



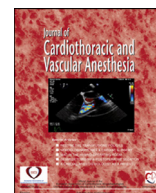
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Original Research

Airway Surgery for Laryngotracheal Stenosis During the COVID-19 Pandemic: Institutional Guidelines

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Objective: The management of laryngotracheal stenosis is challenging, as patients usually require in-time interventions. The current coronavirus disease 2019 (COVID-19) pandemic has added unique challenges to this procedure. The presence of the virus in high concentrations in the aerodigestive tract and the need for an open airway during surgery can increase the risk of aerosolization of the virus and subsequent infection of the surgical, anesthetic, and operating room (OR) personnel.

Design: Retrospective cohort study.

Setting: University hospital.

Participants: Patients who underwent airway interventions between March and October 2020.

Interventions: A protocolized strategy was initiated during the COVID-19 pandemic to facilitate the consistent management of all patients undergoing airway interventions.

Measurements and Main Results: During a seven-month period, 34 patients were managed with this policy. All threatened airways were managed successfully and no healthcare workers dealing with such procedures were infected. Priorities during the current novel coronavirus pandemic are ensuring the safety of healthcare professionals and offering urgent bronchoscopic and surgical airway interventions for patients with progressive symptoms and threatened airways.

Conclusions: Surgical and bronchoscopic management of laryngotracheal stenosis presents a unique challenge during the COVID-19 pandemic, requiring careful consideration of patient triage and the development of protocols that minimize risk to patients and healthcare professionals. Close collaboration between thoracic surgeons and anesthesiology teams is essential to safely navigate and handle these threatened airways while mitigating the risk of viral aerosolization.

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Key Words: COVID-19; airway; tracheal stenosis

CORONAVIRUS disease 2019 (COVID-19) is a viral respiratory tract infection caused by a coronavirus that was first documented in Wuhan, China, in December 2019.¹ The current pandemic has presented an unprecedented challenge for healthcare professionals and systems around the world. Healthcare systems have adapted differently in terms of COVID-19 planning of adopting infection control measures, providing regular health services, and prioritizing essential hospital services in the context of a

burning pandemic patient load and inevitable surge. The maintenance and provision of specialized thoracic surgery services in this context require good preplanning and vigilance to infection control measures across all levels.²

Airway surgeries differ from other thoracic surgeries in the current pandemic. It previously has been shown that airway interventions carry a very high risk of aerosol production and airborne-transmitted infections.³ With the current COVID-19 pandemic and the presence of the virus in the aerodigestive tract and the high rate of aerosol production in airway procedures, it is essential to consider the safety and protection of healthcare professionals involved in treating patients with laryngotracheal stenosis (LTS) in face of the in-timing interventions required by this group of patients.

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Although it is crucial to try to reduce nonurgent airway procedures to avoid the risk of viral transmission for the patients and healthcare professionals; patients with a threatened airway need urgent bronchoscopic or surgical interventions to reduce chances of asphyxiation/respiratory failure and death, but clear guidelines regarding their triage and management protocols do not exist.

Anesthesiologists and other perioperative care providers are particularly at risk when providing care for patients with COVID-19 undergoing airway surgery. This article draws anesthesia team attention and the surrounding team to the importance of appropriate precautions when providing care and intubation for these critical patients.

In this review of the authors' institutional guidelines and protocols developed for managing LTS in the COVID-19 pandemic, the authors discuss the triage of LTS stenosis patients, the different management routes according to the urgency of the procedure/viral testing, and the safety measures taken to perform the different interventions in the protocol. During a seven-month period, 34 patients were managed with this policy.

