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Best Practice Recommendations for Pediatric Otolaryngology during the COVID-19 Pandemic

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Abstract

Objective. To review the impact of coronavirus disease 2019 (COVID-19) on pediatric otolaryngology and provide recommendations for the management of children during the COVID-19 pandemic.

Data Sources. Clinical data were derived from peer-reviewed primary literature and published guidelines from national or international medical organizations. Preprint manuscripts and popular media articles provided background information and illustrative examples.

Methods. Included manuscripts were identified via searches using PubMed, MEDLINE, and Google Scholar, while organizational guidelines and popular media articles were identified using Google search queries. Practice guidelines were developed via consensus among all authors based on peer-reviewed manuscripts and national or international health care association guidelines. Strict objective criteria for inclusion were not used due to the rapidly changing environment surrounding the COVID-19 pandemic and a paucity of rigorous empirical evidence.

Conclusions. In the face of the COVID-19 pandemic, medical care must be judiciously allocated to treat the most severe conditions while minimizing the risk of long-term sequelae and ensuring patient, physician, and health care worker safety.

Implications for Practice. The COVID-19 pandemic will have a profound short- and long-term impact on health care worldwide. Although the full repercussions of this disease have yet to be realized, the outlined recommendations will guide otolaryngologists in the treatment of pediatric patients in the face of an unprecedented global health crisis.

Keywords

COVID-19, SARS-CoV-2, otolaryngology, pediatric otolaryngology

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A cluster of viral pneumonia cases associated with a novel coronavirus (2019-nCoV) was first identified in Wuhan, Hubei province, China, in December 2019 and has rapidly spread around the world, causing a global health crisis.[1] The disease was subsequently named coronavirus disease 2019 (COVID-19) by the World Health Organization (WHO). The causative agent is a novel coronavirus closely related to the severe acute respiratory syndrome (SARS) and Middle Eastern respiratory syndrome (MERS) coronaviruses and has been designated SARS-CoV-2.[2] The precise route of transmission has yet to be elucidated, but mounting evidence indicates respiratory droplets as a primary vector. Otolaryngologists are at increased occupational risk for contracting COVID-19 relative to other specialties due to high concentrations of virus in the nasal cavity, nasopharynx, and oropharynx.[3,4]

In this review, we summarize the important features of COVID-19 in children and provide best practice recommendations for otolaryngologists to provide necessary care while ensuring safety for themselves, other health care workers, and patients, taking into account the particular needs of pediatric otolaryngology patients. A summary of our recommendations is provided in **Table 1**. These recommendations are based on the best available evidence but may be subject to change given the rapid evolution of the pandemic.

Epidemiology and Clinical Characteristics of COVID-19

As of April 14, 2020, nearly 2,000,000 cases of COVID-19 have been identified worldwide, resulting in >120,000 deaths (https://coronavirus.jhu.edu/map.html). In adults, COVID-19 typically presents with cough, fever, fatigue, increased sputum

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Table 1. Summary of Practice Recommendations.

Section	Measure/Procedure	Recommendation
1	Infection control precautions	Care should be restricted to only patients with urgent or emergent needs pending further guidance from the American Academy of Otolaryngology–Head and Neck Surgery and/or control of the COVID-19 pandemic. Patients with COVID-19 may be contagious prior to the development of symptoms. CDC recommendations for infection control should be followed even for asymptomatic patients. Enhanced PPE[a] should be used for asymptomatic patients with unknown COVID-19 status when examining, instrumenting, or performing procedures involving the oral cavity, oropharynx, nasal cavity, or nasopharynx. Encounters for patients with suspected or known COVID-19 requiring examination within 3 feet should proceed only with enhanced PPE.[a]
2	Surgical scheduling and operating room management	Elective surgical cases should be postponed indefinitely pending control of the COVID-19 pandemic. Semielective and semiurgent cases may proceed following preoperative COVID-19 diagnostic testing. Urgent/emergent cases should be performed under the presumption that patients are positive for COVID-19. Enhanced PPE[a] should be used for all clinical staff for procedures involving the upper aerodigestive tract and may be considered for other surgical sites. Preoperative COVID-19 testing should be performed 48 hours prior to any planned procedure with the patient held in strict quarantine until the date of surgery. Caregivers involved in the direct care of the patient should also be tested and subjected to quarantine. If available, rapid COVID-19 testing should be repeated the day of surgery. Surgery should be delayed for patients or caregivers testing positive unless absolutely necessary, in which case enhanced PPE[a] should be used. For any case with unknown, suspected, or positive COVID-19 status, operating room staff should be limited to essential personnel (ie, attending surgeon, senior surgical resident/fellow, senior attending anesthesiologist, surgical technologist, scrub nurse) Negative-pressure operating rooms with HEPA filtration should be used for any patient with unknown, suspected, or positive COVID-19 status.
3	Airway management and diagnostic airway procedures	Enhanced PPE[a] should be used for any airway procedure, including intubation and extubation of patients with unknown, suspected, or positive COVID-19 status. Intubation of patients with unknown, suspected, or positive COVID-19 status should be performed by the most senior available practitioner using rapid-sequence intubation techniques. The use of disposable laryngoscopes and video laryngoscopes is encouraged to reduce spread of infection and maximize intubation success. High-flow nasal cannula should be avoided in the setting of unknown, suspected, or positive COVID-19 status. Fiberoptic intubation should be avoided when possible but is preferable to emergent surgical airway for patients with unknown, suspected, or positive COVID-19 status. Difficult airway should be managed per published guidelines, with the exception that extracorporeal membrane oxygenation, if available, may be preferable to emergent surgical airway for patients with unknown, suspected, or positive COVID-19 status. Emergent tracheotomy confers significant risk of virus aerosolization and should proceed with extreme caution. Enhanced PPE[a] should be used for all patients with unknown, suspected, or positive COVID-19 status. Routine surveillance direct laryngoscopy, bronchoscopy, and/or tracheoscopy should be deferred pending resolution of the COVID-19 pandemic for stable patients without airway symptoms. Patients with airway symptoms may proceed to surgery on a semielective or semiurgent basis following COVID-19 testing and the use of appropriate PPE.

