

## Cardiac Operation Amidst of COVID-19 Pandemic: A Review of Precautionary Measures

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### Abstract

Severe acute respiratory syndrome coronavirus 2 emerged from the city of Wuhan, Hubei province of China in December 2019 and swarm over the world proclaiming pandemic in March 2020 by the World Health Organization as COVID-19. In order to minimize the infection as well as transmission of infection, globally social lockdown was introduced along with prioritizing the health care services. All the health care services were mainly focused on mitigating COVID impact and halting the elective operations. However, cardiac and aorto-vascular disease had a rapid progression and high mortality rate which obligate early intervention. Also, cardiac patients are high risk patient on whom the covid impact is more and cardiac operation involves exceptionally high exposure to health care personals. The authors emphasize the precautionary and safety measures to be followed in the cardiac operating room concerning covid outbreak.

**Keywords:** Cardiac operation; COVID-19 pandemic; Precautionary measure; RT-PCR; Personal protective equipment (PPE).

### Introduction

The novel Corona virus disease 2019 (COVID-19) was first reported in Wuhan, Hubei Province of China on 31<sup>st</sup> December, 2019.<sup>1-6</sup> In view of worldwide spread, WHO declared the COVID-19 as pandemic on March 11, 2020.<sup>7</sup> There was a significant impact on health care services and risking the health care providers. Especially, anesthesiologists are at higher risk of COVID-19 infection because of direct involvement in the aerosol-generating procedures. It imposed notable restriction in elective cardiac operation diverting the manpower and resources for escalating COVID-19. On 27<sup>th</sup> March Cheney C mentioned about prevention elective surgery during the pandemic and its postponement according to the guidelines of the centers for disease control.<sup>8</sup>

Albeit COVID spread is high in cardiac and aorto-vascular surgery, it cannot be postponed because of rapid deterioration. However, certain precautions

and safety measures in the operating room provide safe guard to the health worker, the front liners. Hopefully, this manuscript will offer some insight on precautionary measures to be followed in order to mitigate the challenge.

### Background of Covid-19

The evidence suggested zoonotic transmission of virus due to illegal wildlife trade from Huanan Seafood Wholesale Market and first case was reported to WHO on 31<sup>st</sup> December, 2019.<sup>3,5</sup> WHO renamed the infection as coronavirus disease 2019 (COVID-19) on 11<sup>th</sup> February, 2020 and declared as pandemic on March 11, 2020.<sup>7,9</sup> Despite of aggressive isolation and segregation by the China, it has spread like wildfire and affected more than 71 crores cases worldwide with a death toll as high as 1.6 million.<sup>10</sup>

The SARS-CoV-2 appears to be transmitted

through droplet or aerosol generation.<sup>11</sup> Therefore, precaution towards droplet spread, aerosol generation, proper environmental hygiene and effective infection control practices are advised for halting COVID spread.

The recommendations for providing health care facilities to the patients undergoing surgery during COVID-19 pandemic was published by the Centers for Disease Control and Prevention (CDC).<sup>12,13</sup> Additional essential information was reported by the American College of Surgeons in order to guide further.<sup>14</sup> Both these recommendations guide remarkable in reducing elective cases and executing safety measures. The Workforce for Adult Cardiac and Vascular Surgery and the Society of Thoracic Surgeons COVID-19 Task Force also put forth on patient triage.<sup>15</sup>

### *Cardiac Disease and Covid-19 Infection*

Patients with cardiac disease were prone to COVID infection because of their modifiable and non-modifiable risk factors and associated comorbidities. Moreover, COVID-19 virus acts on certain receptors which were augmented by medications consumed by cardiac patients. Owing to frailty and futility, COVID cause severe organ dysfunction in this category.

On analyzing a retrospective cohort study which includes 201 COVID-19 patients with 31.2% patients had hypertension, 10.1% had diabetes mellitus which were the most common risk factors associated with cardiac patient and moreover, 14.5% COVID-19 patient had underlying cardiac diseases.<sup>16</sup> Patients having cardiac disease had severe pneumonia and progressive organ dysfunction, which requires intensive care management and cause increases morbidity as well as mortality.<sup>17</sup>

Zheng et al. notified upregulation of angiotensin converting enzyme-2 (ACE 2) receptor expression from chronic use of renin angiotensin aldosterone system inhibitors, which is commonly used for management of cardiac patients.<sup>18</sup> However, there are no guidelines which recommend discontinuation of ACE inhibitors in these patients and define at risk for COVID-19 infection due to lack of clinical trials confirming the effects COVID-19 infection on these drugs.<sup>19</sup>

Zheng et al. concluded that COVID-19 patients with underlying cardiac and aorto-vascular disease have worse prognosis due to chronic cardiac illness or acute myocardial injury with multiple system involvement. Therefore, the healthcare provider

should thoroughly adhere to all infection control measures to save these patients.

