Circulation

CONSENSUS REPORTS

Guidance for Cardiac Electrophysiology During the COVID-19 Pandemic from the Heart Rhythm Society COVID-19 Task Force; Electrophysiology Section of the American College of Cardiology; and the Electrocardiography and Arrhythmias Committee of the Council on Clinical Cardiology, American Heart Association

ABSTRACT: Coronavirus disease 2019 (COVID-19) is a global pandemic that is wreaking havoc on the health and economy of much of human civilization. Electrophysiologists have been impacted personally and professionally by this global catastrophe. In this joint article from representatives of the Heart Rhythm Society, the American College of Cardiology, and the American Heart Association, we identify the potential risks of exposure to patients, allied healthcare staff, industry representatives, and hospital administrators. We also describe the impact of COVID-19 on cardiac arrhythmias and methods of triage based on acuity and patient comorbidities. We provide guidance for managing invasive and noninvasive electrophysiology procedures, clinic visits, and cardiac device interrogations. In addition, we discuss resource conservation and the role of telemedicine in remote patient care along with management strategies for affected patients.

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The novel coronavirus (severe acute respiratory syndrome coronavirus 2) emerged in Wuhan, China, in late 2019 and has quickly become a pandemic, significantly impacting the health and economy of the United States and the rest of the world.[1,2] There are several hundred thousands of cases and thousands of deaths related to coronavirus disease 2019 (COVID-19) (the disease caused by severe acute respiratory syndrome coronavirus 2) worldwide, with an estimated mortality rate ranging from 1% to 5%.[2] The United States has been impacted by this pandemic significantly with hundreds of deaths reported; these numbers will continue to rise.[1] This healthcare crisis has imposed an unprecedented strain on society and has challenged the ability of healthcare organizations to provide adequate care.

Electrophysiologists play an important role in cardiovascular health, with >40% of cardiology encounters being related to arrhythmia. In a recent report from Wuhan, China, 16.7% of hospitalized and 44.4% of patients in an intensive care unit with COVID-19 had arrhythmias.[3] In addition, there have been anecdotal reports of patients experiencing late myocardial dysfunction, and cardiopulmonary arrest with pulseless electrical activity or ventricular fibrillation during the recovery phase of their pulmonary illness, as well. The purpose of this joint statement from the Heart Rhythm Society, the American College of Cardiology Electrophysiology Council, and the American Heart Association Electrocardiography and Arrhythmias Committee is to address numerous issues facing electrophysiologists (and other healthcare providers who manage arrhythmias) during the pandemic and to provide corresponding general guidance.

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POTENTIAL RISKS OF EXPOSURE TO PATIENTS, PHYSICIANS, ALLIED HEALTHCARE STAFF, INDUSTRY REPRESENTATIVES, AND HOSPITAL ADMINISTRATORS

Severe acute respiratory syndrome coronavirus 2 is a highly infectious virus associated with significant morbidity and mortality. Individuals may maintain high viral loads in the upper respiratory tract with significant potential for viral shedding and transmission even if they are asymptomatic.[4,5] Although primarily transmitted by droplets, airborne transmission is possible through aerosolization in the setting of high-flow oxygen, bronchoscopy, open tracheal suctioning, intubation, extubation, noninvasive positive pressure ventilation, endoscopy, or transesophageal echocardiography.[6]

As the prevalence of COVID-19 increases exponentially, patients presenting with seemingly nonrelated medical problems may expose healthcare providers to increased risk of contracting the disease if not properly protected. Such exposure puts electrophysiology staff, physicians, and other clinical personnel at increased risk of contracting COVID-19. Reducing contact between healthcare personnel and patients who have COVID-19 is an integral step in limiting its spread and resource use, including the use of personal protective equipment (PPE).

In a hospital, the number of individuals who participate in rounds should be minimized and social distancing should be practiced. For patients with suspected or confirmed COVID-19 infection, time and personnel spent in the room should also be limited. Many electrophysiology consultations may be completed without a face-to-face visit, by reviewing the chart and monitoring data. Nonurgent or nonemergent procedures should be postponed to a later date. Clinic visits and in-person cardiac implantable electronic device (CIED) checks should be converted to telehealth and remote checks whenever feasible. Minimizing fellow trainee contact with patients may include rotation of days involved in direct patient service, managing remote checks, and conducting patient telehealth visits. Attempts should be similarly made to limit exposure of electrophysiology allied professionals, including nurses, device clinic personnel, hospital administrators, and medical device company representatives. Additional steps may need to be taken to minimize exposure for higher risk individuals (eg, >60 years of age, pregnant, immunocompromised, and other comorbid conditions).

