

A Cardiac Surgery Mini-Elective Increases Specialty Knowledge Acquisition Among Pre-Clinical Medical Students

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ABSTRACT

Background: The introduction of integrated thoracic surgery residency programs has led to increased recruitment efforts of medical students to pursue a career in cardiac surgery. With little representation of cardiac surgery in medical school curriculum, we assessed a cardiac surgery mini-elective's efficacy in improving perceived knowledge among medical students.

Methods: Preclinical medical students were offered the opportunity to participate in a cardiac surgery mini-elective, which consisted of five 2-hour sessions. These sessions consisted of didactic and simulation components and covered topics including cardiopulmonary bypass (CPB) and extracorporeal membrane oxygenation (ECMO), aortic disease, aortic valve replacement (AVR), transplant and left ventricular assist devices (LVAD), and coronary artery bypass grafting (CABG). Students completed pre- and post-session surveys describing their perceived knowledge in these topics.

Results: Overall, 22 students completed at least one session of the mini-elective. Fourteen (73.7%) of the students were male. Fifteen (68.2%) students completed at least three out of five sessions. The post-session survey responses showed significantly higher perceived knowledge compared with pre-session responses for all survey prompts of all five sessions. The CPB/ECMO and aortic disease sessions showed the greatest increase in post-session familiarity and perceived knowledge after the session ($P < 0.001$) compared with the CABG, AVR, and transplant/LVAD sessions ($P < 0.05$).

Conclusions: Beyond developing interest in cardiac surgery, these data indicate that a well-planned didactic and surgical simulation program may build confidence in students' knowledge of various cardiac surgical topics. Further studies will need to address how this increase in perceived ability lasts over time and impacts career selection.

INTRODUCTION

As a strategy to increase interest in the specialty, create a more efficient training pathway and meet the increased demand for the field, the integrated 6-year (I-6) cardiothoracic surgery residency programs were introduced [Zhu 2019]. Since its inception, the I-6 model has shown continued success with a 100% match rate for three consecutive years and has experienced consistent growth to include 33 programs participating in the 2021 match [Electronic Residency Application Service; National Resident Matching Program 2000-2020]. As the training paradigm continues to grow, recruiting highly capable medical students is becoming increasingly vital to the specialty's future.

With a paucity of cardiac surgery in the preclinical curriculum and few clinical elective opportunities for medical students, there is a substantial need to recruit this talent pool through alternative means [Kilcoyne 2020; Tesche 2010]. Previous authors have demonstrated success with mentorship, simulation, and research programs to increase medical students' interest in cardiac surgery [Trehan 2015; Bridgeman 2016; Haggerty 2014; Lou 2013]. We previously published our experience with a cardiac surgery mini-elective, where preclinical medical students participated in five didactic and simulation-based sessions. Participants completed pre- and post-elective surveys to describe how the elective changed their perception of cardiac surgery. The results demonstrated a significant increase in the perceived ability to find a new mentor within the field, and 81% percent of participants reported an increased interest in cardiac surgery as a future career [Coyan 2019]. Despite these encouraging findings, it remains unclear what topics in cardiac surgery are deficient in the traditional medical school curriculum and how exposure during this type of focused mini-elective can improve knowledge in such subjects. We hypothesized that our mini-elective in cardiac surgery would increase understanding and assist in developing a core knowledge base in cardiac surgery.

MATERIALS AND METHODS

Ethics statement: This project was reviewed by the Institutional Review Board at the University of Pittsburgh and classified as exempt. All students voluntarily took the pre- and post-course surveys. Survey results were utilized for course quality improvement and this study.