### *Cardiac Surgery and Covid-19 Infection*

In contrast to general elective surgeries, cardiac surgery involves use of cardiopulmonary bypass (CPB) which is unique extracorporeal circulation where blood is exposed to the non-endothelial surfaces. Extracorporeal exposure triggers an inflammatory response due to activation of complement system, coagulation pathways, and increasing interleukin 10 (IL-10) and tumor necrosis factor  $\alpha$  (TNF- $\alpha$ ).<sup>20</sup>

COVID-19 patients succumb by acute respiratory distress syndrome (ARDS) which is the major cause of long-term pulmonary disability and major cause of mortality.<sup>21</sup> Evidence suggestive of cytokine storm syndrome attributed to ARDS in COVID-19, especially with high levels of proinflammatory cytokines. TNF- $\alpha$  and IL-10 were elevated in patients with COVID-19 and has also been correlated with disease progression and its severity.<sup>22</sup> CPB and COVID infection has doubling effect on cytokine storm. Therefore, on-pump cardiac surgery has a deleterious effect in COVID-19 infection, and vice versa. Moreover, off-pump cardiac surgeries and catheter-based interventions were popularized amidst of COVID outbreak precluding the use of CPB. In addition, minimizing extracorporeal circulation time and using cytokine filter and cell-saver during CPB reduces the inflammatory markers significantly.<sup>23</sup>

Pulmonary dysfunction after cardiac surgery under CPB can range from a temporary mere reduction in arterial oxygenation and ventilation to a life-threatening pulmonary disability manifested in the form of ARDS or chronic lung fibrosis.<sup>24</sup> The COVID-19 patients were presented with dry cough in 76%-82%, fever in 83%-98% of patients, and chest radiographs show bilateral patchy infiltrates in the basal and peripheral region and computed tomography confirmed ground glass opacities with reverse halo sign.<sup>25</sup>

The pulmonary infection due to COVID-19 ARDS has resemblance with the pulmonary complications following cardiac surgery under CPB. The silent carriers are especially prone for its severe impact. Lei et al did retrospective analysis of 34 patients undergoing elective surgeries showed to develop pneumonia after surgery were found to be in the incubation period, with a mortality rate of 20.5%.<sup>26</sup> This necessitates preoperative testing and

postoperative follow-up.

**Cardiac Procedures during The Covid-19 Pandemic: Perform or Postpone**

During the COVID-19 era, Cardiac surgeries bear enhanced risk for patients with multiple associated comorbidities and are at greater risk for the COVID-19 pulmonary disabilities. The silent carriers affect the healthcare workers who are already at higher viral exposure. Therefore, the decision to postpone or proceed with elective cardiac surgery should be individualized and decided after weighing the risk of delaying surgery and its consequences over the risk of transmitting the infection to the futile patient and over burden health care provider.

I.M. Shehata et al. concluded solicitous decision-making remains the responsibility of healthcare provider systems to preserve the health capacity, which is under increasing pressure of the COVID-19 pandemic and to protect both cardiac patients and healthcare personals.<sup>27</sup>

Emergency surgery and life-threatening surgery cannot be avoidable. There should always a balance between risk of cardiac disease progression and acquiring nosocomial COVID infection. There is short supply of blood and blood products which is required in huge amount for cardiac surgery because of decreased voluntary donation amidst of COVID.

Jonathan W. Haft et al provided Tiered Patient Triage Guidance Statement for adult cardiac surgery patient.<sup>15</sup> They categorized patients in whom surgery to be carried out on emergency basis (Table 1) and in whom surgery to be postponed (Table 2).

