Tracheostomy in 80 COVID-19 patients: a multicenter, retrospective, observational study

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Research Article

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Abstract

The aim of our study was to describe the clinical characteristics and outcomes of patients with confirmed severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) pneumonia who underwent elective tracheostomies. We investigated all COVID-19 patients who underwent elective tracheostomies in intensive care units (ICUs) of 23 hospitals in Hubei Province, China, from January 8, 2020 to March 25, 2020. Demographic information, clinical characteristics, treatment, details of the tracheostomy procedure, successful weaning after tracheostomy, and living status were collected and analyzed. A total of 80 patients were included. The median duration from endotracheal intubation to tracheostomy was 17.5 [IQR 11.3-27.0] days. Most tracheotomies were performed by ICU physicians (62 (77.5%)) and using percutaneous techniques (63 (78.8%)) at the ICU bedside (76 (95.0%)). At 60 days after intubation, 31 (38.8%) patients experienced successful weaning from the ventilator, 17 (21.2%) patients were discharged from the ICU, and 43 (53.8%) patients had died. Higher 60-day mortality (22 (73.3%) vs 21 (42.0%)) was identified in patients who underwent early tracheostomy. In patients with SARS-CoV-2 pneumonia, tracheostomies were feasible to conduct by ICU physicians at bedside with few major complications. However, tracheostomies within 14 days of endotracheal intubation should be avoided.

Introduction

The novel coronavirus disease 2019 (COVID-19), caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), has resulted in a worldwide pandemic and a large and increasing number of patients who are critically ill and require endotracheal intubation and mechanical ventilation[1-3]. Tracheostomy is a common procedure for critically ill patients who require long-term mechanical ventilation[4]. Compared with an orotracheal tube, a shorter tracheostomy tube that bypasses the mouth and pharynx can avoid oropharyngeal and laryngeal lesions, improve patient comfort and reduce sedative drug use[5]. In addition, a tracheostomy tube can provide less airway dead space and thus less work of breathing, facilitate weaning from mechanical ventilation, make airway suctioning much easier, and potentially reduce the incidence of ventilator-associated pneumonia[6].

In COVID-19 patients with requirements of prolonged ventilation, tracheostomy is one of the important clinical considerations for optimal management[7]. However, studies concerning tracheostomy in COVID-19 patients are scarce. In this study, we aim to describe the clinical characteristics of patients with confirmed SARS-CoV-2 pneumonia who underwent elective tracheostomies and to explore the association between the timing of tracheostomy and the outcomes of these patients.

Methods

Study design and patients

This multicenter, retrospective, observational study was conducted in Hubei Province, China. Patients treated in intensive care units (ICUs) of 23 hospitals from January 8, 2020 to March 25, 2020 were screened. All patients who were diagnosed with COVID-19 and underwent elective tracheostomies were included. COVID-19 was diagnosed according to the World Health Organization interim guidance[8]. This study was approved by the Ethics Committee of Union Hospital, and written informed consent was waived. All methods were carried out in accordance with relevant guidelines and regulations.

Data collection

Medical records of patients were reviewed, and data were collected by investigators at each ICU by using a standardized case-report form. Sociodemographic and clinical data were collected for all patients, including age, sex, chronic medical histories, vital signs, laboratory tests, acute physiology and chronic health evaluation II (APACHE II) scores and sequential organ failure assessment (SOFA) scores. We also collected details of the tracheostomy procedure, including timing, type (percutaneous or surgical), location, the clinicians performing the procedure, and complications. Whether successful weaning was achieved was also recorded, and successful weaning was defined as no need for mechanical ventilation for more than 48 hours at any time after tracheostomy. Treatment was recorded for the duration of hospitalization. The living status at 60 days after intubation was also recorded.

