Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

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Management of Cardiovascular Disease During Coronavirus Disease (COVID-19) Pandemic

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ABSTRACT

Patients with pre-existing cardiovascular disease and risk factors are more likely to experience adverse outcomes associated with the novel coronavirus disease-2019 (COVID-19). Additionally, consistent reports of cardiac injury and de novo cardiac complications, including possible myocarditis, arrhythmia, and heart failure in patients without prior cardiovascular disease or significant risk factors, are emerging, possibly due to an accentuated host immune response and cytokine release syndrome. As the spread of the virus increases exponentially, many patients will require medical care either for COVID-19 related or traditional cardiovascular issues. While the COVID-19 pandemic is dominating the attention of the healthcare system, there is an unmet need for a standardized approach to deal with COVID-19 associated and other traditional cardiovascular issues during this period. We provide consensus guidance for the management of various cardiovascular conditions during the ongoing COVID-19 pandemic with the goal of providing the best care to all patients and minimizing the risk of exposure to frontline healthcare workers.

INTRODUCTION

The novel coronavirus disease 2019 (COVID-19) pandemic caused by severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) has affected millions medically and billions due to its social, economic, and psychological impact, disrupting the global order [1]. While the COVID-19 pandemic is dominating attention, reports are emerging that patients with urgent non-COVID-19 health concerns may not be getting adequate or standard treatment due to resource constraints, or concerns regarding the risk of coronavirus exposure to the self, to other patients or healthcare workers (HCW). These ripple effects may affect many patients adversely with long-lasting and deleterious outcomes. Hospitals and healthcare systems must adopt a standardized approach to provide the best possible care to all patients regardless of their COVID-

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19 status. This is particularly important for the cardiology community, given that patients with pre-existing cardiovascular disease and risk factors are potentially more likely to acquire COVID-19 and experience adverse outcomes [2-5]. As the spread of the virus increases, many cardiac patients will seek medical care either for COVID-19 related illnesses or traditional cardiac issues such as acute coronary syndrome, arrhythmia, or heart failure. Many of these patients will require a cardiac procedure while simultaneously infected with SARS-CoV-2. Additionally, increasing reports of acute and de novo cardiac presentations such as myocarditis, arrhythmia, and heart failure in patients without prior cardiovascular disease or significant risk factors are also emerging, possibly due to an accentuated host immune response and cytokine storm [2]. The international cardiovascular community urgently needs to develop consensus algorithms to provide the best care for all such issues, while minimizing the risk to HCW. Here we present our consensus guidance for the management of various CV conditions in patients with suspected or confirmed COVID-19. It is important to note that all recommendations are made in the setting of emerging, but limited evidence and will most likely evolve as additional clinical information becomes available. Recommendations in this best practice document should be used as a general clinical guidance only and decisions need to be individualized.

METHODS

A writing group consisting of experts in the fields of CV medicine was compiled. An extensive literature review was performed using the PubMed index and reports from the World Health Organization (WHO) as well as the Chinese Center for Disease Control and Prevention. The search incorporated the text words and Medical Subject Headings (MeSH) for coronavirus, SARS-CoV-2, and COVID-19. References of review articles were also searched for relevant titles. The authors also searched clinicaltrials.gov for any ongoing relevant clinical trials. To incorporate rapidly evolving knowledge of the subject, we also included the search of unpublished and non-peer reviewed literature (available on medRxiv) and included selective evidence after careful review. Priority was given first to evidence from randomized controlled trials or meta-analysis, followed by evidence from cohort and case-control studies, and finally to expert opinion and clinical practice. The recommendations detailed in this document are based on the available literature (May 22, 2020) and represent consensus agreement among the writing group.

SIGNIFICANCE

Pre-existing Cardiovascular Disease

In an early single-center report from China describing hospitalized patients infected with pneumonia due to SARS-CoV-2, 40% had pre-existing CVD, particularly coronary artery disease (CAD) and cerebrovascular disease [4]. However, the following larger cohort from China describe a lower overall rate of affected patients with underlying CAD (8%). Beyond pre-existing CVD, consistent data have described a high prevalence of SAR-CoV-2 infection among elderly, and with concomitant CV comorbidities, particularly hypertension (30%) and diabetes (19%) (5). While a higher prevalence of CVD, diabetes, and hypertension is reported in patients with severe COVID-19, the impact of these comorbid conditions after adjusting for age and obesity remains unknown.

Outcomes in Patients with Cardiovascular Disease

Early reports from China show that the COVID-19 mortality rate among hospitalized patients was highest among elderly, and in patients with CVD (13.2%) compared to other comorbidities, and was disproportionately higher for patients with CV risk factors such as diabetes (9.2%) and hypertension (8.4%) compared to approximately 1% for patients without these comorbidities [1].

Acute Cardiovascular Injury

Many patients with COVID-19 experience acute myocardial injury, as evident by an increase in cardiac troponin levels. A significant proportion of hospitalized patients, particularly those with severe illness developed heart failure (23%) [4]. Moreover, troponin levels were significantly higher in patients admitted to the ICU and in non-survivors, suggesting that CV complications might contribute to the severity of illness and adverse outcomes. Myocarditis, arrhythmias, and cardiac arrest have also been reported [4].

Mechanism of Cardiovascular Injury

The exact mechanisms of COVID-19 associated CV injury are not well understood; however, several potential mechanisms include [2, 6]:

i Direct toxicity through the viral invasion of cardiac myocytes (i.e., myocarditis)
ii ACE-2 receptor-mediated CV (cardiac and endothelial) injury
iii Microvascular dysfunction and thrombosis

iv. Cytokine release syndrome (mainly IL-6 mediated) v. Stress cardiomyopathy due to the imbalance in myocardial supply and demand

ACE-2 serves as the cellular entry point for coronaviruses, including SARS-CoV and SARS-CoV-2 [6]. The spike protein of these coronaviruses binds ACE-2, which is highly expressed in the lungs, endothelium, and heart, leading to not just respiratory but also potential CV damage [2]. One potential explanation for the higher risk of acquiring infection and more severe symptoms and adverse outcomes with COVID-19 in patients with pre-existing CVD could be the higher than usual expression of ACE-2 in these patients. In autopsy specimens and animal models of SARS-CoV infection, there was a marked decrease in cardiac ACE-2 expression. Thus, it is possible that like SARS-CoV, SARS-CoV2 may decrease ACE-2 expression in the heart and promote vascular and myocardial injury [7]. Other possible mechanisms of CV injury include excessive cytokine release triggered by an imbalanced response by type 1 and type 2 T-helper-cells and hypoxemia secondary to respiratory dysfunction [2].

