Simulation: Present and Future Roles

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Interventional cardiology is a broad and expanding field that requires cognitive elements, clinical experience and judgment, and a strong technical component. In addition, because of technological advances and application of this technology to a variety of noncardiac vascular beds such as carotid, peripheral, or renal vessels as well as structural cardiac lesions such as patent foramen ovale, operators are constantly challenged to adapt to new approaches.

Assessment of cognitive elements has been studied extensively, and the metrics have been tested and validated. The establishment of the Interventional Cardiology Board Examination in 1999 in the U.S. as an “added qualification” was founded, in large part, on assessing cognitive elements in the candidates. This and subsequent examinations also tested some aspects of judgment using case examples that required synthesis of data and judgment.

A crucial component has been the teaching and then testing of technical skills, which is the least standardized component in the typical interventional cardiology curriculum. In the typical training experience, trainees in percutaneous coronary intervention develop knowledge and skills through studying, observing, assisting a senior operator, and then ultimately performing the procedures independently. This experience is dictated by the random admission of patients, rather than a timely consistent exposure to the wide range of patient and anatomic conditions. Simulation has the potential to be the platform technology for not only teaching, but also for evaluating and testing.

Background

Simulation has been applied in many disciplines. One of the most well-recognized applications has been in the airline industry where pilot applicants as well as experienced pilots are routinely exposed to realistic flight simulators. A similar robust application has been in the military with advanced technology simulators.

Medical applications of simulators are increasing rapidly for a variety of specialties both medical and surgical and for increasing use in team training (1,2). For interventional cardiovascular disease, simulators have extremely valuable current and future roles (3–5). The field, however, is complex. An important component of the complexity is that there is little standardization among vendors. Important differences include among others:

1. The setting in which the simulator portrays the question to be addressed. For example, is it necessary to have the entire simulator appear like a cardiac catheterization suite with mounted monitors, electrocardiographic and pressure wave forms, or will a tabletop suffice?
2. The interface between the simulator and the trainee. For example, will a “talking head” with the potential for the simulated patient to relay symptoms be required?
3. The ease and efficiency of adding specific clinical and angiographic scenarios. If adding a new scenario takes weeks of dedicated programming time, some applications will be very limited.
4. The necessity and role of the technical support personnel guiding the use of the simulator. For example, do the technical support people need to function like trained catheterization laboratory nurses?
5. The specific role of haptics. This is extremely important for some applications where it is crucial to know how much force is exerted by the operator during the simulation. For example, a simulator that might be used for chronic total occlusion, quantitating the force used in probing the occlusion with guide wires is essential for measurement.

The ideal simulator should provide an environment that closely approximates the characteristics of the environment in which the task will be
performed, with accurate and realistic details. It should mimic the visual–spatial and real-time characteristics of the procedure, provide realistic feedback, and be able to compile and assess the performance of the procedure using validated and objective scoring methods. In addition, a simulator teaching environment should also be used for identifying optimal strategies including material and technique selection, identifying potential difficulties, and presenting complications that will require adjusting the subsequent performance of the simulated procedure.

In addition to the issues of variability in the specific vendor capabilities, other complexities relate to the economics and efficiencies. In some regional areas, fixed simulation centers have been developed, although these may be very expensive to maintain and staff. In other situations, a specific vendor may bring a simulator to a hospital to train operators in a specific technology; for example, a specific distal protection device. Finally, Board Review courses or other annual educational venues may feature simulation alternatives. Funding for these may be problematic.

The roles of simulation in interventional cardiology vary. This variability will be important for defining the future.

Simulation for Testing

The American Board of Internal Medicine is taking a leading role in this application (R. S. Lipner, personal communication, August, 2008). There are multiple considerations involved. The tool used must be able to distinguish between operators who are experienced and those who are not; it must also be able to distinguish between operators who perform satisfactorily and those who do not. This latter function will be used in combination with testing cognitive skills to decide whether a person “passes” or “fails” an examination. The metrics of determining satisfactory performance are difficult because for some technical maneuvers there may not be any body of scientific evidence that can be quoted. Some aspects will be easier than others; for example, if the test taker selects a 3.5-mm stent to position in a 2.5-mm vessel, distinguishing performance will be straightforward. Part of the difficulty will relate to the degree of separation between the 2 alternatives offered. Developing the metrics for constructive validity requires collaboration between experienced interventional cardiologists, behavioral scientists, and computer experts (3).

