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Editorial

The Reality of Virtual Reality in Echocardiography Education?

VIRTUAL REALITY (VR) is a technology that immerses the user in an artificial 3-dimensional (3D) environment via wearable technology, namely VR headsets. Lately, VR systems have evolved to be portable, realistic, and smoother to navigate in real-time. Dropping costs has made handheld devices more accessible, and finding use in a variety of areas in healthcare. The VR experience comes from a feeling of being connected to the environment, the ability to manipulate it and receive feedback that can be visual, auditory, and even sensory. The ability to perform repetitions of a task or procedure in a realistic environment but without the risk of patient harm or need for supervision makes its application attractive to healthcare.[1]

Echocardiography, specifically transesophageal echocardiography (TEE), has a substantial learning curve that requires manual dexterity, pattern recognition, as well as image interpretation, and simulation has long assisted learners in navigating it. In this edition, Arango et al. described the development of a software system that uses commercial VR headsets (Oculus; Meta, Menlo Park, CA) to present a very realistic model of the heart.[2] This was made possible by first procuring fresh human hearts explanted but not suitable for transplant, and fixing them in an end-diastolic state using formalin. High-resolution (90-to-120-micron voxel resolution) scans of these hearts were then amalgamated with a computed tomography-derived extracardiac dataset to complete the model. Out of 9 such generated models, 1 represented normal anatomy, whereas the rest demonstrated pathologic states such as valve replacements, presence of medical devices, intracardiac shunts, etc. The user can then, using the VR handsets, toggle among different heart renderings. as well as manipulate the model in space. Their model offers the advantage of either a transthoracic echocardiography that includes bone, lung, and chest wall structures, or a TEE mode with the ability to manipulate the simulated probe inside the esophagus. The user can visualize the 3D image and simultaneously visualize the 2D ultrasound representation. Like other commercially available simulators, the user is able to interact with the model, identifying how a particular TEE image is "sliced" through the heart model. The authors offer this simulator free of cost to everyone, and include a description of the implementation of VR training within their cardiothoracic anesthesiology fellowship.

After its inception in the 1990s, VR technology underwent a period of quiescence due to a lack of eligible content and adequate computing power in the then-current hardware.[3] Progressive improvements in innovative optics and photonics have led to VR expansion beyond its niche in gaming and entertainment, and fueled widespread application in manufacturing, engineering, and healthcare. The use of VR technology to bolster learning (irrespective of age) consistently has been associated with numerous advantages, such as increased motivation, active learning, and reflective thinking. When tested, not only is problem-solving better when assisted by VR, but participants report a more enjoyable experience.[4] Specifically, in healthcare, the hands-on apprenticeship paradigm has given way to the development of high-fidelity learning tools that aim to provide a realistic experience while minimizing cost, risk, and the pressure of time. The success of this process hinges on the fidelity of rendering and the realism of the created environment. Traditional echocardiography simulators, through the use of augmented reality cardiac models, do not possess the clarity and/or resolution offered by the system designed by Arango et al., and one suspects this positively will impact the engagement of the end-user.[2]

Working memory has been shown to be the first step in cognitive learning, which then translates into problem-solving and goal-directed behavior.[5] Understanding spatial relationships and anatomic correlates provide that vital base from which clinical performance can be improved. This has been well-documented in the surgical space, specifically for liver surgery.[6] The work by Arango et al. provides that first step, in which the improvement in anatomic depiction (on a substantially higher resolution heart model) will prove invaluable for newer learners to associate actual cardiac structures with its visualization on corresponding echocardiography planes. In the field of echocardiography, the use of VR for education, as

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well as for validation of competency, is not new.[7] On testing, learners have rated VR as a better learning tool than live demonstration when used for teaching echocardiography.[8] Although relatively novel, one can foresee TEE education becoming more reliant on VR with time. The authors perhaps understated one big advantage of their devised system, and that is portability and accessibility. The cost of an Oculus VR headset system is not out of reach for most trainees or training programs, and this tool could perhaps give the trainee the flexibility to practice on their own time. Although current commercially available simulators offer the experience of holding a TEE probe as opposed to VR hand controllers, the cumbersome size of the simulator with a dummy human, a computer, and a simulated probe reduces the accessibility. A single headset per institution can be used by multiple users, which provides access to training at a much larger scale.

A common hindrance to VR adoption is the side effect of motion sickness. The incidence of motion sickness reported in the current paper was 15.6%, which is not trivial. However, other authors have reported a much higher incidence (approximately 57%) with the Oculus headset when reporting on rendered environments that involve motion.[9] One of the ways in which user comfort can be improved is by providing multisensory feedback, thus integrating sensory input into the visual signal. The VR system in discussion, despite its aforementioned advantages, does not replicate the feel of the TEE probe in the hands of the trainee. The muscle memory formed by repeatedly manipulating the probe and using the keyboard buttons is an integral part of ultrasound learning.[10] The actual display of the TEE image is still on a 2D screen, so perhaps even more important than 3D manipulation, the system needs to replicate the feel of the probe in hand. For the interested reader, a very similar sensory experience exists in guitar learning, with a device called the Jamstik (Zivix), which replicates the fretboard.[11] The output is auditory instead of visual, but the concept is similar. The other issue is that of access. Although within reach of the average United States trainee, the cost of an Oculus VR headset ($300, as reported in the article) would be prohibitive for a resident in a developing nation like Pakistan, where 25% of trainees are unpaid.[12] Finally, the largest prohibitive factor with the currently described system is that the heart model is static in end-diastole. Although the current model may aid in the identification of anatomy and TEE images, the realistic feel of cardiac imaging requires motion through the full cardiac cycle. The authors note future iterations will include an animation of the heart model.

There are often many avenues to achieve excellence at any skill, and TEE is no exception. Although there are many more developments necessary to lead to widespread adoption of VR technology in echocardiography education, Arango et al. have helped to tackle several concerns, including high-resolution heart models, accessibility, and portability. Future iterations and research will continue to tackle concerns of full motion of a high-resolution heart model, VR motion sickness, and improvement to the "feel" of the probe in hand. As improvements occur, VR technology will continue to play an increasing role in the future education of trainees.

Conflict of Interest

None.

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