EVAR 2020: Training Future Aortic Specialists

Emerging needs and the role of simulation.

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Endovascular aneurysm repair (EVAR) has emerged as a safe alternative to open surgical repair to treat most abdominal aortic aneurysms (AAAs). Short-, mid-, and long-term outcomes are excellent if a patient with an aneurysm ≥ 55 mm has a proper workup and suitable anatomy is treated by an experienced team in a high-volume center using modern imaging techniques. Unfortunately, some cases may still be technically demanding, especially in more complex anatomy and older and sicker patients.

The endovascular revolution has altered the management of aneurysmal disease. More importantly, endovascular specialists should not only be able to exclude the aneurysm, but also know how to select the appropriate patients, accurately measure on dedicated workstations to choose the correct type and size of stent grafts, and have a clear management plan using fusion imaging with bailout options before entering the hybrid angiosuite. To achieve good outcomes, an adequate case volume is required to become an experienced EVAR implanter, but training opportunities are diminishing due to drastic shortening of postgraduate training.[1] It is even more challenging to develop sufficient experience in open aortic surgery.[2]

Fortunately, new training modalities have become increasingly popular and sophisticated to allow physicians with various backgrounds and levels of experience to learn, practice, and improve both endovascular and open vascular skills to manage aortic pathology. Both techniques require a different psychomotor skill set, and it is challenging to keep up with changes in EVAR technology, imaging, and the operating room environment.

Human cadaver and animal models have traditionally been used in open surgical training, but now synthetic

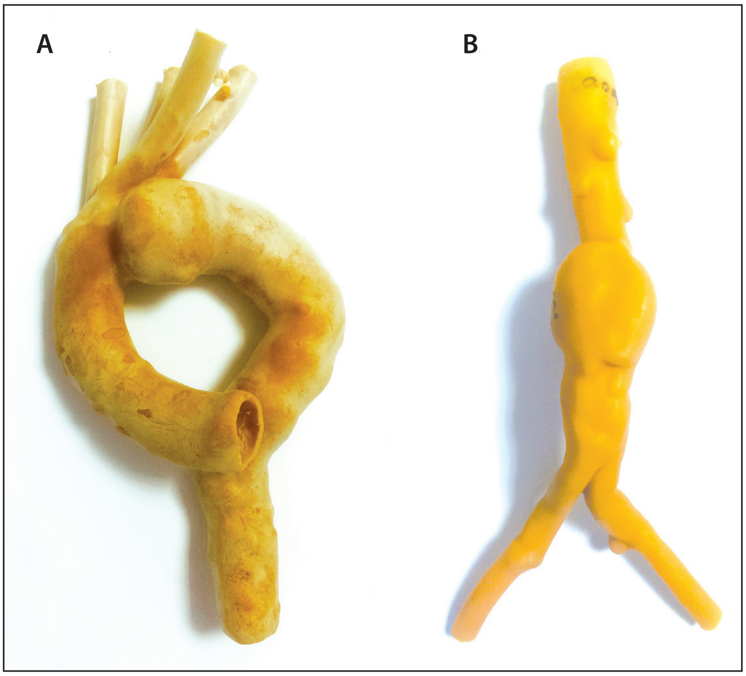

Figure 1. Elastomeric 3D model of the thoracic (A) and abdominal (B) aorta based on patient-specific CTA.

three-dimensional (3D) prints and virtual reality (VR) simulators are increasingly used for endovascular skills training. These safe, generic training environments allow the various endovascular team members to increase their knowledge, learn the sequence and steps of an EVAR procedure, learn how to deploy various stent graft devices, and acquire tips and tricks such as positioning and cannulating the contralateral limb to manage a narrow aortic bifurcation. Multiple studies have shown that simulated skills training aids physicians in the acquisition, enhancement, and maintenance of complex psychomotor skills in a variety of surgical specialties.[3,4] Furthermore, these skills transfer from the simulated to the operative environment and result in improved operative performance with a reduction in procedural errors during real operations on patients.[5,6]

