



Effect of COVID-19 on cardiac electrophysiology practice: a systematic review of literature

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Abstract

The authors conducted a systematic review on the effect of coronavirus disease 2019 on electrophysiology (EP) practice and procedure volume in various settings. This review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement. PubMed/MEDLINE, Scopus, Web of Science, CINAHL, and Embase were examined with combinations of medical subject headings terms for identification of the relevant studies. After excluding duplicates, irrelevant, and ineligible studies, 23 studies were included for full qualitative analysis. The overall study-level volume reduction of EP procedures ranged from 8 to 96.7%. All studies reported an overall reduction in EP physiology procedures being carried out except one in Poland, which reported an overall increase in the total EP procedures carried out in 2020. This study still reported a decrease in EP procedure volume during the first lockdown phase. Procedural volume reduction was seen most commonly for cardiovascular implantable electronic device placement (20/23 studies, 86.9%), electrophysiology studies (11/23 studies, 47.8%), and ablations (9/23, 39.1% studies). The most common reason stated for the observed decline in EP procedures was the cancellation and postponement of nonurgent elective cases in the hospitals (15/23 studies, 65.2%). There has been an overall reduction in EP procedure volume across different centers. The impact of the decline in EP procedures will be seen only after the services resume to pre-pandemic levels, but an increase in-patient volume and procedure waiting time is expected. This review will provide insights into improving healthcare service delivery in times of unprecedented public health emergencies.

Keywords: catheter ablation, COVID-19 pandemic, elective procedures, electrophysiology, emergency treatment, implantable cardioverter defibrillator, pacemaker

Introduction

A severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) caused a global pandemic of Coronavirus Disease 2019 (COVID-19), starting in the province of China (Wuhan) in December 2019^[1]. An emergency was declared by the WHO in March 2020, and stay-at-home protocols were introduced throughout the world^[2]. Many health and therapeutic guidelines were changed with the disease's

HIGHLIGHTS

- Many health and therapeutic guidelines were changed with the disease's growing prevalence globally.
- There was a reduction of nonemergency diagnostic and therapeutic procedures to make room for coronavirus disease 2019 patients and take advantage of the structural and functional capacity of the hospitals.
- All medical services returned to normal slowly after 1.5 years of lockdown.

growing prevalence globally. At the start, the main initiative for these guidelines was to minimize the exposure of healthcare workers to COVID-19^[3]. Second, there was a reduction of nonemergency diagnostic and therapeutic procedures to make room for COVID-19 patients and take advantage of the structural and functional capacity of the hospitals^[4]. However, as more research was conducted on COVID-19, the non-pulmonary complications came to light, including cardiovascular diseases^[5–7]. Therefore, all medical services slowly returned to normal after 1.5 years of lockdown. Among these, electrophysiological studies (EPSs) and cardiac implantable electronic device (CIED) placement, which were notably decreased during the pandemic, returned to normal^[8]. Due to the increased incidence of cardiac arrhythmias, and ischemic/nonischemic cardiomyopathies associated with COVID-19,

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cardiac electrophysiology (EP) procedures were started again^[7]. We conducted a systematic review on the effect of COVID-19 on EP practice and procedure volume in various settings.

Methods

This review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement^[9]. All the data were extracted from the original investigations published on the topic. All data is presented in Table 1, and the consolidated data can be obtained from the references section.

Search strategy/Selection criteria

Various databases, including PubMed/MEDLINE, Scopus, Web of Science, CINAHL, and Embase were examined with combinations of medical subject headings (MeSH) terms for identification of the relevant studies. There were no time or language restrictions on the inclusion criteria, and to find the relevant articles, references of the included studies and reviews were performed to extract unidentified articles skipped in the primary search. The medical subject headings consisted of the following sets: 'electrophysiology' OR 'EP' OR 'cardiac electrophysiology' OR 'electrocardiology' AND 'COVID-19' OR 'SARS-CoV-2' OR 'pandemic' AND "procedures" OR 'procedure volume' OR 'radiofrequency ablation' OR 'pacemaker' OR 'permanent pacemaker' OR 'cardiac implantable electronic device'. All the sets were systematically combined using the Boolean operators, and the results from all the combinations were extracted into the Covidence library.

