



# Enhanced congenital cardiac surgery knowledge with multidisciplinary collaborative education series for paediatric cardiology fellows and nurse practitioners

## Original Article

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**Corresponding author:** Madonna Lee;  
Email: [madonna.lee@yale.edu](mailto:madonna.lee@yale.edu)

Madonna E. Lee<sup>1</sup> , Joshua Price<sup>2</sup>, Jenna Schauer<sup>2</sup>, Lauren Carlozzi<sup>2</sup>, Kathryn Virk<sup>2</sup>, Kaitlyn Freeman<sup>2</sup>, Joan Lee<sup>3</sup>, Troy A. Johnston<sup>2</sup> and Aarti Bhat<sup>2</sup>

<sup>1</sup>Division of Cardiac Surgery, Department of Surgery, Yale University School of Medicine, New Haven, CT, USA; <sup>2</sup>Division of Pediatric Cardiology, Department of Pediatrics, Seattle Children’s Hospital, University of Washington, Seattle, WA, USA and <sup>3</sup>Northwest Congenital Heart Care, Tacoma, WA, USA

### Abstract

**Introduction:** Paediatric cardiologists and nurse practitioners lack structured education tools focused on basic cardiac surgery principles. However, non-surgical specialties caring for surgical patients require this knowledge for comprehensive clinical care. We created a cardiac surgical educational curriculum focused on improving knowledge and attitudes towards communication for non-surgical trainees and advanced practice providers. **Methods:** Over one academic year, six paediatric cardiology fellows and seven paediatric cardiac surgery nurse practitioners at Seattle Children’s Hospital participated in this study. With surgical supervision, six lectures were prepared by each fellow and delivered monthly. Sessions were hybrid and recorded for later viewing. Pre- and post-intervention survey of attitudes regarding surgical topics and pre- and post- test-based knowledge assessments were administered. **Results:** Participants positively rated the usefulness of the lecture series (4.2/5) and would recommend it to a colleague (4.5/5). Self-reported confidence discussing surgical concepts with patients increased from 2.3 to 3.4 among paediatric cardiology fellows ( $p < 0.001$ ) and from 2.8 to 3.9 among nurse practitioners ( $p < 0.001$ ), out of 5. In both groups, knowledge assessment scores improved from 54 to 79% post-intervention ( $p < 0.001$ ). **Conclusions:** After a six-part educational series taught by paediatric cardiology fellows, both paediatric cardiology fellows and paediatric cardiac surgery nurse practitioners demonstrated improved knowledge and reported increased comfort counselling families on basic cardiac surgery topics. Structured, active-learning lessons taught by fellows for non-surgical audiences can improve attitudes and build clinically relevant knowledge. Creating an effective level-appropriate multidisciplinary curriculum accessible to various types of medical providers could enhance comprehensive care of complex congenital cardiac surgery patients.

There is a lack of structured curriculum for formal surgical knowledge building for non-surgical trainees focused on the diagnosis and management of congenital heart disease. Specifically, paediatric cardiology fellows and nurse practitioners may not have any formal training in surgery; however, they are required to have an adequate understanding of cardiothoracic surgery in order to effectively counsel patients and families pre-operatively, perform diagnostic imaging intraoperatively, and identify complications post-operatively. For paediatric cardiology fellows, this framework is provided by the Training Guidelines for Pediatric Cardiology Fellowship Programs.<sup>1</sup> During training, there may be a lack of structured lessons focused on building knowledge of key surgical concepts, such as technical considerations or cardiopulmonary bypass. Yet, in stride with expert faculty, non-surgical trainees are expected to navigate the complexities of multidisciplinary care discussions and clinical decision-making daily, despite this education gap. Most established 3-year paediatric cardiology fellowship curricula do not explicitly mention “surgery” as a dedicated subspecialty topic.<sup>2,3</sup> The challenge of preparing non-surgical fellows for clinical practice feasibly with as much relevant knowledge, in the face of restricted residency work hours, continues to spur innovative programmes such as a short-course entry level “boot camps.”<sup>3,4</sup> Even in these boot camp series, there is a lack of focused surgical topics in non-surgical training programmes despite a large amount of clinical responsibility in caring for congenital cardiac surgery patients in inpatient and outpatient clinical settings.

