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Supplementary appendix

This appendix formed part of the original submission and has been peer reviewed. We post it as supplied by the authors.

Supplement to: McGrath BA, Brenner MJ, Warrillow SJ, et al. Tracheostomy in the COVID-19 era: global and multidisciplinary guidance. *Lancet Respir Med* 2020; published online May 15. http://dx.doi.org/10.1016/S2213-2600(20)30230-7.

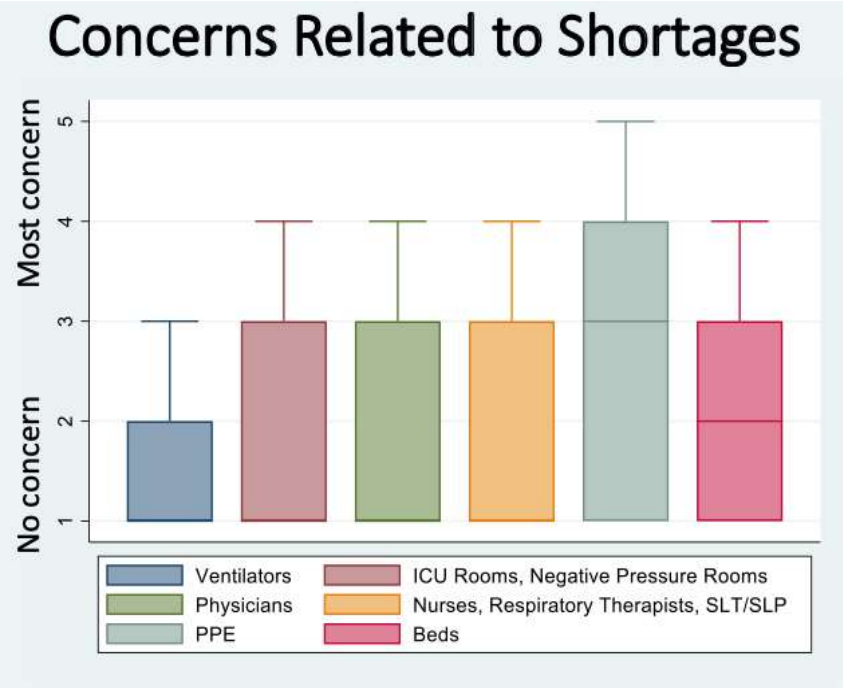
Tracheostomy in the COVID-19 Era: Global and Multidisciplinary Guidance

Supplemental Table 1. *Recommended location for tracheostomy insertion and subsequent management*

Tier of Recommendation	Recommended Location
1	Negative pressure (single occupancy) ICU room with antechamber
2	Negative pressure single occupancy ICU room without antechamber
3	Positive pressure single occupancy ICU room with HEPA / virus filter
4	Negative pressure (closed door) cohort area/ward
5	Standard pressure (closed door) cohort area/ward with HEPA / virus filter
6	Negative pressure operating room
7	Closed door cohort area

Supplemental Table 2 (following page): Summary of multi-national opinion and perspectives regarding tracheostomy during COVID-19. This information is from analysis of the survey responses of authors from United States, United Kingdom, Hong Kong, Spain, Italy, France, Germany, Switzerland, China, and Australia. Key points are illustrated with figures and supplemented by quotes. Data in box and whisker plots represent mean and interquartile range. Outlier (outside the interquartile range) are depicted as colored dots in above figures.

Supplemental Table 2.