The documents were then reviewed by two independent investigators (J.M. and S.M.J.Z.) for titles and abstracts in the initial search. Articles that reported EP procedure volumes before and during COVID-19 were included in the review. All randomized controlled trials, observational studies, and research letters were included. All preprints, conference papers, and studies with no previous procedural data were excluded from the analysis. The first author validated all the data; in the case of missing information, the authors of the original article were contacted. The last search ended on 7 July 2022, and the search strategy is shown in Figure 1.

Data extraction/Analysis

The data about CIED placement, EPS, or any other EP-related procedures were extracted independently by the two authors (J.M. and T.A.). Detailed study-level baseline characteristics, including the type of study, sample size, country, and the number of procedures pre-COVID-19 were abstracted. Finally, any predictors or conclusions were extracted for each article.

The statistical analysis was executed through the Statistical Package for Social Sciences version 26 (IBM Corp.). The data were presented as mean and SD for continuous variables and frequency (*n*) and percentages (%) for categorical variables.

Quality assessment

The overall methodological quality was not an exclusion criterion for this review, and the Newcastle–Ottawa scale was used for assessing the nonrandomized studies^[32]. These are presented in Figure 2.

Results

The initial search revealed 2988 articles. After removing duplicates (954) and irrelevant studies (1966), 68 were screened for full-text review. Of these, 45 studies were excluded based on the inclusion criteria. A total of 23 studies qualified for the final qualitative analysis^[4,10–31]. A total of 4 studies were from the United States of America, 14 from Europe, and 1 from Pakistan, Oman, Iran, Japan, and New Zealand. Most of the studies were from high-income countries with just two studies from middle-low-income countries^[20,21]. All of the included studies were retrospective cohorts except for two cross-sectional surveys^[11,20]. All studies were published between 2020 and 2022.

The overall study-level volume reduction of EP procedures ranged from 8 to 96.7%. All studies reported an overall reduction in EP physiology procedures being carried out except one^[24] in Poland, which reported an overall increase in the total EP procedures carried out in 2020. This study still reported a decrease in EP procedure volume during the first lockdown phase.

There was heterogeneity in procedure volume reduction and detailed procedure types carried out at different centers of the world with the most common ones being CIED placement (20/23 studies, 86.9%), EPS (11/23 studies, 47.8%), and ablations (9/23, 39.1% studies). The most common reason stated for the observed decline in EP procedures was the cancellation and postponement of nonurgent elective cases in the hospitals (15/23 studies, 65.2%). Seven (30.4%) studies reported their hospitals/centers being converted into COVID-19 referral centers^[4,10,14–16,18,19]. Six (26.1%) studies reported an inverse relationship between rising COVID-19 cases and the declining rates of EP procedures^[11,17–20,27]. Organizational restructuring in response to the pandemic and the issuance of new guidelines for EP procedures were reported in nine (39.1%) studies^[4,10,14–17,19,29,30].

An estimated 19 124 EP procedures were carried out during the COVID-19 pandemic in all studies compared to 24 916 EP procedures carried out before the pandemic. Nineteen studies reported pre-COVID-19 data on EP procedures being carried out in tertiary level care centers^[4,12–18,20,22–31]. Only one study reported data on postCOVID EP procedure volumes^[15]. Only two studies reported any EP procedures carried out on COVID-19 positive cases^[4,16]. Only two studies reported any kind of mortality due to EP procedures carried out during the pandemic^[4,15]. A total of seven fatalities were reported in these two studies of which three were due to COVID-19. Two studies showed an increase in ventricular tachycardia (VT) ablation rates despite a decline in other EP procedures^[27,28]. One study from Pakistan elaborated on gender and regional disparities in emergency EP procedures documenting a five-fold reduction in-patient volume in centers outside the main city as well as a decrease in the number of women attending the facilities. Although another study from Iran reported no significant difference in EP practice based on sex^[20]. One study^[19] reported worsened patient outcomes due to the postponement of EP procedures. One study showed the impact of postponement on cardiac rhythm management waiting lists during the pandemic^[31].