Long-term Cardiovascular Effects

While we do not yet understand the long-term CV impact of SARS-CoV-2 infection, a similar pathogen, SARS-CoV has been associated with dysregulation of lipid and glucose metabolism in long-term survivors. Given the structural similarities between these two pathogens, SARS-CoV-2 may also cause chronic damage to the CV system [2].

RECOMMENDATIONS

We provide recommendations applicable to common scenarios that cardiology consultants may encounter in caring for patients in the new era of COVID-19 infection (Figure 1] [3]. General principles are summarized in Figure 1.

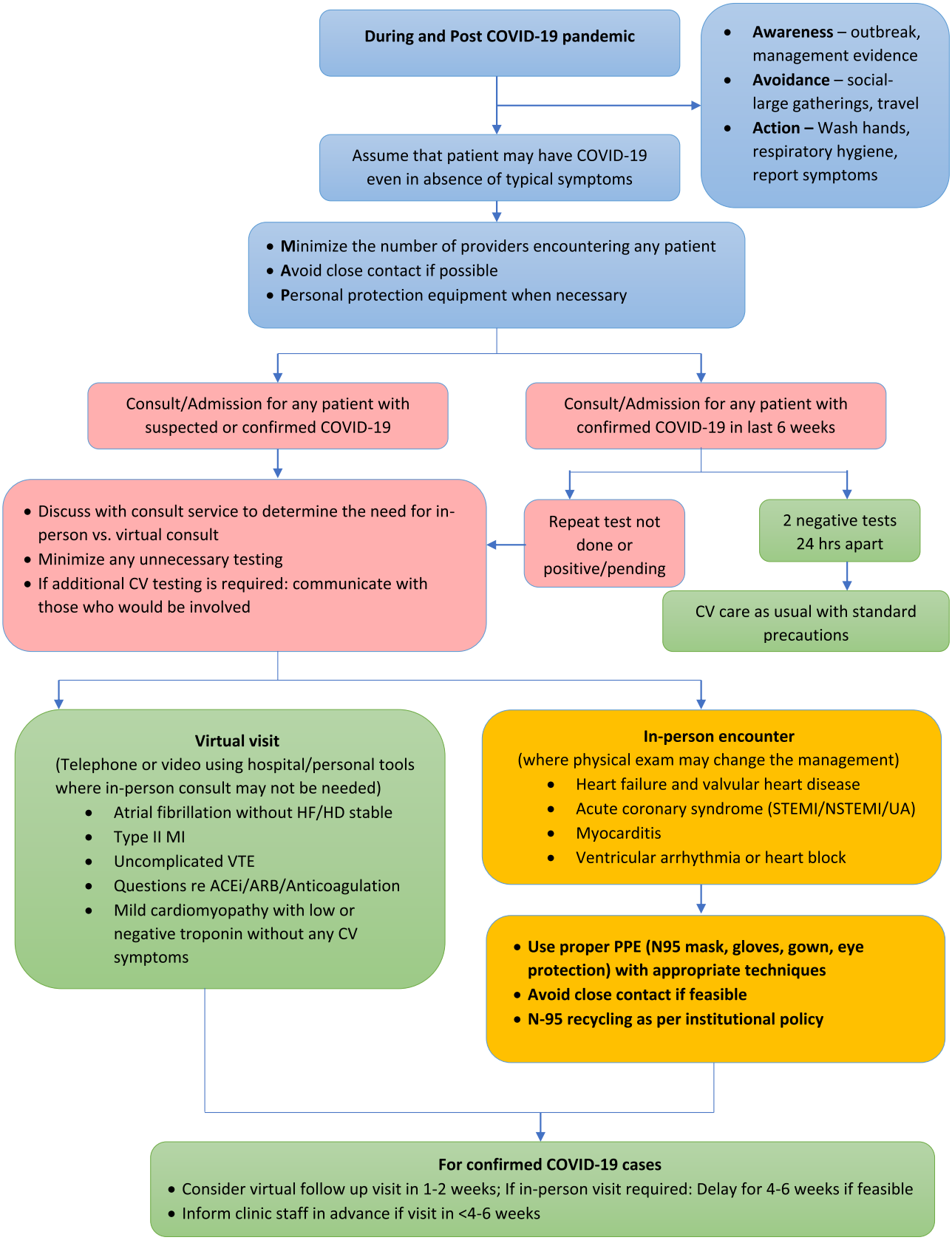

Fig. 1. General approach for patient care during COVID-19 pandemic

Management Consideration for Specific Clinical Cardiovascular Scenarios in Patients with Suspected or Confirmed COVID-19

1. COVID-19 associated myocardial injury;

Approximately 20-30% patients with COVID-19 experienced de novo myocardial injury defined as elevated cardiac troponin with or without cardiomyopathy [2, 4]. While the understanding of this entity is limited and is evolving, typically, the rise in troponin is reported late in the course [4 days after onset of the symptoms/presentation), and many do not have any typical CV symptoms. Elevated troponin is associated with worse outcomes, including the need for admission in intensive care unit (ICU) and increased mortality [4).

The management strategy for patients with COVID-19 associated myocardial injury is not well defined and is largely targeted towards supportive care as well as management of the infection itself (Figure 2, 3].

