Endovascular Simulation Leads to Efficiency and Competence in Thoracic Endovascular Aortic Repair Procedures

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OBJECTIVE: Endovascular interventions such as thoracic endovascular aortic repair (TEVAR) have largely replaced invasive open procedures, and have been demonstrated to be effective in treating patients. Our study used endovascular simulation to assess the effect of TEVAR rehearsal on surgical trainees at different levels in training.

DESIGN: Participants were oriented on an endovascular simulator and subsequently a simulated TEVAR was performed during 4 separate sessions over a 1-month period. Metrics included total procedure/fluoroscopy time and volume of contrast used. Likert scale qualitative analysis evaluated participant's skills involving major procedural steps. Analysis of data across cohorts included 1-way analysis of variance, Kruskal-Wallis, and paired *t*-tests.

SETTING: All data were collected at University Hospitals—Case Medical Center, Cleveland, OH.

PARTICIPANTS: In all, 12 trainees in 3 cohorts (student, surgery resident postgraduate year [PGY] 1-3, surgery resident/fellow PGY 4-7, $n = 4$ each) were recruited.

RESULTS: All trainees reduced total procedure time (mean $= 537 \pm 148$ vs 269 ± 66 s, first session vs fourth, $P < 0.05$, CI: 195-341) and fluoroscopy time (mean $= 201 \pm 74$ vs 110 ± 37 s, $P < 0.05$, CI: 51-132) with TEVAR case progression. The student cohort decreased procedure time from 551 ± 84 s to 313 ± 65 s ($P < 0.05$, CI: 189-287) whereas PGYs 1 to 3 decreased procedure time from 591 ± 149 s to 264 ± 29 s ($P < 0.05$, CI: 113-541). Use of contrast decreased over time, but the difference was not significant. Participants acquired proficiency after a few runs in most steps of the procedure. The average qualitative score for all groups combined improved significantly ($P < 0.03$). PGY 4 to 7 trainees had higher technical scores but this was not statistically significant. The initial gap in junior vs senior trainee performance narrowed after a few practice sessions in all aspects evaluated.

CONCLUSIONS: TEVAR rehearsal on an endovascular simulator can reduce overall procedure and fluoroscopy time, independent of trainee skill level or experience, as well as improve subjective measures of technical success. Further studies are needed to compare simulator performance to outcomes in live cases. (J Surg 72:1158-1164. © 2015 Association of Program Directors in Surgery. Published by Elsevier Inc. All rights reserved.)

KEY WORDS: simulation, endovascular surgery, aneurysm, training, assessment

COMPETENCIES: Medical Knowledge, Practice-Based Learning and Improvement

INTRODUCTION

The advancement of endovascular surgery over the last 20 years has dramatically expanded the scope of therapy available to treat patients. In the span of a decade between 1996 and 2006 the number of endovascular procedures in peripheral vascular beds tripled from 138 to 445/100,000 Medicare patients although the rate of lower extremity bypasses decreased by 50%.[1] Endovascular interventions have replaced more invasive open procedures[2,3] and have been demonstrated to be effective in treating patients with aneurysmal and occlusive disease.[4-7] In addition, for patients with thoracic aortic disease, thoracic endovascular aortic repair (TEVAR) has become an attractive minimally invasive option.[8] A Cochrane review comparing thoracic stent graft vs open surgery for thoracic aneurysm showed reduction of early adverse outcomes (e.g., paraplegia), mortality, and hospital stay in the first group.[9]

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This rapid endovascular development has required a significant transition in skill set as both surgeons and trainees have had to adopt entirely new modes of practice. In the setting of resident work hour restrictions and streamlined training regimens, considerable pressure has been placed on the training programs to adequately prepare residents and fellows for independent practice. This challenge is compounded by the need for adequate case volume experience. For example, complex procedures such as carotid artery stenting have been shown to yield the best patient outcomes when performed by experienced surgeons as compared with less experienced practitioners.[10]

Senior Integrated Vascular ("0-5") residents recently reported decreased confidence in performing low-volume cases, with less common endovascular procedures such as carotid stenting and TEVAR procedures representing the lowest training volume overall. However, those trainees with access to simulation reported a significant increase in confidence level over those with no access at all.[11] This suggests that the use of high-fidelity simulation has a role to play in ensuring that residents are adequately exposed to less common clinical cases.

