Neuroanesthesia Practice During the COVID-19 Pandemic: Recommendations from Society for Neuroscience in Anesthesiology & Critical Care (SNACC)

Alana M. Flexman, MD FRCPC
Department of Anesthesiology and Perioperative Care
Vancouver General Hospital
University of British Columbia
Vancouver, BC, Canada
Alana.flexman@vch.ca

Arnoley Abcejo, MD
Department of Anesthesiology and Perioperative Medicine
Mayo Clinic
Rochester, NY, USA
Abcejo.Arnoley@mayo.edu

Rafi Avitisian MD FASA
Professor of Anesthesiology
Program Director, Neuroanesthesiology Fellowship
Department of General Anesthesiology
Cleveland Clinic
AVITSIR@ccf.org

Veerle De Sloovere, MD
University Hospitals Leuven
Department of Anesthesiology
Herestraat 49
3000 Leuven, Belgium
veerle.desloovere@uzleuven.be

David Highton, MBChB, FRCA, FFICM, FANZCA, PhD
Princess Alexandra Hospital
University of Queensland
Australia
david.highton@health.qld.gov.au

Niels Juul, MD
Department of Anesthesia,
Head of Division of Neuroanesthesia
Aarhus University Hospital,
Aarhus, Denmark
niels.juul@aarhus.rm.dk

Shu Li, MD
Department of Anesthesiology
Beijing Tian Tan Hospital, Capital Medical University
Beijing, PR China
emilyneuro@gmail.com

Lingzhong Meng, MD
Department of Anesthesiology
Yale University School of Medicine
New Haven, CT, USA
lingzhong.meng@yale.edu

Chanannait Paisansathan, MD
Department of Anesthesiology
University of Illinois
Chicago, IL, USA
Oon@uic.edu

Girija Prasad Rath, MD DM
Department of Neuroanesthesiology and Critical Care
Neurosciences Centre
All India Institute of Medical Sciences (AIIMS)
New Dehli, India
girijarath@aiims.edu

Irene Rozet, MD
Department of Anesthesiology
University of Washington
Seattle, WA, USA
irozet@uw.edu

Corresponding Author: Dr. Alana M. Flexman, Department of Anesthesiology, Pharmacology and Therapeutics, University of British Columbia, Vancouver General Hospital, Room 2449 JPP 899 West 12th Avenue, Vancouver, BC, Canada, V5Z 1M9; Phone (604) 875-4304; Email: alana.flexman@vch.ca.

Funding: No funding received for this manuscript.

Financial Disclosures: The other authors have no disclosures.

Introduction

The novel coronavirus, severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), first emerged in Wuhan, China, in December 2019,[1] and has since spread across the globe. On February 11, 2020, the World Health Organization named the disease caused by this virus COVID-19, and subsequently declared a pandemic on March 11, 2020.[2] COVID-19 is characterized by fever (89%), cough (58%), dyspnea (46%), myalgias (29%), lymphopenia[3] and typical imaging features of bilateral ground glass opacities and consolidation.[4] Although symptoms can range from mild to severe, overall 20% of infected patients require admission to the intensive care unit (ICU).[3] Risk factors for severe disease or death include older age, smoking, COPD, diabetes, hypertension, immunocompromise and malignancy.[5, 6] This novel disease has several implications relevant to neuroanesthesiologists, including neurologic manifestations, and implications for specific neurosurgical procedures and electroconvulsive therapy.

Aim and Scope

The aim of this document is to provide a focused overview of the novel SARS-CoV-2 virus and COVID-19 disease for neuroanesthesiologists. This statement will provide information on the neurological manifestations of COVID-19, and considerations for the clinical practice related to neuroanesthesia including electroconvulsive therapy, emergent neurosurgery, interventional radiology, transnasal neurosurgery, awake craniotomy and healthcare provider wellness. Endovascular therapy for acute ischemic stroke is covered in a separate publication.[7] The information provided can be used to inform local and institutional policies and procedures. The authors also acknowledge that the information provided in this document will evolve as our

knowledge about this virus increases over the coming months and these recommendations are subject to change. Finally, these recommendations must be adapted to regional and institutional resources and requirements.

Writing Group

The authors of this practice advisory were appointed by SNACC. The authors were chosen based on clinical expertise in various aspects of neuroanesthesia practice, and to represent a range of geographic locations (North America, Australia, Europe, China, India) and clinical practice settings.