A related issue is the relative weighting of different aspects of the procedure being tested. For example, is selecting a 3.0-mm stent to treat a 3.5-mm vessel as “bad” as selecting a 3.0-mm × 13-mm stent when you used a 3.25-mm × 20-mm balloon to pre-dilate the lesion? The issue of how “badness” or “suboptimal” are defined will be crucial. Similarly, will some maneuvers be given negative points so that conceivably the total score could be negative or will those maneuvers be given fewer positive points?

Finally, will some maneuvers be so egregious that the patient scenario immediately stops or will points be given for problem solving even though the problem was initially caused by operator mistake?

Yet another issue relates to the specifics of the test facility. Will physicians be given test cases to become familiar with the simulation technology before the testing? Will physicians have their own simulators? Will it be a timed exposure? Who will provide and staff the simulators? These questions among others must be addressed before simulation becomes mainline.

Simulation for Teaching/Training

Simulation for teaching/training has now been used for several years. In other fields such as urology, this approach leads to improved procedural performance. The application of this for interventional cardiovascular disease has been studied for teaching physicians to perform carotid angiography and more recently carotid stenting (4,5). In this setting, which has been applied for interventional cardiologists as well as for surgeons, training on the simulator improves performance and decreases operator errors. In this arena, metrics include the number of times a wire contacts the vessel wall, contrast utilization, catheter vessel errors, and catheter movement errors. In addition, metrics that measure deviations from optimal performance and consistency are important. This application has now become part of the required process by which operators can gain access to carotid stents and distal protection devices. This approach has also been used for training in renal/iliac stenting (2) and for the correct optimal utilization of vein graft distal protection devices. Exciting new approaches for this application will include learning platform technology such as transseptal catheterization, access to the pulmonary veins or left atrial appendage, and approaches to intracranial vessels for stroke treatment. Such platform training will then be used as a basis for training with new specific devices.

A related teaching/training application involves cardiac catheterization teams. Some complications such as cardiac perforation with tamponade are extremely uncommon. Optimizing the outcome in these uncommon complications involves team-based care that can be practiced repetitively on simulators.

There are issues with each of these applications that include how many cases are available, how access to the simulator will be accomplished with either regional simulator centers or a traveling simulator setup, as well as the economics involved. The latter is of great importance as the simulators, program development, and trainers involved are expensive and education is often underfunded. In 2008, at the American College of Cardiology Annual Scientific Sessions, simulator stations were available and were completely filled meeting the needs for physicians each of whom
signed up for 3-h sessions. Similarly at EuroPCR, simulators play a prominent role in the scientific program.

**Case Planning and Practicing**

A unique simulator potential relates to identifying complex patients or complex anatomy, then programming a specific case’s details into a simulator prior to the procedure (1). Once the relevant anatomic details are programmed, the operator can then practice with a range of technology to identify the optimal efficient approach. This application has great potential; there are, however, crucial details of how rapidly a specific case can be programmed and how reflective of actual performance the handling of each specific wire or device is in terms of the simulator.

**Recertification in Interventional Cardiology**

The American College of Cardiology Interventional Council is studying the applications for simulation training and testing by the American Board of Internal Medicine. Dangas and Popma (6) have previously documented the steps and requirements for recertification in interventional cardiology. This process includes home study modules, practice improvement modules, and case volume issues. Simulation may play several roles in this regard. It is possible that performance of a certain number of simulator cases may be used as a surrogate for actual clinical procedural performance. Alternatively, simulation procedures may be a module by itself and count toward the required number of points for recertification. As previously mentioned, simulator sessions are becoming an important part of many Board Review courses.

**Summary**

Simulation for interventional cardiovascular applications is becoming an increasingly robust and important technology. It can play many roles—testing, teaching, training, credentialing, and practicing. Each of these areas has specific challenges, but as platform technology, simulation will improve the quality of our training and help to optimize patient outcome.

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