Risk of COVID-19 infection after cardiac electrophysiology procedures

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BACKGROUND During the COVID-19 pandemic, attempts to conserve resources and limit virus spread have resulted in delay of nonemergent procedures across all medical specialties, including cardiac electrophysiology (EP). Many patients have delayed care and continue to express concerns about potential nosocomial spread of coronavirus.

OBJECTIVE To quantify risk of development of COVID-19 owing to in-hospital transmission related to an EP procedure, in the setting of preventive measures instituted in our laboratory areas.

METHODS We contacted patients by telephone who underwent emergent procedures in the electrophysiology lab during the COVID-19 surge at our hospital (March 16, 2020, to May 15, 2020, reaching daily census 450 COVID-19 patients,) 2 weeks after the procedure, to assess for symptoms of and/or testing for COVID-19, and assessed outcomes from medical record review.

RESULTS Of the 124 patients undergoing EP procedures in this period, none had developed documented or suspected coronavirus infection. Seven patients described symptoms of chest pain, dyspnea, or fever; 3 were tested for coronavirus and found to be negative. Of the remaining 4, 2 had a more plausible alternative explanation for the symptoms, and 2 had transient symptoms not meeting published criteria for probable COVID-19 infection.

CONCLUSION Despite a high hospital census of COVID-19 patients during the period of hospital stay for an EP procedure, there were no likely COVID-19 infections occurring in follow-up of at least 2 weeks. With proper use of preventive measures as recommended by published guidelines, the risk of nosocomial spread of COVID-19 to patients in the EP lab is low.

KEYWORDS Ablation; Coronavirus; Electrophysiology; Implantation; Nosocomial transmission

Introduction
The current pandemic associated with the coronavirus disease 2019 (COVID-19) has conferred an unprecedented stress on the U.S. healthcare system. To mitigate the risk of iatrogenic infection and facilitate rationing of personal protective equipment (PPE), ventilators, and hospital beds, a variety of stakeholders including policymakers, payers, and professional societies issued guidelines for postponing elective procedures. In electrophysiology (EP), the Heart Rhythm Society COVID-19 task force specifically recommended postponing left atrial appendage occlusion, ablation in clinically stable patients, and many cardiac implanted electronic device (CIED) implants.1 Following the Connecticut governor’s declaration of a Public Health Emergency on March 10, Yale New Haven Hospital leadership enacted its Disaster Plan, including a decision to halt elective procedures on March 16. The COVID-19 inpatient census at Yale New Haven Hospital rose to a peak of 450 cases in mid-April before gradually declining again in early May. During this period, emergent cardiac EP procedures continued, including pacemaker placement for severe bradycardia, generator replacement for those CIEDs nearing end of service, cardioversion for severely symptomatic atrial arrhythmias refractory to rate control, ventricular tachycardia ablation for refractory ventricular tachycardia, and device extraction for infected CIEDs. A number of measures were instituted to protect patients who did require emergent procedures, including increasing use of masking / other PPE, and preprocedure testing, facilitating appropriate cohorting and patient flow, as well as protocols and education regarding their use (Figure).

A fluctuating landscape requires a dynamic assessment of the risks and benefits of delaying routine healthcare. In many areas, hospitalization rates for COVID-19 are decreasing, and patients who have postponed nonemergent healthcare continue to accrue. In addition, there
has been increasing recognition of morbidity and mortality associated with delays in cardiac care, including arrhythmia procedures such as biventricular implantable cardioverter-defibrillator implantation for those with advanced heart failure and ablation for those with severe symptoms from atrial fibrillation or atrial flutter. These considerations, along with increased testing and PPE resources, have led policymakers, health system administrators, and physicians in many areas to reopen facilities for nonemergent care.

However, the COVID-19 exposure risk in this setting remains unquantified, with varying reports of in-hospital transmission among hospitalized patients. Anecdotally within our community patients have continued to express hesitancy to proceed with elective procedures, and accounts from the lay press suggest similar sentiments nationally. As part of a quality initiative, we performed systematic follow-up after discharge to determine rates of COVID-19 infection among patients who underwent EP procedures during the current COVID era.

