


Protection for Otolaryngologic Surgery in the COVID-19 Pandemic

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Abstract

Objective. The coronavirus disease 2019 (COVID-19) has placed unprecedented challenges on the world and the medical community. It is transmitted through droplets, contact, the fecal-oral route, and airborne transmission under certain conditions that allow droplets to combine with air particles to form an aerosol. Viral loads are higher in the nasal area and similar in symptomatic and asymptomatic patients. Medical situations have been classified into high and low risk of generating aerosols. Most procedures and surgery in otolaryngology correspond to high-risk medical situations. This review aims to gather the vast amount of available information and generate recommendations for different surgical procedures according to aerosolization risk and COVID-19 status, with use of specific personal protective equipment in each case.

Data Sources. PubMed, MEDLINE, and Embase. Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, and Food and Drug Administration.

Review Methods. We conducted a review on the literature on personal protective equipment for otolaryngologic surgery and surgical indication restrictions during the COVID-19 pandemic.

Conclusions. SARS-CoV-2 is an easily transmitted virus. Asymptomatic and symptomatic patients with COVID-19 present an upper airway high viral load, conferring otolaryngologic procedures a high risk of aerosolization. Surgical procedures must be categorized according to aerosolization risk and the possibility of COVID-19 diagnosis, according to use of personal protective equipment.

Implications for Practice. This review contributes to scientific knowledge regarding the detailed description of protective personal equipment and, most important, surgical recommendations to reduce the risk of infection in the otolaryngologic community during the COVID-19 pandemic.

Keywords

otolaryngology, surgery, COVID-19, protection equipment, respirators

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Coronavirus disease 2019 (COVID-19) emerged in Wuhan, Hubei province, mainland China, in December 2019,¹ placing unprecedented challenges on the world and the medical community. Six coronavirus genotypes were previously known to infect humans,² including SARS-CoV, responsible for the severe acute respiratory syndrome in 2002, and MERS-CoV, responsible for the Middle East respiratory syndrome in 2012.³ COVID-19 is a highly contagious zoonosis, produced by the novel coronavirus SARS-CoV-2, first identified in January 2020.⁴

SARS-CoV-2 is a single-stranded RNA virus, and its size ranges from 0.07 to 0.09 μm .⁵ It is transmitted through droplets, contact, the fecal-oral route, and airborne transmission under certain conditions that allow droplets to combine with air particles to form an aerosol.⁶⁻⁸ The virus has been proven to survive in surfaces with varying stability: 4 hours in copper, 24 hours in cardboard, 48 to 96 hours in stainless steel, and 72 to 96 hours in plastic surfaces. It has been shown to remain as an aerosol for >3 hours, with a half-life of 1.1 hours.⁷ A study in Guangdong, China, by Zou et al⁹ in January 2020 measured the cycle threshold for polymerase chain reaction (PCR) COVID-19 in 17 patients with the disease and 1 asymptomatic contact. Viral loads, inversely proportional to the cycle threshold, were compared in nasal and throat swabs in patients with different degrees of disease severity, in function of time. The study showed that the viral load was higher in the nasal area and in severe illness, that it decreases gradually with time, and that it is similar in symptomatic and asymptomatic patients.⁹

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In light of this information, medical situations have been classified as high and low risk of generating aerosols.⁶ Most procedures and operations in otolaryngology correspond to high-risk medical situations; hence, the need arises to define protective measures for the specialty in the surgical field.