Discussion

In this systematic review, we report the effect that the COVID-19 pandemic had on EP procedure volumes throughout the world. A decrease in all kinds of EP procedures was observed in all studies

Table 1

Study characteristics.

References	Country	Type of study	Type of procedure mentioned	PreCOVID-19 procedure volume	Procedures during COVID-19	Overall reduction (%)	PostCOVID-19 procedure volume	Summary
Sulaiman <i>et al.</i> ^[10]	Oman	Retrospective cohort	EPS	Not reported	Not reported	50	Not reported	Overall 35% reduction in catheterization lab procedures and 50% reduction in EP procedures
Anca <i>et al.</i> ^[4]	USA	Retrospective cohort	CIED placement EPS	426	115	73	Not reported	EP laboratories in the hot spot areas, with a significant number of COVID-19 positive patients, have had to adapt. 14 EP procedures were reduced to many fold during the pandemic
Boriani <i>et al.</i> ^[11]	Italy	Retrospective cohort	CIED placement EPS	Not reported	Not reported	> 50% for PPM > 50% for ICD > 50% for EPS	Not reported	In this period a reduction of > 50% in the number of implants of cardiac electronic devices was reported, and involved pacemakers and ICDs, with an important reduction not only on ICD implants for primary prevention of sudden death, but also on ICD implants for secondary prevention. The number of ablation procedures was markedly reduced and the reduction also affected emergency procedures, especially for centers directly involved in the care of COVID-19
Compagnucci <i>et al.</i> ^[12]	Italy	Retrospective cohort	CIED placement EPS	592	100	83.1	Not reported	The data reinforce the concept that COVID-19 can have major direct as well as indirect effects on the practice of electrophysiology
Elliot ^[13]	New Zealand	Retrospective cohort	CIED	127	114	10.2	Not reported	The fall in total EP procedures was largely due to reduced elective volumes. The number of in-patient EP procedures has remained relatively constant throughout the lockdown
Fersia <i>et al.</i> ^[14]	UK	Retrospective cohort	CIED	71	28	60.5	Not reported	This UK single-center experience showed that the COVID-19 pandemic has led to a significant reduction in all sections of cardiology service, particularly the intracardiac devices and EP procedures
Li <i>et al.</i> ^[15]	Multicenter (Italy, UK, China)	Retrospective cohort	CIED EPS VT/AF ablation	Milan (Italy): 26.3 week London (UK): 15.1 week Wenzhou (China): 25.3	All centers: 0.85 week	Milan (Italy): 96.7 London (UK): 94.3 Wenzhou (China): 96.6	Wenzhou (China): 20.6 week	Interventional electrophysiology is vulnerable to closure in times of great social difficulty including the COVID-19 pandemic. Intense public health intervention can permit suppression of local disease transmission allowing resumption of some normal activity with stringent precautions
Mazzone <i>et al.</i> ^[16]	Italy	Retrospective cohort	CIED EPS VT/AF ablation Lead extraction LAAC	953	79	91.7	Not reported	Only urgent EP procedures, including ventricular tachycardia ablation and extraction of infected devices, were both maintained and optimized to meet the needs of external hospitals. In addition, most of the nonurgent EP procedures were postponed. Finally, following prompt internal reorganization, both out-patient clinics and on-call services underwent significant modification, by integrating telemedicine support whenever applicable
Pothineni <i>et al.</i> ^[17]	USA	Retrospective cohort	CIED EPS VT/AF ablation	EPS: 781 CIED: 896	EPS: 158 CIED: 475	EPS: 80 CIED: 47 VT: 59 AF: 83 82	Not reported	A strong inverse relationship between regional EP procedure volume and the surge in COVID-19 cases was observed. In addition to physician practice variations, patient avoidance of medical care may have also affected EP case volume similar to the reduction seen in ST-elevation myocardial infarction interventions
Rao <i>et al.</i> ^[18]	USA	Retrospective cohort	EPS	380	68	82	Not reported	Same-day discharge after PCI, pacemakers, ICDs, and routine ablation was encouraged. These have been shown to be safe, preferred by patients, and cost saving. Adoption of 7-day a week model facilitated capability to perform all necessary procedures even on the weekend and reduce length of stay
Satomi <i>et al.</i> ^[19]	Japan	Retrospective cohort	CIED EPS	EPS: 4318 CIED: 1832	EPS: 3671 CIED: 1550	EPS: 8 CIED: 15.3	EPS: 4638 CIED: 1570	Physicians should determine the indication for an elective EP procedure while considering three principle factors: (1) the regional burden of the COVID-19 pandemic, (2) the PPE supply level, and (3) severity of the arrhythmias
Shahabi <i>et al.</i> ^[20]	Iran	Cross-sectional survey	CIED EPS	EPS: 55 CIED: 48	EPS: 11 CIED: 10	CIED and EPS: 80	Not reported	Based on the results of the present study and other surveys, COVID-19 pandemic decreased the numbers of referred patients with cardiac problems for EPS or intracardiac device implantation to hospitals as patients/medical staff fearing to infect of COVID-19 and/or low willingness of the healthcare system to provide these services

