



The Efficacy of Tracheotomy for Covid-19 Pneumonia: Impacts on Survival and Prognostic Factors

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Received: 2 June 2021 / Accepted: 27 June 2021
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Abstract The role of tracheotomy during the pandemic remains to be determined for severe COVID-19 pneumonia. We evaluated the effect of tracheotomy on prognostic markers and assessed 4 weeks survival in terms of clinical and biochemical characteristics of patients and time and type (open or percutaneous) of the operation. We performed a retrospective study considering ICU patients with COVID-19 pneumonia and tracheotomy, between May 30 and December 31, 2020. Four weeks survival postoperatively and alteration of biochemical markers were analyzed. 24 patients with COVID-19 pneumonia and tracheotomy, included in this study. Median age was 68.3 years (range 38–90) with male:female ratio 16:8. All the patients were diagnosed with COVID-19 pneumonia considering clinical symptoms and COVID-19 specific CT findings. RT-PCR test results were positive in 58.3%. Prognostic markers were found to be increased postoperatively with both types of surgery (75%). 1 week and 4 weeks survival after the operation was 66.7% and 45.8%, respectively. 4 weeks survival was decreased significantly with $NLR \geq 10$ compared to $NLR < 10$ (15.3–81.8%). Nevertheless, 4 weeks survival differences between males and females (12.5% and 62.5%) and between age ≤ 50 and > 50 (100% and 35%) were also found to be statistically significant. Patients with younger age, male gender, and $NLR < 10$, were found to have longer survival after tracheotomy. Positive PCR results and preoperative

critically increased biochemical markers were related to decreased survival. The number of comorbidities, time and type of surgery, and postoperative increment of prognostic markers seemed not to affect survival.

Keywords Covid-19 · Tracheotomy · Biochemical markers · Prognostic markers · Survival

Introduction

Coronavirus disease 2019 (COVID-19) is a respiratory illness caused by a novel coronavirus (SARS-CoV-2). It was first described in Wuhan, China in December 2019 and has now been declared a global pandemic by the World Health Organization. About 5% of patients present severe ARDS and require admission to the intensive care unit (ICU) [1]. Critically ill patients have a high likelihood (42%) of needing prolonged intubation and invasive mechanical ventilation (IMV) and may subsequently require a tracheotomy [2].

The role of tracheotomy during the pandemic remains to be determined [3]. There is no evidence that tracheotomy, either percutaneous (PT) or surgical (ST), improves a patient's clinical course, and there is not enough experience about its impact on a survival of patients with severe COVID-19 pneumonia.

In this study, we evaluated the values of preoperative ferritin, C-reactive protein (CRP), D-dimer, neutrophil-lymphocyte ratio (NLR), and the effect of the operation on these values. We compared survival rates and duration of intensive care unit (ICU) stay in terms of time and type of tracheotomy surgery, clinical characteristics of patients, and alteration of prognostic markers pre and postoperatively.

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Methods

We conducted a retrospective analysis of clinical records of all patients consulted to otorhinolaryngology (ORL) clinics for surgical tracheotomy because of prolonged intubation (more than 14 days) in ICU between May 01, 2020, and December 31, 2020. Patients were included in the study according to the following criteria:

Inclusion criteria: any age and any sex, diagnosis of COVID-19 pneumonia by the joint decision of a radiologist, an infection specialist, and a pulmonologist, application of RT-PCR test, treatment consisting in IMV and subsequent tracheotomy, follow up period until death or at least four weeks, whichever comes first.

Exclusion criteria: patients without COVID-19 pneumonia, insufficient laboratory data within ten days pre and postoperatively, death or extubation before planned tracheotomy operation.

24 patients are included in the study. Survival data up to four weeks and total ICU days are recorded, comparison between PT and ST is performed. Preoperative NLR and median ferritin, CRP, D-dimer values within ten days before and after tracheotomy operation are recorded. Changing processes of these prognostic markers postoperatively are evaluated.

Preoperative critical alteration limit for ferritin, CRP, and D-dimer levels are assumed as ferritin ≥ 1000 , CRP ≥ 100 , D-Dimer ≥ 2 , respectively. Two groups are created according to the number of altered biochemical markers, effects on the survival and duration of ICU stay are evaluated.

Group A: 0–1 of the biochemical markers altered critically in the preoperative period.

Group B: at least 2 biochemical markers altered critically in the preoperative period.

PT was performed with a bedside approach inside the ICU room by an anesthetist with personal protective equipment (PPE). ST was performed in a negative pressure operating room by an experienced ORL surgeon with PPE, under general anesthesia.

Effects of tracheotomy operation on biochemical markers were evaluated. Two groups were created according to the number of increased biochemical markers postoperatively and effects on the survival and duration of ICU stay were evaluated.

Group 1: 0–1 of the biochemical markers increased postoperatively (considering the preoperative values).