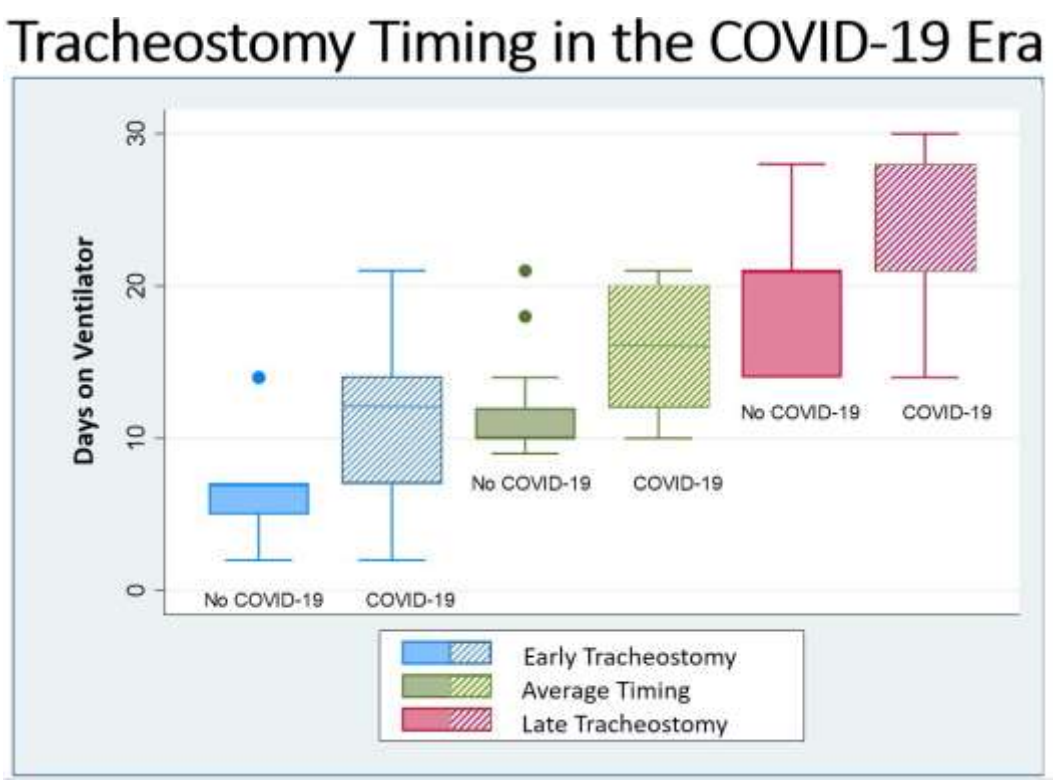
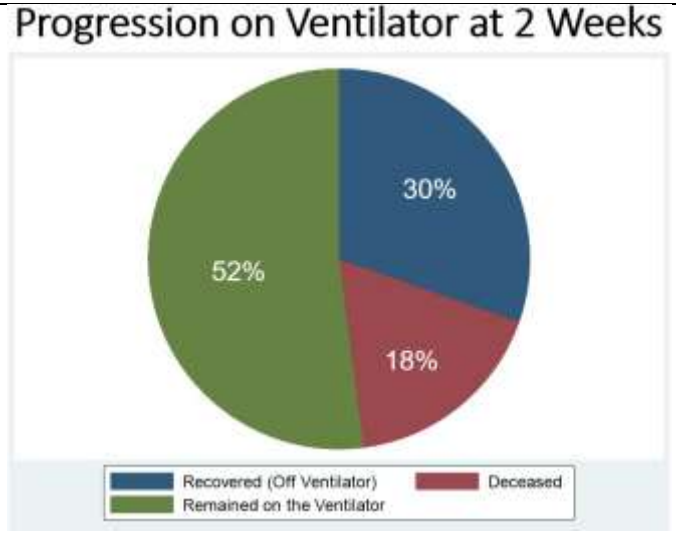
<table>
<tr><th>Theme</th><th>Consensus opinion on key topics and associated selected quotes</th></tr>
<tr><td>Evolving indications for performing a Tracheostomy</td><td>In the COVID-19 era, consensus opinion was that the most important benefit of tracheostomy in a COVID-19 positive patient who required invasive mechanical ventilation was ensuring that critical resources, such as ventilators, ICU beds, and staff can be made available to other critically ill patients. Benefits of tracheostomy for the actual patient receiving invasive mechanical ventilation were rated lower. These benefits to the individual patient, in rank order from most to least important included:
maximizing ICU space / resources
decreasing sedation
improved pulmonary hygiene and ease of suctioning of secretions
preventing laryngeal injury or other complications of prolonged intubation
facilitating communication
preventing muscle atrophy</td></tr>
<tr><td>Concerns about risks to safety of healthcare workers</td><td> 

The workgroup noted that the paucity of definitive studies on infectious transmission with COVID-19 leaves significant questions unanswered about safety. When queried about concerns regarding shortages, the foremost concern related to insufficient personal protective equipment (PPE), as reflected in the work group's severity ratings of concerns.