IMPACT OF COVID-19 ON CARDIAC ARRHYTHMIAS

Patients infected with COVID-19 can exhibit a wide range of clinical manifestations, ranging from an asymptomatic state to severe disease with hypoxia and acute respiratory distress syndrome–type lung injury.[7,8] In the setting of hypoxemic respiratory failure, ground-glass opacification on chest imaging is found in >50%.[7] Because the majority of patients will experience only mild symptoms, including fever, cough, headache, anorexia, diarrhea, and malaise, it can be difficult to distinguish COVID-19 from the common cold.

COVID-19 has the potential to cause myocardial injury, with at least 17% found to have an elevated troponin and 23% noted to have heart failure in a study of 191 inpatients from Wuhan, China.[9] Cases of fulminant myocarditis with cardiogenic shock have also been reported, with associated atrial and ventricular arrhythmias.[10,11] Given that hypoxia and electrolyte abnormalities that are common in the acute phase of severe illness can potentiate cardiac arrhythmias, the exact arrhythmic risk related to COVID-19 in patients with less severe illness or those who recover from the acute phase of the severe illness is currently unknown. Improved understanding of this is critical, primarily in guiding the need for additional arrhythmia monitoring (eg, mobile cardiac telemetry) after discharge and whether an implantable cardioverter-defibrillator (ICD) or wearable cardioverter-defibrillator will be needed in those with impaired left ventricular function thought to be secondary to COVID-19.

TRIAGE OF PROCEDURES BASED ON SCREENING AND PPE

The experiences in China, Italy, South Korea, and Taiwan have informed the need to quickly test and triage patients with suspected infection. It is important for all electrophysiologists to have a high degree of suspicion for COVID-19 in any patient they interact with in the electrophysiology laboratory, hospital, or outpatient setting. A thorough travel history and assessment of contact with individuals or family members who were sick or received hospitalization is mandatory. Patients with fever, cough, and upper respiratory tract symptoms deserve special attention and should be immediately isolated. Testing for severe acute respiratory syndrome coronavirus 2, along with other respiratory viruses (eg, influenza, respiratory syncytial virus) should be pursued.

Personal Protective Equipment

In patients with suspected COVID-19 infection, it is recommended that all clinicians and healthcare providers don PPE, which include a face mask, protective eyewear, gown, and gloves. Initial PPE recommendations in these patients included the use of fitted N95 or powered air-purifying respirator masks, protective

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eyewear, gloves, and gowns. However, because of a shortage of N95 masks and increased understanding of droplet and airborne transmissibility during routine care of patients with suspected and positive COVID-19, substitution with a surgical mask with a face shield combination or other protective eyewear during routine nonprocedural care has been recommended by the US Centers for Disease Control and Prevention (CDC).

Recommendations related to PPE may continue to change on the basis of supply chain, contingency, and crisis capacity status. Consultation with the hospital infection control team is strongly recommended. Appropriate donning and doffing procedures should be followed as outlined by the CDC (see the Useful Links section). It is also important to know how to report potential COVID-19 cases or exposure to public health authorities; local or hospital COVID-19 hotlines can be useful in this regard.

GUIDANCE FOR MANAGING INVASIVE AND NONINVASIVE ELECTROPHYSIOLOGY PROCEDURES, CLINIC VISITS, AND CIED INTERROGATION

Because of the increased numbers of COVID-19 cases and the anticipated impact on healthcare resources (eg, hospital and intensive care unit beds, ventilators, PPE, and the blood supply), it is recommended, and increasingly mandated, to postpone or cancel nonurgent, elective procedures. The definition of what constitutes an elective or nonurgent case should be based on individualized risk assessment, informed by the patient's clinical status. In general, it is reasonable to consider deferring any test or procedure that is unlikely to directly impact clinical care or outcomes over the next several months. The rationale for delaying nonurgent or elective procedures should ideally be discussed with the patient and documented in the medical record (Figure 1). In contrast, semiurgent, urgent, or emergent procedures include those in which there is (1) threat to the patient's life if the procedure is not performed urgently, (2) threat of permanent dysfunction of an extremity or organ system, or (3) risk of rapidly worsening to severe symptoms.

