Special Review

# Review of Simulation Training in Interventional Radiology

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Simulation training has evolved and is now able to offer numerous training opportunities to supplement the practice of and overcome some of the shortcomings of the traditional Master-Apprentice model currently used in medical training. Simulation training provides new opportunities to practice skills used in clinical procedures, crisis management scenarios, and everyday clinical practice in a risk-free environment. Procedural and nonprocedural skills used in interventional radiology can be taught with the use of simulation devices and technologies. This review will inform the reader of which clinical skills can be trained with simulation, the types of commercially available simulators and their educational validity, and the assessment tools used to evaluate simulation training.

**Key Words:** Simulation training; medical education; interventional radiology.



## INTRODUCTION

Clinical skills training in medical education is on the cusp of change. Increased pressure on the health-care system to be safer has caused the current Master-Apprentice model of training to fall under scrutiny. The current model has many shortcomings pertaining to patient safety as training is done with real patients; time constraints on training because of shortened resident working hours; and the lack of uniformity in training as trainees are limited to only learning about clinical cases that their patients' present. Medical simulation can effectively address these shortcomings. Medical simulation is broadly defined as "devices, life-like virtual environments and contrived social situations that mimic problems, events or conditions that arise in professional [medical] encounters" (1). Medical simulation allows trainees to train in virtual environments or on models, which eliminates the need to train on patients in the early stages of learning. Simulation training is not limited by working hours as training is done outside of the clinical setting. Instead, it can be administered as a self-paced curriculum tailored to a learner's needs, or as part of a training course. Finally, medical simulation facilitates training uniformity by offering a wide range of scenarios that can be repeated indefinitely.

Interventional radiology (IR) is a specialty where medical simulation training can be especially beneficial. Because of advances in medical imaging, diagnostic angiographic procedures have become less common, reducing the number of opportunities for trainees to practice basic catheter manipulation skills. Additionally, specialists outside of IR are also interested in acquiring these skills (2). By adopting simulation training, trainees from all specialties will have the opportunity to learn these skills. Adding simulation will bring IR into the new era of medical training pioneered by anesthesiology, gynecology, and emergency medicine, specialities that have already implemented simulation training to supplement the apprenticeship model (3–5). The widespread use of simulation in the aforementioned specialities has triggered institutional support with the creation of a Joint Medical Simulation Task Force in 2007 by the Radiology Society of North America, Society of Interventional Radiologists, and Cardiovascular and Interventional Radiological Society of Europe. The Task Force's mandate is to improve patient care by guiding the implementation of simulation in IR (6). The Food and Drug Administration is another institution driving the adoption of simulation training by stipulating that physicians must undergo proficiency training on a simulator before performing carotid artery stenting (CAS) (7).

Historically, simulation in medical education started with the widespread use of standardized patients and animal laboratories (8). Pigs are widely used for learning vascular and nonvascular interventional procedures guided by fluoroscopy, endoscopy, or cross-sectional imaging (9). This review paper will not address these types of medical simulation but instead will focus on technologies and devices used in IR simulation training. Some of the earliest technologies used in IR simulation training were computer-based training modules such as Radiology Society of North America's Medical Imaging Resource Centre and AuntMinnie.com's case of the day (2). Nowadays, augmentative reality simulators such as the VIST-Lab endovascular simulator by Mentice and computer-assisted mannequins are available (10). The sections in this paper

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will address the following questions: what skills can be taught with simulation; what types of commercially available simulators exist for training IR skills, and what is their educational validity; and what assessment tools can be used to evaluate the skills trained with simulation?

## SECTION 1: SKILLS TRAINING

Clinical skills can be broadly categorized as either procedural or nonprocedural skills. A growing body of literature shows that simulation can be used to teach both kinds of skills. Procedural skills are defined as practical physical skills performed by a physician to complete a medical procedure. Conversely, nonprocedural skills, which are just as integral to medical practice, include interpersonal, cognitive, and personal resource skills. The following subsections detail the procedural and nonprocedural skills that can be trained with simulation.

