Seminars in Cardiothoracic and Vascular Anesthesia
1–6

DOI: 10.1177/1089253220922327
journals.sagepub.com/home/scv
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Anesthesia Professionals: Helping to Lead the COVID-19 Pandemic Response From Behind the Drape and Beyond

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Beginning in early December 2019, Wuhan, Hubei Province, China began having unexplained severe acute respiratory illness and pneumonias that have since been traced to the new virus that the World Health Organization has named *severe acute respiratory syndrome coronavirus 2* (SARS-CoV-2) and the disease it causes *coronavirus disease* COVID-19.[1] In just a few weeks after its discovery, COVID-19 became a global health pandemic and as of mid-April March 2020, there are more than 2.5 million reported cases spanning across the globe and more than 170 000 deaths from the disease, with numbers rising by the hour.[2] Given that SARS-CoV-2 is a novel virus, little was known about how the virus was transmitted, what the infectivity profile looked like, and how the disease would progress, which left health care workers across the globe scrambling to prepare. It is now known the virus does have human-to-human transmission that is primarily spread via droplets and close contact though spread from surface contact transmission, such as door handles and transmission through other bodily fluids is still under investigation.[3] The progression of the disease in its most severe form is known, as the name suggests, to cause an acute respiratory distress syndrome, frequently requiring mechanical ventilatory support and hence airway management.[4] Despite the media coverage about the shortage of ventilators and personal protective equipment (PPE), little has been mentioned about the role of the anesthesiologist on the front lines to help manage airways for COVID-19 patients and manage ventilatory support.

As anesthesiologists and intensivists, our expertise is sought in airway management, hemodynamic management of critically ill patients, supervision of advanced mechanical circulatory support, ventilatory proficiency, and other skills in the face of the pandemic. Many commonly performed procedures by anesthesia personnel such as endotracheal intubation, bag-mask manual ventilation, and noninvasive positive pressure ventilation are known to be highly aerosol-generating procedures (AGPs) putting anesthesia and intensive care personnel at high risk for exposure.[5] To protect anesthesia providers during AGPs, a joint position statement from the American Society of Anesthesiologists, Anesthesia Patient Safety Foundation, American Academy of Anesthesiologist Assistants, and the American Association of Nurse Anesthetists was recently published recommending the use of PPE for all AGPs on all patients given the rate of asymptomatic carriers.[6] PPE for airway manipulation is defined as a properly fitted N-95 respirator or powered air purifying respirator (PAPR). It is known that many hospitals are facing a shortage of PPE for providers both from increased utilization and decreased supply. In these circumstances, the US Centers for Disease Control and Prevention has developed guidelines for PPE utilization and extended use or limited reuse of N-95 masks until PPE supplies can be replenished.[7,8]

Tang and Wang's timely review of "Anesthesia and COVID-19: What We Should Know and What We Should Do" highlights the topical importance of the need for more information and data surrounding the SARS-CoV-2 and the need to protect health care providers especially those performing high-risk AGPs such as anesthesiologists and intensivists.[9] The knowledge base is expanding at a rapid pace, and clinicians overwhelmed with patient care may find it difficult to keep up with the large volume of evidence disseminating on a daily basis.

