



Impact of electrophysiologists at daily multidisciplinary report in a paediatric cardiac care unit

Original Article

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Abstract

Background: Paediatric cardiac electrophysiologists are essential in CHD inpatient care, but their involvement is typically limited to consultation with individual patients. In our integrated heart centre, an electrophysiologist reviews all cardiac inpatient telemetry over the preceding 24 hours and participates in daily multidisciplinary morning report. This study investigates the impact of the strategy of consistent, formalised electrophysiologist presence at multidisciplinary morning report. **Methods:** This is a single-centre, prospective, observational study of electrophysiologist participation in patient encounters during heart centre multidisciplinary morning report from 10/20/2021 to 10/31/2022. Multidisciplinary morning report includes discussion of all intensive care and non-intensive care cardiac patients. An encounter was defined as reporting on one patient for one day. Electrophysiologists were initially blinded to observations. **Results:** Two electrophysiologists were observed over 215 days encompassing 6413 patient encounters. Electrophysiologists made comments on 581 (9.1%) encounters in 234 unique patients with diverse diagnoses, equating to a median of 3 [interquartile range: 1–4] encounters per day. These included identifications of arrhythmias and describing electrocardiographic findings. Recommendation to change management occurred in 282 (48.5%) encounters, most commonly regarding medications (n = 142, 24.4%) or pacemaker management (n = 48, 8.3%). Of the 581 encounters, there were 61 (10.5%) in which they corrected another physician's interpretation of rhythm or electrocardiogram. **Conclusion:** Routine electrophysiologist involvement in multidisciplinary morning report provides significant, frequent, and timely input in patient management by identifying precise rhythm-related diagnoses and allowing nuanced, patient-specific medication and pacemaker management of all cardiac patients, not just those consulted. Electrophysiologist presence at multidisciplinary morning report is a vital resource and this practice should be considered at integrated paediatric cardiac centres.

Paediatric cardiac electrophysiology began formally in the 1970s and has continued to evolve as a cardiology subspecialty.^{1,2} Necessary in the treatment of children and adults with CHD, electrophysiologists fulfill a wide variety of diagnostic and therapeutic roles including, but not limited to, diagnostic electrophysiology studies, catheter ablations, non-invasive rhythm testing, intraoperative arrhythmia mapping, pacemaker and defibrillator management, and medication management of arrhythmias.^{1,3,4} There has been increasing awareness of the increase in non-invasive electrophysiologist demands such as taking on the management of patients with arrhythmias in the outpatient setting, managing advanced cardiovascular implantable electronic devices, and contributing to the care of the ever-growing number of adult CHD patients requiring complex, multidisciplinary management.^{5,6} Furthermore, electrophysiologists are vital in the inpatient management of children with cardiac conditions, reflected in the current paediatric electrophysiologist fellowship training paradigm that is 1–2 additional years after congenital cardiology fellowship and only available at programmes with robust paediatric cardiology and cardiovascular surgery services.^{1,3,6,7}

Despite the recognition of electrophysiologist expertise, there are few data detailing the influence of electrophysiologist contribution to care in the inpatient setting. For example, electrophysiologists frequently do not participate in daily medical or surgical rounds in dedicated paediatric cardiac care units other than by direct consultation on individual patients. In our heart centre, we have an integrated model for inpatient care including a multidisciplinary morning report that develops a daily unified plan for all patients in the heart centre. An electrophysiologist, who has reviewed the telemetry of all patients presented over the preceding 24 hours, additionally participates daily at multidisciplinary morning report. This study sought

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to assess, in a quantitative manner, the strategy of formalised electrophysiologist participation during multidisciplinary morning report in a prospective manner.

Methods

This is a single-centre, prospective, observational study of electrophysiologist participation at multidisciplinary morning report at the Texas Center for Pediatric and Congenital Heart Disease at Dell Children's Medical Center, from 10/20/2021 to 10/31/2022. Observation and data collection were performed by one of the authors (MFM). In the initial portion of the study (10/20/2021–03/25/2022), data collection was not disclosed to the electrophysiologist and most members of the care team were blinded to the study to limit the Hawthorn Effect. In the second part of the study (03/26/2022–10/31/22), electrophysiologist and other care team members were unblinded but observation and data collection continued in the same manner.

