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Diagnostic coronary angiography: initial results of a simulation program

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ABSTRACT

Background: The use of simulator-based teaching in cardiology has unfortunately lagged behind other procedural specialties. This study investigates the utility of a simulator-based training program for fellows in cardiovascular disease with no prior experience in diagnostic coronary angiography.
Methods: First-year cardiology fellows at University of Illinois-Chicago (UIC) using AngioMentor™ simulators completed benchmark cases requiring basic coronary engagement. Subsequently, benchmark cases were completed one day later and at 9 months following 2–3 months of training in the cardiac catheterization lab. In addition, 1st year cardiology fellows were compared to 3rd year fellows. Objective measures assessed from benchmark cases were total procedural time, total contrast used, and total fluoroscopy time.
Results: All 1st year fellows improved their total time to complete the benchmark case from initial to second attempt one day later (14:56 on Day 1, 8:30 on Day 2, $P = 0.03$). Total contrast used (60 mL on Day 1, 39 mL on Day 2, $P = 0.11$) and total fluoroscopic time (6:30 on Day 1 and 4:26 on Day 2, $P = 0.16$) also both decreased. Overall procedure time and contrast use were similar among 1st and 3rd year fellows after simulation training. Decreases in procedure and fluoroscopy time were maintained in 1st year fellows after 2–3 months of training.
Conclusion: Fellows displayed technical and procedural improvement at diagnostic coronary angiography in a short period of time and in a safe, patient free environment. In this study, a computer-based simulator was successfully incorporated into a first year cardiovascular fellowship curriculum and represents a contemporary means to provide the fellow increased procedural training without added risk to the patient.
Sentence summary: The use of simulator-based teaching in cardiology has unfortunately lagged behind other procedural specialties. In this study, a computer-based simulator was successfully incorporated into a first year cardiovascular fellowship curriculum. A firm teaching curriculum is the next step towards implementing this modality in an organized fashion.

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1. Introduction

Simulator-based training offers the potential to provide high-yield training in diagnostic and interventional cardiology without added risk to the patient. The appeal of virtually unlimited practice in a patient free, risk-free training environment is evident by the rapid adoption of simulator training nationwide [1,2]. The advantages of this technology have been recognized by numerous teaching consortiums, most notably the Accreditation Council of Graduate Medical Education (ACGME), which now recommends simulation training for numerous specialties as well as the Society for Cardiovascular Angiography and Intervention [3,4]. There are numerous examples of successful implementation of this training methodology in general surgery, neurosurgery, vascular surgery and interventional radiology [5–7]. The utility of this as an evaluation method has also been assessed for experienced cardiologists for high-risk endovascular procedures [8].

The use of simulator-based teaching in cardiology has unfortunately lagged behind other procedural specialties. In this study we sought to evaluate the utility of the AngioMentor™ as an introductory tool for novice cardiology fellows prior to hands-on exposure and training in the cardiac catheterization laboratory.

2. Methods

Seven first-year cardiology fellows were introduced to the Simbionix AngioMentor™ (Simbionix USA, Cleveland, Ohio, USA) at the start of their fellowship training. None of the fellows had previous exposure to angiography or endovascular training, and none of the fellows had previous exposure to simulator-based training. The AngioMentor™ uses actual catheters and wires that are introduced through a port, allowing the simulator to capture the movements of both wire and catheter in a three-dimensional space. For this protocol, only femoral access was simulated. A Judkins Left (JL4) and a Judkins Right (JR4) catheter were used as the simulated diagnostic catheter. Visual angle manipulations simulating a typical C-arm along with fluoroscopic images were monitored on an adjacent screen.

Abbreviations: ACGME, Accreditation Council of Graduate Medical Education; JL4, Judkins Left; JR4, Judkins Right; UIC, University of Illinois-Chicago.

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After completing a brief step-by-step tutorial to become familiar with the technical features of the machine, each participant performed a full diagnostic catheterization simulation. Each simulation starts with a brief patient clinical summary and electrocardiogram. Next the fellow proceeded to the interactive portion of the simulation, which consisted of a full diagnostic coronary angiogram.

The interactive portion of the study was organized into three phases. Phase one consisted of the seven 1st year fellows performing 4 distinct simulated cases consisting of one benchmark case that was completed before (on Day 1) and after (Day 2) 3 practice cases. In other words, after the initial benchmark case on Day 1, each fellow was allowed to train further by completing 3 additional AngioMentor™ simulations similar to the initial one, albeit with different culprit coronary artery lesions. One day later, each participant was reassessed with the initial benchmark case. Engagement of both right and left main coronary arteries was performed in standard views of each artery (left anterior oblique cranial, left anterior oblique caudal, right anterior oblique cranial, right anterior oblique caudal views for the left system; right anterior oblique and left anterior oblique views for the right system). Objective performance criteria measured includes total procedural time, total contrast used, and total fluoroscopy time.

In phase 2, three 3rd year training (expert) fellows were given the benchmark AngioMentor™ simulation to perform. Third year expert fellows were given the same step-by-step tutorial and practice cases prior to completing the benchmark cases. Two iterations were completed by the 3rd years and the average of the total procedure time, total contrast used and total fluoroscopy time was measured and compared to the benchmark study completed by the 1st years after practice simulations.

The third phase of the study was completed after 9 months of 1st year cardiology curriculum. At this time 1st year fellows had experienced 2 months of diagnostic and percutaneous interventions at the University of Illinois at Chicago and Advocate Christ Medical Center in Oak Lawn, IL. During this time, each fellow was exposed to 80–120 diagnostic and interventional coronary procedures that include a mixture of femoral and radial approach. Three 1st year fellows volunteered to be retested on the benchmark study. Objective measures recorded from the benchmark study included total procedure time, total contrast used, and total fluoroscopy time. As with the first two phases, each fellow used exactly 2 diagnostic catheters and 1 guidewire for the procedures.

