ADULT CARDIAC SURGERY DURING COVID-19 PANDEMIC

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ABSTRACT

Coronavirus Disease 2019 (COVID-19), which is caused by the SARS Coronavirus 2 (SARS-CoV-2), has affected over 200 countries worldwide. First case of COVID-19 was found in Wuhan, China, precisely around December 2019. COVID-19, especially in those with underlying health conditions or comorbidities, has an increasingly rapid and severe progression, often leading to death. This virus is a single-strand RNA coronavirus, binding the angiotensin-converting enzyme 2 (ACE2) receptor which enters human cells. Coronavirus disease has been reported to affect cardiac and vascular organs. cardiomyocyte death and inflammation are results of a direct mechanism that involves viral infiltration into myocardial tissue. Some cardiovascular manifestations of myocardial injuries associated with COVID-19 are arrhythmias, myocardial infarction, heart failure, and elevated biomarkers (cardiac troponin I and brain-type natriuretic peptide). Some of this manifestation requires immediate intervention or surgery. Criteria are needed for hospitals or institutions that mostly maintain cardiac surgery services and surgery-urgent patients depending on severity of the disease and hospital resources. These criteria also limit the risk of exposure to patients and healthcare workers and allocate resources appropriately to those in greatest need. This paper aims to share our discussion and give an overview of patients undergoing cardiac surgery, providing clinicians with recommendations to triage and plan these procedures during the COVID-19 outbreak effectively.

Keywords: Cardiovascular, adult cardiac surgery, covid-19

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1. INTRODUCTION

The ongoing global pandemic caused by Coronavirus Disease 2019 (COVID-19), which is caused by the SARS (Severe Acute Respiratory Syndrome) Coronavirus 2 (SARS-CoV-2), has affected over 200 countries worldwide.[1] The first case of COVID-19 was reported in Wuhan, China, precisely around December 2019.[2] On March 2nd, 2020, the Ministry of Health in Indonesia confirmed the first case of COVID-19 disease. As of August 23rd, 2020, Indonesia had 153.535 confirmed cases of COVID-19, the highest in Southeast Asia. In terms of death numbers, Indonesia ranks ninth in Asia, with 6.680 deaths with a case fatality rate of 4.35%.[3] This virus is a single-strand RNA coronavirus, which enters human cells mainly by binding the angiotensin-converting enzyme 2 (ACE2) receptor.[4] Receptor downregulation happens after the virus binds with ACE2 and enters the cell, which is supposed to be the host's defense mechanism to limit further viral invasion to escape the immune system.[5] The downregulation of ACE2 leads to decreased ANG1-7 level and increased ANG2 level. Physiologically, ANG2 can cause vasoconstriction, aldosterone secretion, increase inflammation and ROS (Reactive Oxygen Species) production, thrombosis, and fibrosis; simultaneously, ANG (Angiopoietin) 1-7 can be classified as a regulatory enzyme that contradicts the effect of ANG2 and becomes cytoprotective (e.g., anti-fibrosis and anti-inflammation). This condition may induce uncontrollable cytokine storm and could lead to organ dysfunction in critical cases.[6]

Respiratory tract symptoms largely characterize the clinical manifestation of SARS-CoV-2 infection, including fever, dry cough, dyspnea, myalgia, fatigue, and most frequently presents with respiratory symptoms. These symptoms most likely progress to pneumonia, and in some cases, might become acute respiratory distress syndrome and shock. However, some patients may present with non-specific cardiac manifestation.[2,7,8] COVID-19, in those with underlying health conditions or comorbidities, has an increasingly rapid and severe progression, often leading to death.[9] The outcomes after COVID-19 infection might get worse on patients with risk factors such as old age, cardiovascular diseases (e.g., hypertension, coronary disease, or cardiomyopathy), diabetes, and chronic kidney disease.[10] In Indonesia, the first comorbidity that patient had confirmed COVID-19 positive is hypertension, and the third is cardiovascular disease.[3] All necessary precautions to avoid getting infected with COVID-19 should be taken by patients with comorbidity, as they usually have the

worst prognosis.[9] The Medical Association Indonesian General Surgery Specialist ("Persatuan Dokter Spesialis Bedah Umum Indonesia" in Indonesian or PABI) has also published work guidelines for all members of PABI in Indonesia for performing surgical services, including restrictions on visits to the surgical clinic and postponing surgical procedure. Prior to surgery, pre-operative assessments were conducted to identify patients' risk, followed by necessary procedure adjustment. As an example, surgery-urgent patients with clear symptoms of clinical pneumonia or COVID-19 rapid test with reactive result will be treated as a patient with supervision use of PPE (Personal Protective Equipment) level 3.[11,12]

