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Evaluation of TEE Training for Chinese Anesthesiology Residents Using Two Various Simulation Systems

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Abstract

Objective: This study was designed to compare the efficacy of simulator-based VRSim TEE training system and web-based virtual TEE program in training anesthetic residents.

Methods: 28 second-year anesthetic trainees with no record of TEE experience were randomly assigned to two groups: simulator group and e-learning group. The simulator group undertaken training via simulator-based VRSim TEE training system. In contrast, e-learning group received training via web-based virtual TEE training program. At the end of the training, all participants were examined aiming to find if there is a difference between these two training systems and which is better for use in training future anesthetic Resident.

Results: Average scores in the final exam were compared for the two groups using two independent samples t-test accepting a $p<0.05$. Anesthetic resident in simulation group received scores an average of 63.75 ± 3.96, which was significant high comparing to the e-learning group (46.61 ± 2.67).

Conclusion: This study suggests that simulator-based VRSim TEE training is more effective in training anesthetic residents in understanding TEE imaging and manipulation of the TEE probe compared to the web-based TEE modules alone.

Keywords: Transesophageal echocardiography; Simulator-based education; Web-based education

Introduction

Transesophageal echocardiography (TEE) has become a standard practice in cardiac operation room attributed to its major advantages of noninvasiveness, real-time assessment of cardiac function and accurate evaluation of cardiac anatomy [1-3]. In recent years, TEE has also been widely used as an intraoperative monitoring tool in high-risk, non-cardiac surgeries [4] as well as in intensive care units [5]. As TEE becomes more utilized and accepted, it is of great interest for anesthesiologists to acquire the basics techniques of TEE. For this reason, basic TEE training is being integrated into anesthesia residency training programs in many countries [6-11].

In performing basic TEE and meet the criteria of basic intraoperative TEE competency, a minimum of 150 to 180 cases of TEE examination should be performed [12] under supervision, while present TEE training is designed to be one patient-one procedure paradigm. However, there are many limitations and disadvantages involved in this model. Limited opportunities of onsite practice for anesthesia residents due to medical ethics restriction. Time constraints in surgical theatre also restrict the training efficiency. Training may also distract medical staff's attention from important patient care. Prolonging and repeating of the TEE examination cause unnecessary risk and complications to the patients [13].

As trainee has minimal opportunities to perform a TEE exam in the operation room, simulator-based TEE training is developed and introduced as a new training method [14]. Several TEE simulators have been tested in the past few years, such as a web-based training system or a mannequin- and computer-assembled simulation training module [15]. In comparing with traditional TEE training, both web simulator based TEE training and mannequin based TEE training module greatly simplify the understanding of TEE anatomy, image orientation and significantly reduce the learning time and curve [6, 16]. There are few disadvantages of these simulators, for example, using web based TEE simulator, trainees is not allowed to have onsite practice in actual probe manipulations and image acquisition, while mannequin based TEE training module is very expensive and such high cost prohibit its widespread use. Moreover, these two TEE simulators only provide normal anatomy, but sometimes, "abnormal" anatomy and function is more important in training.

Many previous reports have confirmed that simulator (web-based or mannequin) is better than the traditional method in training program. However, to our knowledge, no studies yet compared the effectiveness

of a web-based training system with the mannequin-assembled computer, simulation-based training module. Virtual TEE, a web-based TEE training program developed by the Department of Anesthesia and Pain Management of Toronto General Hospital, has been translated into several languages and is the most popular program in world [17]. The VRSim TEE training system, developed by the Department of Anesthesiology in the West China Hospital of Sichuan University and the Chengdu Branch of Chinese Academy of Sciences in 2010, is the first Chinese TEE simulator [6]. In the present study, we compared these two TEE training systems and analysed the effectiveness of the two simulator training system for TEE beginners in basic TEE skills.

Materials and Methods

This study was approved by the West China Hospital ethic committee 2013(15). Written informed consents were obtained from all 28 anesthesia residents who were recruited in May 2014. For this study, 14 anesthesia residents per group allowed us to detect a 20% difference between two training systems (α=0.05; β=0.8, power calculation n=5). All of the participants were second year residents who never received any training and inexperience in intraoperative TEE or cardiac operation room rotations. Participants were randomly assigned to two groups: Virtual TEE group and VRsim TEE group. The randomization sequence was generated using online randomization software (www.randomization.com). All participants were requested to study the "American Society of Echocardiography for Intraoperative Echocardiography and the Society of Cardiovascular Anesthesiologists (ASE/SCA) guidelines" for TEE exam 2 hours prior to simulation training.

