


# Surgical Tracheostomy Outcomes in COVID-19-Positive Patients

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 on behalf of the Chelwest COVID-19 AICU Consortium\*

## Abstract

**Objective.** The aim of this case series was to demonstrate that surgical tracheostomy can be undertaken safely in critically ill mechanically ventilated patients with coronavirus disease 2019 (COVID-19) and that it is an effective weaning tool.

**Study Design.** Retrospective case series.

**Setting.** Single academic teaching hospital in London.

**Methods.** All adult patients admitted to the adult intensive care unit (AICU), diagnosed with severe COVID-19 infection and requiring surgical tracheostomy between the March 10, 2020, and May 1, 2020, were included. Data collection focused upon patient demographics, AICU admission data, tracheostomy-specific data, and clinical outcomes.

**Results.** Twenty patients with COVID-19 underwent surgical tracheostomy. The main indication for tracheostomy was to assist in respiratory weaning. Patients had undergone mechanical ventilation for a median of 16.5 days prior to surgical tracheostomy. Tracheostomy remained in situ for a median of 12.5 days. Sixty percent of patients were decannulated at the end of the data collection period. There were no serious immediate or short-term complications. Surgical tracheostomy facilitated significant reduction in intravenous sedation at 48 hours after tracheostomy formation. There was no confirmed COVID-19 infection or reported sickness in the operating surgical or anesthetic teams.

**Conclusion.** Surgical tracheostomy has been demonstrated to be an effective weaning tool in patients with severe COVID-19 infection.

## Keywords

surgical tracheostomy, COVID-19, outcomes

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As of May 26, 2020, the coronavirus disease 2019 (COVID-19) pandemic had resulted in 6,515,796 confirmed cases and 387,298 deaths across 215

countries.<sup>1</sup> Early experiences from Italy suggested that approximately 30% of all patients with COVID-19 would require hospital admission and 4% would require critical care treatment.<sup>2</sup> Data from a large US observational study showed that 14% of patients admitted to the hospital required admission to the adult intensive care unit (AICU), and 86% of those required invasive mechanical ventilation (IMV).<sup>3</sup> Latest UK data suggest that 69.8% of patients admitted to the AICU required advanced respiratory support, for a median of 9 days (interquartile range [IQR], 5–15).<sup>4</sup> Furthermore, around 10% of patients admitted to the AICU will require prolonged IMV for over 14 days, and in these patients, tracheostomy should be considered.<sup>5</sup>

The principal indication for tracheostomy in patients with COVID-19 is to assist in respiratory weaning in patients who have undergone (or are anticipated to undergo) prolonged IMV.<sup>5</sup> Tracheostomy is also indicated in patients who have failed (or are anticipated to fail) tracheal extubation or in the presence of laryngeal edema.<sup>5</sup> Tracheostomy can reduce the risk of ventilator-associated pneumonia and duration of sedation.<sup>6,7</sup> There are 2 main tracheostomy techniques—surgical tracheostomy (ST) and percutaneous tracheostomy (PT), with no significant difference in the rate of major complications between the two (in non-COVID patients).<sup>8</sup> During the initial peak of the COVID-19 pandemic in the spring 2020, critical care bed occupancy at our hospital increased by 69%, overwhelming the critical care bed, ventilator, and staffing capacity. To facilitate safe and efficient reallocation of resources, an exclusively surgeon-delivered standardized open tracheostomy service has been

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established at our hospital to liberate procedural responsibility from the limited number of critical care physicians.

Since the emergence of the COVID-19 pandemic, multiple guidelines have been released addressing the relative safety of tracheostomy procedures. The primary concern is that tracheostomy is an aerosol-generating procedure that potentially exposes staff to an increased risk of COVID-19 transmission and should ideally be performed in patients with COVID-19 with reduced viral load (2 negative COVID-19 tests 48 hours apart).<sup>9</sup> Several guidelines have suggested performing tracheostomy in patients who have had IMV for over 21 days.<sup>9</sup> To date, only 1 publication has presented short-term outcomes of a modified PT technique in patients with COVID-19.<sup>10</sup> Another short communication suggested that there was no difference between ST and PT in the rate of COVID-19 staff infection; however, no clinical outcome data have been presented to allow for adequate assessment of the evidence.<sup>11</sup> Furthermore, there are no published data regarding the outcomes of tracheostomy performed in patients with severe adult respiratory distress syndrome (SARS) during the coronavirus outbreak in 2003.