Many potential sources of infection were noted as concerns, including exposures during aerosol generating procedures (tracheostomy, bronchoscopy, intubation, bag masking, etc.); contact with surfaces not adequately cleaned in hospital wards; community-based COVID-19 infections; poor room ventilation or crowded conditions; and inadequate training in donning and doffing of personal protective equipment.

"*We believe that in the treatment and care of critically ill patients with COVID-19, the most important thing is to do a good job in the protection of the medical staff, especially when doing operations that may produce aerosols.*"

"Many healthcare workers have been infected. Some of them require mechanical ventilation, and we have lost at least six MD in France (North-East and Paris).I know that one operating room…at the early beginning of the pandemic, had ten healthcare workers infected by one patient who underwent emergent tracheostomy when acute dyspnea occurred in a patient with recently diagnosed laryngeal cancer. Surgeons, residents and nurses were infected, with diagnosis of COVID-19 2-3 days after tracheostomy with usual symptoms"</td></tr>
</table>

Tendency to proceed with caution in COVID-19 tracheostomy		The workgroup was queried regarding how the COVID-19 pandemic had influenced the timing of tracheostomy. The usual/average timing was recorded as well as what would be the earliest and latest that tracheostomy is performed, in absence of contraindications. Two patterns were apparent: first that tracheostomy tended to be performed at later time points in COVID-19 positive patients and second that the spread of responses on timing was wider in patients with infection, reflecting lack of consensus Prominent concerns in several countries related to limited access to testing, as well as difficulty in assessing infectivity/ potential for transmission.
Liberation from Ventilator		When queried regarding progression of COVID-19 positive patients on the ventilator at 2 weeks, the consensus was that approximately half of patients would have achieved successful liberation. In subsequent discussion, the group noted that a significant number of patients will require 3 weeks or more weeks of invasive mechanical ventilation. Such data are important in understanding the capacity required for chronically ill patients that may have a protracted course. *"Up to 80% of patients* [at our institution] *requiring mechanical ventilation remain on ventilator beyond 2 weeks… due to work overload caused by this pandemic."*

	Statements developed during the consensus process, grouped into major headings: selection, timing, performance and subsequent management.
	Case selection: The role of tracheostomy in critical illness and respiratory failure Patient selection for tracheostomy should be adapted during the COVID-19 pandemic Tracheostomy has a continuing role in managing weaning from prolonged mechanical ventilation. The tracheostomy procedure and subsequent care poses risks to healthcare workers Decision-making around access to critical care and tracheostomy in the COVID-19 pandemic is based mainly on existing practice Tracheostomy in the context of critical illness is not always in the patient's best interests. Tracheostomy for patients with COVID-19 may not always provide benefit. These decisions may become more important in an overwhelmed healthcare system with limited resources to care for critically ill and recovering, highly dependent patients. An independent triage/ethics committee may help guide decisions.
	Timing of tracheostomy Do emerging virology data with respect to COVID-19 alter optimal timing of tracheostomy? Tracheostomy should be delayed until at least 10 days of mechanical ventilation. Tracheostomy should only considered when patients are showing signs of clinical improvement. Is there a minimum time to delay before undertaking a tracheostomy? A negative viral PCR swab is necessary prior to tracheostomy. Detection of antibodies is necessary prior to tracheostomy. Does tracheostomy have a role in preference to attempting primary extubation in selected patients? A conservative approach to attempted extubation should be used, limited to those predicted to have a high chance of success. Patient selection for attempted primary extubation should be based on established practice. All patients undergoing tracheostomy should have had a trial of primary extubation Prone positioning is contraindicated with a tracheostomy. Ensuring adequate PPE is among the foremost considerations in decisions around management of COVID-19 patients in the critical care unit.