Statistical analysis

Normally distributed and non-normally distributed continuous variables are presented as the mean (SD) and median [IQR], respectively. Categorical variables are presented as numbers (%). Early tracheostomy was defined as tracheostomy within 14 days of intubation, and late tracheostomy was defined as tracheostomy after 14 days. The comparison between the two groups was conducted using Student's *t* test, Mann-Whitney U test or Fisher's exact test when appropriate. The Kaplan-Meier method was used to depict survival curves, and the log-rank test was used to compare the survival rates between the early tracheostomy group and the late tracheostomy group. Cox proportional hazards regression analysis was used to explore the hazard ratio (HR) of variables with a *p*-value less than 0.05 in univariate analysis. No imputation was made for missing data. A 2-tailed p-value < 0.05 was regarded as statistically significant. All statistical analyses were performed using the SPSS software system (vision 20.0, SPSS, Inc., Chicago, IL) and GraphPad Prism 5 software.

Results

From January 8 to March 25, 2020, a total of 80 patients from 23 hospitals in Hubei Province, China, were included in our study. Their mean (SD) age was 63.9 (14.0) years, and 61 (70.1%) were male. The median duration from intubation to tracheostomy was 17.5 [IQR 11.3-27.0] days. Sixty (69.0%) patients had chronic medical illnesses, and the most common illnesses were hypertension (40.0%), coronary heart disease (21.1%), diabetes (17.5%) and cerebrovascular disease (10.0%) (Table 1). Thirty (37.5%) patients received tracheostomies within 14 days after intubation, and their median duration between intubation and tracheostomy was significantly shorter than that of the late tracheostomy group (9.5 [IQR, 5.0-13.0] days vs 24.5 [IQR, 18.8-32.0] days, $p < 0.001$). Compared with patients in the early tracheostomy group, the patients in the late tracheostomy group had lower SOFA scores (5 [IQR 4-7] vs 6 [IQR 4-9], $p = 0.014$)

and APACHE II scores (11 [IQR 9, 17] vs 15 [IQR 11-21], $p = 0.034$) at ICU admission and lower APACHE II scores (13 (SD 4) vs 17 (SD 6), $p = 0.010$) before tracheostomy. Among all 80 patients, lymphocytopenia and hypoalbuminemia at hospital admission and hypoxemia at ICU admission were prominent (Table 2). However, no differences were identified between the two groups.

Most tracheotomies were performed by ICU physicians (62 (77.5%)) and using percutaneous techniques (63 (78.8%)) at the ICU bedside (76 (95.0%)). Powered air-purifying respirators (PAPRs) were used by operating teams in 68 (85.0%) tracheostomies (Table 3). Furthermore, neuromuscular blocking drugs were applied in 46 (57.5%) patients, which may help avoid coughing-induced viral aerosolization. The most common complication was tracheostoma bleeding, which occurred in 14 (17.5%) patients. Major bleeding occurred in 4 (5.0%) patients, who received transfusion of red blood cells. Other complications included subcutaneous emphysema (2.5%), tracheostoma infection (1.2%), and mediastinal emphysema (1.2%) (Table 3). No patients experienced cardiac arrest or tracheoesophageal fistula. No differences were identified between the early and late tracheostomy groups in terms of complications. For treatments, no differences were identified between the two groups, except extracorporeal membrane oxygenation (ECMO). Compared with early tracheostomy patients, more patients who underwent late tracheostomy received ECMO (19 (8.0%) vs 2 (6.7%), $p = 0.002$) (Table 4).

In the 80 COVID-19 patients who underwent elective tracheostomies, 43 (53.8%) patients had died at 60 days. Higher 60-day mortality (22 (73.3%) vs 21 (42.0%), $p = 0.007$) was identified in patients who underwent early tracheostomy (Figure 1). At 60 days after intubation, 31 (38.8%) patients experienced successful weaning from the ventilator, and 17 (21.2%) patients were discharged from the ICU. Because collinearity existed between the SOFA and APACHE II scores at ICU admission, only the SOFA score was incorporated into the Cox proportional hazards regression analysis. After adjusting for SOFA (HR 1.00 (95% CI, 0.91-1.11)) and ECMO (HR 1.06 (95% CI, 0.49-2.28)), late tracheostomy was identified with a decreased risk of death (HR 0.34 (95% CI, 0.17-0.70)).

