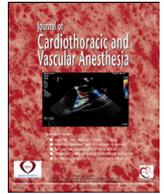


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Special article

Chinese Society of Anesthesiology Expert Consensus on Anesthetic Management of Cardiac Surgical Patients With Suspected or Confirmed Coronavirus Disease 2019

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The outbreak of a new coronavirus (severe acute respiratory syndrome coronavirus 2 [SARS-CoV-2]) in China in December 2019 has brought serious challenges to disease prevention and public health. Patients with severe coronavirus disease 2019 (COVID-19) who undergo cardiovascular surgery necessitate extremely high demands from anesthesia personnel, and face high risks of mortality and morbidity. Based on the current understanding of COVID-19 and the clinical characteristics of cardiovascular surgical patients, the authors provide anesthesia management guidelines for cardiovascular surgery along with the prevention and control of COVID-19.

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Since the first case of coronavirus disease 2019 (COVID-19) was reported at the end of 2019 in Wuhan, China, this outbreak has spread to more than 80,000 patients in China, and more than one million patients around the world at the time of this manuscript preparation. Control of the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) is still a grim situation, and it was defined as a pandemic by the World Health Organization (WHO) on March, 11, 2020.

The entire population is prone to infection, and the person-to-person transmission route is through respiratory droplets, contact with infected items, and aerosol transmission when in a relatively closed space with high viral concentration.¹ COVID-19 virus enters cells through the angiotensin converting enzyme II (ACE2) receptor, resulting in down-regulation of ACE2 receptor function. This leads to an increase of angiotensin II activity, activation of the renin-angiotensin-aldosterone system (RAAS), and pulmonary, cardiac, or systemic dysfunction.^{2,3}

Cardiac surgical patients usually have multiple comorbidities, and invasive monitoring is commonly required. This creates great challenges for the perioperative cardiac surgical team, while managing suspected or confirmed COVID-19 patients during cardiac surgery. The Chinese Society of Anesthesiology developed this expert consensus document on anesthetic management of cardiac surgical patients with suspected or confirmed COVID-19 from experts with significant experience in taking care of COVID-19 cardiac surgical patients and available literature in English and Chinese.

Preoperative Evaluation of COVID-19 Cardiac Surgical Patients

The incubation period for COVID-19 is usually between 4 and 6 days and could be as long as 14 days. Patients usually present with mild symptoms, including low fever and fatigue, or they may be asymptomatic. As invasive monitoring is usually required for cardiac surgery, all patients should be treated as confirmed COVID-19 cases when the disease is suspected or when the test result is not yet available. Elective or semi-elective cardiac surgeries should be postponed until COVID-19 virus detection results are negative at least twice with a minimum of 24 hours between tests.

For patients with indications for emergent cardiac surgery, COVID-19 status should be immediately evaluated from the patient's recent epidemiologic history, respiratory infection history, clinical manifestations, and laboratory and radiographic testing, including but not limited to temperature, respiratory pathogen testing, serum immunoglobulin G (IgG) level, complete blood count, C-reactive protein (CRP) and procalcitonin (PCT) level, SARS-CoV-2 nucleic acid testing, and chest computed tomography (CT) scanning. If preoperative evaluation could not be completed in time before surgery, preoperative preparation should follow the guidelines for suspected/confirmed COVID-19 cases. These patients should be admitted to an airborne isolation room (single room with negative pressure and frequent air

exchange). If time permits, SARS-CoV-2 nucleic acid testing and chest CT scanning should be performed. The need of quarantine is based on the results of this examination.

A multidisciplinary team consisting of cardiac surgeons, cardiac anesthesiologists, pulmonologists, infectious disease experts, perfusionists, and nursing staff shall coordinate the care and participate in the decision-making process. For healthcare providers involved in suspected or confirmed COVID-19 cases, level 3 infection control precautions (consisting of disposable hat, medical masks [N95 or above], powered air purifying respirators [PAPR], scrubs, disposable gloves, and disposable shoe covers) should be practiced throughout the perioperative period. Clinical observations should be carried out closely after their clinical involvement. If there are exposure risks during the care, at least 14 days of isolation should be mandated.⁴

Preoperative Preparation of COVID-19 Cardiac Surgical Patients

Personal Protective Equipment for Healthcare Providers

It is highly recommended that all healthcare providers wear an N95 mask, surgical cap, gown, eye goggles, shoe covers, double gloves, and PAPRs or a full-face shield.⁵⁻⁷ The operating room should be converted to a negative pressure environment with airflow changes, and a warning sign should be posted outside the operating room (OR). A dedicated pathway should be used for pre- and postoperative transportation of COVID-19 patients and should be disinfected regularly.

