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Consensus statement on cardiac electrophysiology practices during the coronavirus disease 2019 (COVID-19) pandemic: From the Indian Heart Rhythm Society

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1. Introduction

As the global prevalence of Coronavirus disease 2019 (COVID-19) caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) has grown exponentially over the last one and half years, healthcare systems have been overwhelmed by the unprecedented challenges. Patients with cardiovascular risk factors and established cardiac diseases represent a vulnerable population when affected by COVID-19.

A wide range of arrhythmias have been reported to complicate the course of COVID-19 and, in many, these could present as life-threatening emergencies [1–4]. Isolated cases of atrioventricular (AV) block have also been described in patients with COVID-19 [4]. Furthermore, medical treatment targeted at COVID-19 could have potential pro-arrhythmic effects. Another major concern during this pandemic is the potential risk of contracting the virus infection by the electrophysiologists and other healthcare workers involved in electrophysiology (EP) and cardiac implantable electronic device (CIED) implant procedures.

The purpose of this statement from the Indian Heart Rhythm Society is to address issues during this period of healthcare crisis involving patients with cardiac arrhythmias and healthcare providers who manage them during the pandemic and to provide corresponding general guidance. The authors realized that a live document could guide its members for the practice of EP and CIED services in India. This document has taken into account published statements from international societies, and recent updates to

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adapt to the evolving pandemic and its impact on the national health system [5–8].

As the practice of cardiac EP varies among centers even within the country, these guidelines are intended to provide a framework for implementing clinical services during the pandemic. We concede that many of the recommendations are based on clinical observations and personal experience rather than on evidence, as robust evidence is yet to evolve. Furthermore, the guidance provided in the document should not interfere with recommendations provided by national healthcare authorities. Certain aspects of the guidance provided in this document are subject to change as knowledge on the pandemic evolves with accumulating clinical experience and results from larger studies. Hence, these recommendations should be tailored to the local demands in the delivery of medical care, understanding these limitations.

1.1. COVID-19 and cardiac arrhythmias: pathophysiology

Arrhythmic events are a frequent cardiovascular manifestation of SARS-Cov-2 infection and are a considerable cause of concern for patients and physicians alike. Rhythm disturbances have been reported in the previous coronavirus and influenza epidemics as well [9,10]. Rhythm disorders in the entire spectrum, ranging from sinus bradycardia or tachycardia to sudden cardiac death, have now been reported with SARS-CoV-2 infection in the acute as well as convalescent phase.

Among 4526 patients hospitalized with COVID-19 in an international multi-center registry, 18.2 % had cardiac arrhythmias. More arrhythmias were seen in intensive care units and ventilated patients, and cardiac co-morbidities were common in these patients. More than 80 % were atrial arrhythmias while ventricular arrhythmias and bradyarrhythmias were about 20 % each [11].

The genesis of these events is complex and differs depending on the severity, setting, and type of organ involvement during the illness. Fig. 1 shows the major causes for arrhythmias during and after acute COVID-19 infection. Atrial arrhythmias, particularly common, can happen due to several reasons, e.g., paroxysm of a preexisting arrhythmic disorder, dyselectrolytemia, severe hypoxia, pneumonitis, pulmonary embolism, pericarditis or medications. In addition, these factors are not mutually exclusive and frequently interact, e.g., rupture of pre-existing plaque due to hemodynamic or direct COVID-19 vascular damage causing acute coronary syndrome and ventricular fibrillation; atrial flutter precipitated by combined effects of hypoxia, right ventricular strain, and inotropes in sick patients with COVID-19 infection or mild inflammatory channelopathy aggravated by QT-prolonging drugs. As pre-existing cardiovascular disease increases the risk of serious COVID-19 infection, it is sometimes difficult to differentiate primary COVID-19-induced arrhythmia from triggered exacerbation of existing pathologies.

Hypoxia due to lung involvement may be a frequent cause due to its effects on action potential and electrical properties of the myocardium [12]. Direct myocardial injury by virus binding to angiotensin-converting enzyme −2 (ACE2) receptors in heart or cell-mediated cytotoxicity can cause myocarditis and subsequent arrhythmias [13]. Specific targeting of cardiac conduction system via ACE2 receptors, causing heart blocks and tachyarrhythmias in absence of overt myocarditis are also possible [14] Abnormal immune response during the delayed phase of illness may not only cause myocardial injury but can also trigger cytokine-mediated inflammatory channelopathies [15]. Hyperinflammation along with cytokine release can cause plaque rupture, coronary vasoconstriction as well as microvascular dysfunction causing arrhythmias. Similar to other settings of serious illnesses, arrhythmias also occur in COVID-19 secondary to involvement of other organs (especially lungs), metabolic abnormalities as well as proarrhythmic drugs.