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Mini-elective structure: Medical students at our institution had the option of participating in the cardiac surgery mini-elective as an adjunct to their standard medical courses during the spring semester of their first and second preclinical years, as previously detailed [Coyan 2019]. In brief, the mini-elective consisted of five 2-hour sessions that reviewed a major topic within cardiac surgery. The first hour consisted of a didactic component, reviewing the pertinent anatomy, pathophysiology, and surgical management of cardiovascular disease. The second hour of the session consisted of a hands-on simulation component to solidify the concepts discussed and review the critical steps of the operation (this involved a combination of porcine heart wet-labs, electronic simulation of transcatheter procedures, and live demonstrations of circulatory support devices). The sessions were led by cardiac surgery faculty at our institution and assisted by cardiac surgery residents. The five-session topics included cardiopulmonary bypass (CPB) and extracorporeal membrane oxygenation (ECMO), aortic disease, aortic valve replacement (AVR), coronary artery bypass grafting (CABG), and transplant and left ventricular assist device (LVAD).

Pre- and post-session surveys: Students voluntarily completed surveys before and after each of the five sessions. Students provided demographic information, baseline interest in cardiac surgery, and prior exposure to cardiac surgery at the initial session. The surveys assessed the students' perceived familiarity with the clinical findings, diagnosis, and treatment of the individual topics using a 10-point Likert scale (0=Not familiar at all; 10=Extremely familiar). The same survey was then administered to the students after the session. The complete surveys can be found in the supplemental materials. Only students who completed both pre- and post-session surveys were included in our analysis. The number of students who only completed pre- or post-session surveys was three in the aortic repair session, six in the AVR session, and two in the heart failure/LVAD session. All students in the CABG and CPB/ECMO completed both pre- and post-session surveys. De-identified student identification numbers also were recorded, allowing us to compare pre- and post-session responses and track students' longitudinal experience over multiple sessions accounting for variance in attendance between sessions.

Statistical analysis: Survey data was collected and summarized using an anonymous electronic survey platform (Qualtrics, Raleigh, NC). Categorical variables are reported as number (%), with continuous variables reported as mean \pm standard deviation and compared using χ^2 and Fisher's exact analysis where appropriate. Ordinal data from the pre- and post-session analyses were compared using the Wilcoxon Sign-Rank test. Linear correlation analyses were performed using the Pearson's correlation test. Comparison analysis was completed using SPSS Version 26 (IBM, Armonk, New York).

RESULTS

Student demographics are summarized in Table 1. (Table 1) Overall, 22 students completed at least one session of the mini-elective. The average age was 23.9 ± 1.52 years old, and

Table 1. Demographics ($N = 19$)

Age, y	23.9 \pm 1.52
Male, n (%)	14 (73.7)
Race, n (%)	
Caucasian	11 (57.9)
Asian	5 (26.3)
African American	1 (5.3)
Middle Eastern	1 (5.3)
Multiracial	1 (5.3)
Previous suturing or simulation lab?, n (%)	8 (42.1)
Observed or scrubbed cardiac surgery case?, n (%)	8 (42.1)
Interest in cardiac surgery, n (%)	
0 – No interest	0 (0)
1	0 (0)
2	0 (0)
3	13 (68.4)
4	5 (26.3)
5 – Extremely interested	1 (5.3)
Number of students who completed, n (%)	
All 5 courses	5 (22.7)
Only 4 courses	3 (13.6)
Only 3 courses	7 (31.8)
Only 2 courses	3 (13.6)
Only 1 course	4 (18.2)

14 (73.7%) of the students were male. Eight (42.1%) students had previously participated in a suturing or simulation lab, and eight (42.1%) had observed or scrubbed into a cardiac surgery case. There were no significant differences when comparing males and females in previous suturing/simulation lab experience ($P = 0.912$), observing/scrubbing cardiac surgery case ($P = 0.912$), and baseline interest in cardiac surgery as a career ($P = 0.478$). Observing or scrubbing a cardiac surgery case did not have a significant relationship with interest in cardiac surgery ($P = 0.429$).

