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ORIGINAL RESEARCH

Tracheotomy in COVID-19 patients: A retrospective study on complications and timing

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Abstract

Objectives: The aim of this study was to analyze the timing of tracheotomy and the duration of mechanical ventilation and stay in the intensive care unit (ICU) in patients with COVID-19 infection. Furthermore, we aimed to investigate tracheotomy complications and mortality.

Methods: Consecutive patients with COVID-19 infection admitted to the Department of Infectious Diseases in Gothenburg, Sweden were identified. Medical records were retrieved and retrospectively assessed.

Results: One hundred eighty-eight patients with COVID-19 infection requiring hospital care were identified. Of these, 116 patients were critically ill and intubated, and 55 patients underwent tracheotomy. The mean time from endotracheal intubation to tracheotomy was 12 days (range 5-28 days). There was a correlation between the timing of tracheotomy and the duration of mechanical ventilation, where a shorter time between intubation and tracheotomy was correlated with a shorter duration of mechanical ventilation (r .58, $P < .001$), and a correlation was identified between the timing of tracheotomy and the duration of ICU stay (r .52, $P < .001$). Perioperative hypoxemia was registered in 9% of tracheotomies performed, whereas postoperative bleeding was observed in 27% of cases, the majority of which were minor.

Conclusions: This retrospective cohort study indicates that early tracheotomy is related to a reduced need for mechanical ventilation and a shorter duration of stay in the ICU in severe cases of COVID-19 disease. Complications during and after tracheotomy in this specific cohort included risk perioperative hypoxia and postoperative bleeding. Prospective randomized controlled trials would be of value to confirm these findings.

Level of Evidence: 4, Case series.

KEYWORDS
coronavirus, COVID-19, intensive care unit, pandemic, tracheotomy

1 | BACKGROUND

The onset of the COVID-19 pandemic has resulted in an increase in patients with severe acute respiratory distress syndrome (ARDS) in intensive care units (ICUs) worldwide.[1-3] Tracheotomy is often performed to facilitate the process of weaning from mechanical ventilation, reducing sedation in patients in need of prolonged mechanical ventilation.[4,5] Another reason for this surgical procedure is to minimize the risk of oropharyngeal and laryngeal harm caused by the endotracheal tube.[6] There has been a debate on when to perform tracheotomy and whether early or late tracheotomy is better for patients. Previous studies on tracheotomy timing indicate that early tracheotomy is advantageous in terms of a shorter time on mechanical ventilation; however, previous trials are based on heterogeneous groups of patients in the ICU, including trauma patients, neurosurgical patients and patients with chronic heart and lung diseases.[7-9]

With COVID-19, a new dimension has been added to the debate on tracheotomy timing, given that tracheotomy can be an aerosol-generating procedure with a risk of spreading infection to involved health care workers. Caution and late tracheotomy were initially advocated by professionals in otorhinolaryngology to avoid exposure to high viral load during surgery.[10,11] However, increasing evidence now suggests that the risk to the surgical team is very low if protective measures are thoroughly implemented.[12-14]

Another aspect of tracheotomy procedures in COVID-19 patients is the potential risk of bleeding given the nature of the disease with coagulopathy, thrombosis and with frequent corresponding high doses of anticoagulants, which raises questions on risks and complications to surgery.[15-18] To our knowledge, data on tracheotomy in COVID-19 in relation to complications and timing are scarce.

Therefore, the aim of this study was to analyze critically ill patients with COVID-19 infection with respect to the timing of tracheotomy and the duration of mechanical ventilation and stay in the ICU. Furthermore, we aimed to analyze complications related to tracheotomy in COVID-19 patients and the overall mortality.