Urgent or Emergent Procedures

Procedures are considered urgent or emergent if they substantially decrease the risk of clinical decompensation, hospitalization, or death (Figure 1). Screening for COVID-19 should be performed if it is suspected, and a high level of suspicion for COVID-19 infection should be maintained.

1. Ventricular tachycardia ablation for medically uncontrolled electrical storm in a hemodynamically compromised patient
2. Catheter ablation of incessant, hemodynamically significant, severely symptomatic tachycardia (supraventricular tachycardia/atrial fibrillation/atrial flutter) not responding to antiarrhythmic drugs, rate control, and cardioversion
3. Catheter ablation for Wolff-Parkinson-White syndrome or preexcited atrial fibrillation with syncope or cardiac arrest
4. Lead revision for malfunction in a pacemaker-dependent patient or patient with an ICD receiving inappropriate therapy
5. Generator change in pacemaker-dependent patients who are at elective replacement indicator or at device end of life
6. Pacemaker or ICD generator change with minimal battery remaining, depending on specific clinical situations
7. Secondary prevention ICD
8. Pacemaker implant for complete heart block, Mobitz II atrioventricular block, or high-grade atrioventricular block with symptoms or severe symptomatic sinus node dysfunction with long pauses
9. Lead/device extraction for infection, including patients not responding to antibiotics, or for endocarditis, bacteremia, or pocket infection
10. Cardiac resynchronization therapy in the setting of severe refractory heart failure in guideline-indicated patients
11. Cardioversion for highly symptomatic atrial arrhythmias or rapid ventricular rates not controlled with medications
12. Transesophageal echocardiogram for patients who need urgent cardioversion (further guidance on this issue from the American Society of Echocardiography).

Semiurgent Procedure

Some electrophysiology procedures are not emergent yet clinically may need to be performed in a timely manner because of clinical circumstances (Figure 1). Often, the decision of when to schedule a procedure will depend on the clinical judgement of the electrophysiology physician, in partnership with the patient and the associated healthcare teams. As noted previously, appropriate PPE and a high level of suspicion for COVID-19 infection is required.

1. Ventricular tachycardia ablation for medically refractory recurrent ventricular tachycardia
2. Supraventricular tachycardia ablation, in patients with medically refractory supraventricular tachycardia resulting in emergency department visits

