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Experience With the Cardiac Surgery Simulation Curriculum: Results of the Resident and Faculty Survey

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Background. The Cardiac Surgery Simulation Curriculum was developed at 8 institutions from 2010 to 2013. A total of 27 residents were trained by 18 faculty members. A survey was conducted to gain insight into the initial experience.

Methods. Residents and faculty were sent a 72- and 68-question survey, respectively. In addition to demographic information, participants reported their view of the overall impact of the curriculum. Focused investigation into each of the 6 modules was obtained. Participants evaluated the value of the specific simulators used. Institutional biases regarding implementation of the curriculum were evaluated.

Results. Twenty (74%) residents and 14 (78%) faculty responded. The majority (70%) of residents completed this training in their first and second year of traditional-track programs. The modules were well regarded with no respondents having an unfavorable view. Both residents and faculty found low, moderate, and high fidelity simulators to be extremely useful, with particular emphasis on utility of high fidelity components. The vast majority of residents (85%) and faculty (100%) felt more comfortable in the resident skill set and performance in the operating room. Simulation of rare adverse events allowed for development of multidisciplinary teams to address them. At most institutions, the conduct of this curriculum took precedence over clinical obligations (64%).

Conclusions. The Cardiac Surgery Simulation Curriculum was implemented with robust adoption among the investigating centers. Both residents and faculty viewed the modules favorably. Using this curriculum, participants indicated an improvement in resident technical skills and were enthusiastic about training in adverse events and crisis management.

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Cardiothoracic surgical training has been challenged over the last several years for a multitude of factors. Duty hour restrictions have limited direct clinical experience with measurable effects [1, 2]. Changes to general surgery training have resulted in a diminished open surgery experience as a result of a proliferation of endovascular and minimally invasive approaches to disease management. Further, exposure to cardiothoracic surgery has decreased nationwide during general surgery training, and junior resident operative experience has suffered because of a proliferation of fellowship training programs [3, 4]. Recognizing these

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challenges, technical and cognitive skills training for cardiothoracic surgery may benefit from an increased use of simulation-based learning for both the new trainee as well as the experienced trainee needing refinement of advanced skills.

A comprehensive cardiac surgery simulation curriculum was developed as part of a multiinstitutional effort from 2010 to 2013 at 8 centers [5]. Over the course of the study, the curriculum was extensively modified based upon the assessment of the investigators [6]. The curriculum was divided into 6 modules: cardiopulmonary bypass (CPB), coronary artery bypass grafting (CABG), aortic valve replacement (AVR), massive air embolism (MAE), acute intraoperative aortic dissection (AIAD), and sudden deterioration in cardiac function (SDCF). The modules were designed with basic simulation principles in mind—repetition, deliberate practice, supervision, progressive simulation complexity, formative feedback, and summative assessment [7].

At the completion of the study, a survey was administered to residents and faculty to gain insight into the initial experience using this educational tool. This survey was designed to specifically evaluate institutional experiences, resident and faculty impressions of the curriculum, resident and faculty impressions of the simulators used, and an overall assessment of this curricular experience.

Material and Methods

The institutional review boards (IRBs) at all 8 institutions reviewed the study of cardiac surgery simulation training; the IRBs at 6 institutions exempted the study from further review because it was done in an educational setting; 2 IRBs required participating residents to sign consent forms.

A comprehensive survey was constructed and distributed for participating residents and supervising faculty using a secure online server based at the University of Washington (Catalyst WebQ, Seattle, WA). The survey was collected anonymously, and completion was voluntary. All questions on the survey were mandatory in order to proceed to the next question. Fifty-nine questions were common to both surveys; the resident answered 13 distinct questions and the faculty answered 9 distinct questions. (Appendix). In addition to demographic information, participants reported their overall impressions of the curriculum. Focused investigation (including session-to-session assessments) into each of the 6 modules (CPB, CABG, AVR, MAE, AIAD, SDCF) was obtained. Participants also evaluated the specific simulators used. Institutional practices regarding implementation of the curriculum were evaluated. Data were separated and reported based upon the role of the individual completing the survey (resident versus faculty).

