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Recent guidelines in perioperative management of patient covid_19

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Abstract

Background: The novel coronavirus began in Wuhan, China in December 2019. As a result of its rapid spread to other parts of the world, the World Health Organization (WHO) declared the virus as a pandemic on March 11, 2020. Infected individuals can manifest the signs and symptoms ranging from fever, dry cough, headache, and respiratory distress. Other documented clinical features include sore throat, fatigue, lethargy, diarrhea, and chest tightness, while some other infected persons may remain asymptomatic throughout the incubation period with the ability to transmit the infection to others, with incubation period of COVID-19 being between 2 and 14 days. The timing of elective surgery after recovery from covid_19 utilizes both symptom and severity-based categories. Four weeks for an asymptomatic patient. Six weeks for a symptomatic patient (e.g. cough, dyspnea). Aim of work: The goal of this essay is to provide the anesthesia care provider with an understanding of the basics, clinical aspects and recent advances of anesthesia management and perioperative infection control in coronavirus patients in order to diminish related morbidity and to avoid adverse perioperative event. Conclusion: The use of regional anaesthesia during the COVID-19 pandemic should be the preferred method of anaesthesia, whenever possible. In addition to its many benefits in the prevention of postoperative complications, the appropriate regional technique can preserve respiratory function and avoid aerosolization and airway instrumentation to prevent viral transmission.

Key words: perioperative management, Recent guidelines, covid_19 patients

1. Introduction

The novel coronavirus began in Wuhan, China in December 2019. As a result of its rapid spread to other parts of the world, the World Health Organization (WHO) declared the virus as a pandemic on March 11, 2020. Infected individuals can manifest the signs and symptoms ranging from fever, dry cough, headache, and respiratory distress. Other documented clinical features include sore throat, fatigue, lethargy, diarrhea, and chest tightness, while some other infected persons may remain asymptomatic throughout the incubation period with the ability to transmit the infection to others, with incubation period of COVID-19 being between 2 and 14 days [1]

Preoperative preparation:

In elective surgeries:

The timing of elective surgery after recovery from covid_19 utilizes both symptom and severity-based categories. Four weeks for an asymptomatic patient. Six weeks for a symptomatic patient (e.g. cough, dyspnea). Eight to Ten weeks for a symptomatic patient who is diabetic, immunocompromised or hospitalized. Twelve weeks for a patient who was admitted to an intensive care unit due to covid-19 infection. Before entering the operating room, triage was performed .Including a medical history, physical examination, and review of blood test results, CT and tests for SARS-CoV-2 nucleic acid or antibodies. Because individuals might be infected with SARS-CoV-2 but be asymptomatic. Patients wore surgical or N95 masks throughout the process.[2]

In emergency surgeries:

Special attention given to the cardiopulmonary systems in patients who have recovered from covid-19 and especially with residual symptoms. The doctors should quickly and completely collect history from their family members. Pharyngeal swabs were collected in patients requiring emergency surgery, and secretions of the lower respiratory tract were collected by tracheal intubation for polymerase chain reaction (PCR) testing of coronavirus. [3]

Intraoperative:

In elective surgeries:

After the patient entered the operating room, monitoring by electrocardiography, regular noninvasive blood pressure, and peripheral pulse oximetry . Spinal anesthesia or combined spinal–epidural anesthesia was the first choice. General anesthesia with tracheal intubation was an option if contraindications of spinal anesthesia, maternal or fetal emergencies, or failed spinal anesthesia. During tracheal intubation, surgery started as soon as possible after induction. [4]

In emergency surgeries:

Before general anesthesia, the patient should be fully pre-oxygenated while wearing a mask. The tracheal intubation was performed after muscles were fully relaxed. Fast-acting muscle relaxants such as rocuronium bromide were recommended to prevent coughing during intubation. During the operation, the vital signs were closely monitored.[5]

Postoperative:

Post-operative, full blood count and coagulation tests were performed. If COVID-19 was suspected or confirmed, chest CT, SARS-CoV-2 nucleic acid, or antibodies were tested again. Body temperature or any other symptoms associated with COVID-19 were recorded daily by nurses. Supplemental oxygen was delivered via nasal cannula or mask to maintain a SpO2 of 95% or above. Analgesia was given to relieve postoperative pain [6].

The goal of this essay is to provide the anesthesia care provider with an understanding of the basics, clinical aspects and recent advances of anesthesia management and perioperative infection control in coronavirus patients in order to diminish related morbidity and to avoid adverse perioperative event.

Corona virus

Corona viruses are enveloped, positive single-stranded large RNA viruses that infect humans, but also a wide range of animals. Coronaviruses were first described in 1966 by Tyrell and Bynoe, who cultivated the viruses from patients with common colds. Based on their morphology as spherical virions with a core shell and surface projections resembling a solar corona, they were termed corona viruses (Latin: corona = crown). Four subfamilies, namely alpha-, beta-, gamma- and delta corona viruses exist. While alpha- and beta-coronaviruses apparently originate from mammals, in particular from bats, gamma- and delta-viruses originate from pigs and birds [7].