Timing of Intervention for Patients With Laryngotracheal Stenosis

The timing of airway intervention is crucial in patients with laryngotracheal stenosis. Appropriate timing can be decided after taking into account such factors as counseling the patient for symptoms, the patient's symptoms if this is a recurrent stenosis, clinical examination, anticipation of the likely progress of the disease, site of stenosis (with low tracheal stenosis, there is no way out with a tracheostomy), type of pathology (postintubation tracheal stenosis is likely to progress more than other pathologies), surgeon's expertise, operating room (OR), and staff preparation for protection. The use of all these factors can prevent the need for an emergency procedure to rescue a stenosed airway in a patient suffering asphyxiation, as this is likely to lead to a major risk to the medical team due to the high risk of aerosol production while full preparation for protection of medical staff may be suboptimal. This previously has been recommended early in the pandemic in electing to intubate patients with confirmed/suspected COVID-19 with respiratory distress early to avoid the need for emergency intubation.⁴

Optimal Approach to Patients With Laryngotracheal Stenosis

Given its high rates of recurrence in the authors' experience,⁵ they cannot see a role for repeated balloon dilation, laser/argon therapy, or stent insertion as a definitive treatment for benign postintubation tracheal stenosis in centers where specialized airway surgeons are available. Endoscopic dilation should be reserved for unfit patients or as a temporary bridge measure in nonequipped centers. In the authors' normal practice they believe that patients with LTS can have first-line laryngotracheal resection and anastomosis (LTRA) to avoid the

need for multiple dilating procedures or the insertion of a tracheostomy (Fig 1A). In the authors' experience this yields better results.⁵ In the COVID-19 era, tracheal resection and anastomosis (TRA) should not be performed in patients with a secure airway having a tracheostomy in-situ. In symptomatic patients with a threatened airway who have suspicious/confirmed COVID-19, it should be substituted by the less aerosol-producing bronchoscopic intervention until patients become negative for reverse transcriptase polymerase chain reaction (RT-PCR) severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (Fig 1B). Postponing COVID-19-confirmed/-suspected patients who potentially are operable for first-line tracheal resection and substituted with a temporary tracheal dilatation is based on the fact that the safety of the medical team is a priority and a less-invasive procedure will reduce the chances of aerosol production and viral spread. Secondly, patients who undergo major procedures with a COVID-19 infection are more prone to higher mortality rates and postoperative pulmonary complications.⁶

The rationale to avoid tracheostomy in resectable patients is based on:

- A longer segment of trachea will need to be resected for clean margins.
- A nonvirgin plane during LTRA
- A higher chance of tracheomalacia associated with prolonged tracheostomy
- A higher chance of vocal fold dysfunction
- Patients have an inhibited cough reflex, which can be associated with post-LTRA atelectasis and pneumonia.

General Safety Steps While Performing Airway Interventions in the COVID-19 Era

Although testing for SARS-CoV-2 in asymptomatic patients with no laboratory findings of the virus 48 hours before the planned procedure is essential in the authors' protocol as this may change the type of procedure offered to patients with LTS (namely a less aerosol-producing procedure), patients who have a negative test and undergo an LTRA or a bronchoscopic procedure are treated as being a possible false negative, as a single negative test may be misleading.⁷ Patients who are clinically suspicious or have laboratory findings hinting a possible SARS-CoV-2 infection have another RT-PCR before the procedure. In patients with two successive negative swabs, healthcare professionals will deal with this patient as being negative for COVID-19 infection. Otherwise, all healthcare professionals in the OR are wearing full personal protective equipment (PPE) with all necessary precautions taken.

Using barriers when managing a stenosed airway can reduce the risk of viral spread and aerosolization. This increased risk of infection can occur during use of face masks or supraglottic oxygenation, intubation, bronchoscopic manipulation and extubation.⁸

The indication for airway intervention in a patient with suspected/confirmed COVID-19 is the presence of stridor caused

