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Case Report

Iatrogenic Tracheal Injury During Endotracheal Tube Exchange in a COVID-19 Patient: A Case Report

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Abstract

Background: The coronavirus disease 2019 (COVID-19) pandemic has increased the need for prolonged intubation, mechanical ventilation in prone positioning, and high-dose steroid usage. Though a rare complication of mechanical intubation, tracheoesophageal fistulas (TEFs) are severe and life-threatening.

Case Report: We present a patient with COVID-19 pneumonia who developed an iatrogenic TEF suspected to have been acquired during traumatic reintubation. After optimizing her for surgery, management of the TEF included tracheostomy tube placement at the distal end of the tracheal injury and stent placement over the defect. Computed Tomography scan later showed migration of the stent into the esophagus that required removal. Despite receiving supportive therapy, the patient declined in status and passed away shortly after.

Conclusion: By increasing demand for prolonged mechanical ventilation, complicating intubations amid fears of transmission, and potentially causing inflammatory tracheal damage, COVID-19 creates heightened obstacles to intubation that may put patients at risk of acquiring tracheal injuries. Increased awareness of possible tracheal injuries should be made by considering the many risk factors.

Keywords: Tracheoesophageal fistulas, tracheal injuries, tracheal inflammation, endotracheal tube exchange, COVID-19, neutrophil extracellular traps (NETs), Case Report

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Background

The coronavirus disease 2019 (COVID-19) pandemic has triggered an unprecedented rise in the incidence of acute respiratory distress syndrome (ARDS) requiring prolonged intubation and mechanical ventilation. Occurring in 0.3-3% of patients on chronic mechanical ventilation, tracheoesophageal fistulas (TEF) are a rare, but severe complication [1]. Iatrogenic TEFs are predominantly caused by elevated endotracheal tube (ETT) cuff pressure (>22 cm H2O) as well as high-volume low-pressure ventilation, prolonged intubation and proning, errant placement of ETTs, and stylus penetration [2-5]. TEFs can result in pneumomediastinum, pneumothorax, subcutaneous emphysema, hemorrhage, dysphagia, and death. Diagnosis is commonly made with the combination of thoracic imaging studies and endoscopy. In patients who are not sedated or ventilated, a barium esophagram can show contrast moving through the fistula and into the airway. In sedated and ventilated patients, a CT scan of the chest can evaluate for TEFs and demonstrate their etiology, such as an overinflated endotracheal cuff [2, 6-8].

There are several approaches to the management of iatrogenic TEFs. Patients should be preoperatively optimized with intensive supportive therapy including tracheostomy distal to the TEF with <22 mmHg cuff pressure, weaning from mechanical ventilation, parenteral nutrition, gastric decompression, aspiration and pneumonia preventative measures, and in the event of a pneumothorax, chest tube drainage [1,3]. Endoscopic management via esophageal and/or tracheal stents has lower morbidity and mortality compared to surgical interventions [9]. Because stents do not provide an airtight seal around the TEF, aspiration can still occur. Self-expanding metal stents (SEMS) have shown variable degrees of success for endoscopic TEF closure ranging between 67-100% [9]. Complications associated with SEMS include migration, aspiration, cough, dysphagia, perforation, pneumonia, tracheal compression, and chest pain [9]. Stent migration frequency has been shown to reach as high as 40% [9]. Newer techniques with limited studies include the usage of fibrin adhesive, endoscopic clips, ASD occluder devices in cases with extensive fibrosis, and endoluminal vacuum-assisted closure (EVAC) with a polyurethane sponge in the fistula lumen to accelerate closure [9]. Although endoscopic techniques are less invasive, only surgical repair provides definitive treatment. Surgical TEF repair has high morbidity and mortality due to its complexity; however, definitive fistula closure occurs in about 90-95% of cases, yielding excellent long-term outcomes [1].

We aim to highlight potential high-risk intubation techniques and endogenous changes to the trachea conferred by COVID-19 that, in conjunction, may increase the risk of developing tracheal injuries as well as outline different techniques in proper TEF management. We present a 56-year-old woman with COVID-19 who sustained an iatrogenic TEF during endotracheal tube (ETT) exchange with a bougie stylet.