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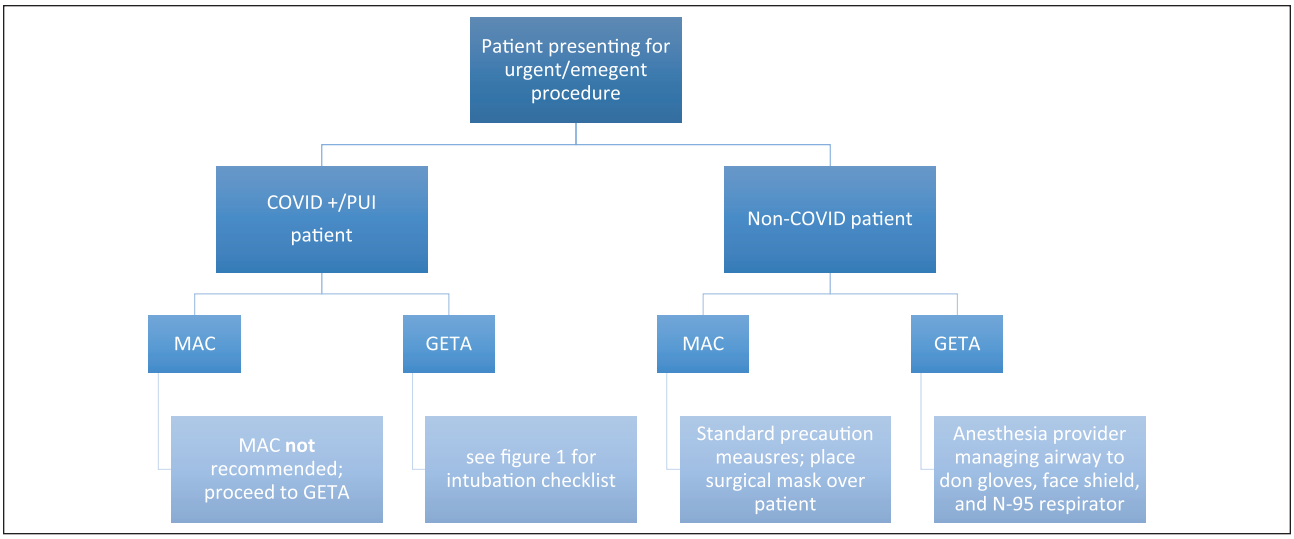

Figure 1. Algorithm for anesthetic decision making and the appropriate personal protective equipment precautions to utilize for cases presenting for urgent and emergent procedures.

Anesthesiology departments across the country have found themselves the leaders of developing and introducing safety and planning measures during these uncertain times. Our training as acute care physicians working under high-stress situations primes our specialty for leadership in times such as this. In many large academic medical centers, the Anesthesiology departments have been institutional leaders by instituting various measures to protect providers while attempting to conserve PPE. It must now be assumed that even asymptomatic patients may be carriers for of the SARS-CoV-2, thus utmost care should be taken when performing AGPs in any patient. In line with the Surgeon General's recommendations, as well as many other surgical governing bodies including the American College of Surgeons, elective cases have been postponed and only procedures deemed as urgent or emergent are being performed.[10] For those cases that have been vetted as urgent/emergent, Figure 1 outlines the algorithm for anesthetic decision-making and the appropriate PPE precautions to utilize. If intubation of a COVID-19-positive or person under investigation (PUI) is deemed necessary, Figure 2 is an example checklist created at the Vanderbilt University Medical Center, Nashville, TN, USA for ensuring appropriate PPE for anesthesia providers while minimizing risk to other staff.

At Vanderbilt, like many institutions, all COVID-19 +/PUI cases are to be performed as general endotracheal anesthesia, including standalone transesophageal echocardiograms (TEE), gastrointestinal endoscopies and colonoscopies, bronchoscopies, and so on, as the risk of aerosolization from intubation is thought to be less than coughing and sputtering with continued aerosolization of viral particles throughout the procedure. During induction, coughing, vomiting, and dys-synchrony between spontaneous breathing and assisted breathing may increase the exposure risk of aerosolized particles and oral secretions. Therefore, higher induction medication dosage and muscle relaxation may be required, which can aggravate severe hemodynamic instability in patients with inherent cardiac disease and added COVID-19–related myocardial injury further discussed below.[11] Many institutions have also implemented some version of a "COVID-19 airway team" that responds to airway emergencies throughout the hospital for COVID-19+/PUI. This "airway team" is composed of experienced anesthesia providers only (no junior residents or students) and have premade PPE equipment on standby to minimize response time. The "COVID-19 airway team" follows the same checklist outlined in Figure 1 as is followed in the operating room. Additional deployment of Anesthesiology workforce is in staffing COVID-19 Procedure teams, which work with the Airway team, but serve to place invasive lines, perform TEE as needed, and serve as a backup Airway team to help overwhelmed intensive care units (ICUs) and intensivists.