Discussion

As the number of patients infected by SARS-CoV-2 around the world is increasing, the demand for endotracheal intubation and invasive mechanical ventilatory support secondary to acute respiratory failure is increasing accordingly[9, 10], which will certainly lead to an increase in tracheostomy in the following days[1]. Our study described the clinical characteristics and outcomes of COVID-19 patients who underwent tracheostomies, comprising 80 patients from 23 hospitals in Hubei Province, China. We found that tracheostomies were feasible to conduct by ICU physicians at bedside with few major complications, and compared with tracheostomies conducted after 14 days of intubation, tracheostomies within 14 days were associated with an increased mortality rate.

Most clinicians were concerned with the aerosol-generating risk while conducting tracheostomies in patients with COVID-19, so optimal management should be applied in the tracheostomy procedure to maintain the safety of operators[11]. In our study, most procedures were performed by ICU physicians using percutaneous techniques at bedside, which avoided the unnecessary transport of ventilated patients and repeated connection and disconnection of ventilatory circuits during transfer. Regarding the type of tracheostomy performance, some argued against percutaneous tracheostomy performed in COVID-19 patients because it usually involves opening the ventilator circuit more frequently than surgical tracheostomy, and serial dilations during the procedure may put surgeons in face of the airway from the beginning[12]. However, there is currently no evidence across the literature to advise which approach is less aerosol generating[13]. In addition to standard personal protective equipment (PPE), PAPR is beneficial in preventing contracting. Another important aspect is paralytics, which reduce cough and facilitate the procedure.

Timing for elective tracheostomy performance is always controversial. Outside the context of the COVID-19 pandemic, Rumbak and colleagues[14] reported that early tracheostomy was associated with a reduced mortality rate and incidence of pneumonia and shorter MV and ICU durations. However, Young and colleagues[15] found that there was no difference in 30-day mortality and 1- and 2-year survival or length of ICU stay between early and late groups. During the pandemic of COVID-19, it remains unclear whether early tracheostomy performance is beneficial to critically ill COVID-19 patients. Some guidelines[16-18] suggested that tracheostomy should be delayed until at least 14 days from endotracheal intubation because viral load in the upper and lower airway may be high in the early course of the infection in COVID-19 patients.

Our study presented evidence that, compared with tracheostomies conducted after 14 days of intubation, tracheostomies within 14 days were associated with an increased mortality rate. Univariate analysis showed that patients who underwent early tracheostomies had higher SOFA scores and APACHE II scores, and more of these patients received ECMO. However, after adjusting SOFA and ECMO, the timing of tracheostomy was the only variable significantly associated with mortality. Further studies are needed to explore the relationship between the timing of tracheostomy and mortality.

This study has several limitations. First, the sample size of our study was relatively small, which might cause bias and limit the reliability or generalizability of our results. Second, some patients were still hospitalized at the end of this study, so some clinical outcomes, such as length of ICU stay and hospital stay, were unavailable at the time of analysis. Third, due to its retrospective design, the lack of randomization for patients who underwent early and late tracheostomy may increase the possibility of confounding in the subsequent comparison. In future research, rigorous prospective randomized trials with large samples are needed to make the research results more accurate.

In conclusion, in patients with severe SARS-CoV-2 pneumonia, tracheostomies were feasible to conduct by ICU physicians at bedside with few major complications. However, tracheostomies within 14 days of endotracheal intubation should be avoided.

Declarations

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Author contributions

Y.T., Y.W., F.Z., X.Y., C.H., G.H., W.X., M.H., L.Z., A.C., Z.X., B.L., S.H., G.Z., X.F., X.Z., Y.Y., H.F., L.Y., B.W., Z.L., Y.P., Z.S., S.F., Y.O., J.X. and Xi.Z. collected the epidemiological and clinical data. Y.T., Y.W., and F.Z. summarized all the data. Y.T., Y.W., F.Z., X.Y., C.H., and G.H. drafted the manuscript. M.F., Z.Y., B.H., and Y.S. revised the final manuscript. All authors read and approved the final manuscript.

Data availability

The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare no competing interests.

Abbreviations

COVID-19: Coronavirus disease 2019; SARS-CoV-2: severe acute respiratory syndrome coronavirus 2; ICU: Intensive care unit; COPD: chronic obstructive pulmonary disease; SOFA: sequential organ failure assessment; APACHE: acute physiology and chronic health evaluation; ECMO: extracorporeal membrane oxygenation; PPE: Personal Protective Equipment; PAPRs: Powered air-purifying respirators

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Tables

Table 1. Demographic data and vital signs in 80 COVID-19 patients receiving early and late tracheostomies.