The initial clinical sign of the SARS-CoV-2-related disease COVID-19 which allowed case detection was pneumonia. More recent reports also describe gastrointestinal symptoms and asymptomatic infections, especially among young children 2. Observations so far suggest a mean incubation period of five days and a median incubation period of 3 days (range: 0–24 days) 3. The proportion of individuals infected by SARS-CoV-2 who remain asymptomatic throughout the course of infection has not yet been definitely assessed. In symptomatic patients, the clinical manifestations of the disease usually start after less than a week, consisting of fever, cough, nasal congestion, fatigue and other signs of upper respiratory tract infections [8].

The infection can progress to severe disease with dyspnoea and severe chest symptoms corresponding to pneumonia in approximately 75% of patients, as seen by computed tomography on admission. Pneumonia mostly occurs in the second or third week of a symptomatic infection. Prominent signs of viral pneumonia include decreased oxygen saturation, blood gas deviations, changes visible through chest X-rays and other imaging techniques, with ground glass abnormalities, patchy consolidation, alveolar exudates and interlobular involvement, eventually indicating deterioration. Lymphopenia appears to be common, and inflammatory markers (C-reactive protein and proinflammatory cytokines) are elevated [9]

A combination of the antiretroviral drugs lopinavir and ritonavir significantly improved the clinical condition of SARS-CoV patients and might be an option in COVID-19 infections. Further possibilities include leronlimab, a humanized monoclonal antibody (CCR5 antagonist), and galidesivir, a nucleoside RNA polymerase inhibitor, both of which have shown survival benefits in several deadly virus infections and are being considered as potential treatment candidates. Repurposing these available drugs for immediate use in treatment in SARS-CoV-2 infections could improve the currently available clinical management.

2.Patients and staff protection

Healthcare professionals working in anaesthesia and critical care departments, anaesthesia units, intermediate care units and critical care units face an elevated risk of covid-19 exposure [**10]**. In order to protect them during this pandemic, strict safety measures should be implemented. These measures should be carried out all throughout the patient's healthcare pathway: preanaesthetic assessment, operating theatres, recovery rooms, intermediate care units and critical care units. These safety measures will be implemented directly by providing healthcare professionals with adequate PPE, but also indirectly by supplying patients with the right equipment.

Administrative measures (patient information, preoperative laboratory testing, check-up modalities, an aesthesia modalities, dedicated healthcare pathways, patient and surgery selection), which also help protecting staff members, will be detailed in the following/other chapters. Staff members should apply strict social and physical distancing measures when not caring for patients (team rounds, discussions about patients, hand-offs, breaks, meals. . .): they must keep at least 1 to 2 meters apart from one another, especially during times when wearing a mask is not possible

Preanaesthetic assessment/check-up

During this COVID-19 pandemic, every patient could potentially be contaminated and should therefore protect other patients and hospital staff by applying alcohol-based hand gel and wearing a surgical mask type II or IIR. By blocking large droplets, surgical masks protect staff members from droplet and contact transmission. Surgical masks can provide protection for healthcare professionals against droplet transmission within a one-meter radius of the patient. Four RCTs compared the efficiency of N95 or FFP2 masks and surgical masks in healthcare workers performing non-aerosol generating procedures (11).

Operating theatre

There is a great risk of becoming infected during airway management. Therefore, strict safety measures should be applied during aerosol-generating procedures, such as bag mask ventilation, endotracheal intubation, open/endotracheal suctioning and extubation. The use of a respirator filtering face piece mask (FFP) type 2 is recommended by the French Society of Hospital Hygiene (SF2H) and the French-Speaking Society of Infectious Disease for all healthcare professionals manipulating the airway. Respirators are tight fitting masks, designed to create a facial seal that protect the person wearing them from droplets and airborne particles inhalation.

However, wearing this type of mask can bring more discomfort than wearing a surgical mask (overheating, respiratory resistance.) They have the advantage of blocking at least 94% of aerosol particles (total inward leaking < 8%) and are more effective than surgical masks typeII/IIR in blocking < 5 mm particles. Nonetheless, a poorly fitted N95 or FFP2 respirator does not protect more than a surgical mask. A leak test must be performed systematically. Furthermore, a beard (even a stubble one) reduces the mask's adherence to the face and thus decreases its global efficiency. In case of N95 or FFP2 respirators shortage, some experts suggested using N99 or FFP3 respirators, which block at least 99% of aerosol particles (total inward leaking < 2%). However, the problem with these respirators in that the air is most often exhaled through an expiratory valve

without being filtered. They do not filter the wearer's exhalation, only the inhale. This one-way protection puts others around the wearer at risk, in a situation like COVID-19 [12].

COVID-19 can also be transmitted by aerosol contact with conjunctiva and lead to a respiratory infection. The fact that unprotected eyes increase the risk of transmission has been demonstrated with coronaviruses. Face shields provide a barrier against high velocity aerosol particles and are commonly used as alternatives to safety goggles as they provide greater face protection. Using a droplets simulator loaded with influenza viruses (mean droplet diameter: 3.4 mm) and a breathing simulator, it was demonstrated/shown that the use of a face shield reduces the risk of aerosol inhalation by 70% [13].