The aim of this case series was to demonstrate, by analyzing patient-specific outcomes, that a standardized ST can be undertaken safely in the COVID-19 critically ill mechanically ventilated population and that it is an effective weaning tool.

## Methods

### *Study Design and Participants*

This retrospective case series was conducted at a single center in London. All adult patients (18 years and older) admitted to the AICU, diagnosed with severe COVID-19 infection, and requiring surgical tracheostomy between March 10, 2020, and May 1, 2020, were included in this case series. Surgical tracheostomy was performed as part of the patients' routine AICU treatment on the basis of clinical indications, such as mechanical ventilation for over 10 days, fraction of inspired oxygen (FiO<sub>2</sub>) requirements of less than 50%, positive end-expiratory pressure <10, and cessation of proning for at least 72 hours.

### *Ethics Committee Approval*

Ethics committee approval was not required for this retrospective case series. The data were extracted, anonymized, and analyzed by the first (A.C.) and second (L.L.) authors in accordance with internal information governance review, National Health Service (NHS) Trust information governance approval, and Caldicott Guardian procedures outlined under the Strategic Research Agreement (SRA).

### *Data Collection*

Data were collected from electronic patient records stored in the Cerner PowerChart database. Data collection focused upon key demographics, AICU admission data, tracheostomy-specific data, and clinical outcomes. All data and clinical outcomes available until the end of data collection period, May 1, 2020, are presented. At the end of the data collection period,

some patients remained hospitalized; therefore, data on their length of stay, discharge destination, or long-term complications were not available for reporting. All data were collected by 2 investigators to ensure accuracy.

## Definitions

Patients were confirmed to have COVID-19 by detection of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) antigen on respiratory swab specimens. Type 1 respiratory failure was defined as hypoxia in the presence of normocapnia. Diagnosis of pulmonary embolism (PE) was confirmed on computed tomography (CT) pulmonary angiogram, reported by a consultant radiologist. Diagnosis of ventilator-associated pneumonia (VAP) was defined as worsening oxygenation and the requirement for new antibiotic therapy in patients on IMV for over 2 days. Acute respiratory distress syndrome (ARDS) was defined according to Faculty of Intensive Care Medicine/Intensive Care Society (FICM/ICS) guidelines. Hyponatremia was defined as serum sodium levels above 145 mmol/L. Diagnosis of acute kidney injury (AKI) and decision to commence continuous venovenous hemodialysis (CVVHD) was based upon current National Institute for Health and Care Excellence (NICE) guidelines. Diagnosis of cerebrovascular accident (CVA) was confirmed on brain CT, reported by a consultant radiologist. The diagnosis of laryngeal edema was based upon the absence of tracheal tube cuff leak on repeated assessment prior to making the decision for tracheostomy. Muscle weakness was determined on bedside assessments of voluntary limb muscle strength (where possible). Immediate complications were defined as occurring during the perioperative period. Short-term complications were defined as occurring within the first month following tracheostomy.

## Statistical Analysis

Statistical analysis was performed using IBM SPSS Statistics Subscription software. All data were checked for normal distribution (Q-Q plots) and homogeneity (Levene's test), and appropriate statistical tests were selected based on their outcomes.

## Results

### *Inclusion Criteria and Demographics*

Sixty-five patients with COVID-19 were admitted to the AICU at our center, of whom 18 patients died and 47 patients were alive at the end of the data collection period. Fifty-six patients underwent tracheal intubation and invasive mechanical ventilation, of whom 20 proceeded to subsequent ST under general anesthesia. All patients who underwent ST were included in this case series (mean [SD] age, 54 [8.6] years; 75% were male). Patient ethnicity had the following distribution: 40% white (all backgrounds), 25% Arab, 15% Asian, 15% black, and 5% Chinese.