Unique environmental considerations may also play a role in management of COVID-19 patients. Locations at higher altitude may well experience a different clinical profile for patients with COVID-19 as the respiratory symptoms are a predominant issue. Colorado is one such area with the initial cases located in Summit County due to travelers arriving for the ski season following exposure elsewhere. Initial spread was similar to other locations, with a hot spot in the ski areas in Summit county, subsequently leading to closure of the ski areas, as well as a shutdown of Summit county, nearly a week before the rest of the state of Colorado. At this point, the higher elevation has not played out to be a major clinical outlier for cases located in Colorado, however, the majority at this point are now in Denver, CO which is not as high as Summit County. Current patient outcomes are very similar to those reported in

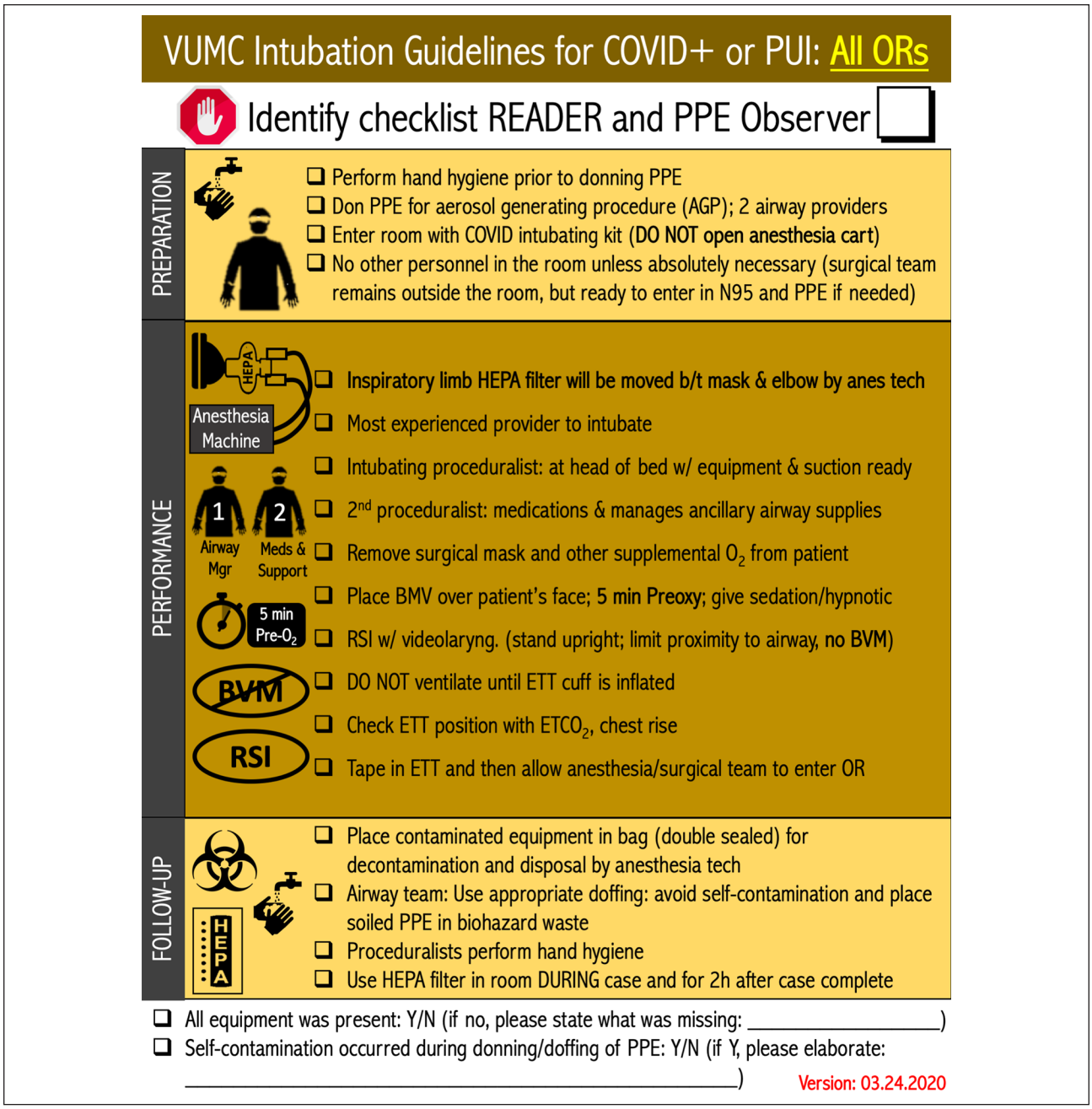

Figure 2. Checklist created at the Vanderbilt University Medical Center (Nashville, TN, USA) for ensuring appropriate personal protective equipment for anesthesia providers while minimizing risk to other staff.
The checklist was created by Drs Brent Dunworth, Mathew McEvoy, Amy Robertson, Edward Sherwood, and Lisa Weavind, all at the Department of Anesthesiology, Vanderbilt University Medical Center, Nashville, TN, USA and used by their permission.

China and elsewhere, suggesting that the altitude may not be a major contributing factor to the COVID-19 clinical presentation. Time will tell if the respiratory outcome is different from lower elevations. As in many other states, Colorado is following very similar protocols as outlined above and public health leaders hope that the effort does indeed flatten the curve in the near future.

Pediatric Anesthesia Relevance

Less is known of COVID-19 in children. Among the 75 000 confirmed and suspected SARS-CoV-2 infections in China through February 2020, 2.4% were in children younger than 19 years, and <1% were younger than 10 years.[12,13] Through February 6, 2020, there were just 9

