Impact of COVID-19 pandemic on cardiac rhythm management services: Views from the United Kingdom

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BACKGROUND Effects of the COVID-19 pandemic on cardiac rhythm management (CRM) services remain poorly quantified.

OBJECTIVE To describe the impact of COVID-19 on specialist CRM centers in the United Kingdom (UK).

METHODS Two-center study involving the Liverpool Heart and Chest Hospital NHS Foundation Trust and Royal Papworth Hospital NHS Foundation Trust. The first nationwide lockdown lasted from April to July 2020 and the second from December 2020 to March 2021.

RESULTS Compared to the pre-pandemic period, *pandemic 1* (April–July 2020) was associated with a 52.2% reduction in electrophysiology (EP) procedures ($P = .083$), 32.7% reduction in device procedures ($P = .003$), and 36.8% decrease in CRM referrals ($P < .001$). There was also a 13.4% increase in the use of conscious sedation (CS) ($P < .001$) and day-case procedures for EP ($P = .003$), with no change in day-case device procedures ($P = .555$). Corresponding numbers for *pandemic 2* (August–November 2020) were a 0.7% increase in EP procedures ($P = .925$), 7.9% reduction in device procedures ($P = .232$), 13.9% decrease in referrals ($P = .014$), 5.5% increase in CS for EP ($P = .009$), 7.1% increase in day-case EP procedures ($P < .001$), and no change in day-case device procedures ($P = .537$). Corresponding numbers for *pandemic 3* (December 2020–March 2021) were a 31.6% reduction in EP procedures ($P = .001$), 22.3% reduction in device procedures ($P = .006$), 8.4% decrease in referrals ($P = .094$), 11.0% increase in CS for EP ($P < .001$), 7.6% increase in day-case EP procedures ($P = .003$), and no change in day-case device procedures ($P = .146$). By the end of March 2021, the CRM waiting list was 167.8% pre-pandemic levels.

CONCLUSION During the COVID-19 pandemic, specialist centers in the UK were affected such that the number of procedures performed was greatly reduced in the initial period with latter improvements as better coping strategies were developed.

KEYWORDS COVID-19; Pandemic; Cardiology; Electrophysiology; Device; Cardiac rhythm management; Service; Impact; UK

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Introduction

The outbreak of COVID-19 has affected more than 200 million people worldwide, with 4 million confirmed deaths attributable to the disease.[1] In addition to those infected, a large proportion of the population is also being affected by the reallocation of healthcare resources required to meet the pandemic's demands, the impact of which may not be fully realized for many years.[2,3] Overall, there has been a major impact on various healthcare services, though the effect has been heterogeneous.

Trends observed within cardiovascular services included dramatic reductions in healthcare utilization,[4] including emergency care for ST-elevation myocardial infarction, heart failure, stroke, deep venous thrombosis, and pulmonary embolism.[5,6] These may stem from patients' reluctance to seek medical attention owing to fear of infection during hospital visits.[7] Furthermore, cardiovascular procedural numbers were also reduced owing to a number of factors, including available hospital beds and resource reallocation to care for patients with COVID-19; reduced number of healthcare professionals owing to clinical reassignment, sickness, and the need to shield; and increased procedural times owing to added infection control measures.[7]

The effects of COVID-19 on cardiovascular services in specialist centers remain poorly quantified. Here, we aimed to describe the impact of the COVID-19 pandemic on cardiac rhythm management (CRM) service provision in specialist centers across the United Kingdom (UK).

Methods

Setting

The Liverpool Heart and Chest Hospital NHS Foundation Trust (LHCH) and Royal Papworth Hospital NHS

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KEY FINDINGS

- The onset of the pandemic saw drastically reduced numbers of both cardiac rhythm management referrals received and procedures performed.
- Emergency procedure numbers also reduced, however, representing a reluctance of patients to present to hospital, as seen across a wide range of medical emergencies.
- As we developed a better understanding of the disease and adapted our services to cope with the pandemic, there were increased numbers of cardiac rhythm management referrals and procedures performed (though not to pre-pandemic levels), even during the second and third lockdowns in England when there were very high numbers of COVID-19 cases.

Foundation Trust (RPH) are 2 of the 3 largest CRM centers in the UK (Supplemental Figure 1). Both sites are specialist cardiorespiratory centers without accident and emergency departments or direct admission of unselected general medical patients.