Diagnostic Recommendations

a. For patients without any significant CV symptoms and low-level troponin release (e.g. Troponin <2 times upper limit of normal [ULN]], in the absence of hemodynamic instability, we do not recommend routine assessment of left ventricular function, and therefore would not routinely recommend echocardiography during acute COVID-19. This will reduce exposure to HCW as echocardiography is unlikely to change management significantly in these patients. However, this strategy may need to be re-evaluated on a case-by-case basis. b. For patients with hemodynamic or electrical instability, more than mild troponin elevation or heart failure, further CV testing, including bedside echocardiography or a point of care ultrasound (POCUS), should be considered, based on expertise [8]. If the patient with suspected or confirmed COVID-19 has any specific CV symptoms, ECG abnormalities, arrhythmia/heart block, and elevated troponin, CAD and myocarditis should be considered. Although cardiac MRI is considered the gold standard non-invasive test for the diagnosis of myocarditis, in patients with COVID-19 and suspected myocarditis, the risk of exposure to HCW and other patients should be weighed carefully. If needed, abbreviated imaging tailored to the specific clinical question should be considered. The role of endomyocardial biopsy in this situation is unclear and may be considered if there is a suspicion for an alternative etiology.

Treatment Recommendations

While there is no specific proven treatment for COVID-19 associated myocardial injury, current therapy is based on reducing viral replication and modulating the host inflammatory response. The choice of therapy should be guided by the severity of illness and hemodynamic compromise.

a. Avoid Non-Steroidal Anti-Inflammatory Drugs (NSAIDs):

NSAIDs are often used in the management of myopericarditis. However, there is a theoretical concern that they may increase ACE-2 levels [9]. Additionally, NSAIDs may also increase the risk of acute kidney injury (AKI]. Hence, we recommend avoiding NSAIDs in any patients with suspected or confirmed COVID-19.

b. Experimental anti-viral therapy:

Several anti-viral therapies -are under investigation

Early experience with hydroxychloroquine, with or without azithromycin from France and China in COVID-19 patients with mild symptoms, was promising [10], but a subsequent larger study in patients with severe COVID-19 has not shown any significant clinical benefits [11]. Similarly, a recent large scale multinational registry as well as meta-analysis did not demonstrate any clinical benefit of HCQ [12]. Furthermore, the combination of hydroxychloroquine and azithromycin may cause QT prolongation and life-threatening arrhythmias and should only be used with caution and continuous telemetry monitoring [13].

In a compassionate use, open-label single-arm study of 53 patients with severe COVID-19 (64% receiving invasive ventilation], remdesivir was associated with clinical improvement in 84% of patients. Younger patients (< 70 years], and those requiring non-invasive ventilation were more likely to benefit from remdesivir [14]. The United States Food and Drug Administration has issued an emergency use authorization for the use of remdesivir for the treatment of hospitalized patients with severe COVID-19 [15]. While the evidence is limited, for patients who remain severely ill despite supportive care, such medications may be considered after consultation with infectious disease specialists.

c. Anti-inflammatory therapies:

While corticosteroids are typically avoided in the treatment of COVID-19, due to the concern for prolonging viral illness, in later stages of inflammation that are typically associated with excessive cytokine release leading to hemodynamic instability and end-organ damage, corticosteroid administration may be considered after a multidisciplinary discussion. While the use of corticosteroids have been efficacious in treating myocarditis from immune checkpoint inhibitors or giant cell myocarditis [16], its use in COIVD-19 related myocarditis has been limited to case reports [7].

IL-6 contributes to the development of cytokine release syndrome (CRS] and may play a significant role in SARS-CoV-2 associated lung and myocardial injury. Anti-IL-6 antibodies, such as tocilizumab and siltuximab, may have a role in the management of patients with COVID-19 [17]. While the evidence for their use is limited, ongoing clinical trials will clarify its value. Tocilizumab has been shown to reduce CV injury and associated adverse outcomes in patients with chimeric antigen receptor (CAR] T-cell therapy associated CRS [18, 19]. We recommend that for patients with hemodynamic or electrical instability, high cardiac troponin (Troponin>x2 ULN], new-onset LV systolic dysfunction (EF < 40%], or in context of high-grade (grade≥2) CRS (even without significant CV complications], therapy with an IL-6 antibody should be considered. A second dose can be given 8-12 hours after the first dose if needed.

d. Immunomodulatory therapy:

Intravenous immunoglobulin (IVIg] has been utilized in a limited number of cases with COVID-19 associated myocarditis. The evidence is currently limited to single case reports [7]. Given that IVIg is well-tolerated, its potential efficacy in improving passive immunity and modulating inflammation, it might be considered in severely ill patients, at the early stage of clinical deterioration of patients with COVID-19, especially if anti-IL-6 agent is not available.

Convalescent plasma from patients who have recovered from SARS-CoV-2 infection is also being studied as a potential therapy for severely ill COVID-19 patients [20]. However, its specific utility in patients with COVID-19 associated CV injury and feasibility of the therapy is unknown at this time.