Results

Twenty (74%) residents and 14 (78%) faculty responded to the questionnaire. Demographic information is summarized in Table 1. The residents' intended specialization was relatively evenly distributed between adult cardiac and general thoracic surgery, with a small portion seeking congenital training. Residents who completed this training were largely in their first and second year of a traditional track program (70%); the remainder represented integrated 6-year programs and 3-year traditional programs. The majority of faculty members (64.3%) specialized in adult cardiac surgery, and 14% were retired. Most faculty were in practice for more than 20 years (57%), followed by 29% in practice 10 to 20 years, and 14% in practice 2 to 9 years; no faculty had less than 2 years experience. The majority of the faculty members (57%) were the local Principal Investigator in this study; they were well supported by faculty who participated in more than 20 sessions (21%) or faculty who participated in 6 to 20 sessions (21%). No faculty reported participating in fewer than 6 sessions.

The curriculum was always completed in a dedicated simulation laboratory or space (Table 2). Most centers chose a specific time and day of the week for these activities, and this curriculum superseded clinical responsibilities in most cases. Despite this commitment, only 10% of centers were able to complete the 42-session curriculum in 42 weeks; this most commonly took 50 to 60 weeks to complete, and in 10% of centers required more than 80 weeks to complete. Both residents and faculty reported that the reasons for the extended time required were multifactorial, and included other faculty responsibilities, lack of support from nonsimulation faculty, away time, and resident availability.

Overall assessment of the 6 modules was excellent (Fig 1). There were no respondents for any module who provided an unfavorable view. Each component of the 6 modules was evaluated by both residents and faculty (Table 3). In modules for CPB, AVR, MAE, and SDCF, the majority of residents and faculty felt that all components were valuable, and should be maintained in the syllabus. In CABG and AIAD, both residents and faculty reported the greatest value in the high fidelity simulator experience. Overall, the residents noted the highest value in the high fidelity simulators, although the faculty also considered moderate fidelity simulators to be of value, and both groups noted limited but important utility in the low fidelity simulators (Fig 2).

Familiarity and comfort in the operating room was felt to be improved for both residents and faculty. Residents (93%) noted that faculty members were more comfortable in the operating room with them, and faculty (85%) reported that residents were more comfortable operating with the simulation faculty members. These views were reinforced by improved faculty perception of resident self-confidence (much more, 79%; slightly more, 21%) and resident self-assessment of technical proficiency (much more, 45%; slightly more, 45%). The majority of residents and faculty (50% and 57%, respectively) felt that there was a divisional/departmental commitment to simulation training as well.

The adverse events protocols were viewed extremely favorably. Fully 80% of residents expressed a plan to

Table 1. Demographic Information

Question	Resident (n = 20)	Faculty (n = 14)
Average age, years (range)	35.95 (32–47)	58.0 (42–77)
Male sex, %	90.0	92.9
Average medical school completion year (range)	2005 (1996–2010)	1982 (1962–2002)
Intended practice, %		
Adult Cardiac	35	-
General thoracic	40	-
Congenital	5	-
Adult cardiothoracic	20	-
Current specialty, %		
Adult cardiac	-	64.3
General thoracic	-	14.3
Congenital	-	14.3
Critical care	-	7.1

implement these plans in their future practices, and 50% of faculty had already done so. Simulation of rare adverse events increased confidence and allowed for development of multidisciplinary teams to address them. There was a suggestion to continue adverse event training beyond the resident years into both chief resident years and to junior faculty. Numerous write-in comments stated that adverse events training exercises were the most valuable aspect of this approach.

Comment

As with other specialties, the residency training environment in cardiothoracic surgery has been affected by numerous factors that have impacted the trainees' starting point, acquisition of technical and cognitive skills, and achievement of independence. The cardiac surgery simulation curriculum that has been developed attempts to mitigate these shortcomings by providing component-based teaching, repetition, and progressive simulation complexity [5]. This survey provides complementary data that reinforces the importance of this approach.