Time periods

CRM activity was retrospectively analyzed for both centers between April 2019 and March 2021. For the purposes of this study, April 2019 to March 2020 was defined as the pre-pandemic period and used as a reference to which activity during the COVID-19 pandemic was compared. The time period from April 2020, to coincide with the first lockdown in the UK, which began on March 23, 2020 (Supplemental Figure 2), was defined as the pandemic period. The pandemic period was then divided into 3 separate 4-month periods reflecting the variation in COVID-19 cases nationally and the start and end of national lockdown periods: *pandemic 1* (April–July 2020), *pandemic 2* (August–November 2020), and *pandemic 3* (December 2020–March 2021).

Data collection

Caseload data in terms of referral patterns, procedures, and waiting times relating to CRM activity were collected from institutional databases. Patients who were reviewed by a cardiac rhythm specialist and listed for a procedure were considered to be on the waiting list. CRM data across the UK were obtained from the National Institute for Cardiovascular Outcomes Research online database,[8] which uses standardized data collection methods to collect information about all implanted cardiac devices and all patients receiving interventional procedures for management of cardiac rhythm disorders in the UK. COVID-19 data for the UK were obtained from https://coronavirus.data.gov.uk/.[9] No patient-level data were used. The research complied with the Declaration of Helsinki, the study protocol was approved by the ethics boards at both participating institutions, and all patients provided written informed consent for their procedures.

Patients or the public were not involved in the design, or conduct, or reporting, or dissemination plans of our research.

Statistical analysis

Aggregate data are presented unless otherwise stated. Continuous variables are presented as mean ± standard deviation (SD) and compared using Student *t* test. Categorical variables are presented as count and percentage and are compared using the χ^2 test. A P value of less than .05 was considered statistically significant. Statistical analyses were performed using SPSS version 27 (IBM Corp, Armonk, NY).

Results

Burden of COVID-19

The burden of COVID-19 in the UK and specifically for Liverpool (LHCH) and Cambridge (RPH) is shown in Supplemental Figure 3. Overall trends were similar across both sites, with fewer COVID-19 in-patients during pandemic 2 than pandemics 1 and 3. LHCH and RPH have bed capacities of 187 and 300, respectively. RPH was under a greater strain from COVID-19 during pandemic 1 and pandemic 3, owing to planned regional load-leveling maneuvers (Figure 1). The percentage of beds used for COVID-19 patients at LHCH were 3.8%, 2.5%, and 5.3% during pandemic 1, pandemic 2, and pandemic 3, respectively. At RPH, corresponding numbers were 7.6%, 1.2%, and 11.3%.

CRM referrals and procedures performed

Early in the pandemic period, triage systems with similar criteria were introduced at both sites to prioritize patients based on clinical urgency (Table 1). During the pre-pandemic period, 597 ± 49 monthly referrals were received across both sites. A total of 202 ± 28 ablations and 261 ± 31 device procedures were performed per month. The monthly trends in total numbers of referrals and procedures performed at both sites across the study period are displayed in Figure 2. After the national lockdown that commenced on March 23, 2020, all elective CRM activity ceased for 6 weeks, in accordance with national policy at the time. Compared to the pre-pandemic period, pandemic 1 was associated with a decrease of 36.8% (377 ± 112, $P < .001$) in the number of CRM referrals and reduction of 52.2% (96 ± 83, $P = .083$) and 32.7% (176 ± 66, $P = .003$) in the number of EP and device procedures performed, respectively. While pandemic 2 was associated with a decrease of 13.9% (514 ± 60, $P = .014$) in the number of referrals, both EP (increase of 0.7%, 203 ± 25, $P = .925$) and device procedural numbers (decrease of 7.9%, 240 ± 17, $P = .232$) had returned to similar numbers to pre-pandemic. During pandemic 3, referral numbers were similar to pre-pandemic levels (547 ± 47, $P = .094$ for difference) while numbers of both EP and device procedures were again significantly reduced by 31.6% (138 ± 23, $P = .001$) and 22.3% (203 ± 33, $P = .006$), respectively.