When creating new curricula for medical professionals, despite the traditional structure of teacher-centred lectures, the opportunity to incorporate engaging, active learning strategies continues to increase, especially in the current era of hybrid or virtual-only classrooms. The benefits of active learning strategies include increased medical knowledge, critical thinking, and

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**Table 1.** Six-lesson cardiac surgery education series topics.

Lesson #	Pediatric cardiac surgery lecture topics	Subtopics (examples)	Total # views
1	Basics of cardiothoracic surgery	Incisions, chest tubes, and wires	81
2	CPB basics	Cannulas, cross-clamp, and cardioplegia	63
3	Advanced CPB	DHCA, myocardial protection, cerebral protection, and MUF	31
4	Re-operative sternotomy	Pre-operative imaging	32
5	Surgical shunts	Shunt types: central, Glenn, mBTTs, etc.	16
6	Valve and valved-conduits	Patient-prosthetic mismatch	16

CPB, cardiopulmonary bypass; DHCA, deep hypothermic circulatory arrest; MBTTs, modified-Blalock-Taussig-Thomas shunt; MUF, modified ultrafiltration.

positive attitudes when compared to lecture-based learning formats.<sup>5</sup> One way to encourage active learning is the resident-as-teacher (RaT) model which has been widely implemented across many medical specialties.<sup>6,7</sup> Residents and fellows are in a unique position to increase their own knowledge base while simultaneously developing their individual teaching skills and efficacy. This is an approach to provide mutual learning formats between non-professional teachers and trainees. How to formally incorporate opportunities to train residents to master teaching is still an educational skill that Graduate Medical Education (GME) programmes continue to work on formally incorporating throughout specialties – with the target-learner as a medical student.<sup>8,9</sup> Yet, the opportunity to share knowledge and adapt learning models should extend beyond medical students. In fact, the ability to teach other resident/fellow peers across subspecialties (residents-as-resident-teachers) is another complex skill which can be practiced during training.

Therefore, to address this surgical knowledge gap for trainees and to incorporate residents-as-teachers with an active learning model, the paediatric cardiology and cardiac surgery trainees created and implemented an innovative, collaborative solution. A six-course educational series on paediatric cardiac surgery basic topics was created and administered by paediatric cardiology fellows, with supervision by paediatric cardiology attendings and a congenital cardiac surgery fellow. A qualitative survey of attitudes regarding surgical topics and a test-based knowledge assessment were administered pre- and post-educational intervention to measure effectiveness.

## Materials and methods

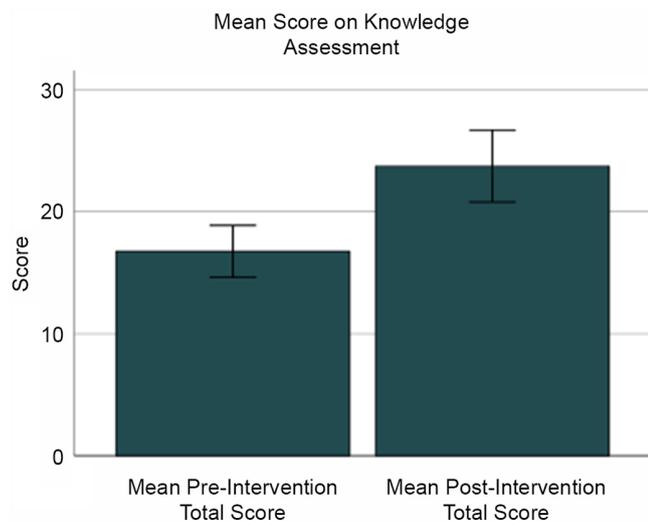
The study population included six paediatric cardiology fellows (two from each of the 3 years of categorical fellowship) and seven paediatric cardiac surgery nurse practitioners at Seattle Children's Hospital over the course of one academic year in 2020–2021. A total of six educational surgical topic sessions were prepared (one per paediatric cardiology fellow) and delivered monthly to the rest of the study participants. The list of topics was created by two project-lead cardiology fellows and coordinated by a congenital cardiothoracic surgery fellow (Table 1). Examples of subtopics include surgical incisions, cannulation for cardiopulmonary bypass, considerations for re-operative sternotomies, and comparison of surgical shunts. Specific content objectives were developed based on the American Board of Pediatrics cardiology content outline, as well as with input provided by the congenital cardiac surgery fellow and two paediatric cardiology attendings, including the paediatric cardiology fellowship programme director.<sup>1</sup> These lectures were presented in a hybrid format with in-person and virtual attendance due to meeting