In the e-learning group, an experienced perioperative trasesophagel echocardiographer was a demonstrator and showed the group of basic techniques of probe manipulation, image orientation, anatomy 20 standard views on the Virtual TEE program which was developed by Toronto General Hospital group (http://pie.med.utoronto.ca/TEE) (Figure 1). The training session was finished in 60 minutes. Participants in the simulator group were exposed to the VRSim TEE training system -a simulator-based TEE training module. The training was supervised as same as the demonstrator in e-learning group and also finished in 60 minutes (Figure 2). Immediately after the training session, a 30-minute anonymous multiple choice question (MCQ) test was administered to all study subjects. The test was designed according to ASA/SCA T EE exam guidelines and consists of two sections with a total score of 100 points. The first section involved the recognition of cardiac anatomy on 20 standard views, and the second section was related to orientation of TEE views and manipulation of the TEE probe to get a particular TEE view. The study flow is shown in Figure 3.

Statistics

The mean scores of the written test for the two groups were compared using two independent-sampled t tests with P<0.05 considered significant. All the statistical evaluations were estimated by using SPSS 19.0.

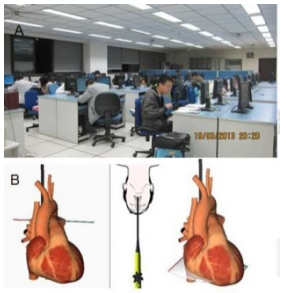

Figure 1: Teaching mode in the control group. A: Every resident has a computer and link to an internet-based TEE learning resource. B: Relationship of TEE probe and three-dimensional heart model shown in the Virtual TEE program.

Figure 2: Teaching mode in the study group. A: Residents sit in a classroom and watch the tutor use the VRSim TEE training system to show them basic technique of TEE. B: TEE probe and three-dimensional heart model shown in the VRSim TEE training system with a dummy probe and mannequin.

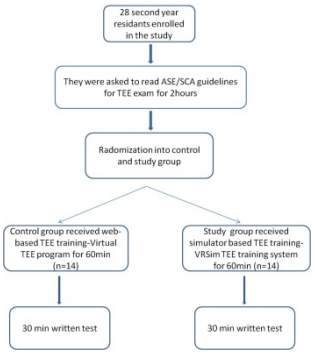

Figure 3: Study flow chart. ASE/SCA, American Society of Echocardiography/Society of Cardiovascular Anesthesiologists.

Results

The mean score of the e-learning group was recorded at 46.61 ± 2.67, comparing to the simulator group score at 63.75 ± 3.96 (P<0.05), with the 95% confidence interval of the difference being -27.03, -7.25. Results for both first and the second MCQ sections indicated a statistically significant difference between the e-learning group (25.18

in Section 1 and 21.43 in Section 2) and the simulator group (34.11 in Section 1 and 29.64 in Section 2). The simulator group achieved significantly higher scores in average comparing to the e-learning group (Figure 4).

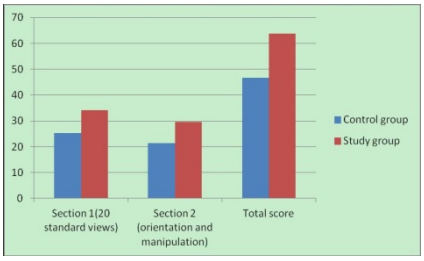

Figure 4: Comparison of the effectiveness of the Virtual TEE and VRSim TEE training systems.

Discussion

It has been reported that simulator training compared with traditional methods could enhance resident performance in transesophageal echocardiography [13,16-18]. However, there have been no previous reports to compare the efficiency among different simulator training modes. Our presented study compared two simulator training modes for the efficiency of the training, which showed that mannequin-based TEE simulator substantially improved the ability of residents for the recognition of cardiac anatomy, orientation of TEE views and manipulation of the TEE probe.

Virtual TEE use, which consists of 20 standard cross-sections as well as 19 non-standard was recommended by ASE/SCA but only used two-dimensional TEE views [9]. In this virtual scenario, trainees can learn the spatial relationship between the probes, the anatomic structures of the (three-dimensional) heart, and the cross-section of cardiac anatomy relevant to echocardiographic views. This design can help for improving a trainee's spatial cognition and implementing their mental model transformation from two-dimensional echocardiographic planes to a three-dimensional heart remodeling. Training guide for the 20 standard cross-sections TEE view also facilitates a trainee's understanding of the relationship between these views with easy memorization. Jerath and his colleagues reported a significant improvement in TEE learning for 10 trainees using this system [9]. Jerath's study suggested that Virtual TEE was a useful adjunctive tool for learning TEE [17] without hand-on experience Moreover, this team also found that 1 hour training using the virtual TTE simulation is essential for improving the knowledge of navigation among the 20 standard views for the trainees [18]. However, limited number of participants in both studies and no control group may not precisely validate if virtual TEE system can replace traditional TEE methods for training purpose