Neurological Manifestations of COVID-19

Table 1. Neurological Manifestations of COVID-19
• Common neurologic symptoms are: headache, dizziness, alternations in taste and smell • Early reports suggest a 5% risk of ischemic stroke • Coronaviruses have a propensity for invasion into the central nervous system

The neurological manifestations of COVID-19 have only recently been described and preliminary unpublished evidence suggests that these patients are at elevated risk of ischemic stroke. A recent pre-publication report from China Patients with COVID-19 suggests that neurological symptoms are common (36%), such as dizziness, headache, hypogeusia and

hyposma.[8] Encephalopathy has also been reported in patients infected with the SARS-CoV-2 virus.[9] Other neurological complications may also result from COVID-19, and cerebrovascular disease including ischemic stroke (5.7%) and impaired consciousness (15%) are more common in severe disease.[8] These results are consistent with another pre-publication report of 221 patients from Wuhan, China, which found a 5% incidence of acute ischemic stroke (5%) compared to a 1% incidence of cerebral hemorrhage.[10] In this cohort, patients with cerebrovascular complications were more likely to be older, have severe disease, and demonstrate evidence of hypercoagulability and inflammation. Ultimately, thirty-eight percent of patients with cerebrovascular complications died. Together, these preliminary reports suggest that patients with COVID-19 could present more frequently for endovascular treatment of acute ischemic stroke and could also be at elevated risk of perioperative stroke if they require surgery during acute infection.

Other coronaviruses with close similarity to SARS-CoV-2 have been shown to invade the central nervous system (CNS). The SARS-CoV and MERS-CoV viruses are closely related to the SARS-CoV-2 virus in structure and infection pathway, and both of these viruses have been shown to infect the CNS. In animal models, the brainstem was found to be heavily infected by both SARS-CoV[11] and MERS-CoV.[12] Furthermore, CNS infection was closely related to high mortality rate, possibly due to dysfunction of the cardiorespiratory center in the brainstem. A predisposition to neuroinvasion is considered to be a common feature of the coronavirus family, and the SARS-CoV-2 virus should be presumed to have similar features.[13] The alternations in smell observed with COVID-19, in particular, have been postulated to reflect the access of the virus to the brain

through the transcribrial route as described in other pathogens,[14] although this remains to be proven for SARS-CoV-2. Overall, direct invasion of the CNS is plausible, and may account for some of the neurological symptoms reported by patients.[13]

Urgent Neurosurgical Procedures During the COVID-19 Pandemic

Table 2. Urgent Neurosurgical Procedures During the COVID-19 Pandemic
• Urgent and emergent neurosurgery will be required during the COVID-19 pandemic and can be centralized to free up resources • Patients should be screened for COVID-19 using a combination of history, CT chest, and RT-qPCR testing depending on institutional policies, availability and turn-around time • Patients undergoing emergent neurosurgical procedures could be presumed to have COVID-19 until further information is available • General anesthesia for patients suspected or confirmed to have COVID-19 should follow published recommendations and be done using appropriate personal protective equipment

The COVID-19 pandemic has necessitated a reduction in elective surgeries to increase capacity and free up resources,[15-17] and this includes limitations on neurosurgical procedures. Nevertheless, patients will continue to require emergent and urgent neurosurgical interventions for life-threatening conditions. The hard-hit region of Lombardy, Italy, described

creating a centralized network of three “hub” hospitals that accepted all urgent neurosurgical referrals, while one additional center was designated for urgent oncological neurosurgery.[18]

The diagnostic criteria for suspected or confirmed COVID-19 cases include epidemiological history, clinical manifestation, real-time quantitative fluorescence polymerase chain reaction (RT-qPCR) test and COVID-19-specific IgM and IgG antibody test. RT-qPCR testing of respiratory specimens,[19] including nasopharyngeal swabs, bronchoalveolar lavage fluid, sputum, or bronchial aspirates, for SARS–CoV-2 RNA is currently widely used for case diagnosis.[1, 20] Due to the possibility of false-negative RT-qPCR test results,[21] RT-qPCR testing on two consecutive respiratory samples obtained at least 24 hours apart should be considered when resources are available.[22] Together, typical clinical symptoms, chest CT imaging, and epidemiological history (history of travel or high risk exposure) can be used to assess the risk of COVID-19 infection and indication for testing. The accepted criteria for the diagnosis to COVID-19 includes one of the following: 1) RT-qPCR is positive for COVID-19 nucleic acid; 2) the viral gene identified by gene sequencing is highly homologous with know COVID-19; or 3) presence of COVID-19-specified IgM and IgG antibodies.

For patients requiring aerosol-generating procedures (AGPs) by providers, protection against viral aerosolization should be used for all patients using an N95 mask, or a powered, air-purifying respirator (PAPR) is recommended.[23] Anesthesiologists should refer to detailed published recommendations for perioperative management of COVID-19 patients,[24-26] which are summarized as the following. To conserve PPE and limit exposure, only essential personnel

should be present for AGPs that occur during general anesthesia. Ideally, intubation and induction of GA should be performed in a negative-pressure environment and intubation performed using rapid sequence induction, videolaryngoscopy, and minimizing bag mask ventilation. Extubation following GA should, if possible, be performed in a negative-pressure environment using airborne PPE, and coughing avoided during extubation. The patient should wear a surgical mask after extubation and high flow oxygen (>5L/min) avoided given the risk of aerosolization.[27] Finally, patient transportation requires attention to safety and minimization of contamination, and extubated patients should wear a face mask oxygen delivery system and, if possible, an additional surgical mask placed on the patient.