infants reported COVID-19 positive in Chinese hospital records.[14] A small number of neonatal cases have been reported. Neonatal transmission appears to be postpartum maternal to neonatal transmission, as there is no evidence of vertical (maternal-fetal) transmission.[15] Emerging data from the Italian epidemic report that 1% of confirmed cases are in children younger than 19 years.[16] Children infected with SARS-CoV-2 have relatively milder symptoms than adults, and there are multiple reports of asymptomatic infections in children, including 16% in one cohort study.[17] On the other hand, a severe presentation of the disease is possible in children; 8 children in Wuhan City Hospital developed a severe presentation of the disease requiring intensive care.[18] As of early March 2020, there has been 1 reported pediatric death in China.[17]

Viral lower respiratory tract infections in children with poorly compensated congenital or acquired heart disease have a heightened risk of morbidity and mortality. Such infections risk elevated pulmonary vascular resistance, poor gas exchange at the alveoli, ventilation-perfusion mismatch, change or reversal of intracardiac shunt fractions, and ultimately hypoxemia, particularly in those with a tenuous cardiopulmonary status. There are not yet reports of COVID-19 in children with cardiac disease at the time of the writing of the editorial. However, if one uses respiratory syncytial virus infection as an approximation of COVID-19 in this cohort, the mortality rate due to respiratory syncytial virus in the pediatric cardiac population was markedly elevated at nearly 2%, including rates of approximately 10% in those with transposition of the great arteries, Ebstein's anomaly, heart failure, and cardiomyopathy.[19] Likewise, the risk of COVID-19–associated morbidity and mortality in immunosuppressed patients after pediatric heart transplantation is not known, but they likely represent a higher risk pediatric population.

