**Electrophysiology in the time of coronavirus:**

**Coping with the great wave**

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 **ABSTRACT**

**Aims:** To chart the effect of the COVID-19 pandemic on the activity of interventional electrophysiology services in affected regions.

**Methods:** We reviewed the electrophysiology laboratory records in 3 affected cities: Wenzhou in China, Milan in Italy and London, United Kingdom. We inspected catheter lab records and interviewed electrophysiologists in each centre to gather information on the impact of the pandemic on working patterns and on the health of staff members and patients.

**Results:** There was a striking decline in interventional electrophysiology activity in each of the centres. The decline occurred within a week of the recognition of widespread community transmission of the virus in each region and shows a striking correlation with the national figures for new diagnoses of COVID-19 in each case. During the period of restriction, workflow dropped to <5% of normal, consisting of emergency cases only. In 2 of 3 centres, electrophysiologists were redeployed to perform emergency work outside electrophysiology. Among the centres studied, only Wenzhou has seen a recovery from the restrictions in activity. Following an intense nationwide program of public health interventions, local transmission of COVID-19 ceased to be detectable after February 18th allowing the electrophysiology service to resume with a strict testing regime for all patients.

**Conclusion:** 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.

**Key Words:** Catheter ablation; pandemic; COVID-19; electrophysiology; arrhythmia; ablation

**CONDENSED ABSTRACT**

COVID-19 has affected every aspect of life worldwide. In the electrophysiology labs of Wenzhou, Milan and London, activity was suspended as the disease took hold. Only Wenzhou has resumed normal services, facilitated by a monumental nationwide program of public health interventions and supported by stringent testing protocols.

**WHAT’S NEW**

* We describe the impact of the COVID-19 pandemic on interventional electrophysiology units in 3 cities: Wenzhou, Milan and London.
* In all cases, the routine work of the electrophysiology was virtually suspended within a week of the recognition of widespread virus transmission in the area.
* During the period of restricted activity imposed by the pandemic, centres have dealt with a small number of emergency ablations only, a balanced mix of atrial, ventricular and junctional arrhythmias.
* In 2 of the 3 centres, electrophysiologists were redeployed to perform other medical duties including in COVID-19 wards.
* COVID-19 infection occurred in medical and nursing staff in 2 of the 3 centres.
* Only in the cases of Wenzhou, China, has a resumption of normal activity been possible; this follows intensive public health intervention and is protected by stringent testing.

**BACKGROUND**

The COVID-19 pandemic has caused suffering and death across the world since late 2019.1,2 Physicians and journalists witnessing its arrival typically describe a wave, a tide or a tsunami of disease. It has had a widely publicised impact on the economy of afflicted areas. Medical services have suffered massive disruption. Even services far removed from respiratory medicine and critical care have suffered because of the diversion of resources needed to support the victims of the epidemic and through the illness of staff. As a resource-intensive speciality that deals predominantly with non-emergency cases, interventional electrophysiology is particularly vulnerable to disruption.

While the pandemic disrupts the delivery of routine electrophysiology services, COVID-19 is associated with cardiac complications which could bring an additional burden of acute problems to electrophysiology.3-5 The relative importance of the reduction in elective cases and any increase in emergency work is undefined.

Wenzhou, Milan and London are cities with a metropolitan area population of more than 4 million people; each has been struck by the pandemic. In January 2020, Wenzhou experienced the greatest concentration of COVID-19 cases of any Chinese city outside the Hubei province.6 Following an intense nation-wide program of public health interventions7, new cases declined and have now vanished. As of April 6th, 2020, Wenzhou has had no new case of COVID-19 for the last 48 consecutive days. With this, many sectors have begun to return toward normality with stringent precautions. Milan was close to the centre of the Italian outbreak of COVID-19 and had to suspend all activity the first week in March.8 London, like the rest of the United Kingdom has seen an abrupt rise in the disease incidence only since the second week of March 2020.9 The disruption for cardiac electrophysiology labs has begun.