The structure of multidisciplinary morning report in our heart centre consists of table rounds and includes discussion of all congenital cardiac patients currently admitted to the hospital, including the cardiac ICU, neonatal ICU, and stepdown/floor cardiac patients to provide a comprehensive plan for patients for the day. Of note, multidisciplinary morning report does not take the place of individual, formal, bedside cardiac ICU, neonatal ICU, or stepdown/floor rounds later in the day, but allows for the entire heart centre to coordinate and discuss the overall plans of care. Attendance at multidisciplinary morning report occurs either in-person in an auditorium or through a virtual option, which requires pre-registration to attend. Without resident or fellow physicians in our heart centre, patient presentations are given by paediatric cardiac intensivists for the cardiac ICU-status patients, neonatologists or neonatology advanced practice providers for neonatal ICU-status cardiac patients, and paediatric hospitalists for stepdown/floor-status cardiac patients. Learners do not routinely present patients. Electrophysiologists do not present patients during multidisciplinary morning reports, but are present and participate in all levels of patient care.

Electrophysiologist activities were observed and rhythm-related comments, diagnoses, and recommendations about patient care were recorded for each patient encounter. Patient encounter was defined as each occurrence that a patient was presented during morning report; therefore, individual patients, who are presented daily, could have multiple encounters depending on the duration of their hospitalisation. Diagnoses and recommendations were recorded verbatim without further interpretations by the transcribing author.

Descriptive statistics were used for demographics, clinical characteristics, and outcomes. Categorical variables are reported as n (%). Normally distributed continuous variables are reported as mean \pm standard deviation, while non-normally distributed continuous variables are reported in median (interquartile range). Unpaired Wilcoxon signed-rank test was used for univariate comparisons of non-normally distributed continuous variables.

Results

Morning report and study period baseline characteristics

Two fellowship-trained electrophysiologists (EP#1 and EP#2) were observed at multidisciplinary morning report over 215 out of 250 possible weekdays/non-public holidays (86% of possible days),

with multidisciplinary morning report lasting 39.3 ± 9.5 min per day observed. Electrophysiologist was present in-person at 209(97.2%) instances of multidisciplinary morning report and virtually on the remaining 6(2.8%) days. EP#1 was present on 96(44.7%) days and EP#2 was present on 113(52.6%) days. The average roster of physicians present at multidisciplinary morning report is present in Table 1. Although there are many advanced practice practitioners, medical students, researchers, social workers, and other personnel that were not counted, there was a wide variety of specialties present. This allowed for blinding during rounds by the transcribing author as a member of a large group of medical professionals.

Over the study period, there were 6413 total patient encounters presented among all cardiac patients in the hospital, with a mean of 29.8 ± 4.2 patients presented per day (range: 20–40 patients). Of the 6413 encounters, electrophysiologist commented on 581(9.1%) encounters encompassing 234 unique patients. Electrophysiologist commented on 0–35% of all patient encounters on any given day, most frequently in the 5.1–10% range (Fig. 1). Of note, of the 215 days observed, electrophysiologist commented on at least one patient encounter on 182(84.7%) days.

There was a wide variety of underlying CHD diagnoses among the 234 patients discussed by electrophysiologist (Table 2), most frequently having a ventricular septal defect ($n = 52$, 22.2%) or having a prior history of supraventricular tachycardia ($n = 36$, 15.4%). Among these patients, electrophysiologist commented on a median 1.5[interquartile range: 1–3] encounters per patient, with 117(50%) patients discussed for one encounter only and 117(50%) discussed on more than one encounter (range: 1–22).

Electrophysiologist commented on a median of 3[interquartile range: 1–4] total patient encounters per day, with EP#1 commenting less frequently than EP#2 (median 1[interquartile range: 0.75–3] versus 3[interquartile range: 3–5] encounters, $p < 0.001$). Electrophysiologist commented on procedural encounters (status post cardiac surgery or electrophysiologist/interventional cardiology catheterizations) in 383(65.9%) or in pre-procedural or medical encounters in 198(34.1%) (Table 3).

Diagnoses and recommendations

Of the 581 encounters in which electrophysiologists were involved, the most common cardiac rhythm identified was ventricular tachycardia ($n = 63$, 10.8%) (Table 3). They additionally gave electrocardiogram and/or telemetry interpretations, most commonly premature atrial contractions ($n = 45$, 7.7%) and ventricular ectopy ($n = 43$, 7.4%). Other frequent comments included discussions of medication choice and dosing as part of the multidisciplinary team ($n = 76$, 13.1%) and discussion of pacing management without specific recommendations ($n = 66$, 11.4%).