### *AICU Admission Data*

SARS-CoV-2 antigen was detected in all 20 patients. The primary indication for AICU admission was the requirement

**Table 1.** Ventilator Settings and Sedation Use Before and After Surgical Tracheostomy.

Characteristic	Before ST	After ST	P value
Ventilator settings, median (IQR)			
PEEP	8.0 (5.0-10.0)	8.0 (6.0-8.0)	.821
PS	9.5 (5.0-12.0)	5 (0.0-10.3)	.116
FiO <sub>2</sub>	0.35 (0.30-0.40)	0.30 (0.28-0.35)	.399
Mode of ventilation, number (%)			
CPAP	3 (15)	4 (20)	
CPAP ASB	15 (75)	14 (70)	
SIMV VC	2 (10)	1 (5)	
Unknown		1 (5)	
Sedation, median (IQR)			
Fentanyl, mcg/h	210 (112.5-287.5)	100 (50.0-200.0)	.021
Propofol, mg/h	80.0 (0.0-157.5)	0.0 (0.0-50.0)	.017
Clonidine, mcg/h	0 (0.0-5.0)	2.0 (0.0-3.0)	.968

Abbreviations: ASB, assisted spontaneous breathing; CPAP, continuous positive airway pressure; FiO<sub>2</sub>, fraction of inspired oxygen; IQR, interquartile range; PEEP, positive end-expiratory pressure; PS, pressure support; SIMV VC, synchronized intermittent mandatory ventilation volume control mode; ST, surgical tracheostomy.

for respiratory support in all patients, with 45% requiring tracheal intubation in the emergency department. Type 1 respiratory failure was the main reason for tracheal intubation in all patients. Continuous positive airway pressure (CPAP) noninvasive ventilation was trialed in 40% of patients prior to tracheal intubation. Bilateral pulmonary consolidation was observed on the initial chest x-ray in 65% of patients; unilateral consolidation was present in 25% of cases. Median time from admission to transfer to AICU was 1 day.

Raised body mass index (BMI) was the most commonly identified patient comorbidity in this group, with 50% of patients having a BMI >25 and 30% having a BMI >30 at the time of tracheostomy. Hypertension (35% of patients) and type 2 diabetes mellitus (30% of patients) were also commonly identified comorbidities. Two patients had a pre-existing respiratory condition (asthma, 10%), and 2 patients were postpartum (10%). Most patients did not smoke (65%); only 1 patient was a current smoker (5%) and 5 patients were ex-smokers (25%).

### AICU Progress and Medical Complications

Seventy-five percent of patients required prone positioning during their AICU admission. Tracheal extubation had been attempted (failed) in 1 of the 20 patients prior to referral for surgical tracheostomy. Common medical complications observed in this cohort of patients included PE (35% of patients), AKI requiring CVVHD support (40%), hypernatremia (35%), VAP (15%), and CVA (10%).

### Indication and Timing of Tracheostomy

The predominant reason for ST was to assist respiratory weaning from IMV (70%), in addition to the presence of muscle weakness (20%) and laryngeal edema (15%). The median duration of mechanical ventilation prior to tracheostomy formation was 16.5 days (IQR, 14.0-19.5).

Patients had spent a median duration of 4 days (IQR, 3.3-8.5) on continuous infusions of a neuromuscular blocking agent (atracurium) during their AICU admission, prior to tracheostomy formation. Median time from cessation of prone positioning to tracheostomy was 5 days (IQR, 3.0-6.0). Median partial pressure of oxygen (PaO<sub>2</sub>) was 9.8 (IQR, 9.3-10.5), and median PaO<sub>2</sub>/fraction of inspired oxygen [FiO<sub>2</sub>] ratio (PF ratio) was 27.9 (IQR, 24.5-33.9) on the day of the tracheostomy procedure. Median lymphocyte count was  $1.4 \times 10^9/L$  (IQR,  $1.1-2.0 \times 10^9/L$ ), and median C-reactive protein was 73.6 mg/L (IQR, 50.3-141.2 mg/L) prior to ST.