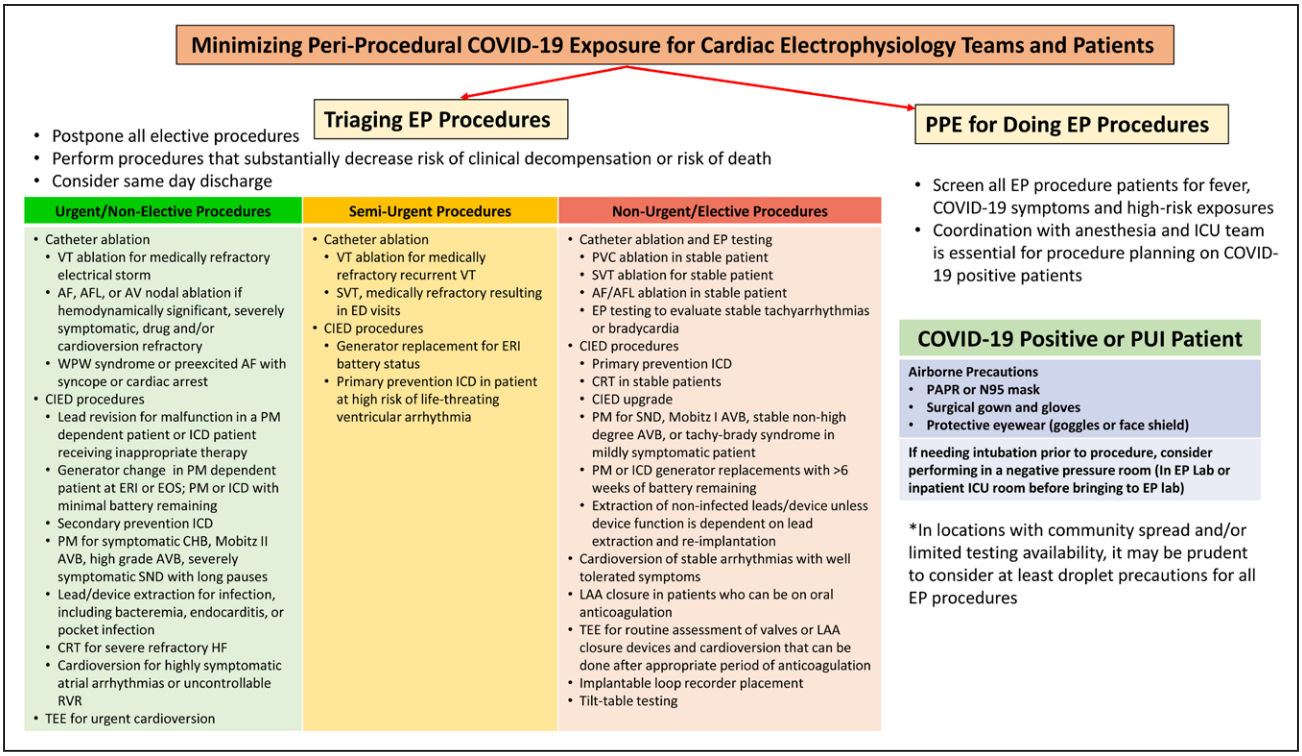

Figure 1. Guidance on EP procedures for urgent, semiurgent, or nonurgent procedures in the hospital setting.
See text for details. AF indicates atrial fibrillation; AFL, atrial flutter; AV, atrioventricular; AVB, atrioventricular block; CHB, complete heart block; CIED, cardiac implantable electronic device; COVID-19, coronavirus disease 2019; CRT, cardiac resynchronization therapy; ED, emergency department; EOS, end of service; EP, electrophysiology; ERI, elective replacement indicator; HF, heart failure; ICD, implantable cardioverter defibrillator; ICU, intensive care unit; LAA, left atrial appendage; LBBB, left bundle-branch block; PAPR, powered air-purifying respirator; PM, permanent pacemaker; PPE, personal protection equipment; PUI, patient under investigation for COVID-19; PVC, premature ventricular contraction; RVR, rapid ventricular rate; SND, sinus node dysfunction; SVT, supraventricular tachycardia; TEE, transesophageal echocardiography; VT, ventricular tachycardia; and WPW, Wolff-Parkinson-White.

3. CIED generator replacement for elective replacement indicator battery status that is not urgent or emergent
4. Primary prevention ICD in patients at particularly high risk of life-threatening ventricular arrhythmia.

Nonurgent or Elective Procedures

Procedures are considered nonurgent or elective if they do not meet the aforementioned criteria for semiurgent, urgent, or emergent procedures (Figure 1). It may be reasonable to delay the following procedures for several weeks or months until the pandemic subsides and restrictions on elective procedures are lifted:

- Premature ventricular complex ablation
- Supraventricular tachycardia ablation
- Atrial fibrillation and atrial flutter ablation in stable patients without heart failure, not at significant risk of getting hospitalized by delaying the procedure or at high risk for procedure-related complications attributable to comorbidities
- Electrophysiology testing to evaluate stable tachyarrhythmias or bradycardia
- Primary prevention ICD that is not semiurgent
- Cardiac resynchronization therapy in stable patients
- CIED upgrade
- Pacemaker implant for sinus node dysfunction, Mobitz I atrioventricular block, other stable non–high-degree atrioventricular block, or tachy-brady syndrome in mildly symptomatic patients
- Pacemaker or ICD generator replacements in patients with >6 weeks of battery remaining
- Extraction of noninfected devices/leads, unless device function is dependent on lead extraction and reimplant
- Cardioversion for stable arrhythmias with well-tolerated symptoms.
- Left atrial appendage closure in patients who can be on anticoagulation
- Transesophageal echocardiogram for routine assessment of valves or left atrial appendage closure devices and cardioversions that can be done after appropriate period of anticoagulation
- Implantable loop recorder implants
- Tilt-table testing