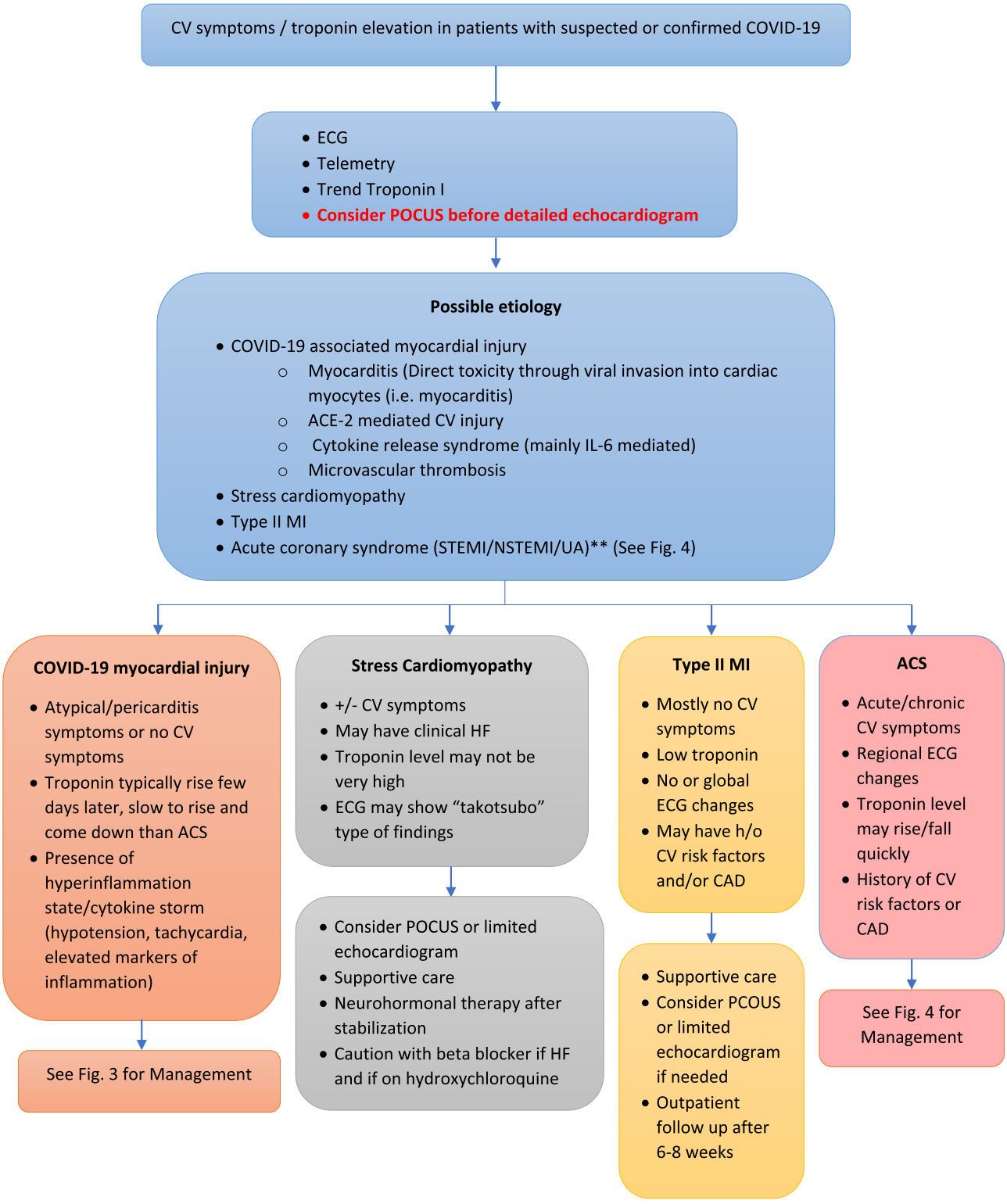

Fig. 2. Approach to troponin elevation in patients with suspected or confirmed COVID-19

2. Acute coronary syndrome (ACS):

There have been reports of ACS in patients with COVID-19; however, the incidence and relationship are unclear [21]. The hyperinflammatory response seen with COVID-19 may lead to coronary plaque destabilization and thrombosis. Therefore, it is crucial that we develop a strategy to provide timely and optimal care to patients with ACS, regardless of their COVID status (Figure 4].

Non-ST Elevation Myocardial Infarction (NSTEMI) or Unstable Angina (UA):

Caution is recommended in diagnosing ACS, particularly NSTEMI in patients with COVID-19. Mild elevations in troponin could be secondary to multiple etiologies rather than plaque instability. The diagnosis of NSTEMI or UA should be made based on the clinical presentation and ECG changes, in addition to troponin.