The Society of Cardiothoracic Surgeons published criteria for hospitals or institutions that maintain cardiac surgery services and surgery-urgent patients.[13] Patients with a state of emergency that need immediate surgery are the ones with the acute coronary syndrome unsuitable for percutaneous intervention, ascending aortic dissection, acute valvular endocarditis, and heart failure patients expecting a heart transplant. Patients with such conditions cannot be discharged without a definitive procedure (e.g., severe coronary artery disease, symptomatic critical aortic stenosis, progressive angina, aortic aneurysm at risk based on size and familialassociation, cardiac tumors at risk of obstruction or embolization, and patients with correctable, anatomic causes of heart failure).[14] This paper aims to share our discussion and give an overview of patients undergoing cardiac surgery, providing clinicians with recommendations to triage and plan these procedures during the COVID-19 outbreak effectively. This guidance will help limit the risk of exposure to patients and healthcare workers and allocate resources appropriately to those in greatest need.

2. CARDIAC AND VASCULAR MANIFESTATION IN COVID-19 PATIENTS

The mechanisms of cardiac injury from COVID-19 are not well established but likely can result in direct or indirect mechanisms. The cardiomyocyte death and inflammation results from a direct mechanism that involves viral infiltration into myocardial tissue. Indirect mechanisms include cardiac stress due to respiratory failure and hypoxemia and cardiac inflammation secondary to severe systemic hyper inflammation.[15] The manifestations of myocardial injury are arrhythmias, myocardial infarction, heart failure, and elevating biomarkers (cardiac troponin I and brain-type natriuretic peptide). Increased troponin level

represents evidence of myocardial injury, and these may come from cytokine storm, hypoxic injury, coronary spasm, micro thrombin, myocarditis, or actual plaque rupture.[16,17] The HFpEF indicates heart failure with preserved ejection fraction, HFrEF, heart failure with minimized ejection fraction, and SARS-CoV-2, severe acute respiratory syndrome novel coronavirus.[15] Although the respiratory tract is the primary target for SARS-CoV-2, the Cardiovascular system may get involved in a few different ways.[18] The following are the common Cardiovascular disease associated with COVID-19. (table 1)

Table 1. Guidance from each cardiovascular presentation of COVID-19 (Adapted and Modified from [8, 19,20,21])

COVID 19 Associated Cardiovascular Disease	
ST Segment Elevation	- Myo-pericarditis should be considered in patients with chest pain, ECG changes, and biomarker elevation. Maintain a low threshold to assess for cardiogenic shock in this setting. - Use bedside TTE and possibly CCTA to triage cases before cardiac catheterization, consider a conservative strategy in appropriately selected cases. - Consider bedside pulmonary artery catheterization and bedside IABP placement. IABP might be the preferred device for a cardiogenic shock as an effect of lower management requirements. - Even most of the clinical presentation is dominated by cardiac manifestations, and there is no fever, COVID-19 should be in the differential.
Cardiogenic Shock	- Myocardial dysfunction might be caused by direct mechanism injury by virus or secondary to cytokine storm. - ECMO provides circulatory (VA) and respiratory support (VV). Low flows on VA ECMO may be sufficient. - Stabilization and recovery of profound cardiac dysfunction related to COVID-19 are viable with temporary mechanical circulatory support. - ECMO requires high resource utilization and should be appropriately used during the COVID-19 pandemic.
Arrhythmias	- In addition to blood pressure abnormalities, patients can also develop arrhythmias, ranging from tachycardia and bradycardia to asystole. - That cardiac arrhythmia was reported significantly more common in patients with critical forms of COVID-19 - Arrhythmias can arise just second to hypoxemia, metabolic derangements, systemic inflammation, or myocarditis. - Amiodarone, a widely used antiarrhythmic drug, has been shown to inhibit the SARS coronavirus's in vitro spreading.
Decompensated Heart Failure	- Preexisting HF with diastolic dysfunction or chronically elevated end diastolic pressures who develop capillary leak, might be exacerbated by COVID-19. - Invasive hemodynamic management and achievement of euvolemia monitoring might be valuable in some cases to manage both cardiac and respiratory failure. - The use of QT-prolonging agents (azithromycin, hydroxychloroquine) should be nearly monitored in patients with underlying cardiomyopathies.