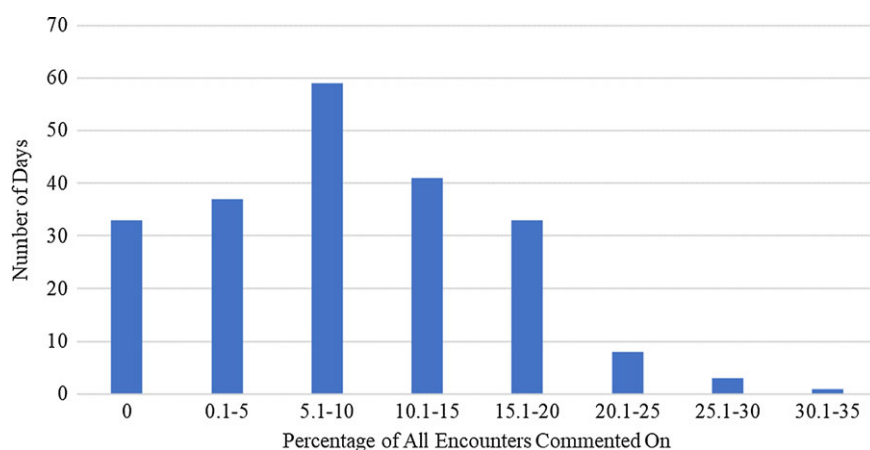
Electrophysiologist made specific recommendations about patient management in 282(48.5%) of the 581 total encounters in which they commented (Table 4). Recommendations about changing medication or medication doses were the most frequent ($n = 142$, 24.4%) followed by pacing or pacemaker-specific recommendations ($n = 48$, 8.3%), but also included recommendations about patient disposition, imaging, or further workup. Electrophysiologist comments relative to all patient encounters can be found in the Supplement.

Relation to other clinician rhythm interpretations

Electrophysiologist changed the cardiac rhythm or electrocardiographic interpretation from another attending physician in 61

Table 1. Mean providers present at multidisciplinary morning report per day

Clinician type	Mean \pm Standard deviation	Minimum	Maximum
Total	16.4 \pm 2.9	8	25
Cardiologist	5.1 \pm 1.8	1	10
Cardiac surgeon	2.1 \pm 0.8	0	3
Cardiac intensivist	4.4 \pm 1.2	2	8
Neonatologist	1.8 \pm 0.5	0	4
Hospitalist	1.2 \pm 0.4	1	3
Anaesthesiologist	0.9 \pm 0.9	0	4

**Figure 1.** Percentage of encounters per day commented on by electrophysiologists.

encounters, which covered 10.5% of the encounters in which electrophysiologist commented and 1% of all possible encounters over the study period. This included changing 44(72%) interpretations by cardiac intensivists, 8(13%) by general hospitalists, 4(7%) by neonatologists, 3(5%) by cardiac surgeons, and 2(3%) by cardiologists. These “overcalls” led to a recommendation to change management in 26(43%) of those encounters. Additionally, other attending physicians explicitly asked for electrophysiologist input in rhythm interpretations or requests to assist in management in 32(5.5%) of electrophysiologist encounters.

Blinding and difference between electrophysiologists

Of the 215 observed days, 94(43.7%) were blinded and 121(56.3%) were unblinded. Of the 581 encounters, 247(42.5%) were during the blinded period and 334(57.5%) were after. To assess for a Hawthorne effect for frequency of comments before and after blinding, an unpaired Wilcoxon signed-rank test was performed showing no aggregate difference in the frequency of encounters per day commented on ($p = 0.932$), or on an individual basis for EP#1 ($p = 0.743$) or EP#2 ($p = 0.333$), before and after blinding.

Subgroup analysis of cardiac ICU patients

As it relates to cardiac ICU-specific patient encounters, there were 458 encounters involving electrophysiologist comments on cardiac ICU patients. There were 50(10.9%) overcalls from electrophysiologist over other medical professionals during that time, of which 41(82%) overcalls were from cardiac intensivists, 3(6%) from cardiothoracic surgeons, 2(4%) from cardiologists, and 4(8%) from paediatric hospitalists. These overcalls were mostly regarding

rhythm-related diagnoses ($n = 46$, 92%), with the remainder being about medication regimens ($n = 2$, 4%), pacemaker management ($n = 1$, 2%), or ECG findings ($n = 1$, 2%).

