

Modified percutaneous tracheostomy in patients with COVID-19

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ABSTRACT

Background Patients hospitalized with COVID-19 are at risk of developing hypoxic respiratory failure and often require prolonged mechanical ventilation. Indication and timing to perform tracheostomy is controversial in patients with COVID-19.

Methods This was a single-institution retrospective review of tracheostomies performed on patients admitted for COVID-19 between April 8, 2020 and August 1, 2020 using a modified percutaneous tracheostomy technique to minimize hypoxia and aerosolization.

Results Twelve tracheostomies were performed for COVID-related respiratory failure. Median patient age was 54 years (range: 36–76) and 9 (75%) were male. Median time to tracheostomy was 17 days (range: 10–27), and 5 (42%) patients had failed attempts at extubation prior to tracheostomy. There were no intraprocedural complications, including hypoxia. Post-tracheostomy bleeding was noted in two patients. Eight (67%) patients have been discharged at the time of this study, and there were four patient deaths unrelated to tracheostomy placement. No healthcare worker transmissions resulted from participating in the tracheostomy procedure.

Conclusions A modified percutaneous tracheostomy is feasible and can be safely performed in patients infected with COVID-19.

Level of evidence Level V, case series.

INTRODUCTION

Since December 2019, the novel coronavirus (SARS-CoV-2) has spread widely and now affects more than 180 countries.¹ Transmission of the virus occurs via respiratory droplet, aerosols, or direct contact. To date, over 26 million cases have been confirmed worldwide, with more than 870 000 confirmed fatalities.¹ Patients infected with SARS-CoV-2 may develop symptomatic disease (COVID-19), which can progress to hypoxic respiratory failure. These patients are at risk for prolonged mechanical ventilation (PMV).^{2,3} Prior to the COVID-19 pandemic, tracheostomy placement in patients with PMV was common for a variety of indications.^{4–9} For these patients, timing of tracheostomy varies but is typically performed anywhere between 1 and 3 weeks of PMV. Advantages of tracheostomy placement may include increased patient comfort, decreased laryngeal complications, minimized sedation, decreased rates of ventilator-associated pneumonia, improved patient

communication, ease of replacement, shortened ventilator wean time, and earlier transfer out of an intensive care setting.^{8 10–12}

Performing tracheostomies on patients with COVID-19 remains controversial. Both patient-related and provider-related safety issues have been discussed in existing guidelines.^{13–15} These patients anecdotally have poor oxygen reserve and do not tolerate periods of airway derecruitment and deoxygenation. Additionally, manipulating the airway of a patient who is COVID-19 positive (even without bronchoscopy) is an aerosol-generating procedure and puts the medical team at higher risk of infection.¹⁶ Early society guidelines for patients with COVID-19 emphasized delayed tracheostomy, in some cases recommending to wait 21 days after the patient is intubated and tests negative for COVID-19 before performing elective tracheostomy to reduce the risk of viral transmission.^{13 14} During the early stages of the pandemic, when little was known about transmission or expected hospital courses, such conservative guidelines were prudent. However, these guidelines were not based on objective measure of risk, and could lead to prolonged sedation, increased risk of secondary pneumonia, or repeat intubations as patients struggle to regain respiratory independence.

As the pandemic has progressed, our institution has become more comfortable with earlier placement of tracheostomies in patients who are infected with COVID-19. We also developed a modified technique to limit aerosolization during the procedure. The aim of this study is to describe the safety profile and our single-institution experience with tracheostomies performed for patients with COVID-19.

METHODS

Patients and variables

We performed a retrospective review of all tracheostomies performed in patients with an initial diagnosis of COVID-19 at our institution between April 8, 2020 and August 1, 2020. Demographic and outcome variables were abstracted from chart review. A COVID-19 diagnosis was defined by a nasopharyngeal swab which was positive for COVID-19 on reverse-transcriptase PCR. Cardiac comorbidities included coronary artery disease and congestive heart failure. Diabetes was also recorded as a comorbidity. Chronic kidney disease was defined as a baseline glomerular filtration rate <60 mL/min and included end-stage renal disease.