Ajl ^[21]	Pakistan	Retrospective cohort	CIED	250	168	32.8	Not reported	A marked reduction in the number of patients who presented for emergency intra cardiac devices and PPM procedures was seen during COVID-19 lockdown. The patients who presented from outside the city of the hospital and women in rural setting were significantly more effected
Arbelo <i>et al.</i> ^[22]	Spain	Retrospective cohort	CIED	250 month Before first lockdown: 70	131 month After first lockdown: 56	56.5	Not reported	During the first wave of the COVID-19 pandemic, a substantial decrease in CIED implantations was observed in Catalonia
Bechlioulis ^[23]	Greece	Retrospective cohort	CIED	Before second lockdown: 146	After second lockdown: 50	First lockdown: 20Second lockdown: 65.7	Not reported	It is evident that during the first wave of COVID-19 pandemic (February 2020–April 2020) a marked decrease of hospital visits and admissions for EP procedures were noted, although emergency pacemaker implantations were not significantly affected in many centers
Budrejko <i>et al.</i> ^[24]	Poland	Retrospective cohort	CIED EPS	932	971	4increase	Not reported	Effort made to restore and further sustain the numbers of electrotherapy procedures throughout the first pandemic year, brought a result that only a few would have predicted in early 2020, that is the maintenance of high volume in most electrotherapy procedures, as supported by the above analysis
Konig ^[25]	Germany	Retrospective cohort	CIED EPS	CIED: 5826 EPS: 4481	CIED: 5391 EPS: 4039	CIED: 7EPS: 10	Not reported	A significant performance deficit for all studied cardiovascular interventions was found in this study
Pescariu <i>et al.</i> ^[26]	Romania	Retrospective cohort	CIED	Not reported	Not reported CIED: 677	DM: 81.8Non-DM: 79.3	Not reported	COVID-19 pandemic determined a dramatic decrease of intracardiac devices related procedures, which were mostly limited to emergency pacemaker implantations. Diabetic patients which are predisposed to develop dilated cardiomyopathy and/or cardiac arrhythmias, requiring more frequently and at a younger age therapy based on intracardiac devices, were particularly affected by the reduction of elective cardiovascular procedures during the COVID-19 pandemic, and that, because of the fear of infection with SARS-CoV-2 virus, they avoided medical services and/or ignored their symptoms
Sezenoz ^[27]	Turkey	Retrospective cohort	CIED EPS	CIED: 762 EPS: not reported	EPS: Not reported	CIED: 11.1EPS: 22.2	Not reported	The study showed that the EP procedures were significantly affected by the outbreak. The pandemic created an unprecedented clinical scenario
Wranicz <i>et al.</i> ^[28]	Poland	Retrospective cohort	CIED EPS	841	742	11.7	Not reported	The total number of selected electrotherapy procedures in the first quarter of 2020 was similar to the quarterly mean value for 2019 (742 vs. 841). Conversely, the number of procedures performed in the second quarter of 2020 was lower than the quarterly mean value for 2019
Ferrari <i>et al.</i> ^[29]	Italy	Retrospective cohort	CIED	42	9	80	Not reported	The impact of COVID-19 on the number of procedures performed has been dramatic: there was a reduction of about 80% during the first semester of 2020 if compared to 2019
Barbhaiya <i>et al.</i> ^[30]	USA	Retrospective cohort	AF ablation	200	111	44.5	Not reported	There was marked reduction of AF ablations in COVID-19 era and the findings demonstrate the feasibility of safe resumption of complex electrophysiology procedures during the COVID-19 pandemic, reducing healthcare utilization and maintaining quality of care
Ding <i>et al.</i> ^[31]	UK	Retrospective cohort	EPS	Not reported	Not reported	52.2	Not reported	The COVID-19 pandemic has had a significant impact on EP services at specialist centers in the UK. The number of procedures performed was greatly reduced in the initial period with latter improvements as better coping strategies were developed. However, the waiting lists for both EP and device procedures have continued to rise steadily