Table 2. Curriculum Overview

Question	Resident (n = 20)	Faculty (n = 14)
Where did you complete this curriculum? (%)		
Dedicated simulation lab	60	64
Dedicated space outside of simulation laboratory	40	36
When did you complete this curriculum? (%)		
At a set day and time every week	60	71
At a set day, time varied based on clinical schedule	15	7
Most dependent on resident availability	20	21
Most dependent on faculty availability	5	0
Curriculum took precedence over clinical obligations	85	64

The use of simulation training for technical and cognitive skills acquisition is well established in medicine [8, 9]. Simulation training in cardiothoracic surgery was introduced into mainstream conversation by the Thoracic Surgery Directors' Association Boot Camp, which has now passed its eighth year [10–12]. Principles learned from this experience were deliberately integrated into this curriculum, and can be credited with the maturity of the first iteration. Nonetheless, additional lessons have been revealed with this longitudinal effort.

Dedicated time for both residents and faculty were cited by survey respondents as a beneficial factor for the success of this endeavor at several centers. Clinical responsibilities were noted by several respondents as obstacles to the completion of the curriculum. The balance of skills training in the clinical and simulation environments remains challenging and reflects philosophical and logistical considerations. Further, essential to resident training using simulation-based learning is commitment and support from faculty members who were previously considered "nonsimulation" faculty in the department. The overall length of training was further prolonged because of vacations, holidays, illness, leave, and clinical emergencies. There was also one center whose training was interrupted by a rotation away from their simulation center. For these reasons, the curriculum was shortened from an original 42 weeks to 29 weeks. Interestingly, some residents relayed that their initial cynicism was supplanted by overwhelming support and acceptance of the activity, particularly if focused in the earlier years of training.

Evaluations of the simulators revealed somewhat predictable results—the residents were most enthusiastic about the high fidelity simulators, and the faculty saw more utility in the lower fidelity analogs. Surprisingly, evaluation of the modules demonstrated that the majority of the components were useful, and that the majority did not need to be eliminated ("Keep them all"). This partially contradicts the evaluation of the low fidelity simulators,

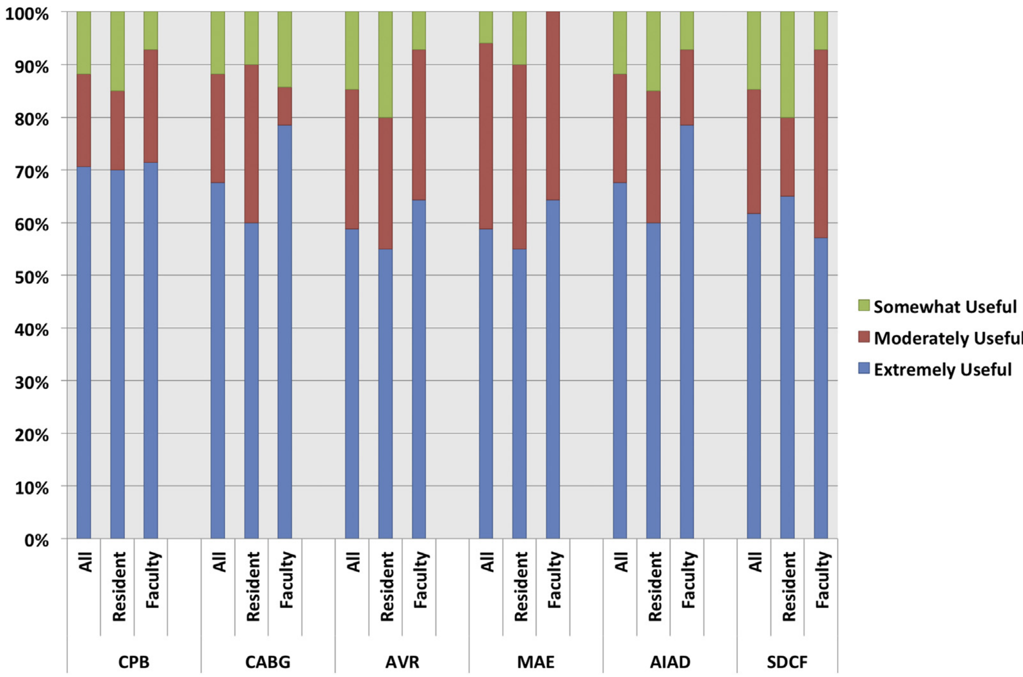

Fig 1. Overall assessment of module utility by both residents and faculty. (AIAD = acute intraoperative aortic dissection; AVR = aortic valve replacement; CABG = coronary artery bypass surgery; CPB = cardiopulmonary bypass; MAE = massive air embolism; SDCF = sudden deterioration in cardiac function.)

and demonstrates that the first principles of simulation training—repetition, deliberate practice, supervision, progressive complexity in skill level, formative feedback, and summative assessment—were in fact valued by both the educators and trainees in spite of their prejudices towards low fidelity simulators.