The causes for sudden death in the convalescent phase following COVID-19 infection are still not clear but are likely to include arrhythmic etiology. Besides, inappropriate sinus tachycardia and orthostatic tachycardia are also commonly noted after COVID-19 infection. Post-viral altered autoimmune response and

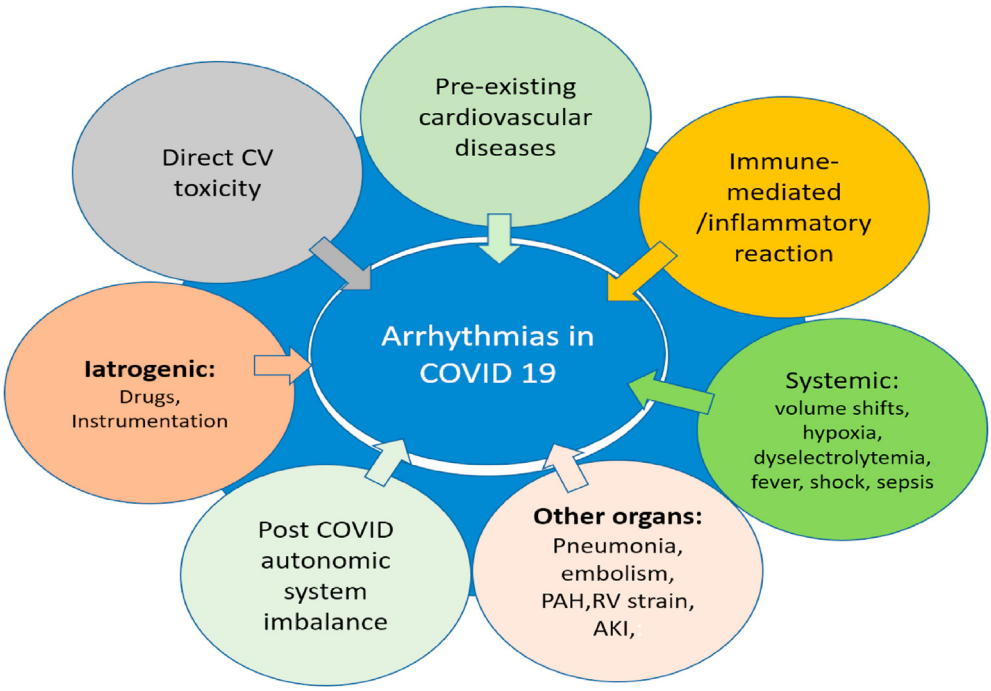

Fig. 1. Major causes for arrhythmias during and after acute SARS-CoV-2 infection. Several of these mechanisms are interrelated and may act in conjunction with each other.
Abbreviations: AKI: Acute kidney injury; CV: Cardiovascular; PAH: Pulmonary artery hypertension; RV: Right ventricle.

development of autoantibodies to the autonomic system have been implicated in these [16].

1.2. Cardiac EP practices during the pandemic: general principles

The management of patients with cardiac arrhythmias and CIEDS during the COVID-19 pandemic should be aimed at providing appropriate treatment irrespective of COVID-19 infection status, at the same time, minimizing the risk of infection to non-infected patients and healthcare workers. A few modifications on EP practices can help to achieve the above.

Many cardiac EP consults can be completed without a face-to-face visit, by reviewing the chart and monitoring data including the ECGs online. Remote monitoring can be utilized for the follow-up programming of patients with CIED. Routine 6-monthly visits for CIED can be made yearly if the battery status is good and the patient stable. The elective ablation and CIED procedures can be rescheduled, and antiarrhythmic medications can be intensified to allow control of symptomatic arrhythmia recurrences during the pandemic period. There are concerns about the potential role of cross-infection between healthcare workers (HCW) and patients too. Direct unprotected contact with COVID-19 patients should be limited during any invasive procedure, with the appropriate use of personal protective equipment (PPE) during the procedure.

In a symptomatic and suspect case of COVID-19, the elective EP procedure must be postponed to prevent cross-infection within the hospital. However, If an EP procedure is urgent, life-saving, or intended to prevent deterioration in the clinical condition, it should not be denied, irrespective of the availability or result of screening.

1.3. ***Screening for COVID-19 infection before EP procedures*** *[17–19]*

Recommendations for the screening of patients for COVID-19 infection before an EP procedure (ablation, CIEDs, etc) must consider the epidemiology – nationwide test positivity rate, the urgency of the procedure, hospital setting – urban *vs.* rural, public *vs.* private, the status of the molecular testing laboratory – network, technical proficiency, 24 × 7 operationalization, extraordinary caseload and costs involved. Within our country, there is a wide variation in these different aspects.

Even in absence of symptoms or signs of COVID-19, patients should be tested before an elective EP procedure. Almost 40 % of patients with COVID-19 infection are pre-symptomatic, asymptomatic (subclinical infection), or pauci-symptomatic with an attendant risk of transmission. In them, the viral load is similar to symptomatic patients and may be detectable in the upper respiratory tract 1–3 days before the onset of symptoms.

Reverse transcriptase-polymerase chain reaction (RT-PCR) is the gold standard test for the diagnosis of COVID-19. It detects the virus ribonucleic acid (RNA) by nucleic acid amplification test (NAAT). RT-PCR should be done as per hospital guidelines before hospital admission for the planned procedure. The sensitivity would be highest earlier in the course of the infection and should be equally effective prior to or at the onset of symptoms. Rapid antigen test (RAT), another screening test, detects early infection with a moderate sensitivity and a high specificity. RAT is positive 1–3 days prior to the onset of symptoms and up to 5–7 days after the onset of symptoms. In contrast to NAATs, there is no amplification of the target that is detected, making antigen tests less sensitive. The sensitivity of antigen tests reportedly varies from 34 to 80 %, which means there could be nearly 50 % of false-negative results. A positive RAT need not be retested, but if RAT is negative, the patient needs to undergo RT-PCR for definitive decision-making.