Discussion

While electrophysiologists are not always a formal part of inpatient rounds or sign-out in paediatric cardiac ICUs nationwide, this prospective observational study of daily multidisciplinary morning report demonstrates the key role electrophysiologist plays in day-to-day inpatient management of CHD patients. To the authors’ knowledge, this study is the first to quantify the influence of electrophysiologist on inpatient care, detailing their involvement prospectively over an entire calendar year. We demonstrate the importance of electrophysiologist involvement with electrophysiologist contributing to 9% of all patient encounters, many of which would likely not have had an electrophysiologist consult in the traditional arrangement nationwide. We additionally demonstrate frequent electrophysiologist involvement, with 85% of days observed having electrophysiologist comments or recommendations. Lastly, these contributions were over the course of ~39 min per day, providing a high influence in a short amount of time. Integrated electrophysiologist involvement in multidisciplinary morning report, as opposed to electrophysiologist as a traditional consult service, provides a unique means of augmenting care for all cardiac patients in the hospital.

Advanced expertise

It is well documented that CHD patients require a multidisciplinary approach to deliver comprehensive patient care and improve

Table 2. CHD diagnoses of the study cohort

Cardiac diagnosis (most frequent to least)	Number of patients n = 234	%
Structural		
Ventricular septal defect	52	22.2%
Atrioventricular septal defect	30	12.8%
Tetralogy of Fallot	30	12.8%
Transposition of the great arteries	30	12.8%
Atrial septal defect	22	9.4%
Pulmonary stenosis	20	8.5%
Hypoplastic left heart syndrome	19	8.1%
Aortic coarctation or hypoplasia	17	7.3%
Atrioventricular valve regurgitation	15	6.4%
Heterotaxy	14	6%
Double-outlet right ventricle	12	5.1%
Pulmonary atresia	12	5.1%
Left or bilateral superior vena cava	9	3.8%
Shone syndrome	9	3.8%
Total or partial anomalous pulmonary venous return	9	3.8%
Aortic stenosis	8	3.4%
Double-inlet left ventricle	8	3.4%
Ebstein anomaly	7	3%
Mitral stenosis	7	3%
Pulmonary artery stenosis	7	3%
Pulmonary atresia with intact ventricular septum	7	3%
Hypertrophic cardiomyopathy	6	2.6%
Right or double aortic arch	6	2.6%
History of orthotopic heart transplant	5	2.1%
Idiopathic left ventricular noncompaction or dysfunction	5	2.1%
Truncus arteriosus	5	2.1%
Bicuspid aortic valve	4	1.7%
Idiopathic right ventricular noncompaction or dysfunction	4	1.7%
Left ventricular outflow tract obstruction	4	1.7%
Pulmonary arterial hypertension	3	1.3%
Right ventricular outflow tract obstruction	3	1.3%
Semilunar valve regurgitation	3	1.3%
Tricuspid stenosis or atresia	3	1.3%
Anomalous left coronary artery from the pulmonary artery	2	0.9%
Ectopia cordis	1	0.4%
Interrupted aortic arch	1	0.4%
Rhythm-based		
Supraventricular tachycardia (past history)	36	15.4%

(Continued)

Table 2. (Continued)

Cardiac diagnosis (most frequent to least)	Number of patients n = 234	%
Historical pacemaker or automatic implantable cardioverter defibrillator presence	11	4.7%
Sinus node dysfunction	10	4.3%
Wolff-Parkinson-White	6	2.6%
Congenital atrioventricular block	4	1.7%
Long QT syndrome	2	0.9%
Ventricular tachycardia (past history)	2	0.9%
Catecholaminergic polymorphic ventricular tachycardia	1	0.4%
Permanent junctional reciprocating tachycardia	1	0.4%

outcomes.^{3,8-10} Electrophysiologist is an integral part of that multidisciplinary team and provides a level of expertise that has the potential to greatly enhance care across the spectrum of inpatient CHD care. This was evidenced by the sheer variety of assistance electrophysiologist provided: they commented on patients with 45 different structural or rhythm-related CHD pathologies, provided perspectives on medical, preoperative, and postoperative patients, discussed various tachy- and bradyarrhythmias and ECG findings, and offered frequent recommendations that affected day-to-day patient management. It should be noted that this study did not seek to demonstrate the total arrhythmia burden in the heart centre as there would be no need for the electrophysiologist to repeat, for example, a ventricular tachycardia diagnosis that was already being presented by a cardiac intensivist.