CIED, cardiac implantable electronic device; COVID-19, coronavirus disease 2019; EP, Electrophysiology; EPS, electrophysiology studies; SARS-CoV-2, Severe Acute Respiratory Syndrome Coronavirus 2.

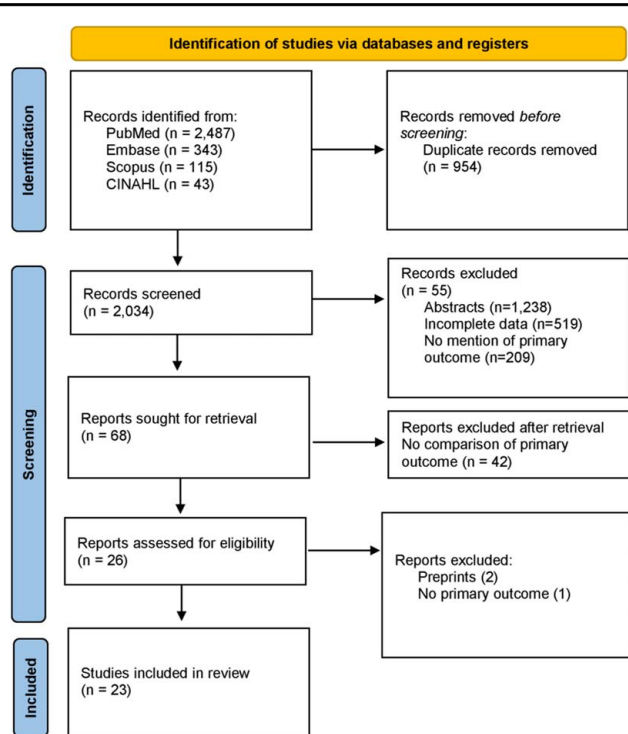


Figure 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses flowchart.

($n = 23$) included in this systematic review, except one^[24] which shows a uniform decline in EP practice throughout the world. The most common reason for this decline was the cancellation or postponement of nonurgent elective EP procedures as a result of organizational restructuring to shift healthcare services towards battling the rising COVID-19 cases in the region. This restructuring of healthcare services was reported in nine (39.1%) studies included in this systematic review. In light of the COVID-19 pandemic and the burden placed on healthcare service delivery, the American College of Cardiology and Heart Rhythm Society released a statement to guide hospitals/healthcare systems in better managing heart rhythm disorders amidst the rising COVID-19 cases. The statement recommended triaging all EP procedures into three categories: urgent, semi-urgent, and non-urgent. The guidelines recommended postponing all urgent/elective cases to decrease patient exposure to infection as well as to better utilize hospital resources towards battling the pandemic^[33]. This restructuring and cancellation of elective procedures might not be the sole reason for the decline in procedure volume and the actual cause might be multifactorial. Nine studies reported an inverse relationship between COVID-19 cases and EP procedure volumes in their hospitals, which also shows the negative impact of the pandemic on electrophysiology service delivery. Seven studies reported their facilities being turned into COVID-19 referral centers, in which cases electrophysiologists and staff involved in cardiac care were re-routed to help in providing care for COVID-19 patients. This shows how healthcare systems adapt to a global public health emergency. Only two studies reported any kind of mortality among patients who underwent EP procedures, of which three deaths were due to COVID-19 infection.