### Efficacy of Tracheostomy as Weaning Tool

There was no statistically significant difference in ventilator settings or mode of ventilation 48 hours before or after surgical tracheostomy. However, there was a reduction in pressure support and FiO<sub>2</sub> requirements after tracheostomy insertion ( $P > .05$ ). There was a significantly reduced requirement for intravenous sedative agents (fentanyl and propofol) at 48 hours after tracheostomy formation ( $P < .05$ ; **Table 1**). At the end of the data collection period (May 1, 2020), 60% of patients had been successfully decannulated (tracheostomy removal). The median time from tracheostomy insertion to decannulation was 12.5 days (IQR, 9.0-13.8) (**Table 2**). At the end of the data collection period, 50% of patients remained as inpatients on the AICU, 1 patient had been discharged home, and 2 patients had been discharged to a rehabilitation facility. Median duration of hospital stay for current inpatients was 34.5 days (IQR, 27.0-38.5; **Table 3**).

### Tracheostomy Complications

The rate of minor immediate complications was 25% (**Table 2**). There were no immediate major complications.

**Table 2.** Surgical Tracheostomy Indication, Timing, Tube Size, and Complications.

Characteristic	No. (%)
Surgical tracheostomy size	
7	1 (5)
7.5	2 (10)
8	7 (35)
8.5	4 (20)
9	6 (30)
Immediate complications	5 (25)
Oozing from tracheostomy site	1 (5)
Mucous plug + initial problems ventilating	1 (5)
Pneumomediastinum	1 (5)
Positional cuff leak	1 (5)
Cuff pierced, suction not working	1 (5)
Short-term complications	6 (30)
Cuff leak	1 (5)
Mucous plug	1 (5)
Oozing from tracheostomy site	2 (10)
Tracheostomy change	1 (5)
Minor bleeding from tracheostomy site after decannulation	1 (5)
Duration of tracheostomy in situ, median (IQR), d	
Decannulated	12.5 (9.0-13.8)
Not decannulated (tracheostomy in situ)	9.5 (6.5-11.8)

Abbreviation: IQR, interquartile range.

**Table 3.** Clinical Outcomes (n = 20, Surgical Tracheostomy Patients Only).

Characteristic	No. (%)
Length of admission (current inpatients), median (IQR), d	34.5 (27.0-38.5)
Number of patients decannulated	12 (60)
Discharged from AICU	10 (50)
Discharged home	1 (5)
Rehabilitation facility	2 (10)
Died	0 (0)

Abbreviations: AICU, adult intensive care unit; IQR, interquartile range.

The rate of short-term minor complications was 30%, which included minor oozing and bleeding from the tracheostomy site (n = 3) and mucous plugging (n = 1) (**Table 2**). There were no major short-term complications. At the end of the data collection period, there had been no deaths reported in these patients.

## Discussion

To our knowledge, this is the first case series that presents the findings of ST in critically ill patients with severe COVID-19 infection requiring IMV. Surgical tracheostomy

appears to be a safe technique and an effective weaning tool.

## Effectiveness as Weaning Tool

Surgical tracheostomy facilitated a significant reduction in intravenous sedation at 48 hours after tracheostomy formation. This is important since minimizing sedation is one of the evidence-based strategies to reduce long-term cognitive and functional sequelae of critical illness.<sup>12</sup> In addition, reduced sedation use following ST enabled increased social interaction between patients and their family members (via media devices), which is especially crucial in this isolated patient cohort. Given the risk of COVID-19 transmission to patients' families and the importance of maintaining patient isolation, interaction between patients and their families was impossible prior to ST.