Current or previous infection can be identified by detecting anti–SARS-CoV-2 antibodies in blood and saliva specimens. These tests detect all antibody isotypes (IgG, IgM, and IgA) against S and N protein. Antibodies take 15–21 days to develop, therefore these tests have a limited utility to diagnose acute infection. Further, IgM does not appear much earlier than IgG, therefore IgM detection is not for early diagnosis. Antibody testing should not be used for screening or to estimate immunity or protection from COVID-19.

Triaging of cases at admission into emergent, semi-urgent, and non-emergent cases.

It is advisable to admit the patients who present with.

1. Atrial fibrillation (new onset or otherwise) and
   a. Fast ventricular rate and symptoms irrespective of the underlying cardiac function
   b. Inappropriate defibrillator shocks
   c. Rapid conduction over an accessory pathway
2. Ventricular arrhythmia if
   a. Non-sustained ventricular tachycardia (VT) if there are symptoms of cerebral hypoperfusion correlating to the episodes
   b. Sustained monomorphic or polymorphic VT irrespective of the underlying cardiac function
   c. Single or recurrent appropriate defibrillator shocks
   d. Presenting as an episode of VT storm
   e. Premature Ventricular Complexes with burden >10 % in the setting of reduced cardiac function or with persistent symptoms of cerebral hypoperfusion attributable to them
   f. Present in a case of inherited channelopathy syndromes
   g. Secondary to bradycardia caused by atrioventricular blocks or reverse rate dependence property of anti-arrhythmic medications
3. Bradycardia secondary to
   a. Sinus node dysfunction associated with falls or side effects of essential medications
   b. Grades of AV block equal to and higher than Mobitz type II AV block irrespective of the symptoms
   c. Grades of AV block lower than Mobitz type II AV block when symptomatic either due to acquired pathology or due to side effects of essential medications
   d. Congenital complete AV block
4. CIED in-situ and
   a. Erosion of device at the site of incision
   b. Discharge from the site of incision
   c. Recent onset of symptoms similar to the symptoms prior to the implantation of the device
   d. New symptoms of cerebral hypoperfusion or decrease in activity in patients dependent on their devices for pacing function
   e. Attainment of elective replacement interval (ERI) or end of service (EOS) or nearing the same in the next month
   f. Abnormal values of impedance or sensing or threshold in patients dependent on their device for pacing function
5. Loss of consciousness and
   a. Unclear etiology of same and trauma secondary to the fall
   b. Associated with an arrhythmia deemed to be contributing to the loss of consciousness and unlikely to be controlled by medications as per existing literature
   c. Cause considered as secondary to a malfunctioning CIED
6. Investigations show a prolonged QT interval and
   a. History of sudden cardiac arrest
   b. Use of a medication known to cause prolongation of QT interval
   c. Evidence of arrhythmias seen on prolonged monitoring deemed to be secondary to the increase in the QT interval

Interventional EP procedures can be performed as per Table 1 where there are grouped in grades of urgency for performing the procedure.

1.4. EP procedures during COVID-19 pandemic: peri-procedural concerns

The elective EP procedures during periods of the high load of COVID-19 cases in the region should be postponed to prevent the spread of infection. However, emergent and semi-urgent procedures need to be performed while taking all necessary precautions.

1. Testing for COVID-19 should be done before a procedure in all patients to classify their risk status (Table 2)
2. In emergencies, HCWs who are one-month post two vaccination doses may be preferred over those who may not have completed the dosing schedule or are in the waiting period post-second dose.
3. General recommendations that should be followed in the hospital to reduce the risk of transmission and spread of the COVID-19 virus during the pandemic are outlined in Table 3.
4. A special informed consent mentioning the risk of getting infected with the COVID-19 virus despite taking all adequate precautions should be obtained before all procedures.
5. EP lab procedures in patients with no COVID-19 -related symptoms and negative COVID-19 test can be performed using standard precautions.
6. Specific precautions needed while performing a procedure in a COVID-19 suspected or confirmed patient include

- A multidisciplinary meeting including departments involved in the procedure is advisable to create a workflow to ensure minimal or nil exposure of staff during the process [6].
- Use of a separate (if possible) lab with negative pressure ventilation. If a negative pressure lab is not possible, the central air conditioning should be stopped during the procedure to prevent contamination.
- Use of complete protective equipment including surgical cap, N-95 or FFP-2/3 mask, scrubs, gown, shoe covers, full face protective shields, and surgical gloves by all personnel. The correct procedure for donning and doffing as recommended should be followed by all and preferably supervised.
- Limit the number of personnel inside the lab as much as possible.
- Sanitization and disinfection of equipment and lab after the procedure as per the guidelines and hospital disinfection policy.
- For a procedure requiring general anesthesia, it is preferable to intubate the patient at another location (e.g., in intensive care units before shifting to the lab.
- The route of shifting of the patient to the post-procedure place of stay should be well known to the operating team and nurses to prevent any confusion.

1.5. EP procedures during COVID-19 pandemic: post-procedural concerns

1. Measures to reduce the risk of transmission to the workforce should continue in the postoperative setting as well: physical distancing, PPEs, wearing a well-fitted face mask, eye protection, hand washing, etc.
2. Complications occur less frequently in COVID-19 positive patients undergoing elective surgery versus an emergency surgery [23]. Also, there is a dramatically increased risk of complications in patients that turn COVID-19 positive after surgery [24,25].
3. Elderly patients with congestive heart failure or renal disease have a higher rate of developing COVID-19 related complications and need to be continuously monitored for clinical deterioration [26].