(continued)

Table 1. (continued)

Section	Measure/Procedure	Recommendation
4	Interventional airway procedures, tracheotomy, and airway reconstruction	Whenever possible, preoperative COVID-19 testing should be performed prior to planned airway intervention. Elective tracheotomy should be postponed pending control of the COVID-19 pandemic. Semielective or semiurgent tracheotomy may be considered after COVID-19 testing, but the benefits of tracheotomy must be weighed against the risk of COVID-19 infection. Procedures for patients with unknown, suspected, or positive COVID-19 status should be performed with endotracheal intubation, when possible, to avoid aerosol generation. Spontaneous ventilation and repeat intubation/extubation should be minimized. Tracheotomy should not be routinely performed in patients with COVID-19. If tracheotomy is required in this setting, precautions should be taken to avoid aerosol generation. Tracheotomy patients with COVID-19 should be maintained on a closed circuit with in-line suction to reduce aerosol generation. Tracheotomy tube changes should be delayed whenever possible pending resolution of infection. If tracheotomy tube change is required, this should be performed in a negative-pressure room with HEPA filtration, and enhanced PPE[a] should be used for all personnel. Heat and moisture exchange devices with integrated hydroscopic antimicrobial filters should be used for patients with existing tracheotomies whenever possible to minimize virus particle inhalation. Airway reconstructive procedures are resource intensive and should be delayed pending availability of local resources and control of the COVID-19 pandemic.
5	Procedures involving the oral cavity, oropharynx, nasal cavity, and nasopharynx	Procedures involving the nasal cavity, nasopharynx, oral cavity, and oropharynx pose a high risk for COVID-19 due to the high viral burden in these anatomic locations and should be deferred whenever possible. Patients and caregivers should undergo preoperative COVID-19 testing whenever possible prior to surgical intervention involving the oral cavity, oropharynx, nasal cavity, or nasopharynx. Enhanced PPE,[a] with a strong recommendation for the use of PAPR, should be used for any patient with unknown, suspected, or positive COVID-19 status. The use of powered instrumentation, including microdebriders, should be limited to reduce aerosol generation.
6	Audiologic evaluation and otologic surgery	Routine newborn hearing screening and early intervention should be performed according to JCIH recommendations. Tympanostomy tube placement for unilateral otitis media with effusion should be deferred pending control of the COVID-19 pandemic. Patients with bilateral otitis media with effusion and hearing loss should be prioritized for intervention but may be deferred based on available of COVID-19 testing. The middle ear and mastoid cavity are in continuity with the upper aerodigestive tract and may contain SARS-CoV-2. Surgery involving the middle ear and mastoid should be considered high risk for virus transmission. Mastoidectomy should be deferred whenever possible. If mastoidectomy is required, enhanced PPE[a] should be used and the use of high-speed drills should be avoided. For otologic procedures requiring the use of high-speed drills in patients with unknown, suspected, or positive COVID-19 status, the use of PAPR is strongly recommended.
7	Head and neck surgery and deep neck space infections	Surgical excision of benign neck masses should be deferred pending control of the COVID-19 pandemic. Pediatric patients with solid tumors of the head and neck, including thyroid cancer, should be discussed at a multidisciplinary tumor board to decide the most appropriate treatment modality, taking the availability of local resources into account. Whenever possible, medical management of infectious conditions should be attempted prior to surgical intervention. Patients and caregivers should undergo COVID-19 testing on admission and be strictly quarantined pending test results.

(continued)

Table 1. (continued)

Section	Measure/Procedure	Recommendation
8	Craniomaxillofacial trauma	Patients requiring urgent or emergent bedside procedures, including closure of facial lacerations, should be presumed positive for COVID-19 even in the absence of symptoms. Procedures should be performed in a negative-pressure room (if available) using enhanced PPE.[a] When possible, closed reduction techniques should be used for the management of craniomaxillofacial fractures until preoperative COVID-19 testing is available. The use of high-speed drills should be avoided to reduce aerosol formation. Patients with conditions requiring urgent or emergent surgical intervention should be presumed positive for COVID-19 even in the absence of symptoms and enhanced PPE should be used.