Methods

A review of the literature on personal protection measures in otolaryngologic and head and neck surgery was performed in various sources: PubMed, MEDLINE, and Embase. The first literature search was done to identify manuscripts that described the different personal protective equipment (PPE) and air-purifying respirators, such as filtering facepiece respirators (FFRs), elastomeric half or full facepiece respirators, and powered air-purifying respirators (PAPRs). The second literature search was done to identify recommendations for different surgical procedures according to aerosolization risk and COVID-19 status, with use of specific PPE in each case. Recommendations were also sought from international and national otolaryngology societies and characteristics of PPE in the Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health (NIOSH), and Food and Drug Administration (FDA). The main search terms were *personal protective equipment, otologic, nasal, oral and head and neck surgery, tracheostomy, and COVID-19*. The final article selection was subjectively determined. Most of the recommendations found in this search were summarized from the literature; however, to our knowledge, there are no guidelines or reports describing specific surgical indications and restrictions for nasal endoscopic surgery, microlaryngoscopy, and rigid bronchoscopy. Hence, we incorporated what we do in our clinical practice for these surgical procedures as a suggestion in this review.

Discussion

Respirators

There are different types of air-purifying respirators, such as FFRs, elastomeric half or full facepiece respirators, and PAPRs. It is worth noting that for the effective particle filtration of facepiece respirators, a proper fit must be achieved: men must be shaved, and a mandatory fit test must be performed before their use.

Disposable FFRs are regulated by different entities worldwide, regarding their category and filtering efficiency. In the United States, this entity is the NIOSH, which classifies respirators by the letter N when it is not resistant to oil, R when it is resistant to oil, and P when it is oil proof. This letter is followed by a number indicating the filtering efficiency, which is determined according to the capacity to filter 0.3 μm particles. The MPPS (most penetrating particle size) in uncharged particles ranges from 0.2 to 0.3 μm ; however, aerosol particles below the MPPS have been shown to decrease in penetration levels with decreasing particle size, as explained by the single-fiber filtration theory, so smaller particles are also filtered effectively.^{10,11} In the

United States, FFRs are also classified into standard and surgical respirators, the latter including approval from the FDA for surgical use, and with fluid resistance properties.^{12,13}

Respirators with a 95% filtering efficiency or superior are recommended for use in the prevention of airborne infectious diseases, as in the COVID-19 pandemic, without requiring oil proof or resistance.¹⁴ In Europe, respirators are regulated by the European Norm and the European Committee for Standardization, classified in FFP1, FFP2, and FFP3, meeting minimum filtration efficiencies of 80%, 94%, and 99%, respectively. In this way, an FFP2 respirator is equivalent to N95 and FFP3 to N99.^{10,15}

Elastomeric respirators are reusable and have replaceable cartridges or filters. They are recommended by the Centers for Disease Control and Prevention as an alternative to N95 FFRs; nevertheless, since they have a 1-way valve to expel expired air, they are not recommended for use in surgery. Given the massive deficit of PPE, its use for surgery can be considered with a surgical mask over the respirator, covering the valve and protecting the filters from contamination.¹⁴

PAPRs are composed of a motorized system that pushes air through a HEPA filter (high-efficiency particulate air), into an integrated hood, where the head and neck are protected. The assigned protection factor range by the Institute of Medicine is 25 to 1000 for PAPRs and 10 for the N95 mask.^{16,17} Also, PAPRs are useful when there is facial hair or if the user fails the N95 fit test. Nevertheless, one of their main disadvantages is their high cost, making them less accessible worldwide.¹⁴

In response to the massive PPE shortage, other alternatives have arisen, such as the use of a full face snorkeling mask, connected through an adapter to a filter (**Figure 1**).¹⁸ The adapter is custom 3-dimensionally printed, matching either a mechanical ventilator HEPA filter or elastomeric respirators filters, both with a filtration efficiency >99%. The air enters the mask through the filter on the top and then is expelled by a 1-way valve near the chin. As with elastomeric respirators, if used in a sterile field, a surgical mask should be worn over this valve. The creators have conducted studies under NIOSH standards to validate the filtration efficiency for this mask; however, the FDA has not yet approved it.¹⁸

General Protective Measures in Otolaryngologic Surgery

Based on the high aerosolization risk in otolaryngologic surgery, several recommendations have been published worldwide. Preoperatively, a COVID-19 detection test, such as PCR, should be performed if conditions allow it.¹⁹ This would help for patient safety and operating room (OR) personnel safety. Surgery performed in patients incubating COVID-19 has been shown to present higher mortality, risk of pneumonia, and need for hospitalization in the intensive care unit (ICU).²⁰ Therefore, a positive COVID-19 PCR test result defines the need to delay surgery or, in urgent cases, the need for extra personal protection measures.