The reported increased resident self-confidence and faculty confidence in residents as a result of this simulation training is difficult to quantify, but more importantly, invaluable to simulation enthusiasts. This finding suggests that this process of simulation training extended beyond the simulation environment, and had an impact in the clinical or operative setting. Whether this was a result of resident experience, resident–faculty rapport, faculty comfort, or other factors cannot be discriminated by this tool, and bears ongoing investigation.

The inclusion of and emphasis on adverse events in this curriculum were well received by trainees and educators alike. Throughout this survey, the importance of adverse event simulation was highlighted, and numerous write-in comments were highly supportive. Again, the first principles of simulation training provided a framework for skill development and practice, which translated into the reactionary skills necessary in an emergency scenario. Indeed, crisis scenarios encountered were not teachable outside of this environment because of their rarity. In fact, the utility of the adverse event training may well extend beyond that of resident training, and could well apply to practicing physicians and teams. This is an area of ongoing investigation.

One of the most interesting and controversial aspects of this training paradigm is timing: The first three modules appear well suited for novice trainees, and could even be extrapolated to "prerequisite" training. This may manifest in training programs at the Integrated Resident third year, or during/preceding a traditional training program. At the same time, the adverse events modules could be equally applicable to novice and experienced trainees because of their overall rarity. It may also be reasonable to extend the adverse events training to new and experienced practicing surgeons. This is likely the basis by which all modules were viewed favorably by the respondents, and the majority of residents intended to carry the adverse events protocols on to their new institutions.

Limitations

This study is limited by the nature of survey data, which were obtained retrospectively with incomplete participation and subject to bias. Nonetheless, the value of simulation training is in part related to its how it is perceived in terms of its realism and its utility as noted in the survey. Importantly, future studies and data analyses are focused on skills assessment during and after completion of the simulation curriculum. The simulators represent varying levels of fidelity; not surprisingly, even high fidelity simulators can be considered by some as not fully representative of the clinical experience. The curriculum reported in this study is notably based on the latest iterations of cardiac surgery simulators, which are intended to provide a means of deliberate practice during residency training.

Conclusions

The Cardiac Surgery Simulation Curriculum that has been developed provides component-based teaching,

Table 3. Component Task Evaluations

Module	Component	Resident (n = 20)	Faculty (n = 14)
CPB	Most useful component		
	Understanding steps	45	36
	Aortic cannulation on porcine aorta	5	0
	Venous cannulation on porcine heart	0	0
	Cardioplegia cannulation on porcine heart	0	0
	Full bypass on high fidelity simulator	30	43
	All of the above	5	21
	Other	15	0
	Least useful component		
	Understanding steps	0	0
	Aortic cannulation on porcine aorta	5	0
	Venous cannulation on porcine heart	20	7
	Cardioplegia cannulation on porcine heart	10	43
	Full bypass on high fidelity simulator	0	0
	None – keep them all	60	43
	Other	5	1
CABG	Most useful component		
	Anastomoses on low fidelity simulator	0	0
	Anastomoses on static porcine heart	30	36
	Full CABG on high fidelity simulator	70	57
	Homework (technical practice at home)	0	7
	Least useful component		
	Anastomoses on low fidelity simulator	25	21
	Anastomoses on static porcine heart	0	0
	Full CABG on high fidelity simulator	5	0
	Homework (technical practice at home)	40	29
	None – keep them all	30	50
AVR	Most useful component		
	Aortotomy and aortotomy closure	0	7
	De-airing the heart	0	0
	Valve resection, suture placement, and seating	30	36
	Full AVR on high fidelity simulator	70	43
	All of the above	0	14
	Least useful component		
	Aortotomy and aortotomy closure	5	7
	De-airing the heart	10	43
	Valve resection, suture placement, and seating	5	0
	Full AVR on high fidelity simulator	5	0
	None – keep them all	75	50
MAE	Most useful component		
	Development of multidisciplinary plan	30	43
	Deliberate practice of plan	65	50
	Both equally important	5	7
	Least useful component		
	Development of multidisciplinary plan	5	7
	Deliberate practice of plan	0	0
	None – keep them both	95	93
AIAD	Most useful component		
	Development of multidisciplinary plan	30	21
	Femoral arterial cannulation	0	7
	Static repair of aortic dissection	10	14

