Basic Cardiac Surgery Skills on Sale for $22.50: An Aortic Anastomosis Simulation Curriculum

Meghana R. K. Helder, MD, Phillip G. Rowse, MD, Raaj K. Ruparel, MD, Zhuo Li, MS, David R. Farley, MD, Lyle D. Joyce, MD, PhD, and John M. Stulak, MD

Department of Surgery and Division of Biomedical Statistics and Informatics, Mayo Clinic, Rochester, Minnesota

Background. **Current resident and student duty-hour restrictions necessitate efficient training, which may be aided by simulation. Data on the utility of low-cost simulation in cardiothoracic surgery are scant. We evaluated the effect and value of a low-cost, low-fidelity aortic anastomosis simulation curriculum.**

Methods. **Twenty participants (11 medical students, 9 residents) completed an aortic anastomosis on a porcine heart as a pretest. Participants were then provided access to a 14-minute online video created by a cardiac surgeon and given a low-cost task trainer for self-directed practice. Five weeks later, participants performed another aortic anastomosis on a porcine heart as a posttest. Pretest and posttest performances were filmed, deidentified, and graded blindly and independently by two cardiac surgeons using a standardized assessment tool (perfect score, 110; passing score, 58 or higher). Participants were surveyed anonymously after the posttest.**

Results. **The mean (SD) aortic anastomosis performance score improved significantly from pretest (53.3 [25.3]) to posttest (83.6 [15.3]; $p < 0.001$). Pass rates also improved significantly (35% versus 95%, $p < 0.001$). Medical students' scores improved most ($p = 0.01$). All 20 participants reported improved confidence in performing the task, and 18 believed that the online video was essential to better performance. The cost of the curriculum totaled $22.50 per participant, with 6 hours of total staff time required for assessment.**

Conclusions. **An aortic anastomosis training and simulation curriculum improves the skills of student and resident trainees with minimal expense and staff time commitment. Such a curriculum may be of great value to both cardiothoracic training programs and their trainees.**

(Ann Thorac Surg 2015;■:■–■)

Integrated surgical programs are transforming cardiothoracic surgical training in the United States. The challenges inherent in an integrated approach, compared with the traditional 5-year general surgery residency and cardiothoracic fellowship pathway, most importantly include the need to instill sound vascular surgical techniques into younger, less-experienced trainees. In addition, the 80-hour work week imposed by the Accreditation Council for Graduate Medical Education has aroused valid concern regarding technical skill acquisition, number of operative repetitions, and the preparedness of exiting trainees in the disciplines of cardiac and vascular surgery [1, 2]. Furthermore, the intrinsic high risk nature of cardiac operations raises an ethical concern regarding trainee readiness and their ability to maintain excellent patient outcomes. In other words, should novice trainees be allowed to "practice" basic cardiovascular skills on patients?

An alternative means of gaining fundamental cardiothoracic surgical techniques before working in real operating rooms is desirable to both staff surgeons and trainees. We postulate that a teaching curriculum consisting of a Web-based instructional video and an inexpensive aortic anastomosis task trainer will provide a platform to enhance experiential learning outside of the operating room and improve acquisition of cardiothoracic surgical skills through repetition.

Material and Methods

Participants

Twenty trainees of various levels participated in our aortic anastomosis simulation curriculum. Of these 20 participants, 11 were first- and second-year medical students; 9 were integrated cardiac, thoracic, and vascular surgery residents (postgraduate year 1 or 2, n = 5; postgraduate year 3 or more, n = 4). Most participants (70%) had no experience in performing any vascular anastomosis before the study. Of the 6 participants who did have experience with an anastomosis, 3 had performed one vascular anastomosis and 3 had performed two vascular anastomoses. Approval was obtained from our Institutional Review Board for filming and analyzing the performance of these participants, all of whom consented to the study.

Curriculum

The curriculum commenced with a pretest on a porcine heart model that required participants to complete an

Accepted for publication Aug 7, 2015.

Presented at the Fifty-first Annual Meeting of The Society of Thoracic Surgeons, San Diego, CA, Jan 24–28, 2015.

Address correspondence to Dr Stulak, Department of Surgery, Mayo Clinic, 200 First St SW, Rochester, MN 55905; e-mail: stulak.john@mayo.edu.

Published by Elsevier

0003-4975/$36.00
http://dx.doi.org/10.1016/j.athoracsur.2015.08.005

aortic anastomosis. After completion of the pretest, trainees were given a task trainer for practice, given a copy of the scoring rubric that would be used to assess their performance, and given access to a 14-minute online video created by a cardiac surgeon on the same porcine model that addressed not only potential pitfalls and fixes but also correct technique in context of the assessment tool. Each participant was given a DeBakey forceps, vascular needle driver, a supply of 4-0 double-armed polypropylene sutures, and a task trainer. They were instructed to keep a log of both number of practice attempts and number of times they viewed the online instructional video.