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Table 1 Supply list for percutaneous tracheostomy

Surgical supplies	Anesthesia supplies	Respiratory therapist supplies
Sterile surgical gloves	Medications	Ventilator circuit
Sterile surgical gown	Fiber-optic bronchoscope	In-line ETCO ₂ monitor
Percutaneous dilation kit	Endotracheal tube with stylet and backup tube	In-line HEPA filter
		Suction tubing
Two tracheostomies (No 6 or No 8 Shiley)	Laryngoscope blade	Bronchoscope adapter for ET tube
	Ambu bag	
Open tracheostomy kit*	10 cc syringes	
3/4 sterile drape	Pulse oximetry on loudest setting	
Sterile saline flushes	Yankauer suction	
3–0 nylon suture to secure tracheostomy	LMA, bougie available in case emergent airway required	

List of surgical and airway supplies required to perform percutaneous tracheostomy. Nylon suture used for single stitch to secure tracheostomy to skin at midline.

*Open tracheostomy kit to be available for backup if necessary.

ET, endotracheal; HEPA, high-efficiency particulate air; LMA, laryngeal mask airway.

Post-tracheostomy bleeding was defined as bleeding from the tracheostomy site within 5 days of the procedure requiring surgery consultation. Outcomes of interest included complications, death, or healthcare worker infection. Statistical analysis was performed using Microsoft Excel (Redmond, Washington).

Tracheostomy protocol

Criteria and timing for tracheostomy followed an institutional protocol established on April 2, 2020. Potential candidates for tracheostomy were discussed between the COVID-intensive care unit (ICU) team and the COVID tracheostomy team. Prior to tracheostomy, patients had to demonstrate ability to maintain oxygen saturation (SaO₂ >90%) with a fraction of inspired oxygen of 50% or less and a positive end-expiratory pressure of 12 mm Hg or less. All procedures were performed at the patient's bedside in a negative pressure ICU room.

A minimum number of healthcare staff were present for the procedure: an attending surgeon (performing tracheostomy), an anesthesiology attending (performing bronchoscopy and assisting with airway and medications), and a respiratory therapist (assisting with equipment and the ventilator). An ICU nurse was available immediately outside the room to assist with donning and doffing, and to record procedure events. All team members wore a gown, double gloves, and a powered air purifying respirator (PAPR). The person performing the tracheostomy also wore an N-95 respirator and eye protection under the PAPR in the event the PAPR mask became obscured and would need to be removed. All materials were gathered and available prior to anyone entering the room. A list of materials that were collected for use is included (table 1).

Tracheostomy technique

All tracheostomies were placed using a modified percutaneous technique as described (box 1). In general, our procedural steps are adapted from general percutaneous tracheostomy technique, but with several important modifications which were designed to minimize aerosolization and reduce apnea time. A brief review is conducted with team members prior to entering the room to ensure clear roles, task assignments, and anticipated order of events. The first modification is to put the patient on 100% inspired oxygen as soon as the team enters the room. We also sedate and paralyze the patient early to assist with positioning. This helps minimize the time from room entry to procedure start by making the set-up phase more efficient. The second modification is to perform the cut-down onto the trachea prior to any

manipulation of the airway. This allows the surgeon to verify patient anatomy and assess surgical exposure prior to committing to entering the airway. The third modification is the cessation of ventilation at the end of an exhalation cycle immediately prior to bronchoscope insertion, as we assume this reduces risk of aerosolization during the procedure. Fourth, we leave the endotracheal (ET) balloon inflated during the procedure. This facilitates quick and adequate withdrawal of the ET tube to the vocal cords, to enable rapid access into the trachea with the introducer

