Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

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Appendix A. Supplementary data

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Opening Pandora's box: surgical tracheostomy in mechanically ventilated COVID-19 patients

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Editor—Coronavirus disease 2019 (COVID-19) is the third coronavirus infection witnessed in past two decades.[1] Key lessons derived from the cumulative experience of Asian and European ICUs, which dealt with critically ill patients during the early phase of the COVID-19 pandemic, and lessons from the previous severe acute respiratory syndrome (SARS) and Middle East respiratory syndrome (MERS) outbreaks allowed hospitals in the UK to prepare preventive measures and adopt specific processes for the COVID-19 crisis.[2] Proactive management strategies implemented during this crisis based on previous knowledge may have limited the number of COVID-19-related hospital admissions, reduced mortality, and limited the initial trajectory of coronavirus spread in the UK.

Our hospital has seen an increase in demand for open surgical tracheostomies in COVID-19 patients admitted to the ICU. In contemporary critical care practice the most common

indication for a tracheostomy is to allow gradual weaning of patients undergoing prolonged mechanical ventilation. Tracheostomised patients benefit from improved patient comfort, reducing or completely removing the need for sedation, and decreasing breathing circuit dead space, all of which may aid weaning from mechanical ventilation. The current COVID-19 pandemic has presented a particular challenge to providers in this area, as large numbers of COVID-19 positive patients will require prolonged mechanical ventilation and thus potentially require a tracheostomy to facilitate withdrawal of this support.

Performing a conventional tracheostomy in a COVID-19 patient can be compared with the Greek myth of opening Pandora's box, which unleashed untold evils. Because of the highly contagious nature of SARS coronavirus 2 (SARS-CoV-2), a tracheostomy without modification of the technique would expose the intensivist, surgeon, and supporting healthcare workers to this deadly pathogen. Thus, it is vital to implement precautionary steps during this high-risk aerosol-generating procedure. When an open surgical tracheostomy is performed in a COVID-19 patient, the risk of viral transmission to all involved team members can be reduced by implementing a systematic and integrated approach with the surgeon and the intensivist/anaesthesiologist working in a synchronised manner. Tay and colleagues[3] recently published a literature review of tracheostomies performed during the 2003 SARS epidemic. They highlighted several important preoperative, intraoperative, and postoperative considerations while planning for open tracheostomy in a COVID-19 patient.[3] Many institutions and organisations including ours have incorporated these findings into their own COVID-19 tracheostomy guidelines. We outline our approach for performing open surgical tracheostomy in mechanically ventilated COVID-19 patients within the ICU setting (Table 1). These recommendations should be regarded as an early framework during our continued understanding of COVID-19.

The indication for tracheostomy and the choice of technique are contentious issues irrespective of the decision to perform surgical tracheostomy or percutaneous dilational tracheostomy. It is a multidisciplinary medical decision made by the intensivist in charge of the patient after discussion with the surgeon/proceduralist. There is currently no level 1 evidence from randomised trials related to the degree of SARS-CoV-2 aerosolisation with open *vs* percutaneous tracheostomy techniques. Irrespective of which of the two techniques

Table 1 Approach for performing open surgical tracheostomy in mechanically ventilated COVID-19 patients within the ICU setting. INR, international normalised ratio; APTT, activated partial thromboplastin time