Of note, no significant difference in ventilation requirements was observed at 48 hours after tracheostomy formation. The most plausible explanation is the severity of the disease in these patients. Prior to tracheostomy formation, all of these patients required prolonged IMV, as well as continuous infusions of neuromuscular blocking agents for a median of 4 days and multiple prone positioning to achieve improvement in respiratory function. A third of these patients had PE, negatively affecting ventilation/perfusion matching. Copious, thick secretions were common to all patients prior to and after tracheostomy insertion, and this is also likely to have contributed to delays in respiratory weaning, despite our critical care unit nursing staff undertaking regular and frequent suctioning procedures and inner canula changes every 2 to 4 hours.

Severity of patients' disease and higher survival rates (67.9%; 18 patients died of the 56 ventilated) among ventilated patients on our AICU are most likely reasons for our high tracheostomy rate (35.7%; 20 tracheostomies in the 56 ventilated patients), compared to the guideline prediction of 10%.<sup>5</sup> Only 1 patient in our cohort was deemed suitable to have a trial of (failed) tracheal extubation prior to tracheostomy procedure. All other patients did not meet the criteria for attempted tracheal extubation; they failed cuff leak assessment, demonstrated significantly reduced muscle strength, or represented too great a risk in the event of failed tracheal extubation (eg, raised BMI or difficult initial tracheal intubation). The mortality rate among all ventilated patients on our AICU was 32.1%, which is much lower than 50% predicted by the National Tracheostomy Safety Project (NTSP)<sup>5</sup> and observed in other studies.<sup>3,13</sup>

## Patient and Staff Safety of Surgical Tracheostomy

Despite our higher tracheostomy rate, there were no serious immediate or short-term complications, and crucially, no deaths were associated with the procedure in our cohort of patients. All tracheostomies were performed for 1 of the 3 indications highlighted by NTSP.<sup>5</sup> At the end of the data collection period, 60% of patients had been successfully decannulated, with median tracheostomy time in situ of 12.5 days. Our low rate of complications highlights the

importance of a dedicated specialist team of surgeons and anesthetists involved in the surgical tracheostomy procedures, alongside an agreed-on and standardized technique. It has not been possible to identify any long-term complications due to the short duration of the data collection period; however, all patients will be followed up at 3 and 6 months postdischarge from the AICU.

Furthermore, to our knowledge, none of the surgeons, anesthetists, or intensivists (see Chelwest COVID-19 AICU Consortium, Supplemental File 1, in the online version of the article) involved in the 20 surgical tracheostomy procedures have been diagnosed with COVID-19 or have required to take sickness leave. Our findings support the current guideline that suggests that infectivity is low after 10 to 14 days of IMV,<sup>5</sup> as the median time to ST at our institution was 16.5 days. In addition, our data confirm that clinical improvement, evidenced by cessation of proning and near-normal lymphocyte count prior to tracheostomy procedure, could be used as surrogate marker for reducing level of infection. All staff members involved in the patients' operations and subsequent AICU care will be followed up for development of symptoms and subsequent positive COVID-19 results to confirm the safety of this procedure for health care professionals.

### Study Limitations

This case series is a single-center experience and based upon a small number of patients. Nevertheless, the patient demographics (predominantly male, mean age 54 years) and patient comorbidities (raised BMI, hypertension, type 2 diabetes mellitus) are relatively representative of international prevalence reports and UK Intensive Care National Audit and Research Centre (ICNARC) data.<sup>4</sup> Hence, our results remain reasonably generalizable to other hospitals and other countries.

All data were collected retrospectively from electronic medical records, which may affect data accuracy. Data were collected by 2 investigators to increase data reliability.

Due to the short data collection period, 85% of our tracheostomy patients remain in the hospital, such that our tracheostomy outcomes, complications, and mortality rate may be underreported. We intend to follow up all patients at 3 and 6 months after AICU discharge. In addition, lack of a comparator group of patients who did not undergo a surgical tracheostomy prohibited us from comparing AICU outcomes.

Further research and larger-scale studies are required to understand the use of the tracheostomy technique in patients with COVID-19, including optimal timing, type of tracheostomy, long-term complications, and procedural safety.