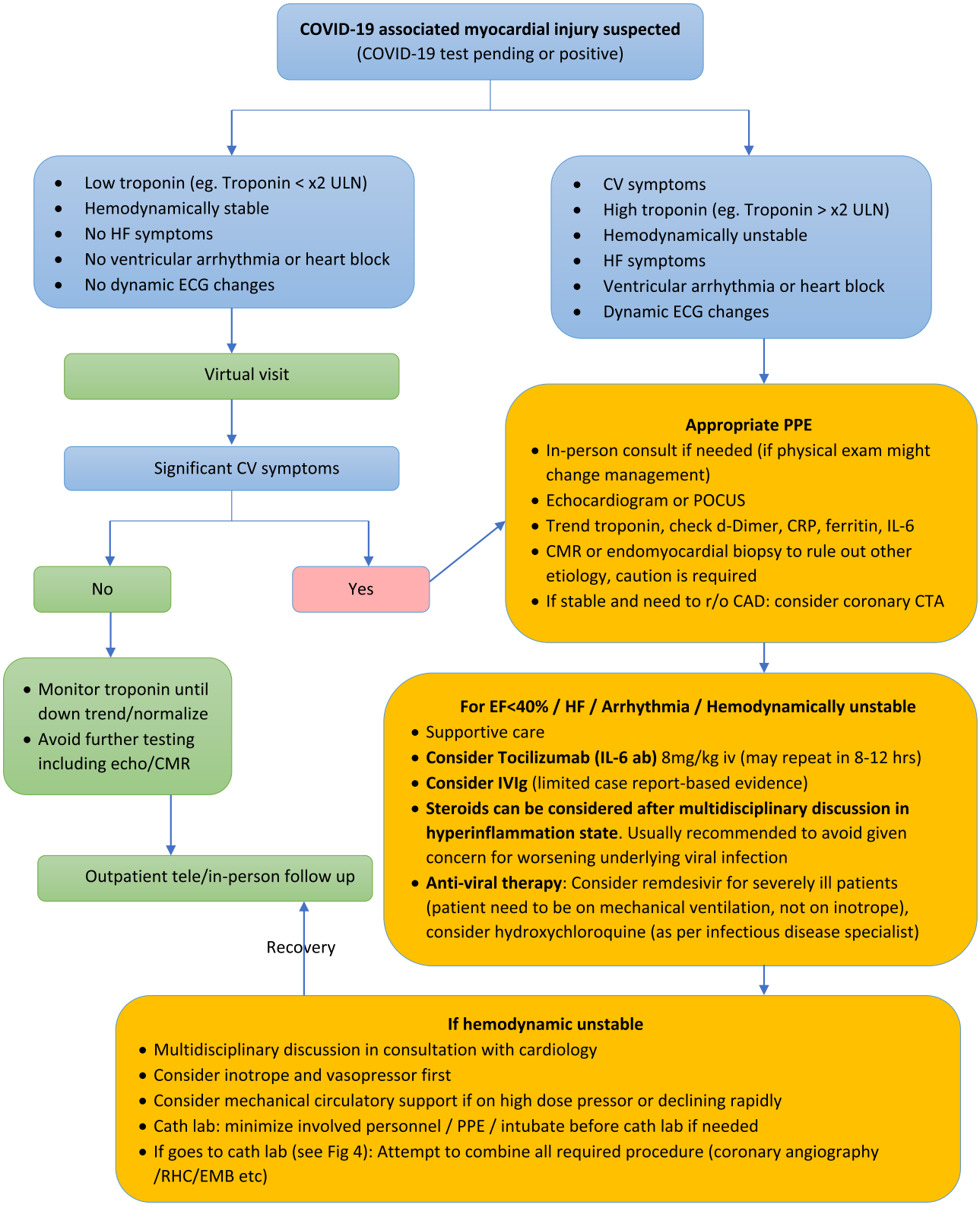

Fig. 3. Proposed management pathway for COVID-19-associated myocardial injury

Once again, we do not recommend routine echocardiography in patients who are hemodynamically stable without clinical heart failure to minimize the exposure to sonographers, however, POCUS might be considered if needed. Medical therapy with anticoagulation, dual antiplatelet therapy, and high-intensity statins are a reasonable first-line strategy for such patients. Beta-blockers should be considered with caution in patients with decompensated heart failure. Coronary CT angiogram with or without fractional flow reserve (FFR) can be considered instead of invasive cardiac catheterization if needed for risk stratification. For patients with ongoing chest pain despite medical treatment or with other high-risk features such as arrhythmia, heart failure, or hemodynamic instability,

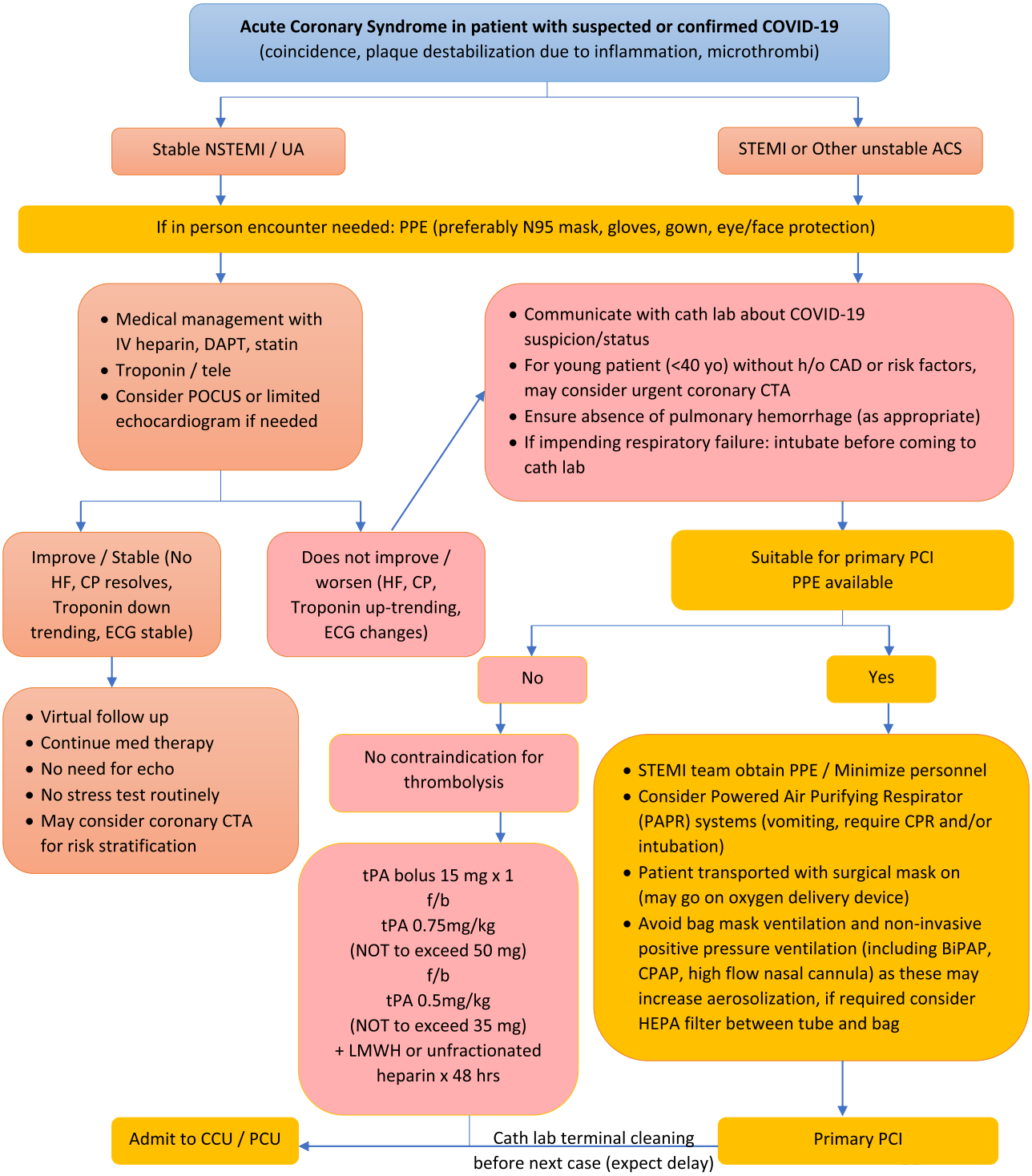

Fig. 4. Management of acute coronary syndrome in patients with suspected or confirmed COVID-19

an early invasive approach with coronary angiography should be pursued with appropriate preparation of the catheterization laboratory and its staff to minimize the exposure to HCW.