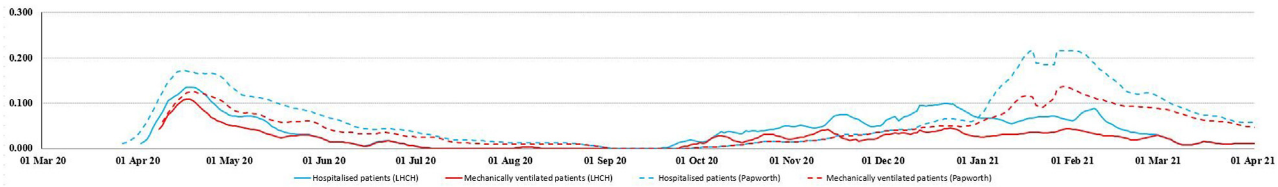


Figure 1 Proportion of hospitalized and mechanically ventilated patients with COVID-19 to bed capacity at Liverpool Heart and Chest Hospital NHS Foundation Trust (LHCH) and Papworth Hospital over a 1-year period, using 7-day rolling averages.

Sedation vs general anesthesia

During COVID-19, anesthetists were redeployed to intensive care units and COVID-19 duties, leading to loss of general anesthesia support for CRM procedures. Overall, there was an increase in the proportion of EP procedures that were performed under light CS during the pandemic period (Supplemental Figure 4). Pre-pandemic, an average of 127 ± 21 monthly EP procedures were performed under CS. Compared to the pre-pandemic period, there was an increase in the percentage of EP procedures that were performed under CS by 13.4% (70 ± 66, $P < .001$) in pandemic 1, 5.5% (139 ± 14, $P = .009$) in pandemic 2, and 11.0% (100 ± 6, $P < .001$) in pandemic 3.

Day case vs overnight stay

The percentage of EP procedures that were performed as day-case procedures (vs overnight stay) increased steadily through the pandemic (Supplemental Figure 5). Pre-pandemic, an average of 129 ± 25 monthly EP procedures was performed as day-case procedures. Compared to the pre-pandemic period, there was an increase in the number of EP procedures that were performed as day-case procedures by 5.4% (69 ± 59, $P = .003$) in pandemic 1, 7.1% (144 ± 16, $P < .001$) in pandemic 2, and 7.6% (98 ± 12, $P = .003$) in pandemic 3.

Pre-pandemic, an average of 166 ± 25 monthly device procedures was performed as day-case procedures. Compared to the pre-pandemic period, there was no significant change in the percentage of device procedures that were performed as day-case procedures (vs overnight stay) in pandemic 1 ($P = .555$), pandemic 2 ($P = .537$), or pandemic 3 ($P = .146$).

Caseload and waiting list

A breakdown of caseload of EP and device procedures at both sites is shown in Supplemental Figures 6 and 7, respectively. Notably, the number of implantable loop recorder implants declined significantly during the pandemic period. In contrast, the number of device extractions remained consistent throughout the 2-year period.

The number of patients on waiting lists for EP and device procedures was fairly consistent during the pre-pandemic period (Figure 3), with a mean of 631 ± 74 patients. However, this figure has risen dramatically during the pandemic such that by the end of March 2021, there were 1059 patients on the CRM waiting list across both sites (455 [282 EP; 173 devices] at LHCH and 604 [452 EP; 152 devices] at RPH). This represents a 67.8% increase above the pre-pandemic levels.

Discussion

In this multicenter study, we described the significant impact that the COVID-19 pandemic has had on CRM services in 2 large tertiary centers in England. The onset of the pandemic saw drastically reduced number of both referrals received and procedures performed. Emergency procedure numbers also reduced, however, representing a reluctance of patients to present to hospital, as seen across a wide range of medical emergencies.[10] As we developed a better understanding of the disease and adapted our services to cope with the pandemic, there were increased numbers of CRM referrals and procedures performed (though not to pre-pandemic levels), even during the second and third lockdown in England when there were very high numbers of COVID-19 cases.

The effects of COVID-19 have also been reported in other cardiology services at district UK hospitals, where there were anecdotal reports of patients avoiding admission owing to fear of developing infection or concern that hospitals may be too overwhelmed to provide appropriate care.[11] Nonetheless, it seems that CRM services have been more badly affected by the COVID-19 pandemic when compared with other cardiology services.[12] The COVID-19 pandemic has had a similar impact on clinical activities relating to arrhythmias and EP in other parts of the world.[13,14] In Italy, a survey of 104 physicians from 84 centers found that more than 95% and 75% of centers had a significant reduction in the number of elective pacemaker implantations and ablation, respectively, during the initial 2 months of the pandemic (March–April 2020) compared to the corresponding 2 months of the year 2019. There has been a reduction across all cardiology performance indicators, from referrals to investigations, diagnoses, and management, owing to a shift in focus to deal with the COVID-19 pandemic and patients' reluctance to seek medical attention.[15] Widespread adoption of clinical priority scoring which, quite appropriately, prioritizes those patients with life-threatening disease, may also exacerbate waits for patients with arrhythmia.