### Conclusion

Surgical tracheostomy has been demonstrated to be an effective weaning tool in patients with severe COVID-19 infection. It appears to be a safe technique for patients and health care professionals when performed at an optimal time; however, our data set is very small. ST can increase availability of limited resources during this pandemic, particularly liberating specialist AICU ventilators and freeing

up AICU bed capacity, by facilitating safe step-down to ward-based care, led by a non-ICU tracheostomy-trained multidisciplinary team.

### Author Contributions

**Alona Courtney**, acquired data, analyzed and interpreted data, drafted the manuscript, contributed to conception and design, revised the manuscript critically for important intellectual content, and approved the final version of the manuscript to be published; **Leda Lignos**, acquired data, commented on and advised on the manuscript, contributed to conception and design, revised the manuscript critically for important intellectual content, and approved the final version of the manuscript to be published; **Patrick A. Ward**, commented and advised on the manuscript, contributed to conception and design, revised the manuscript critically for important intellectual content, and approved the final version of the manuscript to be published; **Marcela P. Vizcaychipi**, commented and advised on the manuscript, contributed to conception and design, revised the manuscript critically for important intellectual content, and approved the final version of the manuscript to be published.

### Disclosures

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### Supplemental Material

Additional supporting information is available at <http://journals.sagepub.com/doi/suppl/10.1177/2473974X20984998>

### References

1. World Health Organization. WHO Coronavirus Disease (COVID-19) Dashboard. June 5, 2020. Accessed May 26, 2020. <https://covid19.who.int>
2. Kiekens C, Boldrini P, Andreoli A, et al. Rehabilitation and respiratory management in the acute and early post-acute phase. "Instant paper from the field" on rehabilitation answers to the Covid-19 emergency [published online April 15, 2020]. *Eur J Phys Rehabil Med*.
3. Richardson S, Hirsch JS, Narasimhan M, et al. Presenting characteristics, comorbidities, and outcomes among 5700 patients hospitalized with COVID-19 in the New York City area. *JAMA*. 2020;323(20):2052-2059.
4. ICNARC Case Mix Programme Database. May 1, 2020. Accessed May 3, 2020. <https://www.icnarc.org/Our-Audit/Audits/Cmp/Reports>
5. National Tracheostomy Safety Project. Multidisciplinary COVID-19 tracheostomy guidance. April 30, 2020. Accessed May 5, 2020. [http://tracheostomy.org.uk/storage/files/Multidisciplinary%20COVID\\_19%20tracheostomy%20guidance%2030\\_4\\_20.pdf](http://tracheostomy.org.uk/storage/files/Multidisciplinary%20COVID_19%20tracheostomy%20guidance%2030_4_20.pdf)
6. Cheung NH, Napolitano LM. Tracheostomy: epidemiology, indications, timing, technique, and outcomes. *Respir Care*. 2014;59(6):895-919.
7. Andriolo BN, Andriolo RB, Saconato H, Atallah AN, Valente O. Early versus late tracheostomy for critically ill patients. *Cochrane Database Syst Rev*. 2015;1:CD007271.

8. Johnson-Obaseki S, Veljkovic A, Javidnia H. Complication rates of open surgical versus percutaneous tracheostomy in critically ill patients. *Laryngoscope*. 2016;126(11):2459-2467.
9. Heyd CP, Desiato VM, Nguyen SA, et al. Tracheostomy protocols during COVID-19 pandemic. *Head Neck*. 2020;42(6):1297-1302.
10. Angel L, Kon ZN, Chang SH, et al. Novel percutaneous tracheostomy for critically ill patients with COVID-19. *Ann Thorac Surg*. 2020;110(3):1006-1011.
11. Mattioli F, Fermi M, Ghirelli M, et al. Tracheostomy in the COVID-19 pandemic [published online April 22, 2020]. *Eur Arch Otorhinolaryngol*.
12. Rengel KF, Hayhurst CJ, Pandharipande PP, Hughes CG. Long-term cognitive and functional impairments after critical illness. *Anesth Analg*. 2019;128(4):772-780.
13. Arentz M, Yim E, Klaff L, et al. Characteristics and outcomes of 21 critically ill patients with COVID-19 in Washington State. *JAMA*. 2020;323(16):1612-1614.