Case Presentation

A 56-year-old woman with a past medical history significant for hypertension, diabetes mellitus, hyperlipidemia, and morbid obesity (BMI 52.23 kg/m2) presented as a transfer from an outside hospital for evaluation of a presumed TEF. The patient had no smoking history or chronic obstructive pulmonary disease. She had presented to the outside hospital with dyspnea in the setting of known COVID pneumonia. She was initially treated with a course of dexamethasone 6 mg intravenously daily for a total of 10 days but declined treatment with Remdesivir and convalescent plasma due to personal preference. On hospital day three, she developed ARDS requiring intubation with prone positioning for multiple days. Eleven days after intubation, she was noted to have a persistent cuff

leak and the decision was made to exchange the ETT with a bougie stylet. During the procedure, the patient became hypoxic and developed a left-sided tension pneumothorax, which was resolved by chest tube placement. Despite ETT exchange, the patient continued to have a persistent cuff leak and frothy oral secretions. Bedside bronchoscopy performed five days after the exchange revealed a linear tear in the posterior tracheal wall, exposing the orogastric (OG) tube. Additionally, there was another tracheal tear on the anterior tracheal wall midway between the larynx and carina. The ETT was advanced past the area of trauma and positioned 23 cm at the lip. The patient's hospital course was also complicated by multi-organ system failure.

Upon transfer to our facility, she remained critically ill with multi-organ failure, including circulatory failure requiring hemodynamic support, renal failure requiring continuous renal replacement therapy (CRRT), new onset anemia suspected to be due to a gastrointestinal bleed, and methicillin-resistant staphylococcus epidermidis (MRSE) bacteremia. Due to concerns of mediastinitis secondary to TEF and ongoing pneumonia, broad-spectrum antibiotics including vancomycin, piperacillin/tazobactam, and micafungin were continued. Cisatracurium was administered to prevent migration of the ETT and thus, worsening of the tracheal tear. She underwent bronchoscopy through the ETT where a 2.5 cm TEF was observed posteriorly at 5 cm above the carina and 1.5 cm below the vocal cords (Figure 1). Neck CT scan showed an overly insufflated balloon of the ETT, causing displacement and deformity of the esophagus (Figure 2).

It was determined by thoracic surgery that she was not a surgical candidate due to her ventilator requirements and comorbidities. Additionally, due to the proximal position of the fistula that was less than 2 cm distal to the upper

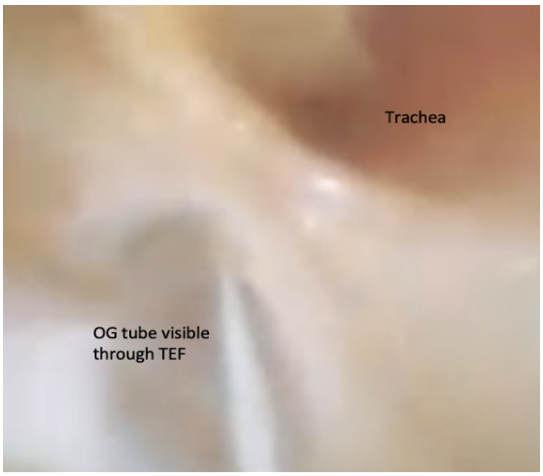

Figure 1: A large tracheoesophageal fistula is visualized in the posterior trachea with an orogastric tube seen in the esophagus.

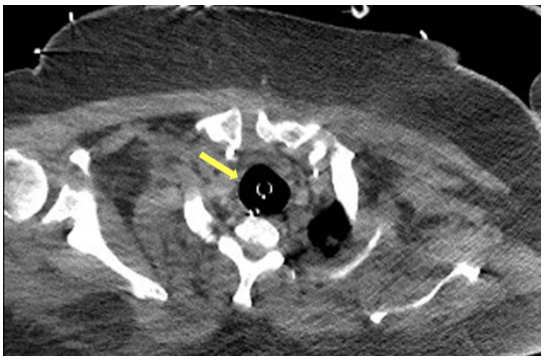

Figure 2: An overly insufflated endotracheal tube balloon causing displacement and deformity of the esophagus.

esophageal sphincter, an esophageal stent could not be placed. Multidisciplinary discussions were held, and it was decided to proceed with tracheostomy placement below the fistula followed by covered metal stent placement above the tracheostomy tube (Figure 3).