Figure 1. Adapted full face snorkel mask, 3-dimensionally printed adapter, and filter.

In the OR, the surgical team should include only 1 otolaryngology surgeon and 1 otolaryngologist as an assistant, prescinding of residents, interns, or observers. The surgery should be performed by the most experienced surgeon in the shortest time possible.¹⁹ During surgery, the use of pharyngeal packing should be avoided,²¹ and an adhesive dressing should be used to cover the nostrils and mouth opening depending on the surgical approach.²² Intraoperatively, there is controversy regarding the use of mono- or bipolar diathermy. Some authors describe higher risk of aerosolization,^{19,23} while others debate that there is weak evidence, and aerosolization can be reduced by constant suction of generated plume.²⁴ The use of electric diathermy should be considered case to case, balancing the risk of aerosolization with the risk of bleeding during surgery. Other devices, such as microdebriders, drills, or saws, may generate aerosolization and should be avoided if the surgical plan allows

it.²⁵ Regarding the OR characteristics, if possible, it should count with a negative pressure system and a closed-circuit suction system, with an antiviral filter.²⁶ After the surgery ends, doffing steps must be strictly supervised and followed precisely, with particular attention to the respirator, to avoid health care professionals to become infected.^{24,27}

Otolaryngologic surgical procedures have been classified as high and low risk for aerosolization (**Table 1**).^{16,19} The protective measures will vary depending on the urgent or emergent character of the case. Knowing that SARS-CoV-2 can be transmitted while presymptomatic, asymptomatic, or oligosymptomatic stages, every patient should be considered positive for COVID-19 until proven otherwise.^{28,29} Elective surgery should be postponed, and emergencies should be performed with no delay, with use of PPE according to the aerosolization risk and with the presumption that the patient has tested positive for COVID-19. In an urgent case, PCR should be tested, and measures should be taken according to the result. Based on the literature research and the previously exposed information regarding air-purifying respirators, a classification is proposed for PPE into 3 groups, depending on the patient's COVID-19 condition and the aerosolization risk inherent to the surgical procedure (**Table 2**).^{16,19}

Specific Protective Measures in Otolaryngologic Surgery

Intranasal Surgery. Intranasal surgical procedures are considered high risk of aerosolization of viral particles, taking into account the high viral load within the nasopharynx in symptomatic and asymptomatic patients.^{19,25} Any interaction between the airway mucus and high-speed flow generates mucus aerosolization. Milling generates the most aerosols, followed by the use of microdebrider, saline irrigation, use of Endoscrub or similar, and anesthetics or vasoconstrictor sprays to a lesser degree.^{19,25} Restriction for intranasal surgery indications is advised with a panel expert discussion. To our knowledge, in the literature, there are no specific recommendations for which intranasal surgical procedures must be restricted, so we propose a list of urgent or emergent intranasal surgery (**Table 3**). During these procedures, local anesthetic or vasoconstrictor must be applied with pledgets; a constant second nasal aspirator should be used for continuous aerosol particle suction, and milling or

Table 1. Risk Categories for Aerosolization in Otolaryngologic Surgery.

High-risk surgery	Low-risk surgery
Transoral (abscess drainage, adenotonsillectomy, larynx surgery)	Transcervical (cervical dissection, thyroidectomy, external abscess drainage)
Airway (tracheostomy, bronchoscopy)	Skin cancer
Intranasal	Ear with no mastoidectomy or middle ear approach
Transtracheal	
Mastoidectomy	

Table 2. Personal Protective Equipment According to the Presence of COVID-19 and Risk of Aerosolization From Surgery.