Transnasal Neurosurgical Procedures

Table 3. Transnasal Neurosurgical Procedures
• Given the high degree of viral shedding from the nasopharyngeal muscosa, transnasal procedures may aerosolize virus into the environment • Recently, neurosurgical and otolaryngology organizations have recommended screening patients for symptoms of COVID-19, testing preoperatively and considering alternative surgical approaches to transnasal surgery

Transnasal endoscopic neurosurgery facilitates access to the sellar region, and is most frequently employed for transsphenoidal hypophysectomy for pituitary tumors. The SARS-CoV-

2 virus is thought to have a high degree of viral shedding from the nasal mucosa,[28] and early reports have highlighted the propensity of nasal surgery to aerosolize virus with high potential for transmission. Early reports from Wuhan, China, have highlighted the risk of transsphenoidal hypophesectomy in patients who reported mild flu like symptoms.[29] Early in the pandemic in China before testing became widespread, patients who underwent emergency transsphenoidal hypophesectomy resulted in viral transmission to multiple healthcare workers within days of the surgery, even with appropriate PPE.[29] As a result of these reports, concern has rapidly escalated about the safety of nasal surgery amongst otolaryngologists, particularly driven by widespread reports of infected colleagues.[29]

Despite these concerns, patients may still require urgent or emergent transsphenoidal hypohysectomy, such as for acute vision loss, pituitary apoplexy with neuroophthalmic signs or deteriorating level of consciousness,[30] Recent recommendations have highlighted the high risk of nasal surgery in patients infected with SARS-CoV-2, making recommendations to deferral non-urgent surgery, evaluate for SARS-CoV-2 via symptoms, radiological imaging and two COVID RT-PCR tests separated by 24 hours and use appropriate PPE.[31, 32] If transsphenoidal hypophysectomy is required emergently, SARS-CoV-2 testing may not be available, and identifying infected patients is problematic due to the high proportion of asymptomatic patients. As such, only essential staff should be in the operating room with appropriate PPE. An alternative surgical approach may therefore be considered, i.e. craniotomy rather than the transnasal approach.[29, 33] These options should be considered on a case-by-case basis.

Awake Craniotomy

Table 4. Awake Craniotomy
• Awake craniotomy can be offered selectively during the COVID-19 pandemic • If chosen, airway interventions should be avoided and light sedation before and after neurocognitive testing is recommended • Minimize the risk of intraoperative coughing (e.g. lidocaine or fentanyl priming) • Prepare for emergent airway management with appropriate PPE • Patients should wear a surgical mask and use low-flow nasal cannula under mask if supplemental oxygen is needed • A microphone can be used to facilitate communication with the patient at a distance

An awake craniotomy requires the patient to participate in various neurocognitive testing during the surgery, although the patient can be awake, sedated, or under general anesthesia before and after periods of intraoperative testing.[34] This type of surgery is typically used for brain tumor and epilepsy surgery when the lesion is in close proximity to eloquent areas of the brain, in order to facilitate surgeon's decision-making.[35] Amid the COVID-19 pandemic, an awake craniotomy presents with several challenges for anesthesiologists, with little specific evidence to guide practice. The following discussion is primarily opinion-based.

In principle, an awake craniotomy should not be performed emergently, given the relative risks and benefits. An awake craniotomy requires a complex teamwork of multidisciplinary experts that cannot be assembled urgently, as well as patient preparation for the operating room procedures. Moreover, emergent awake surgery has other risks, including full-stomach and lack of time for preoperative optimization. Occasionally, however, an urgent awake craniotomy undertaken out of surgical necessity or patient comorbidities.[36]

If the COVID-19 pandemic persists, as it is likely to, what should we do for those patients who would otherwise be candidates for awake craniotomy? Awake craniotomy can offer unique benefits to patients[37] and may still be offered to patients in the coming months. In order to prepare for this situation, several steps should be undertaken. First, the patients should be screened for the presence of the SARS-CoV-2 virus through clinical and radiologic assessment, and RT-qPCR testing, if available. During the outbreak in Wuhan, China, all surgical patients, even if asymptomatic, were carefully evaluated with a COVID-19 test and radiographic imaging. If the patient has respiratory symptoms or hypoxemia preoperatively, the etiology should be investigated and the decision to pursue an awake craniotomy should be re-considered as patients with respiratory distress or hypoxemia should not undergo an awake craniotomy.