When spraying fluorescent dye (particle diameter = 5 mm) from a distance of 50 cm towards a mannequin head equipped with an N95 respirator and a face shield, no contamination was noted in either nostrils nor eyes nor mouth folds. The same researchers found that using safety goggles in combination with an N95 respirator did not prevent some eye contamination. Face shields also contribute to sparing N95 or FFP2 respirators by limiting their contamination with aerosol projections. N95 or FFP2 respirators can be used for up to 8 hours [14]

Recovery rooms

Whenever possible, in order to spare N95 or FFP2 respirators and to protect staff members and other patients, extubation should be performed in the operating theatre by the person who performed the intubation. If this is not possible, the same precautions should be taken in the recovery room for staff protection. In the latest World Health Organization (WHO) recommendations for COVID-19, healthcare personnel and other staff are advised to maintain a one-meter distance away from a person showing symptoms of disease. The Centre for Disease Control and Prevention recommends a two-meters separation. However, these distances are based on estimates of range that have not considered the possible presence of a high-momentum cloud carrying the droplets long distances Recent work has shown that exhalations, sneezes and coughs emit turbulent multiphase flows that can contain pathogen-bearing droplets of mucosalivary fluid. When sneezing or coughing, these droplets/gas clouds can travel in the air for up to 7 to 8 meters [15].

This new understanding of respiratory emissions dynamics has implications on social distancing strategies during the COVID-19 pandemic. Similarly, swabs taken from air exhaust outlets in COVID+ patients' rooms were found to contain RNA fragments, suggesting that small virus-laden droplets may be displaced by airflows. However, in this study, no viral culture was done to demonstrate virus viability. For these reasons, extubation should remain exceptional in the recovery room, and giving out surgical masks type II/IIR to patients after their extubation is essential [16]

Critical care units/intermediate care units wearing a surgical mask type II/IIR in common areas. Barrier measures should be followed strictly during medical and paramedical team rounds, hand-offs and breaks (opening additional spaces for lunch breaks).

Benefit and risk of operating, and patient information

In asymptomatic patients, during a COVID-19 pandemic, experts suggest evaluating the benefit/risk ratio of the intervention according to criteria related to the patient, the pathology and the procedure.

The circulation of SARS-CoV-2 in the population and the existence of asymptomatic carriers affect the risk-benefit ratio of performing a planned surgical procedure during the COVID-19 pandemic and require rigorous evaluation. This consideration must integrate three types of criteria related to the patient, the pathology and the procedure.

The data in the literature, although heterogeneous and with a low level of evidence, identify several patient-related risk factors for serious forms of COVID-19 potentially associated with an increase in postoperative complications: ASA class, obesity, age (> 65 years, < 1 year), underlying respiratory (asthma, COPD, cystic fibrosis) or cardiovascular (hypertension, coronary artery disease and chronic heart failure) pathology, obstructive sleep apnea syndrome, diabetes, and immunosuppression. This increase in perioperative risk is, however, offset by the potential deleterious effect of cancelling or postponing the procedure on the patient [17].

The loss of chance in the absence of intervention must be estimated and the effectiveness and availability of therapeutic alternatives (curative or waiting) explored. Finally, two types of factors related to the surgical procedure must be considered: resource utilisation and the risk of transmission of SARS-CoV-2 to the healthcare team. Surgical time and expected length of stay provide an indication of the staff and hospital resources required. For each intervention, the foreseeable use of postoperative management in a critical care area must be anticipated in order to adapt surgical activity to the supply available at the time. Transfusion needs must also be assessed due to the difficulties of public access to blood donation collection points.

During the preanaesthetic consultation, detailed information must be provided to the patient and/or his/her legal representative about the perioperative strategy decided regarding his specific situation in the context of COVID-19 pandemic. The message must be clear, objective and based on the currently available data, while trying to be reassuring for the patient and/or his legal representative. This message must be given orally during the consultation but also disseminated through a document (established and validated by each structure), which can be given to the patient and/or his legal representative during the preoperative consultation (surgical or preanaesthetic).

This information must appear in the medical record. In the appendix, based on current data, we propose examples of model documents. In the event of cancellation or postponement of the intervention, it is essential to keep in touch with the patient, mostly through the surgical teams, and to reassess the possible alternatives and the feasibility of the procedure

according to the evolution of the circumstances. If the decision of postponement or cancellation of the surgery is taken by the patient, it must be recorded in the medical record.

Preoperative assessment and decision regarding surgery

The use of a standardised questionnaire increases the completeness of the symptom collection and the reproducibility of the medical examination. It is an appropriate tool for collecting accurate information from a large number of subjects. The data collected are easily quantifiable and traceable. The essential qualities of such a questionnaire are acceptability, reliability and validity. The questions must be formulated to be understood by the largest number of patients, without ambiguity, and be based on validated items. Because of the wide variety of symptoms attributable to the SARS-CoV-2, the questionnaire should be designed to look for the most frequent symptoms (fever, dry cough, etc.) and/or the most evocative ones (anosmia, ageusia, etc.), without however declining all the unusual symptoms that have been reported in the literature. An example of a standardised questionnaire distinguishing between major and minor symptoms is proposed for adults and for children.

Assessment of specific perioperative risk during the COVID-19 pandemic requires, as in the usual situation, the joint consideration of the surgical, patient and anaesthetic risks. In addition, searching usual and/or evocative symptoms of SARS-CoV-2 infection is an important time of the preanaesthetic consultation in the current pandemic context and during the first months following the easing of the lockdown. The presence of major (i.e. very frequent or relatively characteristic) and/or minor (i.e. more inconsistent and/or less specific) symptoms allows to orient the preoperative COVID-19 status assessment, and then to estimate the benefit/risk balance of maintaining or postponing the surgery, taking into account the risk of contamination of health personnel and others patients within the care structure [18]

The integration of these different risks must be collectively weighed against the potential consequences of postponing or cancelling a scheduled intervention [17].