**Table 1:** Cardiac surgery to be carried out amidst of COVID-19.

Emergency services:
<input type="checkbox"/> Ascending aortic dissections
<input type="checkbox"/> Acute coronary syndromes
<input type="checkbox"/> Acute valvular endocarditis
<input type="checkbox"/> Heart failure patients awaiting heart transplant or VAD)
Outpatients at greatest risk of adverse event:
<input type="checkbox"/> Symptomatic critical aortic stenosis or CAD
<input type="checkbox"/> Severe CAD with large territory of myocardium at risk
<input type="checkbox"/> Asymptomatic CAD with reduced systolic function
<input type="checkbox"/> Progressive angina
<input type="checkbox"/> Cardiac tumors at risk of obstruction or embolization
<input type="checkbox"/> Aortic aneurysm at risk based on size and familial association

- Patients with correctable, anatomic causes of heart failure
- End-stage heart failure patients in evaluation for mechanical assist devices who are inotrope dependent

**Table 2:** Cardiac surgery to be avoided amidst of COVID-19.

Asymptomatic outpatients
Truly elective intervention
<input type="checkbox"/> Asymptomatic or minimally symptomatic severe
<input type="checkbox"/> MR (mitral regurgitation)
<input type="checkbox"/> ASD or PFO surgery, or both
<input type="checkbox"/> Asymptomatic aneurysm with demonstrated stable size
<input type="checkbox"/> Isolated arrhythmia procedures

**Precautionary Measures in Cardiac Operating Room During Covid-19**

During COVID pandemic cardiac surgeries were postponed as it involved high aerosolized blood generating procedure, inherent patient comorbidities, high risk of lung injury, increased man power involvement, long hospital course. However, certain cardiac surgeries do not give halting period requiring urgent intervention. Therefore, precautionary measures can curtail the disease spread in this situation.

Each and every staff of operating room should use either N95 or FFP 2 masks as per centers of disease control and prevention recommendation. They are effective for certain viruses including the corona virus. For longer duration surgeries like cardiac and aorto-vascular surgeries Powered air purifying respirators [PAPR] is preferred. Aerosolized blood generating is most common in these surgeries therefore double surgical masks should be avoided. Either a surgical spacesuit or the second layer of sterile protective garments should be donned. A face-shield is also desirable. For scrubbing, an aqueous alcohol solution is used followed by a sterile surgical scrub suit and double surgical gloves. Surgical gowns or Coveralls should be prioritized along with surgical cap for aerosol or blood generating procedures. Surgical hood should be tied to prevent direct aerosol exposure. Fluid resistant Shoes along with shoe cover are preferable.

Strict and periodical screening of the each and every staff involving is mandatory. There should be rotation between members and should take off for self-quarantine and should report immediately if any signs of illness. Besides contact tracing and infection control measures should be implemented periodically, to avoid unavoidable exposure (Table 3).

**Table 3:** Operating room consideration during COVID-19 pandemic.

Pre-operative	Intra-operative	Post-operative
<input type="checkbox"/> Team simulation	<input type="checkbox"/> Intubation by experienced hand	<input type="checkbox"/> Dedicated transport ventilator
<input type="checkbox"/> Team briefing	<input type="checkbox"/> Use of intubation box, video laryngoscope, suction apparatus, HME filter, tube clamp	<input type="checkbox"/> Contact tracing
<input type="checkbox"/> Allotting the runner	<input type="checkbox"/> Adequate paralysis	<input type="checkbox"/> Terminal cleaning of operating room
<input type="checkbox"/> Machine and equipment check	<input type="checkbox"/> Avoid bag-mask ventilation	<input type="checkbox"/> Sanitization of equipments and machines
<input type="checkbox"/> Personal protecting equipment (N95 mask, gown, gloves, shoe cover)	<input type="checkbox"/> Avoid unnecessary oral or tracheal suction	<input type="checkbox"/> Discard disposables
<input type="checkbox"/> Use of face-shield before proceeding for tracheal intubation, suction and any procedure near the patient's airway	<input type="checkbox"/> Other personal stay outside during intubation	
<input type="checkbox"/> Prepare drugs in advance	<input type="checkbox"/> Reduce CPB time	
<input type="checkbox"/> Shift the patient with mask	<input type="checkbox"/> Lung protective ventilation	

### *Transfer of Patient*

Before planning for an elective surgery patient should be tested for COVID reverse transcriptase-polymerase chain reaction (RT-PCR) and within 72 hours negative report should be available. In emergency situation rapid antigen test to be carried out because of scarcity of time and emergency surgery should be carried out similar to that of COVID positive.