ST Elevation Myocardial Infarction (STEMI)

STEMI in patients with suspected or confirmed COVID-19 may represent plaque destabilization due to acute systemic inflammation and endothelial ACE-2 receptor modulation by SARS-CoV-2 [6] or microthrombi formation. Myopericarditis should be considered in the differential diagnosis, particularly for young patients without any prior CVD or significant risk factors [7].

There is no evidence-based guidance in treating COVID-19 STEMI patients. If there is high suspicion for myopericarditis as the cause of ST-elevations with an extremely low suspicion for plaque rupture, a coronary CT angiogram may be considered for stable patients to rule out CAD. POCUS may also be useful to rule out regional wall motion abnormalities. While the use of thrombolytic therapy has been suggested as first-line therapy in patients

presenting with non-anterior STEMI and those who are hemodynamically stable [22]; primary percutaneous coronary intervention (PCI] should be the standard practice where available unless contraindicated, even in patients with COVID-19, given the higher risk of incomplete revascularization and bleeding complications with thrombolytic therapy [23].

Although the door-to-balloon time is emphasized as a quality measure in patients presenting with STEMI, in patients with suspected COVID-19, there may be a slight delay due to the necessity of using appropriate PPE to minimize exposure to HCW. If appropriate PPE is not available or if a patient is not considered a good candidate for PCI, then thrombolysis could be considered [22]. If thrombolytic therapy is used, anticoagulation should be provided for 48-hours, and the patient should be admitted and monitored for evidence of incomplete reperfusion and revascularization.

3. Type II Myocardial Infarction:

Many patients with COVID-19 may experience type II MI given acute stress, hypoxemia, and excessive inflammation secondary to cytokine release [2]. It is important to make the distinction between primary ACS and type II MI in COVID-19 patients to minimize any further downstream CV testing and exposure to HCW. Usually, patients with type II MI do not have angina, troponin rises mildly and without ECG changes suggestive of ischemia or with global ischemia pattern. However, sustained chest pain is a commonly reported symptom of acute COVID-19 in patients with or without myocardial necrosis [4, 5]. For patients with suspected Type II MI, it is reasonable to consider conservative management directed towards the treatment of the underlying acute condition. Supportive care, along with anti-viral, anti-inflammatory, and immunomodulatory medications can be considered as described previously on a case-by-case basis.

4. Venous Thromboembolism (VTE) Prophylaxis and Treatment:

COVID-19 associated hypercoagulability has been reported in early clinical and autopsy data. Although the mechanism is not well understood, it is likely multifactorial and influenced by:

1) Systemic inflammatory response due to infection
2) Venous stasis secondary to critical illness
3) Direct endothelial damage from viral injury by ACE-2 receptor binding

Small retrospective studies of severely ill COVID-19 patients in ICU have reported VTE in 25-30% patients, despite prophylactic anticoagulation [24]. Similarly, microthrombi in the segmental pulmonary arteries have been noted on autopsy [25]. However, these findings could be secondary to cellular debris rather than microthrombi, and in some cases, they could be secondary to Disseminated Intravascular Coagulation (DIC], as seen with sepsis from other etiologies.

D-dimer elevation has been associated with increased risk of VTE as well as mortality, and markedly elevated D-dimer levels are frequently present at the time of presentation with acute COVID-19 [4] Recently, the presence of antiphospholipid antibody has also been reported, which arises transiently in patients with critical illness and may also not be specific to COVID-19 [26]. Coagulation factors Xa and IIa have been demonstrated to be capable of cleaving the SARS-CoV-2 spike protein and may, hence promote infectivity [27]. Therefore, anticoagulation might inhibit this process and suppress SARS-CoV-2 replication. While the empiric use of therapeutic anticoagulation for all critically ill patients with elevated D-dimer (>6 times the ULN] has been recommended by several centers in China even without a diagnosis of VTE [28], given lack of any significant evidence of its utility and potentially increased risk of bleeding, particularly pulmonary hemorrhage in patients with ARDS and DIC decision needs to be individualized and carefully weighed against the risks.

We recommend thromboprophylaxis with low molecular weight heparin (LMWH] or fondaparinux (suggested over unfractionated heparin to reduce contact] for all hospitalized patients with COVID-19 unless the patient is judged to be at increased risk of bleeding. LMWH has a theoretical advantage of possessing anti-inflammatory properties, which can be of additional benefit in COVID-19 infection. For patients with acute kidney injury or creatinine clearance <30 ml/minute, unfractionated heparin at a dose of 5,000 units subcutaneously two to three times a day should be utilized.

If a COVID-19 patient develops VTE or presents with VTE despite prophylactic anticoagulation, we recommend pharmacotherapy, preferably with full therapeutic dose LMWH (unless CrCl<30 ml/min). Catheter-directed thrombectomy or thrombolysis should be reserved only for those patients with massive or sub-massive pulmonary embolism or proximal deep vein thrombosis with either limb-threatening ischemia who either fail systemic thrombolysis or are not considered good candidates for thrombolysis given the increased risk of bleeding. The safety and efficacy of direct oral anticoagulants, as well as warfarin, remain unknown. However, it may be reasonable to transition to an oral anticoagulant upon discharge.

5. Arrhythmias:

In a case series of 138 patients, arrhythmias, including atrial fibrillation, were reported in 17% of hospitalized patients, with higher rates in critically ill patients (44%] [29]. In another study of 189 hospitalized patients from Wuhan, China, 5.9% were noted to have ventricular arrhythmias [30]. We recommend baseline 12-lead electrocardiogram (ECG] and telemetry monitoring for all hospitalized COVID-19 patients.

