The current COVID-19 pandemic, caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), presents significant challenges to the surgical community worldwide and the otolaryngology community in particular. The major transmission route of COVID-19 occurs through the upper respiratory tract, with high levels of virus shedding occurring in the nasal cavity.\(^1\)\(^2\) COVID-19 is typically spread by droplets, but aerosol-generating procedures (AGPs) are thought to aerosolize the virus and increase the chance of viral spread.\(^3\)\(^4\) In the international otolaryngology community, surgeons are considered to be at high risk of COVID-19 infection owing to routine inspection of the upper respiratory tract and the need to perform AGPs at both the patient bedside and in the operating theater.\(^5\)\(^6\)

In Western Australia, community transmission of COVID-19 is currently at low levels.\(^7\) There has been the opportunity to devise and refine treatment algorithms for AGPs. Worldwide, otolaryngologists have been collaborating through traditional channels, such as scientific journals; modern channels, such as webinars; and informally through applications, such as WhatsApp.

All urgent pediatric airway procedures are currently managed at a single tertiary pediatric hospital. Procedures involving the upper aerodigestive tract are considered high risk for COVID-19 transmission.\(^8\) It is important to reduce the aerosolization of respiratory secretions during airway management, and changes to our routine pediatric airway algorithm have been made with this aim.\(^9\) The current technique used for diagnostic and therapeutic microlaryngoscopy and bronchoscopy (MLB) in the operating theater in patients with unknown or positive COVID-19 status will be described. In keeping with the approach of other otolaryngology departments, all patients with unknown status are regarded as positive.\(^10\)
Institutional ethics committee approval for this project was granted by the Child and Adolescent Health Service Human Research and Ethics Committee. A waiver of consent was approved to complete the audit. The procedure used for MLB in this case series of pediatric patients with unknown COVID-19 status is described. The protocol has been documented and distributed to all theater staff, and a laminated hard copy is in the operating theater.

Diagnostic MLB with or without therapeutic intervention was performed in the same operating theater for every case. The procedures were performed by a consultant otolaryngologist. Two anesthetists and an anesthetic technician and 2 nurses made up the team in the theater. A cleaning anesthetic technician and a second circulating nurse remained outside the theater to collect anything that may have been required during the case.

The nurse was positioned on the surgeon’s right, with the endoscopy equipment, and the anesthetic team was to the surgeon’s left. All staff in the theater wore personal protective equipment appropriate for an AGP, including an N95 mask or powered air-purifying respirator, a face shield, a hooded surgical cap wrapped around the neck, an impermeable surgical gown, and double gloves.

All patients were first anesthetized with volatile gas on the operating table, and intravenous access was secured. In most cases, maintenance of anesthesia was achieved with total intravenous anesthesia. The suspension box (a polymethyl methacrylate box with 3 open sides, routinely used for suspension; Figure 1) was placed over the patient. This box and the patient were covered with a transparent plastic sheet. The sheet extended onto the scrub nurse’s trolley, at the surgeon’s right-hand side. The sheet was secured to the surgeon’s gown with drape tape at waist height. It was also secured to the operating table below the Perspex box and to the patient’s left.

The surgeon’s arms remained under the sheet at all times, with instruments passed under the sheet. The patient was visualized through the sheet and with a Hopkins rod. Indirect laryngoscopy was performed, and the glottis and subglottis were sprayed with lidocaine using a C-MAC video laryngoscope (Karl Storz). Routine MLB has been performed with a straight Miller blade and a rigid Hopkins rod lens telescope. When intervention to the supraglottic or glottic structures (supraglottoplasty or injection laryngoplasty) was planned, the patient was intubated with auffed tube as soon as practicable, and the surgeon proceeded with the intervention. Following intervention, the patients were extubated under the plastic sheet in an effort to contain aerosolized particles produced by coughing on extubation. The sheet was removed and discarded, and the child was transferred to the postanesthetic recovery unit.

Feasibility was assessed by observation of the surgeon’s ability to, first, perform a diagnostic MLB and obtain diagnostic information, and second, to perform intervention using the modified technique. Adverse events were described as intra-operative or postoperative. Intraoperative adverse events included surgical complications and anesthetic complications. Postoperative complications included unexpected postoperative reintubation, unplanned admission to the pediatric critical care unit, or unplanned return to the operating theater.

The modified MLB procedure was performed on 8 pediatric patients using the technique described (Table). Patient median (range) age was 160 days (27 days to 2 years 6 months); 5 patients were male, and 3 were female. The technique was first used March 23, 2020, and the last in the series (prior to submission for publication) was performed on April 9, 2020. All patients and their families had unknown COVID-19 status. No intraoperative or postoperative adverse events were observed. The median (range) follow-up was 24.5 (11-28) days.

### Supraglottoplasty

Two patients underwent cold-steel supraglottoplasty for laryngomalacia. Before the COVID-19 pandemic, supraglottoplasty was routinely performed with spontaneous ventilation with a Benjamin-Lindholm laryngoscope in suspension and a microscope for visualization. With the modified protocol, after the diagnostic MLB, the child was intubated with auffed endotracheal tube and placed in suspension. The supraglottis was visualized with the Hopkins rod lens telescope, which was inserted into the side port of the Benjamin-Lindholm rigid laryngoscope and held in place by an assistant (Figure 3). The operating surgeon performed a 2-handed supraglottoplasty.