2 | MATERIALS AND METHODS

Consecutive patients with confirmed COVID-19 infection admitted to the Department of Infectious Diseases at the Sahlgrenska University Hospital, Gothenburg, Sweden between the seventh of March and the fifth of June 2020 were identified. During this time period, this department was the only department in the area responsible for admission of COVID-19 patients. Medical records were retrieved and retrospectively assessed with respect to patient characteristics, age, sex, BMI, and comorbidities. Patients requiring mechanical ventilation and intubation or tracheotomy in the ICU were further assessed. Medical records were surveyed for data on mechanical ventilation and length of stay in the ICU. Moreover, information regarding tracheotomy and complications of surgery was collected, including perioperative and postoperative complications, such as stoma infection, stoma bleeding, airway bleeding, intraoperative desaturation/hypoxemia, tracheotomy tube dislocation, and subcutaneous emphysema.The primary endpoints were duration of mechanical ventilation and length of stay in the ICU. Secondary endpoints were complications to the tracheotomy surgery and the overall mortality rate.

Inclusion criteria:

- confirmed COVID-19 infection
- ICU-stay
- need for mechanical ventilation and endotracheal intubation

2.1 | Tracheotomy procedure

During the study period, a COVID-19 tracheotomy procedure checklist was developed for surgical tracheotomy. Concerning percutaneous tracheotomies, no specific COVID-19 alterations were made. Surgical or percutaneous technique was used based on local routines, competence, and capacity and varied over time. All surgical tracheotomies were performed by two otolaryngologists in an operating room. All involved staff were equipped with approved filter masks and face shields. Before incision of the trachea, a time-out was performed to go through the checklist to assess the following steps:

1. Preoxygenation of the patient.
2. The endotracheal tube was placed distally in the trachea to avoid puncture of the cuff during incision.
3. Control of the tracheotomy tube dimension and cuff function.
4. Preparation of ventilation tubing and connections between the tracheotomy tube and the ventilator.
5. Removal of endotracheal tube fixations.
6. Review of steps and measures in case of tracheotomy tube cuff leakage.
7. Tracheal incision during end-expiratory apnea.
8. Mechanical ventilation was reactivated when the airway circuit connected to the inflated tracheotomy tube.
9. Complete removal of the endotracheal tube just before completion of the surgery, when tracheotomy tube position is confirmed by the surgeon.

Regarding suturing the cannula, suturing of the outer flange of the tracheal cannula has not previously been the standard procedure at our clinic, and there was an apprehension that suturing could amount to false security and that in a situation of cannula obstruction would delay removal of the cannula. However, our guidelines have been updated and now include suturing in COVID-19 tracheotomies.

2.2 | Percutaneous tracheotomy procedure

Percutaneous tracheotomy was performed using a dilatational technique (Seldinger technique) including the following steps

1. The patient was placed in supine position with the neck extended to facilitate identification of the following anatomical landmarks: notch of the thyroid cartilage, cricoid cartilage and sternal fossa.
2. A small horizontal skin incision was made below the cricoid cartilage. Blunt dissection with a dissection tool was performed down to the level of the trachea.
3. Deflation and slow withdrawal of the endotracheal tube was performed during apnea.
4. Under the surveillance of a bronchoscope through the endotracheal tube, an introducer needle was inserted into the anterior wall of the trachea.
5. A guide wire was then inserted through the introducer needle. Next, a tracheal dilatator was inserted, and progressive dilatation was performed before insertion of the endotracheal cannula.

2.3 | Anticoagulant treatment regimen

For anticoagulants, the majority of patients were treated with low-molecular-weight heparin (LMWH), typically Fragmin administered subcutaneously, according to the following dosage: for patients <50 kg: 2500 IU two times per day; for patients 50 to 90 kg: 5000 IU two times per day; and for patients >90 kg: 75 IU/kg two times per day.

3 | STATISTICAL METHODS

For categorical variables, n (%) is presented. For continuous variables, the mean (SD)/median (Min; Max)/n = is presented. For comparisons between groups, Fisher's exact test (lowest one-sided *P*-value multiplied by 2) was used for dichotomous variables, the Chi-square test was used for nonordered categorical variables, and the Mann-Whitney *U* test was used for continuous variables. The confidence interval for the mean difference between groups was based on the Fisher nonparametric permutation test. Correlation analysis was performed using Spearman correlation coefficients.