Abbreviations: CDC, Centers for Disease Control and Prevention; COVID-19, coronavirus disease 2019; HEPA, high-efficiency particulate air; JCIH, Joint Commission on Infant Hearing; PAPR, powered air-purifying respirator; PPE, personal protective equipment; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2.
[a]Enhanced PPE for patients with unknown, suspected, or positive COVID-19 status includes an N95 respirator plus face shield or PAPR (preferred), disposable surgical cap, disposable gown, and gloves. Standard, procedure-appropriate PPE may be used for patients with confirmed negative COVID-19 testing within 48 hours of surgery, who have been subjected to strict quarantine pending test results, and who have undergone repeat rapid testing the day of surgery.

production, dyspnea, myalgias, sore throat, and chills,[5] with a median incubation period of 5.1 days and 95% of patients developing symptoms between 2.2 and 11.5 days after exposure.[6] Laboratory evaluation commonly demonstrates leukopenia; lymphocytopenia; elevated C-reactive protein, D-dimer, and lactate dehydrogenase levels; transaminitis; and decreased procalcitonin.[5] Chest computed tomography is typically abnormal, with >85% of cases demonstrating ground-glass opacities, patchy shadowing, and interstitial changes. Most cases are mild (81%), but 14% of patients develop severe disease and 5% of patients develop critical disease.[7] The initial reported overall mortality rate in Chinese patients is approximately 2.3%,[7] although some estimates predict a global mortality rate of nearly 6%.[8] The mortality rate in patients with critical disease approaches 50%.[7]

While the data regarding COVID-19 in adults are sobering, children appear relatively resistant to the disease. Although the total number of pediatric COVID-19 cases is not known due to limited testing of asymptomatic patients, in the largest global study to date of 44,672 patients, only 2% (n = 976) were <18 years of age.[7] However, the true incidence of pediatric COVID-19 may be higher because 4.4% to 28% of children are asymptomatic while an additional 51% have only mild, possibly subclinical, symptoms.[9,10] Only 5.1% of children develop severe or critical symptoms, although children <5 years of age and particularly those <1 year of age are more likely to develop severe or critical symptoms (7% and 11%, respectively).[9] Fortunately, mortality associated with COVID-19 infection remains rare among pediatric patients,[9] and the first pediatric death was only recently reported in the United States.[11] Among symptomatic patients, the presentation appears to be similar to that of adults.

Methods

Due to the rapid evolution of the COVID-19 pandemic, articles and guidelines were identified via independent searches in PubMed, MEDLINE, Google, and Google Scholar from March 23 to 27, 2020, by the first, second, and third authors. Searches were designed to identify studies that specifically described the manifestations of COVID-19 and its impact on pediatric otolaryngology using the Boolean method and relevant search term combinations. A variety of search terms were used alone and in combination, including *COVID-19, SARS, MERS, Otolaryngology, Pediatric Otolaryngology, aerosols, adenotonsillectomy, pediatric nasal obstruction, pediatric rhinosinusitis, intubation, difficult airway, tracheotomy, airway reconstruction, middle ear effusion, mastoidectomy, craniomaxillofacial trauma*, and *deep neck abscess*. Practice recommendations were developed by consensus among all authors based on peer-reviewed manuscripts and national or international health care association guidelines. Non-peer-reviewed preprint manuscripts and popular media articles were reviewed to provide up-to-date background information in a rapidly changing environment but did not serve as a basis for practice recommendations.

Discussion

1. Infection Control Precautions

It is important to recognize that asymptomatic COVID-19 patients may still be highly contagious. Asymptomatic adult carriers of COVID-19 have been reported,[12] and asymptomatic infection appears to be more common in children.[13] Thus far, there is no definitive evidence of vertical transmission from infected mothers to a fetus, although anti-SARS-CoV-2 IgM antibodies were detected in 1 infant immediately after birth.[14-16] However, there are popular media reports of COVID-19 in newborns.[17] Given the frequent asymptomatic presentation of COVID-19 in children, *all pediatric patients, regardless of age, with unknown COVID-19 status should be presumed positive until proven otherwise*.

To reduce nosocomial transmission, the American Academy of Otolaryngology–Head and Neck Surgery (AAO-HNS) currently recommends limiting care to time-sensitive and emergent problems. When patient care is required, appropriate measures

should be taken to prevent transmission from potentially infected patients to other patients or health care providers. Although the precise mechanism of SARS-CoV-2 transmission has yet to be elucidated, the primary mode appears to be via respiratory droplets and aerosols, although transconjunctival and fecal-oral transmission may also occur.[18] Social distancing and isolation have therefore become key methods of reducing viral transmission. The number of patients and caregivers present in waiting areas should be limited to the minimum number possible, and waiting area seating should be placed at least 6 feet apart to encourage separation.[19] Surgical masks should be provided to any patient with symptoms of upper respiratory infection, and consideration may be given to having all patients wear surgical masks given the prevalence of asymptomatic carriers. Health care providers should perform appropriate hand hygiene using soap and water or alcohol-based hand sanitizers containing 60% to 95% alcohol.[19]