	Total (n = 80)	Early Tracheotomy (n = 30)	Late Tracheotomy (n = 50)	*P*-value
Male	55 (68.8%)	21 (70.0%)	34 (68.0%)	0.852
Age, years	63.9 (14.0)	66.5 (15.1)	62.3 (13.2)	0.194
Duration from intubation to tracheostomy, days	17.5 [11.3, 27.0]	9.5 [5.0, 13.0]	24.5 [18.8, 32.0]	<0.001
Chronic medical illness				
Hypertension	32 (40.0%)	12 (40.0%)	20 (40.0%)	1.000
Coronary heart disease	17 (21.2%)	3 (10.0%)	14 (28.0%)	0.057
Diabetes	14 (17.5%)	6 (20.0%)	8 (16.0%)	0.649
Cerebrovascular disease	8 (10.0%)	4 (13.3%)	4 (8.0%)	0.700
Dementia	5 (6.2%)	3 (10.0%)	2 (4.0%)	0.358
Chronic renal disease	4 (5.0%)	2 (6.7%)	2 (4.0%)	0.628
Chronic hepatic disease	4 (5.0%)	0 (0.0%)	4 (8.0%)	0.291
Cancer	3 (3.8%)	2 (6.7%)	1 (2.0%)	0.553
COPD	2 (2.5%)	0 (0.0%)	2 (4.0%)	0.525
At hospital admission				
Temperature, °C	36.7 [36.3, 37.2]	36.8 [36.4, 37.0]	36.5 [36.3, 37.3]	0.811
Heart rate, beats per minute	96 (18)	97 (20)	96 (18)	0.800
Respiratory rate	22 [19, 30]	22 [19, 30]	23 [19, 30]	0.731
Systolic blood pressure, mm Hg	133 [123,146]	132 [120, 146]	135 [123, 146]	0.827
Diastolic blood pressure, mm Hg	78 [70, 88]	77 [70, 90]	78 [67, 85]	0.365
At ICU admission				
Temperature, °C	36.8 [36.5, 37.2]	36.8 [36.5, 37.5]	36.7 [36.4, 37.2]	0.324
Heart rate, beats per minute	99(20)	102 (19)	98 (20)	0.334
Respiratory rate	25 [20, 32]	27 [20, 32]	25 [20, 32]	0.988
Systolic blood pressure, mm Hg	133 [121, 148]	136 [114, 155]	133 [123, 146]	0.769

Diastolic blood pressure, mm Hg	75 [65, 87]	76.5 [65, 88]	75 [65, 83]	0.754
SOFA score	5 [4, 7]	6 [4, 9]	5 [4, 7]	0.014
APACHE II score	12 [9, 18]	15 [11, 21]	11 [9, 17]	0.034
On the day before tracheostomy				
Temperature, °C	37 [36.6, 37.7]	36.8 [36.4, 37.7]	37 [36.7, 37.7]	0.260
Heart rate, beats per min	96 (20)	93 (26)	97 (16)	0.212
Respiratory rate	21 [19, 25]	22 [19, 25]	21 [20, 23]	0.595
Systolic blood pressure, mm Hg	129 (18)	129 (21)	129 (16)	0.949
Diastolic blood pressure, mm Hg	70 [61, 78]	69 [60, 78]	71 [62, 78]	0.835
SOFA score	7 [5, 10]	8 [6, 10]	7 [5, 9]	0.371
APACHE II score	15 (5)	17 (6)	13 (4)	0.010

Data were presented as mean (standard deviation), median [interquartile range] or count (%).

Abbreviations: COVID-19: coronavirus disease 2019; ICU: intensive care unit; COPD: chronic obstructive pulmonary disease; SOFA: sequential organ failure assessment; APACHE: acute physiology and chronic health evaluation.

Table 2. Laboratory tests in 80 COVID-19 patients receiving early and late tracheostomies.

