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Extensive Tracheal Injuries: A Reasoned Multistep Approach to Guarantee Mechanical Ventilatory Support Developed During the COVID-19 Pandemic

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Abstract

The COVID-19 pandemic has notably increased the need for prolonged mechanical ventilation (MV) in patients with respiratory failure. This has increased the risk of extensive tracheal injury (ETI) associated with life-threatening complications in complex cases. Furthermore, tracheal injury treatment in patients with COVID-19 has not been described yet. Three patients with COVID-19 and ETI who required MV between April and November 2020 were included. A multistep approach was performed to restore tracheal integrity with a custom-remodeled stent and tracheostomy tube placement to allow ventilatory support. Efficient MV with no residual air leaks was obtained in all cases. One patient died 6 weeks after the procedure due to COVID-19 lung damage. Two patients have completely been weaned from MV. This multistep procedure could be used to maintain ventilatory support in the case of ETI, working as a bridge to subsequent surgery when clinical conditions improve.

Keywords

tracheal injury, mechanical ventilation, tracheal stent, COVID-19

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Extensive tracheal injury (ETI) is a rare (0.3%-3%) but serious complication of prolonged invasive mechanical ventilation (MV).[1] Furthermore, a marked increase in incidence has been observed in patients with COVID-19 as compared with matched controls without COVID-19 and previous case series.[1] Several surgical approaches have been advocated for treating ETI, yet direct or flap surgical closure is not always feasible. Management of ETI for patients requiring prolonged MV is even more challenging, as positive pressure hinders conservative treatment and surgery is not always feasible. ETI treatment in patients with COVID-19 has not been described yet.

Materials and Methods

Between April and November 2020, 3 patients with COVID-19 who had ETI following percutaneous tracheostomies were observed in the COVID-19 intensive care unit at the University Hospital of Modena. The observed ETI ranged from tracheal necrosis (6-8 rings) to major tracheocutaneous fistula (4-6 cm in diameter) and life-threatening air leaks (**Figure 1**). All patients presented extensive pneumomediastinum and cervicofacial subcutaneous emphysema. Given the patients' clinical conditions and massive extent of injuries, surgical repair was considered unfeasible.

To sustain lifesaving MV, a multistep reasoned approach was adopted. The first step was placing a tracheal silicon stent (Novatech) by rigid bronchoscopy to re-create the necrotic tracheal wall (**Figure 2A**). The tracheal stent size was based on computed tomography scan measurement of the trachea and tracheal injury. During the same surgical session, immediately after ensuring the stability and correct positioning of the stent, an orotracheal 7.0 tube was positioned inside the stent and anchored with the cuff just above the carina to avoid selective lung ventilation. This maneuver allowed maintenance of MV and progressive reduction of pneumomediastinum, emphysema, and air

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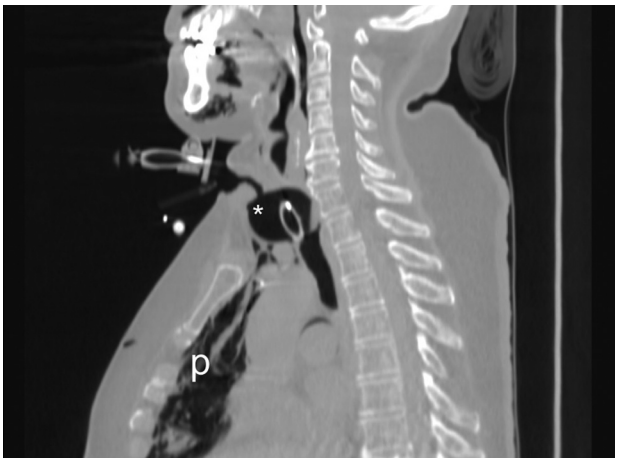

Figure 1. Computed tomography scan showing the extent of tracheal injury. *Tracheal rupture due to excessive cuff pressure. P, pneumomediastinum.

