on mechanical ventilation (red) and stay in the ICU of COVID-19 patients (green). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

5. Conclusions

The mean time on mechanical ventilation in COVID patients is longer than in other critically ill patients who require ventilatory support. Some severity scores variables influence mortality of tracheostomized patients with SARS-CoV-2. Tracheostomy in patients with SARS-CoV-2 reduces the total mechanical ventilation time but does not influence the final intensive unit care stay.

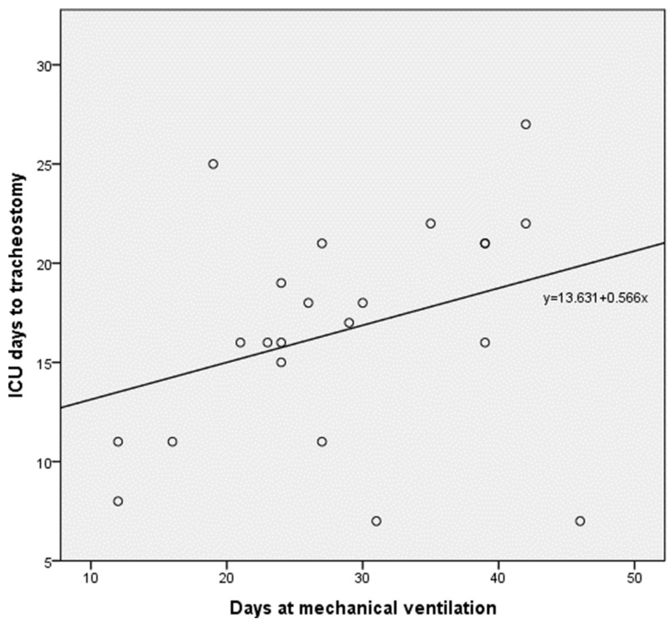

Fig. 3. Scatterplot between days on mechanical ventilation and ICU days to tracheostomy. Bilateral correlation ($p < 0.001$).

CRediT authorship contribution statement

N. Mata-Castro designed the study and wrote the main paper; N. Mata-Castro, L. Sanz López and P. Pinacho Martínez et al. performed surgeries at the centre in Spain; P. Pinacho Martínez, L. Sanz López and MC Martín Delgado collected and analyzed data from the centre; N. Mata-Castro and D. Varillas provided statistical analysis and critical revision. M. Miró Murillo and MC. Martín Delgado provided final revision. All authors discussed the results and implications and commented on the manuscript at all stages.

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