They not only commented on 9% of all patient encounters over the course of a year but also assisted on 85% of days from a diagnostic or recommendation standpoint. In other centres where electrophysiologists are consulted on only a small subset of inpatients, this expertise is likely missed and may delay care or lead to inappropriate diagnoses and/or treatments. These mishaps could significantly impact patient outcomes, although the direct assessment of patient outcomes was impossible to quantify in this study. For example, in the traditional model of electrophysiologist consultation, non-electrophysiologist personnel need to identify which patients require an electrophysiologist consult. In our setting, all patients are reviewed by electrophysiologist, thus electrophysiologist often decides who needs more specific involvement.

Electrophysiologists relative to other specialties

Electrophysiologist expertise was highlighted when their comments were juxtaposed with other dedicated, experienced cardiac practitioners. Roughly 10% of all electrophysiologist encounters were to correct another attending physician's interpretation of a rhythm or electrocardiogram finding, with roughly 50% of those instances directly leading to a recommendation to change management. Many of those changes in rhythm interpretation were over paediatric cardiac-trained specialists. It is likely that those incorrect diagnoses would have remained if electrophysiologist had not integrated into multidisciplinary morning report. Furthermore, their expertise was demonstrated in the 5% of comments where other cardiac-trained

Table 3. Rhythm-related diagnoses, electrocardiographic findings, or other comments discussed at multidisciplinary morning report

Finding (most frequent to least)	EP encounters	EP procedural	EP medical or pre-procedural
	n = 581	n = 383	n = 198
Cardiac rhythm			
Ventricular tachycardia	63 (10.8%)	45 (11.7%)	18 (9.1%)
Normal	45 (7.7%)	24 (6.3%)	21 (10.6%)
Atrial tachycardia	37 (6.4%)	22 (5.7%)	15 (7.6%)
Supraventricular tachycardia	30 (5.2%)	12 (3.1%)	18 (9.1%)
Sinus bradycardia	27 (4.6%)	12 (3.1%)	15 (7.6%)
Sinus tachycardia	26 (4.5%)	22 (5.7%)	4 (2%)
Junctional rhythm or junctional ectopic tachycardia	26 (4.5%)	20 (5.2%)	6 (3%)
Atrial flutter	10 (1.7%)	1 (0.3%)	9 (4.5%)
Central venous catheter-induced dysrhythmia	10 (1.7%)	5 (1.3%)	5 (2.5%)
Re-entrant supraventricular tachycardia	9 (1.5%)	3 (0.8%)	6 (3%)
Sinus pauses	7 (1.2%)	3 (0.8%)	4 (2%)
Indeterminate tachycardia	6 (1%)	3 (0.8%)	3 (1.5%)
Telemetry or ECG findings			
Ventricular ectopy	43 (7.4%)	38 (9.9%)	5 (2.5%)
Premature atrial contractions	45 (7.7%)	40 (10.4%)	5 (2.5%)
Premature ventricular contractions	35 (6%)	27 (7%)	8 (4%)
Atrial ectopy	27 (4.6%)	20 (5.2%)	7 (3.5%)
Wide QRS	19 (3.3%)	11 (2.9%)	8 (4%)
P wave morphology changes	18 (3.1%)	9 (2.3%)	9 (4.5%)
Atrioventricular block	16 (2.8%)	14 (3.7%)	2 (1%)
ST changes (elevation or depression)	15 (2.6%)	13 (3.4%)	2 (1%)
PR prolongation	7 (1.2%)	6 (1.6%)	1 (0.5%)
QS complexes or patterns	3 (0.5%)	2 (0.5%)	1 (0.5%)
Other comments			
Medication discussions without a specific recommendation	76 (13.1%)	46 (12%)	30 (15.2%)
Pacing or pacemaker discussion without a specific recommendation	66 (11.4%)	57 (14.9%)	9 (4.5%)
Other specialties asked for EP input	32 (5.5%)	25 (6.5%)	7 (3.5%)

TEP = electrophysiologist.

specialists directly asked for electrophysiologist input regarding rhythm-related pathology.