Different anesthetic techniques have been described to carry out awake craniotomy: Awake-Awake-Awake (AAA) technique (without any sedation), conscious sedation or monitored anesthesia care (MAC), asleep awake (AA) technique, and Asleep-Awake-Asleep (AAA) technique.[38] During the COVID-19 pandemic, coughing should be avoided to minimize the

potential of contamination and aerosolization, and can be mitigated through the use of intravenous medications such as low dose lidocaine, or priming with fentanyl.[39] In addition, we advocate an approach that avoids airway instrumentation and uses only light sedation (i.e. drowsy but arousable) before neurocognitive testing to minimize the possibility of airway complications from over-sedation, which may be particularly detrimental during the pandemic. In addition, regional scalp blocks can also provide analgesia and minimize sedation. Given that patients can potentially be infected by SARS-CoV-19 and remain asymptomatic,[40] patients should wear a surgical mask whenever possible, including during the procedure although the mask can be temporarily removed during neurocognitive testing. Low-flow nasal cannula (<6 L/min) can be placed under the mask if supplemental oxygen is needed. A microphone may facilitate intraoperative communication and maintain distance between the patient and the operating room team to lessen the chance of cross infection.

Neurointerventional Radiology Procedures

Table 5. Neurointerventional Radiology Procedures
• Patients suspected of COVID-19 should be tested prior to the procedure • Intubation and extubation should ideally occur in an airborne isolation room, which may be outside the neurointerventional radiology suite • Lead must be worn underneath PPE as the anesthesiologist may be required to stay in the radiology suite itself

With the exception of endovascular therapy for acute ischemic stroke, most neurointerventional radiology (NIR) procedures performed during the pandemic are considered urgent, rather than emergent (e.g. embolization of intracranial aneurysms, spine tumors). Therefore, any patients with suspected COVID-19 should be tested prior to undertaking the procedure (provided rapid testing <24 hours is available), and appropriate PPE implemented according to institutional policies. Only essential personnel should be present during airway management and, ideally, intubation should be performed in an airborne isolation room with negative pressure relative to the surrounding area.[41] However, we recognize that this may not be available near many NIR suites, and that intubation will need to occur in the radiology suite.

Anesthesia for neurointerventional radiology procedures carriers several other unique considerations. For example, anesthesia providers must ensure lead protection is donned underneath PPE, as the anesthesia practitioner may be required to stay in the NIR suite rather than the control room. After the procedure, the lead suits worn during the procedure require rigorous decontamination with disinfection wipes that contain a quaternary ammonium compound and alcohol.[42] A top-down cleaning sequence may reduce bioburden. Locations for donning, doffing and cleaning of lead will need to be established in close proximity to the NIR suite, and appropriate PPE available. Finally, given the remote location of many interventional radiology suites, a plan for extubation is required, with consideration for transport to a negative pressure isolation room in another location first. At a minimum, caution must be taken to ensure that patients are transported without risk of urgent airway intervention or coughing during transit.

Electroconvulsive Therapy

Table 6. Electroconvulsive Therapy (ECT)
• ECT can be considered lifesaving in some cases and cannot be delayed, although other treatment options should be exhausted • The population undergoing ECT may be at higher risk of COVID-19 and COVID-19-related morbidity • Patients must be COVID-19 negative and asymptomatic to undergo ECT • Bag mask ventilation increases the risk of aerosolization and contamination, and should be minimized

Electroconvulsive Treatment (ECT) has been successfully utilized in a wide variety of neurological and psychiatric disorders.[43, 44] During and following the COVID-19 pandemic, we should prepare for potential increase in demand of ECT procedures. Pandemics are likely to cause damaging effect on mental health including increases in suicide rate, particularly in survivors of the disease, health care providers, and previously healthy, but isolated or quarantined populations. Of particular concern are those affected by the economic down fall as the suicide rate in the US rose dramatically during the Great Depression.[45] A previous outbreak of a related virus, SARS-CoV-1, in 2003 significantly impacted mental health of SARS survivors and health care providers. About 41–65% of SARS survivors suffered persistent psychologic and/or psychiatric problems, predominantly Post Traumatic Stress Disorder (PTSD) and Depression, lasting as long as 30 months after recovery from SARS (12-15), including healthcare

providers who were infected and recovered from SARS.[46, 47] Even health healthcare providers who were not infected, experienced substantial psychological distress years after the outbreak.[48] Today, the magnitude of COVID-19 pandemic is at least two orders greater than SARS, and a recent survey suggests health care providers taking care of COVID-19 patients in China report high rates of distress, depression, anxiety, and insomnia.[49]

During pandemic of COVID-19, the risks and benefits of ECT must be carefully considered. ECT should be considered as urgent or semi-urgent intervention for suicidal ideation, severe depression, mania and catatonia and should not be delayed.[43, 50] However, when considering secondary ECT, both anesthesiologist and psychiatrist must ensure that all conservative interventions had been pursued and exhausted prior to administration of the ECT as a "last resort" therapy.[43]