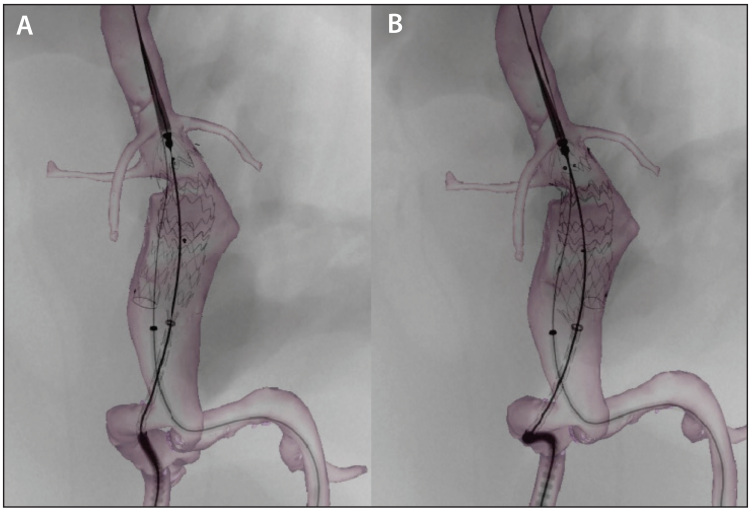

Figure 2. Patient-specific rehearsal of EVAR for a ruptured AAA on the Angio Mentor VR simulator, rehearsing deployment of a stent graft in the ballerina (A) and standard (B) configuration.

ROLE OF SIMULATION

A structured, stepwise, proficiency-based, valid endovascular e-learning and simulation-based program has been developed to train cognitive, technical, and human factor skills for treating symptomatic atherosclerotic iliac and superficial femoral arteries.[7] Similar simulation-based training programs to teach cognitive and psychomotor skills for EVAR have been provided by various societies (eg, European Society for Vascular Surgery, Society for Vascular Surgery, Cardiovascular and Interventional Society of Europe) in collaboration with industry. Ideally, these workshops should be integrated within the endovascular training curricula, as they significantly improve a trainee's planning process and endovascular performance.[8] Generic VR simulation modules offer stepwise training opportunities to develop good hand-eye coordination and manual dexterity and master EVAR procedures. Trainees can improve their accuracy in deploying stent grafts in an angulated aortic neck using simulation-based EVAR courses.[9]

Simulated practice of EVAR procedures has also been shown to lead to decreased fluoroscopy time to exclude aneurysms for both novice and experienced operators.[9] Future curricula will increasingly focus on radiation safety for patients and the endovascular teams by practicing the as low as reasonably achievable (ALARA) and 3D image fusion principles. Radiation exposure is significantly reduced with routine use of image fusion, which applies the ALARA principle, as well as with real-time displayed x-ray exposure during standard and complex EVAR procedures in the hybrid angiosuite.[10]

Simulation can also be used to practice techniques for treating ruptured AAAs using a bifurcated or aorto-uni-iliac stent graft and endoclamping to stabilize the patient. These modules include hemodynamic monitoring based on real patient data and allow the endovascular team, including the anesthesiologist, to administer the appropriate drugs when inflating the aortic balloon. These sophisticated VR simulators can be integrated in a hybrid angiosuite (in situ training) or in a simulated angiosuite (Orcamp, Orzone AB) to train the implanter and the entire team how to manage a crisis such as a ruptured AAA. The annual ESVS (European Society for Vascular Surgery) Management of Aortic Rupture course in Zurich, Switzerland uses these training environments successfully.

More challenging anatomy (eg, short, conical, wide, or angulated necks) may require more advanced planning and endovascular skills to exclude the aneurysm by implanting standard, fenestrated, branched, or parallel grafts. To teach, practice, and master these more complex skills, the next generation of VR simulators is under development to allow for multiple access and permit usage of multiple tools, especially to cannulate various vessels while deploying the stent graft. In the meantime, 3D printed modules are increasingly used to practice these cases (Figure 1).

