The ongoing coronavirus disease 2019 (COVID-19) pandemic has created many changes and difficulties in healthcare, and the anesthesia specialty is no exception. Both the increased need for personal protective equipment (PPE) and the potential for infection and contamination through respiratory droplets have been sources of much concern. Policies and protocols have been adapted worldwide to help neutralize infection risk and exposure. Transmission of the virus to healthcare workers has been a major concern, and the risk of infection is exceptionally high for Certified Registered Nurse Anesthetists (CRNAs) because of their close contact with infected patients. CRNAs are in a unique position to help decrease exposure for themselves and other members of the healthcare team by taking extra precautions during airway manipulation. A great deal of focus has been placed on reducing risks during intubation, but reports describing methods of reducing contamination and exposure to respiratory droplets during emergence and extubation are scarce. The authors have reviewed techniques to reduce coughing, thereby decreasing the potential of virus exposure through contact with large respiratory droplets and aerosolized particles that may remain suspended in air.

Keywords: Certified Registered Nurse Anesthetist, coughing, COVID-19, deep extubation.
19 is spread by respiratory droplets, recent findings have shown that COVID-19 can also be spread by aerosol.\textsuperscript{8,10} Most airborne pathogens fall into the fine particle or ultrafine particle category and can remain suspended in air for days or even weeks.\textsuperscript{11} According to the American Society of Anesthesiologists Committee on Occupational Health, an airborne infection isolation room with negative pressure and at least 6 air changes per hour should be used for patients who have COVID-19.\textsuperscript{12} Additionally, air from these rooms should be directly vented to the outside atmosphere, or a high-efficiency particulate air (HEPA) filter should be used before recirculation.\textsuperscript{12}

Potential causes of respiratory droplet exposure include saliva spray during positive pressure ventilation and the passive expiration that follows, during coughing, or during any placement or removal of airway equipment that mobilizes sputum in the operating room. It is incumbent on CRNAs to minimize any forceful movement of air from the patient to decrease the risk of airborne exposure to either themselves or any other operating room personnel involved in the care of these patients. Several methods are available that CRNAs can use to decrease risk of exposure to airborne pathogens in the operating room, but the most notable method is a modified rapid sequence induction to avoid positive pressure ventilation and forceful passive expiration. Although guidelines have continually evolved during the COVID-19 pandemic, the use of clear drapes, intubation shields, and video laryngoscopy has been advocated during induction and intubation. However, reports focusing on emergence and extubation techniques during the pandemic have been elusive. Emergence from anesthesia is another opportunity for airborne pathogen exposure, especially if accompanied by excessive coughing and spewing of secretions from the nasal and oral pharynx. When the patient meets qualifying criteria, the CRNA can perform a deep extubation and greatly reduce the risk of airborne pathogen exposure to healthcare providers during the patient’s emergence from anesthesia.

History and Review of Literature

• **Coronavirus Recognition and Transmission.** In their early 2019 report, Wang and colleagues\textsuperscript{6} detailed the clinical characteristics of hospitalized patients in Wuhan, China, who were infected with the severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2), the virus that causes COVID-19, and in whom pneumonia subsequently developed. Initially, characteristics of the disease were limited, as the infection rapidly spread through humans who were in close contact or in cluster groups. The outbreak of infections was quickly recognized internationally, with signs and symptoms including fever, dry cough, muscle pain, fatigue, leukopenia, pneumonia, cardiovascular shock, cardiac and renal injury, acute respiratory distress syndrome (ARDS), and death. The CDC identified older adults and people with certain medical conditions, such as cancer, chronic kidney or liver disease, chronic obstructive pulmonary disease, immunocompromised state, obesity, heart conditions, sickle cell disease, diabetes, asthma, hypertension, pregnancy, and smoking, as being at an increased risk of becoming sick with severe COVID-19 illness. Also according to the CDC, those who need to take extra precautions include racial and ethnic minority groups, rural community residents, those with developmental disorders, and the homeless population.\textsuperscript{13} The virus is similar to SARS and Middle East respiratory syndrome (MERS). Bats have been believed to be the primary source. Although the origination of the virus is still under investigation, current evidence suggests the spread to humans occurred via transmission from wild animals sold illegally in the Huanan Seafood Wholesale Market in Wuhan, China.\textsuperscript{14} On January 1, 2020, the Chinese government temporarily closed the market after identifying it as a source of COVID-19.\textsuperscript{14} On January 26, 2020, China banned the sale and consumption of wild animals as a food source.\textsuperscript{14} Thereafter, the director of the wildlife trade monitoring organization, Xu Ling, reported the market remained closed.\textsuperscript{14}