Group 2: at least 2 biochemical markers increased postoperatively (considering the preoperative values).

Statistical analysis: Categorical variables were presented as percentages. Continuous variables were summarized as mean \pm standard deviation or median and range. Comparisons between groups were performed by Pearson's chi-squared test or Fischer's exact test for discrete variables, as appropriate. Statistical significance was presented as a p-value, with observed differences considered statistically significant at a $p \leq 0.05$. IRB approval: This research was conducted in accordance with ethical principles, including the World Medical Association Declaration of Helsinki (2002). This study was approved by our Institutional Ethics Committee, Bursa City Hospital, Bursa, Turkey (Approval reference number, 2021–1/3, 2021 January 06).

Results

There were 72 patients consulted to ENT surgeons for elective tracheotomy between May 1 and December 31, 2020. Ten patients deceased before the operation. 38 patients with tracheotomy were excluded from the study because of the absence of COVID-19 pneumonia considering thoracic computed tomography (CT) and clinical findings.

24 patients met the inclusion criteria and were included in the analysis. The median age was 68.3 years (range 38–90); male to female ratio was 16 to 8. Patients were diagnosed with COVID-19 pneumonia -considering CT findings with bilateral (95.8%) or unilateral (4.1%) ground-glass opacities-by the joint decision of a radiologist, an infection specialist, and a pulmonologist. All the patients were applied nasopharyngeal swab RT-PCR tests either before or during the ICU period and test results were positive in 58.3%. We recorded comorbidities including the cardiovascular system, hypertension (HT), diabetes mellitus (DM), central nervous system, renal system, and oncology. Past medical history was relevant for ≥ 3 comorbidities in 25% of patients.

Just before the tracheotomy operation, NLR was between 1.8 and 37.6, median 14.9. It was higher than 3 in 87.5% and higher than 10 in 54.1% of patients. Preoperative median ferritin, CRP, and D-Dimer levels were 838.9 (180 and 2000), 89 (17–240), and 3.03 (0.3–6.2), respectively. Levels of the preoperative biochemical markers; ferritin, CRP, D-Dimer and NLR are listed in Table 1.

Postoperatively, at least 2 of the prognostic markers were found to be increased in 75% of the patients, compared to preoperative values and the difference between PT and ST was statistically insignificant ($p > 0.05$). Comparison is listed on Table 2.

Patients underwent elective tracheotomy; 19 of which were applied ST in a few days after the consultation, while 5 patients underwent PT because of the prolonged

Table 1 Levels of the biochemical markers preoperatively; ferritin, CRP, D-dimer and NLR

Ferritin \leq 400 29.1%	D-dimer \leq 1 8.3%
400 < ferritin < 1000 45.8%	1 < D-dimer < 2 20.8%
1000 \leq ferritin 25%	2 \leq D-dimer 66.6%
CRP \leq 50 20.8%	NLR \leq 3 12.5%
50 < CRP < 100 45.8%	3 < NLR < 10 33.3%
100 \leq CRP 33.3%	10 \leq NLR 54.1%

Table 2 Postoperative biochemical alterations and comparisons between types of surgery ($p = 0.568$)

	Group 1 (n = 6)	Group 2 (n = 18)
Surgical tracheotomy (n = 19)	16.7%	62.5%
Percutaneous tracheotomy (n = 5)	8.3%	12.5%
Total (n = 24)	25%	75%

Group 1: 0–1 of the biochemical markers increased postoperatively (considering the preoperative values)

Group 2: at least 2 biochemical markers increased postoperatively (considering the preoperative values)

preparation process for surgery. No conversion from PT to ST was required. One week survival after the operation was 66.7% (63.1% with ST and 80% with PT; $p > 0.05$) and four weeks survival was 45.8% (42.1% with ST and 60% with PT; $p > 0.05$).

Patients' median stay in ICU was 48.4 days (min 18 days- max 140 days) and 83.3% was less than 60 days (80% with PT and 78.9% with ST; $p > 0.05$). ICU stay less than 60 days was 25% with age \leq 50 and 95% with age $>$ 50, in terms of age the difference was statistically significant, and patients younger than 50 were found to stay longer in the ICU ($p \leq 0.05$). Also, patients with lower NLR were found to stay longer in ICU (less than 60 days was 63.6% and 100%, with NLR $<$ 10 and NLR \geq 10, respectively) and the difference was statistically significant ($p \leq 0.05$). In terms of gender, the preoperative value of prognostic markers, time and type of surgery, comorbidities, and PCR results, the differences in duration of ICU stay were found to be statistically insignificant ($p > 0.05$).

Survival in 1 week and 4 weeks were found to be decreased in patients with NLR $>$ 10, and the differences were statistically significant ($p \leq 0.05$). Nevertheless, 4 weeks survival was decreased in female patients and patients with age $>$ 50 ($p \leq 0.05$). The results are listed in Tables 3, 4, and 5.