For patients with suspected COVID-19 requiring electrophysiology procedures, it is optimal to await confirmation of COVID-19 test status to avoid unnecessary use of resources. PPE including N95 or powered air-purifying respirator masks should be used by healthcare personnel treating patients with suspected or

confirmed COVID-19 requiring conscious sedation (which carries a risk for aerosolization with high-flow oxygen) or intubation. Close coordination between anesthesia and the electrophysiology laboratory teams is required. For general anesthesia cases, consideration should be given to elective intubation in the intensive care unit or a negative-pressure room before entering the electrophysiology laboratory. Because the care team is restricted to the laboratory or procedure room until the procedure has finished, staff should pay particular attention to having all supplies and equipment in the room at the start of the case. Consideration can also be given to performing procedures on patients with confirmed or suspected COVID-19 in a negative-pressure operating room.[12]

It is important for hospitals to review the ventilation system of their electrophysiology laboratories to determine whether there is sharing of an air return that might require disinfection of other rooms. Where possible, procedure time should also be minimized. For example, among patients undergoing ventricular tachycardia ablation, extensive ventricular tachycardia induction and activation mapping may be minimized to reduce risk. Same-day discharges after device implantation should be considered to minimize the patient's risk of nosocomial infection. To minimize the transport of infected patients, direct-current or chemical cardioversions can be performed at the bedside in the intensive care unit with suitable anesthesia support. When feasible, patients with confirmed or suspected COVID-19 infection should be scheduled as the last case of the day, given the extensive cleaning required after the procedure. The CDC's recommendations for environmental cleaning and disinfection should be followed (see the link later in this article).

Limit Clinic Visits to Those Considered Time Sensitive or Urgent

Where possible, in-person clinic visits should be avoided. Instead, telehealth or virtual visits (secure internet, phone, or video) should be adopted to minimize unnecessary exposure.

The majority of incision site inspections after CIED implantation or catheter ablation can be managed through telehealth by inspecting the site using a video conference or by asking the patient to send a picture in a secure email message. Similarly, many of the clinic follow-ups and some new consults can be performed through telehealth, leveraging electronic medical record data and obtaining vital signs and ECG tracings by using digital wearables where available. As the number of application-based technologies evolves, they will continue to be an integral part of telehealth. Examples of low-risk patients for whom in-person visits could be deferred include asymptomatic patients with satisfactory CIED battery longevity, patients who are not dependent on a pacemaker, and patients who have primary prevention ICDs without symptoms suggesting worsening of heart failure or arrhythmia burden. Patients on antiarrhythmic drugs, such as dofetilide, that require QTc and laboratory monitoring may need to defer testing if prior values and their clinical condition have remained stable and if no new drugs that may prolong the QTc have been added. Patients with borderline values may need continued access to ECGs and laboratory testing. Although several studies have evaluated the use of mobile ECG devices for QTc monitoring, none of the currently available single- and 6-lead mobile ECG devices have been cleared by the US Food and Drug Administration for such purposes. However, regulations are evolving quickly in this area.

Other urgent or semiurgent clinical indications can be evaluated in person on an individualized basis. Select patients with worsening heart failure or arrhythmia symptoms or for whom there is a need for device reprogramming may warrant office evaluation. These include but are not limited to patients who have atrial fibrillation with worsening heart failure, patients who have an ICD with recent shocks or syncope, patients with a CIED who have recent symptoms suggesting possible device malfunction (eg, syncope or heart failure exacerbation), or suspected device infection. A limited physical examination may well be appropriate on the basis of their clinical presentation. When possible, in-person visits and procedures should be coordinated on the same day to minimize multiple exposures for the patient. In patients coming for outpatient visits, measures should be taken to screen patients for concerning symptoms (eg, fever, cough) before they present to clinic. If suggestive symptoms or a fever are present, patients should be redirected to an appropriate screening clinic or facility, with appropriate measures taken (Figure 2).

Limit In-Person CIED Interrogation to Those Considered Urgent or Time Sensitive

To minimize exposure of electrophysiology staff and device manufacturer representatives to patients with suspected or confirmed COVID-19 infection, it is prudent to perform in-person CIED interrogations only as follows. It is important to note that device interrogation programmers, cables, and wands should be disinfected between all patients.