CCTA indicates cardiac computed tomographic angiography; COVID-19, coronavirus disease 2019; ECMO, extracorporeal membrane oxygenation; IABP, Intra aortic balloon pump; TTE, transthoracic echocardiogram; VA, veno-arterial; and VV, venovenouw

Most of the latest reports on COVID-19 have only shortly described Cardiovascular manifestations in these patients. The poor prognosis of COVID-19 indicated by altered biomarkers, including troponin, natriuretic peptides, and coagulation parameters, reflects cardiac injury and stress. Adverse effects of various therapies, various antiviral drugs, corticosteroids, and other therapies aimed at treating COVID-19 can also have deleterious effects on the Cardiovascular system.[18] Given the enormous burden posed by this illness and the significant adverse prognostic impact of cardiac involvement, further research is required to understand the incidence, mechanisms, clinical presentation, and outcomes of various Cardiovascular manifestations in COVID-19 patients. Besides that, intensive monitoring of these biomarkers could help early detections of cardiac injury and possibly prevent further decline with appropriate management if available.

3. TIMING OF CARDIAC SURGERY INTERVENTION ON CASE TYPE AND URGENCY CATEGORY

During this pandemic, hospital resources divide three phases of handling patients. The division of three phases was carried out, aiming to determine the operating decisions taken based on the level of emergency and urgency. This division is also carried out considering that each hospital has the policy to reduce operations number by up to 30%, while the increase only depends on the phase.[13,22,23] Therefore, operations classified as elective should be postponed, and only work on emergency and urgent cases. Emergency cases are more comfortable to determine, and intervention should be undertaken immediately to reduce mortality. Whereas in urgent cases, intervention does not have to be done immediately, but surgery must be done within 1-2 weeks. In semi-emergency cases, surgery should be performed within of 2-4 weeks.[13,24] Whereas in elective cases, surgery can be postponed for more than four weeks. (table 2)

Table 2. Timing of cardiac surgery intervention depending on case type and urgency category (Adapted from[25])

Category timing	Emergent immediate entry – 72 h	1: Urgent 1-2 weeks	2: Semi-urgent 3-4 weeks	3: Elective >1 month
CAD (not amenable to PCI)	• Critical CAD/LM ± shock/IABP/pressors	• LM, ACS or w/3VD with high-risk anatomy	• 3VD w/ increasing Sx	• Stable CAD
AV (not amenable to TAVR)	• Severe AI w/shock • Severe AS w/shock	• Severe AI/AS w/NYHA IV HF, syncope • BHV SVD w/NYHA IV HF	• Critical/severe AS w/high-risk features or pregressive Sx • Progressive severe Al with progressice Sx	• Stable severe AI/AS
MV disease (not amenable to MC)	• Acute MR w/shock	• Acute MR with NYHA IV HF • BHV SVD w/NYHA IV HF	• Severe MR w/drop in EF recurrent HF • MS with NYHA III-IV HF	• Stable severe MR/MS
Tricuspid valve disease	• NA	• NA	• NYHA IV Sx	• Stable severe TR
Aortic surgery / other	• Type A dissection • PTE w/massive dot	• Giant TAA/PSA w/Sx or rapid expansion	• TAA >6-7 cm	• Stable TAA • PTE for CTEPH
Transplant	• NA	• Inpatient + status 1-2	• NA	• Stable outpatient

Cases classified as elective should be postponed as long as possible. The postponed surgery in this elective case aims to prevent COVID-19 infection during the operation period. The presence of COVID-19 infection in heart surgery cases shows a high mortality rate. A study by Lei et al. in Wuhan, China, on 34 patients with heart surgery in the early phases of the pandemic showed COVID-19 infection in all patients. As many as 44% of patients in the study required ICU admission, resulting in the mortality rate of 20.5%. The causes of death included in the study were ARDS, shock, arrhythmias, and acute cardiac injury.[2] It is also necessary to watch out for patients with old age and patients with comorbid diseases. Regardless of these categorizations of emergencies and urgency, cardiac surgeons should carry out close monitoring of patients whose surgery is delayed. The progression of the patient's disease should be noted while waiting for surgery. George et al., in their literature review, recommended one consultation per week for monitoring. The classification of emergencies and urgencies is also carried out based on the organs involved, namely the coronary, atrial valves, mitral valves, tricuspid valves, and aorta.[14,26]

As mentioned before, the phases of patient handling during the COVID-19 pandemic are divided into three. In phase 1, COVID-19 positive patients are 0-30% (Table 3) of the total patients, reduction in the number of surgeries at the mild level, with sufficient ICU and ventilator capacity.