On ICU day four, the patient underwent veno-venous extracorporeal membrane oxygenation (V-V ECMO) via the right internal jugular vein with a 27-French Avalon Elite cannula to optimize ventilatory and oxygenation support for surgery. With a multidisciplinary team, a #6 Shiley™ (Minneapolis, MN) tracheostomy tube was placed at the distal end of the tracheal injury and a 16X40 mm Merit Medical

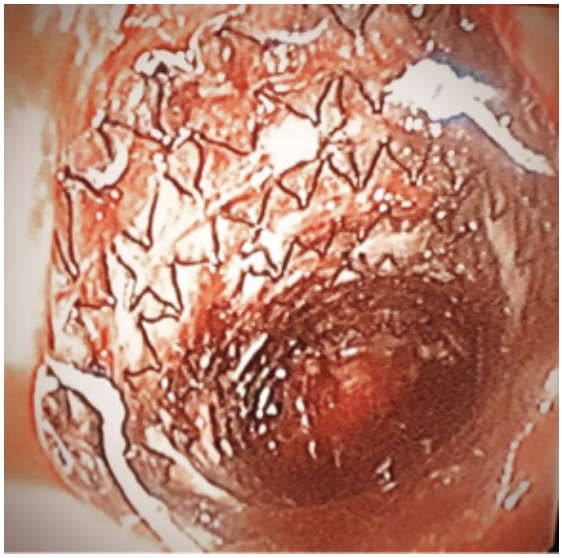

Figure 3: 16x40 mm metal stent visualized covering the tracheoesophageal fistula.

Endotek® (South Jordan, UT) fully covered tracheal self-expanding metal stent was placed to cover the defect. On postoperative day (POD) two, a CT scan showed migration of the tracheal stent into the esophagus as well as complete left lung collapse requiring bronchoscopy (Figure 4). On POD three, four attempts were made to remove the stent, leading to stent migration in the caudad direction by approximately 2 cm. Increased edema in the already edematous trachea and mild bleeding were noted, prompting termination of the procedure. A second attempt was made on POD four with successful stent removal as well as clearance of multiple clots in the mouth and upper airway. On the evening of POD five, the patient had significantly decreased tidal volume on the ventilator.

Despite being on V-V ECMO, her hemoglobin-oxygen saturation decreased to the 70s and she developed worsening acidosis with increased pressor requirement. Her family was notified of her decline in status and poor prognosis and the family decided to change the patient's code status from "do not resuscitate" to "comfort care" only. The decision was made with the family to wean off pressors and turn off V-V ECMO. The patient passed away shortly thereafter. Primary cause of death was respiratory failure followed by TEF and traumatic reintubation with underlying COVID-19 pneumonia.

Discussion

The existing literature suggests several risk factors associated with tracheal injuries in COVID-19 patients, including morbid obesity, high-dose steroid therapy, prolonged mechanical ventilation with prone positioning, and multiple intubations [6-7, 10]. Furthermore, in emergent situations and amid fears of transmission, intubations are likely done expeditiously with larger ETTs, overinflated cuffs, and less suctioning to minimize aerosolization [11]. Though critical to patient care, high-dose steroid therapy can interfere with tissue healing [12]. Additionally, prone positioning can augment pressure on the tracheal wall and dislodge the ETT. A study of 132 patients found that almost half had ETT migration $\geqslant$ 10 mm after supine-to-prone position change [13]. Overinflating cuffs and utilizing larger ETTs can also place increased pressure on the tracheal mucosa [3, 11].

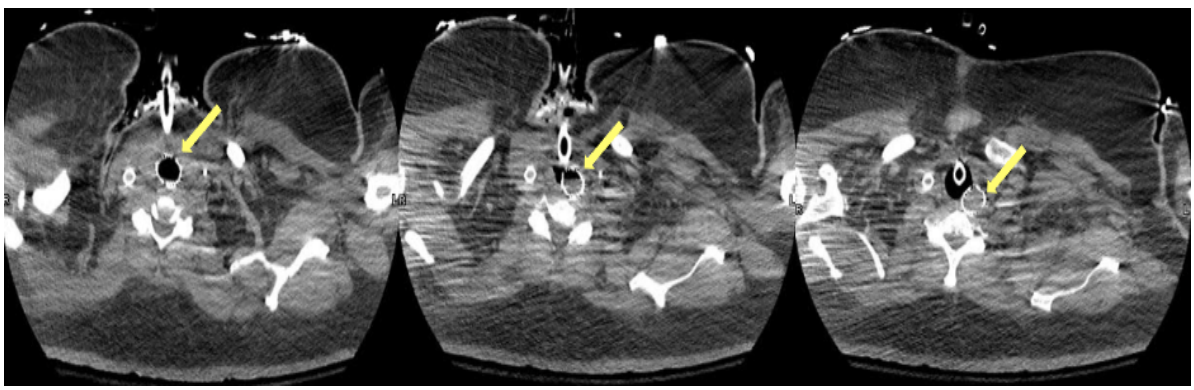

Figure 4: CT scan showing migration of the tracheal stent into the esophagus.