At a large academic center children's hospital, we have categorized intubation, extubation, mask ventilation, airway suctioning, bronchoscopy or other airway surgery, and upper endoscopy as procedures that risk aerosolized small particles. All providers must wear an N-95 mask or PAPR, face shield, gown, and gloves during these procedures in children who are COVID-19 laboratory positive, suspected COVID-19 or asymptomatic without COVID-19 testing within 72 hours. All children are COVID-19 screened prior to surgery. Children with a negative result within 72 hours are cared for using standard precautions.

The American and British Societies of Echocardiography have stated that TEE increases exposure to aerosolized secretions.[20,21] In children, TEE is nearly always performed in anesthetized and intubated patients. At our large pediatric medical center, Seattle Children's Hospital, University of Washington Medical Center, Seattle, WA, USA we have surmised that risk of aerosolized secretions from TEE in an intubated, paralyzed child is negligible and thus does not require strict isolation in an asymptomatic child with unknown COVID-19 status.

Cardiac Anesthesia Relevance

Angiotensin-converting enzyme 2 (ACE2) is a membrane-bound aminopeptidase that has a vital role in the cardiovascular and immune systems. ACE2 is involved in heart function and the development of hypertension and diabetes mellitus. In addition, ACE2 has been identified as a functional receptor for coronaviruses, including SARS- CoV-2.[22] SARS-CoV-2 infection is triggered by binding of the spike protein of the virus to ACE2, which is highly expressed in the heart and lungs.[22] Myocardial injury associated with the SARS-CoV-2 occurred in 5 of the first 41 patients diagnosed with COVID-19 in Wuhan, Hubei, China, which mainly manifested as an increase in high-sensitivity cardiac troponin I levels.[23] ACE2-related signaling pathways might have a role in heart injury.[24] Cardiac anesthesiologists are likely to experience severe hemodynamic instability in COVID-19 patients during noncardiac and cardiac surgical procedures. Cardiac anesthesiologists might be called emergently into noncardiac operating rooms, cardiac catheterization laboratories, emergency rooms, ICU or wards to assist with resuscitation, TEE, or endotracheal intubations for COVID-19 patients. Cardiac anesthesiologists must follow the strict highest level infection control guidelines efficiently and effectively to protect themselves, the patients, and their colleagues. Adequate training and meticulous attention to detail must be observed in the face of the ongoing pandemic.

Direct hemodynamic monitoring with arterial and central lines is necessary for cardiac surgery. However, wearing multiple pieces of heavy protective equipment makes these procedures difficult to perform. Real-time ultrasound guidance should be used to improve the efficiency and safety. The ultrasound probe should be covered with a disposable cover to prevent probe contamination, which may lead to cross-infection.[11]

The longer duration of cardiac surgical procedures and PPE increase the physical burden for cardiac anesthesiologists, and the protective efficacy of wet PPE will decrease significantly over time. Moderate hypothermia and decreased humidity in the operating room can make staff more comfortable, reduce sweating, and reduce the risk of infection. Longer procedures may increase the risk for aerosolzation of airway secretions and thus increase the risk for viral exposure. Therefore, cardaic anesthesia team members involved in the care of a COVDI-19+/PUI patient should consider use of medical adhesive tape to strengthen the connection between the goggles and mask, between the goggles and the protective clothing cap, and between the mouth and nose of the protective clothing to effectively prevent an insufficient seal. In addition, protective equipment should be replaced frequently to maintain the best protective function if supplies allow. One approach to help avoid physical and mental fatigue of the cardiac anesthesia team could be to have a plan in place for a backup team available with shift changes that should occur every 2 to 3 hours.[11]