Performance of tracheostomy

Where is the optimal setting for tracheostomy insertion during the COVID-19 pandemic?

A hierarchical approach to operative location is recommended.

Performing a tracheostomy in the ICU is associated with

- sub-optimal equipment/lighting
- limited assistants
- positioning on wide ICU beds

Performing a tracheostomy in an operating room is associated with

- the need to transfer (exposure risks to multiple staff, and associated logistics)
- better operating conditions
- a better environment for aerosol management

Percutaneous, surgical, or hybrid approaches can be utilised in either location.

Portable high-efficiency particulate air filtration (HEPA) systems may be an acceptable alternative.

The optimal personal protective equipment for staff performing tracheostomy includes:

- powered air-purifying respirators (PAPR)
- eye protection
- fluid-repellent disposable surgical gown
- double gloves

Operators continue to conduct tracheostomy using the techniques and equipment with which they are familiar.

Bronchoscopic guidance may improve safety for percutaneous tracheostomy.

There is likely greater aerosol potential with percutaneous tracheostomy compared with surgical approaches.

There are no data to establish superiority of one approach over the other (perc vs surgical) from standpoint of

- infectious transmission
- safety
- bleeding risk

	Single-use bronchoscopes with a sealed ventilator circuit are preferable. Modifications to the surgical approach that may reduce risks to staff • maintenance of a bloodless field • minimal use of diathermy • use of a smoke evacuator Careful tracheostomy tube choice and meticulous evaluation of position once inserted is essential to minimise risks of later displacement. Displacement risks are especially important in the obese. Paralysis eliminates patient movement and coughing during tracheostomy. Neuromuscular monitoring is useful to ensure adequate paralysis during tracheostomy. Pausing ventilation during insertion minimises aerosol spread. Placing the inflated cuff of the endotracheal tube well below the tracheostomy site in surgical tracheostomy can minimise apnoea duration. A trial of apnoea in the ICU can simulate the apnoea required during tracheostomy and can demonstrate physiological readiness to tolerate the procedure. Rapid desaturation during an apnoea trial predicts a similar response during tracheostomy and tracheostomy should be deferred. Multidisciplinary clinical judgement should be used when considering the risks and benefits of undertaking tracheostomy in a given patient.
	Optimal management following tracheostomy It is important to ensure that patients are managed by experienced tracheostomy-trained staff. Key principles include: • a focus on essential care • avoidance of unnecessary interventions • avoidance of aerosol generating procedures • early recognition of deterioration • timely responses to emergencies.

	Airway interventions should be planned where possible to allow appropriate PPE to be applied. Standard approaches to managing tracheostomy emergencies should be followed. Tracheostomy initially requires a 'closed' system to deliver pressure to the lungs. Strategies to minimise ventilator circuit disconnection and aerosol risks to staff include: • use of a cuffed tube • use of a non-fenestrated tube • use of 'in-line' suction • avoidance of unnecessary airway interventions. Cuffs should remain initially inflated, and pressures checked every 12 hours. Cuff pressure should be maintained at 20-30 cmH_2O. Cuff pressure should be maintained at or above ventilator peak inflation pressures Tube changes should be delayed until patients are considered 'non-infectious'. The frequency of changing an inner cannula should be reduced. A simple Heat-Moisture-Exchange (HME) filter should be used initially for humidification. Active water-based humidification may be used. Communication is important for patients with tracheostomies to reduce a sense of isolation and increase safety during this pandemic. Cuff deflation trials should be managed in dedicated COVID-19 locations by experienced staff protected by appropriate PPE. Swallowing assessment should rely on clinical skills rather than the use of instrumental swallowing examinations. Decannulation should be considered as soon as it is safely possible. Post tracheostomy care is optimally managed by a multidisciplinary tracheostomy team.

Supplemental Figure 3. *Flow diagram: the patient journey following tracheostomy.*