Impact on waiting list

Worryingly, the number of patients on the CRM waiting list has steadily risen such that with return to pre-pandemic levels of activity, it will likely require up to 3 years to clear the current backlog. Given that similar pressures are being described

Table 1 Triage system at Liverpool Heart and Chest Hospital NHS Foundation Trust and Royal Papworth Hospital NHS Foundation Trust

Category 1 (high risk)
Secondary prevention ICD or CRT-D
PPM for high grade AV block
PPM for syncope and an approved indication for pacing
Generator changes for PPM / ICD / CRT-D at EOL
Lead revision for fracture/dislodgement leading to arrhythmia, hemodynamic compromise, inappropriate shock, and/or hospital admission
Lead extraction in sepsis
VT ablation in medically refractory electrical storm
Ablation of wide complex tachycardia leading to syncope
Ablation of pre-excited AF
Ablation of atrial arrhythmias with uncontrolled ventricular rate leading to decompensated heart failure despite maximum medical therapy
Category 2 (intermediate risk)
Primary prevention ICD for increased risk of SCD
Generator changes for PPM / ICD / CRT-D at ERI
CRT-D / CRT-P for recurrent heart failure hospital admissions and an approved device indication
ILR for recurrent or malignant syncope
PPM / CRT prior to AV node ablation for AF and unstable heart failure
Lead revision for fracture/dislodgement leading to symptoms but low risk of arrhythmia, hemodynamic compromise, inappropriate shock, and/or hospital admission
LAA occlusion procedures
AV node ablation for coexisting arrhythmias and heart failure with device in situ
Ablation of atrial arrhythmias with recurrent AED visits and/or hospital admissions
Category 3 (Low risk)
Primary prevention ICD or CRT-D
PPM for sinus node dysfunction
CRT-P for pacing-induced cardiomyopathy
LV lead revision in stable patient
PPM / CRT prior to AV node ablation for AF and stable heart failure
ILR for arrhythmia monitoring or unexplained symptoms
SVT ablation
AF ablation
Atrial tachycardia or atrial flutter ablation
Ablation of idiopathic VT or PVC
AV node ablation in stable patient
Diagnostic EPS
Routine cardioversion

AED = accident and emergency department; AF = atrial fibrillation; AV = atrioventricular; CRT = cardiac resynchronization therapy; CRT-D = cardiac resynchronization therapy defibrillator; CRT-P = cardiac resynchronization therapy pacemaker; EOL = end of life; EPS = electrophysiology study; ERI = elective replacement indication; ICD = implantable cardioverter-defibrillator; ILR = implantable loop recorder; LAA = left atrial appendage; LV = left ventricular; PPM = permanent pacemaker; PVC = premature ventricular complex; SCD = sudden cardiac death; SVT = supraventricular; VT = ventricular tachycardia.

across the health service, and many of the conditions being treated with ablation are not immediately life-threatening, it may be argued that such patients "will have to wait." However, when considering atrial fibrillation (AF) in particular, which not only is the most common reason for interventional CRM treatment but also is a condition with significant morbidity and associated healthcare costs, strategies will be required to reduce or mitigate the prolonged waiting times. It is well recognized that catheter ablation is more successful for paroxysmal than persistent AF,[16,17] and a proportion of patients will transition to more persistent forms of arrhythmia during a prolonged time on the waiting list. Those already in persistent AF will expect their chances of maintaining sinus rhythm to drop further if allowed to continue in AF for a year or more. In fact, it has previously been suggested that patients with persistent AF of more than 2 years' duration should not undergo ablation, and a significant number of patients could cross this threshold on the extended waiting lists. Because this study reports data from 2 specialist cardiac centers, it can be assumed that waiting lists in CRM departments in general hospitals where the impact of COVID-19 admissions has been higher will likely have increased by even greater proportions.

Furthermore, recent evidence suggests that there may be a mortality benefit in early rhythm control among patients with AF[18] and that catheter ablation may be superior to antiarrhythmic drugs as a first-line treatment.[19] Translating this evidence base for an early interventional approach into clinical practice will be extremely challenging in the face of already overburdened waiting lists. Therefore, there is a need to recruit additional staff (anesthetists, technicians, and staff nurses) to facilitate the delivery of more CRM procedures and reduce the impact if a similar situation were to arise again.