	Preoperative steps	Intraoperative steps	Postoperative care
1	Establish a COVID-19 surgical airway team comprising of surgeons and intensivists/ anaesthesiologists.	Advancement of oral tracheal tube (TT) using videolaryngoscopy above carina distal to 2nd/3rd/4th tracheal ring.	Outer tracheostomy tube: not changed until patient is stable enough to be decannulated.
2	Designated negative pressure room within the ICU setting (reducing need to transfer patient to operating theatre).	Skin preparation and draping followed by standard open surgical tracheostomy approach.	Inner tracheostomy tube: **COVID-19 positive patient**: Checked/cleaned or changed every 12 h depending on production of secretions. **COVID-19 negative patient:** Checked/cleaned or changed every 4 h.
3	Entire team in full personal protective equipment.[5]	Inform intensivist/anaesthesiologist once the anterior tracheal wall has been exposed and incision for tracheal stoma is imminent.	**Step down from ICU with tracheostomy:** To a dedicated surgical ward. or **Step down from ICU after decannulation:** Medical ward acceptable.
4	Surgical tracheostomies to be performed on a planned semi-elective basis.	Ventilation is switched off at the end expiratory phase with intrathoracic pressure only at atmospheric.	
5	A consent form to be signed by two consultants involved in care of the patient.	Tracheal window created and suture stitch placed.	
6	Ensure all patients are clinically stable: On FiO_2 <0.5, PEEP <10 cm H_2O PAP <28 cm H_2O, platelets >80 000 INR/APTT ratio <1.5 Anticoagulation stopped preoperatively	TT cuff is deflated, and retracted slowly until the end is just above the stoma.	
7	Tracheostomy packs including surgical kits are prepared and stored in advance for ICU cases. Only use cuffed, non-fenestrated tracheostomy tubes to minimise aerosolisation.	Tracheostomy tube inserted, introducer out, inflate cuff, manually secure tube, transfer catheter mount.	
8	Patient is transferred to a surgical trolley with sandbag between shoulders and head ring to attain maximum head extension. Adequate mobile lighting to be available.	Wet swabs over wound as a precautionary measure if cuff leaks and recommence ventilation.	
9	Use of agreed hand signals to aid communication when all staff members in personal protective equipment.	Chest movements and CO_2 checks are made by the intensivist. The TT can then be disposed of safely.	
10		Secure flange by suture.	

are chosen, the operator needs to be highly experienced to reduce potential surgical complications, procedure time, and coronavirus aerosolisation. Furthermore, the type of tracheostomy is influenced by local factors such as availability of a negative pressure room within the ICU setting, and patient-related risk factors such as anatomical anomalies of the neck, obesity, and serious bleeding disorders.[4–8]

A tracheostomy should not be considered too early after patient admission. One should wait until day 14 for the prognosis to be clearer and for the viral load to decrease.[9,10] These recommendations are based on recent audit data from Intensive Care National Audit and Research 2020 and unpublished reports from Italy and China. These reports suggest that a significant proportion of COVID-19 patients are being successfully weaned and extubated between day 5 and day 10, and patients requiring longer mechanical ventilation often have poorer overall prognosis.[11] Published guidelines for open surgical tracheostomy in COVID-19 patients suggest that tracheostomies should not be routinely considered in any patient with tracheal intubation until the patient has been determined to be free from the virus and isolation precautions have ended.[12,13] In our practice, tracheostomy is considered from day 8 to day 10 of the critical care stay onwards and 14 days after onset of COVID-19 symptoms. Patients should be clinically stable with FiO_2 <0.5, PEEP <10 cm H_2O, and positive airway pressure (PAP) <28 cm H_2O (Table 1).

COVID-19 patients succumb to multiple pathological processes including coagulopathy, with disseminated intravascular coagulation being a primary concern.[14] COVID-19-associated coagulopathy and underlying traditional risk factors predispose these patients to an increased risk of acute pulmonary embolism.[15] Therefore, patient-specific evaluation of bleeding risk is required. In the absence of significant bleeding risk, patients should receive prophylactic low molecular weight heparin to prevent thromboembolism.[16] We administer daltaparin twice daily, omitting the morning dose if surgery is scheduled in the morning.

Undertaking an open surgical tracheostomy opens up a Pandora's box of a novel viral disease, which we still do not understand fully. Pandora's curiosity got the better of her for a second time. She opened the box once more and released the only thing that was left in the box — hope. A surgical tracheostomy opens up a window of hope for the patient with benefits such as patient comfort, mobility, and speech. If carried out following the approach outlined above, it may be beneficial in this cohort of patients, while ensuring the well-being of all team members involved in the procedure.

Declarations of interest

The authors declare that they have no conflicts of interest.

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