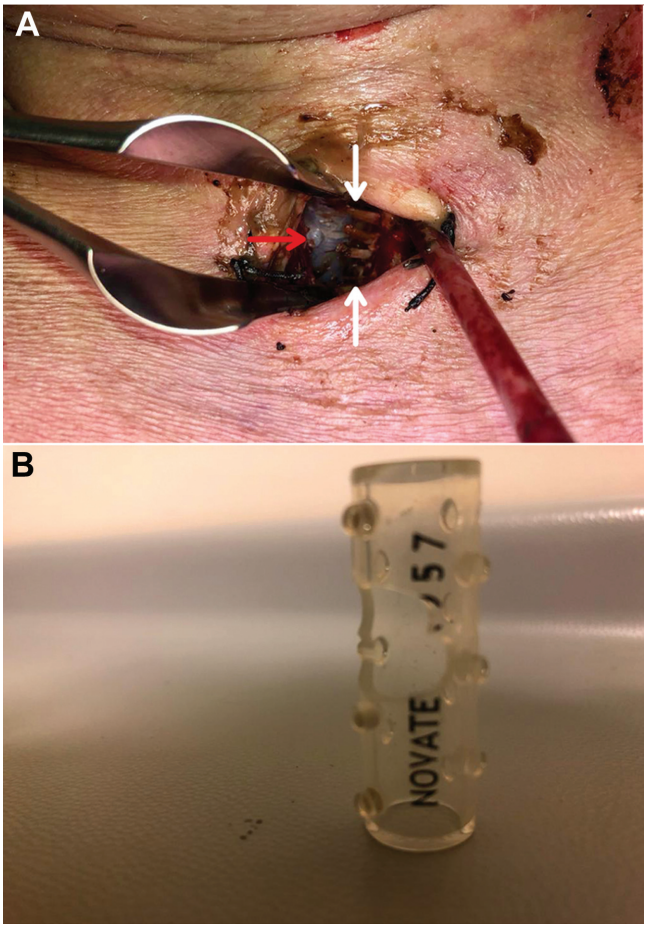

Figure 2. (A) Reconstruction of the necrotic tracheal wall with a silicone stent. White arrows, multiring tracheal rupture. Red arrow, tracheal wall reconstruction with tracheal stent. (B) Silicone stent fenestration.

leaks while stabilizing ventilatory parameters. The second step was to create a stent fenestration through the tracheal stoma (**Figure 2B**). A tracheostomy tube (Rüsch Ultra Tracheoflex 7.0; Teleflex Medical) was inserted through the fenestration and cuffed over the carina under flexible bronchoscopy guidance. The result was an efficient MV with no residual air leaks in all patients (**Figure 3**). Our hospital ethics committee (Comitato Etico Area Vasta Emilina Nord) does not require approval for anonymized retrospective chart reviews.

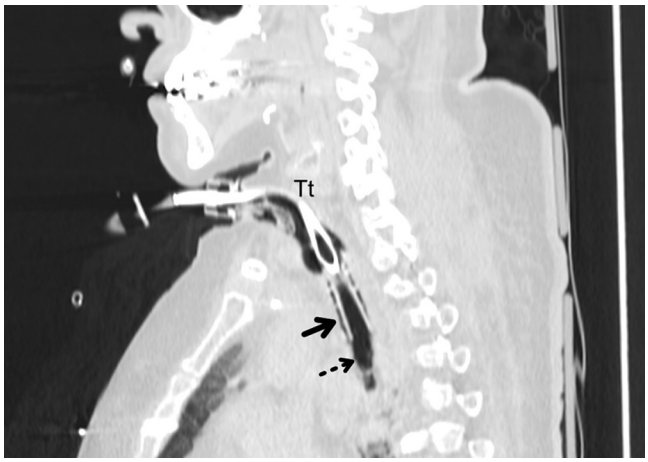

Figure 3. Computed tomography scan showing the tracheostomy tube through the fenestrated silicone stent. Tt, tracheal tube. Black arrow, tracheal wall reconstruction with tracheal stent. Dotted arrow, tracheal tube cuff placed above the carina to avoid selective ventilation.