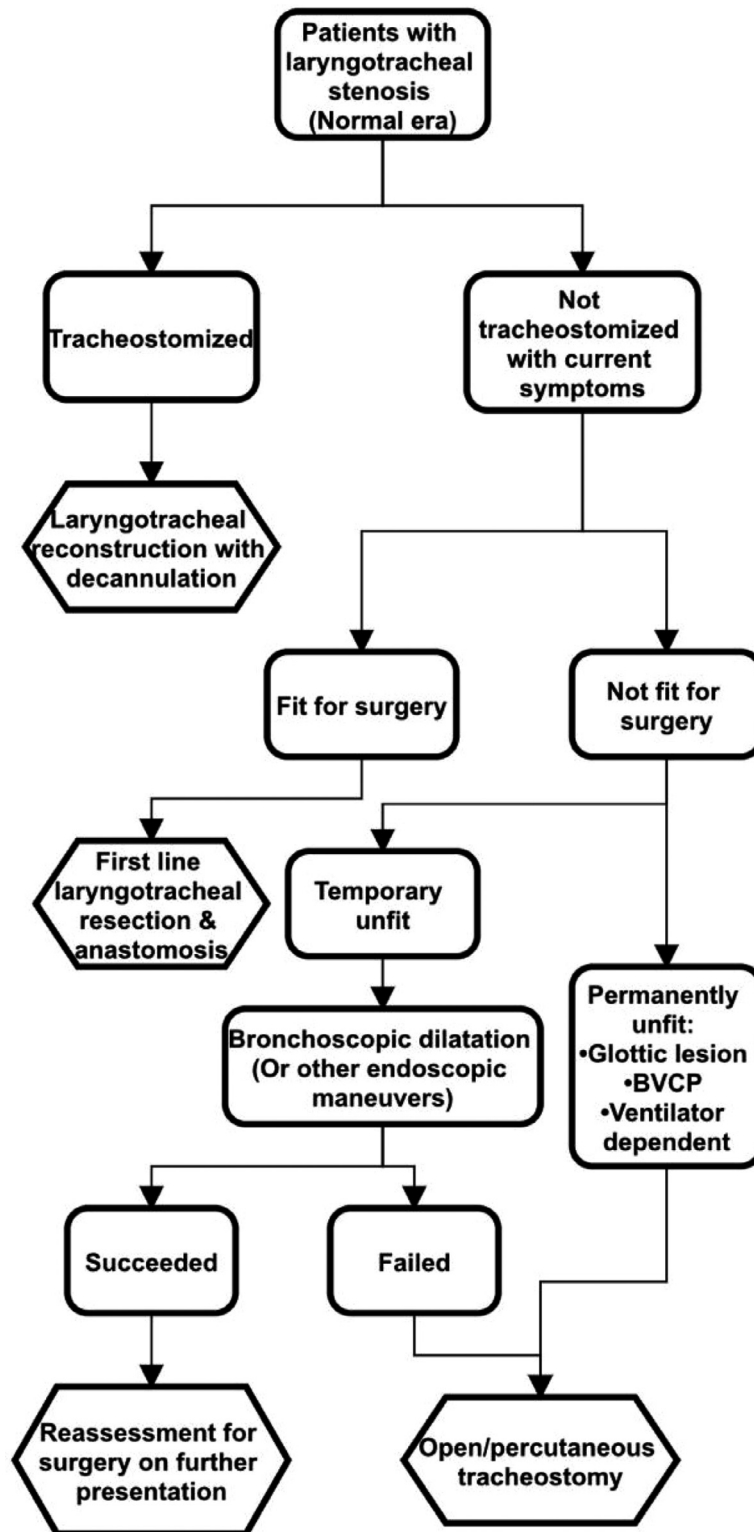


Fig 1. (A) Flowchart for management of laryngotracheal stenosis (LTS) in the normal era. (B) Flowchart for management of LTS in the coronavirus disease 2019 era. Abbreviations: BVCP, bilateral vocal cord paralysis; COVID-19, coronavirus disease 2019; LTRA, laryngotracheal resection and anastomosis; TRA, tracheal resection and anastomosis.