Nineteen students completed both pre- and post-surveys for the CPB session, 16 for aortic repair, 12 for AVR, 12 for CABG, and 12 for transplant/LVAD. Fifteen (68.2%) students completed at least three out of five sessions. The average pre- and post-session survey responses and individual survey prompts are described in Figures 1-5. (Figure 1) (Figure 2) (Figure 3) (Figure 4) (Figure 5) The post-session survey responses showed significantly higher familiarity and perceived knowledge compared with pre-session responses for all survey prompts for all five sessions. The CPB/ECMO and aortic disease sessions showed the greatest increase in familiarity and perceived knowledge after the session ($P < 0.001$) compared with the CABG, AVR, and transplant/LVAD sessions ($P < 0.05$). There was no significant correlation between the number of courses completed by a student

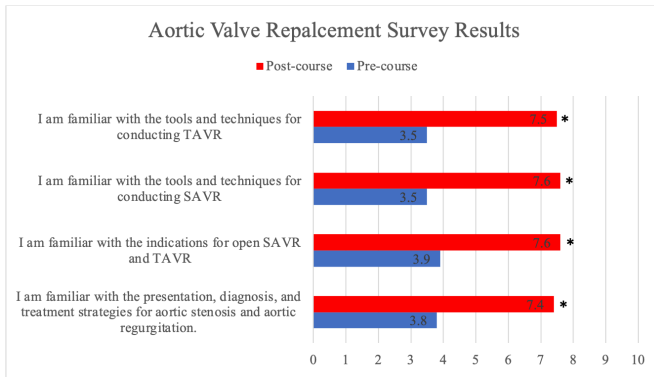


Figure 1. Comparison of medical student pre- and post-session familiarity with cardiopulmonary bypass and extracorporeal membrane oxygenation using the Wilcoxon Sign-Rank test.

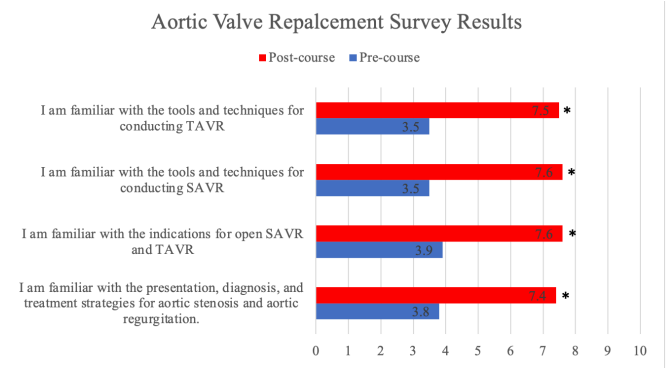


Figure 3. Wilcoxon Sign-Rank test of medical student pre- and post-session familiarity with surgical and transcatheter aortic valve replacement.

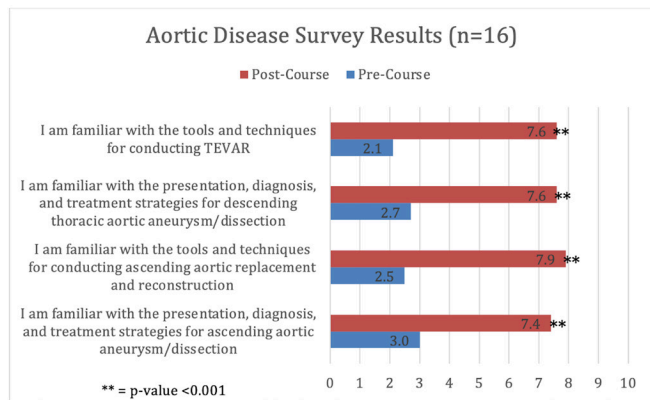


Figure 2. Comparison of medical student pre- and post-session familiarity with aortic disease using the Wilcoxon Sign-Rank test.

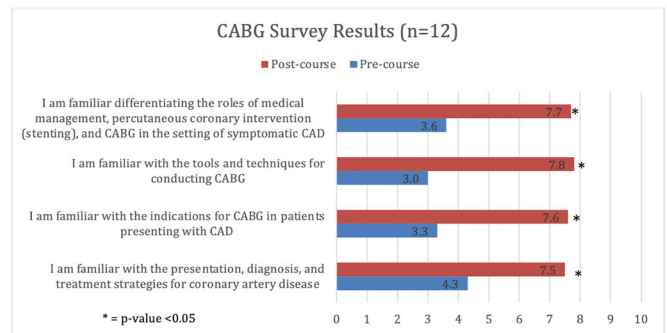


Figure 4. Comparison of medical student pre- and post-session familiarity with coronary artery disease and coronary artery bypass grafting using the Wilcoxon Sign-Rank test.