In phase 2, COVID-19 patients account for 30-60% of total hospital patients (Table 4).[27] The reduction in the number of surgeries was at a moderate level. There are limitations to the ICU, ventilators, medical personnel, and PPE facilities in this phase. In phase 3, COVID-19 patients account for >60% of the total patients in the hospital (Table 5). The reduction in the number of surgeries is at a severe level. In this phase, the ICU, ventilators, medical personnel, and PPE are critical, so that only emergency operations are carried out.[13]

Table 3. Phase 1 of Cardiac Surgery Patient Handling During COVID-19 Pandemic (Adapted from[13])

<table>
<tr><td colspan="2">Phase 1</td></tr>
<tr><td>Essential services</td><td>Deferred</td></tr>
<tr><td>• All inpatients waiting for surgery, including emergency services (i.e., ascending aortic dissections, acute coronary syndromes, acute valvular endocarditis, and heart failure patients awaiting a heart transplant or VAD)
• Outpatients who are at most significant risk of adverse event, examples of which include:
○ Symptomatic critical aortic stenosis
○ CAD
○ Severe CAD with the large territory of myocardium at risk
○ Asymptomatic CAD with reduced systolic function
○ Progressive angina
○ Cardiac tumors at risk of obstruction or embolization
○ Aortic aneurysm at risk based on size and familial association
○ Patients with correctable, anatomic causes of heart failure (valvular or myocardial; i.e., HCM, adult congenital)
End-stage heart failure patients in evaluation for mechanical assist devices which are inotrope dependent</td><td>• Asymptomatic outpatients
• Truly elective intervention could include:
○ Asymptomatic or minimally symptomatic severe MR
○ ASD or PFO surgery or both
○ Asymptomatic aneurysm with demonstrated stable size
○ Isolated arrhythmia procedures</td></tr>
<tr><td colspan="2">• Programs are encouraged to adopt a mechanism by which patients can be screened regularly in order to identify those having increased symptoms or progression of the disease
• Transcatheter interventions will follow the same recommendations
• Alterntive precutaneous therapies with rapid discharge from the hospital should be considered
• Thoracic organ transplant guidance is provided by the United Network for Organ Sharing</td></tr>
</table>

VAD, Ventricular assist device; *CAD,* coronary artery disease; *HCM,* hypertrophic cardiomyopathy; *MR,* mitral regurgitation; *ASD,* arterial septal defect; *PFO,* patient foramen ovale

Table 4. Phase 2 of Cardiac Surgery Patient Handling During COVID-19 Pandemic (Adapted from[13])

Phase 2	
Essential services	Deferred
• All inpatients waiting for surgery, including emergency services • Outpatients with progressive symptoms who have demonstrated a failure to medical management ○ Symptomatic CAD • Asymptomatic CAD with impaired systolic function	• Asymptomatic outpatients and patients with anatomy and physiology suggesting delay can be provided with reasonable safety
• Programs are encouraged to adopt a mechanism by which patients can be screened regularly in order to identify those with increased symptoms • Transcatheter interventions will follow the same recommendations • Alternative percutaneous therapies with rapid discharge from the hospital should be considered	

Table 5. Phase 3 of Cardiac Surgery Patient Handling During COVID-19 Pandemic (Adapted from[13])

Phase 3	
Essential services	Deferred
• All inpatients who cannot be discharged safely without surgical intervention/correction, including emergency services	• All patients who are outpatients • Patients deteriorating while waiting would need to meet criteria for admission before consideration for surgery
• Programs are encouraged to adopt a mechanism by which patients can be screened regularly in order to identify those with increased symptoms • Transcatheter interventions will follow the same recommendations • Alternative percutaneous therapies with rapid discharge from the hospital should be considered • The United Network provides thoracic organ transplant guidance for Organ Sharing	

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