	Normal Range	Total (n = 80)	Early Tracheotomy (n = 30)	Late Tracheotomy (n = 50)	*P*-value
At hospital admission					
White-cell count, ´ 10^9 /L	3.5-9.5	8.7 [6.2, 12.6]	9.5 [6.8, 11.4]	8.4 [5.7, 14.6]	0.518
Hemoglobin, g/L	130-175	124.0 [104.5, 136.0]	125.0 [103.5, 138.5]	124.0 [103.8, 136.0]	0.760
Platelet count, × 10^9 /L	125-350	154.5 [111.8, 204.8]	152.0 [101.5, 233.0]	157.0 [118.0, 200.5]	0.971
Neutrophil count, × 10^9 /L	1.8-6.3	7.8 [4.7, 11.9]	8.4 [6.1, 10.0]	7.4 [4.4, 14.3]	0.580
Lymphocyte count, × 10^9 /L	1.1-3.2	0.64 [0.42, 0.96]	0.60 [0.40, 0.93]	0.66 [0.43, 1.00]	0.435
Total bilirubin, μmol/L	0-26	15.3 [10.3, 22.4]	16.1 [10.3, 24.1]	15.0 [10.3, 20.6]	0.388
ALT, U/L	9-50	32.0 [21.0, 57.0]	29.0 [20.5, 60.0]	32.0 [22.0, 55.0]	0.683
AST, U/L	15-40	37.5 [24.0, 58.3]	38.0 [23.0, 63.5]	37.0 [27.7, 56.5]	0.852
Albumin concentration, g/L	40-55	32.0 (5.7)	31.5 (6.1)	32.2 (5.5)	0.588
Serum creatinine, μmol/L	57-111	72.1 [54.9, 92.0]	78.8 [55.5, 128.6]	70.7 [54.8, 84.4]	0.174
Blood urea nitrogen, mmol/L	3.6-9.5	7.1 [5.1, 9.9]	8.3 [5.3, 11.5]	6.7 [4.9, 9.4]	0.200
C-reactive protein, mg/L	0-5	73.2 [16.8, 115.5]	57.2 [15.0, 134.0]	76.1 [19.4, 111.5]	0.631
Procalcitonin, ng/mL	< 0.5	0.17 [0.08, 0.43]	0.29 [0.10, 0.78]	0.14 [0.08, 0.40]	0.075
At ICU admission					
PH	7.35-7.45	7.42 [7.36, 7.47]	7.42 [7.39, 7.47]	7.41 [7.34, 7.48]	0.737
PaO_2, mm Hg	83-108	68.4 [54.0, 97.0]	68.9 [57.6, 90.8]	66.0 [53.0, 108.0]	0.680
$PaCO_2$, mm Hg	35-48	37.0 [33.0, 48.3]	36.4 [32.2, 46.2]	41.0 [34.0, 49.0]	0.250

Ratio of PaO_2 to FiO_2, mm Hg	400-500	112.0 [72.7, 178.7]	108.5 [63.1, 178.8]	114.0 [75.0, 178.7]	0.552
On the day before tracheostomy					
PH	7.35-7.45	7.41(0.07)	7.41(0.07)	7.41(0.07)	0.671
PaO_2, mm Hg	83-108	88.5 [72.9, 113.5]	82.3 [67.0, 94.8]	91.5 [77.8, 131.3]	0.052
$PaCO_2$, mm Hg	35-48	49.2 (12.9)	51.7 (15.1)	47.8 (11.5)	0.226
Ratio of PaO_2 to FiO_2, mm Hg	400-500	183.0 [126.0, 268.3]	147.6 [93.0, 253.8]	214.5 [146.3, 279.8]	0.061

Data were presented as mean (standard deviation) or median [interquartile range].

Abbreviations: COVID-19: coronavirus disease 2019; ICU: intensive care unit; ALT: alanine aminotransferase; AST: aspartate aminotransferase; PaO_2: partial pressure of oxygen; $PaCO_2$: partial pressure of carbon dioxide; FiO_2: fraction of inspired oxygen.

Table 3. Details of the Tracheostomies in 80 COVID-19 patients.