Risk of aerosolization	High	Low	
COVID-19 status	PCR+ Suspicious case with PCR– Impossibility to wait for PCR result	PCR+ Suspicious case with PCR– Impossibility to wait for PCR result	Nonsuspicious case, PCR–
Personal protective equipment	Disposable surgical cap Shoe covers Double gloves Waterproof surgical gown PAPR, adapted snorkeling mask, surgical N95 with face shield or goggles	Disposable surgical cap Shoe covers Double gloves Waterproof surgical gown Surgical N95 with face shield or goggles	Disposable surgical cap Surgical mask Waterproof surgical gown Surgical gloves

Abbreviations: PAPR, powered air-purifying respirator; PCR, polymerase chain reaction. +, positive; –, negative.

Table 3. Restricted Indications for Otolaryngologic Surgery.

Surgery	Restricted indication
Intranasal	
Nasal endoscopic	Acute invasive fungal rhinosinusitis Rhinosinusitis complications Undeferrable nasal tumors and uncontrollable epistaxis with nasal tamponade
Endoscopic skull base	Pituitary apoplexy and pituitary macroadenoma with rapid impairment of visual acuity Infected Rathke cyst and pituitary abscess
Intranasal endoscopic	Nasal fracture reduction and drainage of septal hematoma Removal of nasal foreign body of difficult access in a vigil patient
Transoral	
Microlaryngoscopy and rigid bronchoscopy	Airway foreign body extraction and laryngeal tumor with high suspicion of malignancy
Oral and oropharyngeal	Peritonsillar or deep cervical abscess drainage and biopsy for malignant tumor suspicion
Ear	Myringotomy with or without mastoidectomy in acute or chronic otitis media complications Surgery for a malignant tumor of the ear or temporal bone, cerebellopontine angle tumor with compression symptoms Acute facial paralysis, advanced cholesteatoma, high-volume cerebrospinal fluid fistula, cochlear implant after meningitis and removal of infected cochlear implants

microdebrider use must be avoided. If microdebrider use is essential, it must be operated in a closed position and turned off when extracted.^{19,25}

Transoral Surgery. Microlaryngoscopy and rigid bronchoscopy must be considered high-risk procedures due to the need for continuous gas flow within the rigid bronchoscopy circuit. This, combined with the manipulation of the mucosa, significantly increases the volume of aerosols in the air. Therefore, it is imperative to shorten the surgical time to the minimum necessary.²¹ Teamwork and communication with anesthesiologists are crucial.²¹ To our knowledge, in the literature, there are no specific recommendations for which transoral procedures must be restricted, so we propose a list of urgent or emergent transoral surgery (**Table 3**).

Ear Surgery. It is unknown whether COVID-19 compromises the middle ear respiratory mucosa and mastoid cells. Due to the presence of a high viral load of SARS-CoV-2 in the

nasopharynx, it is highly likely that the virus may ascend through the eustachian tube to the middle ear and mastoid cells. Furthermore, previous studies have demonstrated the presence of respiratory virus through PCR in 55% of the patients with middle ear effusion, with a viral concordance between the nasopharynx and middle ear of 82% to 98%.³⁰ Therefore, publications suggest reducing ear surgical indications, which are summarized in **Table 3**.³⁰ The rest of the surgical procedures should be postponed.

When a mastoidectomy is performed, milling through the mastoid cells generates droplets and aerosols, bestowing high-risk of aerosolization and infection of OR medical and nonmedical personnel.¹⁶ Publications recommend to avoid or reduce milling and to use a second drape to cover the microscope and the patient's head as a "tent" to isolate aerosols.³¹

Also, given that any surgical procedure where mastoid cells are exposed is high risk, the use of an N95 surgical respirator and goggles that achieve a proper facial seal is

necessary. PAPRs or face shields are not compatible while the microscope is being used to perform surgery.³²