The aim of this study is to quantify trainee improvement through participation in a series of TEVAR-specific simulations.

METHODS

Study Design

Trainees volunteered to participate in the study and, after informed consent, were assigned to 3 different cohorts according to their level of training (student, junior surgery resident postgraduate year [PGY] 1-3, senior surgery resident, or fellow PGY 4-7, $n = 4$ each). Each participant attended a standardized orientation that included an introductory PowerPoint (Microsoft, Redmond, WA) presentation and a practice TEVAR case on the simulator. This was designed to standardize instruction about the basics of catheters and guidewires in vascular surgery as well as the steps on how to perform a straightforward TEVAR case. The practice case was not assessed and allowed for the participants' queries to be addressed. Following orientation, each participant performed a TEVAR simulation case, on 4 separate occasions with a minimum of 5 days between sessions. Primary end points included total procedure and fluoroscopy time, total contrast use, and subjective qualitative performance assessment. A Likert scale qualitative analysis was used to evaluate participant proficiency during each simulation. The scoring tool was adapted specifically for TEVAR procedures from one developed for lower extremity simulation by Chaer et al.[12] (Table 1). Observing and scoring all performances were conducted by 2 study investigators. A qualified thoracic vascular surgeon with thoracic aortic experience instructed this team on specifically what to look for during evaluation. Immediately after each case, these 2 investigators completed scoring independently and then discussed results for each category. Consensus was reached based on the average of the 2 scores. Interobserver agreement was found to be moderate using Cohen's kappa analysis ($\kappa = 0.576$). The scores were not shared with the participants until they had completed all 4 sessions.

Simulation Device

All simulations were conducted on the Angio Mentor Dual Slim (Simbionix, Cleveland, OH) endovascular simulator. It is a dual-access system with 2 representative lower limbs, each measuring 104 × 10 × 13 cm. The individual limb contains 3 haptic sensors responsible for generating sensory and tactile information to the participant. The system also contains a 17 in monitor for displaying live radiographic imaging, a replica foot pedal for controlling fluoroscopy, and a laptop used to control selection of wires and catheters. To the simulator, 2 computed tomographic scans of prior thoracic aneurysm cases were uploaded. Raw digital imaging and communication in medicine data were segmented manually for 3-dimensional reconstruction of the thoracic aneurysm. A case was used for the practice session and the other was serially used for performance assessment (Fig. 1).

Statistical Methods

Continuous variables between first and last cases for each cohort were analyzed with paired *t*-tests. Intergroup comparisons were done using 1-way analysis of variance. Combined overall Likert scores between first to last case were compared using a Kruskal-Wallis test with a Dunn's test for multiple comparisons. Individual cohort scores were assessed by comparing first and last cases using a Wilcoxon signed-rank test. Threshold for statistical significance was defined as $P < 0.05$.

RESULTS

Study Participants

A total of 12 participants were recruited to 3 vascular surgical experience-based cohorts, each containing 4 individuals. The student group consisted of Masters of Physiology candidates from our institution with no previous exposure to endovascular procedures but with some didactic knowledge of thoracic aortic disease. The junior trainee group was composed of a vascular surgery integrated resident (PGY-2) and 3 third-year general surgery residents with 2 clinical years of experience. The mean number of months of dedicated vascular training each person had was 3.8 ± 2.4. The senior trainee group was the most experienced and consisted of a vascular surgery fellow (PGY-7), a minimally invasive surgery fellow (PGY-6), and 2 general