4 | ETHICS

The study was approved by the Swedish Ethical Review Authority (Dnr 2020-02372) and was performed in accordance with the Declaration of Helsinki.

5 | RESULTS

During the specified time period, 188 patients with confirmed COVID-19 infection were admitted to the Department of Infectious Diseases. Of these, 116 patients were critically ill and required endotracheal intubation and mechanical ventilation at the various ICUs within the region. One patient was excluded from analysis after being transported to an out-of-region hospital from which medical records could not be obtained.

Eighty-two percent of patients were male, the vast majority (86%) were overweight (BMI >25), and 43% were obese (BMI >30). Hypertension and diabetes were the most common comorbidities. No significant differences were found with respect to age, sex, BMI, or comorbidities between patients requiring mechanical ventilation with or without subsequent performance of a tracheotomy (Table 1). The overall mortality rate was 20% (Table 2).

5.1 | Tracheotomy

Fifty-five patients underwent tracheotomy. Surgical tracheotomy was performed in 40 cases, and percutaneous tracheotomy was performed in 15 cases. The indication for tracheotomy was an expected long-term need for mechanical ventilation in all cases. The mean time from endotracheal intubation to tracheotomy was 12 days, whereas the overall mean duration of mechanical ventilation was 25 days (Table 3).

Portex size 8 (Cuffed Blue Line Ultra Suctionaid, Smiths Medical) was the most commonly used tracheotomy tube type. A UniPerc adjustable tracheotomy tube (UniPerc Adjustable Flange Extended-Length Tracheostomy Tubes, Smiths Medical) was used in a few cases (n = 5) where the patient's anatomy was complicated, necessitating a longer tracheotomy tube. Outer flange sutures to anchor the tracheotomy tube were used in 75% of surgical tracheotomy procedures and in only n = 1 (5%) of the percutaneous tracheotomies.

5.2 | Tracheotomy complications

In total, perioperative complications were observed in 17% of tracheotomy procedures. The most common perioperative complications were desaturation and hypoxemia (9%). Notably, this was not documented in any of the percutaneous tracheotomy procedures.

Postoperative bleeding was seen in 31% of cases. Superficial bleeding from the tracheotomy stoma represented the vast majority of bleeding problems (Table 4). Deeper bleeding affecting the airway was seen in 7% (n = 4) of all tracheotomy cases. Out of these four cases, three occurred following percutaneous tracheotomy. One patient presented with hoarseness and a granuloma of the larynx after decannulation. In another case, tracheotomy tube dislocation occurred after the outer flange sutures had been removed and the patient was awake and planned for decannulation.

Overall, there were no statistically significant differences between the open surgical and percutaneous tracheotomy procedures with respect to complications (Table 4).

5.3 | Correlation analysis

There was a positive correlation between the timing of tracheotomy and the duration of mechanical ventilation, where a shorter time between intubation and tracheotomy was correlated with a shorter duration of mechanical ventilation (r = .58, P < .001). Likewise, the

TABLE 1 Patient characteristics and comorbidities in COVID-19 patients requiring endotracheal intubation with or without subsequent tracheotomy

	All patients (n = 115)	Endotracheal intubation only (n = 60)	Tracheotomy (n = 55)	*P*-value
Age mean (min-max)	58.2 (21; 84) n = 115	57.6 (21; 84) n = 60	58.7 (29; 81) n = 55	.67
Female	21 (18%)	11 (18%)	10 (18%)	
Male	94 (82%)	49 (82%)	45 (82%)	1.00
BMI mean (min-max)	30.5 (19.7; 54.2) n = 94	30.4 (19.7; 54.2) n = 51	30.7 (20.2; 51.5) n = 43	.94
BMI ≤25	15 (16.0%)	7 (13.7%)	8 (18.6%)	
BMI 26-30	39 (41.5%)	22 (43.1%)	17 (39.5%)	
BMI >30	40 (42.6%)	22 (43.1%)	18 (41.9%)	.82
Comorbidity				
Chronic heart failure	12 (11.5%)	6 (12.0%)	6 (11.1%)	1.00
Chronic pulmonary failure	8 (7.7%)	4 (8.0%)	4 (7.4%)	1.00
Renal-kidney failure	1 (1.0%)	1 (2.0%)	0 (0.0%)	.96
Diabetes	24 (23.1%)	15 (30.0%)	9 (16.7%)	.17
Hypertension	48 (46.2%)	21 (42.0%)	27 (50.0%)	.54

Abbreviation: BMI, body mass index (kg/m^2).