Five weeks later, participants returned for a posttest that was identical to the pretest. All participants were filmed during their performance on the pretest and posttest. Each video was edited to provide a representative clip of the participant's setup of the anastomosis, back and front wall suturing, and knot tying. During editing, all identifiable aspects of the participants were removed. These clips were then viewed and assessed independently by two cardiac surgeons (J.M.S. and L.D.J.) who were masked to participant identity and timing of test (whether pretest or posttest).

Porcine Model

Pig hearts were purchased from a local slaughterhouse. Skewers were used to suspend the heart in a cardboard box to mimic the exposure and surgical ergonomics of a conventional sternotomy. The pulmonary artery was freed from the aorta, and the aorta trimmed to immediately below the arch. A size-matched portion of porcine aorta was situated next to the porcine aorta (Fig 1A).

Task Trainer

Task trainers were assembled using blocks of wood (2 × 4 × 8 inches) with a felt overlay. Pieces of aortic conduit were donated by Maquet Cardiovascular (Wayne, NJ) or were from unused portions of grafts from our operating rooms. The aortic grafts were secured to the wooden block and felt overlay with rubber bands, which allowed both excellent exposure for anastomosis and for the grafts to be moved closer to each other for multiple practice efforts (Fig 1B). The total cost of the task trainer assembly was $1.10.

Assessment Tool

The assessment tool used for grading trainees was initially crafted to assess aortotomy closure for the national cardiothoracic simulation effort funded by an Agency for Healthcare Research and Quality (AHRQ) grant (1R18HS020451-01). This particular tool was created by a cardiothoracic surgeon and then vetted by the eight cardiothoracic surgeons who were the principal investigators for the grant. The components of the assessment were bite, spacing, needle holder use, use of forceps, needle angles, needle transfer, suture management, knot tying, hand mechanics, use of both hands, and economy of time and motion. Scoring details are presented in Figure 2. A perfect performance yielded a grade of 120, and a passing grade was given if both reviewing surgeons believed that the participant passed. A defined score of 58—an arbitrary point on which all investigators agreed—was the cutpoint for passing in case there was disagreement between the surgeons.

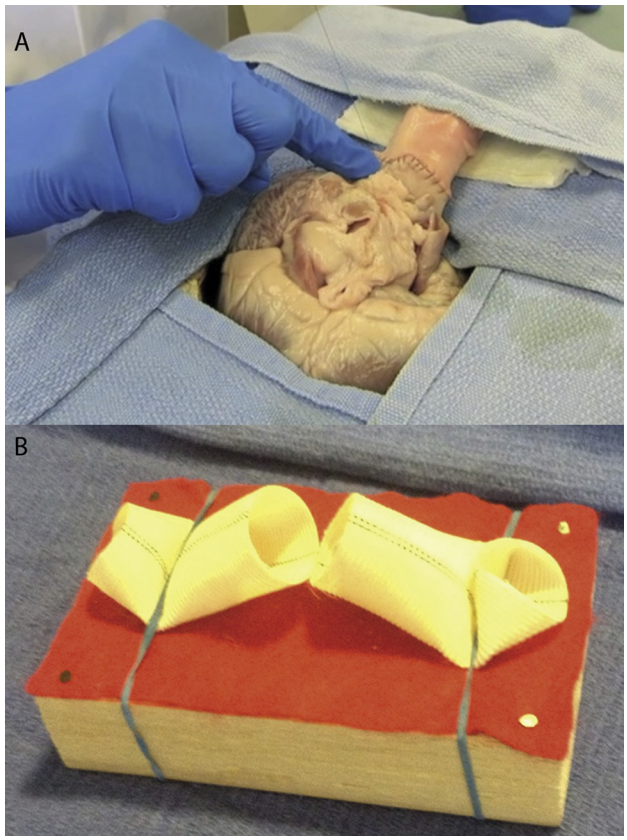

Fig 1. High-fidelity aortic anastomosis model and task trainer. (A) Porcine heart model used for the pretest and posttest. Whole porcine hearts with aorta dissected away from the pulmonary artery were suspended in a cardboard box with metal skewers. An opening was made in the box, and blue towels were used to cover it to mimic the operating room look and feel of a sternotomy. A free piece of porcine aorta was used for the distal end of the anastomosis and was held in place by the assistant. (B) Anastomosis task trainer: the practice model of an aortic anastomosis included two pieces of Dacron graft held onto a wooden board with rubber bands, allowing for several practice runs.

Survey

Participants were surveyed anonymously after the posttest. The 20-question appraisal evaluated trainee perspectives regarding the curriculum in the following areas: enjoyability of learning surgical skills through an online video curriculum, feasibility of learning proper surgical setup and techniques, attitudes regarding learning from procedural videos, realism of both the task trainer and porcine test models, the value of home practice on performance, and fairness of the assessment criteria.