Results

One patient died 6 weeks after the procedure due to COVID-19 lung damage. The other 2 patients have been completely weaned from MV but maintain the fenestrated stent with the tracheal tube and are candidates for tracheal reconstruction surgery.

Discussion

Tracheostomy is largely performed on patients presenting with acute respiratory failure (ARF) requiring prolonged MV to facilitate weaning, reduce breathing effort, and curb complications due to extended intubation. Although the optimum timing of tracheostomy in patients with COVID-19 and ARF remains controversial, the current trend is to anticipate the procedure within the first 2 weeks of MV.[2] Even though ischemic lesions are common in critically ill patients, full-thickness lesions are rare complications of prolonged MV. In a recent cohort study, tracheal injuries associated with life-threatening complications occurred in almost half of patients with COVID-19 treated with prolonged MV, with a marked increase in incidence as compared with matched controls and previous case series.[3] Risk factors include hyperinflation of the tracheal cuff (>30 cm H_2O), arterial hypotension, hypoxemia, and inflammation.[4] Furthermore, increased tracheal wall pressure by pronation maneuvers, high dose of systemic steroids, a hypercoagulable state related to COVID-19, mucosal weakening by high viral replication, and tracheal mucosa hypoxic damage have been proposed as factors that might explain this higher incidence.[3] Although surgical treatment is

associated with high rates of mortality and morbidity, ETI in patients with ARF who underwent MV requires aggressive management. Even though a shared definition of ''extensive'' tracheal injury does not exist, full-thickness tracheal loss >3 cm and tracheal necrosis involving >3 rings may both fall within the definition. We previously described a case report of a wide tracheocutaneous cuff-induced fistula treated by selectively intubating both main bronchi and adding a Y-shaped bridge for ventilator connection.[5] However, this procedure poses the risk of endotracheal tube misplacement and bronchial rupture and is indicated as an extreme attempt in selected cases where a short period of MV is required.

Although the present technique was developed to treat tracheal injuries in patients with COVID-19, we believe that this multistep approach could be extended to every ETI where a tracheal stent could work as a bridge to subsequent surgery when clinical conditions improve. In our experience, silicone stents are preferable to self-expanding stents for several reasons. First, in patients who require prolonged MV, the silicone stent allows a fenestration, which is useful for the positioning of a tracheal cannula. Second, metallic-nitinol self-expanding stents are associated with more extensive granulations and with potential risks of injury during stent removal. Stent treatment strategy in tracheal lacerations aims at adequately covering the wall damage, leading to full healing of the trachea, which allows removal of the prosthesis. To this aim, silicone stents are easily removable and present fewer risks of tracheal injury. Guidelines on timing for stent removal are lacking, but previous reports and our experience suggest that 5 to 6 weeks are sufficient for satisfactory healing of most tracheal tears.

Conclusion

To the best of our knowledge, this is the first study showing the management of ETI in patients with COVID-19 who require prolonged MV in an intensive care unit setting. Under extreme conditions, this multistep procedure could be used to maintain ventilatory support in case of ETI. Large case series should help to delineate alternative solutions in this life-threating scenario.

Author Contributions

Francesco Mattioli, study concept, study design, manuscript review; **Andrea Martone,** study concept, manuscript draft and editing; **Alessandro Andreani,** study design, data acquisition, manuscript review; **Gaia Cappiello,** data acquisition and analysis, manuscript draft; **Roberto Tonelli,** manuscript editing and review; **Enrico Clini,** study design, manuscript review; **Alessandro Marchioni,** study concept, manuscript editing and review.

Disclosures

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Informed Consent

Informed consent was given for publication.

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