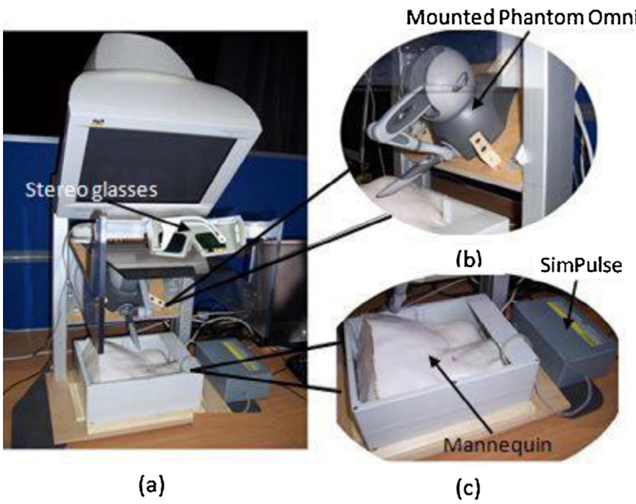


**Figure 1.** ImaGiNe Seldinger workstation 1 where trainees can visualize and palpate the pulse for practicing needle insertion. This is an augmented reality simulator where the stereoscopic glasses (a) provide visualization for a realistic needle insertion onto the mannequin which is equipped with a pulse simulator (c) and a haptics model for force feedback (b) (72).

### Subsection A: Procedural Skills

*Vascular Skills*

*Seldinger technique*.—The Seldinger technique is an essential skill in vascular IR. Johnson et al. compared IR resident's Seldinger technique performance in a patient procedure after clinical or clinical and simulation training on the ImaGiNe Seldinger augmented reality simulator (11). Results showed that the group that got simulation training tended to perform better than the group with just clinical training (Figs 1, 2).

*Cannulation*.—Simulation can also be used to train cannulations under fluoroscopy guidance. Narra et al. compared didactic training of cannulation against simulation training taught on their in-house augmented reality simulator (12). They found that the simulation group scored significantly better than the didactic group in the assessment exercise performed on the simulator. The majority of participants also found that the simulator was a valuable teaching tool and that they would use it for self-directed training.

*Catheterization*.—Simulation has been shown to effectively train catheter-based endovascular skills to residents without any prior endovascular experience. Residents trained on the VIST-Lab showed improved performance in the angio laboratory compared to a control group who did not receive simulation training (13). A 1-week simulation course was given to a group of residents on a cardiac catheterization rotation (14). After training on the VIST-Lab, patient procedures revealed improved performance compared to their pretest scores and the scores of their peers who did not receive training. Notably, training allowed the residents with the lowest pretest scores to improve the most.

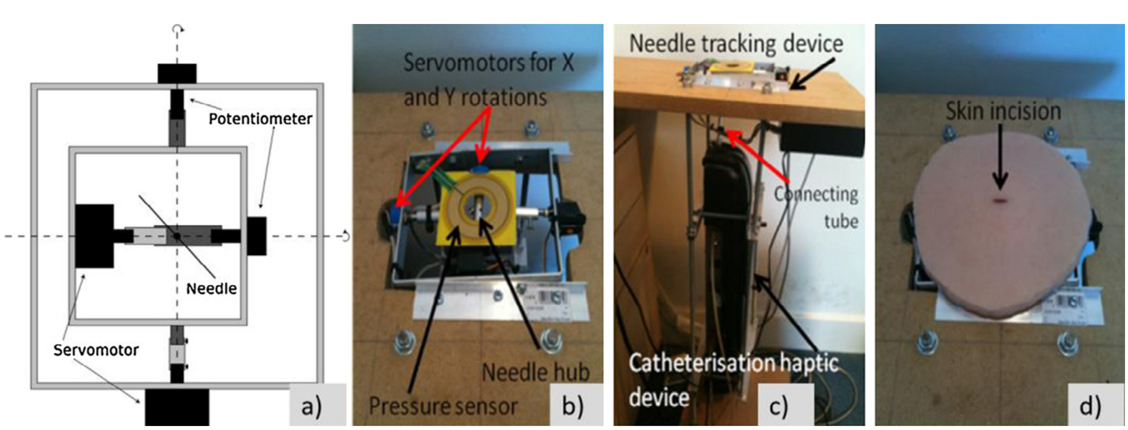


**Figure 2.** ImaGiNe Seldinger workstation 2 (a) where trainees can practice catherization of a vessel including insertion (d) and maneuvering of the guidewire and placement of the catheter. The model includes haptics (b, c) and a computer for visualizing the virtual vessels and IR tools (72).