Less suctioning of especially thick mucus can lead to airway occlusion and hypoxia[11]. Furthermore, repeated and rushed intubations can result in rough and erroneous placement of the ETT[11]. Lastly, improper selection of tools during the ETT exchange (bougie stylet as opposed to an ETT exchanger such as a Cook catheter) can lead to mucosal wall trauma and perforation.

In COVID-19 patients, high-risk intubation techniques and endogenous changes to the trachea together may impose an even greater risk of developing tracheal injury. A randomly controlled trial found that COVID-19 patients experienced greater incidence of pneumomediastinum, pneumothorax, subcutaneous emphysema, and TEF than non-COVID patients despite matching by age, sex, and duration of mechanical ventilation[12]. This discrepancy may be attributed to the disease's several endogenous changes. Specifically, COVID-19 patients present with increased tracheal-laryngeal edema, thicker mucus secretions, and hypercoagulability conducive to hemorrhage, predisposing them to difficult intubations and airway obstruction[10-12, 14-16]. The increased edema and mucus secretions can potentially induce tracheal stent migration. The observed edematous nature can be attributed to COVID-19 binding angiotensin-converting enzyme 2 (ACE2) receptors found on ciliated respiratory epithelia. These cells range in density in the airway, which may explain why COVID-19 patients are distinctly edematous in the subglottis, trachea, and lungs and only partially so in the supraglottis[17]. Further, patients in two case reports with COVID-19 who underwent mechanical ventilation had profound ulceration of the epiglottis and subglottis, edema, and granulation of the subglottis and upper trachea, as well as tracheal narrowing[17]. The ulceration, a condition distinct to COVID-19 termed laryngotracheitis, persisted despite the patients' clinical improvement and resolution of COVID-19 by clinical, radiologic, and bronchoscopic standards[17]. These factors in summation rendered intubation/extubation nearly impossible[17]. Finally, COVID-19 patients can also progress to cytokine storm syndrome, as evidenced by notably elevated levels of neutrophil extracellular traps (NETs) in tracheal aspirate and lung tissue[18]. In vitro, high viral replication was found to induce NET release, causing epithelial apoptosis and weakening of the lung tissue[18]. An important mediator of tissue damage in inflammatory diseases, NETs are suspected to play a role in the detrimental pathophysiology of COVID-19. Further research is needed to determine if NETs also trigger apoptosis in tracheal epithelium.

Contrary to the observed ulceration, edema, and granulation found in the trachea and elevated NETs in tracheal aspirate and lung tissue, a single-center study found no difference in histological findings of tracheal samples between COVID-19 patients and non-COVID-19 patients undergoing mechanical ventilation[19]. The minor difference suggested that tracheal inflammation can be attributed to mechanical irritation and cuff pressure rather than COVID-19 disease-specific pathogenesis. The contradictory data found in these three studies highlights the importance of observing COVID-19's effect on tracheal tissue in a large, multi-center study. This crucial research could inform necessary changes to our current practices in airway management to ensure patient safety during the COVID-19 pandemic.

Conclusion

The COVID-19 pandemic complicated this patient's TEF management due to heightened concerns for infection control and underlying inflammatory risk factors that may have led to poorer prognosis and subsequent decline in status. ETT migration, exacerbated by inflammatory tracheal edema, is suspected to have caused the persistent cuff leak and potentially increased the risk for tracheal injury during airway manipulation and ETT exchange. This patient's susceptibility to

acquiring an iatrogenic TEF was further exacerbated by the several risk factors highlighted in the current literature including her debilitating COVID-19 infection, prolonged intubation, prone positioning, dexamethasone regimen, and elevated ETT cuff pressure. These risk factors may in summation make the patient's tracheal tissue more friable and inflamed. Given the rigid nature of a bougie, we can infer that her bougie-guided ETT exchange may have contributed to this patient's TEF. Despite receiving supportive therapy before minimally invasive tracheal stent placement, the patient still passed away.

COVID-19 confers endogenous changes to tracheal tissue and complicates airway management, creating heightened obstacles to intubation that may put patients at risk of acquiring tracheal injuries. It is imperative to remain vigilant in preventing tracheal injury by being cognizant of its many risk factors as well as staying well-informed of the options for management. These tracheal injuries should be recognized and diagnosed promptly in order to prevent possible adverse outcomes.

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