restrictions during the COVID-19 pandemic. Lectures were also recorded and saved for later viewing. Each lecture was approximately 20 minutes long with time for questions at the end. Short-term knowledge retention was assessed with a short quiz format of multiple-choice questions electronically administered monthly between each lecture session. Viewing of these lessons sessions was tracked by the number of times they were uniquely accessed from the available streaming website.

A pre- and post-intervention 30-question multiple-choice knowledge assessment of surgical topics was customised by the congenital cardiothoracic surgery fellow. These exam-style questions were adapted from cardiothoracic surgery trainee-level examination preparation materials and edited to ensure a focus on relevant paediatric congenital cardiac surgery topics to align with the predetermined content objectives.<sup>10</sup> Specific pre- and post-intervention knowledge questions were different but covered the same topics with similar distribution of difficulty. A pre-intervention quiz covering these multiple-choice questions was completed at baseline prior to the first lecture, and then a post-intervention quiz was administered 1 month after the last educational lecture.

As a qualitative measure, a separate survey was administered pre- and post-intervention asking participants about attitudes regarding surgical education and relevance to patient care. This baseline survey was administered prior to education intervention, and all responses were anonymous/self-reported. For example, questions included asking about confidence in counselling patients and families about relevant aspects of surgical techniques and cardiopulmonary bypass using Likert scales 1–5. One question asked, on a scale from 1 (“not at all comfortable”) to 5 (“extremely comfortable”), how comfortable participants were in discussing cardiac surgery topics with patients and families. This survey was re-sent to participants 1-week after conclusion of the education series. After completion of the educational series, respondents were asked how useful they thought the lecture series had been, on a scale from 1 (“not at all useful”) to 5 (“very useful”). They were also asked about their likelihood of recommending this lecture series to a colleague with 1 (“not at all likely to recommend”) to 5 (“very likely to recommend”).

REDCAP survey was used to collect anonymous survey and quiz results. Using SPSS, statistical analysis of results included a t-test to compare pre- and post-intervention mean scores of subjective self-reported confidence and objective knowledge assessment scores. The primary objective of this educational intervention was to demonstrate a 50% improvement from baseline in test-based knowledge on surgical topics after implementation of the lecture series. A secondary objective was to improve self-reported confidence by 1-point (on a 1–5 Likert scale) discussing surgical technique and cardiopulmonary bypass



**Figure 1.** Mean score total percent correct of cardiac surgery basics 30-question knowledge assessment pre- and post-intervention for all participants. Error bars represent 95% confidence interval.

with patients and families by paediatric cardiology fellows and nurse practitioners.

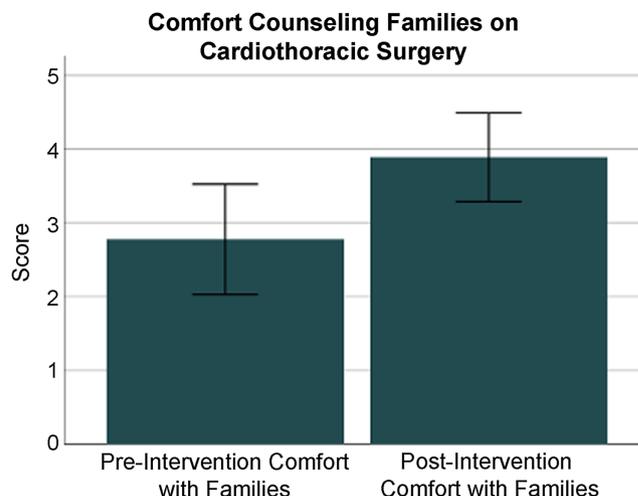
## Results

There was improvement in surgical knowledge as well as self-reported confidence across the entire non-surgical population (six paediatric cardiology fellows and seven nurse practitioners). Average knowledge assessment improved from 54% (16 correct out of 30 questions) pre-intervention to 79% (24 correct out of 30 questions) post-intervention ( $p < 0.001$ ). Mean score was calculated by total percent correct (Fig. 1). This increase was observed 1 month after all six monthly lectures had been given indicating a cumulative impact.