### Injection Laryngoplasty

Modified MLB and filler injection (hyaluronic acid) to treat type 1 clefts were performed in 2 cases with recurrent aspiration. In both cases, following the modified MLB, the patient was intubated with auffed endotracheal tube and placed in suspension. The tube remained outside the straight laryngoscope, and the injection was performed under direct vision with the Hopkins rod.
MLB for Airway Foreign Body Retrieval

The fifth patient in the series had a clinical presentation concerning for an inhaled foreign body and underwent an emergency MLB procedure. The modified MLB protocol described was used. No airway foreign body was found. Our planned approach is to perform low-dose computed tomography scanning for all cases with a suspected airway foreign body when clinically safe, but the approach was not deemed safe in this case.

Patients With Tracheostomy

In patients with a tracheostomy, our protocol is to insert a cuffed tracheostomy tube and confirm the absence of a leak prior to surgical intervention to the larynx or suprastomal trachea. During this time, 2 other MLB procedures (one required repair of a laryngeal cleft, and the other progressed to a slide tracheoplasty) were performed without the need for this technique in patients who had tested negative for SARS-CoV-2. Both of these children presented with respiratory illnesses and a fever and therefore were qualified for preoperative testing. The patient who underwent the cleft repair already had a tracheostomy in situ, and the technique identified above was used.

Discussion

The COVID-19 era is challenging otolaryngologists to change usual practice to ensure the safety of patients and the otolaryngology team. Surgeons and their teams are challenged to consider the indications for surgery: Is the surgery an emergency or urgent procedure? Will a delay result in significant morbidity or mortality? Should alternative investigations and therapeutic options that do not involve AGPs be considered?

To reduce the risk to surgeons, the theater team, and patients, changes to surgical protocols and clinical behavior are required. It is essential that any proposed changes are discussed thoroughly with the theater team, with adequate time to prepare. When possible, a simulation of the new process takes place. The most experienced and efficient surgeon, anesthetists, and nursing team should perform the procedure. It is important to predict if any additional equipment may be required and have it available in the operating theater to reduce staff movement while a case is under way. Efficient teamwork is essential. In the case series described, procedures took two to three times longer than during usual conditions.

The technique for pediatric MLB described herein continues to evolve. Securing the plastic sheet with drape tape at 3 sides has reduced slippage, improved coverage of the patient, and made it easier for the surgeon to operate beneath it. Use of indirect laryngoscopy with a C-MAC blade for application of topical anesthesia (lignocaine) by the surgeon, under the plastic sheet, is a change from usual practice of application under direct laryngoscopic vision by the anesthetist. Over time, more instruments are being...
placed under the sheet at the commencement of the procedure to reduce the number of times the side of the sheet must be lifted during the procedure. One needs to balance the risk of transmission of SARS-CoV-2 to health care teams against the risk to the patient of delaying or heavily modifying the procedure.

With reconsideration of the surgical approach in light of specific COVID-19 infection risks, the primary aim is to reduce the spread of aerosolized respiratory secretions perioperatively and intraoperatively, while ensuring satisfactory patient outcomes. Supraglottoplasty is performed with a cuffed endotracheal tube rather than an open airway. Cold-steel therapeutic techniques are likely to be less aerosol generating than techniques using powered devices; no cases in the series required intervention with a powered instrument.

Asymptomatic virus carriage by children is not uncommon, and children provide a means of transmission to health care workers and otolaryngologists and subsequent transmission to patients and community spread. For this reason, the described technique is being used for all pediatric patients with unknown or positive COVID-19 status. Preoperative COVID-19 testing was very recently approved at the institution, and preoperative testing in patients undergoing urgent category 1 AGPs will commence. Even though this will reduce the risk to the staff involved, there is still a false-negative rate. Protocols regarding this are currently being evaluated by our institution.

Worldwide, otolaryngology departments are using and communicating practical strategies to reduce the transmission risk of COVID-19. The otolaryngological surgical community must remain flexible and willing to adapt the approach to surgical procedures as more is understood about SARS-CoV-2. International collaborations among medical professionals of all disciplines have exemplified the response to the COVID-19 pandemic, and the otolaryngology community has been at the forefront of this collaboration.

### Limitations

There are limitations to this case series study. The number of cases reported is small, and the technique will continue to evolve as more cases of MLB are performed. Outcome measures were observational, with no control group. There is a lack of representativeness and generalizability of a small, single-centered series with currently low levels of SARS-CoV-2 transmission.
Conclusions

In this small case series, we demonstrated the feasibility of use of a modified technique for pediatric MLB. By reconsidering the surgical approach in light of specific COVID-19 infection risks, this technique may help to reduce the spread of aerosolized respiratory secretions perioperatively and intraoperatively, but the technique and patient outcomes require further study.

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REFERENCES