The PCR will ideally be performed in the 24 hours preceding the intervention, at most 48 hours, in order to have an idea of the viral carriage as close as possible to the high-risk procedure while taking into account the time required to obtain the results in each structure in order to have them available before the intervention.

Finally, non-major surgeries in an asymptomatic patient can be performed in a conventional non-COVID-19 circuit. If possible, it is suggested that the close contacts of these patients (such as the immediate neighbours in the postoperative recovery room) should be traced to facilitate contact tracing if the patient develops symptoms consistent with SARS-CoV-2 infection in the days following surgery [19].

It should be noted that if the presence of antibodies in the plasma of a convalescent patient 7 to 10 days after the onset of symptoms has been reported, the positivity of the serology is sometimes later (up to several weeks). In addition, the antibody titre and their neutralising character against SARS-CoV-2 may vary depending on the patient . Furthermore, diagnostic performances vary greatly depending on the type of kit used in the laboratory. Finally, the neutralising character of the detected antibodies depends on the viral antigens against which the detected antibodies are directed [20].

For emergency surgery

By definition non-deferrable, the surgery has to take place. However, PCR sampling should be performed in symptomatic or mildly symptomatic patients who have had close contact with a COVID-19 patient within the last 15 days, or who themselves have risk factors for severe forms of COVID-19 or are operated from surgery with postoperative respiratory risk. Surgery is performed without waiting for the results. In the case of major surgery, a postoperative surveillance in the intensive care unit (potentially already justified by the complexity of the surgery and/or the patient's comorbidities) may be considered, especially in a symptomatic patient, as a risk of synergy between perioperative lung injury and infection/carry of SARS-CoV-2 cannot be excluded at this time.

Preanesthetic patient assessment

The current outbreak of COVID-19 has placed a heavy burden on global medical systems, particularly with regard to the preoperative assessment of patients for surgery. For all elective surgeries in France and in many countries for major surgery, preoperative physical assessment by physicians had become a standard of care. The current crisis has reduced this possibility because patients should not be exposed to potentially contagious structures. In this context, telemedicine is an alternative to face-to-face consultation. The World Health Organization now defines telemedicine “as the provision of healthcare services via the use of communication technology for the diagnosis and treatment of diseases and for continuing education of healthcare providers in settings where distance is a factor, and now COVID-19”.

Anaesthesia Management For Emergency Trauma Surgery and Acute Care Cases During the COVID-19 PandemicChoice of Anaesthesia Method

For patients with suspected or confirmed COVID-19, choice of anaesthesia should be based on the patient’s overall situation, trauma condition, and needed surgical treatment. Regional anaesthesia is preferred if it can meet the needs of surgery. Patients receiving regional anaesthesia can use oxygen through a nasal cannula, with a surgical mask on top and a suction tube placed next to the mask. But for patients who are already on high-flow nasal oxygenation or mechanical ventilation or who have other indications for endotracheal intubation due to COVID-19, general anaesthesia with endotracheal intubation should be applied. It is worth noting that SARS-CoV-2 may affect the central nervous system. According to recent studies, SARS-CoV-2 was discovered in patients’ cerebral spinal fluid and corpses’ brain tissues. Some patients also

demonstrated symptoms of intracranial infection, such as headache, epilepsy, and consciousness disorder. [21]

Therefore, for patients with viremia, neuraxial procedures that breach the dura may carry a theoretical risk of viral translocation, although early experience from the hospitals in Wuhan did not show meningoencephalitis related to neuraxial anaesthesia in COVID-19 patients. Because no guidelines have been established regarding the safety of neuraxial procedures, the decision should be made after discussion among anaesthesia, surgery, and infectious disease colleagues and following a thoughtful discussion with the patient. Furthermore, nearly 20% of patients with COVID-19 have coagulopathy, and almost all the severe and critical patients have coagulation dysfunction. These conditions may represent a contraindication to neuraxial anaesthesia [22]

Although there is no specific antiviral treatment recommended for COVID-19, some potential drugs are widely in use, including an antiviral drug remdesivir, the malaria medication chloroquine/hydroxychloroquine, a combination of the human immunodeficiency virus (HIV) drugs lopinavir–ritonavir, and an immune system messenger interferon-β. Chloroquine and hydroxychloroquine have received intense attention because of positive results from small studies. But chloroquine and hydroxychloroquine have many side effects, including toxic myopathy, retinal impairment, and even heart injury in rare cases. Some animal studies showed that administration of chloroquine could increase the severity of sevoflurane anaesthesia–induced neuronal apoptosis and memory impairment. There is also evidence showing that treatment with lopinavir–ritonavir may significantly increase the placental transfer of bupivacaine enantiomers during epidural anaesthesia for cesarean delivery.[23]

Therefore, we suggest that thorough preoperative medication history should be collected, and special attention should be paid to the side effects of the COVID-19 treatment and its potential interactions with anaesthetics. Furthermore, there has been speculation that consumption of angiotensin-converting enzyme inhibitor and nonsteroidal anti-inflammatory drugs might worsen the consequences of infection. But strict avoidance of these drugs is ill advised, because there is no clinical evidence supporting these hypotheses yet [24].