There was improvement of self-reported confidence in counselling families around surgical principles. Cardiology fellows self-reported confidence average increased from 2.3 to 3.4 out of a maximum of 5 ( $p < 0.001$ ). Nurse practitioners reported an average increase in confidence from 2.8 to 3.9 out of a maximum of 5 ( $p < 0.001$ ). Both groups reported an increase in self-reported comfort when talking with families (Fig. 2).

The educational series was successful in generating sustained interest and participation from the entire participant group. Specific survey-based feedback indicated that trainees rated the overall usefulness of the lecture series at 4.2/5 (range 3–5). Also, most participants would highly recommend the lecture series to a colleague at 4.5/5 (range 3–5).

In addition to the fellows and nurse practitioners who were able to attend live virtual sessions, these recorded lessons are available and continue to be watched by various learners and medical providers at Seattle Children's Hospital. After approximately 1 year of lectures being recorded and available for online viewing, the total amount of views for each lecture is listed (Table 1). The first two lectures covering cardiopulmonary bypass were accessed the most (Lecture #1 with 81 views and Lecture #2 with 63 views). There was cumulatively a total of 239 views and about 80 hours of reviewed content. Only 16 respondents out of the 239 views, including fellows, advanced practice providers and cardiac sonographers provided demographic information and



**Figure 2.** Mean self-reported comfort counselling patients and families on basics of cardiothoracic of surgery. Score from 1 to 5 on a 5-point Likert scale. Error bars represent 95% confidence interval.

feedback on the videos through an optional, anonymous online form.

## Discussion

As one of the earliest paediatric cardiology fellowship programmes founded at Boston Children's Hospital in 1949 by Dr Alexander S. Nadas, the field of paediatric and adult CHD has developed at a rapid rate over the past 50 years.<sup>2</sup> Currently, most hospital paediatric "Heart Centers" practice models are necessarily designed to be multidisciplinary and collaborative. This often implies a team-based approach, even though training backgrounds are distinct and have minimal content overlap. Despite this clinical reality of multiple specialties and care provider roles, the lack of cohesive and structured education across training programmes continues to exist. In order to adapt to a comprehensive health care delivery model for care of complex CHD patients, foundational knowledge deficits need to be creatively addressed early in training and work experience. Our work was prompted by requests from paediatric cardiology fellows to the congenital cardiac surgery fellow at our institution to have shared educational sessions to fill in these knowledge gaps, as well as address the content outline provided by the American Board of Pediatrics.<sup>1</sup> These deficits were focused on basic surgical principles, bypass, surgical decision-making – all aspects of surgery that are pertinent to effective understanding of CHD and important for patient and family counselling as a cardiologist or nurse practitioner.

In assessing the quality of this novel RaT multidisciplinary medical education curriculum to provide useful educational content, evaluation tools continue to be limited. Limited medical education literature for establishment of new curricula and utilisation of assessment tools do exist. In a literature review performed by Bree et al., only a few articles were identified where curriculum could be easily reproduced. There is also inherent challenge in conducting robust outcomes measurements for these RaT curricula. Furthermore, only 2 papers out of 39 projects included "various" specialties with the majority only encompassing a single specialty. A six-part educational series was effective in knowledge transfer, as evidenced by improved test scores after 6 months at the conclusion of the series. Objective

measures were effective in demonstrating average knowledge assessment improved from 54% pre-intervention to 79% post-intervention. Considering this small sample size and multidisciplinary nature of this curricula, measures of subjective effectiveness also appear to be significant. After completing the educational series, paediatric cardiology fellow and paediatric cardiac surgery nurse practitioners had improved comfort counselling patients and families on cardiac surgery and would largely recommend the course to their colleagues. Translating this result using the Kirkpatrick evaluation model for effectiveness of health education interventions, this study demonstrated key positive findings on the early levels of the scale: reaction, learning through change in attitudes, and learning in modification of knowledge or skills (Level 1-2B).<sup>8</sup> In comparison to other residents-as-teachers curricula, only 25% of medical specialties (10 out of 39) and 43% of surgical studies (three out of seven) included educational outcomes that met Kirkpatrick's highest levels of effectiveness evaluation (Scale 1-Reaction, 2-Learning, 3-Behavior, and 4-Change in System or Participant's/Peers), with most studies focused on changes in resident reactions, attitudes and knowledge, and/or behaviours.<sup>8,9</sup> Further curricula and evaluation measures would need to be designed in order to measure changes to higher levels of the Kirkpatrick model. This project demonstrates essential success with residents-as-resident-teachers model and should encourage innovative small-group based, multidisciplinary, collaborative learning.