- Clinically actionable abnormality of CIED noted on remote monitoring, telemetry, or ambulatory monitoring
- ICD shocks, presyncope, or syncope concerning for an arrhythmic event, to perform programming changes

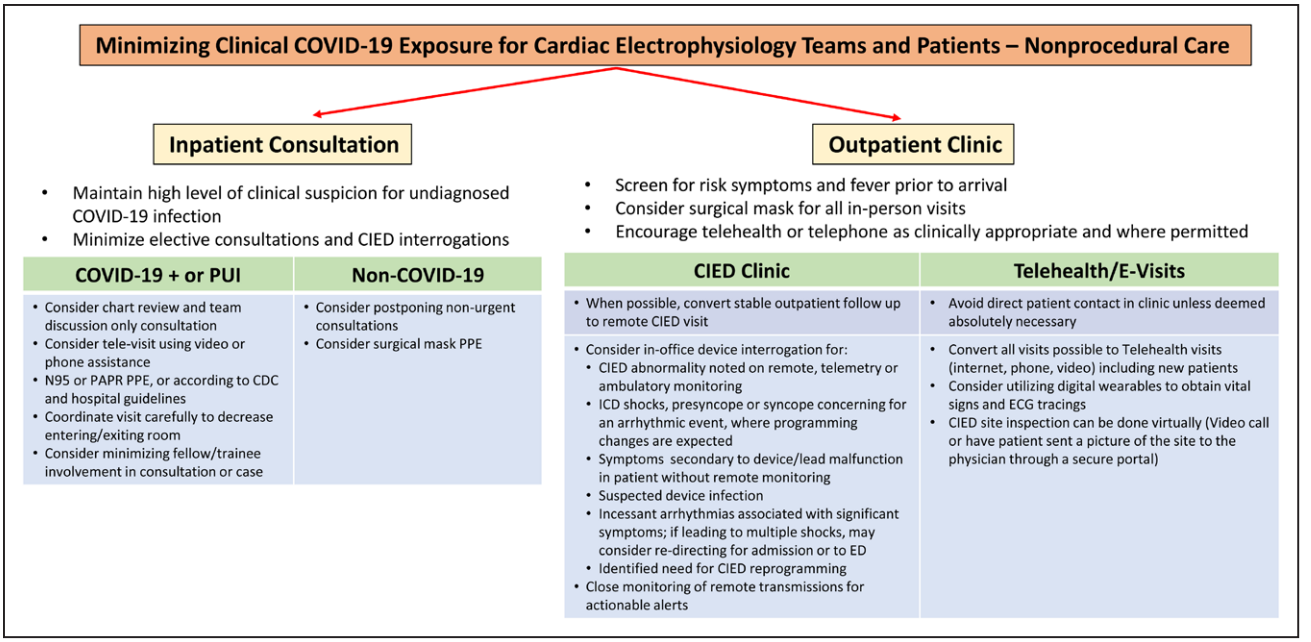

Figure 2. Guidance on nonprocedural care in outpatient clinic visits and CIED monitoring in the outpatient and inpatient settings.
CDC indicates Centers for Disease Control and Prevention; CIED, cardiac implantable electrical device; COVID-19 indicates coronavirus disease 2019; ED, emergency department; ICD, implantable cardioverter defibrillator; PAPR, powered air-purifying respirator; PPE, personal protection equipment; and PUI, patient under investigation for COVID-19.

- Evaluation of symptoms suspicious for arrhythmia or abnormal device function in patients who are not enrolled in remote monitoring
- Identified need for reprogramming of the device
- For patients with CIED who need urgent or emergent magnetic resonance imaging scanning, consider performing a computerized tomography scan instead, if possible (to minimize the need for additional healthcare provider or device manufacturer representative contact); if not urgent, delay the magnetic resonance imaging.
- Patients in the emergency department where remote monitoring is not available; remote monitoring should be used wherever possible.

Cardiac electrophysiologists have a responsibility to protect patients, their families, other caregivers, and themselves. This includes resource stewardship, keeping themselves safe while delivering care, and collaboration with other healthcare professionals on the front lines (Figure 3).

REMOTE DEVICE MONITORING

A substantial number of electrophysiology patients with a CIED have remote monitoring, which remains a powerful tool for off-site cardiac rhythm management. Current guidelines give remote monitoring a class I recommendation for routine use in patients with CIEDs.[13] Despite its effectiveness, remote monitoring is significantly underused because of a variety of patient- and system-based issues. Amid the pandemic, remote monitoring should be used in most circumstances to reduce the need for nonurgent clinic visits. When feasible, remote monitoring should be reconsidered in patients who are currently not enrolled.