Anaesthesia Induction and Endotracheal Intubation

During the COVID-19 outbreak, all patients scheduled for emergent surgery should wear masks without an air outlet before being intubated, if possible. Anaesthesiologists should pay special attention to the airway evaluation, because cervical spine injury, airway injury, and difficult airway are common in trauma patients. Patients with COVID-19 may suffer from respiratory distress and/or hypoxemia or even respiratory failure. Therefore, delays during tracheal intubation and multiple attempts at laryngoscopy may increase the risk of complications, including severe hypoxemia, cardiac arrest, and death To shorten intubation time and increase "first-pass success" rate, intubation should be performed by experienced anaesthesiologists and facilitated by video laryngoscope [25].

Anaesthesia Monitoring

Mild trauma patients may only require basic noninvasive monitoring, including electrocardiogram, blood pressure, pulse oxygen saturation, Etco2, body temperature, and urine output. COVID-19 may cause pneumonia of varying degrees; thus, lung compliance, airway pressure, oxygen index, and arterial blood gas should be monitored closely. A lung-protective ventilation strategy should be implemented. Acute cardiac injury and renal injury are common in severe or critical COVID-19 patients. Therefore, myocardial enzymes, echocardiography, and renal function analysis are highly recommended before emergency surgery in severe COVID-19 patients [26].

Anesthesia Management

Emergency trauma patients should be treated promptly to avoid hypothermia, acidosis, and coagulative dysfunction. Surgical hemostasis, body temperature monitoring and preservation, volume resuscitation, coagulative monitoring and management, and thromboprophylaxis should be implemented as needed.

Damage Control Surgery.

COVID-19 can cause immune dysfunction, which presents as overall immunosuppression The rate of severe infection secondary to trauma can be predicted to increase in COVID-19 patients. If COVID-19 patients are complicated with secondary infections, sepsis and multiple organ dysfunction syndrome (MODS) may occur; thus, emergency surgery should follow the principles of damage control. Surgical manipulation should be minimized, and surgical duration should be shortened. Emergency trauma surgeries in COVID-19 patients should be limited to damage control surgeries, including (1) blunt injury with prehospital index (PHI) ≥4; (2) hemodynamic instability caused by thoracic or abdominal penetrating injury; (3) uncontrolled external hemorrhage, such as thoracic or abdominal organ injury, tension or open pneumothorax, cardiac tamponade, massive hemothorax, severe craniocerebral injury, cerebral hernia, and other severe injuries; and (4) acute care surgery occurring in patients with confirmed or suspected COVID-19 during hospitalization, such as organ perforation or obstruction [27]

Fluid Management.

Perioperative systolic blood pressure (SBP) and mean arterial blood pressure (MAP) should be maintained within 80–90 and 50–60 mm Hg, respectively, in emergency trauma patients. For patients with craniocerebral injury, SBP should be maintained at 100–110 mm Hg during resuscitation. Goal-directed fluid therapy is recommended to avoid either hypovolemia or hypervolemia [28].

Whether restrictive fluid management is beneficial for pulmonary protection in COVID-19 patients remains unknown. For patients with uncontrolled hemorrhage, fluid therapy and vasopressor can be used to maintain the targeted blood pressure. As allogenic blood transfusion may cause circulatory overload and lung injury, blood

products should be transfused with caution. Red blood cells should be transfused to maintain adequate oxygen supply, indicated by lactic acid level and mixed venous oxygen saturation. Plasma and other blood products should be transfused according to the results of coagulation testing. Blood samples of COVID-19 patients should be double-bagged and labeled with a warning sign of "COVID-19." During the COVID-19 epidemic, a severe shortage of blood is foreseeable; thus, intraoperative blood protection strategies are recommended to minimize the requirements of allogenic blood transfusion [29].

Respiratory Management

Acute respiratory distress syndrome is one of the main clinical manifestations in severe COVID-19 patients, and pulmonary contusion is common in emergency trauma patients. Perioperative lung-protective ventilation strategy is recommended to reduce the risk of ventilator-associated lung injury. During surgery, lung compliance, airway pressure, oxygen index, and arterial blood gas should be monitored closely, to provide guidance for optimal ventilator settings. According to Guidelines of Diagnosis and Treatment of COVID-19 (Seventh Edition), small tidal volume (6–8 mL/kg ideal body weight) and low plateau pressure (≤30 cm H2O) with permissive hypercapnia are recommended, except for patients with known or suspected brain injury.76 In the setting of plateau pressure ≤35 cm H2O, a proper level of positive end-expiratory pressure can also be used. To reduce viral contamination to the anaesthesia machine and maintain heat and moisture within the breathing circuit, high efficiency particulate air filters should be installed between the mask and the breathing circuit and at the expiratory end of the breathing circuit. Considering the amount of airway secretions, endotracheal suction using a closed system should be performed regularly. Recruitment maneuvers 3–5 times/h are recommended to reduce atelectasis. The pressure used for recruitment maneuvers should be tailored to the compliance of the patient's lung.