(*Continued*)

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Table 3. Continued

Module	Component	Resident (n = 20)	Faculty (n = 14)
	Full dissection repair on high fidelity simulator	60	50
	All of the above	0	7
	Least useful component		
	Development of multidisciplinary plan	5	0
	Femoral arterial cannulation	45	64
	Static repair of aortic dissection	10	0
	Full dissection repair on high fidelity simulator	5	0
	None – keep them all	35	36
SDCF	Most useful component		
	Emergency chest opening	15	29
	Failure to wean from CPB	25	29
	Issues with CABG	10	7
	Issues with AVR	0	7
	Final exam	45	14
	All of the above	5	14
	Least useful component		
	Emergency chest opening	35	14
	Failure to wean from CPB	0	7
	Issues with CABG	0	0
	Issues with AVR	5	0
	Final Exam	0	0
	None – keep them all	60	79

Values represented as percent.

AIAD = acute intraoperative aortic dissection; AVR = aortic valve replacement; CABG = coronary artery bypass surgery; CPB = cardiopulmonary bypass; MAE = massive air embolism; SDCF = sudden deterioration in cardiac function.

repetition, and progressive simulation complexity. With robust adoption of the curriculum among the investigating centers, residents and faculty viewed the modules favorably, recognizing its impact in training. This training also translated into improved confidence and perceived performance by both residents and faculty in the clinical operative setting. Specifically, participants indicated an improvement in resident technical skills and both

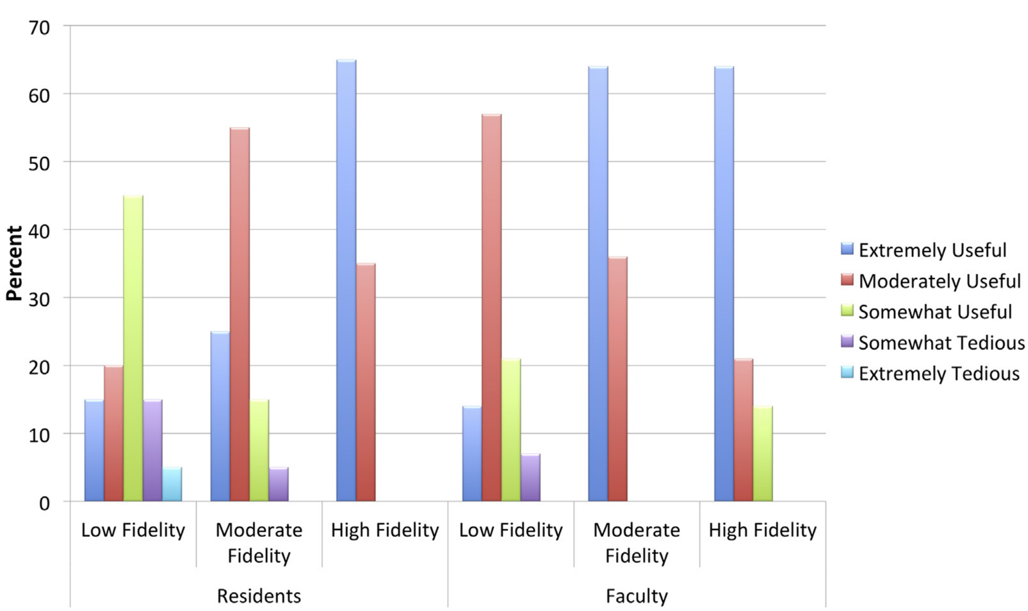

Fig 2. Resident and faculty evaluation of low, moderate, and high fidelity simulators.

residents and faculty were enthusiastic about training in adverse events and crisis management.

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