Patient use of surgical masks is impractical for the majority of otolaryngology patient encounters, and therefore otolaryngology providers should take appropriate personal protective measures. Concentrations of the SARS-CoV-2 virus appear to be highest in the nasopharynx and oropharynx, and therefore any patient evaluation involving examination or instrumentation of or through the oral cavity, oropharynx, nasal cavity, or nasopharynx should be considered high risk for SARS-CoV-2 exposure.[4,20] We recommend the use of enhanced personal protective equipment (PPE), defined here as an N95 mask plus face shield or powered air-purifying respirator (PAPR; preferred), disposable cap, disposable gloves, and impermeable gown, when examining or instrumenting the oral cavity, oropharynx, nasal cavity, or nasopharynx of any patient with unknown COVID-19 status. This recommendation is based on Centers for Disease Control and Prevention (CDC) guidelines for the use of enhanced PPE with any procedure likely to induce coughing[19] given the inability of many children to suppress cough while being examined. Enhanced PPE must be used for any clinical encounter for a patient with suspected or positive COVID-19 status.[19]

2. Surgical Scheduling and Operating Room Management

Due to the actual and projected scarcity of hospital resources during the COVID-19 pandemic, the Centers for Medicare & Medicaid Services (CMS) and the American College of Surgeons have recommended that all elective surgeries, including dental exams and procedures, be postponed until further notice.[21] Furthermore, CMS has released a tiered system to help triage patients requiring more timely intervention.[21] It is important to note that the CMS guidelines apply only to adult patients. In **Table 2**, we provide definitions and examples for elective, semielective, semiurgent, and urgent/emergent procedures as related to pediatric otolaryngology. While this table is intended to provide guidance, care should be directed by individual surgeons, considering both the needs of the patient and local resource availability.

Elective surgeries are performed on an outpatient basis and have extremely low expected morbidity if the procedure is not completed. We support the cancellation or postponement of purely elective cases and procedures pending the resolution of the COVID-19 pandemic. Conditions that do not require immediate correction but could produce significant morbidity if not corrected within 3 to 6 months are defined as semielective and may be reasonably postponed but should be given priority once resources are available. Semiurgent conditions pose a significant risk of morbidity or mortality if not corrected but can be delayed for 48 to 72 hours.

Any semielective or semiurgent case should undergo preoperative COVID-19 testing. Because pediatric patients are often unable to provide independent self-care, patients and their immediate caregivers should be tested 48 hours prior to the planned procedure and subjected to strict quarantine until the time of the procedure. If available, rapid COVID-19 testing of both the patient and caregivers should then be repeated the day of surgery. If testing is positive, semielective cases should be rescheduled. The decision to reschedule a semiurgent procedure in the setting of positive COVID-19 testing should be made on a case-by-case basis. If the decision is made to proceed with surgery, PPE guidelines for COVID-19-positive patients should be followed (**Table 1**). Urgent and emergent conditions must be corrected as soon as possible to avoid significant morbidity or mortality. Patients undergoing urgent or emergent procedures should be presumed positive for COVID-19 and appropriate PPE guidelines should be followed (**Table 1**).[20]

Enhanced PPE should be used by all operating room staff for any patient with unknown, suspected, or positive COVID-19 status. To minimize procedural time and exposure to health care workers, we recommend that operating room staff consist of a senior anesthesiologist, the attending surgeon, a fellow or senior surgical resident if necessary, a surgical technician, and a circulating nurse. All attempts should be made to avoid aerosol generation during otolaryngologic surgery. Electrocautery devices, lasers, and high-speed powered instruments produce blood-containing aerosols and smoke plumes, which may contain bacteria and viruses.[22-25] Furthermore, although aerosol generation by microdebriders has not been extensively studied, there are anecdotal reports of COVID-19 transmission to multiple operating room staff following microdebrider use.[26] Accordingly, the use of electrocautery, high-speed powered instrumentation, microdebriders, and lasers should be avoided whenever possible. If microdebriders or high-speed instruments are required, the use of PAPRs is highly recommended. Procedures for any patient with unknown, suspected, or positive COVID-19 status should be performed in a negative-pressure operating room equipped with high-efficiency particulate air (HEPA) filters to provide environmental containment.

Table 2. Classification of Select Pediatric Otolaryngologic Conditions and Procedures.