Methods
Patients undergoing procedures in the Cardiac EP Laboratories at Yale New Haven Hospital between March 16, 2020, and May 15, 2020 were contacted by telephone for follow-up. Patients were asked in a structured interview format about any postprocedure testing for COVID-19 and presence and time frame of any symptoms, in themselves or anyone in their household or family, including fever, cough, dyspnea, or chest pain, or hospitalization since the procedure. Data were obtained by telephone for 117 patients (94%) and chart review for the remainder. The population was 67% male with a mean age of 69 (standard deviation [SD] 14) years. Procedures included CIED implants (n = 56) or revisions (n = 22), EP studies/ablations (n = 19), and cardioversions (n = 27). Clinical, hospitalization, and procedure-related characteristics are shown in the Table.

Results
A total of 124 patients met inclusion and exclusion criteria and were contacted for follow-up. Data were obtained by telephone for 117 patients (94%) and chart review for the remainder. The population was 67% male with a mean age of 69 (SD 14) years. Procedures included CIED implants (n = 56) or revisions (n = 22), EP studies/ablations (n = 19), and cardioversions (n = 27). Clinical, hospitalization, and procedure-related characteristics are shown in the Table.

There were 2 deaths during the follow-up interval: 1 94-year-old patient was admitted emergently with complete heart block and heart failure that failed to improve with pacing and ultimately died during the index admission. This patient tested negative for COVID on the date of death. The second patient was a long-term care facility resident with death occurring >60 days after an implantable cardioverter-defibrillator generator change.

Of the remaining patients, 7 (6%) described 1 or more of the symptoms assessed. Three of these patients had COVID testing after symptom onset, which was negative. Of the 4 not tested, 1 described chest pain diagnosed as ischemia and underwent angioplasty. Another with dyspnea was diagnosed owing to pericarditis with increased atrial fibrillation burden. One patient described a 3-day isolated fever with temperature not exceeding 99°F. The final patient had transient dyspnea for the first 3 days after atrial fibrillation ablation that self-resolved but was never tested for COVID-19. No patient described illness in a household or family member.

Discussion
In this systematic follow-up of 124 patients who underwent cardiac EP procedures during the peak COVID period in our health system, no patients were diagnosed with COVID-19, nor were any cases suspicious for COVID-19 identified, despite a high census of COVID-19 at our institution. Four patients described symptoms commonly associated with COVID-19 illness and were not definitively ruled out for infection; however, 2 of these patients had an alternative explanation for the symptoms and in the other 2, symptoms were minimal, brief, and in time frames not suggestive of infection in the EP laboratory (ie, immediately after); thus, none met published criteria for probable COVID-19.
There has been interest internationally in assessing hospital-acquired infection rates for patients and healthcare providers. High reported rates of nosocomial spread in the initial stages of disease before transmission routes were fully understood remain highly publicized and frequently cited. More recent accounts internationally have reported much lower rates of hospital-acquired infection in the setting of escalating precautions. However, since the United States is in the nascent stages of reopening for elective care, there have been no large systematic studies in U.S. healthcare settings. Further, no prior studies have systematically evaluated risk of infection from exposure to the hospital setting during periods of high COVID-19 census through follow-up to 2 weeks after possible exposure, the accepted time frame for development of symptoms. Patient exposure rates were assessed to be low in China in the prepandemic stage; however, this study was conducted at a time when the overall viral prevalence remained low, thereby reducing the likelihood of nosocomial exposure regardless of protective measures. For healthcare workers, data from cardiac catheterization laboratories in Italy suggest that a regimented protocol designed to minimize exposure resulted in lower rates of infection compared to units without these protocols in a prospective study. Data from China also showed a low rate of nosocomial spread after implementation of early isolation and expanded testing. However, these results are not necessarily generalizable to patients, who do not benefit from personally fitted PPE supplied to healthcare providers in these studies and who are undergoing procedures that may increase their vulnerability such as intubation and sedation. Furthermore, in an era of fluctuating availability of testing and PPE, results from highly protocolized studies may not offer a realistic profile of the infectious risk in a more fluid setting. Our systematic follow-up of all patients for 2 weeks after discharge offers a pragmatic view of procedural safety that is generalizable to a wider range of infection-prevention strategies.