RESOURCE CONSERVATION AND TRAINING FOR ALL PERSONNEL

As the pandemic spreads and affects more individuals, resource conservation becomes even more important. Accordingly, it is critical to conserve valuable resources, such as PPE, medical, and ancillary staff, by minimizing routine patient health care that can be postponed in the short to intermediate term. Although hospitals in currently low-incidence geographies may feel confident of their capacity to handle elective procedures, current projections predict a spread of COVID-19 that is likely to overwhelm resources. Social distancing, limiting exposure of patients with COVID-19 infection to other patients and healthcare personnel, and access to testing regardless of the incidence of the infection are critically important steps. Patient education about these measures should be reinforced at every opportunity.

TELEMEDICINE AND DIGITAL HEALTH PARADIGMS

Although effective use of telemedicine predated the pandemic, it was largely limited by technical and reimbursement barriers. In the current COVID-19 crisis, adoption of virtual medical services is rapidly increasing.

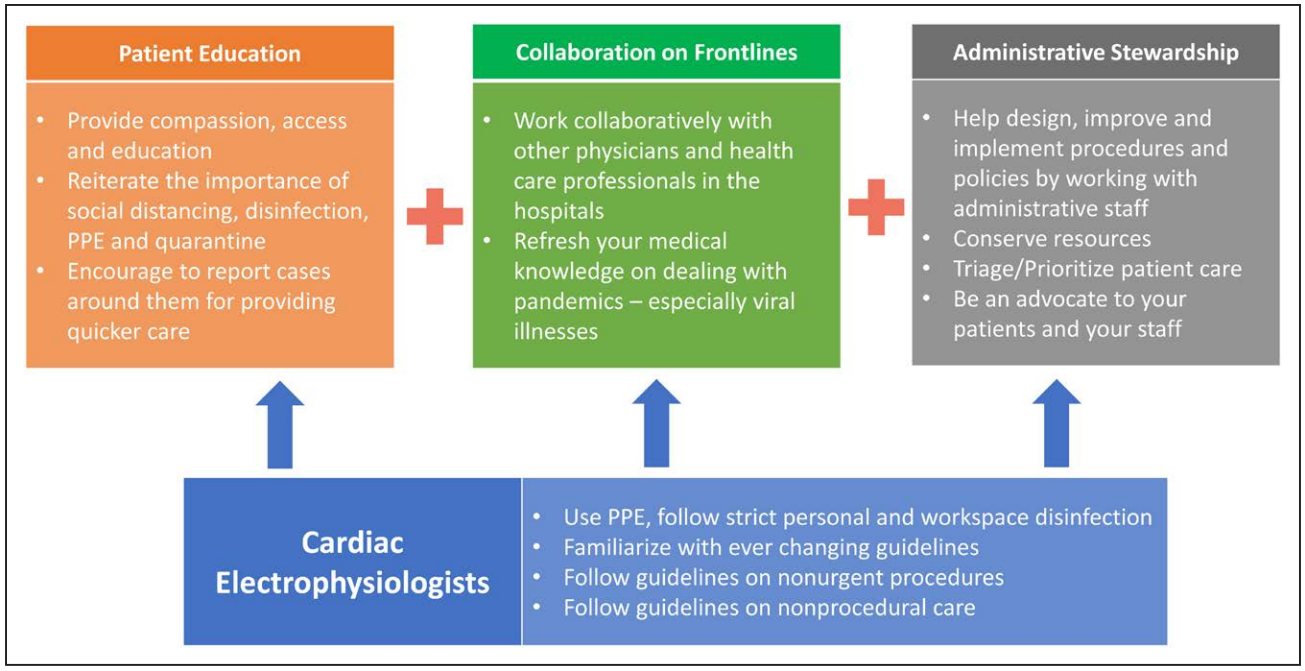

Figure 3. Role of an electrophysiologist in being an important solution in managing a pandemic such as COVID-19.
One has responsibility to self, family, patients, other healthcare professionals and to be a good steward for resource conservation. COVID-19 indicates coronavirus disease 2019; and PPE, personal protection equipment.