Box 1 Steps of modified percutaneous tracheostomy for patients with COVID-19

Task

- ▶ All supplies prearranged and confirmed prior to room entry.
- ▶ Procedural team supervised donning PPE.
- ▶ Initial procedural time out prior to room entry.
- ▶ Preoxygenate patients upon entering the room.
- ▶ Sedate and paralyze patients early.
- ▶ Arrange procedural set-up.
- ▶ Prep patient sterilely.
- ▶ Second procedural time out prior to making skin incision.
- ▶ Infiltrate local anesthesia.
- ▶ Make 2 cm vertical incision 2 cm above the sternal notch.
- ▶ Blunt dissection down to trachea.
- ▶ Cessation of ventilation.
- ▶ Bronchoscope inserted by anesthesia team member to end of ET tube.
- ▶ ET tube withdrawn with ET balloon inflated until balloon is near vocal cords.
- ▶ Introducer needle placed through trachea with wire.
- ▶ Confirm that physiology remains suitable.
- ▶ Serially dilate trachea.
- ▶ Place tracheostomy tube and inflate balloon.
- ▶ Confirm endotracheal placement of tracheostomy with bronchoscope.
- ▶ Connect ventilatory circuit and begin ventilating, confirm end-tidal CO₂.
- ▶ Secure tracheostomy in place with single superior midline stitch and tracheostomy ties around neck.

Step-by-step procedure and technique for modified bedside percutaneous tracheostomy. ET, endotracheal; PPE, personal protective equipment.

Table 2 Clinical characteristics of patients with COVID-19

Variable	Patients (n=12)
Age (years)	54 (36, 76)
Male	9 (75%)
Median BMI (range)	27 (22, 45)
Comorbidities	
Cardiac	6 (50%)
DM	5 (42%)
Asthma/COPD	2 (17%)
CKD	4 (33%)
Stroke	0 (0%)
Extubation trial	5 (42%)
Time to tracheostomy* (days)	17 (10, 27)
COVID-19 status prior to tracheostomy	
Positive	9 (75%)
Negative	1 (8%)
Unknown	2 (17%)
Intraprocedural complication	0 (0%)
Postprocedure bleeding	2 (17%)
Tracheostomy decannulated	5 (42%)
Discharged from hospital	8 (67%)
Death	4 (33%)
Follow-up (weeks)	5 (3, 16)
Healthcare worker infection	0 (0%)

Data portrayed as either median (range) or n (%). Follow-up indicates number of weeks of follow-up since tracheostomy.

*Indicates time from initial intubation to tracheostomy placement.

BMI, body mass index; CKD, chronic kidney disease; COPD, chronic obstructive pulmonary disease; DM, diabetes mellitus.

needle. Fifth, once the wire is introduced, we perform a quick check: if the patient has any signs of pending desaturation at this point the bronchoscope is removed and ventilation resumed temporarily with finger occlusion over the wire. We think that the risk of aerosolization during this maneuver is low based on controlling any possible small air leak. Finally, serial tract dilation and tracheostomy tube placement are done under apnea. Ventilation is not resumed until the tracheostomy tube balloon is inflated and placement confirmed by end-tidal CO₂. A ventilator adapter with a high-efficiency particulate air filter is attached to minimize aerosolization.

RESULTS

Twelve tracheostomies were performed between April 8, 2020 and August 1, 2020 for patients requiring PMV who tested positive for COVID-19 (table 2). All patients were admitted primarily for COVID-related conditions, including shortness of breath, fevers, and altered mental status. Patients were intubated for respiratory failure between hospital day 1 and day 6. Median age was 54 years (range: 36–76) and 9 (75%) were male. Median time to tracheostomy was 17 days (range: 10–27), and 5 (42%) patients had at least one failed attempt at extubation prior to tracheostomy. Prior to the tracheostomy procedure, most patients were retested for COVID-19: 9 (75%) remained positive, 1 (8%) was negative, and 2 (17%) were not retested. There were no intraprocedural complications. Only two patients required a pause in the procedure to reoxygenate, neither experienced an oxygen saturation <80%. After the procedure, two patients (both of whom were therapeutically anticoagulated)

exhibited bleeding around the tracheostomy site which was controlled with hemostatic agents and pressure. Eight (67%) patients were discharged, either to home or a long-term care facility. There were four patient deaths: one due to neurological sequelae, two related to pulmonary complications of COVID-19, and one due to invasive fungal infection in an immunocompromised transplant patient; none were due to complications from the tracheostomy placement. There were no healthcare worker infections among those participating in the tracheostomies.