The patient population commonly undergoing ECT presents specific challenges during the COVID-19 pandemic. These patients more often belong to lower socio-economic class,[51] (21,22) having poor hygiene,[52] living in crowded places or being homeless, inevitably increasing chance of being infected themselves and potentially spreading infection in the hospital ward.[50] As ECT patients tend to be older,[53] with comorbidities, they are higher risk for both ECT-associated[54] and COVID-19 related morbidity and mortality.[5, 6] Only COVID-19 asymptomatic patients should be considered for ECT and each patient should be tested for SARS-CoV-2 virus close to the time of their procedure. SARS-CoV-2 positive patients should not be allowed to proceed with ECT. If asymptomatic, patients who test positive for SARS-CoV-2 but remain asymptomatic should be

allowed to proceed only if subsequent testing 14 days later is negative, and ECT is considered a life-saving procedure.

The conduct of anesthesia for ECT during the COVID-19 pandemic requires careful consideration. The most challenging anesthetic consideration in ECT during COVID-19 is airway management. Commonly managed mask ventilation and hyperventilation without definitive airway represents significant risk of infection for healthcare providers and anesthesiologists and should be minimized.[55] To minimize risk of viral transmission, the following is recommended:

1. Since anesthesia management for ECT inevitably involves positive pressure mask ventilation with unprotected airway, it should be ideally performed in negative pressure single airborne suite, utilizing full PPE, restricted personnel, and careful disinfection (e.g. minimum 75% alcohol[50]) of the suite, allowing at least 30 minutes between patients[55, 56];
2. To minimize hypersalivation, glycopyrrolate 0.2-0. 4 mg intravenously can be safely administered prior to induction of anesthesia[57];
3. To reduce coughing on emergence, remifentanil can be safely administered during procedure, and lidocaine (1-1.5 mg/kg of ideal body weight) can be administered intravenously after the seizure is completed;[55, 56]
4. Although hyperventilation can improve seizures quality, the evidence is weak.[58] and aerosolization is increased. Therefore, this strategy should be avoided during the COVID-19 pandemic, unless adjustments of other measures improving seizure are unsuccessful. If

possible, induction agents providing best possible quality of seizure should be employed: ketamine, etomidate and methohexital.[59]

5. With mask ventilation, consider careful preoxygenation and nasal prongs with high oxygen flow during apnea[55];

6. In cases requiring hyperventilation, Laryngeal Mask Airway allowing capnography[55] may be considered an alternative to manual mask ventilation

7. Patients should be recovered in designated areas wearing masks[50, 55]

Wellness for Health Care Providers During the COVID-19 Pandemic

Table 7. Wellness for Health Care Providers
• During an epidemic, the physical and mental health of healthcare professionals is essential for sustainability • Prolonged procedures, physical exhaustion, a high risk of contamination and psychological stress are common in neuroanesthesia practice • Multiple specialty societies provide resources on strategies to relieve stress and improve wellness

During a pandemic, the concept of "duty to treat" by healthcare workers is a given for general population although many significant changes are observed in healthcare delivery and risks to healthcare providers.[60] The notion of self-sacrifice is a grave mistake; success in controlling and ultimately eradicating an pandemic depends on availability of resources, and personnel.[61] Physicians, nurses and other health care workers may not realize that during a pandemic, the nature of "the patient" changes from a single individual to a community. We reinforce the

utmost importance of safety to preserve the human resources necessary to overcome the pandemic. The wellness of healthcare workers could encompass both physical and mental fitness.

Physical wellness is a primary concern to ensure a sustainable workforce during a pandemic. In addition to the risks that general anesthesiologists face in contracting the virus including airway management, neuroanesthesiologists have additional exposure risk due to close proximity to patients and long surgical procedures. Wearing PPE for a prolonged time may cause excessive heat and need for frequent rehydration and neurointerventional procedures may be particularly uncomfortable due to the addition of lead protection under PPE. It should be remembered that all steps of doffing should be thoroughly completed and meticulous hand washing performed before any consumption, and all food or drink be consumed outside of any patient care area. Due to these practice restrictions, anesthesiology departments should ensure additional staffing is available to provide breaks and clinical support during these cases.