and their increase in familiarity ($r=0.377$, $P = 0.532$). Our methodology, results, and their implications are summarized in Figure 6. (Figure 6)

CONCLUSIONS

The ability of didactic and simulation activities to effectively cultivate medical student interest in cardiac surgery is well documented [Bridgeman 2016; Lou 2013; Coyan 2019; Macfie 2018]. This is particularly important given the scarcity of other opportunities to introduce students to cardiac surgery [Kilcoyne 2020]. How these didactic and simulation programs affect knowledge and understanding of cardiac surgery has been less thoroughly investigated. While developing interest may be the primary objective, educating these future physicians remains a pertinent area of inquiry as most of these students are unlikely to pursue cardiac surgery as a career. In the current analysis, we demonstrated our mini-elective could be an effective method in improving medical students perceived knowledge in cardiovascular disease and specifically cardiac surgery. This was significant across all major topics

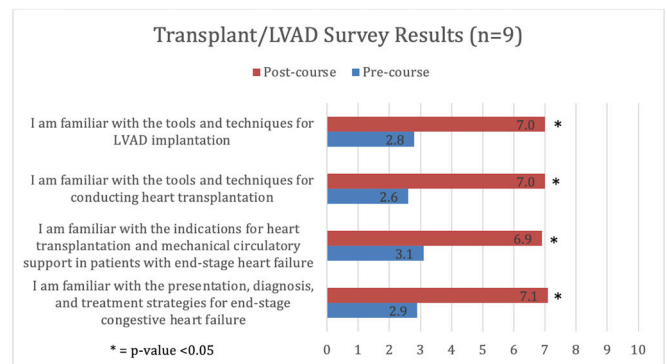


Figure 5. Comparison of medical student pre- and post-session familiarity with transplant and left ventricular assist devices using the Wilcoxon Sign-Rank test.

covered in a cohort that varied in baseline interest in cardiac surgery and prior exposure to the field.

We attribute our success to numerous aspects of the mini-elective curriculum. First, the longitudinal experience is a crucial aspect of creating lasting interest in a particular subspecialty. When exposure is limited to one isolated experience, interest can fade as quickly as one month after the event

[Markovic 2012]. Repetitive exposure is also more effective at creating a better understanding of the pathophysiology, clinical presentation, and treatment topics covered within a specialty [Moulton 2006]. Secondly, we included multiple faculty members and thoracic surgery residents to lead these sessions. By having residents participate as instructors, we increased the teacher-to-student ratio, allowing us to break into small groups and provide a tailored learning experience. Including residents in medical student education provides an instructor who may be viewed as more approachable and significantly improve medical student learning [Bennett 2018].

Lastly, the addition of a simulation component is a proven method to enhance the educational experience and cultivate interest [Teschke 2010; Lou 2013; Macfie 2018; Yanagawa 2019]. This is particularly true for cardiac surgery, where the interaction between technique, anatomy, and pathophysiology are especially interconnected. During the mini-elective, students used porcine heart models and device simulations to walk through the technical and cerebral aspects of these operations, bridging the gap between cardiovascular physiology learned during the lecture to applying these principles. A unique part of our simulation events is the inclusion of endovascular procedures, such as transcatheter aortic valve replacement and thoracic endovascular aortic repair. To our knowledge, previous events held for medical students primarily have focused on open cardiac surgery. As transcatheter interventions continue to evolve in cardiac surgical practice, medical students must be introduced to the vast array of procedures that will become an increasingly important aspect of the specialty's future.