TABLE 2 Data on days from onset of symptoms to ICU care, duration of mechanical ventilation and indications for intubation in COVID-19 patients requiring endotracheal intubation with or without subsequent tracheotomy

	All patients (n = 115)	Endotracheal intubation only (n = 60)	Tracheotomy (n = 55)	*P*-value
Days from onset of symptoms to ICU care Mean (SD) median (min-max)	10.7 (4.8) 10 (2; 30)	10.8 (5.0) 10 (3; 30)	10.7 (4.7) 10 (2; 30)	.87
Duration mechanical ventilation (days) Mean (SD) median (min-max)	16.5 (13.0) 12 (3; 92)	8.43 (3.89) 8 (3; 21)	25.2 (13.9) 21 (8; 92)	<.0001
Indication intubation				
Desaturation	111 (96.5%)	56 (93.3%)	55 (100.0%)	.14
Fatigue	24 (41.4%)	14 (42.4%)	10 (40.0%)	1.00
Mortality	23 (20.0%)	16 (26.7%)	7 (12.7%)	.10

Abbreviation: ICU, intensive care unit.

timing of tracheotomy and the duration of ICU stay were correlated (r = .52, P < .001), and a shorter time between intubation and tracheotomy was correlated with a shorter duration of ICU stay, as shown in Table 5. No significant correlations were found between BMI and complications in surgery, comorbidity or mortality with respect to complications to surgery. There was no significant correlation between BMI and duration of mechanical ventilation or ICU stay.

6 | DISCUSSION

In this retrospective cohort study on patients with severe ARDS due to COVID-19 infection, we identified a significant correlation between early tracheotomy and a shorter duration of mechanical ventilation, as well as a shorter ICU stay. These findings are well in line with a recently published prospective study on tracheotomy in COVID-19 by Avilés-Jurado et al.[19]

Furthermore, bleeding after surgery was observed in almost one-third of cases, with the majority being superficial bleeding from the tracheostoma.

6.1 | Patients

The patient characteristics in this study cohort were similar to those in other study populations of COVID-19 patients requiring ICU care with respect to age, comorbidities, and obesity when compared to reports from national and international databases and larger case series. However, the proportion of female patients was lower than that in other studies, that is, 18% of women compared to approximately 30% of women in other studies.[20-22] The overall mortality of patients with COVID-19 in need of ICU care was 20% in this study. Patients who were intubated but not in need of tracheotomy can be further divided into two groups consisting of those who were either too sick to undergo surgery or

TABLE 3 Data on days from endotracheal intubation to tracheotomy, days in mechanical ventilation after tracheotomy, duration of mechanical ventilation, BMI and comorbidity in surgical or percutaneous tracheotomies in COVID-19 patients