Anesthetic Preparation for COVID-19 Patients

Staffing Management

Two experienced cardiac anesthesiologists should be present inside the cardiac operating room to directly manage the patient. The third cardiac anesthesiologist should be available outside the OR serving as backup and a consultant. OR traffic should be limited to the minimum. Dedicated staff should be assigned for specimen collection and delivery. All involved healthcare providers should wear the following in this order: N95 mask, hat, scrub, gown, anti-fog goggles, shoe covers, first layer glove, isolation gown, and PAPR. Anesthesiologists must wear gloves before contacting the patient; body fluids such as blood, urine, mucus, and so on; or other contaminated objects. After that, the outer gloves should be removed and hand hygiene should be performed. Contaminated zones, semi-contaminated zones, and clean zones should be clearly defined. Protective equipment should be removed in sequence according to the hospital guidelines.

Equipment Preparation

Anesthesia machines, monitors, transesophageal echocardiography (TEE) probes, ultrasound machines, blood gas

analyzers, activated-clotting time (ACT) machines, and disposable supplies in the operating room should be prepared in advance.

The Waste Anesthetic Gas Disposal system should be equipped with appropriate filtering and sterilizing functionalities. The Centralized Waste Anesthetic Gas Disposal system should be avoided to prevent the spread of SARS-CoV-2 virus among operating rooms when standard negative pressure in the OR cannot be achieved. A negative pressure suction device should be available independently for each OR.

It is strongly recommended to use video laryngoscopes (disposable laryngoscopes whenever possible) to improve the success rate, reduce the exposure time during tracheal intubation, and avoid unplanned emergency tracheal intubation.

Cardiac Patient Preparation

Patients should wear a surgical mask at all times and should be transported to the OR through a dedicated pathway. Nasal cannula oxygen therapy can be used underneath the mask when needed. A Venturi mask should not be used.⁴ In patients with severe cardiac and pulmonary dysfunction, intra-aortic balloon pump, or extracorporeal membrane oxygenation (ECMO) might be considered.⁸

Intraoperative Management of COVID-19 Cardiac Surgical Patients

General Principles

1. Arterial and central venous catheterization are recommended to be performed under ultrasound guidance to improve success rate and reduce procedure time.
2. Awake intubation or topical airway anesthesia should be avoided when possible because coughing and nebulization might cause aerosol dispersal and virus spread.
3. Rapid sequence induction and endotracheal intubation are recommended. Fast-acting muscle relaxants such as succinylcholine or rocuronium are preferred. Low-pressure mask ventilation with 100% oxygen can be given to patients with poor oxygen reservoir.
4. With personal protective equipment in place, anesthesiologists cannot perform auscultation to confirm placement of the endotracheal tube (ETT). Tube position should be verified by detection of end-tidal carbon dioxide (EtCO₂) waveform, symmetrical chest rises, pulse oximetry, and depth of the ETT.⁹
5. Electrostatic heat and moisture exchange filters (HMEF) should be used in the anesthesia circuit throughout the intubation process as its virus filtration efficiency reaches 99.9995%.¹⁰
6. For suspected patients, lower respiratory tract secretions should be collected through the ETT, and specimens should be sent for examination as soon as possible.

Cardiovascular Considerations in COVID-19 Patients

Cardiovascular Manifestations of COVID-19

Studies have shown that patients with COVID-19 may have viral myocardial damage. Elevated cardiac injury biomarkers are most commonly found in COVID-19 patients.¹¹ In addition, hypertension, heart failure (high incidence in elderly patients), hypoxia-induced myocardial injury (high incidence in patients with previous myocardial infarction, unstable angina, or history of percutaneous coronary intervention [PCI] surgery), and stunned myocardium all have been reported.¹² It is speculated that high expression of ACE2 receptors in the heart, blood vessels, and lungs might play a role in the virus-induced activation of the RAAS system.¹³

Cardiovascular Monitoring in COVID-19

Advanced invasive hemodynamic monitoring such as PiCCO (Getinge, Wayne, NJ), FloTrac (Edwards Lifesciences, Irvine, CA), Swan-Ganz catheters (Edwards Lifesciences, Irvine, CA), and TEE is recommended to guide fluid therapy and the use of inotropic or vasoactive medications. In addition, patients with acute myocardial injury should be considered for early intra-aortic balloon pump, ventricular assist device, or ECMO mechanical circulatory support. Previous studies have shown that perioperative infusion of dexmedetomidine at a rate of 0.5 µg/kg/h can lower pulmonary systolic blood pressure (PASP), reduce the use of sedative drugs after surgery, and shorten extubation time in patients with pulmonary hypertension.¹⁴ It is still unclear whether dexmedetomidine is beneficial in COVID-19 patients.

Pulmonary Considerations in COVID-19 Patients

Patients with SARS who receive mechanical ventilation have a high incidence of pneumothorax, and it is one of the major causes of death.¹⁵ Based on these experiences, the authors recommend that pneumothorax should be excluded preoperatively by CT scanning. Protective mechanical ventilation strategy (target tidal volume 6 mL/kg [predicted weight], platform pressure ≤30 cm H₂O, PEEP to target SaO₂ about 88% to 95%, and pH ≥ 7.25) should be applied in all suspected and confirmed patients.^{16,17} Pneumothorax should be suspected when a patient's SpO₂ decreases with increased airway pressure, unilateral breath sounds, or sudden blood pressure decreases. Pulmonary ultrasound could be used for fast evaluation and diagnosis,¹⁸ and a chest tube should be placed if a pneumothorax is diagnosed. Lung re-expansion should be checked before chest closure.