Table 1
Guidance on the performance of electrophysiological Interventional procedures [6,8,20,21].

Emergent	Urgent	Elective
Temporary pacing in patients with symptomatic bradyarrhythmia or for overdrive suppression of Torsades de Pointes in acquired long QT	Permanent pacing in patients where the bradyarrhythmia is deemed irreversible	All hemodynamically stable supraventricular arrhythmia (other than those in Urgent)
Implantation of a defibrillator in a patient presenting with resuscitated cardiac arrest or sustained monomorphic ventricular arrhythmia, not in VT storm	Implantation of a resynchronization device in patients presenting with refractory heart failure fulfilling indications	Implantation of a resynchronization device in patients presenting with heart failure fulfilling indications and hemodynamically stable
Lead extraction in patients with CIEDs in situ presenting with sepsis, or impending septicemia or endocarditis	Pulse generator change in patients with CIEDs in ERI or EOS state	Implantation of a defibrillator in a patient fulfilling indications of primary prevention of sudden cardiac arrest
Lead revision in patients with dependency on pacing in case of lead-related issues	Ablation for patients presenting with recurrent monomorphic ventricular arrhythmias refractory to medications	CIED upgrade
Pericardiocentesis in a patient with an implanted CIED	VT storm refractory to conservative medical management including stellate ganglion blockade	Cardioversion for asymptomatic atrial arrhythmias (first presentation) or mildly symptomatic atrial arrhythmias with well-controlled ventricular rates
Computerized tomography scan/transesophageal echocardiography for patients needing urgent reversion to sinus rhythm	Ablation for patients with accessory pathway when associated with a. Atrial fibrillation or b. Resuscitated sudden cardiac arrest	Ablation for atrial arrhythmias or ventricular arrhythmias or premature ventricular beats fulfilling indications for intervention
	c. Multiple accessory pathways	Lead extraction in patients non-dependent on ventricular pacing with CIEDs in situ presenting with device erosion with normal parameters of the CIED leads
	Arrhythmia documented to be associated with symptoms of cerebral hypoperfusion despite attempts to control using medical therapy	
	Ablation of AV node and implantation of appropriate pacing device for hemodynamically significant or severely symptomatic atrial arrhythmias deemed drug/cardioversion refractory	
	Lead extraction in patients dependent on ventricular pacing with CIEDs in situ presenting with device erosion with abnormal parameters of the CIED leads	
	Lead revision in patients with inappropriate ICD discharges secondary to lead-based issues	

Abbreviations: AV: atrioventricular; CIED: cardiac implantable electronic device; EOS: End of Service; ERI:Elective replacement indicator; ICD: Implantable cardioverter defibrillator.

Table 2
Risk status of the patient based on symptoms and COVID-19 diagnostic tests.

COVID Positive	• Laboratory test positive for COVID-19 irrespective of symptoms
COVID Negative	• No symptoms and negative test • Recovered from COVID-19 and a negative test • Suspected of COVID-19 with two negative tests
COVID Probable or Suspect	• A suspected case where the test is not performed or result is awaited, or result is inconclusive

Table 3
General guidelines and recommendations in the hospital to reduce the spread of transmission of COVID-19.

Monitoring and testing of HCW	• Assessment of symptoms and recording of the temperature of all HCW and testing for COVID-19 if required
Visitors and patients	• Limit the number of attendants with the patients visiting the hospital • Discourage unnecessary hospital visits of patients and use teleconsultation as far as possible • Encourage home collection of samples for lab work and testing, if possible
Universal Masking	• All HCW should always wear snugly fitting masks in the hospital • The type of mask is determined by the area of work and the hospital policy • N-95, FFP2, or FFP3 masks while assessing or taking care of the patient that is confirmed or suspected to have COVID-19 • PAPR systems may be used, if available, while performing aerosolizing procedures
Hand hygiene	• Handwashing with soap and water or sanitization using alcohol-based sanitizers should be strictly followed by all HCW using the correct technique at different time points during patient care [22]
Social distancing	• Follow social distancing rules at all locations in the hospital
Designated COVID areas	• The hospitals should have separate and designated COVID-19 areas (ICUs, wards, testing locations, etc.) with well-organized separate pathways and in-hospital routes for these locations.
Hospital Policies	• The hospital should define and periodically update its policies during the pandemic and communicate to all employees • The policy should cover the location of Covid and non-COVID areas, the type of PPE to be used in different settings, the rules for the monitoring of HCW, and their isolation policy in case they get infected or have a high-risk contact, etc.

Abbreviations: HCW: Healthcare workers; FFP: Filtering face piece; PPE: Personal protective equipment; ICU: Intensive care unit; PAPR: Powered air purifying respirator.

4. Patients who develop fever and dyspnea should undergo HRCT of the chest and be started on nasal oxygen and their saturation monitored.
5. All non-critically ill hospitalized patients should undergo evaluation for the risk of developing deep vein thrombosis (DVT) and venous thromboembolism (VTE) and should be initiated on prophylactic anticoagulation wherever indicated. **(See Table 4).** One should also be mindful of the interactions between oral anticoagulants and *anti*-COVID-19 therapies **(See Table 5).**
6. Patients on multiple medications like antiarrhythmics, antibiotics, and antivirals should have a periodic measurement of the QT intervals **(See Table 6).** Patients with QTc >500 m s should have continuous ECG monitoring. Prompt correction of serum potassium, magnesium, and bradycardia is advised [20,27].
7. While planning the discharge of isolated patients, their relatives should be given clear instructions on how to prevent transmitting COVID-19 to family members [28].