Head and Neck Surgery. Oncology patients present a higher risk of developing severe COVID-19 symptoms and a higher risk of death due to reduced medical access because of social distancing, reduced ORs, and fewer ICU beds.²⁶ Multidisciplinary discussion of these cases must be held looking for plausible treatment alternatives, such as radiotherapy and chemotherapy.¹⁹

Head and neck procedures that do not expose or violate mucosal surfaces are low risk, such as external cervical procedures (thyroidectomy and cervical dissection).³³ Care must be taken to ensure the correct use of diathermy devices, which may result in aerosolization of the virus from the bloodstream.¹⁶ Regarding head and neck cancer (HNC) surgery, Vukkdala et al¹⁹ proposed stratification of cases by urgency, determining the period in which they must be operated. Cancers with an increased mortality should not be postponed—for example, negative HPV (human papillomavirus) squamous cell HNC, positive HPV squamous cell HNC with significant disease burden or delay in diagnosis, recurrence after radiotherapy, or aggressive thyroid carcinomas.¹⁹ HNC such as low-risk papillary thyroid cancer without metastasis or some melanomas can be postponed >30 days. Other cases with rare histology or diagnostic procedures such as direct laryngoscopy and biopsy should be evaluated on a case-to-case basis.¹⁹

Tracheostomy. Great controversy exists regarding the role of tracheostomy as a part of the mechanical ventilator weaning process in patients recovering from COVID-19,²⁴ given that surgical and percutaneous tracheostomies are high-risk procedures due to exposure of the upper airway and consequent contact with airway secretions.²⁴ This procedure must be correctly planned and carefully executed to achieve safety for the patient and the medical team.^{24,34} The most skilled otolaryngology surgeon and anesthesiologist staff must perform the procedure in the shortest period of time.^{27,33} Clinical guidelines recommend creating a “COVID-19 Airway Team” composed by experienced surgeons, ICU medical staff, anesthesiologist and nurse team. This team will be responsible for teaching and instructing its respective colleagues in case of need (for sick personnel leave, for higher demand, and to distribute the burden of these stressful procedures).³⁴

The question of whether a percutaneous tracheostomy would generate fewer aerosols as compared with a controlled open tracheostomy is debatable, and evidence so far is limited. There are proponents for both techniques, and we believe that local factors, competences, and the experience of each clinical center play an important role.^{27,34,35}

Planning Before the Procedure. Surgical indication for tracheostomy must be clear, weighing risks and benefits.³³ Ideally, COVID-19 testing must be performed in all patients before the procedure.³³ In patients with mechanical ventilation secondary to COVID-19 infection, evidence recommends to avoid or delay performing a tracheostomy in the first 14 days, due to

the high viral load and consequently higher risk for personnel infection,^{16,33} as well as to wait for the resolution of the acute pulmonary phase of the infection.¹⁶

It has also been found that early performance of tracheostomy is not associated with mortality improvement or shorter ICU stay.¹⁶ The primary goal of this surgery must be mechanical ventilator weaning,¹⁶ so the patient must have a favorable prognosis aiming to achieve a full recovery at medical discharge.²³ Furthermore, to perform this surgery, the patient must be afebrile and hemodynamically stable (or stable with a minimum use of vasoactive drugs); ventilator parameters must indicate that the patient can tolerate periods of apnea with a decrease in inflammatory markers (ie, positive end-expiratory pressure ≤ 10 cm H₂O and fraction of inspired oxygen ≤ 0.4); and, ideally, the patient will test negative after 2 PCR nasopharyngeal swabs.²³

OR Preparation. The necessary instruments and equipment must be available. There must be only 1 person outside the surgical room, considered a “runner” in case of requiring missing supplies.³⁴ The minimum equipment needed for this procedure is a nonfenestrated tracheostomy tube with cuff and 2 or 3 suitable sizes according to the patient.³⁴ PPE must be available for the whole team; ideally, PAPRs must be used (**Table 2**).^{23,24,35}