	All patients (n = 55)	Surgical tracheotomy (n = 40)	Percutaneous tracheotomy (n = 15)	Mean difference (95% CI)
Days from endotracheal intubation to tracheotomy Mean (SD) median (min-max)	12.2 (4.6) 12 (5; 28)	12.8 (5.0) 12.5 (5; 28)	10.8 (3.1) 10 (5; 17)	1.95 (−0.82; 4.72)
Days in mechanical ventilation after tracheotomy Mean (SD) median (min-max)	12.7 (12.7) 9 (1; 80)	12.3 (9.0) 9.5 (1; 35)	13.8 (19.7) 8 (1; 80)	−1.48 (−12.67; 9.72)
Duration mechanical ventilation (days) Mean (SD) median (min-max)	25.2 (13.9) 21 (8; 92)	25.4 (10.9) 23.5 (8; 49)	24.7 (20.2) 19 (10; 92)	0.758 (−10.833; 12.349)
BMI kg/m^2 Mean (SD) median (min-max)	30.7 (7.2) 28.7 (20.2; 51.5) n = 43	31.4 (7.7) 29.8 (20.2; 51.5) n = 33	28.2 (4.5) 27.2 (21.7; 36.7) n = 10	3.18 (−2.01; 8.36)
Comorbidity[a] Any comorbidity n (%)	33 (60%) n = 55	25 (63%) n = 40	8 (53%) n = 15	NA

[a]Any of the following comorbidities; diabetes, hypertension, chronic heart or lung failure, or, renal-kidney failure.

TABLE 4 Tracheotomy tube size, type, and complications to surgery in surgical and percutaneous tracheotomies in COVID-19 patients

	Total (n = 55)	Surgical tracheotomy (n = 40)	Percutaneous tracheotomy (n = 15)	*P*-value
Tracheotomy tube size and type				
Portex[a] 7	2 (3.8%)	0 (0.0%)	2 (16.7%)	
Portex 8	28 (53.8%)	21 (52.5%)	7 (58.3%)	
Portex 9	15 (28.8%)	14 (35.0%)	1 (8.3%)	
Uniperc adjustable[b] 8	3 (5.8%)	3 (7.5%)	0 (0.0%)	
Uniperc adjustable 9	2 (3.8%)	2 (5.0%)	0 (0.0%)	
Other	2 (3.8%)	0 (0.0%)	2 (16.7%)	
Tracheotomy tube suture[c]	31 (58%)	30 (75%)	1 (5%)	
Perioperative complications total	9 (16.7%)	8 (20.5%)	1 (6.7%)	.43
Bleeding	1 (1.9%)	0 (0.0%)	1 (6.7%)	.53
Desaturation/Hypoxemia	5 (9.3%)	5 (12.8%)	0 (0.0%)	.39
Cuff failure/leakage	1 (1.9%)	1 (2.6%)	0 (0.0%)	1.00
Tracheotomy tube dislocation	1 (1.9%)	1 (2.6%)	0 (0.0%)	1.00
Postoperative complications total	23 (41.8%)	18 (45%)	5 (33.3%)	.64
Bleeding	15 (27.3%)	11 (27.5%)	4 (26.7%)	.75
Superficial bleeding	13 (23.6%)	11 (27.5%)	2 (13.3%)	
Deep bleeding/airway	4 (7.3%)	1 (2.5%)	3 (20%)	.075
Stoma infection	1 (1.8%)	1 (2.5%)	0 (0.0%)	1.00
Tracheotomy tube dislocation	3 (5.5%)	3 (7.5%)	0 (0.0%)	.98
Tracheotomy tube obstruction	3 (5.5%)	3 (7.5%)	0 (0.0%)	.98
Cuff failure/leakage	3 (5.5%)	3 (7.5%)	0 (0.0%)	.98

[a]Portex (Cuffed Blue Line Ultra Suctionaid, Smiths Medical).
[b]UniPerc adjustable flange extended-length tracheostomy tubes, Smiths Medical.
[c]Outer flange suture to anchor the tracheotomy tube.

those who showed clear early signs of improvement, meaning that they never needed a tracheotomy. Consequently, this potential bias needs to be kept in mind when interpreting the mortality rates in the tracheotomy vs non-tracheotomy groups, where critically ill patients with poor prognosis are most likely overrepresented in the latter group.