Postoperative Pain Management

Multimodal analgesia is recommended, including regional block analgesia, local infiltration analgesia, opioid drugs, and nonopioid drugs. Because patients with COVID-19 may be complicated with hepatic and/or renal insufficiency, as well as coagulation dysfunction, the contradictions and indications of nonsteroidal anti-inflammatory drugs should be prudently evaluated. Considering the diminished pulmonary function in patients with COVID-19, the dosage of opioids should be adjusted to avoid aggravating respiratory depression or carbon dioxide retention.

The Prevention and Treatment of Postoperative Nausea and Vomiting.

Postoperative nausea and vomiting (PONV) can produce virus-containing aerosol. Therefore, PONV should be effectively prevented. A multimodal prevention strategy is recommended, based on the presence of risk factors (female, nonsmoker, history of motion sickness, and postoperative use of opioid). For the patients with one or no risk factor, preventive medication is not necessary. For the ones with ≥2 risk factors, combined use of antiemetic medications is recommended, such as dexamethasone and 5-hydroxytryptamine 3 (5-HT3) inhibitors. Use of opioid drugs should be restricted in high-risk patients [30].

POSTOPERATIVE SURVEILLANCE

Patients who screened negative for COVID-19 diagnosis preoperatively should still be surveilled after surgery, because they may be in the incubation period preoperatively or they might become infected perioperatively. Body temperature, complete blood count, the level of procalcitonin, and C-reactive protein should be monitored regularly. Chest CT and viral nucleic acid test in throat swab specimens should be rechecked, if necessary. Visitation should be restricted, and the wards should be equipped with strict entrance guards. Patients and their accompanying relatives should be educated on personal protective measures, such as wearing masks, hand hygiene, and daily body temperature monitoring.

Pediatric Airway Management in COVID-19 Patients

Protecting Clinicians

PeDI-C agreed that clinicians who are at higher risk of morbidity and mortality from COVID-19 should be protected from clinical exposure. Some suggestions included delegating these at-risk clinicians to staff telemedicine clinics or contribute to scholarly and administrative tasks while maintaining adequate physical distancing. PeDI-C discussed the importance of PPE for anaesthesia clinicians; specifically, there was consensus that airway manipulation, such as endotracheal intubation or extubation, is AGMPs and therefore requires maximum protection. The group also acknowledged that during times of crisis, such as the current pandemic, institutions might have PPE shortages. Several members emphasized that although equipment shortages are essential to consider, the highest priority should be the safety of care teams. Prioritizing the safety of HCWs can maximize the delivery of care for patients during a pandemic. PPE supplies are becoming available from manufacturers, donations, and release from national strategic stockpiles; however, clinicians are impossible to replace if quarantined, severely ill, or, worse yet, dead. PeDI-C felt that centers should err on the side of overprotection rather than underprotection [31].

Nearly 10% of HCWs in Italy and 14% in Spain have contracted COVID-19 with associated morbidity and mortality. Inadequate PPE, deeper lung penetration of aerosolized viral particles, and a high burden of exposure may contribute to these infections. In centers with limited PPE supplies, PeDI-C felt that teams should be pared down to the minimum necessary, and cases should be consolidated into the fewest possible rooms to conserve PPE [32] .

3. Case Preparation

All drugs and equipment should be prepared and readily available before starting an anaesthetic. This preparation reduces the need for clinicians to reach into the anaesthesia workstation drawers and bins once the patient has entered the procedure room. Trash cans and

sharps containers should be readily available and open to avoid dropping equipment on the floor, which increases viral dispersion. For anaesthesia drug dispensing workstations that require touching the screen, a plastic shield should be placed over the screen to minimize contamination. Clinicians should leave badges, keys, cell phones, pagers, and pens outside the OR. Emergency phones may be kept in sealed bags to facilitate communication with other clinician

Premedication

Clinicians should consider the routine use of preprocedural sedatives to reduce anxiety and increase compliance when an intravenous (IV) is placed awake. Additionally, premedication may reduce the risk of vigorous crying and the need for physical restraints during inhalational inductions. Nasal administration of premedication is undesirable because of the potential for high viral loads and the risk of coughing and sneezing. PeDI-C did not recommend parental presence for the induction of anaesthesia to conserve PPE and reduce clinician exposure to SARS-CoV-2. However, this will depend on the local infrastructure and practice especially in areas where PPE shortages are not of concern.

Intravenous Placement and Induction of Anaesthesia

Because inhalational induction may increase exposure to respiratory droplets and aerosols, PeDI-C members agreed that IV induction is preferred. However, clinicians should assess the child's disposition to IV catheter placement as struggling to place a catheter may result in higher exposure to respiratory droplets if the child cries. PeDI-C recommended rapid sequence induction or modified rapid sequence to reduce the risk of reflex airway activation during intubation with associated aerosolization. Rapid Sequence Induction may not be feasible without severe hypoxemia in small children and patients with severe lung pathology. These patients should receive gentle positive pressure ventilation with the goal of using just enough tidal volume to achieve chest rise while maintaining a tight mask seal.

