INTRODUCTION TO TEE SIMULATION

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Transesophageal echocardiography (TEE) is a widely-used technique in the cardiovascular assessment of patients undergoing complex surgery or those that are critically ill. It is recognized as an important element that impacts surgical technique, especially in patients undergoing mitral valve surgery.\(^1\)\(^,\)\(^2\) Image acquisition and interpretation using TEE can also be subject to variability depending on experience and skill of the operator. The National Board of Echocardiography and the Society of Cardiovascular Anesthesiologists (SCA) have therefore established training guidelines that define expectations of competency in TEE during the training period for perioperative physicians.\(^3\) Acquiring minimal proficiency in perioperative TEE can also be challenging for trainees and teaching faculty, as the number of cases required to learn TEE is considerable as is the time for acquiring the cognitive skills through didactic education.\(^3\)

Simulation technology has been used successfully to advance medical training, especially in the last 10 years.\(^4\) Recently, the emphasis has been on scenarios when the skill involved is critical to patient safety and/or the number of procedures required to achieve proficiency is impractical.\(^5\)\(^,\)\(^6\) Simulation technology can be complemented with parallel three-dimensional (3D) models that improve the spatial perception of the procedure (reality-enhanced simulators) or with devices that allow visual feedback and kinesthetic interactions between an operator and the simulator (haptic technology).

Until recently, the development of an echocardiography simulator was limited by the complexities of relationships between cardiac anatomy, echocardiographic imaging planes, viewing interface and probe manipulation in a real-time setting. However, with advances in computer technology and developers keen in echocardiography education, simulation in echo is now a feasible training option, and has been extended to TEE (figure 1).\(^7\)\(^-\)\(^9\) Simulators adapted for TEE include the Heartworks TEE Simulator (Heartworks, Inventive Medical Limited, UK) and the Vimedix Simulator (CAE Healthcare, Montreal, QC, Canada).

Figure 1: A trainee receiving instruction on anatomical correlation with echocardiographic images using a TEE simulator
Although some research in echo simulation has been published, the literature on TEE simulation is sparse. Simulation-based training methods in intraoperative TEE may undergo a significant change and prove to be a safer alternative with trainees with elevated skills in the operating room at the start of their clinical rotation.

A TEE simulator is capable of displaying two images – one that shows a three-dimensional representation of cardiac anatomy, while the other shows the simultaneous echo correlate (figure 2). The location of the TEE probe with the esophagus removed is an added advantage that helps the user visually with anatomical relationships. The manipulation of the echocardiographic scan plane can be accomplished using a keyboard or a connected mannequin.

**Limitations**

Simulation technology is expensive and TEE simulators are not immune to this phenomenon. A TEE simulator can cost from US$ 22,000 up to US$100,000. Maintenance expenses add to the overall cost of a simulator. A simulator also needs to be placed in a dedicated training area and this cost should also be accounted for. Other echo modalities such as M-mode, spectral Doppler and color flow are challenging to reproduce and are not currently available. Similarly simulation of transducer functions, such as gain, compression and depth are not available. Simulation of pathologic states is the next frontier in TEE simulation when the touch of a button can produce mitral valve prolapse, aortic stenosis, or a regional wall motion abnormality.

**Significance**

The availability of reality-enhanced TEE simulation is a significant departure from traditional training models that rely on a combination of didactics and real time clinical teaching. While more ‘real world’ in application, the challenges of simultaneous clinical management may place additional burden on educators in the operating room. Simulation in TEE provides a more controlled environment in which to assess the efficacy of this training methodology over conventional approaches while also providing objective data to justify its routine use.

This technology can also be used by trainees in several disciplines such as anesthesiology, cardiology, cardiac surgery and critical care to improve proficiency in basic TEE image acquisition and interpretation. At the present time, exposure to intraoperative TEE is challenging for trainees outside the operating room environment. The development of cardiac pathology will greatly help trainees develop the
interpretative skills in areas either too complex or infrequent in occurrence to permit enough time for education in the clinical environment. This technology can be used for helping physicians maintain competency in situations where clinical case volume may be insufficient to support current competency requirements.