**METHODS**

We reviewed the catheter lab records of electrophysiology laboratories in each contributing centre. The workflow was quantified before and during the period of restriction of normal activity imposed by COVID-19, and in the case of Wenzhou in the period after restrictions were lifted. The impact on workflow was correlated with the national burden of COVID-19. We charted the burden of emergency procedures performed to look for evidence of any augmentation of these arising from COVID-19; we also examined the record for information about procedures performed for arrhythmias in patients with COVID-19 and enquired from the front-line, arrhythmic complications encountered in the COVID-19 population. We looked for instances of COVID-19 infection acquired in hospital by electrophysiology patients and staff. We documented the protocols used to limit the risk to patients and staff during the period of high burden of COVID-19 and the protocols used to permit the resumption of activity after the first wave of the epidemic.

**RESULTS**

The first diagnosis of COVID-19 in Wenzhou Medical University was in mid-January 2020; in Lombardy a large outbreak became evident on February 22nd, whilst in St George’s Hospital, London cases began to arrive in large number from the second week in March. In all cases, there was a sharp downturn in activity within days after the recognition of widespread COVID-19 transmission in the area **(figure 1).**

*Effect on routine work*

In each of the centres, routine activity of the EP lab was suspended within a week of the first locally transmitted COVID-19 case admitted to the hospital **(table 1).** The primary reason for the prompt suspension in each case was the concern that continuing to admit patients for elective procedures would expose them to the risk of infection from undiagnosed COVID-19 patients already in the hospital.

*Nosocomial Infection*

One patient in London acquired COVID-19, apparently in hospital after her ablation. She died of pneumonia associated with the condition at 18 days after the ablation. Two electrophysiologists in London including a co-author of this paper acquired COVID-19, probably in-hospital and recovered without complication. Three nurses in a cardiology ward in Milan were infected, but none of the electrophysiologists. In Wenzhou, no staff member was infected.

*Electrophysiological emergencies during the COVID-19 crisis*

We encountered no instance of an arrhythmia occurring as a consequence of COVID-19 that required ablation. A small number of patients required emergency electrophysiological study or ablation during the period of restricted activity **(table 2, figure 2)**, but this represented less than 5% of the normal workload of the centres. The distribution of cases was similar to that encountered in normal times with supraventricular tachycardia, ventricular tachycardia and atrial fibrillation all represented.

*Resumption of normal activity*

Of the centres involved, only Wenzhou has been able to resume routine activity. This followed country-wide suppression of the epidemic by an intensive program of public health interventions. Having achieved the virtual elimination of virus transmission in most parts of China by late February, routine activity resumed with stringent precautions:

1. Patients underwent a pre-assessment visit the day before the planned hospital admission. At this visit, a history was taken with specific questioning to exclude any pyrexial illness or cough in the previous 2 weeks. Computer tomography of chest was performed to rule out the presence of peripheral consolidation. A nasal swab was taken and was analysed immediately by polymerase chain reaction for evidence of viral genetic material. Results were available within 2 hours.
2. Patients with a satisfactory screening visit were admitted on the morning of the scheduled procedure and underwent a second nasal swab. If this also was negative for viral genetic material, the procedure went ahead as planned.

At the time of writing, this protocol has been in effect for 6 weeks and has been applied to 85 patients; no instance of transmission of infection has occurred.

*Outpatient activity*

In all centres, outpatient activity was moved to a telephone-based or internet-based format in all possible cases from the time that widespread local transmission of the virus was recognised. Only those who were clinically urgent and were unable to use a telephone or required an instrumental test were allowed to keep their physical appointments. Outpatient investigations were cancelled unless clinically urgent. Patients who had access to mobile phone associated ECG recording were encouraged to use these and transmit recordings in preparation for telephone consultations.

*EP Education*

As part of social distancing, all EP educational meetings were suspended in all centres, including grand rounds, multi-disciplinary team meetings, small-group teaching and journal clubs. All major national and international meetings have been cancelled. Electronic learning has been used but does not replace all of the activities that have been cancelled. Major medical examinations including medical school and postgraduate tests have been deferred indefinitely.

*EP team redeployment*

The EP team in each of the centres defaulted to emergency mode at the arrival of the first COVID cases. With elective work cancelled, the electrophysiologists concentrated on urgent inpatient intervention including pacemaker implantation to minimise the time that any patient had to spend in hospital. The centres differed in their policies on redistributing staff to other duties **(table 1)**.