Discussion

Most humans infected with COVID-19 will have a mild illness but approximately 15% will become severely ill and require oxygen therapy and approximately 5% will require admission to an ICU [1]. Approximately 42% of critically ill patients require IMV with a higher mortality rate [4].

The role of tracheotomy in affected patients is still hazy: few data are reported about the indications, timing, clinical results, and percentage of complications. However there are no current guidelines regarding the optimal time of tracheostomy in COVID-19 patients but most of the European countries following local policy of 14 days before performing tracheostomy [5, 6]. The American Academy of Otolaryngology: Head and Neck Surgery has recommended a multidisciplinary approach in determining indications for tracheotomy in patients with COVID-19. In addition to the necessity of donning appropriate PPE, they recommend not performing tracheotomy until 2–3 weeks postintubation, and repeat COVID-19 PCR testing is negative [7]. However, a negative result does not exclude the possibility of COVID-19 [8, 9] and all the procedures should be performed with a minimal number of care providers and minimal duration of the procedure. In our hospital, we perform tracheotomy to patients with COVID-19 pneumonia, at least 14–21 days after intubation and 2 negative tests within one week before surgery is preferred. Likewise, we perform all our tracheotomy operations in a negative pressure operation room with PPE during this pandemic, and none of our surgeons who participated in the operations was infected within 2 weeks after tracheotomy.

In general, compared with the prolonged endotracheal intubation, a tracheotomy may offer several advantages such as avoiding injury to the larynx and trachea, improving patient comfort, lower airway resistance, smaller dead space, less movement of the tube within the trachea, more efficient suction, ability to oral feeding and communication and facilitating nursing care and decreasing the incidence of ventilator-associated pneumonia [3]. But critically ill patients with COVID-19 pneumonia may differ in some ways. Early experience suggests that patients with COVID-19 produce relatively little mucus and secretions in relation to other causes of respiratory failure. For these reasons, tracheotomy appears less critical for the pulmonary toilet for patients with COVID-19 [10]. Despite concern for airway stenosis due to prolonged intubation, recent data suggests early tracheotomy may be less crucial and the safety issues around the pandemic outweigh the risks of late airway stenosis [11]. Sommer et al, recommended that tracheotomy should not be routinely considered in any endotracheally intubated patient with COVID-19 until the patient has been determined to be cleared of the

Table 3 1 week and 4 weeks survival of patients and duration of ICU days in terms of PCR results and alteration of prognostic biochemical markers

	PCR		NLR		Preoperative prognostic values		Postoperative prognostic values	
	Negative	Positive	< 10	≥ 10	Group A	Group B	Group 1	Group 2
ICU stay ≤ 60 days (n = 20)	80%	85.7%	63.6%	100%	92.8%	70%	66.6%	88.8%
	$p = 1$		$p = \mathbf{0.031}$		$p = 0.272$		$p = 0.252$	
1 week survival (n = 16)	90%	50%	90.9%	46.1%	71.4%	60%	83.3%	61.1%
	$p = 0.079$		$p = \mathbf{0.033}$		$p = 0.673$		$p = 0.621$	
4 weeks survival (n = 11)	50%	42.8%	81.8%	15.3%	57.1%	30%	66.6%	38.8%
	$p = 1$		$p = \mathbf{0.004}$		$p = 0.240$		$p = 0.357$	

Group A: 0–1 of the biochemical markers altered critically in the preoperative period

Group B: at least 2 biochemical markers altered critically in the preoperative period

Group 1: 0–1 of the biochemical markers increased postoperatively (considering the preoperative values)

Group 2: at least 2 biochemical markers increased postoperatively (considering the preoperative values)

Table 4 1 week and 4 weeks survival of patients and duration of ICU days in terms of clinical characteristics

	Age		Gender		Comorbidities	
	≤ 50	> 50	Female	Male	< 3	≥ 3
ICU stay ≤ 60 days (n = 20)	25%	95%	87.5%	81.2%	83.3%	83.3%
	$p = \mathbf{0.008}$		$p = 1$		$p = 1$	
1 week survival (n = 16)	100%	60%	50%	75%	66.6%	66.6%
	$p = 0.262$		$p = 0.363$		$p = 1$	
4 weeks survival (n = 11)	100%	35%	12.5%	62.5%	38.8%	66.6%
	$p = \mathbf{0.031}$		$p = \mathbf{0.033}$		$p = 0.357$	

Table 5 1 week and 4 weeks survival of patients and total ICU days in terms of time and type of surgery

	Preoperative intubation time		Type of tracheotomy	
	≤ 21d	> 21d	Percutaneous	Surgical
ICU stay ≤ 60 days (n = 20)	90.9%	76.9%	80%	78.9%
	$p = 0.596$		$p = 1$	
1 week survival (n = 16)	72.7%	61.5%	80%	63.1%
	$p = 0.679$		$p = 0.631$	
4 weeks survival (n = 11)	45.4%	46.1%	60%	42.1%
	$p = 1$		$p = 0.630$	

COVID-19 virus and isolation precautions have been discontinued, although the endotracheal tube is insufficient to provide an adequate airway [12].