These procedures spanned a secular trend of increasing precautionary measures implemented to reduce the risk of COVID-19 transmission. Increases in local PPE supply

| Public Health | YNHH cancels | Masking instituted | Universal PPE Guidelines | Selected elective procedures allowed in EP lab |
|---------------|--------------|--------------------|--------------------------|---------------------------------------------|
| Masking/symptom screening | All non-emergent procedures | EP Lab | Aerosolized procedures | All hospital staff and patients, All areas |

March 10 | March 12 | March 16 | March 16 | March 20 | April 13 | April 21 | April 22 | June 1 |

Procedures performed
Outpatient/same day discharge | 9 | 9 | 4 | 0 | 21
Outpatient/same day admit | 10 | 16 | 1 | 2 | 11
Inpatients | 5 | 14 | 5 | 1 | 10

Figure Timeline of pandemic response and infection-control measures. CT = Connecticut; EP = electrophysiology; PPE = personal protective equipment; YNHH = Yale New Haven Hospital.

Table Characteristics of patients undergoing procedures in the electrophysiology laboratory

| Patient characteristics | Outpatient—same day discharge (n = 43) | Outpatient—same day admission (n = 40) | Previously admitted (n = 41) |
|-------------------------|---------------------------------------|---------------------------------------|-----------------------------|
| Age (y)                 | 67 ± 16                               | 68 ± 12                               | 73 ± 13                     |
| Male                    | 33 (77%)                              | 27 (68%)                              | 24 (59%)                    |
| Temperature (°F)        | 97.5 ± 0.6                            | 97.4 ± 0.5                            | 97.6 ± 0.6                  |
| COVID tested preprocedure | 22 (51%)                            | 15 (38%)                              | 23 (56%)                    |
| Length of stay (days)   | —                                     | 1.3 ± 0.9                             | 4.4 ± 4.1                   |
| ICU admission           | 0                                     | 3 (8%)                                | 7 (17%)                     |
| TEE with procedure      | 4 (9%)                                | 3 (8%)                                | 8 (20%)                     |
| Intubated for procedure | 2 (4%)                                | 12 (30%)                              | 7 (17%)                     |

ICU = intensive care unit; TEE = transesophageal echocardiogram.
Continuous variables expressed as mean ± standard deviation.

The 60 COVID tests done preprocedure were negative. An additional 3 patients with known positive tests preprocedure were excluded from analysis (see methods).
and testing availability along with advances in community awareness of high-risk aerosolizing procedures have led to more rigorous safety protocols evolving throughout the follow-up interval, as shown in the Figure. The effectiveness of specific interventions for infection prevention cannot be determined. Whether rates are similarly low for other interventional procedures, or are applicable to different hospital systems, cannot be determined. However, the Heart Rhythm Society has recently published further recommendations for minimizing risk to patients and staff, very similar to those we had instituted, as have other groups, suggesting our results may be generalizable to other procedures and systems following these or similar guidelines. Hospital systems should perform quality analyses to determine the efficacy of their viral infection-prevention measures, as is routinely done for infection prevention in general.

We did not query less specific symptoms such as headache or myalgia, and we cannot exclude the possibility of transmission resulting in mild or no symptoms. It is a limitation of this report that routine testing was not performed preprocedure until several weeks into the pandemic, and was not performed routinely postprocedure. This report describes an early experience, during a time period when testing was not easily available and not routinely used even if symptomatic. Similar to the measures taken at our hospital, community precautions also evolved during this time period, with initial limitations on crowd size and closing of certain businesses on March 16 then continuing to evolve. We did not query in detail patients' personal exposures; and so had there been infections, it would have been difficult to confirm their source. However, as we did not see infections, this does not impact the conclusions regarding lack of transmission in the EP lab.

Conclusion
Our findings, along with increasingly well-informed national guidelines promoting patient safety measures, should offer reassurance to patients concerned about the risks of COVID-19 transmission during emergent and elective procedures. As national guidelines seek to standardize transmission precautions, our findings may be generalizable to other types of procedures and healthcare systems employing these guidelines as well.

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