DISCUSSION

Our analysis adds to the growing body of literature that suggests bedside percutaneous tracheostomies in patients who are positive for COVID-19 are a safe procedure when performed with care.^{17–21} We acknowledge that the decision to perform tracheostomy in patients with COVID-19 must be judicious, as there is a careful balance between the risk-benefit analysis to the patient and the provider. For patients with COVID-19, the extent of hypoxia during periods of ventilatory interruption can be dramatic.^{2,3} For providers, tracheostomy can be a high-risk procedure due to virus aerosolization. Yet, despite these risks, percutaneous tracheostomy can still be performed safely in this patient population.

We chose to perform our tracheostomies using a modified percutaneous technique to limit hypoxia and aerosolization. Apnea during tracheostomy to reduce aerosol formation during the procedure has been previously described and is an accepted variation to standard percutaneous tracheostomy.²² We followed a similar technique to minimize aerosolization; if the patient's oxygen saturation drops during the procedure, we would pause and reoxygenate while covering the tracheal puncture site with wire in place before committing to serial dilations. Only two patients required a pause in the procedure to reoxygenate. Another proposed method to decrease aerosolization during percutaneous tracheostomy is to pass the bronchoscope adjacent to the ET tube, rather than through it.¹⁹ However, we thought this method is cumbersome, time consuming, and could expose providers to aerosolization if the ET balloon was inadvertently punctured.

The question around timing of performing tracheostomies in patients with COVID-19-associated respiratory failure remains openly debated. While recommendations about when to perform tracheostomy on standard patients vary by underlying pathology, typical recommendations suggest performing a tracheostomy after 7–14 days of intubation is beneficial.⁹ However, existing guidelines for patients with COVID-19 suggest waiting 10–21 days after mechanical ventilation before considering tracheostomy, ideally to wait for virus clearance although critically ill patients may exhibit prolonged viral shedding.^{13,14,23} Yet objective data remain inconclusive. One series from the UK supported early percutaneous tracheostomies in patients with COVID-19, demonstrating a median tracheostomy time of 4 days after ET intubation with a good safety profile.¹² Conversely, Volo *et al* described a series of 23 open tracheostomies on patients with COVID-19 that demonstrated a higher mortality rate in those performed within 10 days of ET intubation; their recommendation was to wait at least 14 days before tracheostomy.²⁴ Results from our study suggest that tracheostomy earlier than 21 days is safe for patients and providers even when patients have detectable virus. As the pandemic continues and healthcare providers understand the natural history of COVID-19-associated respiratory failure better, we anticipate that early tracheostomy will be found to be advantageous.

This study has several limitations. First, this is a retrospective review at a single institution. Second, matched controls were not compared, which impairs our ability to suggest that early tracheostomy could decrease sedation use, secondary pneumonia, unplanned extubations and reintubations, or death. Finally, this was a single institution study from a high-resource setting with adequate personal protective equipment, and thus findings may not be generalized or extrapolated to other settings.

CONCLUSION

Modified percutaneous tracheostomy can be safely performed in patients who are infected with COVID-19. Future studies should evaluate ideal time to tracheostomy among patients infected with COVID-19.

Contributors BJS - manuscript preparation, data analysis; CJW - manuscript preparation, data analysis; HMB - manuscript preparation, critical review; DF - critical review; JL - manuscript preparation, critical review; PRM - manuscript preparation, critical review; PGM - manuscript preparation, critical review; DAS - manuscript preparation, critical review; TGW - manuscript preparation, critical review; JDF - data analysis, manuscript preparation, critical review.

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