Category	Definition	Example Procedures and Conditions
Elective	May be delayed indefinitely without significant risk of adverse consequences or treats conditions that can be managed medically	• Surveillance direct laryngoscopy and bronchoscopy • Routine diagnostic flexible laryngoscopy • Adenotonsillectomy for mild to moderate OSA, sleep-disordered breathing, or recurrent tonsillitis • Functional endoscopic sinus surgery for chronic rhinosinusitis • Inferior turbinate reduction ± septoplasty for nasal obstruction • Endonasal skull base surgery for benign pathologies • Transnasal mass excision • Excision of uninfected branchial cleft or thyroglossal duct cysts • Tympanoplasty for perforation with dry ear and mild unilateral hearing loss
Semielective	Should be performed within 3 to 6 months to avoid adverse consequences	• Tympanostomy tube placement for otitis media with effusion • Pediatric cochlear implantation for profound sensorineural hearing loss • Mastoidectomy for cholesteatoma
Semiurgent	Should be performed as soon as possible but may be delayed over 48 hours	• Tracheotomy for prolonged intubation • Adenotonsillectomy for severe OSA unresponsive to CPAP • Transnasal nasal stenosis repair (ie, choanal atresia, pyriform aperture stenosis) • Facial fracture repair • Facial nerve decompression for acute facial paralysis • Postmeningitic cochlear implantation • Tympanomastoidectomy for cholesteatoma with persistent infection or progression • Nasal endoscopy with control of refractory epistaxis • Functional endoscopic sinus surgery for complicated acute rhinosinusitis • Tonsillectomy with concern for malignancy or PTLD
Urgent/emergent	Requires acute or subacute surgical intervention in less than 24 to 48 hours	• Peritonsillar abscess drainage • Posttonsillectomy hemorrhage • Acute airway obstruction • Airway or esophageal foreign body • Trauma with significant soft tissue injury, airway obstruction, potential for vision loss • Complicated acute otitis media or complicated/convalescent mastoiditis • Button battery foreign body (nasal cavity, external auditory canal) • Nasal endoscopy for concern for invasive fungal sinusitis with possible biopsy and resection • Nasal endoscopy for foreign body • Endonasal skull base surgery for cranial neuropathies or pituitary apoplexy

Abbreviations: CPAP, continuous positive airway pressure; OSA, obstructive sleep apnea; PTLD, post-transplant lymphoproliferative disorder.

3. Airway Management and Diagnostic Airway Procedures

Concentrations of the SARS-CoV-2 virus appear to be highest in the nasopharynx and oropharynx,[4] and during the 2003 SARS outbreak, mask ventilation, noninvasive ventilation, and endotracheal intubation were associated with increased risk of transmission to health care providers.[27] Current guidelines recommend that intubation be performed by the most senior practitioner available using rapid sequence intubation techniques to minimize aerosol production.[28-30] When available, disposable laryngoscopes and video laryngoscopes should also be used. For pediatric patients, a HEPA filter should be placed on the expiratory limb of the breathing circuit to prevent contamination of the anesthesia machine.[28]

High-flow nasal cannulas (>6 L/min) should be avoided in the setting of unknown, suspected, or positive COVID-19 status due to the potential for aerosol dispersion.[29,31] Fiberoptic intubation can also generate aerosols and requires instrumentation of the nasopharynx and/or oropharynx, which may increase the risk of transmission to health care staff. Therefore, fiberoptic intubation should be avoided when possible[28] but is still preferable to an emergent surgical airway. Difficult airway scenarios should be managed according to published pediatric guidelines,[32] noting that early placement of a second-generation

supraglottic airway device is favored over bag-mask ventilation.[31] Emergent tracheotomy may be associated with significant aerosol generation,[29] and emergent extracorporeal membrane oxygenation (ECMO) may be considered as a temporizing measure, if available.

Routine surveillance direct laryngoscopy and bronchoscopy for tracheotomy patients can be considered a semielective procedure and may be delayed for asymptomatic patients. While airway abnormalities, including increased secretions, suprastomal granulation tissue, and peristomal granulation tissue, are identified in approximately 42% to 73% of asymptomatic patients, only 3% to 15% require surgical intervention.[33,34] By contrast, patients with symptoms including difficult tracheotomy tube changes, respiratory distress, stomal obstruction, and bleeding have a higher incidence of airway findings (70%-92%) and are more likely to require intervention (41%-72%).[33,34] Accordingly, symptomatic patients should be prioritized for operative evaluation and may be scheduled on a more acute basis depending on the severity of symptoms.

Finally, pediatric flexible laryngoscopy is frequently employed in the outpatient and inpatient setting to diagnose a wide variety of disorders of the upper airway that can contribute to respiratory distress, noisy breathing, hoarseness, desaturations, sleep apnea, or feeding difficulties.[35] Outside of an emergent clinical process such as acute airway compromise, elective pediatric flexible laryngoscopy has been deemed as a high-risk procedure and should be deferred, if at all possible.[36] Enhanced PPE should be used for flexible laryngoscopy in patients with unknown, suspected, or positive COVID-19 status.