All analyses were performed using the nonparametric Mann–Whitney U test by SAS statistical software, version 9.2 (SAS Institute Inc., Cary, North Carolina). Data expressed as median ± interquartile range (IQR), rounded to the second or 1 ml. The criteria used for statistical significance was $p < 0.05$. All investigators have read and agree to the manuscript as written. The investigators are solely responsible for the design and conduct of this study, all study analyses, and the drafting and editing of the report and its final contents.

3. Results

Objective simulator recorded assessment demonstrated a decrease in time needed to complete standard coronary angiogram from Day 1 time of 14:58 to a Day 2 time of 8:30; ($p = 0.03$) (Table 1). In addition to decrease in overall procedure time, total amount of contrast injected decreased from 60 mL on the Day 1 simulation to 39 mL on the Day 2 assessment ($p = 0.11$) (Table 1). Moreover, total fluoroscopy time for each simulation decreased from an average of 6:30 on Day 1 to 4:26 on Day 2 assessment ($p = 0.16$).

Table 1
Recorded assessment of benchmark simulation before and after practice simulations.

	Initial	Day 2	p value
Total procedure time (min)	14:56 (11:09–18:29)	8:30 (7:04–12:15)	0.03
Total contrast injected (mL)	60 (46–70)	39 (29–60)	0.11
Total fluoroscopy time (min)	6:30 (4:37–7:42)	4:26 (2:52–7:01)	0.16
N = 7			

Values are median (IQR).

Next, objective simulator performance data of the benchmark case from 1st year fellows after completing simulator training were compared to the 3rd year fellows after they completed two iterations of the benchmark simulations. Total procedure time was 8:30 (IQR, 7:04–12:15) for the 1st years versus 10:13 (IQR, 6:47–11:11) for the 3rd years. Total contrast used was 39 mL (IQR, 29–60 mL) for the 1st years versus 40 mL (IQR, 35–68 mL) for the 3rd years. Total fluoroscopy time was 4:26 (IQR, 2:52–7:01) versus 2:21 (IQR, 1:53–3:06) for 1st year and 3rd year cardiology fellows respectively (Fig. 1.).

Lastly, three out of the seven 1st year fellows volunteered to repeat the benchmark simulation 9 months into cardiology training. Measurements taken at 9 months were compared to the second benchmark study completed earlier in the year (the second benchmark after the initial benchmark study and 3 practice simulations). Total procedure time after 2nd iteration versus after 9 months in fellowship was 7:34 versus 7:55 for fellow 2, 6:11 versus 6:45 in fellow 3, and 8:30 versus 8:27 in fellow 4 (Fig. 2). Total contrast in milliliters used in the 2nd iteration versus after 9 months was 48 mL versus 47 mL in fellow 2, 27 mL versus 49 mL in fellow 3, and 60 mL versus 31 mL in fellow 4 (Fig. 2). Total fluoroscopy time in the 2nd iteration versus after 9 months was 3:39 versus 2:17 in fellow 2, 2:42 versus 2:53 in fellow 3, and 5:35 versus 5:32 in fellow 4 (Fig. 2).

4. Discussion

This study shows that in the AngioMentor™ simulation program, time needed to complete the simulated coronary angiogram by the 1st year fellows was decreased after simulation training (Table 1). Nine

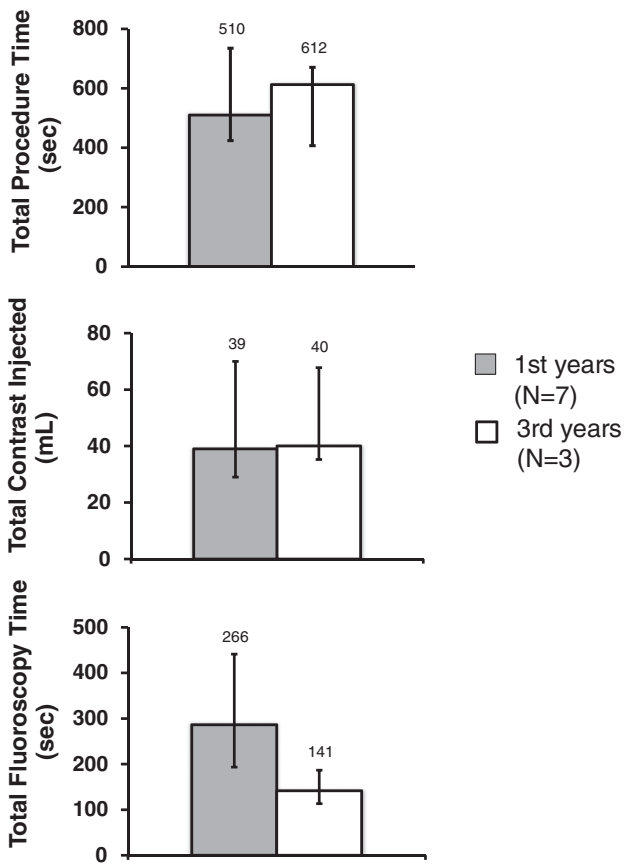

Fig. 1. Objective performance data of 1st year compared to 3rd year fellows after completing simulator training Description: Benchmark diagnostic catheterization simulation performed by 1st year fellows compared to 3rd year fellows using objective measures of total procedure time, total contrast injected, and total fluoroscopy time.