Patient Transfer From the ICU to the OR. Patient transfer must be performed with every PPE needed according to each hospital’s guidelines. Before the patient is moved from the ICU, aspiration of the orotracheal tube through the closed circuit must be performed to reduce aerosolization.^{23,24} When the patient enters the OR, all the medical team must be using correct PPE. The patient is transferred to the surgical table and must be connected to the anesthesia ventilator. This is considered a critical step: aerosolization must be reduced by clamping the endotracheal tube and ensuring that the antiviral filter stays connected to the tube while changing ventilators. When the surgical procedure is over, the patient must be transferred back to the ICU.²⁴

Surgical Procedure. During the procedure, the patient must be paralyzed to reduce unexpected movement or cough that may enhance aerosolization. This is why the anesthesiologist must perform suction of the endotracheal tube before the surgery to ensure muscle relaxation, reducing the risk of aerosolization.²⁴ It is essential to allow easy access to the endotracheal tube and the oral cavity when surgical garments are placed, so that the tube can be manipulated by the anesthesia team when needed. Before opening the airway, the surgeons must notify the anesthesiologist; muscle relaxation must be confirmed; and preoxygenation must be performed. After this, the ventilator must be stopped; the endotracheal tube must be clamped; and the cuff must be deflated. The surgeon then makes the tracheal window, using minimal suction. After the window is achieved, the endotracheal tube is advanced distal to the tracheal window, and the cuff is reinflated, after which the ventilation closed circuit can be restored.²⁶ Sutures are placed, and hemostasis is

performed if needed. Once everything is in place and ready for tracheal tube placement, the ventilator is stopped; the cuff must be deflated; and the endotracheal tube must be clamped and withdrawn carefully to allow the insertion of the tracheostomy tube. The tracheostomy cuff must be inflated and the closed-circuit ventilation connected to it. The capnography CO₂ curve must confirm a correct coupling.²⁴ If the procedure was performed correctly with no associated complications, there is no need for a postoperative chest radiograph.²³ When the surgery is completed, doffing of the PPE must be supervised.³⁶

Postsurgical Care. If it was not possible to request a COVID-19 PCR test before surgery, the literature suggests requesting this test after surgery, given that tracheostomy postsurgical care conveys a higher risk of exposure to aerosols (for the health care team as well as visiting family).³⁵ During the first week after surgery, special care should be taken when mobilizing the patient, always ensuring that the heat and moisture exchanger, antiviral filter, and close-circuit suction are in place. Studies suggest that the first tube change must be delayed and performed when the patient is COVID-19 negative. Different publications describe 4 to 7 weeks after surgery or beforehand if the patient is a candidate for early decannulation.^{23,34,35} Always ensure the use of nonfenestrated tracheostomy tubes with cuff until the patient's PCR test result is negative.³⁴ After the first change of tube, this procedure must be done every 30 days.

Implications for Practice

SARS-CoV-2 is an easily transmitted virus. Asymptomatic and symptomatic patients with COVID-19 present an upper airway high viral load, conferring otolaryngology procedures a high risk for aerosolization. Surgical procedures must be categorized according to aerosolization risk and the possibility of COVID-19 diagnosis, with use of PPE. This review presents a detailed description of protective personal equipment and air-purifying respirators, such as FFRs, elastomeric half or full facepiece respirators, and PAPRs, which are of important knowledge to every health care practitioner, especially to otolaryngology surgeons. In addition, we created recommendations for different surgical procedures according to aerosolization risk and COVID-19 status, with use of specific PPE in each case. These recommendations will help reduce the risk of infection in the otolaryngology community during the COVID-19 pandemic.

Author Contributions

Antonia E. Lagos, research idea, literature research, manuscript writing and manuscript submission process; **Phoebe H. Ramos**, literature research, manuscript writing and manuscript submission process; **Tomás Andrade**, research idea, literature research, manuscript writing, editing and manuscript submission process.

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