1.6. EP procedures during COVID-19 pandemic: modifications in the cath lab

1.6.1. Modification of ventilation system

The standard positive pressure ventilation system of cath lab consists of an air-handling unit (AHU) that distributes conditioned air to different functional units, including the procedure room and control room. In principle, a positive pressure room with adequate air changes could quickly eliminate the virus from the environment and it has been shown that the risk of cross-contamination from airborne infection is low if staff is adequately protected with appropriate PPE. That noted, the use of negative pressure ventilation offers optimal protection to personnel working in adjacent areas. It may be feasible to convert a lab to a negative pressure room temporarily, but this typically cannot be achieved instantaneously.

1.6.2. Adjuvant care during the procedure

Only disposable drapes should be used in COVID-positive

Table 4
Evaluating DVT risks and anticoagulation in hospitalized patients [adapted from [29]].

For Diagnosis of venous thromboembolism	
Routine bedside Doppler for DVT in asymptomatic patients	Most of the guidelines don't recommend it. (NIH, ASH, AC Forum, ISTH, CHEST, Global Covid-19 Thrombosis Collaborative Group)
D-dimer test in asymptomatic patients	Recommend it as part of Covid workup and for risk stratification. (By NIH, AC Forum, ISTH, and Global Collaborative Group)
VTE prophylaxis	
Risk stratification to determine if prophylaxis is indicated.	VTE prophylaxis is indicated for all hospitalized patients with Covid-19. (Recommended by all societies)
Recommended drugs for routine prophylaxis	LMWH (Enoxaparin 40–60 mg SC daily) or UFH. (Recommended by all societies. Some societies did not mention any specific drug)
Extended VTE prophylaxis	Only for patients with high VTE risk criteria (reduced mobility, prior VTE, active cancer, D-dimer>2 upper limits of normal). Up to 45 days of LMWH or DOACs preferred (Rivaroxaban 10 mg daily)

Summary of guidelines: by NIH (National Institutes of Health), ASH (American Society of Hematology), AF forum (Anticoagulation forum), Global Covid-19 Thrombosis Collaborative Group, ISTH (International Society of Thrombosis and Hematology), & CHEST.
Abbreviations: DOAC: Direct oral anticoagulants; DVT: Deep vein thrombosis; LMWH: Low molecular weight heparin; SC: Subcutaneously; UFH: Unfractionated heparin; VTE: Venous thromboembolism.

Table 5
Interactions between DOACs and *anti*-Covid-19 therapies [adapted from (20)].

	Dabigatran	Apixaban	Rivaroxaban	Comments
Chloroquine	potential	Weak	weak	Any DOAC may be used (with caution)
Hydroxychloroquine	potential	Weak	weak	
Azithromycin	potential	–	potential	Use Dabigatran and Rivaroxaban if creatinine clearance is reduced.
Lopinavir/Ritonavir	potential	NO	NO	Dabigatran may be used with caution
Ribavirin	Weak	Weak	weak	Any DOAC may be used (with caution)
Remdesivir	Weak	Weak	Weak	
Favipiravir	Weak	Weak	Weak	
Bevacizumab	–	–	–	
Eculizumab	–	–	–	
Tocilizumab	Weak	Weak	Weak	
Prednisolone	–	–	–	
Methylprednisolone	–	–	–	
Interferon	Weak	Weak	Weak	

Weak: weak interaction, will not need adjustment. *Potential:* Potential interaction which requires additional monitoring. *Adjust:* will need a dose adjustment. *NO:* don't co-administer *Safe:* can be safely given together. –: no data available.
DOAC: Direct Oral Anticoagulants.

Table 6
QTc management [adapted from (27)].

No ECG is required before the start of therapy if	Baseline QTc< 500 m s, No history of structural heart disease or arrhythmias, No bradycardia< 50 bpm, No congenital Long QT.
If QTc >500 m s	Do not start Covid medications likely to prolong QTc
If Acquired Long QT develops	Stop antiarrhythmic medications that prolong QT Maintain K^+ above 4 mEq/L. Maintain Mg^{2+} above 2 mEq/L.
Drugs (used in Covid treatment) that will cause QT prolongation	Chloroquine Hydroxychloroquine Azithromycin Lopinavir-ritonavir (very rare)

Abbreviations – ECG: Electrocardiogram; K: Potassium; Mg: Magnesium.

patients. Patient in the catheterization lab should arrive with an N95 (preferably) mask until he/she needs an oxygen mask [30] Those who require oxygen should be provided the same through a corrugated tube with high flow mask. All the staff of the lab should be fully vaccinated. Although, it may not prevent infection, the severity of infection is much less until immunocompromised. Reuse of any EP catheters which are once used in COVID-19 patients should be avoided. It is advisable to avoid CS catheter (decapolar) by right Internal jugular route and preference should be given to vascular access from the groin to decrease exposure to the operator [31].

1.6.3. Disinfection of the lab

Meticulous deep cleansing and disinfection of the cath lab after the procedure on COVID-19 patients is an important component of infection control [32]. Cleaning all surfaces using sodium hypochlorite and fumigation for appropriate duration is recommended. Also, carbolization of the cath lab surfaces using Lysoformin 3000 (Glutaraldehyde along with other disinfectants) should be done before starting the next procedure. Ultraviolet light-based disinfection may also be a reasonable strategy [33] and the staff members responsible for cleaning should wear full PPE [34,35].