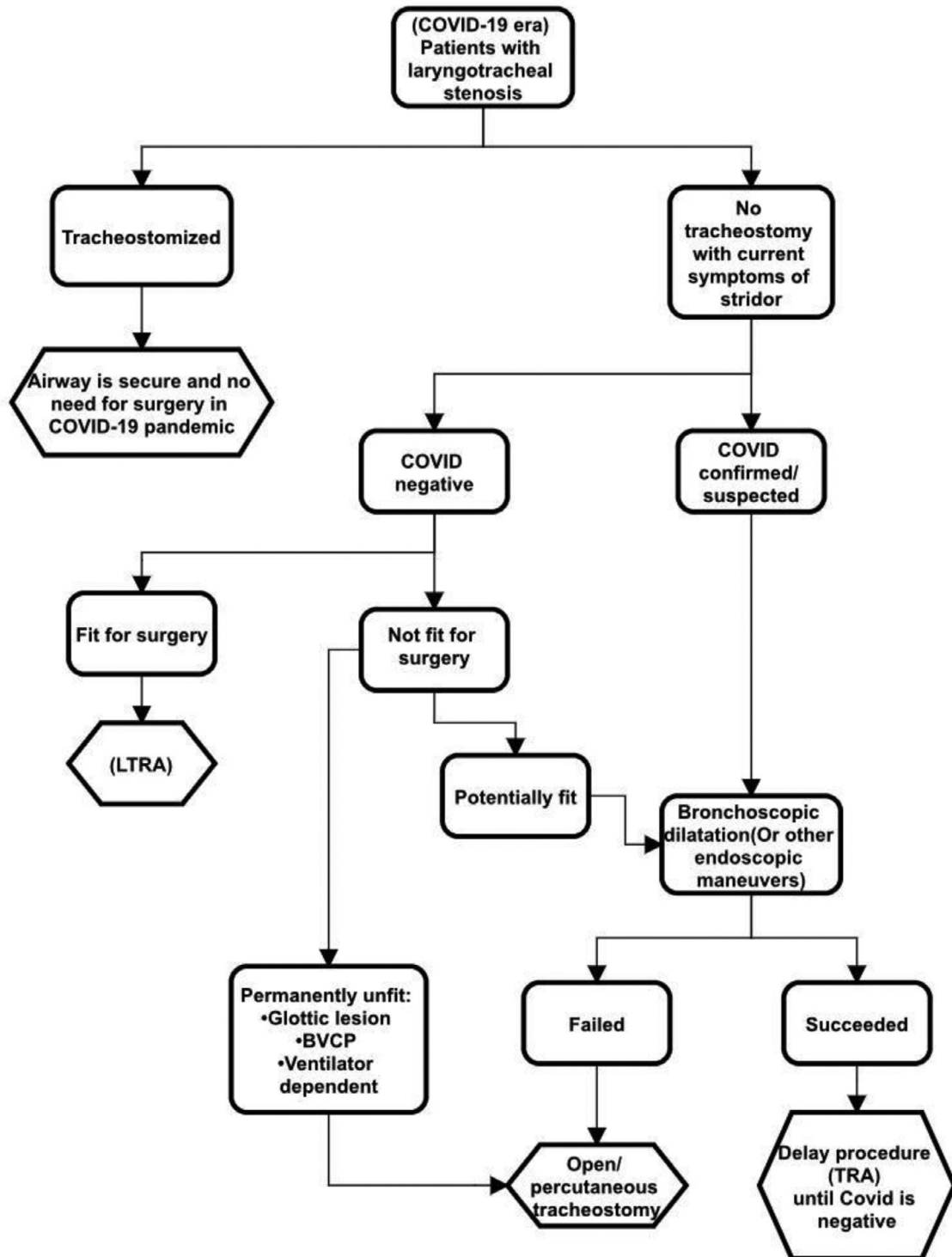


Fig 1. Continued

by a threatened airway due to tracheal/LTS in the absence of a tracheostomy. Operating on a COVID-confirmed/suspected patient should be performed in a timely and efficient manner. The most senior/experienced operator should be performing the procedure to allow a swift and satisfactory result. This is not a training environment. Communication and speaking to

people should be arranged, with the most experienced anesthetic team and scrubbing nurses to be present in the OR.

Video laryngoscopes were used mainly for managing difficult airways as they improve visualization of the glottis and increase chances of successful and first-time intubation. They also are useful training tools, as junior intubators observing

seniors can clearly visualize the path of the endotracheal tube without the need to look inside the patient's mouth. The additional benefit of keeping the physician or surgeon away from the patient's mouth in a patient with suspected or confirmed COVID-19 is invaluable.⁹

The use of viral filters in the airway circuit during airway interventions is an extra precaution that should be undertaken in the COVID-19 pandemic to reduce the chances of viral spread. This should include the airway circuit filters connected to a bronchoscopy, endotracheal tube, ventilator exhalation circuit, ambu bag, and tracheostomy (Fig 1).