The staffs transferring the patient from the ward to the OR should be donned in full personal protective equipment (PPE) including a surgical gown, N95 mask, face shield, and boot covers. The patient should also wear a N95 mask or at least surgical mask. If already intubated to avoid the endotracheal tube should be clamped with forceps in order to prevent aerosolization. Fisrtenberg et al. suggested to use a portable travel ventilator with a HEPA filter between the circuit and the endotracheal tube and another HEPA filter between the circuit and ventilator. If HEPA filter is not available heat and moisture exchanger (HME) filter can be used. They also advised to escort the transporting team by security guards to minimize the risk of transmission to other hospital members and also to minimize the risk of accidental contact with others during the transport. Transfer routes should be precisely planned and should be as short as possible.

### *Anesthesia Considerations*

The most experienced anesthesiologist should

involve in the aerosol generation procedure especially during intubation of the patients to minimize aerosolization and has highest chance of first-time success. Face mask ventilation and open airway suction should be minimized. Bag mask ventilation to be avoided or minimized. Disposable airway equipment was advised. video-laryngoscope should be advised to increase the distance between patient airway and anesthesiologist face and has high success rate. Intubation box and closed suction can be used to minimize transmission of virus. An HME filter to be used on the expiratory limb of the circuit. The soda-lime and filters should be exchanged after each case. One anesthetist and one to two assistants should be present inside the OR during intubation and rest of the team members should wait outside till definitive airway.

Transesophageal echocardiography (TEE) use should be minimized and used in essential condition to avoid aerosolization and risk of transmission. It should be covered with a transparent sheath and inserted to the patient with sheath in situ. After use, sheath should be discarded and probe to be cleaned and sterilized properly. The TEE machine should be covered with transparent plastic during use and plastics were discarded after use.

As COVID affect pulmonary system the most so lung protective ventilation to be used. The extracorporeal circulation time and use of blood and blood products to be minimized which has added detrimental effect on lungs. The perfusion tubing and blood products should be appropriately discarded and device should be thoroughly sanitized.

### *Intraoperative protocol*

Even though there is no data exist currently on COVID-19 viral load in blood, bodily fluids or tissue samples, extreme care should be taken during its handling. In cardiac and aorto-vascular surgical procedures, the use of power tools, such as electrocautery, bone saws, and extracorporeal circuit releases aerosols, increasing the risk of virus spread. Particles in surgical smoke have been demonstrated to contain a various toxic materials and virulent particles. Therefore, a smoke evacuator should be used during the use of electrocautery.

Operations should be performed by the most experienced surgeons. The number of assistants to be reduced to limit exposure time in the OR and use the manpower in the COVID area which needs more attention. Junior residents and novel learners should not involve actively in surgery unless absolutely necessary. Surgical approach and technique should be considered to minimize exposure risk while optimizing patient outcomes. Use of video-assisted thoracoscopic procedures should be avoided when possible because of increased risk of aerosolization from CO<sub>2</sub> insufflation systems and also chance of inadvertent lung injury.

### *Disposal*

After surgical procedure all the disposable materials should be segregated and disposed appropriately. The blood, body fluids, suction fluids, CPB equipment blood and pathological specimens should be disposed of in double bags and should be sealed and leveled. For biopsy, specimens should be placed into a biohazard bag and properly labeled as "Covid positive" or "suspected covid" before being sent to the lab.

### *Setting Up Dedicated Covid Operating Room*

The dedicated operation theatres should be located in the designated COVID Centre and there should be away from inhabited buildings by at least 20 meters. There should be separate changing room, donning area and doffing area with regular scrutinization and sterilization equipment. There should be separate entry route to the donning area and the exit from the doffing area.

Negative pressurized non circulating operating theatre is ideal in order to isolate air borne infection from spreading outside. An independent exhaust blower should be installed to extract and exhaust the

room air after suitable "exhaust air treatment" out into the atmosphere. The exhaust air quantity should exceed the supply air quantity to achieve more than 5 pa negative pressure (minimum of 2.5 Pa) in the room. The minimum air change should be of 12 air changes per hour.

The designated COVID OT should have at least two stand-alone air-conditioners of adequate capacity for appropriate circulation. The room temperature should be maintained between 24°C and 30°C and the relative humidity between 40% and 70%.

Before releasing to outside, the exhaust air should be treated by "exhaust air treatment" preferably by high efficiency particulate air (HEPA) filtration. If HEPA filtration technique is not available, the exhaust air is treated with chemical disinfection by 1% hypochlorite. Ultraviolet (UV) irradiation for 15 minutes and heating at a temperature of 75°C for 45 min can be other options.