4. Interventional Airway Procedures, Tracheotomy, and Airway Reconstruction

Airway intervention is often performed on a semielective, semiurgent, or urgent basis. For semielective and semiurgent procedures, local resource availability should be carefully considered with regards to the planned postoperative disposition of the patient. Pediatric tracheotomy is resource intensive, often requiring several days of intensive care unit (ICU)–level care with mechanical ventilation.[37] Therefore, elective tracheotomy for ambulatory patients should be delayed whenever possible pending local resource availability. Conversely, tracheotomy placement for intubated patients may free ventilators and ICU beds, resulting in a valuable liberation of resources for the potential treatment of COVID-19 patients. However, the risks and benefits of tracheotomy placement should be carefully weighed, as aerosols generated during tracheotomy, tracheotomy tube changes, suctioning, and coughing may result in COVID-19 transmission.[3,38] Importantly, tracheotomy is generally not indicated for patients with respiratory failure secondary to COVID-19.[39] Tracheotomy patients with unknown, suspected, or positive COVID-19 status should be maintained on a closed respiratory circuit with in-line suction until the infection is cleared or testing is performed and is negative.[3] If a closed circuit is unavailable, a heat and moisture exchange (HME) device with an integrated hydroscopic viral/bacterial filter should be used, if tolerated by the patient. The use of filter HMEs is also recommended for ambulatory tracheotomy patients, if tolerated, to potentially reduce the risk of acquiring COVID-19.

For nonintubated patients requiring semiurgent airway intervention, preoperative COVID-19 testing should be performed whenever possible. At the present time, endoscopic minimally invasive airway procedures (eg, balloon dilation, supraglottoplasty) are preferred whenever possible to avoid the need for intubation or tracheotomy placement postoperatively. However, a minimally invasive approach may require multiple procedures in the operating room, and therefore the risks and benefits must be weighed against tracheotomy placement, taking local resource availability into account. Planned airway reconstructive procedures are resource intensive, often requiring prolonged ICU stays, readmission, and reoperation,[40,41] and should be deferred when possible pending increased availability of local resources.

5. Procedures Involving the Oral Cavity, Oropharynx, Nasal Cavity, and Nasopharynx

Oral cavity and oropharynx. Tonsillectomy with or without adenoidectomy remains the second most common surgical procedure in the United States.[42] In recent years, indications for tonsillectomy have transitioned from infectious (ie, recurrent tonsillitis and recurrent peritonsillar abscess formation) to obstructive etiologies (ie, sleep-disordered breathing and obstructive sleep apnea).[43] Importantly, adenotonsillectomy can be a resource-intensive procedure. Key risk factors for postoperative complications include age <2 years, severe obstructive sleep apnea (OSA), body mass index less than the fifth percentile, obesity, craniofacial anomalies, neuromuscular disease, and complex cardiac disease.[44] Furthermore, young age, gastrostomy tube status, and neuromuscular disorders are independently associated with increased likelihood of ICU admission.[45] Due to the urgent need to maximize available medical resources, routine elective adenotonsillectomy should be deferred whenever possible. For patients with mild OSA, important medical therapies include self- or guardian-administered topical intranasal corticosteroids and montelukast, which is associated with normalization of sleep parameters in 62% of patients.[46] For patients with recurrent streptococcal pharyngitis, a 10-day course of per os (PO) clindamycin successfully eradicates *Streptococcus pyogenes* colonization in 85% to 90% of cases.[47]

At this time, elective tonsillectomy for uncomplicated recurrent tonsillitis, PFAPA (periodic fever, aphthous stomatitis, pharyngitis, adenitis), sleep-disordered breathing, and mild to moderate OSA should be postponed until resource availability improves. For semielective and semiurgent procedures, such as severe OSA with an inability to tolerate continuous positive airway pressure (CPAP),

tonsillar asymmetry with concern for malignancy, tonsillar hypertrophy with concern for posttransplant lymphoproliferative disorder, and recurrent peritonsillar abscess formation, surgery may proceed after preoperative COVID-19 testing and quarantine. If testing cannot be performed, cold steel instrumentation should be employed to reduce aerosol formation.

Sinonasal cavity and nasopharynx. Nasal obstruction is one of the most common problems encountered by pediatric otolaryngologists. Typically, this is not an urgent diagnosis, but it is commonly associated with reduced quality of life measures.[48] A variety of congenital etiologies (ie, choanal atresia, pyriform aperture stenosis, midline nasal masses, etc) for nasal obstruction predominate during infancy and the early childhood years; as children get older, inflammatory (ie, inferior turbinate hypertrophy) and infectious pathologies (ie, rhinosinusitis) tend to predominate and may require surgical intervention in the setting of failed medical.

At this time, all elective sinonasal and nasopharyngeal procedures, including adenoidectomy, endonasal skull base surgery, functional endoscopic sinus surgery, inferior turbinate reduction ± septoplasty, and transnasal mass excision for benign lesions, should be postponed pending control of the COVID-19 pandemic and the availability of preoperative testing. For semielective and semiurgent procedures (eg, bilateral choanal atresia repair, pyriform aperture stenosis repair, control of refractory recurrent epistaxis, complicated acute rhinosinusitis with orbital or intracranial extension, intranasal foreign body removal, pituitary apoplexy, or concern for invasive fungal sinusitis with biopsy and possible resection), preoperative COVID-19 testing is recommended. To minimize the dissemination of aerosolized viral particles in patients with unknown, suspected, or positive COVID-19 status, the use of balloons, drills, microdebriders, and suction electrocautery should be limited whenever possible in favor of traditional cold steel sinus instrumentation. Due to the high risk of transmission, enhanced PPE with a strong preference for PAPR should be used for any sinonasal surgery in patients with unknown, suspected, or positive COVID-19 status.