**DISCUSSION**

“*I think it better that in times like these*

*A poet's mouth be silent, for in truth*

*We have no gift to set a statesman right” William Yates10*

The electrophysiologist, like the poet is a luxury that society may dispense with when times are exceptionally difficult. Our work reduces symptoms; in narrow subgroups we may increase life expectancy, but only marginally. In achieving this we expend resources that may be better used elsewhere in difficult times and we bring patients into a healthcare environment that is dangerous in the presence of epidemic disease. We have no expertise that is relevant to managing an epidemic, but we have qualities that might be useful indirectly: Being so vulnerable to cancellation, the cessation or resumption of our work may serve as an indicator of the progress of the fight against contagion.

The present study shows that in representative centres from several of the worst-affected countries, the arrival of COVID-19 caused a complete cessation of routine electrophysiological intervention. A small number of urgent ablations were performed in patients without infection. Although arrhythmias were encountered in patients hospitalised with COVID-19, no instance was encountered of an arrhythmia arising from COVID-19 requiring urgent ablation.

*COVID-19 and the cardiovascular system*

Severe acute respiratory syndrome coronarvirus-2 (SARS-CoV-2), the agent responsible for COVID-19 has an affinity for angiotensin converting enzyme 2 (ACE2) receptors.11 This is central to the pathophysiology of the condition, leading to pneumonia and in critical stages, to multi-organ failure.12 The organ primarily affected is the lung, but cardiovascular injury is also common and those with a rise in Troponin I are more likely to require admission into intensive care13. There is enhanced expression of ACE-2 in those with cardiovascular conditions, possibly accounting for the apparent greater severity of COVID-19 related illness in these patients. Of those with severe infection 44% had a history of ‘arrhythmia’13 and a majority (58%) had a background of hypertension.14 This could relate to up-regulation of ACE2 receptors in those receiving ACE inhibiting drugs, but the link is not strong enough to mandate alterations of therapy.15

A history of ischaemic heart disease also predicts mortality in COVID-19, potentially because COVID-19 like any acute inflammatory condition can destabilise coronary plaque and trigger acute coronary syndromes. It is not clear whether the apparent high mortality in patients with ischaemic heart disease represents an effect on ACE2 receptor expression, a vulnerability to ischaemic complications of the systemic illness or a bias against such patients when ventilators must be rationed. Brugada syndrome is a concern as the fever of COVID-19 has the propensity to trigger arrhythmias. Other inherited conditions are unlikely to be directly relevant but experimental treatments for COVID-19 include anti-retrovirals and hydroxychloroquine which may prolong the QT interval. No instance of arrhythmia from this source has been reported.

*Protecting EP patients and Healthcare providers*

The risk of COVID-19 transmission to healthcare workers is high, with healthcare workers accounting for over 8% of cases reported in Italy.16 Ophthalmologists have been disproportionately affected, probably because of the close contact with the patients in whom conjunctivitis has been a presenting symptom. Intensivists are at risk due to their inevitable extensive contact with severely affected patients and due to aerosol generation during intubation. Cardiology, including ablation and trans-esophageal echo also involves aerosol generation. Under current conditions, these procedures should be undertaken with strict infection control including the use of personal protective equipment (PPE). Protecting staff is vital also to protecting the patients subsequently treated by these staff.

Most patients scheduled for EP procedures fall into categories at high risk of death if exposed to COVID-19. In the London cohort, the average age is 65, and >60% are male.17 Co-existing diabetes, hypertension or heart failure are common, all strong risk factors for COVID-19 related mortality. Not all EP patients can wait on indefinitely. Recent UK guidelines18 include narrow criteria for ablation in this crisis, recommending that it is limited to cases of rapidly conducted pre-excited atrial fibrillation, heart failure secondary to tachycardia, and ventricular tachycardia that is uncontrollable with medication. All of the ablations conducted in all 3 centres during the period of restricted activity met these criteria (**figure 2, table 2)**,and all were performed with strict precautions to minimise the risk to patients and staff including the use of PPE. Local protocols mirrored published consensus documents.19