1.6.4. Remote monitoring of CIEDs during COVID-19 pandemic

Current guidelines give a class I recommendation for routine use of remote monitoring in patients with CIEDs due to the reduction in hospitalizations, emergency visits, outpatient tests, and clinical evaluations [36,37]. We recommend that remote monitoring be utilized as much as feasible during the pandemic, all new implants to be supported with remote monitoring whenever feasible, and patients who are presently not enrolled be counselled about this option.

1.6.5. Remote control programming

Remote Control programming is an FDA-approved technology to interrogate and reprogram the device remotely. This technology eliminates the need for the patients to visit the hospital. We recommend that Remote control programming be utilized as much as possible to reduce exposure to healthcare workers and patients in the pandemic and post-pandemic era.

1.6.6. Remote programming by magnet application

Magnet application helps to derive the battery status, capture thresholds, suspend defibrillator therapies, and to convert the device to an asynchronous mode when required. We recommend judicious use of magnet for patients in remote locations during appropriate indications, who had been until recently (<6 months) on regular in-clinic follow up and not in known ERI/EOL status.

1.6.7. Remote monitoring of arrhythmias by wearable gadgets

Several wearable gadgets (patches, smartwatches, hand-held ECG monitors) facilitate easy and reliable underlying rhythm monitoring [38]. We recommend that the use of wearable sensor gadgets be considered for arrhythmia detection. We discourage the routine use of pulse oximeters and digital blood pressure measuring instruments for heart rate and rhythm monitoring.

1.7. Telemedicine in EP practices

For patients with routine clinical follow-up indications, we

recommend that the treating physician replace routine clinic visits with online video or audio consultations on secured platforms. We discourage routine in-hospital visits for device interrogations in stable patients with calculated battery longevity exceeding 3 months.

The remote monitoring and telemedicine recommendations for cardiac EP practices during the COVID-19 pandemic are summarised in Fig. 2 (see Fig. 3).

1.8. Cardiopulmonary resuscitation, advanced life support, and associated issues

The need for cardiac resuscitation is a poor indicator for survival in nearly all studies (see Fig. 3). Both in-hospital (IHCA) and out-of-hospital cardiac arrests (OHCA) have poor in-hospital and 30-day survival outcomes [39]. The COVID-19 pandemic makes resuscitation a physical and logistical challenge and contributes in part to the incidence of cardiac arrest in patients; lockdowns contribute to an increase in time taken to assist the patient, leading to even poorer outcomes. It is unclear if there is independent causality of COVID-19 infection to the incidence of OHCA, but even in areas where there were no lockdowns, there was an increase in OHCA [40–44]. Survival in OHCA and IHCA is poorer when the victim is COVID positive. Rates of ventilatory assistance provided by bystanders are lower in patients with OHCA during the COVID-19 pandemic. Patients with COVID-19 more often present with non-shockable rhythm to the emergency room compared to patients without COVID. In the absence of lockdown protocols, COVID-19 infected patients formed 10 % and 16 % of all patients with OHCA and IHCA, respectively. These patients were monitored less frequently and had lesser instances of witnessed cardiac arrest despite being in hospital. Sixty-one percent of all patients with IHCA and co-existing COVID-19 infection died within 24 h. The 30-day survival for patients with COVID-19 infection, and cardiac arrest was also poorer (IHCA 2.3 times increase and OHCA 3.4 times increase) [42,44–47].

Principles for resuscitation in patients with/suspected COVID-19 or unclear status [41,48–50].

1. Ensure the safety of the resuscitation provider with appropriate safety gear, including eye care and minimizing the presence of unneeded personnel at the site of resuscitation
2. Managing ventilation and minimizing aerosol dispersal by using cuffed endotracheal tubes, use of high-efficiency particulate filters (HEPA) in the exhaust circuit, and an inline suction catheter is advisable.
   a. Choice of an experienced operator and cessation of the chest compressions for up to 20 s during an attempt for endotracheal intubation may be helpful. It may be advisable to use video-laryngoscopy where available. Clamping the tube when access to the airway is obtained till a respiratory circuit is connected may be of value. All intubations should be considered difficult intubations and appropriate guidelines should be followed.
   b. A non-rebreathing face mask with a surgical mask cover or a bag-mask device with HEPA filters can be used pre-intubation to ventilate the patient. The role of an assistant holding the face mask done over the patient's face with two hands is of uncertain use. Early switch to a supraglottic airway should be considered in the event of challenging or failed endotracheal intubation. Ventilation with a mask or a supraglottic airway is in the ratio of 30:2 compression to ventilation ratio [49,50].
3. Decision to initiate or continue resuscitation needs to be evaluated in the context of the risk-benefit ratio. If asystole is the arrhythmia at presentation, due consideration for an abbreviated effort at resuscitation may be considered [48].
4. Institutional guidelines created after considering local facilities and patient co-morbidity regarding response to IHCA and termination of resuscitation efforts can help frontline providers decide appropriately in their interaction with the patient and their caregivers.
5. Extracorporeal resuscitation in patients with COVID-19 awaits literary justification, as does cough CPR.
6. Situation-specific guidelines ([41,45,51,52])

A. OHCA
   a. Lay rescuers increase the chances of survival in the patients with COVID-19, consistent with data in the literature. Novel