A negative pressure OR, self-sterilization of all OR staff, and thorough disinfection and sterilization of the OR are protective measures that were recognized early in the pandemic, particularly in emergency surgical procedures for suspected COVID-infected patients.¹⁰

Precautions During Bronchoscopic Treatment of Laryngotracheal Stenosis

The indications for bronchoscopic dilatation/laser/argon in patients with LTS in the COVID-19 era include symptomatic fit patients who are otherwise planned for LTRA and turn out to have a positive polymerase chain reaction test to reduce the aerosol production of a laryngotracheal resection procedure. The second indication is in temporarily unfit patients who can be assessed later for surgery after securing their threatened airway (Fig 1B). During dilatation of the stenosed airway, precautions should be taken to minimize the spreading of the aerosol. A summary of precautions taken during bronchoscopic intervention for LTS is summarized in Table 1.

Precautions During LTRA and TRA for Treatment of Laryngotracheal Stenosis

The indication for performing LTRA/TRA in the current COVID-19 era is a patient who has current symptoms of a threatened airway and is not suspicious for COVID-19 infection or has a negative polymerase chain reaction testing. Nevertheless, this is a high aerosol-producing procedure, and full precautions with PPEs should be taken by all healthcare professionals in the OR (Table 1). While performing airway surgery for treatment of laryngotracheal stenosis, the following steps can help reduce the volume of aerosol spread:

- Before opening the airway, ensure the patient is paralyzed completely and ask the anesthesiologists to stop ventilation.
- Make sure the endotracheal tube is advanced with its cuff inflated beyond the stenotic segment while cutting the area required for resection.
- Once the endotracheal tube needs to be pulled proximally, disconnect the patient from ventilation and during this apneic maneuver, airway resection after airway disconnection (if the patient is tolerating hypoxemia) needs to be fast to ensure a distal airway is available.

Table 1
Mitigation of Occupational Hazards Associated With Airway Surgery During the COVID-19 Pandemic

Principle	Implementation
Personnel	<ul style="list-style-type: none"> • Minimize the number of personnel in the OR. • Require all healthcare workers in the OR to wear gowns, gloves, full face shields, and well-fitted N95 masks or PAPR.
Place	<ul style="list-style-type: none"> • Perform the procedure in a negative-pressure operating theater if possible (or using large HEPA filters). If not available, the doors must be closed and sealed with airtight tape to stop outside contamination. • Consider turning off the room's laminar flow (if present). • Ensure the presence of an antechamber or anesthetic room (for donning/doffing and for clean runner).
Communication	<ul style="list-style-type: none"> • Discuss all surgical and anesthetic plans prior to the procedure, as staff communication while wearing full PPE is suboptimal.
Operator	<ul style="list-style-type: none"> • Have the most experienced and expeditious surgeon perform the procedure, as this is not a "training environment."
Reduce virus aerosolization	<ul style="list-style-type: none"> • Use closed circuits and avoid bag ventilation. • Use intermittent apnea and maintain neuromuscular blockade throughout the procedure. • Administer glycopyrrolate during the procedure to reduce secretions and mitigate cough on extubation.

Abbreviations: COVID-19, coronavirus disease 2019; HEPA, high-efficiency particulate absorbing; OR, operating room; PAPR, powered air-purified respirators.

- Insert the endotracheal tube in the distal airway and ensure the cuff is fully inflated before resuming ventilation. A wet swab can be placed on the distal trachea as well and held in place by the second assistant through the manipulation of the proximal airway.
- If the patient becomes hypoxic, insert the endotracheal tube in the distal airway, inflate the cuff, cover the distal trachea with a wet swab, and ask the anesthesiologist to ventilate while dissection in the proximal airway is stopped and the medical team takes a step away from the operating table
- Clamp the endotracheal tube in the proximal airway to ensure no accidental ventilation is performed while working in the field.