For patients in whom surgery is deferred, medical treatment should be maximized. Management options for chronic rhinosinusitis, chronic adenoiditis, and inferior turbinate hypertrophy include nasal saline sprays or irrigations, antihistamines, and intranasal corticosteroids.[49,50] Children who require hospital admission for complicated acute rhinosinusitis with orbital extension but without vision or globe compromise should be trialed on a course of medical treatment, including intravenous (IV) antibiotics, IV corticosteroids, and topical nasal therapy (ie, nasal decongestants, saline irrigation, and topical corticosteroids) for at least 48 to 72 hours prior to considering surgical therapy.

Craniofacial procedures, including cleft lip and palate repair, as well as velopharyngeal insufficiency correction, should generally be deferred pending resolution of the pandemic or availability of preoperative testing. Exceptions to this general rule would include tongue-lip adhesion, mandibular distraction osteogenesis, or maxillary advancement procedures for the correction of airway obstruction unresponsive to nonoperative management.

6. Audiologic Evaluation and Otologic Surgery

Hearing loss. The Joint Commission on Infant Hearing (JCIH) recommends a 1-, 3-, and 6-month guideline regarding early intervention for hearing loss, which should continue to be followed as standard of care because delayed or missed diagnoses of hearing loss result in significant developmental sequelae.[51,52] However, a delay of 1 to 2 months is permissible in the current circumstances. Patients with bilateral hearing loss should be prioritized for intervention. There is presently no definitive evidence supporting intrauterine or transplacental SARS-CoV-2 infection, although newborns are at risk for contracting the virus.[16,53] Although the virus does display neurotropism, the effects on hearing are unknown.[54] Patients should be monitored for signs or symptoms of hearing loss following COVID-19. Sedated auditory brainstem response testing and/or examination of ears under anesthesia should be deferred given the increased potential risk of aerosolization during bag-mask ventilation until preoperative diagnostic COVID-19 testing is readily available. Patients with congenital hearing loss who require imaging studies under general anesthesia should undergo preprocedure COVID-19 testing and quarantine.

Middle ear disease is a common cause of hearing loss in children.[52] Tympanostomy tube placement for unilateral persistent effusion may be considered purely elective and should be postponed. Bilateral otitis media with effusion and hearing loss should be prioritized for operative intervention, given the risk for speech delay after 3 months. However, even cases of bilateral otitis media may be considered elective, and individualized consideration should be taken based on the availability of PPE and COVID-19 testing.

Otologic surgery. Most otologic procedures are classified as elective or semielective and should be deferred; however, a need will remain for semiurgent and urgent/emergent procedures (**Table 2**). Acute mastoiditis with convalescence, complicated mastoiditis, and complicated acute otitis media (AOM) require prompt surgical treatment within 24 to 48 hours. Ear canal foreign bodies may also require emergent or urgent intervention in the setting of retained button batteries or obstructive otitis externa. Cases that may be performed on a semiurgent basis include intracranial tumors with brainstem compression, acute facial nerve paralysis, advanced cholesteatoma, postmeningitic cochlear implantation, and removal of infected hardware.

Respiratory viruses have been isolated from middle ear effusions and demonstrate high concordance with nasopharyngeal specimens during upper respiratory tract infection.[55,56] Therefore, it is reasonable to assume an appreciable viral load of SARS-CoV-2 exists in the middle ear and mastoid cavity of patients with COVID-19. Furthermore, many otologic procedures produce aerosols

through use of high-speed drills. Bone dust generated by high-speed drills does not meet Occupational Safety and Health Administration criteria for respirator utilization; however, surgical masks are ineffective at preventing inhalation of bone dust particles. Furthermore, bony microspicules penetrate the cornea in animal models, and transconjunctival spread of COVID-19 has been reported.[57,58]

For complicated otitis media or acute mastoiditis, a 24- to 48-hour trial of medical management should be attempted prior to surgery. For patients with unknown, suspected, or positive COVID-19 status, myringotomy and tympanostomy tube insertion is preferred to cortical mastoidectomy for uncomplicated acute mastoiditis refractory to medical therapy. Cortical mastoidectomy should only be performed in patients with complicated acute mastoiditis, and use of PAPR use is strongly recommended if high-speed drills are required.

A retained button battery in the external auditory canal should be treated emergently with appropriate PPE. Foreign bodies with a marked inflammatory reaction causing obstructive otitis externa also require operative intervention. If the child is unable to tolerate the procedure awake, conscious sedation may be preferred to general anesthesia, which requires positive pressure ventilation.

If an otologic surgery is performed in the operating room under general anesthesia, intubation is preferred over mask ventilation for patients with unknown, suspected, or positive COVID-19 status. This recommendation is based on data from the SARS and MERS outbreaks demonstrating that mask ventilation posed a significant infection risk for health care workers.[27] In addition, an occult or iatrogenic tympanic membrane perforation has the potential to create an open connection with the nasopharynx during mask ventilation, which may also promote virus transmission.