Cardiac anesthesiologists are leaders of echocardiography in the perioperative setting. TEE carries a higher risk of aerosolization of SARS-CoV-2 exposing the providers to increased risk for spreading the infection. The American Society of Echocardiography published a statement regarding protection of patients and providers during this outbreak.[21] First, indication for doing TEE should be carefully reviewed especially in patients with COVID-19 infection and PUI and the procedure postponed or delayed until it is safe to do. Second, transthoracic point of care ultrasound (POCUS) by an experienced echocardiographer can be utilized to provide answers for hemodynamic instability in most situations. The advantage of POCUS is that the imaging of lung and heart can be done providing much of the necessary information for COVID-19 patients while avoiding unnecessary exposure to aerosolized particles. If POCUS is done in a COVID-19+/PUI patient, covering the patient's face with surgical mask is recommended. Third, most institutions restrict utilizing PPE (N-95 masks) and PAPR for providers only for TEE examination in patients with suspected or proven COVID-19 infection because of shortage of the equipment. Standard and droplet precautions along with frequent hand washing is advised for all echocardiography examinations. Fourth, it is important to dedicate the same operating room, one machine and probe for use in this high-risk patient group, and a careful disinfection process should be followed according to manufacturer guidelines. One person performing TEE and another manipulating the machine controls will help minimize contamination. Finally, examination should be limited to essential staff and all teaching should move to online for trainees.

Transplant Anesthesia Relevance

In the field of organ transplantation, there are several concerns and issues in the area of the COVID-19 pandemic. The main concerns are the COVID-19 infection to the post-transplant patients or the patients waiting for organ transplantation. Due to the immunocompromised status of the former and to significant medical morbidity of the latter, they are at high risk of contracting SARS-CoV-2 and developing a more severe presentation of the disease. There are several case reports of COVID-19 infection to the recipients of organ transplantations. Li and colleagues report on the presentation and outcome of 2 microbiologically confirmed COVID-19 cases in heart transplantation detected in the Hubei province in China.[25] Both were middle-aged men with stable conditions after heart transplantation (16 years and 3 years, respectively) with a low-dose immunosuppression regimen. Both patients recovered well after confirmed COVID-19 infection. The main issues, which are arguably far more relevant to practicing transplant anesthesiologists in this field, are the current and near-future indications of transplantations in hospitals in geographic COVID-19 hot spots. Setting aside the critical discussion on hospital and medical resource utilization, evaluating benefits and risks of recipients waiting for organ transplantation who would undergo organ transplantation in the area of COVID-19 pandemic is a pressing issue. Kumar and international team of authors advocate a 4-phased approach where transplant activity level will be decreased by 25%, 50%, 75%, and 100%, reflecting the severity of COVID-19 pandemic in the particular country.[26] In this recommendation, the life-saving nature of heart, lung, and liver transplantations deems these transplantations to be continued at the 75% reduction phase on a selected population of recipients, while living kidney transplantations are to be halted at the 25% reduction phase. To address the potential issue of transmission of COVID-19 from donor graft to the recipients, they summarized the current COVID-19 screening practices on the deceased donor, living donor, and pretransplant recipient in Canada, Switzerland, Italy, Spain, Korea, and Japan.[26] Of course, the wellness and safety of living donors for liver and kidney have paramount importance. Nevertheless, all transplant activity should be stopped if the programs are overwhelmed with COVID-19 ICU admissions causing severe shortage of health care personnel. It can be advised to offer alternative forms of therapy such as left ventricular assist devices for end-stage heart failure. If the decision is made to proceed with an organ transplant, all donors should be tested for COVID-19 infection. Indeed, there is no consensus on testing all asymptomatic recipients and clinical correlation is suggested. Furthermore, transplantation with marginal organs with anticipated prolonged hospital stay should be avoided during this phase. All standard and droplet precautions should be taken to avoid exposure to the patients.

Summary

The information provided by Tang and Wang[9] highlight the specific role of anesthesiologists and intensivists in the fight of this pandemic as airway and ventilation experts, masters of hemodynamic control, and leaders in advanced circulatory support management. The unique skillsets possessed by them make them essential in the care of critically ill patients not only on a daily basis but also, especially, in the face of a raging pandemic.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

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