Renal Considerations in COVID-19 Patients

Critically ill COVID-19 patients have a high incidence of acute kidney injury (AKI) and severe acid-base imbalances, and electrolyte abnormalities might ensue. Continuous renal replacement therapy should be performed perioperatively when indicated. Goal-directed fluid therapy is recommended to optimize fluid administration.

Perioperative Blood Management in COVID-19 Patients

Blood conservation strategies should be applied for COVID-19 patients, as their coagulation function is usually abnormal. Coagulation status should be evaluated routinely by platelet counts/function, prothrombin time (PT), partial thromboplastin time (PTT), international normalized ratio (INR), and thromboelastography. Antifibrinolytic medications, preoperative hemodilution, autologous platelet-rich plasma technology, mild hypothermia or normothermia during cardiopulmonary bypass (CPB), and intraoperative blood salvage should be used to minimize blood transfusion and reduce transfusion-related lung injury. Coagulation factor concentrates are preferred over blood products when possible to reduce potential transfusion-related lung injuries.

Anesthetic Management of Critically Ill COVID-19 Patients

General Principles

1. Correct hypoxemia and electrolyte imbalance in a timely manner. For patients with severe pulmonary dysfunction, acidosis should be corrected during CPB or ECMO support.
2. Provide adequate sedation. Sedation can quickly relieve symptoms for COVID-19 patients on mechanical ventilation. However, anesthesia depth should be adjusted to avoid hypotension and the need for inotropic drugs.¹⁹
3. The use of steroids in COVID-19 is controversial.²⁰ Owing to limited evidence, steroids are not recommended in COVID-19 unless severe microcirculatory dysfunction caused by a cytokine storm is present. Antimicrobial prophylaxis and anti-inflammatory therapy are important to treat patients with COVID-19.

Intraoperative TEE should be used routinely to monitor ventricular function, volume status, and valvular diseases, and guide the anesthetic management.²¹ The primary heart disease and COVID-19–induced cardiac dysfunction should be evaluated comprehensively by TEE. Right heart dysfunction might develop from increased pulmonary vascular resistance owing to pulmonary edema, left heart dysfunction, and stress cardiomyopathy in COVID-2019. Lung ultrasonography is useful to assess the severity of lung diseases by the presence of B-lines, air bronchogram, and pleural effusion. This can guide the implementation of lung-protective strategies.

Postoperative Care in COVID-19 Patients

Patient Transport

A single dose of 5-hydroxytryptamine receptor antagonist should be given to prevent postoperative nausea and vomiting, which can cause extensive spread of the SARS-CoV-2 virus. Before leaving the OR, all healthcare providers should take off the outer layer of personal protective equipment in the sequence as guided by hospital policy. The transportation team should wear new personal protective equipment in the clean zone. An HMEF-equipped portable ventilator and a dedicated

pathway should be used to transfer the patient to an airborne isolation intensive care unit room. Only remove personal protective equipment after leaving the isolation area.

Medical Waste Management

All medical waste, including breathing tubes, infusion tubing, and disposable laryngoscopes, must be sealed with double-layered medical waste bags and treated as infectious medical waste.

OR Disinfection

The surface of the anesthesia machine and operating table should be wiped with 75% alcohol or chlorine-containing disinfectants. The inner circuit of the anesthesia machine should be removed and disinfected with 75% alcohol or hydrogen peroxide. Mixed O₃ and H₂O₂ atomized gases or pasteurization also can also be used.²⁰ The OR should maintain negative pressure for at least 30 minutes after the patient has been transferred. Filters of exhaust vent (on the ceiling) and return vent (on the wall) in the OR should be replaced. Surgery should not be started in this OR until the OR has been thoroughly disinfected as described.

Equipment Disinfection

The casing and monitor of ultrasound machines should be wiped with 75% alcohol. Ultraviolet light can be used as well. Quaternary ammonium disinfectants should be avoided as they can damage the casing. However, ultrasound probes can be disinfected with quaternary ammonium or hydrogen peroxide. For disinfection of the TEE probe, blood gas analyzer, and ACT machines, please refer to the manufacturer's instructions.

Healthcare Providers

Close observation should be carried out for all healthcare providers involved in the care of COVID-19 patients, and an Infectious Disease Report Form should be completed. If there is a potential exposure risk during the process, a 14-day quarantine is required.²²

In summary, COVID-19 patients present many challenges for cardiac anesthesiologists during cardiac surgery. Meticulous infection control practices must be observed and special attention should be paid to COVID-19–specific cardiac and pulmonary manifestations.

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Conflict of Interest

None.

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