In China, the reported case fatality rate in critically ill patients with COVID-19 has been reported as approximately 50% and occurred within 28 days of ICU admission [2]. We found 1 week and 4 weeks of survival 66.7% and 45.8%, respectively, with our severely ill patients with COVID-19 pneumonia.

It is unclear, whether ST or PT produces fewer aerosolized viral particles. Each procedure should be permitted until more data is available. Cecilia Botti and her colleagues published a series of 44 tracheotomized patients with severe ARDS due to COVID-19 and they reported that the risk of death was not associated with timing or type of tracheotomy. Their median time from orotracheal intubation to surgery was 7 (range 2–17) days. They found the median duration of ICU stay was 22 days (range 10–67)

and fifteen (34.1%) patients died during the follow-up period (median 22 days, range 8–68) after the intubation [4]. Our median stay in ICU was 53.4 days (min 25 days–max 140 days), with a median of 60.8 days with PT and 49.3 days with ST. ORL surgeons in our institution are generally requested for tracheotomy after 14 days of intubation. We performed ST with a median of 23.8 days (range 13–44 days) and PT with a median of 28.6 days (range 17–55 days) of intubation, this may be the reason for our longer duration of ICU stay. PT was performed on the patients whose preparation process for general anesthesia and ST was prolonged. 4 weeks survival was 42.1% with ST and 60% with PT. Survival is found to be decreased with ST compared to PT and this may be the possible adverse effect of general anesthesia on the progress of illness, but the difference was not statistically significant ($p > 0.05$). In terms of the operation time, 4 weeks survival was 45.4% and 46.1%, with preoperative intubation time ≤ 21 or > 21 days, respectively. The time of surgery seems not to be related to postoperative survival or duration of ICU stay in our patients.

In the preoperative period, there was no significant difference in the number of comorbidities between patients with PT or ST, but hypertension was found more with the ST group. The number of comorbidities, RT-PCR results, preoperative or postoperative biochemical markers' alteration seemed not to affect the duration of ICU stay or survival significantly ($p > 0.05$).

Younger patients and male gender were found to have longer stay in ICU and longer survival in our study, these were statistically significant ($p \leq 0.05$). Positive PCR results and preoperative critically increased biochemical markers (ferritin levels higher than 1000 and CRP levels higher than 100) were related to decreased survival but these were statistically insignificant ($p > 0.05$). CRP and ferritin values tended to increase postoperatively with both types of surgery. The number of patients with increased and decreased D-dimer values was close to each other. Postoperative increment of prognostic markers was not found to be related to survival ($p > 0.05$). An increase of the investigated markers after an operative intervention was not surprising and the results confirm that the increase (when comparing an increase of 0–1 to at least 2 markers) did not have a significant impact on survival.

Some limitations can be found in this report. Once, this is a preliminary report as this was a single-center study with a small sample size because we only included the patients with severe COVID-19 pneumonia if they had been consulted to ORL surgeons for tracheotomy. Second, as this is a retrospective study, biochemical tests were studied with irregular intervals. Third, a large number of patients made the first admission to the hospital in the advanced period of the disease, for this reason we also

included the patients with negative RT-PCR tests, and diagnosis of COVID-19 pneumonia was made by the joint decision of a radiologist, an infection specialist, and a pulmonologist in patients with specific clinical symptoms and specific CT features for COVID-19 pneumonia [13].

Conclusion

Young age, male gender, and patients with NLR < 10 was found to have longer survival after tracheotomy in our study and they were found statistically significant. Positive PCR results and preoperative critically increased biochemical markers (ferritin levels higher than 1000 ml/ng and CRP mg/lt levels higher than 100 mg/lt) were related to decreased survival. The number of comorbidities, time and type of surgery, and postoperative increment of prognostic markers seemed not to affect total ICU stay or survival.

In hospitals where medical equipment and experienced healthcare professionals are not sufficient, it may become more important to decide which patient will undergo tracheotomy as a priority.

Funding Not applicable.

Data Availability Data available on request from the authors.

Declarations

Conflicts of interest The authors declare that they have no conflict of interest.

Ethical Approval This research has been conducted in accordance with ethical principles, including the World Medical Association Declaration of Helsinki (2002). This study was approved by our Institutional Ethics Committee, Bursa City Hospital, Bursa, Turkey “Approval reference number, 2021–1/3, 2021 January 06”.

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