The Role of Simulation in Boosting the Learning Curve in EVAR Procedures

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OBJECTIVE: Simulation may be a useful tool for training in endovascular procedures. The aim of this study was to evaluate the effect of endovascular repair of abdominal aortic aneurysms (EVAR) simulation in boosting trainees' learning curve.

DESIGN: Ten vascular surgery residents were recruited and divided in 2 groups (Trainee Group and Control group). At a first session (t_0), each resident performed 2 simulated EVAR procedures using an endovascular simulator. After 2 weeks, each participant simulated other 2 EVAR procedures in a final session (t_1). In the period between t_0 and t_1, each resident in the Trainee Group performed 6 simulated EVAR procedures, whereas the Control Group did not perform any other simulation. Both quantitative and qualitative performance evaluations were performed at t_0 and t_1. Quantitative evaluation from simulator metrics included total procedural time (T_P), total fluoroscopy time (T_F), time for contralateral gate cannulation (T_G), and contrast medium volume (CM) injected. Qualitative evaluation was based on a Likert scale used to calculate a total performance score referred to skills involving major EVAR procedural steps.

RESULTS: All residents in the Trainee Group significantly reduced T_P (48 ± 12 vs 32 ± 8 minutes, t_0 vs t_1, $p < 0.05$), T_F (18 ± 7 vs 11 ± 6 minutes, $p < 0.05$), and CM used over time (121 ± 37 vs 85 ± 26 ml, $p < 0.05$), but not T_G (5 ± 5 vs 3 ± 4 minutes, $p = 0.284$). In the Control Group metrics did not change significantly in any field ($T_P = 55 \pm 11$ vs 46 ± 10 minutes; $T_F = 25 \pm 9$ vs 21 ± 4 minutes; CM = 132 ± 51 vs 102 ± 42 ml; $T_G = 6 \pm 4$ vs 8 ± 5 minutes, all $p > 0.05$). The average Trainee Group qualitative total performance score improved significantly ($p < 0.05$) after rehearsal sessions when compared with the Control Group.

CONCLUSION: Simulation is an effective method to improve competence of vascular surgery residents with EVAR procedures. (J Surg Ed ■:■■■-■■■. © 2017 Association of Program Directors in Surgery. Published by Elsevier Inc. All rights reserved.)

KEY WORDS: simulation, EVAR, training, vascular surgery, virtual reality

INTRODUCTION

In the past decade, the endovascular repair of abdominal aortic aneurysms (EVAR) for the treatment of ruptured and unruptured abdominal aortic aneurysms has become increasingly widespread compared with open surgical repair. Main reasons for this increasing trend of endovascular procedures are related with their less invasive approach, lower perioperative morbidity and faster postoperative recovery compared with conventional open surgical repair.[1-7]

However, the rapid endovascular development requires a significant change in skill set for vascular surgeons with endovascular techniques getting increasingly greater importance in every-day practice.[8,9] Therefore, an adequate endovascular training program should be an essential part in a vascular surgeon's formation.

Owing to current restrictions in training opportunities in endovascular procedures, reduction in weekly working hours (European Working Time Directive) and budgetary

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constraints, traditional training for the new endovascular surgeon generations is no longer ethically and economically accessible.[10-14] Endovascular simulation may be a useful tool for vascular residents since it allows skills acquisition in a safe and controlled environment, helping them to gain confidence with materials and to collect an adequate case volume experience in endovascular practice.

Simulation for endovascular procedures has been increasingly developed over the past decade, with sophisticated virtual reality (VR) simulators now available. The latest developments in the endovascular field include patient-specific VR simulation that allows a patient-tailored approach, enabling the practitioner to perform and practice real cases on a virtual patient prior to perform the procedure on the actual patient.[15,16]

Despite of the technological development of VR endovascular simulators, this learning method has not yet been introduced in the daily practice.

Aim of this study was to evaluate the effect of EVAR simulation in boosting vascular surgery residents' learning curve by quantifying the performance improvement through participation in a series of simulated EVAR procedures.

MATERIAL AND METHODS

Participants

Ten vascular surgery residents from our Institution (Vascular Surgery Fellowship Program, University of Bologna, Bologna, Italy), at various levels of their residency, were recruited. Participants (6 men/4 women, age 28 ± 3 years, 10 right handed) were randomized in 2 groups (Trainee Group and Control Group) in a way that each group included 3 junior residents (postgraduate year 1-2) and 2 senior residents (postgraduate year 3-4).

Simulator

The endovascular Angio Mentor Dual Slim simulator (3D Systems/Simbionix, Littelton, CO) was used for the study. This simulator is a VR system composed of 2 hardware haptic devices, a laptop and 2 liquid-crystal display screens (Fig. 1). Haptic devices represent the groin of a virtual patient with simulated introducers for guidewire insertion/manipulation and balloons/stent graft deployment, allowing simultaneous bilateral access. Controls for table movement, contrast medium injection, fluoroscopic C-arm positioning, cine-loop recording, road mapping, balloon inflation, and stent graft deployment are available. The Procedure Rehearsal Studio software by 3D Systems/Simbionix was used to generate 3D reconstructions from computed tomography scans of real patients, treated at our Center. The reconstructed 3D models were then uploaded on the VR simulator and practitioners were able to rehearse the procedure on real patients' anatomies. All the patient-specific 3D models were anonymized at the time of the upload.

Study Design

A scheme of the study design is reported in Figure 2. All participants attended a preliminary standardized orientation to EVAR provided by a mentor (vascular surgery specialist). Standardized orientation was divided into a theoretical

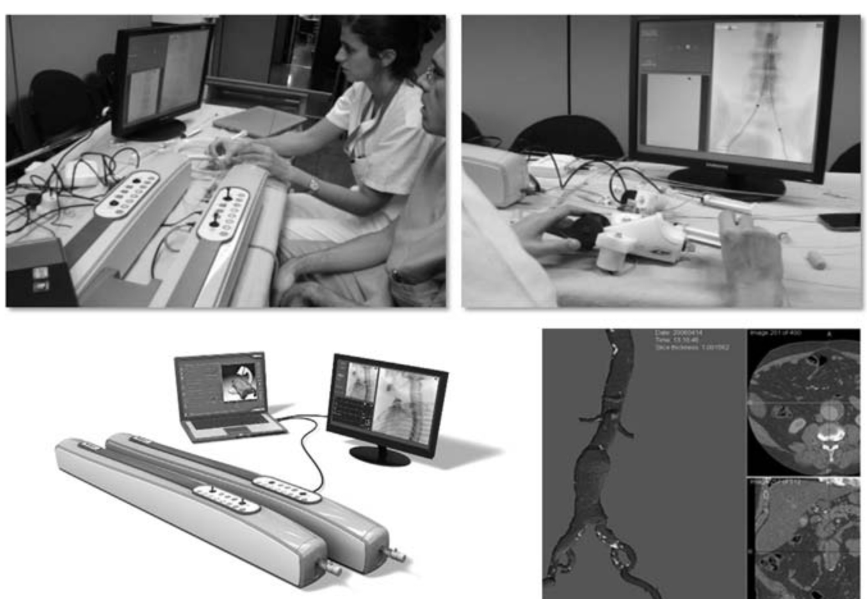

FIGURE 1. The Angio Mentor Dual Slim endovascular simulator used for the study.