7. Head and Neck Surgery and Deep Neck Space Infections

Neck masses and neoplasms. Surveillance, Epidemiology, and End Results (SEER) data demonstrate 12% of childhood cancers are comprised of head and neck malignancies. Most of these tumors are neural tumors and lymphoma. Thyroid carcinoma may represent up to 21% of pediatric head and neck neoplasms, with the most common being papillary thyroid carcinoma.[59] In children, papillary thyroid carcinoma represents a much more aggressive disease compared to the adult population, and patients with this cancer should be offered total thyroidectomy and possible central or lateral neck dissection in a semiurgent manner with preoperative COVID-19 testing used when available.[60] Management of all pediatric head and neck tumors should be discussed at a multidisciplinary tumor board to determine the most appropriate course of action while taking local resource availability into account. If required, surgery may be scheduled on a semiurgent basis. Surgical treatment of benign tumors, uninfected branchial cleft cysts, uninfected thyroglossal duct cysts, dermoid cysts, and lymphovascular malformations should be deferred at this time unless significant mass effect causes an acute issue such as airway compression.

Cervical infections. Deep cervical infections comprise 1% to 2% of all pediatric hospitalizations. Without proper management these infections can rapidly progress to serious complications including airway compromise, internal jugular vein thrombosis, and mediastinal dissemination. Historically, early surgical management has been advocated,[61] but more recent data have suggested that conservative approaches are appropriate for certain children.[62] Along with standard medical management, including IV antibiotics and close observation, dexamethasone use has been shown to decrease the need for operative intervention in pediatric patients with deep space cervical infections and may be considered.[63] For cases failing medical management, image-guided aspiration and drain placement is preferred over traditional open incision and drainage. If image-guided drainage cannot be performed, formal incision and drainage for parapharyngeal and retropharyngeal space infections should preferentially be performed via a transcervical approach, rather than an intraoral approach, to minimize aerosolization and exposure to the oral cavity, oropharynx, and nasopharynx.

8. Craniomaxillofacial Trauma

Fortunately, craniomaxillofacial trauma is less common in the pediatric population than in adults, and many injuries do not require operative intervention. In the acute setting with respect to facial laceration washout and repair, providers should don the appropriate PPE as described previously in the Infection Control Precautions section.

Facial fracture repair should proceed as outlined via the published AO Foundation guidelines.[64] Nondisplaced mandible fractures without malocclusion can be managed conservatively with close observation and a no-chew diet.[65] Closed reduction with mandibulomaxillary fixation (MMF) should be performed using self-drilling, self-tapping screws over open reduction and internal fixation (ORIF) if patient anatomy permits.[64] If ORIF is required, mucosal incisions should be performed using a scalpel, and bipolar electrocautery is preferred to monopolar electrocautery to reduce aerosolization.[25,64] Self-drilling, self-tapping screws should be used when monocortical screws are required, and drilling should be performed using a low-speed drill without saline irrigation. Similar guidelines apply to the management of craniomaxillofacial fractures, with the notable addition that nonpowered instruments such as rongeurs should be used instead of powered burrs and other high-speed devices for frontal sinus cranialization.[64]

Implications for Practice

The COVID-19 pandemic will have a profound short- and long-term impact on virtually every facet of medical practice in the United States and worldwide. The extreme stress on the medical system and resultant scarcity of resources, combined with the threat of disease transmission to physicians and other health care workers, has necessitated triage

of medical care to only the most pressing issues. The recommendations presented here should guide pediatric otolaryngologists in providing effective care to children who need it while ensuring the best possible safety for themselves, other health care workers, and their patients.

Author Contributions

Darrin V. Bann, conceptualization, literature review, formulation of recommendations, drafting and revision of manuscript, final approval of manuscript; **Vijay A. Patel**, conceptualization, literature review, formulation of recommendations, drafting and revision of manuscript, final approval of manuscript; **Robert Saadi**, conceptualization, literature review, formulation of recommendations, drafting and revision of manuscript, final approval of manuscript; **Neerav Goyal**, conceptualization, literature review, formulation of recommendations, drafting and revision of manuscript, final approval of manuscript; **John P. Gniady**, conceptualization, literature review, formulation of recommendations, drafting and revision of manuscript, final approval of manuscript; **Johnathan D. McGinn**, conceptualization, literature review, formulation of recommendations, drafting and revision of manuscript, final approval of manuscript; **David Goldenberg**, conceptualization, literature review, formulation of recommendations, drafting and revision of manuscript, final approval of manuscript; **Huseyin Isildak**, conceptualization, literature review, formulation of recommendations, drafting and revision of manuscript, final approval of manuscript; **Jason May**, conceptualization, literature review, formulation of recommendations, drafting and revision of manuscript, final approval of manuscript; **Meghan N. Wilson**, conceptualization, literature review, formulation of recommendations, drafting and revision of manuscript, final approval of manuscript, project oversight.

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