Implications for different sized or structured programmes

Electrophysiologist expertise at multidisciplinary morning report or other comprehensive electrophysiologist involvement, we believe, has implications regardless of practice setting. Firstly, electrophysiologist assisted during multidisciplinary morning report, which occurred over just 39 min per day. Thus, this intervention likely does not pull electrophysiologist significantly from their other duties. Second, in locations with minimal resident physician involvement or smaller paediatric cardiac centres, having electrophysiologist involvement—even remotely via video conferencing—can help augment inpatient cardiac rhythm understanding and management. Even our institution, which performs >400 cardiac surgeries per year and has robust resources dedicated to cardiac care, the specific level

of knowledge electrophysiologist provides was reflected in that 9% of all encounters still had electrophysiologist involvement. In a more rural or smaller programmes without electrophysiologist on staff, having electrophysiologist remotely video conference in to offer support and consultation on rhythm-related pathology could potentially augment patient outcomes. Telehealth implementation in paediatric electrophysiologist has been investigated and demonstrated to be sustainable, suggesting it can be a viable strategy.¹¹ Furthermore, in larger academic institutions with students, residents, fellows, and other trainees, having electrophysiologist involvement could lead to increased learning opportunities for trainees where they can learn from electrophysiologist perspectives on a more frequent basis. While practice decisions and integration of electrophysiologist would be necessary on an individual, programmatic basis, programmes large or small, with or without a virtual option, can benefit from routine electrophysiologist involvement in inpatient care.

Table 4. Recommendations by electrophysiologists

Recommendations	Total encounters	EP encounters	EP procedural	EP medical or pre-procedural
	n = 6413	n = 581	n = 383	n = 198
Medication changes	142 (2.2%)	142 (24.4%)	87 (22.7%)	55 (27.8%)
Pacing or pacemaker changes	48 (%)	48 (8.3%)	38 (9.9%)	10 (5.1%)
Approval of discharge	32 (%)	32 (5.5%)	21 (5.5%)	11 (5.6%)
Request an ECG	16 (%)	16 (2.8%)	12 (3.1%)	4 (2%)
Life Vest or Automatic Implantable Cardioverter Defibrillator	11 (%)	11 (1.9%)	9 (2.3%)	2 (1%)
Electrophysiology study	9 (%)	9 (1.5%)	1 (0.3%)	8 (4%)
Medication blood levels	9 (%)	9 (1.5%)	3 (0.8%)	6 (3%)
Holter after discharge	7 (%)	7 (1.2%)	2 (0.5%)	5 (2.5%)
Further imaging necessary	5 (%)	5 (0.9%)	4 (1%)	1 (0.5%)
Loop recorder	4 (%)	4 (0.7%)	2 (0.5%)	2 (1%)
Recommend against discharge	4 (%)	4 (0.7%)	2 (0.5%)	2 (1%)

TEP = electrophysiologist.

Limitations

This study has limitations including its single-centre design. Heart centres nationwide are structured differently, with not all programmes having multidisciplinary morning report, potentially limiting its generalizability. One such difference is the absence of residents and fellows in our programme and the fact that presentations were largely done by attending physicians. Other programmes' practices may be different, but the differences in interpretation of electrophysiologist against attendings at our institution demonstrate that there may be an even wider gap at other institutions with trainees presenting patients. While electrophysiologist and other practitioners were blinded initially, after unblinding, there is potential for change in behaviour by practitioners, although electrophysiologist behaviour did not appear to be changed as no Hawthorne effect was found, alleviating some of this concern. While descriptions of electrophysiologist comments, diagnoses, and recommended treatments were documented, it is unclear if the recommendations were always followed, therefore direct assessment on outcomes could not be quantified. However, this occurs with any and all provider interactions, and electrophysiologist input still may have important implications even if a recommendation is not explicitly followed. Lastly, this study was unable to identify if there was communication between electrophysiologist and other medical professionals outside of multidisciplinary morning report, which could influence the frequency of comments during multidisciplinary morning report itself, but this again is true of real-life interactions. This study therefore may reflect an underrepresentation of the influence of electrophysiologist in daily inpatient care.

Conclusion

Electrophysiologists are an integral part of paediatric cardiac inpatient management, whether patients have structural CHD or not. In this prospective study, we found electrophysiologist expertise in diagnosing conduction abnormalities, reading electrocardiograms and telemetry, and evaluating the nuances of patient pacing was evident on a nearly daily basis at multidisciplinary morning report, even for patients they would not be normally

consulted on. We advocate for other centres to consider adopting this model to provide more integrated inpatient cardiac care. At a minimum, electrophysiologist is likely an underutilised resource in hospitals nationwide and we encourage more frequent and standardised input from electrophysiologist in paediatric heart centres.

Supplementary material. The supplementary material for this article can be found at <https://doi.org/10.1017/S1047951124000738>.

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Competing interests. The authors have no financial conflicts of interest to disclose.

Ethical declaration. This study was approved after review by the Institutional Review Board for Dell Medical School at The University of Texas at Austin (STUDY00002146, approved on 01/25/2022).

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