6.2 | Timing

Tracheotomy was performed, on average, 12 days after endotracheal intubation. In concordance with our findings, others have contended that early tracheotomy in general has the benefits of earlier weaning from mechanical ventilation, reduced need for sedation, and

TABLE 5 Correlation analysis of the duration of mechanical ventilation and the duration of ICU stay related to the time between intubation and tracheotomy in COVID-19 patients

	Duration mechanical ventilation	Duration ICU stay
Time intubation to tracheotomy[a]	0.583	0.516
P-value	<.0001	<.0001
n	55	54

[a]Spearmen correlation coefficient.

consequently shorter duration of mechanical ventilation and ICU stay.[23] However, the definition of early tracheotomy varies widely, but tracheotomy within the first week of ICU care has been defined as early tracheotomy in several randomized studies.[24] Other proposed benefits of tracheotomy in patients requiring long-term mechanical ventilation are reduced risk of oropharyngeal and laryngeal damage, as well as increased comfort for the patient and facilitation of oral care.[6] Apart from these patient-related aspects, the COVID-19 pandemic has clearly shown that ICU resources are not unlimited; thus, a shorter duration of ICU stay and reduced consumption of sedative medication are important aspects to consider.

6.3 | Tracheotomy complications

Hypoxia or desaturation during surgery was the most commonly reported perioperative complication in this study. Five cases (9%) of desaturation during surgery were noted, which is a much higher proportion than in earlier studies.[25] The tracheal incision and subsequent insertion of the tracheotomy cannula were performed during apnea in all patients who underwent surgical tracheotomy in this study to minimize the risk of spreading the infection to the surgical team. This factor, together with the respiratory instability of COVID-19 ARDS patients, implies that the rate of perioperative desaturation is not very surprising. It is of course crucial that the time of apnea be kept as short as possible to avoid desaturation. Several papers discuss how patients can be assessed before tracheotomy to minimize the risk of severe desaturation.[26,27] For example, Stubington et al. (2020) suggested that patients with COVID-19 should be eligible for tracheotomy if they could sustain $FiO_2 \leq 50\%$ and PEEP ≤8 cm H_2O 24 hours before tracheotomy.[27] Other authors have suggested technical refinements to minimize the duration of apnea, including connecting the airway circuit to the tracheotomy tube in advance and incising the trachea above the endotracheal cuff during active mechanical ventilation.[28] Hypoxia perioperatively was not registered in any of the cases using the percutaneous technique. One explanation might be that there is a selection of patients with lower degree of comorbidities in the percutaneous tracheotomy group compared to a higher pulmonary risk situation and respiratory instability for the open surgery tracheotomy group.

After surgery, the most commonly observed complication of tracheotomy was bleeding problems and, above all, superficial bleeding from the edges of the skin of the stoma. These rates of postoperative bleeding are higher than those reported in earlier studies[18,25] and can at least partially be explained by the high doses of anticoagulants administered to patients with COVID-19 and ARDS. Additionally, in the literature, there is great discrepancy in the reporting of minor symptoms, largely depending on the study methodology; for example, studies using diagnosis codes from medical records can be assumed to underreport minor symptoms. More severe bleeding affecting the airway was observed in four patients. Of these, three were operated on using the percutaneous technique. Although these small numbers were not supported by statistical significance, this tendency for a higher risk of bleeding using the percutaneous technique was previously observed in larger study populations.[25] One explanation might be that in open surgical procedures, bleeding from deeper anatomical structures is revealed and treated perioperatively, whereas bleeding is more difficult to detect when using percutaneous technique.

6.4 | Study limitations

One limitation of this study is its retrospective design with subsequent collection of nonstandardized data from the medical records. Furthermore, the relatively small size of the study population prevents any far-reaching data analysis or conclusions.

7 | CONCLUSIONS

The results from this retrospective cohort study suggest that earlier tracheotomy is correlated with a reduced need for mechanical ventilation and a shorter duration of stay in the ICU in severe cases of COVID-19 disease. Moreover, complications from tracheotomy in this specific cohort included a risk of perioperative hypoxia and postoperative bleeding, where there was a tendency of deeper bleeding affecting the airway when a percutaneous tracheotomy was performed. The overall mortality for the whole study population was 20%. Prospective randomized controlled trials would be of value to confirm these findings.

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CONFLICTS OF INTEREST

None to declare.

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