All the essential drugs, equipment like anesthesia machine, defibrillation, anesthesia monitors, perfusion equipment, TEE machine, IABP machine, infusion pumps should be available whereas the non-essential equipment should be kept outside the designated COVID area. There should be appropriate plastic covers for the equipment as well as frequent sanitization with terminal cleaning after procedure. The essential drugs and emergency drugs should be discarded after the use in appropriate container. The special equipment requiring in the aerosol generating procedure like video laryngoscope, intubation box, well-functioning suction apparatus, HME filter and tube clamp should be available. Large clear bill boards and signage in English as well as in local language should be placed.

### *Conducting Cardiac Surgery in Covid Patient*

The emergency surgery or lifesaving measures cannot be avoided in COVID-19 infection although the patient and the health care provider are at risk. The need of surgery should overweigh against the risk of COVID infection. The surgery should carry out in a designated COVID operating room.

After putting on the OT clothes, scrub in the scrub room and wear the Personal Protective Equipment (PPE) in the designated Donning Room. The PPE includes coverall suit, well-fitting N95 respirator, goggles, double gloves, the shoe cover and face shield (Table 4).

**Table 4:** Level of PPE kit for COVID and non- COVID patient.

For non- COVID Patient	For COVID Patient
Cap	Coverall suit
Goggles	Goggles
Face shield	Face shield
N -95 mask	N-95 mask
Level 4 surgical Gown	Double gloves
Double gloves	Shoe cover
Shoe cover	

All the equipment should be checked in advance and emergency and essential drugs to be prepared. Two high quality Heat and Moisture Exchange Filters (HMEFs) should be placed, one between expiratory limb and anaesthesia machine and another between tracheal tube and breathing circuit.

Once operating team is ready including surgeon, anesthesiologists, perfusion staff, nursing staff, runner, technician then COVID-19 infected patient is wheeled in through predefined corridor to the operation theatre. The patient should wear cap, operation theatre clothes, preferably N95 mask or surgical mask and should be draped with a plastic sheet. Standard routine anaesthesia monitoring to be instituted.

For general anaesthesia, the patient should be pre-oxygenated with 100% oxygen for five minutes with patient wearing mask. High flow oxygen should be avoided in order to prevent aerosolization. The patient should be instructed not to cough. The choice of induction drugs should be in accordance to hemodynamic considerations. Fentanyl is recommended for analgesia and midazolam for amnesia.

Rapid sequence induction and tracheal intubation with cricoid pressure is preferable and ensure adequate neuromuscular blockade to avoid coughing which enhances aerosolization. Intravenous lignocaine may be used to prevent bucking during tracheal intubation.

In order to prevent aerosolization the tracheal tube cuff should be inflated before starting ventilation. Immediately clamp the tracheal tube and attach the HMEF on tracheal tube. Avoid manual ventilation to prevent generation of aerosolization of virus from airways.

Use plastic or acrylic Intubation box and plastic transparent sheets to cover the patient completely. Tracheal Intubation can be done through the clear transparent plastic intubation box, thus minimizing aerosol generation.

To increase the distance between the patient's airway and the anesthesiologist, Video laryngoscope is the modality of choice. It not only improves

intubation success rate but also avoids multiple attempts for tracheal intubation. Awake fiber optic intubation should be avoided whenever possible as it may increase aerosolization. Nebulization with local anaesthetic also increases aerosolization.

TEE examination should be avoided as far as possible. If its use is essential, the TEE probe should be covered with transparent plastic cover with adequate jelly to prevent its contamination. The perfusion team should follow proper care while handling the major blood and products.

The CPB time should be reduced as minimum as possible to avoid extracorporeal induced inflammatory cytokine generation. The use of blood and blood products should be minimized to avoid transfusion induced lung injury and organ dysfunction.

## Conclusion

The COVID-19 pandemic has caused notable amount of disability, death and resulting in significant emotional impact on families and reframing of social structures with remarkable consequences on economy. There was a significant impact on health care provision with restructuring the health care resources including cardiac surgery. As a consequence, the burden of cardiac and aorto-vascular disease gradually increasing and worsening. These patients are not only high risk for acquiring covid infection but also are nidus for spreading infection. However, with utmost precaution and safety measures such certain untoward situations can be handled.

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