In the hemodynamically stable patient with AF without heart failure, rate control and anticoagulation are preferable to an attempt at rhythm control. An echocardiogram should be deferred for 4-6 weeks after recovery. Atrioventricular nodal blocking agents such as beta-blockers, calcium channel blockers, or digoxin can be used for rate control. Drug-drug interactions should be considered in patients on anti-viral therapy. For example, hydroxychloroquine may increase the level of beta-blockers as well as digoxin and may result in toxicity [31]. If a patient has cardiomyopathy, heart failure, or hypotension, short-term amiodarone can be considered. Urgent electrical cardioversion should be performed with appropriate precautions for hemodynamically unstable patients. As transesophageal echocardiogram (TEE) is considered an aerosolizing procedure with a high risk of contagion, cardiac CT can be considered instead in stable patients for evaluation of left atrial appendage thrombus before cardioversion to minimize potential exposure. Anticoagulation should be considered based on the individual risk profile with appropriate monitoring.

For any patient with sustained ventricular arrhythmia or heart block, myocarditis should be considered in the differential. We recommend cardiac troponin measurement and an echocardiogram or POCUS for further assessment. QTc interval prolongation secondary to anti-viral therapies such as hydroxychloroquine, electrolyte disturbances, and CRS can also lead to ventricular arrhythmia (see recommendations for QTc monitoring below] [13]. Antiarrhythmic therapy can be used after consideration of drug-drug interactions. For any patient with sustained ventricular arrhythmias and hemodynamic instability, prompt defibrillation should be performed. If the temporary transvenous pacemaker is required, bedside placement is preferred instead of in the catheterization or electrophysiology laboratory to minimize the exposure to HCW.

The incidence of arrhythmias in patients with less severe illness or in patients who recover from critical illness related to COVID-19

remains unknown. Further research is required to guide the need for additional arrhythmia monitoring in the ambulatory setting and to determine the need for an implantable or wearable cardioverter defibrillator in those with persistent impaired left ventricular function from COVID-19 associated myocardial injury.

6. QT interval monitoring:

Hydroxychloroquine blocks voltage-gated potassium channel (Kv11.1) and can cause drug-induced QT prolongation by prolonging action potential duration [13]. However, clinically significant arrhythmia is mostly seen in the context of either long-term use or in patients with concomitant use of other QT-prolonging medications (e.g., azithromycin], metabolic derangements, renal failure, or in the setting of an acute overdose. While despite this theoretical risk, hydroxychloroquine is relatively well tolerated for other medical conditions, particularly when used for a short period. However, emerging evidence suggests a significantly increased risk of de novo ventricular arrhythmia when used in hospitalized patients with COVID-19 [13, 32].

We recommend checking the corrected QT duration (QTc) before initiating hydroxychloroquine either via a traditional ECG or high fidelity mobile cardiac telemetry, ongoing telemetry and electrolyte monitoring as well as avoidance of other QT-prolonging medications, especially if the baseline QTc is abnormal. QTc should be reassessed at least once within the first 24 hours after initiating hydroxychloroquine. If the QTc interval remains $<$500 msec and does not increase by $\geq$60 msec from baseline, further QTc monitoring may not be required. However, for patients with QTc prolongation, careful monitoring and correction of reversible causes (electrolyte abnormality, other medications] are required. If QTc remains $>$500 msec, then the potential benefits of continuing hydroxychloroquine should be weighed against the risk of arrhythmia. Empiric intravenous magnesium sulfate can be considered in such scenarios.

7. Use of angiotensin-converting enzyme inhibitors (ACEi) or angiotensin receptor blockers (ARB):

SARS-CoV-2 uses ACE-2 as a co-receptor for cellular entry.[6] It is hypothesized that ACEi and ARB administration leads to upregulation of ACE-2 expression in the lung and the heart, thus increasing the risk of SARS-CoV-2 infection and severity of COVID-19 [2, 6]. However, data from animal models of SARS-CoV infection have shown improvement in virus-induced lung damage with ACEi/ARB treatment. Thus, the role of ACEi/ARB in COVID-19 remains unclear and clinical trials are underway to assess the safety and efficacy of the renin-angiotensin-aldosterone system (RAAS] modulators, in patients with COVID-19 [33]. At present, major societies (ESC/AHA/ACC) recommend continuing ACEi or ARB in patients who take these medications chronically [33]. Besides, if a COVID-19 patient develops cardiomyopathy or heart failure, these agents should be administered as per guidelines.

8. Use of statins:

The toll-like receptor pathway protein MYD88 has suggested to play a role in coronavirus associated lung injury. Statins are hypothesized to reduce the severity of coronavirus infection by stabilizing MYD88 levels and attenuating NF-κB activation [34]. While there is no significant clinical data available, based upon its potential benefits and established safety record, we recommend continuing statins in all patients.

9. Mechanical support for cardiogenic shock and use of Extracorporeal Membrane Oxygenation (ECMO):

The use of percutaneous mechanical circulatory support (MCS) in the setting of cardiogenic shock is generally supported by weak evidence demonstrating a favorable hemodynamic impact. Given the paucity of supportive evidence for MCS devices, the calculus is even more complicated in the setting of an infectious disease with an undefined clinical course and the risk posed to operators involved in the deployment and management of these devices. Thus far, in the COVID-19 pandemic, there has been very little reported use of MCS devices. Even venovenous ECMO for respiratory failure has been used rarely to support patients with refractory hypoxemia [29]. Despite the lack of clarity, it may still be prudent to offer MCS to select patients (young age, limited comorbid ailments without multi-system organ failure] with cardiogenic shock who are refractory to optimal medical therapy (Figure 5].

10. Cardiac arrest and considerations for resuscitation:

Patients who are critically ill with COVID-19 are at very high risk of cardiac arrest either with pulseless electrical activity or ventricular arrhythmia [13, 30]. It is crucial to identify patients who are at high-risk for acute decompensation, and goals of care should be discussed early on to avoid any unwarranted resuscitation efforts. Because of the risk of viral aerosolization in the setting of unplanned resuscitation, early intervention with intubation should be considered for patients with impending respiratory failure [13].

Cardiopulmonary resuscitation (CPR) in patients with COVID-19 poses a significant risk of exposure to HCW, given the high amount of viral aerosolization that can occur with chest compressions and airway management. The number of personnel involved in resuscitation efforts should be minimized for any patient with confirmed or suspected COVID-19. Use of appropriate PPE, including an N95 mask, face shield, gown, and gloves, is crucial for all involved individuals, even if it delays the initiation of resuscitation. There is also a risk of resuscitation cart (code cart) contamination during the process, and institutions could consider preparing “resuscitation bags” with all the necessary medications and instruments for use in patients with either suspected or confirmed COVID-19. All unused material from such bags should be disposed or cleaned afterward.

