COVID-19-related Post-intubation Tracheal Stenosis

Early Experience With Surgical Treatment

Luis F. Tapias, MD, Michael Lanuti, MD,* Cameron D. Wright, MD,* Tiffiny A. Hron, MD,† Amy Ly, MD,‡ Douglas J. Mathisen, MD,* and Harald C. Ott, MD**✉

(*Ann Surg* 2022;275:e271–e273)

The global coronavirus disease 2019 (COVID-19) pandemic has caused >90 million infections by January, 2021.[1] Reports from areas heavily affected by COVID-19 early in the pandemic like New York City and Lombardy, Italy, showed that ~18% of hospitalized patients required admission to an intensive care unit (ICU), and that 79% to 88% of critically ill patients required endotracheal intubation and mechanical ventilation for a median of 18 days.[2,3] However, patients who survived COVID-19 critical illness did so after an even longer course, receiving a median of 27 days of invasive mechanical ventilation.[2]

It has long been recognized that prolonged endotracheal intubation can result in tracheal stenosis or malacia secondary to injury from endotracheal tube cuffs.[4] Additionally, patients who receive a tracheostomy can develop tracheal stenosis at the level of the tracheal stoma. Post-intubation tracheal stenosis can be successfully corrected by tracheal resection and reconstruction in the vast majority of patients.[5] The large number of patients subjected to prolonged invasive mechanical ventilation in the setting of the COVID-19 pandemic is expected to result in a significant number of patients with chronic airway problems secondary to post-intubation lesions. The purpose of the present report is to review our early experience in patients who presented with post-intubation tracheal stenosis after surviving COVID-19 critical illness.

METHODS

The present study consisted of a retrospective review of all patients receiving treatment from April 2020 until December 2020 at the Division of Thoracic Surgery at Massachusetts General Hospital of post-intubation tracheal stenosis after documented SARS-CoV-2 infection with critical illness requiring invasive mechanical ventilation. All patients with suspected or documented post-intubation tracheal stenosis were evaluated with computed tomography (CT) of the neck and chest and bronchoscopy. Definitive surgical treatment consisted of resection of the stenotic segment of airway with primary end-to-end anastomosis for reconstruction. Our institutional technique has been described in detail elsewhere.[5] The end-to-end anastomosis was performed with interrupted, lubricated, 4–0 polyglactin 910 (Vycril; Ethicon, Sommerville, NJ). All anastomoses were covered with a strap muscle flap.

From the *Division of Thoracic Surgery; †MGH Center for Laryngeal Surgery and Voice Rehabilitation; and ‡Department of Pathology, Massachusetts General Hospital, Boston, MA.
✉hott@mgh.harvard.edu.
The authors report no conflicts of interest.

ISSN: 0003-4932/21/27501-e271
DOI: 10.1097/SLA.0000000000004884

RESULTS

We identified 4 patients with COVID-19-related post-intubation tracheal stenosis. There were 2 males and 2 females. Ages ranged from 33 to 70 years. All patients had documented infection by SARS-CoV-2 and required hospitalization and admission to an ICU at different outside institutions due to progressive hypoxemic respiratory failure, requiring invasive mechanical ventilation for 10 to 22 days. Two (50%) patients received a tracheostomy. Patients developed respiratory symptoms within 2 to 4 weeks after discharge from their index hospitalization presenting with stridor and progressive shortness of breath. Both patients that required a tracheostomy presented for evaluation due to inability to decannulate or tolerate capping of the tracheostomy.

All patients had been evaluated by an Ear, Nose, and Throat specialist before referral to our center. Two patients (50%) had documented vocal cord abnormalities. Two (50%) patients underwent multiple bronchoscopic interventions before referral to our center (eg, dilatation, laser, mitomycin C injection). The stenosis was localized to the subglottic space in 3 (75%) patients, whereas it was in the distal cervical trachea (~4 cm below the vocal cords) in the remaining patient (Fig. 1A and B). Length of the stenotic segment ranged from 1.5 to 4 cm. The observed tracheal lesions presented different morphologic patterns, including cicatricial stenosis, segmental tracheomalacia, and presence of granulation tissue resulting in minimal airway diameters ranging from 4 to 9 mm.