Airway Device Placement

The PeDI-C agreed that a cuffed tracheal tube was the ideal device to secure the airway in children with COVID-19. PeDI-C recommends using video laryngoscopy for all intubations, if available, to reduce the laryngoscopist's proximity to the patient's airway. The most experienced laryngoscopist should attempt tracheal intubation to minimize laryngoscopy time and the number of attempts. Open suctioning may create aerosols, and an in-line closed suction system is preferred. If clinically appropriate, patients in the intensive care unit (ICU) should be intubated in the ICU (preferably in a negative pressure room) before transfer to the OR. PeDI-C felt that a supraglottic airway device with a good seal was acceptable in some cases [33].

A simulated cough in a manikin model with a supraglottic airway device in place showed minimal aerosol dispersion (Second-generation supraglottic airway devices have higher leak pressures than first-generation masks and should be considered. PeDI-C agreed that the least desirable approaches were high- or low-flow nasal cannula or bag-mask ventilation, though these techniques may be unavoidable at times. A simple oxygen mask placed on top of a nasal cannula may reduce the risk of aerosol dispersion. PeDI-C recommended avoiding techniques that bring the clinician's face or stethoscope near the patient to verify leak pressures for endotracheal tube (ETT) and supraglottic airway (SGA). Clinicians can use the ventilator's measurements of expired and inspired tidal volume and handheld manometers to titrate cuff inflation. Wireless stethoscopes and point-of-care ultrasound can be used to confirm bilateral ventilation of the lungs [34] .

Maintenance of Anaesthesia

PeDI-C recommended that clinicians use full PPE during the entire operative case given the risk of accidental ventilator circuit disconnection, accidental extubation, and unquantified aerosolization from the procedure, especially airway, laparoscopic, and endoscopic procedures. PeDI-C recommended a transparent barrier over the airway device and patient's head to trap any aerosolized virus. Others have used wet towels and gauze for the same purpose. [35]

Infrastructure

The use of a negative pressure OR for AGMPs is recommended for all proven or suspected COVID-19 patients if feasible. Ensure adequate air exchange and filtration time of the ORs used for patients with COVID-19 and suspected cases before cleaning and preparing for the next case. (36) . If negative pressure ORs are not available, high-efficiency particulate air (HEPA) filters that sufficiently filter the OR's square footage were used. Also, try to avoid rooms with connected ventilation systems.

Difficult Airways

PeDI-C members identified the unique challenges involved in managing difficult airways in patients with known or suspected COVID-19. Many of the recommendations for tracheal intubation of normal airways apply to difficult airways as well. An airway team should be assembled, and all equipment should be setup in the OR and checked. The team should consider a just-in-time review before beginning airway management. The clinician with the most experience with the selected airway device should perform the tracheal intubation. PeDI-C ranked difficult airway management approaches as follows: video laryngoscopy as the primary technique followed by fiberoptic intubation through a supraglottic airway device, combined video laryngoscopy and fiberoptic bronchoscopy and finally freehand fiberoptic. Oral fiberoptic intubation is preferred over nasal fiberoptic intubation and minimizes passive oxygenation as tolerated. Hypoxia can be addressed with intermittent 2-hand mask ventilation to maintain a good seal and low tidal volumes. If safe to do so, consider administering a neuromuscular blocking agent after IV induction. Sugammadex should be immediately available to antagonize the neuromuscular blocking agent if needed. If warranted, perform mask ventilation with low tidal volumes using a 2-person technique to maintain a good

seal. If nasal fiberoptic intubation is required, using an endoscopy mask (Supplemental Digital Content 1, Material 3, a diaphragm that seals around the fiberoptic scope but allows the tracheal tube to be advanced into the airway. It may be prudent to call early for personnel and equipment for a surgical airway. Prolonged attempts at intubation may be associated with increased aerosolization of the virus.

Neuraxial anaesthesia and peripheral nerve blocks during the COVID-19 pandemic

Planning and preparation

Reduce the clinical load and perform routine testing as per local guidelines. Neuraxial anaesthesia and peripheral nerve blocks are the first choice (whenever possible) for anaesthetic management of patients with suspected COVID-19 infection [37].

Reducing the volume of surgical procedures allows time for institutions to: plan for a surge of patients with COVID-19; preserve existing stock of PPE; and plan staffing appropriately, particularly as healthcare workers will be quarantined or unwell themselves. This is based on previous governmental regulations implemented during pandemics. All elective operations should be postponed to reduce the risk of exposure of patients and healthcare workers to COVID-19 and to conserve the capacity of the healthcare system, personnel and resources for a possible increase in demand. Therefore, anaesthesia care should be reserved for urgent and emergent surgery. Guidance for triage of non-emergent surgical procedures may vary in different countries and may change during the course of the pandemic [38].

Location

Care of COVID-19–infected patients should ideally be provided in the operating area and in an airborne infection isolation room if possible. Patients can be operated in a positive pressure room as long as there are measures to prevent airflow from the operating room into the common areas.

If available, the care of patients with confirmed or suspected COVID-19 infection should be provided in a negative pressure room. Nevertheless, surgeries have been safely performed in positive pressure rooms during the SARS outbreak and currently during the COVID-19 pandemic. There is a theoretical risk of spreading the aerosolised particles to the corridors outside the operating room in a positive pressure room. However, operating rooms have a higher air exchange rate compared with hospital wards or floors. With a standard operating room with a minimum of 15 air exchanges per hour, 99% and 99.9% of airborne contaminants will be removed in 18 min and 28 min, respectively. Alternatively, another report suggests decreasing the inflow while increasing the exhaust can enable the room to remain at neutral pressure while still maintaining laminar flow over the surgical area [39].