New endovascular devices are continually introduced, and simulated modules are being created to allow physicians to learn and practice how to use and/or deploy these devices correctly per instructions for use. For example, recently, simulation for the Aptus Heli-FX EndoAnchor system (Medtronic) has been developed in collaboration with 3D Systems.

PATIENT-SPECIFIC REHEARSAL

Other than generic simulation modules, VIST Case-It system (Mentice AB) and Angio Mentor procedure rehearsal studio (3D Systems) have become increasingly popular for practicing EVAR procedures on a VR simulator using patient-specific images prior to treating the patient in real life. Briefly, CTA or MRA images are used to generate 3D reconstructions using dedicated software. Segmentation of the vessel wall is an automated process, but manual augmentation may be needed to adjust modeling of vascular branches (eg, visceral, iliac branches). Bony landmarks and vessel centerlines are assigned and used to align the images within the simulation. These images are then uploaded into software on tabletop VR simulators, and physicians can rehearse the procedure.

Like dedicated 3D software, patient-specific rehearsal allows the implanter to evaluate the anatomy, assess the suitability for EVAR, accurately measure and determine the sizes and number of stent grafts in order to develop a management plan (eg, site of introduction), visualize optimal angles for landing zones, and assess the orientation of contralateral limbs. Patient-specific rehearsal prior to EVAR can reduce the number of angiograms needed to deploy the stent graft, thereby reducing delays and improving procedure efficiency; however, it may also influence the treatment plan, with considerable alterations in 88% of cases (eg, C-arm angulation, choice of grafts).[11,12] With patient-specific rehearsal, both technical and nontechnical skills (communication, coordination), as well as confidence of all team members (both experienced and inexperienced), are enhanced.[13]

Structured didactic programs have demonstrated improved teamwork climate, better communication among team members, and more positive perceptions toward teamwork and may improve team-based attitudes and behaviors within the actual operating room.[14] During these training sessions, less experienced operators tend to focus on technical skills, while more experienced operators realize that human factor skills are paramount to enhance interactions between anesthetists, vascular surgeons, interventional radiologists, nurses, and technicians. In 2020, patient-specific simulation will become an integral part of case selection, especially in unfavorable aortoiliac anatomy (eg, short and/or severely angulated proximal neck) to prevent stent graft malpositioning and insufficient oversizing or predict contralateral gate deployment (Figure 2).[15-17]

LIMITATIONS

Despite the bright future for simulation, biomechanical properties (eg, catheter movement) are not accurately replicated, especially in straightening the iliac arteries in tortuous aortoiliac morphology, where insertion of extra-stiff guidewires induces significant deformations to the vascular structure in real procedures. These deformations may have clinical consequences and must be included both in planning and during the procedure, because they may alter the position of the stent graft within the aneurysm.[18] Likewise, intraoperative 3D image fusion models can also have the same problem, especially in the aortoiliac region.

Furthermore, simulation modules are only designed if device companies are eager to improve the quality of care by offering safe training environments to their customers. Closer collaboration between educators, endovascular experts, engineers, and simulation and device companies is urgently needed to increase the timely application and implementation of simulation-based training for new devices, techniques, and rehearsal in daily practice.

FUTURE

In the future, simulation may not only be used for training and rehearsal. Instead, new techniques or devices may be tested on VR simulators, and more importantly, patient anatomy as well as devices will be printed, tested, and rehearsed with the endovascular team in a simulated environment prior to implantation in the real patient. In 2020, every endovascular team member may be required to be trained and certified on how to use an endovascular device prior to employing it in real life. The operating environment may also change in the future. Endovascular robots using navigation based on preoperative patient-specific rehearsal may become routine practice, while every endovascular team will be debriefed on the procedure based on recordings using a black box (similar to those used in airplanes) in the operating room. Ultimately, the goal is to maintain quality of care and improve patient safety when treating aneurysmal disease in high-tech environments. ■

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