One study conducted in Pakistan that analyzed data regarding EP procedures from 10 hospitals in one province reported regional and gender disparities in emergency arrhythmia procedures among people living outside urban areas, rural cities, and women being disproportionately affected than those living in urban cities^[21]. This indicates how socially and economically disadvantaged populations can be disproportionately affected by the measures applied to combat a global public health emergency and special attention should be placed on these groups in the wake of a pandemic. The impact COVID-19 had on socially and economically disadvantaged communities have been seen in several studies that report communities with low income living in deprived areas and of certain ethnic backgrounds have an increased risk of COVID-19-related death compared to the general population^[34]. Two studies^[27,28] reported an increase in VT ablation procedures despite an overall decline in EP procedure volume. This may be because ventricular tachycardia is a life-threatening condition, and hence VT ablation procedures were undertaken as a matter of priority and classified as urgent non-deferrable cases. These studies; however, did not provide concrete evidence for this reasoning to be established.

The pandemic placed immense strain on the healthcare systems throughout the world; hospitals had to focus their resources on managing the influx of COVID-19 patients, which impacted the delivery of care to other patients. Elective/nonurgent cases were postponed to decrease the load on hospital resources, that is, personal protective equipment, etc. and to lower the risk of infection transmission as well. Telemedicine services were utilized for triaging patients, remote patient monitoring, chronic disease management, and much more thus reducing the risk of infection transmission while still providing healthcare services^[35]. Along with this, the hospital staff was redeployed to COVID-19 ICUs and emergency rooms and some electrophysiologists even served as backup consultants during the time of this emergency^[4]. This restructuring of healthcare services provided us with the resources as well as the manpower to handle the peaks of the pandemic. In addition, the measures enforced by governments throughout the world, including mandatory confinements, strict lockdowns, closing out-patient services, and limiting intercity and international travel all lead to a marked decline in the influx of patients to healthcare centers. It might also be possible that the fear of acquiring the contagion also prevented patients from seeking healthcare. Many other healthcare services also saw a considerable decline during the pandemic, the reasons behind which may be multifactorial and similar to the ones behind EP procedures. A decrease has been reported in ST-segment elevation laboratory activities in the USA^[36] as well as a reduction in hospitalization rates for acute myocardial infarction in Italy^[37]. A similar decline has also been seen in oncology services in many centers throughout the world^[38,39].

Only time will tell about the actual impact of this decline in health-service delivery, but it is still safe to assume that these services will be resumed to prepandemic levels after this public health emergency subsides. Only one study included in this systematic review reported data on postCOVID procedure volumes^[15] in which electrophysiology centers in Wenzhou were able to resume routine activity close to their previous work rates, albeit with strict precautionary measures for COVID-19 due to stringent public health interventions that controlled the spread of disease. It might also be speculated that the postponement of nonurgent elective procedures might cause a resurgence of EP

Study	Risk of bias									Overall
	D1	D2	D3	D4	D5	D6	D7	D8	D9	
Sulaiman	+	+	+	+	+	X	+	+	+	+
Anca	+	+	+	+	+	+	X	+	+	-
Boriani	+	X	+	+	+	X	+	+	+	+
Compagnucci	+	+	+	+	+	X	+	+	X	-
Elliot	+	+	+	+	+	+	+	+	+	+
Li	+	X	+	+	+	X	+	+	+	+
Fersia	+	X	+	X	X	+	+	+	+	-
Mazzone	+	X	+	X	X	+	+	+	+	-
Pothineni	+	+	+	X	+	X	+	+	+	-
Rao	+	X	+	+	+	X	+	+	+	+
Satomi	+	+	+	+	+	X	+	+	+	+
Shahabi	+	X	X	+	X	+	+	X	X	X
Ali	+	+	+	+	+	+	+	+	+	+
Arbelo	+	+	+	-	+	+	-	+	+	+
Bechlioulis	+	+	+	+	+	+	+	+	+	+
Budrejko	+	+	+	+	X	+	+	X	+	+
Konig	+	+	+	+	+	+	+	+	+	+
Pescariu	+	-	+	+	+	+	+	+	+	+
Sezenoz	+	+	+	+	X	+	+	-	+	+
Wranicz	+	+	X	+	+	+	-	+	+	+
Malanchini	+	+	+	-	+	+	+	+	+	+
Barbhaiya	+	+	+	+	+	+	+	+	+	+
Ding	+	+	+	+	+	+	+	+	+	+