While we had a universal increase in perceived knowledge after each course, the low initial familiarity with these topics is worthy of our attention. The average perceived knowledge prior to each session was 3.1 out of 10 for the entire course and is likely the result of cardiac surgery being under-represented in the preclinical curriculum [Preece 2018]. Even for those who do not pursue a career in cardiac surgery, most of these future physicians invariably will encounter cardiac surgery patients and play an active role in their care and may benefit from a more robust preclinical cardiac surgery education. In order to make these changes, cardiac surgeons likely will need to play a larger role in their institution's formal curriculum.

Targeting preclinical medical students may be particularly advantageous for numerous reasons. Previous studies have shown up to 61% of current cardiac surgeons decided to pursue the specialty during their preclinical years making this a critical time in their medical careers [Davis 2019]. It is no surprise then that the impact of events aimed at developing interest in surgical subspecialties are more pronounced the earlier the participant is in training [Macfie 2018]. Simultaneously, interest in cardiac surgery is highest during the first year of medical school but can fall as low as 6% during the fourth year of medical school. Preclinical medical students have the highest incidence of negative preconceptions about surgeons and the field, making this an opportune time to combat misconceptions and capitalize on this interest with meaningful personal interaction [Sood 2012; Cohan 2020]. In

a retrospective analysis assessing the impact of an optional surgery preclinical course on the likelihood of matching into a surgical specialty over a 9-year period, Andersen et al. found that course participation corresponded to a significantly higher chance of matching into a surgical specialty [Anderson 2020]. This long-term data shows the substantial impact these electives have.

Focusing recruitment efforts on preclinical medical students is also conducive to the application process of I-6 programs. Deciding to pursue cardiac surgery early in medical school allows for ample time to develop a competitive application. Organizing elective rotations, performing cardiac surgery research, finding mentors, and networking within the field are vital aspects of a competitive application. These time-intensive endeavors are necessary to demonstrate a commitment to cardiac surgery, which is highly valued by program directors of I-6 programs [Smood 2020].

A challenge in using activities, such as mini-electives, is how to garner enough interest to make students want to participate in the first place. This is a common issue among 'niche' specialties that are not a core part of preclinical or clinical education and may warrant implementing unique approaches. Campwala et al. reported their experience of creating a surgical 'roundtable' discussion where students could hear from various surgical faculty from 20 different surgical subspecialties in one platform. This allowed underrepresented subspecialties, such as cardiac surgery, to describe the current training landscape and practice in that particular field. An analysis of pre- and post-roundtable survey responses found the roundtable significantly increased students' awareness of integrated surgery residencies and changed specialty preferences in 32.5% of students [Campwala 2020]. Events like these may be useful at introducing a particular subspecialty, where the mini-elective can then solidify interest and build a knowledge base.

Our results are limited by a small cohort of students at a single institution taking part in the mini-elective program. Resources and faculty involvement may vary from institution to institution and require other programs to pursue different routes for cardiac surgery recruitment. Our data is based on self-reported perceived knowledge as opposed to a more formal assessment that may under or over-estimate the impact of the mini-elective. While the intention of this elective is to cultivate interest and expose medical students to cardiac surgery, future inquiry assessing the impact of the mini-elective on actual knowledge is warranted. The high level of cardiac surgery interest at the beginning of the course makes it challenging to know its effect on our results. Whether this increase in familiarity leads to a sustainable interest in cardiac surgery also is not determined by our study. Further analyses will need to investigate the relationship between perceived knowledge and pursuit of cardiac surgery as a career.

Our experience in implementing a cardiac surgery mini-elective has demonstrated the ability to significantly improve medical students' perceived knowledge and understanding of cardiac surgery. Creating a longitudinal experience that contains both didactic and simulation components are what we believe to be the foundation of our success. Our findings do

not diminish the role of mentorship and research programs, but rather serve as complementary methods in recruiting diverse and highly qualified medical students. As the I-6 training model shows sustained growth, targeted recruitment of preclinical medical students will become a necessity. The mini-elective is an effective strategy for developing interest and familiarity with cardiac surgery.

DISCLOSURES

Garrett Coyan is a shareholder and serves as the Chief Medical Officer of Neolife, Inc. Arman Kilic receives consultancy fees from Medtronic. IS receives institutional research support from Medtronic and Atricure.

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