During resuscitation, while attempts to secure the airway are in process, oxygen should be applied via a non-rebreather mask without humidification. The use of high-flow nasal cannula, and noninvasive ventilation (CPAP, BiPAP) should be avoided given the high risk of aerosolization [35]. Prior to initiating chest compressions, a surgical facemask should be placed over the patient’s face. When available, external mechanical compression devices should be used to minimize the exposure to HCW. Until a definitive airway is obtained, compression-only resuscitation should be performed given the increased risk of viral aerosolization with bag-mask ventilation. Prolonged resuscitation in patients with poor prognosis should be avoided particularly if there is no reversible etiology identified.

Preparation for post-COVID-19 era

While we are currently focused on how to navigate the medical care during the COVID-19 pandemic, we need to recognize than many non-urgent but required CV testing and procedures are being significantly delayed, which may have a long-term adverse impact. As we try to re-open and normalize, one of the daunting tasks will be to identify high-risk patients, so limited resources can be prioritized to expedite the care of such patients. Although we will be required to ramp up the outpatient visits and CV testing as well as procedures in order to minimize any further delay in care, we need to maintain a high-index of suspicion and precautions to prevent re-surge of the COVID-19. Furthermore, the policies and strategies developed today will serve as the basis for addressing the next similar crisis.

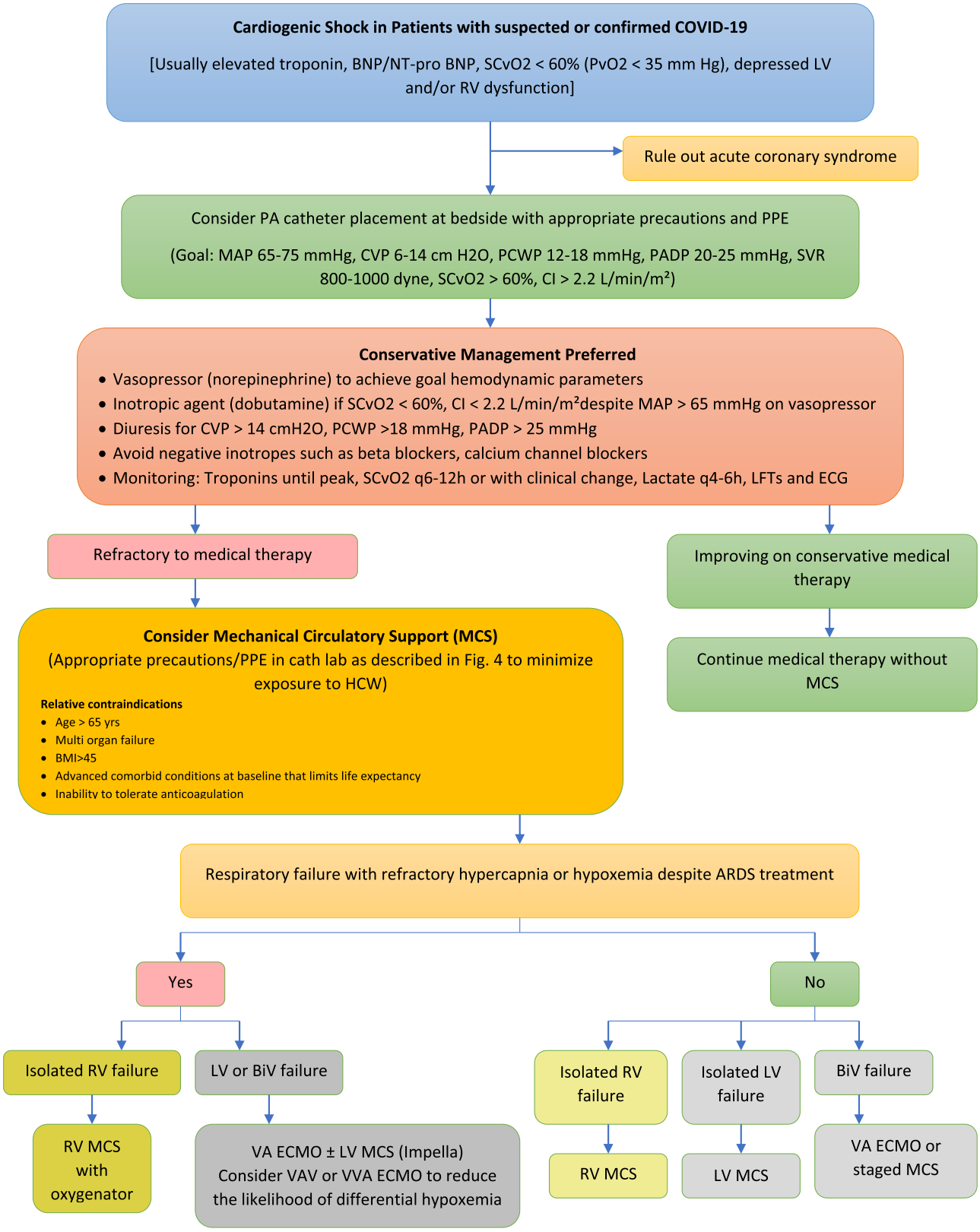

Fig. 5. Management of cardiogenic shock in patients with suspected or confirmed COVID-19. Abbreviations: BiV: biventricular, CI: cardiac index, CVP: central venous pressure, SCvO2: central venous oxygen saturation, tPA: tissue plasminogen activator.

CONCLUSION

Patients with pre-existing CV risk factors and CVD are amongst those most vulnerable with potentially increased risk of acquiring SARS-CoV-2 infection, developing CV complications related to COVID-19, and having adverse outcomes. We provide consensus-based guidance for the management of various CV conditions during the COVID-19 pandemic.

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