The Centers for Medicare and Medicaid Services have expanded telehealth services to keep people safe and help healthcare providers focus on individuals who have the "most dire health care needs." At the present time, telemedicine can be provided by phone and using several secure messaging applications and platforms. Physicians should familiarize themselves with the federal, state, and local policies/regulations and follow procedures at their own institutions. The Office for Civil Rights for the US Department of Health and Human Services recently released a notification of enforcement discretion for telehealth, and is allowing the use of any nonpublic facing audio or video communication product to provide telehealth during the COVID-19 crisis. To this end, the Office for Civil Rights has expressed willingness to forego penalties for Health Insurance Portability and Accountability Act noncompliance among providers enacting good-faith measures for telemedicine during the pandemic.[14] One unexpected outcome of the COVID-19 cloud may be advancement of digital health methodology and practices that leverage smart phones, video conferencing systems, wearables, and remote monitoring.

CARDIOPULMONARY RESUSCITATION, ADVANCED CARDIAC LIFE SUPPORT, AND ARRHYTHMIA MANAGEMENT OF PATIENTS WITH COVID-19

Although there are limited published data currently available on arrhythmia management in patients with COVID-19, such data will be forthcoming. The number of personnel in the room of a patient experiencing cardiac arrest with confirmed or suspected COVID-19 during resuscitation efforts should be minimized. All participants should don PPE before entering the patient's room. Because of the risk of viral aerosolization, consideration should be given to early intubation along with the use of external mechanical compression devices and airborne precautions during intubation.

At the time of this writing, it is unclear what medications may be beneficial for patients with COVID-19. Off-label use of some medications is currently being investigated. Although we are not recommending any specific treatment, safety guidance for clinicians using hydroxychloroquine may be requested of electrophysiology providers. Hydroxychloroquine is known to block Kv11.1 (HERG) and can cause drug-induced long QT.[15] The clinical arrhythmic toxicity (syncope and torsade de pointes) is largely limited to chronic use (because of its long half-life of 40 days), use of multiple concomitant QT-prolonging medications (eg, azithromycin), metabolic derangements, renal failure, or in the setting of an acute overdose.[16,17] To date, it has been widely tolerated in most populations as an antimalarial and has been safely used in the rheumatoid arthritis and systemic lupus erythematosus populations without ECG monitoring.[18] Because the proposed hydroxychloroquine therapy for COVID-19 is relatively short (eg, 5–10 days), the risk of arrhythmic toxicity is likely quite low. However, there are specific precautions to be considered for select patients, however:

- Patients with known congenital long-QT syndrome
- Patients with severe renal insufficiency should have the dose reduced (50% for CrCl <10 mL/min)
- Patients on QT-prolonging drugs
- Electrolyte imbalances (eg, hypokalemia, hypomagnesemia) must be corrected before use, with regular monitoring

None of these conditions is an absolute contraindication if use of hydroxychloroquine is warranted. It is reasonable to temporarily stop class III antiarrhythmic drugs, with use of a reasonable alternative if there is evidence of QT prolongation. It is important to note that aggressive electrolyte correction can mitigate arrhythmic toxicity. ECG monitoring should be considered for patients on multiple QT-prolonging medications and avoidance or careful monitoring may be required for patients with congenital long-QT syndrome. Additional guidance for navigating and circumventing the QTc-prolonging and torsadogenic potential of pharmacotherapies for COVID-19 has been recently published.[19]

CONCLUDING STATEMENTS

At this unprecedented time, it is important for patients to feel that physicians and healthcare systems are not abandoning them. Many patients with arrhythmias are among the sickest of those with cardiovascular disease. To protect patients (many of whom are at high risk because of coexisting comorbidities) and healthcare teams from COVID-19 exposure, preserve resources, and maintain access to necessary cardiovascular care, it is important that nonessential encounters, tests, and procedures be postponed. Although electrophysiology is uniquely suited to leverage virtual care and remote monitoring, it is important to assure patients that they have our full support, and we are ready and able to provide care as necessary.

USEFUL LINKS

CDC COVID-19 site
CDC Information for Healthcare Professionals
Donning and Doffing PPE
CDC Recommendations for Environmental Cleaning and Disinfection
COVID-19 Global Cases
Drug Interactions With Experimental COVID-19 Therapies (Including Antiarrhythmic Drugs)
Resource From China on Fighting COVID-19

ARTICLE INFORMATION

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Disclosures

None.

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