Precautions When Performing a Tracheostomy for Treatment of LTS

The indications of a tracheostomy for treatment of LTS in the authors' normal practice and in the COVID-19 era are patients not fit for LTRA or TRA (ie, glottic lesions, bilateral vocal cord paralysis, or ventilator-dependent

Table 2
Preoperative Characteristics and Postoperative Outcome of Patients Who Underwent Surgery

	Variable	Comment
Male/female	23/11	
Median age, y (range)	27 (3-59)	
Underlying pathology	PITS = 32 ISGS = 2	
Elective/emergent cases	15 Electives 19 Emergent	
Preoperative infection with COVID-19	3/34 = 9%	Plan of intervention in all 3 patients changed from resection of the stenosed segment to bronchoscopic dilatation until turning to a negative RTPCR.
Type of intervention	Tracheal resection and anastomosis = 13 Cricotracheal resection and anastomosis = 18 Bronchoscopic dilatation only = 3 cases	
Median hospital stay, d (range)	5 (1-35)	
Mortality	One case (1/34) = 3%	A 37-year-old diabetic female who had a perioperative myocardial infarction owing to hypoxia following a failed extubation 3 days after a cricotracheal resection and anastomosis
Successful airway restoration	31/34 = 91%	One mortality One case with double-level stenosis had early anastomotic failure and required insertion of a T-tube. One case was not fit for resection after multiple bronchoscopic dilatations and had a permanent tracheostomy.
Postoperative infection of healthcare professionals with COVID-19	None	

Abbreviations: COVID-19; coronavirus disease 2019; ISGS, idiopathic subglottic stenosis; PITS, postintubation tracheal stenosis; RTPCR, reverse transcriptase polymerase chain reaction.

patients). The indication of a tracheostomy also can be on an emergency basis in a patient with a threatened airway who fails bronchoscopic dilation/laser/argon. There is no evidence of the safety of open tracheostomy versus percutaneous tracheostomy in terms of aerosol production in the COVID-19 era, and clinicians should choose the procedure with which they are more familiar and likely to perform in a shorter period.

Maintenance of a bloodless field, minimal use of diathermy, and using a smoke evacuator can all help reducing aerosol spread. Pausing ventilation during insertion of the tracheostomy tube minimizes aerosol spread. Adjunctive maneuvers, such as placing the inflated cuff of the endotracheal tube well below the tracheostomy site in surgical tracheostomy, can minimize the duration of apnea.¹¹

Angel and his colleagues¹² have proposed a novel technique for insertion of percutaneous tracheostomy to reduce the load of viral shed. Its main principle is to insert a flexible bronchoscope anterior to an endotracheal tube—not inside it—while preparing to insert the PCT. The endotracheal tube then is advanced beyond the planned stoma site and the cuff is inflated while the bronchoscope remains proximal to the stoma site for ensuring proper visualization of insertion. After the tracheostomy tube is inserted, ventilation is disconnected, the endotracheal tube cuff is deflated and pulled out while the tracheostomy is advanced, the cuff is inflated, and ventilation is resumed via the tracheostomy tube.

Outcome

During this period, 34 patients were managed with the previous policy and protocols. Twenty-two patients without a tracheostomy were managed on an elective basis with LTRA/TRA, and 12 presented with a threatened airway. No patient from the 22 cases tested/suspected for COVID-19, and three patients of 12 were suspected/confirmed COVID-19 on presentation and underwent bronchoscopic dilatation followed by LTRA/TRA three-to-four weeks after testing negative for SARS-CoV-2 virus. No postprocedure recorded SARS-CoV-2 virus infection for any healthcare professional involved in the management of all patients. Demographics and postoperative outcome of this group of patients are shown in Table 2.

Conclusions

Surgical and bronchoscopic management of LTS present a unique challenge during the COVID-19 pandemic, requiring careful consideration of patient triage and developing protocols that minimize patient and healthcare professionals' risk. A close collaboration between thoracic surgeons and anesthesiology teams is essential to safely navigate and handle these difficult airways while mitigating the risk of viral aerosolization.

Conflict of Interest

None.

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