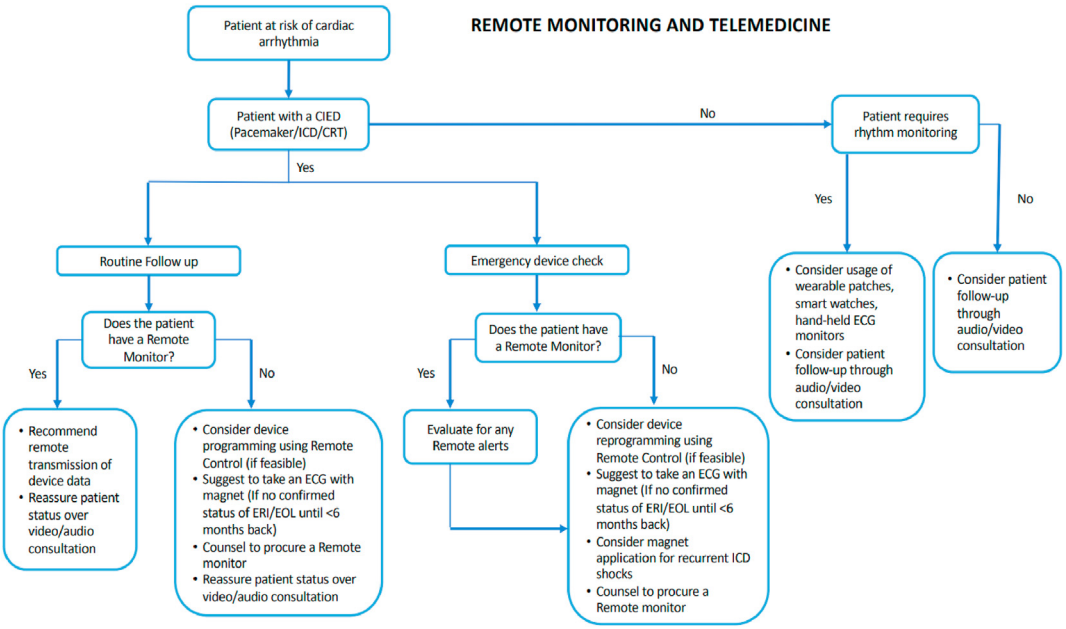

Fig. 2. The remote monitoring and Telemedicine recommendations for cardiac EP practices during the COVID-19 pandemic.

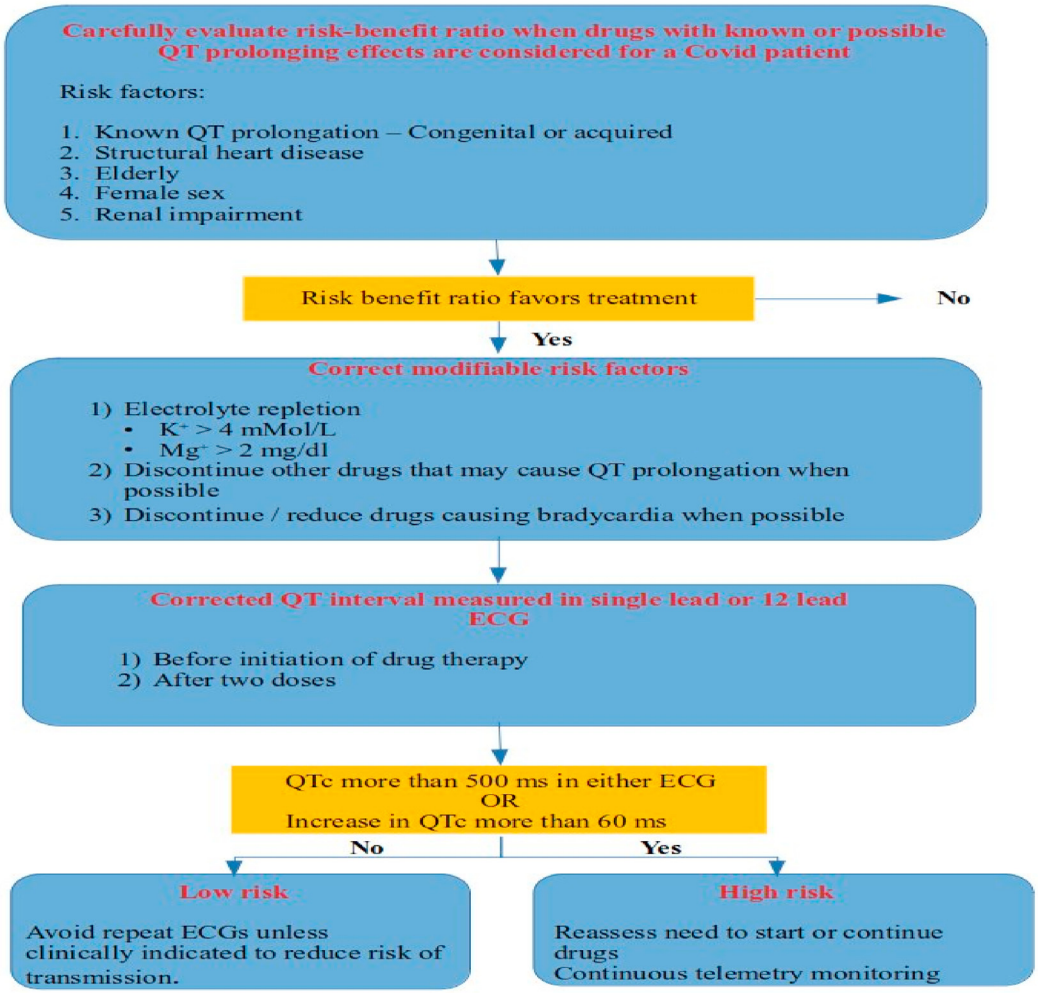

Fig. 3. A simplified flow chart of suggested management when using drugs with known or possible arrhythmogenic potential in patients with COVID-19.