One important factor that influences how society and healthcare professionals manage risk is understanding the modes of COVID-19 transmission. Although it is clear that person-to-person contact is the primary means of transmission today, this understanding is incomplete, as other variables may contribute as well. The WHO began establishing guidelines for infection prevention and control of virus spread based on information gathered related to MERS and SARS, and the organization continues to update its guidelines and information about COVID-19.\textsuperscript{4} These guidelines include early triage and recognition of infections; assurance of safety measures for all patients; and methods to properly observe droplet and airborne precautions, especially when aerosol-generating procedures are performed. The WHO also advises on administrative and environmental controls, handling of specimens, and care for outpatients.\textsuperscript{4} Current data from the CDC suggest that infection occurs from close contact and mainly through respiratory droplets from an infected individual; hence, when an infected individual coughs, sneezes, or talks within about 1.8 m (6 ft), droplets can make direct contact with the mucous membranes in the mouth, eyes, or nose, potentially leading to infection.\textsuperscript{15} Additionally, infection can occur if an individual touches mucous membranes after getting virus particles on his or her hands in some manner.

The ability for COVID-19 to be transmitted via aerosols or droplet nuclei that remain in the air over distance and longer times is a controversial issue. An April 16, 2020, letter to the New England Journal of Medicine editor indicated that COVID-19 remained viable in artificial aerosol for up to 3 hours and was stable on plastic and stainless
steel for 3 days, thereby suggesting the high probability of a super spread of the virus in pandemic proportions.\(^8\)

Guan and colleagues\(^10\) described how the virus spread so quickly through China and assimilated data from more than 1,000 patients to describe clinical characteristics of those infected. In addition, results from 3 different studies showed viral RNA in the air of rooms housing COVID-19–positive patients but did not determine if the particles were enough to cause infection.\(^16-18\) Still, results from 3 additional studies suggested droplets may travel farther than the aforementioned 1.8 m (6 ft) during instances of speaking, coughing, or sneezing.\(^18-21\) The implications of these findings are unclear, but to date, studies that identify infections contracted from respiratory droplets in greater than 1.8 m (6 ft) have yet to be published.\(^22\)

In a letter to the editor of *Lancet*, Lu et al\(^7\) explained that infection through the ocular membranes had been largely overlooked and, noting that this could be a possible source of infection, emphasized the importance of eye protection while caring for infected patients. As reported by Zimmermann and Nkenke,\(^1\) it is important to review the possible sources of infection through mucosal membranes, emphasize the likelihood of spread of virus through oral and maxillofacial surgery, and recognize that all of these cases should be characterized as high-risk for COVID-19 transmission. Large droplet contamination is the primary source of infection, but according to Ereth et al,\(^11\) fine and ultrafine particle contamination is also a possibility for several days or weeks due to suspension in air.

Although it is difficult to assess the risk for CRNAs and other professionals who are in close proximity to and are manipulating or instrumenting the airway of patients with COVID-19, close contact appears to be a high-risk factor due to the proximity of high viral load.\(^23-26\) Furthermore, it has been well documented that tracheal intubation, a commonly performed anesthesia procedure, is a high risk for producing droplets and/or aerosols.\(^27,28\)

Compounding the risk of exposure to healthcare providers who are treating patients with known COVID-19 is the risk of close interaction with asymptomatic viral shedding patients, which also has been reported in numerous study findings.\(^29-33\) These individuals are within the incubation period and have had upper respiratory tract swab tests positive for SARS-CoV-2 from 1 to 6 days before symptoms.\(^34,35\) Investigators have also found that SARS-CoV-2 can remain on surfaces in the hospital rooms of patients with COVID-19 between 6 and 9 days, but this has yet to be shown to equate to infection risk for others.\(^36,37\)

A portion of the literature review encompassed understanding the manner in which virus is spread.