D1: Representation of the exposed cohort
D2: Selection of external control
D3: Ascertainment of exposure
D4: Outcome of interest not present at the start of the study
D5: Incomplete outcome data
D6: Comparability of cohorts
D7: Assessment of outcomes
D8: Sufficient followup time
D9: Adequacy of followup

Judgement
X High
- Unclear
+ Low

Figure 2 . Quality assessment (Newcastle–Ottawa scale).

procedures postpandemic as it was only a short-term strategy and only deferred the burden of disease, which might present at a later time. These patients might even present with adverse health outcomes or emergency life-threatening conditions. One study^[19] in our review reported that 8.5% of centers to experience adverse patient outcomes as a result of postponing elective procedures. A case–control study that evaluated the effect of deferral of non-emergency cardiac procedures during the pandemic revealed increased emergency early cardiovascular hospitalizations in

patients whose elective procedures were deferred during the pandemic compared to the control group^[40]. Subgroup analysis revealed that valvular heart disease patients were particularly susceptible to adverse outcomes. Another effect of deferring elective cases could be an increase in the waiting list for these EP procedures. Another study conducted in the UK^[31] in our review reported a 67.8% increase in the waiting list for cardiac rhythm management services as compared to prepandemic levels, which would require almost 3 years to clear this backlog alone. This

effect might also be seen in other elective healthcare services that were postponed during the pandemic^[41,42]. This increase might prolong the waiting times for EP services postpandemic, which will require strategies to manage the patient load efficiently once services are resumed.

A valuable lesson from the COVID-19 pandemic is that healthcare systems across the world need to adopt strategies and develop preparedness for future pandemics. Several studies have demonstrated exemplary adaptation to the challenges in EP practice in this public health crisis. While some modified procedures and recovery areas to accommodate SARS-CoV-2 positive patients, taking strict precautions regarding cleanliness and disinfection, abiding by triage guidelines, and utilizing telemedicine^[2], others even devised their case prioritization schemes^[19]. The decline in emergency, lifesaving procedures can and must be addressed by ensuring the availability of personal protective equipment and the service of SARS-CoV-2 testing to limit the spread of infection. Strict adherence to COVID-19 protocols can prevent postprocedural COVID-19 infections in both patients and staff amidst marked local COVID-19 prevalence. The practice of postprocedural same-day discharge wherever possible and virtual follow-up decreases the duration of hospital stays and provides adequate care to patients^[30].

Limitations

Our review has certain limitations. First, the studies included were retrospective in nature, and data were recorded for administrative rather than research purposes. There is always a chance of bias in the form of incorrect coding and entry of procedures and diagnoses. Most comparisons were made only between pre-COVID 2019 and the pandemic peak in 2020, which means outcomes could have been caused by year-dependent fluctuations in admission numbers. Furthermore, the survey methodology used in two of the included studies is subject to recall and selection bias.

Conclusion

There has been an overall reduction in EP procedure volume across different centers. Postponement of nonurgent electrophysiology procedures was the main reason behind the decline in procedure volumes. An inverse relationship was reported between COVID-19 cases and EP procedure volumes. Very little data was reported on mortality during EP procedures carried out during the pandemic. The impact of the decline in EP procedures will be seen only after the services resume to prepandemic levels, but an increase in-patient volume and procedure waiting times is expected. This review will provide insights into improving healthcare service delivery in times of unprecedented public health emergencies.

Ethical approval

NA.

Consent

Written informed consent was obtained from the patient for the publication of this case report and accompanying images. A copy of the written consent is available for review by the Editor-in-Chief of this journal on request.

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Author contribution

T.A., A.K.A., H.A., R.A., H.I.: first draft, methodology, final draft; S.M.J.Z.: first draft, methodology, final draft; S.M.J.Z., J.M., T.A.: supervision; M.A., M.E., A.A.K., M.N., S.H.: literature review; M.N.R., M.A., J.Z.: first draft, concept, methodology.

Conflicts of interest disclosure

The authors declare that they have no competing interests.

Research registration unique identifying number (UIN)

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2. Unique Identifying number or registration ID: NA.
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