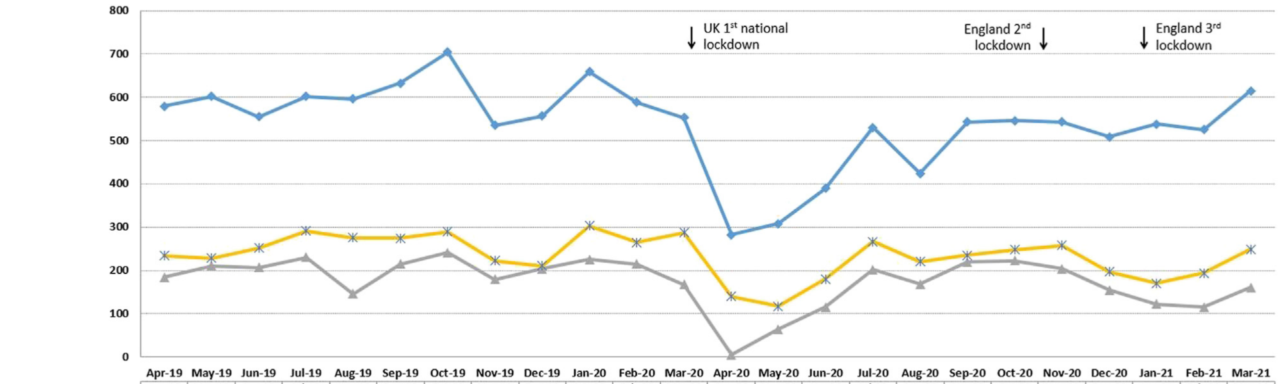
Impact on procedural delivery

The increase in waiting lists described above will necessitate a variety of additional strategies not only to prioritize high-risk patients but also to improve procedural capacity and efficiency while protecting a workforce already at high risk of burnout. Increased number of patients treated as a day case may help by reducing the need for already in-demand in-patient beds. Undertaking procedures without the need for general anesthesia may both facilitate day-case operation and reduce associated infection control risks. From our experience, we found that both these strategies were effective at dealing with some of the challenges imposed by the COVID-19 pandemic and will likely continue to have a role in the future.

Clinical training for physicians

The reduced levels of CRM activity have also had negative consequences on clinical training for physicians subspecializing in cardiac EP and/or devices such that the decreased procedural volume may jeopardize the preparedness of trainees for independent practice,[20] thereby having implications on the future delivery of healthcare in this area. This is especially pertinent in light of the growing number of patients on the CRM waiting list—many of whom will have their treatment delayed by several years in the current climate.

Overall, though the COVID-19 pandemic has had an unprecedented detrimental impact on healthcare provision



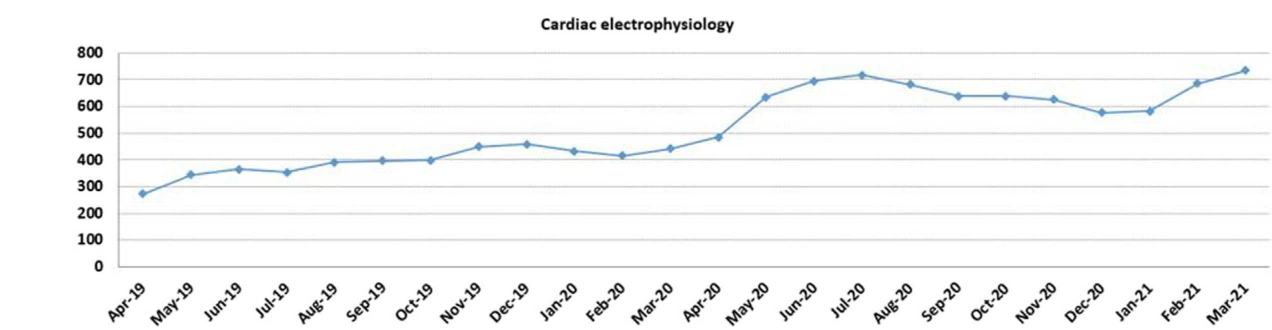
	Apr-19	May-19	Jun-19	Jul-19	Aug-19	Sep-19	Oct-19	Nov-19	Dec-19	Jan-20	Feb-20	Mar-20	Apr-20	May-20	Jun-20	Jul-20	Aug-20	Sep-20	Oct-20	Nov-20	Dec-20	Jan-21	Feb-21	Mar-21
CRM referrals	579	602	555	602	596	633	704	535	557	659	588	553	282	308	389	530	424	543	546	543	509	538	525	615
Number of EP cases performed	184	210	206	230	145	214	241	179	203	225	214	167	5	64	115	201	168	219	222	203	154	122	115	160
Number of device cases performed	234	228	252	291	275	274	289	222	210	303	264	287	139	117	180	266	220	235	248	258	197	170	194	249

Figure 2 Overview of cardiac rhythm management services at Liverpool Heart and Chest Hospital NHS Foundation Trust (LHCH) and Papworth Hospital over a 2-year period. CRM = cardiac rhythm management; EP = electrophysiology.