Measures that CRNAs can take to diminish COVID-19 spread include minimizing forceful exhalation and coughing during airway intubation and extubation. Wax et al\(^25\) reviewed comprehensive precautionary measures for the induction phase of anesthesia to decrease coughing and potential virus spreads through respiratory droplets.\(^35-37\) Asouhidou and Trikoup\(^i\)\(^38\) demonstrated the advantages of decreasing sympathetic outflow related to blunting responses to noxious stimuli. Mechanisms and techniques for deep extubation and helpful medications to decrease airway stimulation and coughing were also noted in prior research findings.\(^39\)

### Discussion of State of the Art

Even in non-COVID-19 situations, intubation and extubation are already extremely challenging and taxing. The risk of COVID-19 exposure adds an additional stressful layer during direct patient care. To decrease exposure to COVID-19, providers should conduct high-risk procedures such as intubation and extubation in negative pressure airflow rooms.\(^23\) Wax et al\(^23\) described practice recommendations for intubations during the COVID-19 pandemic but did not address extubation. Every effort and consideration should be employed to decrease the risk of aerosolizing particles during intubation and extubation. Many reports are available that address intubation, but reports that focus on extubation have proved difficult to find. Therefore, the following recommendations are suggested to decrease the risk of exposure to anesthesia providers and perioperative staff during the extubation phase of patients with COVID-19.

The incidence of coughing on emergence from anesthesia is distressingly high.\(^38\) The return to protective reflexes, in conjunction with generalized awareness and perception of the endotracheal (ET) tube, create a perfect environment to expose anesthesia providers and surrounding personnel to the aerosolized SARS-CoV-2 virus.

Deep extubation, a technique used to minimize or prevent patients from coughing during emergence from anesthesia, involves the removal of the ET tube while the patient is still fully anesthetized. Extubation of a deeply anesthetized or sedated patient routinely produces a smooth emergence without laryngospasm or an excitement phase that would be consistent with the traditional description of “Stage 2” anesthesia.\(^39\) Surgeons will occasionally request that the patient not cough for surgeries such as anterior cervical disc fusion, hernia repairs, cranial surgery, middle ear procedures, or any case in which wound dehiscence is a concern. Smooth, well-controlled extubation reduces coughing, expectoration, and the unnecessary exposure of operating room personnel and intensive care personnel to aerosolized, potentially infectious airway secretions.\(^39\)

Contraindications to this technique include a nonfasting state, achalasia, difficult airway, gastric outlet obstruction or bowel obstruction, gastroptosis, ileus, impaired swallowing, morbid obesity, and pregnancy.\(^39\) Before extubation of patients with COVID-19, all personnel who are not actively participating in airway management should remain outside the operating room with a runner dressed

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in full PPE to retrieve additional supplies and equipment. For all personnel within 2 m of the patient, full PPE with a powered air-purifying respirator is worn. Just like all aspects of anesthesia, there are many ways to provide an anesthetic, and it is very likely that each individual provider has his or her own methods. The authors have outlined the following suggestions to assist those who are less familiar with the technique of deep extubation.

The first task is to ensure that the patient’s secretions are suctioned from the airway. If secretions are left behind, they can stimulate the airway and lead to a laryngospasm. Consider using an antisialagogue such as glycopyrrrolate if not contraindicated. The patient must also be adequately anesthetized, or the CRNA risks the patient being stimulated, which could possibly lead to coughing or laryngospasm. The stimulation caused by suctioning the patient can provide further context to the depth of the patient’s anesthetic. The patient’s anesthetic also should be fully reversed and devoid of residual muscle relaxation. If any other gas mixtures such as air or nitrous oxide were being used, they should be discontinued, thus giving the patient 80% to 100% oxygen, depending on the patient’s respiratory status. After the patient begins to breathe spontaneously, the respiratory rate will give the CRNA an indication that the patient is adequately anesthetized. After the CRNA is satisfied with the depth of anesthesia provided by the volatile agent and level of narcotic, the cuff of the ET tube should be slowly deflated. If an oral airway is not in place, consider placing one at this point. Turn the anesthetic gas off and fresh gas flows up. As the patient takes a breath in, the ET tube should be gently removed. Patients will often breathe-hold following deep extubation and need to be given up to 30 seconds to resume spontaneous respirations. Risk factors with deep extubation include coughing, sore throat, hyperventilation, airway obstruction, hypoxia, increased blood pressure, decreased cardiac ejection fraction, increased ventilation/perfusion mismatch, and regurgitation.

**Conclusion**

Providing safe and effective anesthesia care for every patient is the primary focus of CRNAs. Since the arrival of the novel coronavirus, many new protocols have been developed worldwide to contain its spread by way of respiratory droplets. As CRNAs, we can help reduce exposure to the virus for ourselves and our perioperative partners by enacting measures to decrease direct contact from large droplets or aerosolized particles that can remain suspended in air. Much attention has been directed to decreasing exposure during intubation, but methods to reduce infection during extubation have not been previously reported. Incorporation of methods to reduce coughing on emergence and use of deep extubation techniques have the potential to become important weapons in our arsenal against the spread of this deadly disease.

**REFERENCES**


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