*Public Health Measures*

Before COVID-19, China was already experienced in infection control protocols due to their experience of Severe Acute Respiratory Syndrome (SARS) in 2002-2003. Once the seriousness of the outbreak was recognised in mid-January, central government took direct responsibility for its handling, introducing an integrated set of control measures.7 Best publicised was the lock-down of society and industry to achieve extreme social distancing. A vital adjunct to the lock-down was a system for screening all persons with fever or cough or with a history of contact with known cases, so that they could be isolated in designated facilities. The use of electronic technology and surveillance served as an adjunct to these measures. Other Asian countries with experience of SARS instituted public health measures that were different in detail but similarly intense, also focused on testing, tracing and isolating. In contrast, without any recent experience to draw on, Italy and the UK were unprepared for the scale of the events.

The short-term impact of China’s program of public health measures is evident from the progression of the epidemic (**figure 1**). In China, all necessary measures were brought into being at a time when deaths were in low double figures. In Italy and in the UK as across Europe, distancing measures were introduced piecemeal and later in the course of events, and the infrastructure for the identification of infected individuals and the tracing, testing and isolation of contacts has not been developed uniformly.

The experience from Wenzhou shows that with energetic public health intervention sufficient to suppress the epidemic, aspects of normal life may resume with extreme caution. In the longer term, a vaccine may permit us to dispense with these precautions. The less stringent interventions chosen by the UK and other North European countries risk allowing an epidemic that drags on until a vaccine is available.

**CONCLUSION**

In the Spring of 2020, as in the Summer of 1914, it feels as though “the lamps are going out all over Europe”20, but there is reason for hope. Vigorous public health measures have suppressed the epidemic in parts of Asia, permitting a resumption of aspects of normal life with stringent precautions, including the performance of routine electrophysiological procedures.

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TABLES

**Table 1:** Effects of COVID-19 on electrophysiology staff and services.

|  |  |  |  |
| --- | --- | --- | --- |
|  | Wenzhou | Milan | London |
| Cessation of routine ablations | yes | yes | yes |
|  |  |  |  |
| Redeployment of electrophysiologists |  |  |  |
|  non-EP acute cardiology | yes | yes | yes |
|  intensive care | no | no | yes |
|  COVID-19 ward, non-intensive | yes | no | yes |
|  |  |  |  |
| Nosocomial COVID-19 in electrophysiology |  |  |  |
|  patients infected | 0 | 2 | 1 |
|  electrophysiologists infected | 0/5 | 0/10 | 2/9 |
|  other department staff infected | 0 | 3 nurses | 0 |

**Table 2:** Effects of the pandemic on electrophysiology activity.

|  |  |  |  |
| --- | --- | --- | --- |
|  | Wenzhou | Milan | London |
| Period of restricted activity: | Jan 23rd to March 2nd 2020 | From 5th March 2020 (ongoing) | From 16th March 2020 (ongoing) |
| Electrophysiological studies and ablations performed during this period: |  |  |  |
| electrophysiological study alone | 0 | 2 | 0 |
| ablation for atrial flutter | 1 | 0 | 0 |
| supraventricular tachycardia | 1 | 0 | 0 |
|  ventricular tachycardia / ectopy  | 3 | 1 | 0 |
|  atrial tachycardia / fibrillation | 2 | 0 | 1 |
| Arrhythmias ablated in COVID-19 patients | 0 | 0 | 0 |

**FIGURE LEGENDS**

**Figure 1:** Chronology of events in the first 96 days of 2020.

In each of the electrophysiology labs, routine activity ceased as soon as significant numbers of COVID-19 cases were diagnosed in the vicinity. A few emergency procedures were performed during the suspension of routine activity. Of the 3 centres, only Wenzhou has been able to resume routine activity.



**Figure 2:** Impact of the COVID-19 epidemic on workflow in electrophysiology.

The pie-charts indicate the mean number of each category of each procedure carried out per week in 2020 in each centre. In the period before COVID-19 arrived, the centres averaged 20.8 cases per week; in the period of restricted activity this dropped to 0.85 cases per week, without significant alteration in the breakdown of procedure types. Wenzhou has resumed elective procedures at close to their previous work-rate.