Psychological health is of critical importance as anesthesiologists and intensivists are at the front line of the management of the target organs that the virus attacks and are faced with the task of rapidly reviewing continually evolving guidelines and implementing them in their work environment. In addition to the general anxieties felt generally during the pandemic, these healthcare practitioners face substantial stress due to the stress of remembering all guidelines and implementing them with minimal time to practice. A change in number of work hours and assignments outside familiar environment may be difficult for others. Physicians as well as

other health care workers may have concerns about transmitting the virus to their home environment.[62] High level of anxiety can arise during deviation from routine workflow. This anxiety along with long hours of work can negatively affect the immune system of health care professionals. Healthy nourishment, adequate sleep, and scheduled breaks are ways to cope with stress in epidemic situations. Many hospitals have support systems for all healthcare professionals that are faced with high mortality epidemic. There should also be counseling and designated areas for rest in accordance with social distancing rules.[63] The American Medical Association has released resources for health care leadership to guide them in helping the providers during the COVID-19 pandemic including sustaining physical and mental well-being.[64] Ultimately, a pandemic is a battle; the well-being of the health care professionals who fight the battle is essential in ensuring victory.

Conclusion

Since the novel SARS-CoV-2 virus first emerged in late 2019 in China, the COVID-19 pandemic has spread around the globe and caused massive disruptions to healthcare provision. Neuroanesthesiologists should be aware of several specific considerations related to anesthesia for urgent neurosurgical and neurointerventional radiology procedures, as well as electroconvulsive therapy. These recommendations will continue to evolve as the pandemic progresses, particularly as we gain further insights into the pathophysiology, clinical course, and treatment options for COVID-19.

BIBLIOGRAPHY

1. Huang C, Wang Y, Li X, et al. Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. *Lancet* 2020;395: 497-506.
2. World Health Organization. [Available at: https://www.who.int/emergencies/diseases/novel-coronavirus-2019.
3. Rodriguez-Morales AJ, Cardona-Ospina JA, Gutierrez-Ocampo E, et al. Clinical, laboratory and imaging features of COVID-19: A systematic review and meta-analysis. *Travel Med Infect Dis* 2020: 101623.
4. Zhao W, Zhong Z, Xie X, et al. Relation Between Chest CT Findings and Clinical Conditions of Coronavirus Disease (COVID-19) Pneumonia: A Multicenter Study. *AJR Am J Roentgenol* 2020: 1-6.
5. Guan WJ, Liang WH, Zhao Y, et al. Comorbidity and its impact on 1590 patients with Covid-19 in China: A Nationwide Analysis. *Eur Respir J* 2020.
6. Zhou F, Yu T, Du R, et al. Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: a retrospective cohort study. *Lancet* 2020;395: 1054-1062.
7. Sharma D, Rasmussen M, Han R, et al. Anesthetic Management of Endovascular Treatment of Acute Ischemic Stroke During COVID-19 Pandemic: Consensus Statement from Society for Neuroscience in Anesthesiology & Critical Care (SNACC). *Journal of Neurosurgical Anesthesiology* 2020.
8. Mao L, Wang M, Chen S, et al. Neurological Manifestations of Hospitalized Patients with COVID-19 in Wuhan, China: a retrospective case series study. *medRxiv* 2020: 2020.02.22.20026500.
9. Filatov A, Sharma P, Hindi F, et al. Neurological Complications of Coronavirus Disease (COVID-19): Encephalopathy. *Cureus* 2020;12: e7352.
10. Li Y, Wang M, Zhou Y, et al. Acute Cerebrovascular Disease Following COVID-19: A Single Center, Retrospective, Observational Study (3/3/2020). *Available at SSRN: https://ssrn.com/abstract=3550025* 2020.
11. Netland J, Meyerholz DK, Moore S, et al. Severe acute respiratory syndrome coronavirus infection causes neuronal death in the absence of encephalitis in mice transgenic for human ACE2. *J Virol* 2008;82: 7264-75.
12. Li K, Wohlford-Lenane C, Perlman S, et al. Middle East Respiratory Syndrome Coronavirus Causes Multiple Organ Damage and Lethal Disease in Mice Transgenic for Human Dipeptidyl Peptidase 4. *J Infect Dis* 2016;213: 712-22.
13. Li YC, Bai WZ, Hashikawa T. The neuroinvasive potential of SARS-CoV2 may play a role in the respiratory failure of COVID-19 patients. *J Med Virol* 2020.
14. Baig AM, Khaleeq A, Ali U, et al. Evidence of the COVID-19 Virus Targeting the CNS: Tissue Distribution, Host-Virus Interaction, and Proposed Neurotropic Mechanisms. *ACS Chem Neurosci* 2020;11: 995-998.
15. Surgeons ACo. COVID-19: Elective Case Triage Guidelines for Surgical Care. [2020. Available at: https://www.facs.org/covid-19/clinical-guidance/elective-case. Accessed April 2, 2020.