	Total (n = 80)	Early Tracheotomy (n = 30)	Late Tracheotomy (n = 50)	*P*-value
Type of procedure				0.057
Surgical	17 (21.2%)	3 (10.0%)	14 (28.0%)	
Percutaneous	63 (78.8%)	27 (90.0%)	36 (72.0%)	
Location				0.291
Operating room	4 (5.0%)	0 (0.0%)	4 (8.0%)	
Bedside	76 (95.0%)	30 (100.0%)	46 (92.0%)	
Clinicians performing tracheostomy				0.028
ICU physicians only	62 (77.5%)	28 (93.3%)	34 (68.0%)	
Otolaryngologists only	10 (12.5%)	1 (3.3%)	9 (18.0%)	
Both	8 (10.0%)	1 (3.3%)	7 (14.0%)	
PAPRs	68 (85.0%)	24 (80.0%)	44 (88.0%)	0.518
Neuromuscular blocking drugs	46 (57.5%)	12 (40.0%)	34 (68.0%)	0.014
Complications	18 (22.5%)	5 (16.7%)	13 (26.0%)	0.333
Tracheostoma bleeding	14 (17.5%)	4 (13.3%)	10 (20.0%)	
Subcutaneous emphysema	2 (2.5%)	1 (3.3%)	1 (2.0%)	
Tracheostoma infection	1 (1.2%)	0 (0.0%)	1 (2.0%)	
Mediastinal emphysema	1 (1.2%)	0 (0.0%)	1 (2.0%)	

Data were presented as count (%).

Abbreviations: COVID-19: coronavirus disease 2019; ICU: intensive care unit; PAPRs: powered air-purifying respirator.

Table 4. Treatments in 80 COVID-19 patients receiving early and late tracheostomy.

	Total (n = 80)	Early Tracheotomy (n = 30)	Late Tracheotomy (n = 50)	*P*-value
Prone position ventilation	45 (56.2%)	15 (50.0%)	30 (60.0%)	0.383
ECMO	21 (26.2%)	2 (6.7%)	19 (38.0%)	0.002
Renal replacement therapy	37 (46.2%)	14 (46.7%)	23 (46.0%)	0.954
Vasoconstrictive agents	71 (88.8%)	26 (86.7%)	45 (90.0%)	0.927
Antiviral agents	62 (77.5%)	23 (76.7%)	39 (78.0%)	0.890
Antibacterial agents	87 (100.0%)	30 (100.0%)	50 (100.0%)	1.000
Antifungal agents	61 (76.2%)	21 (70.0%)	40 (80.0%)	0.309
Glucocorticoids	53 (66.2%)	20 (66.7%)	33 (66.0%)	0.951

Data were presented as count (%).

Abbreviation: COVID-19: coronavirus disease 2019; ECMO: extracorporeal membrane oxygenation.

Figures

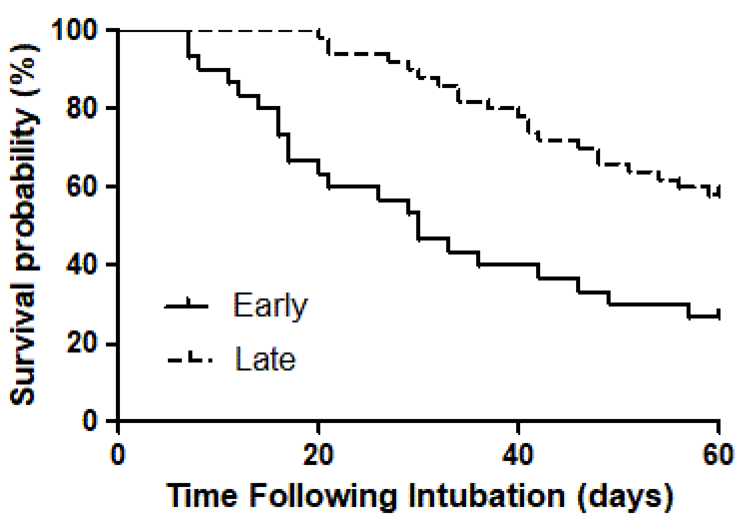

Figure 1

Kaplan–Meier analysis of survival in patients receiving early and late tracheostomies for 60 days (p log-rank test = 0.0003).