By implementing the RaT model as an active learning strategy, the scope of this project did not directly assess the impact of this curricula on fellow's teaching effectiveness. In terms of measuring trainees' baseline attitudes as educators prior to the intervention, additional survey questions could have been administered pre- and post-teaching sessions. Consistent completion of teaching evaluations by participants was lacking and should be emphasised in a future iteration of this project as a method of obtaining feedback from learners regarding each individual's teaching competency. Ultimately, suggested RaT assessment guidelines (e.g., feedback tools with direct teaching observation or reviewing videos of teaching sessions) could be incorporated into the structure of these recorded RaT lessons by supervising faculty to improve teaching ability and attitudes to further strengthen fellows as medical educators.<sup>6,7</sup>

In response to the COVID pandemic, when in-person bedside teaching interactions were restricted, the hybrid format design was created so that more attendees could access these sessions remotely. We found asynchronous learning to be well suited to a busy and diverse clinical care group. However, some challenges from the pandemic, such as lack of the ability to perform direct observation of learners, lead to reliance on self-reported survey outcomes instead. Self-reported confidence levels are subjective and non-standard and may be biased towards trying to please the investigators or feeling a need to validate their time spent on the intervention. For example, "confidence in counselling families," would have been better measured by quantitative scoring from faculty observation of direct patient interactions, such as in incorporated GME feedback. Also, one practical limitation to our small study size is grouping all participants together in a cohort and being unable to assess differences in level of learning and confidence between cardiology fellow by level of training or nurse practitioner years in practice. Lastly, additional knowledge assessments at 6-month or 1-year intervals would have demonstrated whether the learning was truly sustained over a longer period of time.

Surprisingly, even though beyond the scope of our enrolled study participants, once recorded educational sessions were made

available, the total amount of views for the lectures was accessed by many other Heart Center staff members, including students and sonographers. This overwhelming amount of viewership demonstrates the demand for this knowledge, critical lack of accessible educational materials for non-surgical learners, and the popularity of this type of extracurricular on-demand clinically relevant training material. In fact, the largest total amount of views, and presumably the greatest interest, was for the most fundamental topics of surgical incisions, chest tubes, wires, and cardiopulmonary bypass.

A larger cohort with multidisciplinary intervention groups would be a next step in assessing the generalisability of such a programme to other training fellowship programmes and academic institutions. Another venue for this six-session curriculum could also be covered as introductory material for paediatric cardiology fellows in a "boot-camp" format at the beginning of their fellowship.<sup>4</sup> After 3 years of specialty training, some paediatric cardiology fellows pursue a subspecialty fellowship in interventional cardiology, ICU, electrophysiology, advanced imaging, or adult congenital.<sup>3</sup> Surgically relevant topics for these advanced cardiology subspecialties would be another potential educational intervention area for multidisciplinary and multispecialty care. Although the focus of this intervention was related directly to provider-patient interactions, it would also be worthwhile to study the effects on team-based communication and provider-provider interactions during training and in clinical practice.

This method of short-course teaching on the basics of cardiac surgery topics should be applied to even more paediatric cardiology fellowships and advanced practice providers encompassing even more specialties (e.g., intensive care, anaesthesia, etc.). By teaching cardiac surgery knowledge to paediatric cardiology fellows and nurse practitioners responsible for clinical care of surgical patients, this practically aligns medical training with real-world team-based multidisciplinary clinical practices. Placing an emphasis on paediatric cardiology fellowship training and education of all types of medical providers will fundamentally improve multidisciplinary patient care and quality of clinical services for complex congenital cardiac surgery patients by empowering providers through education, innovation, and collaboration.

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**Ethical standard.** None.

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