16. Iacobucci G. Covid-19: all non-urgent elective surgery is suspended for at least three months in England. *BMJ* 2020;368: m1106.
17. Government N. COVID-19: Interim guidance for elective surgery and outpatient clinics. [2020. Available at: https://www.health.nsw.gov.au/Infectious/diseases/Pages/coronavirus-elective-outpatient-guidance.aspx. Accessed April 2, 2020.
18. Zoia C, Bongetta D, Veiceschi P, et al. Neurosurgery during the COVID-19 pandemic: update from Lombardy, northern Italy. *Acta Neurochir (Wien)* 2020.
19. Wang W, Xu Y, Gao R, et al. Detection of SARS-CoV-2 in Different Types of Clinical Specimens. *JAMA* 2020.
20. Commission CNH. Chinese Clinical Guidance For COVID-19 Pneumonia Diagnosis and Treatment. [2020. Available at: http://kjfy.meetingchina.org/msite/news/show/cn/3337.html. Accessed March 22, 2020.
21. Xie X, Zhong Z, Zhao W, et al. Chest CT for Typical 2019-nCoV Pneumonia: Relationship to Negative RT-PCR Testing. *Radiology* 2020: 200343.
22. Lan L, Xu D, Ye G, et al. Positive RT-PCR Test Results in Patients Recovered From COVID-19. *JAMA* 2020.
23. Anesthesiologists ASo. UPDATE: The Use of Personal Protective Equipment by Anesthesia Professionals during the COVID-19 Pandemic. [2020. Available at: https://www.asahq.org/about-asa/newsroom/news-releases/2020/03/update-the-use-of-personal-protective-equipment-by-anesthesia-professionals-during-the-covid-19-pandemic. Accessed April 6, 2020.
24. Chen X, Liu Y, Gong Y, et al. Perioperative Management of Patients Infected with the Novel Coronavirus: Recommendation from the Joint Task Force of the Chinese Society of Anesthesiology and the Chinese Association of Anesthesiologists. *Anesthesiology* 2020.
25. Orser BA. Recommendations for Endotracheal Intubation of COVID-19 Patients. *Anesth Analg* 2020.
26. Zuo MZ, Huang YG, Ma WH, et al. Expert Recommendations for Tracheal Intubation in Critically ill Patients with Noval Coronavirus Disease 2019. *Chin Med Sci J* 2020.
27. Cheung JC, Ho LT, Cheng JV, et al. Staff safety during emergency airway management for COVID-19 in Hong Kong. *Lancet Respir Med* 2020;8: e19.
28. Zou L, Ruan F, Huang M, et al. SARS-CoV-2 Viral Load in Upper Respiratory Specimens of Infected Patients. *N Engl J Med* 2020;382: 1177-1179.
29. Patel Z, Fernadex-Miranda J, Hwang P, et al. Precautions for Endoscopic Transnasal Skull Base Surgery during the COVID-19 Pandemic. [2020. Available at: https://www.entnet.org/sites/default/files/uploads/covid-19_endosb_lettertoeditor_neurosurgery_update3.23.20.pdf. Accessed April 4, 2020.
30. Rajasekaran S, Vanderpump M, Baldeweg S, et al. UK guidelines for the management of pituitary apoplexy. *Clin Endocrinol (Oxf)* 2011;74: 9-20.
31. Givi B, Schiff BA, Chinn SB, et al. Safety Recommendations for Evaluation and Surgery of the Head and Neck During the COVID-19 Pandemic. *JAMA Otolaryngol Head Neck Surg* 2020.

