See Article page 1878.

Commentary: The beat goes on… Beating-heart simulators continue to evolve but have yet to arrive

David D. Yuh, MD, FACS, FACC

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> "Certainly, it cannot matter as much who does the operation, as how it is done."

ADULT

As a Stanford cardiothoracic surgical resident, I was privileged to witness the incisive wit and wisdom of many aphorisms and observations by Norman Shumway. Widely acknowledged as a pioneer of modern cardiac surgical resident training, this quotation from his Presidential Address at the 67th Annual Meeting of the American Association for Thoracic Surgery[1] succinctly reflects his rejection of outdated paternalistic apprenticeships in favor of immersive hands-on, learn-by-doing technical training. Simulator training represents an adaptation of this approach. Unfortunately, the fidelity of simulator platforms to actual operative conditions, particularly in cardiac surgery (eg, tissue quality, blood flow, motion), generally entails increased cost and complexity. In their article in this issue of the *Journal*, Wu and colleagues[2] describe the design and application of a relatively low-cost beating heart simulator platform for off-pump coronary artery bypass grafting (OP-CAB).

CENTRAL MESSAGE

Fidelity to operating conditions, including cardiac motion, reproducibility, and cost, highlight this OP-CAB simulator, but its lack of portability may limit its effectiveness as a training platform.

The described simulator provides an effective platform for developing basic coronary anastomotic skills; however, it does fall short in several important areas as an OP-CAB simulator. First, cardiac rotation and stabilizer positioning maneuvers, critical in the safe and successful conduct of OP-CABG, are not simulated in this platform, nor are the sometimes near-vertical angles frequently encountered in grafting inferior or lateral wall vessels in OP-CAB.

Despite these limitations, however, the most substantive disadvantage with this platform may lie in its lack of portability for the trainee. "Distributed practice," a strategy of learning that makes use of smaller increments of study and practice over a longer time period, is generally considered more effective for long-term learning and retention of knowledge and skills than the "massed practice" approach[3,4] necessitated by the authors' nonportable simulation model and training format. Fann and colleagues[5] used this learning strategy effectively in designing a cardiac surgery simulation curriculum facilitated by portable coronary anastomotic simulators for distributed technical practice at home. Improvement in anastomotic skills over time in both static and beating-heart models were achieved using performance criteria very similar to those used by Wu and colleagues.

Notably, the residents trained on this beating-heart simulator performed more favorably than those trained on the non–beating-heart platform at the study's conclusion, particularly with criteria directly related to needle handling. However, I do not necessarily agree with the authors' notion that using the beating-heart simulator and excluding the static platform might improve training efficiency and outcomes. I would favor initial distributed learning of anastomotic technique facilitated by a static, portable simulator platform, because residents do not possess the same degree of technical dexterity early in their training.

Finally, the Wu group's use of disinfected balloon pump catheters and human saphenous vein remnants likely would be problematic in many institutions outside of China. Unused balloon pumps and synthetic saphenous vein conduits are alternatives; however, these would entail additional costs.

The authors should be congratulated on developing this low-cost beating-heart model and incorporating it in their residency training program. Aside from its advantages

From the Department of Surgery, Stamford Hospital, Stamford, Conn.

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Address for reprints: David D. Yuh, MD, FACS, FACC, Department of Surgery, Stamford Hospital, One Hospital Plaza, PO Box 9317, Stamford, CT 06904 (E-mail: DYuh@stamhealth.org).

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and disadvantages, it undoubtedly provides valuable, reproducible training for OP-CAB.

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See Article page 1878.

Commentary: Getting to Carnegie Hall

Dawn S. Hui, MD,[a] and Richard Lee, MD, MBA[b]

Richard Lee, MD, MBA, and Dawn S. Hui, MD

CENTRAL MESSAGE

Research in technical skills training should account for the various aspects of cognitive load. Study designs may not be able to control or adjust for some confounding aspects.

In 1878, the Russian composer Pytor Ilyich Tchaikovksy completed composition of his *Violin Concerto in D Major* (Op. 35). For the first 3 years, the concerto was not publically performed because the Czar's court violinist Leopold Auer reportedly declared it unplayable. Since then, it has become not only a standard in the repertoire of professional violinists but also among the most frequently performed violin concertos.[1] This radical transformation may be tied to late 19th century pedagogical advancements in violin playing. Although Auer did eventually perform and teach the concerto, of the 3 contemporary violin treatise authors with the greatest influence on modern pedagogy, Auer focused the least on technical aspects.[2]

In human technical skills performance, skills that do not primarily rely on physiology (eg, strength and flexibility) or adjunctive technology must look even more to a systematic method of training. In cardiac surgery, opportunities for technical skill training have traditionally occurred in an apprenticeship model, with experience gained during actual patient care. Increasing patient risk profiles and scrutiny of outcomes has led to investigations of simulation as an adjunctive method of training.[3] This has challenges of fidelity, reproducibility, cost, and efficacy. Hence, widespread standardized simulation remains in evolution more than a decade after its role in cardiothoracic surgical training was envisioned.[4]

Wu and colleagues[5] report their findings of a randomized study of trainees who were novices to coronary artery bypass grafting (CABG), comparing training on a beating heart model with a nonbeating model. Participants were tested on both models after 3 months of training. Significant findings were that those who trained on beating heart models improved to a greater degree in use of needle holder

From the [a]Department of Cardiothoracic Surgery, University of Texas Health Science Center at San Antonio, San Antonio, Tex; and [b]Division of Cardiothoracic Surgery, Department of Surgery, Medical College of Georgia, Augusta University, Augusta, Ga.

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Address for reprints: Richard Lee, MD, MBA, Department of Surgery, Medical College of Georgia, 1120 15th St, BA-4300, August, GA 30912 (E-mail: RICKLEE@augusta.edu).

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