One frail elderly female patient with multiple comorbidities presented with an indwelling tracheostomy and underwent bronchoscopic dilatation with placement of a 9 mm T-tube to restore her voice and as a bridge to definitive surgery. All patients underwent single-stage corrective surgery. Two patients underwent tracheal resection with a trachea-trachea anastomosis (Fig. 1C), whereas the other 2 patients underwent laryngotracheal resection with partial excision of the anterior cricoid cartilage and cricoid-trachea anastomosis. All patients were extubated in the operating room, none required noninvasive mechanical ventilatory support postoperatively. All patients underwent a surveillance bronchoscopy ~7 days after surgery. One (25%) patient had mild ischemic changes on the anterior mucosa of the anastomosis on postoperative day 7. This was the first patient having surgery for COVID-19-related tracheal stenosis in our institution, and given the uncertainty of a different biological behavior of the anastomosis when compared to non–COVID-19-related tracheal stenosis, the patient was started on adjuvant hyperbaric oxygen therapy (HBOT) to assist with anastomotic healing based on our previous experience.[6] Among 483 patients who underwent tracheal or laryngotracheal resection at our institution between 2007 and 2018, HBOT was used in 23 (4.8%) patients to facilitate healing of the airway anastomosis. Repeat flexible bronchoscopy on postoperative day 11 demonstrated a stable and healed anastomosis (Fig. 1D). Final follow-up bronchoscopy on postoperative day 59 demonstrated a normal airway

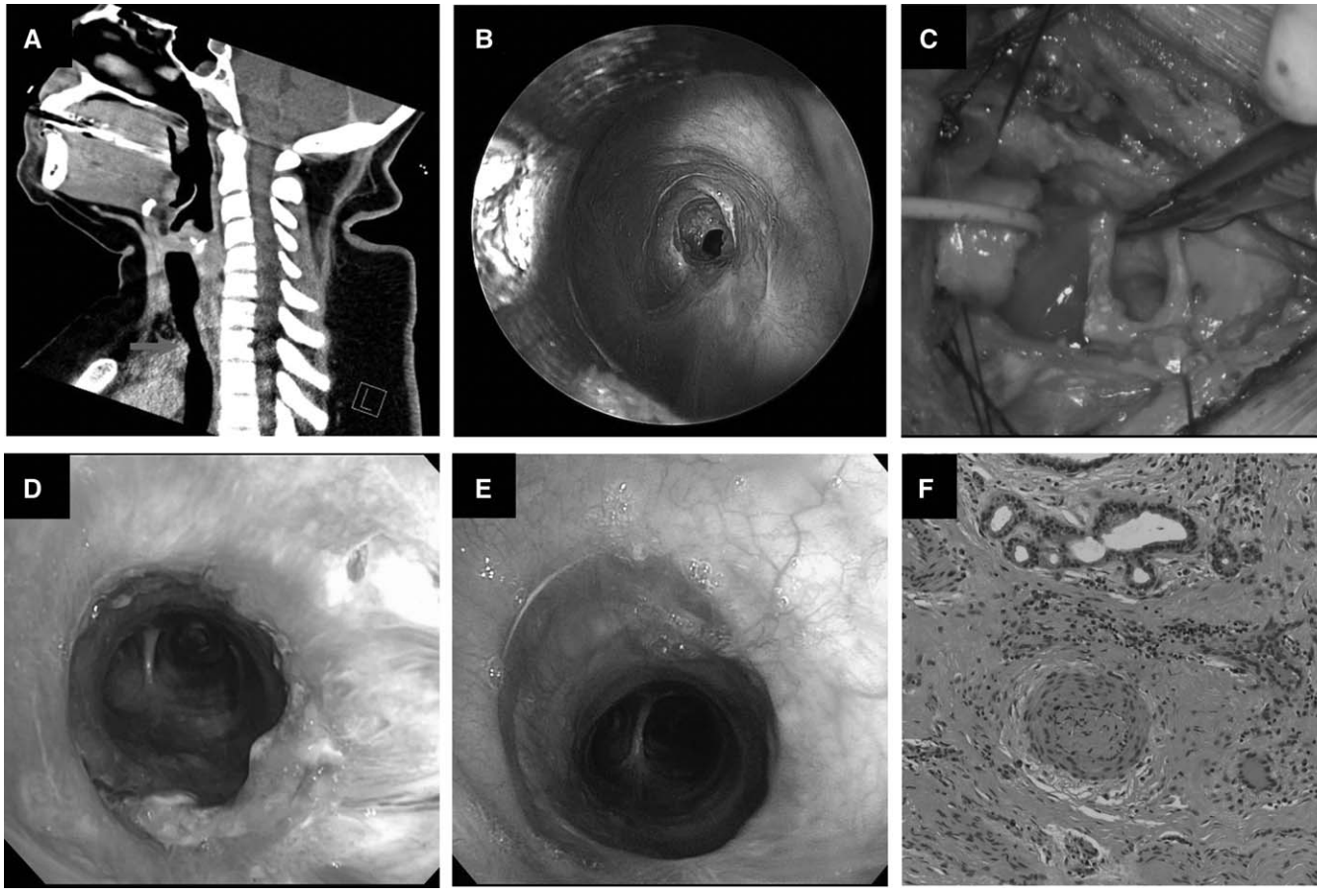

FIGURE 1. A 33-year-old female with COVID-19-related post-intubation tracheal stenosis. A, Sagittal computed tomography image showing stenosis of the distal cervical trachea (red arrow). B, Bronchoscopic appearance of the stenosis. C, Intraoperative photo after resection of the stenotic tracheal segment with restoration of normal airway diameter, followed by primary anastomosis. D, Postoperative result 7 days after surgery with a patent airway. E, Bronchoscopic appearance ~8 weeks after surgery. F, Pathologic section of the tracheal wall at the site of the stenosis showing multiple microthrombi and dense fibrous scarring.

without healing abnormalities (Fig. 1E). All other patients recovered without complications.