32. Australian Society of Otolaryngology HaNSA. Guidance for ENT surgeons during the COVID-19 pandemic. [2020. Available at: http://www.asohns.org.au/about-us/news-and-announcements/latest-news?article=78. Accessed April 4, 2020.
33. Surgeons AAoN. COVID-19 and Neurosurgery. [2020. Available at: https://www.aans.org/en/Patients/Neurosurgical-Conditions-and-Treatments/COVID-19-and-Neurosurgery. Accessed April 4, 2020.
34. Meng L, McDonagh DL, Berger MS, et al. Anesthesia for awake craniotomy: a how-to guide for the occasional practitioner. *Can J Anaesth* 2017;64: 517-529.
35. Hervey-Jumper SL, Li J, Lau D, et al. Awake craniotomy to maximize glioma resection: methods and technical nuances over a 27-year period. *J Neurosurg* 2015;123: 325-39.
36. Meng L, Weston SD, Chang EF, et al. Awake craniotomy in a patient with ejection fraction of 10%: considerations of cerebrovascular and cardiovascular physiology. *J Clin Anesth* 2015;27: 256-61.
37. Meng L, Berger MS, Gelb AW. The Potential Benefits of Awake Craniotomy for Brain Tumor Resection: An Anesthesiologist's Perspective. *J Neurosurg Anesthesiol* 2015;27: 310-7.
38. Hansen E, Seemann M, Zech N, et al. Awake craniotomies without any sedation: the awake-awake-awake technique. *Acta Neurochir (Wien)* 2013;155: 1417-24.
39. Shuying L, Ping L, Juan N, et al. Different interventions in preventing opioid-induced cough: a meta-analysis. *J Clin Anesth* 2016;34: 440-7.
40. Bai Y, Yao L, Wei T, et al. Presumed Asymptomatic Carrier Transmission of COVID-19. *JAMA* 2020.
41. Bourouiba L. Turbulent Gas Clouds and Respiratory Pathogen Emissions: Potential Implications for Reducing Transmission of COVID-19. *JAMA* 2020.
42. Dexter F, Parra MC, Brown JR, et al. Perioperative COVID-19 Defense: An Evidence-Based Approach for Optimization of Infection Control and Operating Room Management. *Anesth Analg* 2020.
43. Jelovac A, Kolshus E, McLoughlin DM. Relapse following successful electroconvulsive therapy for major depression: a meta-analysis. *Neuropsychopharmacology* 2013;38: 2467-74.
44. Sanghani SN, Petrides G, Kellner CH. Electroconvulsive therapy (ECT) in schizophrenia: a review of recent literature. *Curr Opin Psychiatry* 2018;31: 213-222.
45. Tapia Granados JA, Diez Roux AV. Life and death during the Great Depression. *Proc Natl Acad Sci U S A* 2009;106: 17290-5.
46. Lee AM, Wong JG, McAlonan GM, et al. Stress and psychological distress among SARS survivors 1 year after the outbreak. *Can J Psychiatry* 2007;52: 233-40.
47. Kwek SK, Chew WM, Ong KC, et al. Quality of life and psychological status in survivors of severe acute respiratory syndrome at 3 months postdischarge. *J Psychosom Res* 2006;60: 513-9.
48. Maunder RG, Lancee WJ, Balderson KE, et al. Long-term psychological and occupational effects of providing hospital healthcare during SARS outbreak. *Emerg Infect Dis* 2006;12: 1924-32.

49. Lai J, Ma S, Wang Y, et al. Factors Associated With Mental Health Outcomes Among Health Care Workers Exposed to Coronavirus Disease 2019. *JAMA Netw Open* 2020;3: e203976.
50. Tor PC, Phu AHH, Koh DSH, et al. ECT in a time of COVID-19. *J ect* 2020.
51. Nelson G, Hall GB, Squire D, et al. Social network transactions of psychiatric patients. *Soc Sci Med* 1992;34: 433-45.
52. Brewer WJ, Edwards J, Anderson V, et al. Neuropsychological, olfactory, and hygiene deficits in men with negative symptom schizophrenia. *Biol Psychiatry* 1996;40: 1021-31.
53. Slade EP, Jahn DR, Regenold WT, et al. Association of Electroconvulsive Therapy With Psychiatric Readmissions in US Hospitals. *JAMA Psychiatry* 2017;74: 798-804.
54. Blumberger DM, Seitz DP, Herrmann N, et al. Low medical morbidity and mortality after acute courses of electroconvulsive therapy in a population-based sample. *Acta Psychiatr Scand* 2017;136: 583-593.
55. Wax RS, Christian MD. Practical recommendations for critical care and anesthesiology teams caring for novel coronavirus (2019-nCoV) patients. *Can J Anaesth* 2020.
56. Greenland JR, Michelow MD, Wang L, et al. COVID-19 Infection: Implications for Perioperative and Critical Care Physicians. *Anesthesiology* 2020.
57. Christensen STJ, Staalso JM, Jorgensen A, et al. Electro convulsive therapy: Modification of its effect on the autonomic nervous system using anti-cholinergic drugs. *Psychiatry Res* 2019;271: 239-246.
58. Gomez-Arnau J, de Arriba-Arnau A, Correas-Lauffer J, et al. Hyperventilation and electroconvulsive therapy: A literature review. *Gen Hosp Psychiatry* 2018;50: 54-62.
59. Rozet I, Rozet M, Borisovskaya A. Anesthesia for Electroconvulsive Therapy: an Update. *Current Anesthesiology Reports* 2018;8: 290-297.
60. Malm H, May T, Francis LP, et al. Ethics, pandemics, and the duty to treat. *Am J Bioeth* 2008;8: 4-19.
61. Zhang Z, Yao W, Wang Y, et al. Wuhan and Hubei COVID-19 mortality analysis reveals the critical role of timely supply of medical resources. *J Infect* 2020.
62. Draper H, Wilson S, Ives J, et al. Healthcare workers' attitudes towards working during pandemic influenza: a multi method study. *BMC Public Health* 2008;8: 192.
63. Adams JG, Walls RM. Supporting the Health Care Workforce During the COVID-19 Global Epidemic. *JAMA* 2020.
64. Association AM. Caring for our caregivers during COVID-19. [March 26, 2020, 2020. Available at: https://www.ama-assn.org/delivering-care/public-health/caring-our-caregivers-during-covid-19. Accessed April 3, 2020.