Personal protective equipment

Regional anesthesia procedures are not considered aerosol-generating, and therefore droplets precautions are recommended as a minimum. Use of a higher level of precautions (airborne precautions) may be appropriate when caring for patients under spinal anaesthesia in the operating room in certain situations.

Patients should wear surgical facemasks to prevent transmission of COVID-19. Protection of healthcare workers when caring for a patient during the COVID-19 pandemic necessitates appropriate PPE, especially in light of PPE shortages. An appropriate level of PPE is determined by both the medical procedure and the proximity of a healthcare worker to the patient. Personal protective equipment can be classified into three levels.

Oxygen therapy

The mode of delivery and flow rate of oxygen determines the possibility of aerosol generation and its travelling distance, therefore; the flow of oxygen should be kept to a minimum with the goal to maintain saturation while minimizing aerosol generation.

Oxygen supplementation can result in exhaled air jets and may result in droplet nuclei formation. Whether or not this may result in respirable infectious aerosols depends on a variety of factors, such as: the type of oxygen therapy utilised; the viral load in each breath; ventilation and air exchange in the room; and the use of facemask by the patient, among others. The type of oxygen therapy determines the travelling distances of the exhaled air with the least distance (0.4 m) seen with the use of a Hudson mask utilising 4 l.min−1 of oxygen flow, followed by nasal cannula 1 m caudally with the use of 5 l.min−1 of oxygen flow and probably the maximum by a jet nebuliser (> 0.8 m laterally) when using 6 l.min−1 oxygen flows [40].

Management of post-dural puncture headache

As with usual care, pharmacological approaches should be proposed before performing an epidural blood patch. Complications should be discussed on a case-by-case basis.

There are currently no available data to guide the management of post-dural puncture headache (PDPH) in patients with COVID-19 infection. Pharmacological approaches should be proposed as with any other patient. Concern about the injection of viraemic blood into the epidural space with an epidural blood patch has been raised, especially during active illness, although there is currently no evidence to suggest that this may be the case. If the PDPH is severe and debilitating, an epidural blood patch should be proposed, balancing the risk of neurological complications associated with severe untreated PDPH against the theoretical risk associated with the injection of possibly viraemic blood in the epidural space [41].

Peripheral nerve block

If performing a peripheral nerve block near the head and neck area, in addition to droplet precautions, precautions against airborne virus transmission may be considered. Use ultrasound guidance to reduce the risk of local anaesthetic systemic toxicity.

The evidence regarding the use of peripheral nerve blocks is minimal. Recently, Lie et al. published practical considerations for performing regional anaesthesia, and the American and European Societies of Regional Anaesthesia have published a practice

recommendation on the topic. In general, peripheral nerve blocks are considered to result in fewer physiological consequences or hemodynamic side-effects compared with neuraxial techniques. Most peripheral nerve blocks do not cause sympathectomy leading to hypotension. In terms of the risk of hematoma, a few deep peripheral nerve blocks are considered similar but still are less likely to cause compressive symptoms as the peripheral nerves are not enclosed in a spinal canal [42].

Monitoring and conduct of anaesthesia

Thorough testing for block success is encouraged to prevent the need for emergent conversion to general anaesthesia. Respiratory monitoring should be ideally performed with the use of viral filters.

Both neuraxial anaesthesia and peripheral nerve block should be thoroughly tested for block success before proceeding with surgery to minimise the risk of conversion to general anaesthesia. In the case of peripheral nerve block, extra onset time should be allowed to reduce the risk of conversion. If intra-operative conversion to general anaesthesia is required, the emergency airway procedure should be followed, as described in the literature 129. Excessive or deep sedation should be avoided to reduce the need for any airway manipulation or interventions.

Our current understanding of COVID-19 spread suggests that coughing and sneezing lead to the generation of droplets. However, the patient should wear a surgical facemask at all times throughout the procedure. Prolonged close contact with a suspected or confirmed COVID-19 patient should be avoided wherefore possible.

End of surgery

Patients should be recovered in the operating room or an airborne infection isolation room before being transported to a pre-designated area.

The patient should be monitored in the operating room until safe and before transfer to a COVID-19 designated area of the hospital, in accordance with local guidelines. It has been shown that the risk of transmission is highest during the doffing of PPE, therefore extra time should be allowed for donning and doffing. Any re-usable equipment utilised during the procedure should be disinfected as per institutional guidelines [43].

4. Conclusion

The use of regional anaesthesia during the COVID-19 pandemic should be the preferred method of anaesthesia, whenever possible. In addition to its many benefits in the prevention of postoperative complications, the appropriate regional technique can preserve respiratory function and avoid aerosolization and airway instrumentation to prevent viral transmission.

The presence of COVID-19 infection is not a contraindication to performing neuraxial anaesthesia, as it is not an aerosol-generating procedure. Thrombocytopenia should be ruled out in the planning stages of the neuraxial technique. An experienced provider should perform the procedure, and any pre-procedural sedation should be balanced with the risk of respiratory function compromise. Although there is no evidence of viremic spread in this manner, epidural blood patches should only be used in severe, debilitating cases to avoid injection of viremic blood into the epidural space

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