Histopathological examination of the resected airway demonstrated typical findings of post-intubation tracheal injury including mucosal ulceration, squamous metaplasia, stromal fibrosis, mixed acute, and chronic inflammatory infiltrates. One case (the same patient who received HBOT) exhibited several vascular microthrombi in the area of tracheal stenosis (Fig. 1F), although unequivocal viropathic changes consistent with previous reports of COVID-19-related injury were not identified.[7]

DISCUSSION

Prolonged endotracheal intubation and mechanical ventilation have long been recognized to result in injuries of the subglottic larynx and trachea that result in chronic respiratory symptoms and limited functional capacity.[4] These lesions were increasingly recognized after the poliomyelitis epidemics of the mid-20th century, when positive pressure ventilation was popularized.[8] In Spain, a prospective study of 654 consecutive ICU patients receiving mechanical ventilation by orotracheal intubation or tracheostomy for >48 hours, was able to perform a follow up endoscopic examination 6–12 months after extubation in 280 patients.[9] Notably, there were 4 cases of subglottic stenosis (1.4%) and 9 cases of tracheal stenosis (3.2%). Of all these, 7 (2.5%) cases were considered severe. Duration of intubation and days in the ICU were prognostic factors for the development of late post-intubation airway lesions.

The large number of patients worldwide requiring prolonged mechanical ventilatory support in the setting of the COVID-19 pandemic raises the possibility of a large number of patients presenting with post-intubation tracheal stenosis in the near future. Physicians in general need to be aware of this condition and should investigate and exclude post-intubation tracheal stenosis in COVID-19 survivors who received invasive mechanical ventilation and present with persistent shortness of breath or stridor. Some series suggest that up to 4 of 5 patients with severe post-intubation laryngotracheal stenosis do not receive adequate treatment due to lack of recognition.[10] Therefore, active close follow-up of patients who survived COVID-19 critical illness is of utmost importance to identify patients with potentially correctable airway problems. Fortunately, contemporary surgical treatment of post-intubation tracheal stenosis with laryngotracheal or tracheal resection and reconstruction is curative in the majority of patients[5] and should be considered in all patients with this condition.

REFERENCES

1. COVID-19 Dashboard by the Center for Systems Science and Engineering [Internet]. 2020 [cited 2020 Jul 2]. Available from: https://coronavirus.jhu.edu/map.html
2. Cummings MJ, Baldwin MR, Abrams D, et al. Epidemiology, clinical course, and outcomes of critically ill adults with COVID-19 in New York City: a prospective cohort study. *Lancet*. 2020;395:1763–1770. Available from: http://dx.doi.org/10.1016/S0140-6736(20)31189-2.
3. Grasselli G, Zangrillo A, Zanella A, et al. Baseline characteristics and outcomes of 1591 patients infected with SARS-CoV-2 admitted to ICUs of the Lombardy Region, Italy. *JAMA*. 2020;323:1574–1581.
4. Cooper JD, Grillo HC. The evolution of tracheal injury due to ventilatory assistance through cuffed tubes. *Ann Surg*. 1969;169:334–348.
5. Wright CD, Li S, Geller AD, et al. Postintubation tracheal stenosis: management and results 1993 to 2017. *Ann Thorac Surg*. 2019;108:1471–1477.
6. Tapias LF, Wright CD, Lanuti M, et al. Hyperbaric oxygen therapy in the prevention and management of tracheal and oesophageal anastomotic complications. *Eur J Cardiothorac Surg*. 2020;57:1203–1209.
7. Barton LM, Duval EJ, Stroberg E, et al. COVID-19 autopsies, Oklahoma, USA. *Am J Clin Pathol*. 2020;153:725–733.
8. Wunsch H. The outbreak that invented intensive care. *Nature*. 2020. doi: 10.1038/d41586-020-01019-y.
9. Esteller-Moré E, Ibañez J, Matiñó E, et al. Prognostic factors in laryngotracheal injury following intubation and/or tracheotomy in ICU patients. *Eur Arch Otorhinolaryngol*. 2005;262:880–883.
10. Nouraei SAR, Battson RM, Koury EF, et al. Adult post-intubation laryngotracheal stenosis: an underestimated complication of intensive care? *J Intensive Care Soc*. 2009;10:229.