Another prospective randomized study was reported to evaluate the effects of Virtual TEE and simulation-based training on TEE learning for anesthetic trainees [19]. The results showed that trainees who received TEE training via Virtual TEE acquired better image recognition skills compared to those who used traditional methods. In the second part of this study, all participants undertake simulation-based echocardiography training before a test, suggesting that simulation training on subjects with previous experience of e-learning could further improve a trainee's echocardiography knowledge. Bose at al found that simulation-based TEE training can significantly benefits junior anesthesiology trainee compared with conventional methods [20]. The TEE simulator that was used in both Sharma and Bose' studies and the Heart work TEE simulator was developed by Heart works (Inventive Medical, Ltd, London, UK).

The VRSim TEE Simulator used in our study consists of a mannequin, a probe, and a machine with two split screens. When the trainee manipulates the probe on the mannequin, echocardiographic views appear on the left side of the screen, and a corresponding three-dimensional heart model, together with the visible probe, showing on the right side of screen. This set of VRSim TEE simulator provides a friendly environment without pressure and time limitations for hands-on TEE training in the operation room.

The real grayscale images of VRSim TEE obtained from volunteers' TEE exam data have made our simulator unique. The VRSim system images are easy for the instructor and trainees to discuss on echo image manipulation and acquisition.

To the best of our knowledge, our study is the first to compare the training effectiveness of a web-based TEE training system with simulator-based TEE training module. The reason for choosing the Virtual TEE system is because, Virtual TEE uses real grayscale images from volunteers' TEE exam data, unlike the CT2TEE web-based training program [21]. We assume that the use of Virtual TEE will avoid the color image differences and visual effect bias between the two groups, which can potentially enhance the training outcomes. In addition, the Virtual TEE system, which has already been translated into Chinese, also prevents any misunderstanding via a language barrier.

The results of our study shows that residents who received one hour simulator-based VRSim TEE training system performed better in the written test compared to the residents who were only undertaken to web-based Virtual TEE at same time. The written test included factual information, cognitive imaging recognition, descriptive probe manipulation to acquire appropriate images (acquisition and interpretation).

The main difference between these two training methods is that the simulator-based method is able to provide an opportunity for hands-on practice with probe manipulation and image acquisition. Moreover, there are a great amount of echocardiographic views on every aspect of the heart in the VRSim system, which allows the trainees to be able to repeat a simulated comprehensive TEE examination. Hand-eye coordination can also enhance memory and helps to develop spatial orientation. This method is user-friendly for trainees to achieve a visual picture in mind and understanding between probe position, heart anatomy, and two-dimensional images [6]. In addition, VRSim system is the first mannequin- and computer-assembled TEE simulator including a Chinese interface while CAE VImedix and Heartworks has English interface only that are not suitable for most Chinese aneshthesiologists.

Despite these results, the web-based TEE training also has its characteristic advantages. For instance, web-based training does not require any expensive or sophisticated devices. It is available to all students who wish to learn TEE online, with no require on space, facility or supervision. Few limitations in our study need to be concerned. Firstly, we only conducted a short-term experiment and focused on certain learning objectives and teaching points. The impact of long-term learning process on these two methods needs to be investigated in future. In addition, no test was conduct for participants

before the training program, therefore, if any of them has knowledge or experience of TEE was unknown. The different knowledge backgrounds of the participants may also lead to the heterogeneity of the residents that were enrolled in the study. Furthermore, the sample size of the study was small, which limits the extrapolation of the results to a larger population. Only MCQ examination was used to investigate if the simulator is good for improving trainees' knowledge, but in reality about the master of TEE is not sure.

TEE has become a routine check in cardiac and non-cardiac surgeries. However, education on how to use TEE for anesthesiologist residents become a challenge. Simulation-based medical education has been widely accepted as an effective training approach and has been adapted by many subspecialties such as laparoscopic procedures, robotic surgery, basic and advanced life support, and cardiovascular medicine. Simulation-based medical education has achieved remarkable results in last decade [22]. Nowadays, development of a TEE simulator is still in its early stage with only few options of TEE simulators commercially available. In addition to the Virtual TEE and VRSim TEE systems mentioned in our study, similar TEE training devices and programs have been reported previously [20-21,23,24]. A TEE simulator training system provides a friendly, comprehensive learning environment that can reduce the TEE "learning curve" [16]. The application of a TEE simulator is an innovative advancement of simulation-based medical training. Further studies are needed to further validate simulation and e-learning training program on trainees curricula.

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