solutions like an app-based response by people in the vicinity need to be explored [53].

b. In the absence of ready access to PPE, lay rescuers are at risk of contracting COVID-19; however, if they are family members, chances that they may be already exposed exist. Non-family responders have to weigh the chances of infection versus being able to deliver CPR. Use of barrier protection (masks, glasses) by lay rescuer if readily available, have perhaps additive value in decreasing the risk of contracting an infection. The use of a face mask or cloth over the patient may aid in reducing the chances of infection [54].
c. In adults, chest-only compressions by the lay rescuer are the bare minimum in the absence of ventilatory support to the patient. However, in children, due consideration to mouth ventilation, especially by family members, may also be done given the higher chances of respiratory arrest in them
d. Use of a defibrillator when accessible should not be avoided. There may be value in the delivery of 3 shocks before donning PPE and initiation of chest compressions.
e. Family members and suspected contacts should not accompany the patient in the ambulance. Inability to attain spontaneous circulation in the field should prompt considerations against transfer to the hospital for further management

B. IHCA

a. Advance care directives and persons of contact for patients with COVID-19 should be clarified at the time of admission
b. If the patients are intubated at the time of cardiac arrest, consider increasing the FiO2 to 100 % with an asynchronous mode of ventilation with respiratory rate to 10 breath/min for adults/children and 30 breaths/min for neonates, along with an individualized assessment of the need for positive end-expiratory pressures. Care to avoid inadvertent extubation or disconnection should also be reviewed. These settings are the same till there is the return of spontaneous circulation. The ventilator circuit should not be discontinued during chest compressions.
c. If patients are prone and not ventilated at the time of arrest, due care to intubate the patients in the prone position should be considered, along with defibrillation attempts being done in the anterior, posterior position. CPR in these situations should be done with compression over the T7, T10 vertebrae with hands placed traditionally.

1.9. COVID-19 medications and cardiac arrhythmias

The drugs most commonly used today in COVID-19 infection – steroids, remdesivir and tocilizumab, do not have known arrhythmic effects. However, other drugs, notably

hydroxychloroquine (HCQ), with known torsadogenic potential continue to be used. While HCQ is known to cause QT prolongation [55], adverse effects related to its use are uncommon [56]. However, there may be a concern in various settings, notably known QT prolongation, concomitant QT-prolonging medications, and metabolic derangements [57].

Azithromycin is known to cause QT prolongation and proarrhythmia, usually in the presence of additional risk factors [58]. Combination with chloroquine in malaria was found to be safe [59]. But caution should be exercised when using HCQ in COVID-19 and higher mortality in a retrospective cohort given both drugs is concerning [60]. When using either or both of these drugs, attention should be paid to risk factors for proarrhythmia including female sex, older age, pre-existing QT prolongation, structural heart disease, prior antiarrhythmic therapy, renal impairment, and liver impairment. Risks and benefits should be balanced in each patient. Modifiable risk factors, especially hypokalaemia, hypocalcemia, and hypomagnesemia should be corrected. Other drugs causing QT prolongation or bradycardia should be discontinued wherever possible.

The most important risk factor of cardiac arrhythmia is the QT interval. An electrocardiogram (ECG) should be recorded in all patients at baseline. A second ECG should be recorded after two doses. Those with QTc >500 m s in either of the ECGs or with an increase in QTc by more than 60 m s from baseline require a careful re-evaluation of benefit [61] and close monitoring if drugs are continued (see flowchart). While a 12-lead ECG is preferred and more accurate, a handheld ECG with a single lead (lead I or lead II) may reduce infection risk and provide equivalent identification of QT prolongation [62].

Regarding antiarrhythmic therapy in COVID-19 positive cases, we recommend that.

1. Arrhythmogenic potential should be considered, and the risk-benefit ratio carefully examined when using hydroxychloroquine, azithromycin, or other agents with QT-prolonging effects alone or in combination.
2. Attention should be paid to modifying risk factors, especially correcting electrolyte imbalances when starting these drugs.
3. Corrected QT interval measurement is key in risk stratifying patients. QTc should be measured before the first dose and after two doses. QTc >500 m s or an increase by more than 60 m s indicates a high risk of torsades.
4. To minimize the risk of transmission, ECG recording should be restricted to the minimum required and single-lead ECGs recorded from a handheld device may be used when possible.

2. Conclusion

The ongoing COVID-19 pandemic has posed unprecedented challenges to the delivery of routine and emergency care worldwide. To ensure the safety of patients and healthcare personnel, certain changes must be introduced to the practice of cardiac EP. These measures should invariably include but are not limited to, avoiding or postponing nonessential outpatient patient visits and EP procedures. Virtual care and remote monitoring are to be used positively, yet judiciously, in the management of COVD-19 patients who require the attention of cardiac electrophysiologist. These guidelines are intended to provide broad perspectives on diagnosis and treatment measures that need to be tailored to specific local situations. As we learn more about this virus and its impact on cardiovascular diseases, these recommendations are bound to be updated.

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