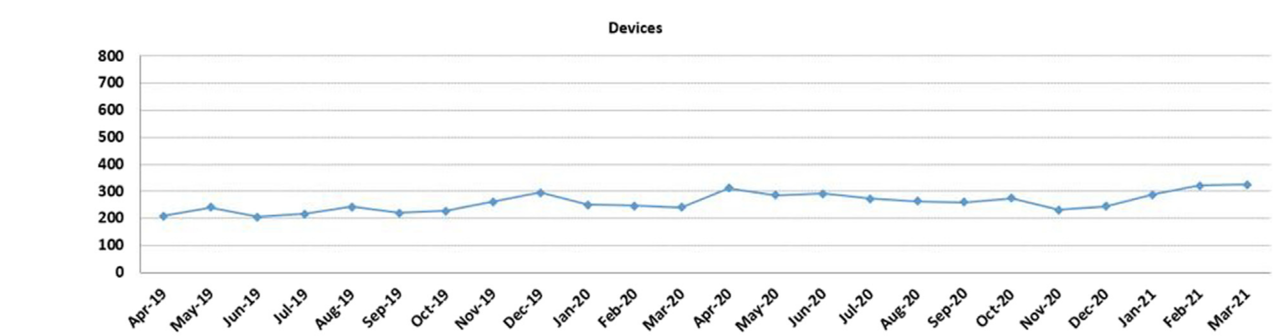
globally, and certainly within the field of CRM, there has been incredible effort made to cope with the situation, including an increased use of digital health and telemedicine.[21] Moving forward, these are likely to have significant benefits to clinical practice and the delivery of holistic care to patients.

Limitations

This study is limited by the small number of participating centers. Furthermore, as it only included UK centers and those without an accident and emergency department, these observations may not be generalized, though it is likely the trend was similar, given the reports from few other



	Apr-19	May-19	Jun-19	Jul-19	Aug-19	Sep-19	Oct-19	Nov-19	Dec-19	Jan-20	Feb-20	Mar-20	Apr-20	May-20	Jun-20	Jul-20	Aug-20	Sep-20	Oct-20	Nov-20	Dec-20	Jan-21	Feb-21	Mar-21
EP waiting list	272	343	365	354	391	396	398	450	458	433	415	441	484	635	695	717	683	639	638	626	577	582	685	734



	Apr-19	May-19	Jun-19	Jul-19	Aug-19	Sep-19	Oct-19	Nov-19	Dec-19	Jan-20	Feb-20	Mar-20	Apr-20	May-20	Jun-20	Jul-20	Aug-20	Sep-20	Oct-20	Nov-20	Dec-20	Jan-21	Feb-21	Mar-21
Device waiting list	210	241	206	216	243	221	227	262	295	250	247	240	311	285	292	273	264	259	275	232	244	287	321	325

Figure 3 Number of patients on the waiting list for cardiac electrophysiology and device procedures at Liverpool Heart and Chest Hospital NHS Foundation Trust (LHCH) and Papworth Hospital over a 2-year period. EP = electrophysiology.

centers/countries. The impact of COVID-19 may have been underestimated in these centers, given the relatively low number of beds that were used to care for COVID-19 patients. Further, the clinical impact of these observations was beyond the scope of this study and not evaluated.

Conclusion

The COVID-19 pandemic has had a significant impact on CRM 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. There is a need for greater efficiency in healthcare systems to deal with the impending challenge.

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Authorship: All authors attest they meet the current ICMJE criteria for authorship.

Patient Consent: All patients provided written informed consent.

Ethics Statement: The research reported in this study was conducted according to the principles of the Declaration of Helsinki. The study was approved by the ethics boards at both participating institutions.

Data Availability Statement: The data underlying this article will be shared on reasonable request to the corresponding author.

Appendix

Supplementary data

Supplementary data associated with this article can be found in the online version at https://doi.org/10.1016/j.hroo.2022.05.013.

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