Simulation in Interventional Cardiology—An Overview

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Coalition for Physician Enhancement

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How Do Interventional Cardiologists Learn to Perform New Procedures?

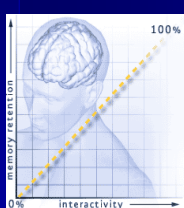
- "Throw-away" magazines on medical topics
- Attend annual or semi-annual meetings of professional societies with didactic lectures
- E-mails sent with links to educational websites
- Local continuing education programs
  - Lunch or dinner programs with speakers
- Watch live cases at meetings
- Practice on patients in their hospitals
  - Apprenticeship model of training of fellows

Human Learning: Level of Interactivity

Why Use Simulations?

	Retention	
Teach Others	90%	Collaborative Simulations
Learn By Doing	75%	Simulations
Discussion Groups	50%	Web Seminars, IM, chat
Demonstration	30%	Animation
Audio Visual	20%	PowerPoint Slides
Lecture	5%	Streaming media

Source: Andersen Consulting



- **Interaction** is associated with learning achievement and retention of knowledge
- Participants **learned faster** and had **better attitudes** when they used an interactive instructional environment

Najjar, L. J. (1998). Principles of educational multimedia user interface design. *Human Factors*, 40(2), 311-323.

Medical Simulation

- Training tools developed to imitate:
  - Anatomic regions
  - Clinical tasks
  - Real patients
  - Real-life circumstances in which medical care is rendered

Issenberg SB and Scalese RJ. *Persp Biol Med*, (51)1:31-46, 2008

Spectrum of Simulations

- Case Scenarios with role playing
- Computerized Case Scenarios
- Programmed Patient Training
- Surgical "Box" Trainer
- Mannequin based Simulation—SimMan™ (Laerdal) or METI HPS
- Anesthesia OR Simulations
- VR Surgical Simulations—MIST-VR, ES3, GI Mentor, etc
- High-Fidelity Endovascular Simulators
- Flight Simulators for Airline Industry

Lower Cost → Higher Cost

Recommendations from IOM

- Use simulators to ensure that clinical training is <u>safe</u> for patients
- Develop simulators for use in skills assessment
- Use simulation technology to improve <u>individual</u> and <u>team performance</u> through interdisciplinary team training
- Use simulation for problem solving and recovery from problems — "crisis management"

To Err is Human: Building a Safer Health System, Institute of Medicine, Committee on Quality, National Academy Press, 1999

Features and Uses of Medical Simulations That Lead to Most Effective Learning

- Feedback
- Repetitive Practice
- Range of Difficulty
- Multiple learning strategies
- Clinical variation
- Controlled environment
- Individualized learning
- Defined outcomes and benchmarks
- Simulator validity and realism
- Curricular integration

Best Evidence Medical Education (BEME) Collaboration
Issenberg SB et al. *Med Teach* 27(1):10-28, 2005

Goals of Simulation Training

- Improve skills through interval practice
- Improve consistency of performance
- Decrease errors
- Provide proximate and summative feedback
- Allow for assessment of progress
- Incorporate a standardized, comprehensive curriculum
- Optimize patient safety by accelerating the learning curve prior to patient exposure

Adapted from Gallagher AG et al. *Ann Surg* 2005;241:364-372

Overview of Simulation Based Training Techniques

Simulation Type	Teamwork competencies	Primary Strengths	Primary Weaknesses
Case Studies/ Role Plays	Knowledge, attitudes	Low costs, (+) trainee reactions	Few opportunities for skill practice
Partial Task Trainers	Knowledge, skills	Low costs, distraction free environment	No opportunity for dual task practice
Full Mission Simulations	Knowledge, skills	Can simulate rare (but critical) tasks in safe environment	High cost, currently limited to few medical specialties

Beaubien JM, Baker DP. *Qual Saf Health Care* 2004;13(supp):i51-56

Why Interventional Cardiology?

- Procedures carry significant risk
- Procedures are becoming more complex
- In the US, too many low volume centers with too many low volume operators
- Training needs to be safe for patients
- Need patient specific anatomy to practice appropriate (rehearsal)

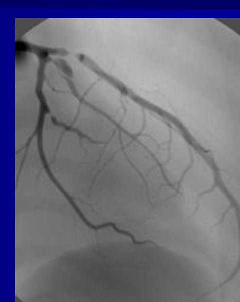
Simulation Platforms for Endovascular Simulation

SIMSUITE
MEDICAL SIMULATION CORPORATION

Simbionix

Simulations in Cardiac Catheterization

- Coronary Angiography
  - Femoral access
  - Radial access
- Right heart catheterization
- Angioplasty
  - Balloon/stent
  - Complications
  - Scenarios (rotablator)
- Special tools
  - Atherectomy
  - Embolic protection devices

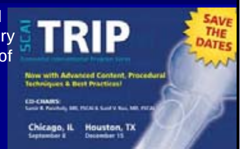


Learning New Skills--Transradial Intervention

Radial Access is associated with reduced bleeding complications and vascular injury
Rates of use in US are very low (<10% of PCI)
Rapid uptake in training and practice

TRIP Program:
Didactic curriculum developed by radial experts with hands on simulation training
- access simulator
- catheter navigation
- angiography and intervention
- complications

Next generation will use simulation evaluation



Simulations in Peripheral Intervention

Peripherals

- Carotid Intervention
  - Angiography
  - Stenting
  - Embolic protection
- Aortoiliac stenting
- SFA/popliteal
- Aneurysm repair
  - EVAR
  - TEVAR

Simulation in Structural Heart Disease

- Percutaneous Aortic Valve Replacement (TAVR)
- Transeptal puncture
- Congenital defect closure
  - PFO/ASD
- LAA occlusion
- Mitral Valve Clipping

Features of Current Generation Simulators

- Use of current cath lab equipment
- Realistic imaging
  - X-ray, echocardiography, ultrasound
- Realistic hemodynamic monitoring
  - Electrocardiograms and pressures
- Pharmacology models
- Realistic catheter/device manipulation

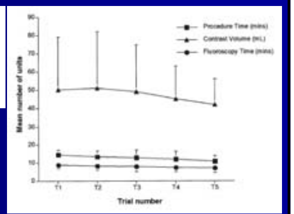
Metrics Applicable to Interventional Procedures

- Procedural time
- Fluoroscopy time
- Catheter advancement time and errors
- Wiring time and errors
- Appropriate diagnostic images obtained
- Device selection, positioning and use
- Recognition and management of errors

Validation Studies in Endovascular Simulation

- Predominantly face validity
  - Does the simulator appear to be a realistic training environment?
- Small studies, with few randomized trials
- Well received by trainees
- No impact on clinical care noted yet

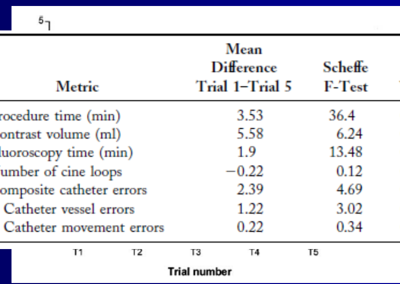
Simulation Training for Carotid Ctenting



N=20 interventional cardiologists
Instruction on carotid angiography
Performed 5 simulated cases
Metrics included
- procedural time
- fluoro time
- contrast volume
- catheter errors

Patel AD et al J Am Coll Cardiol 2006;47:1796-802

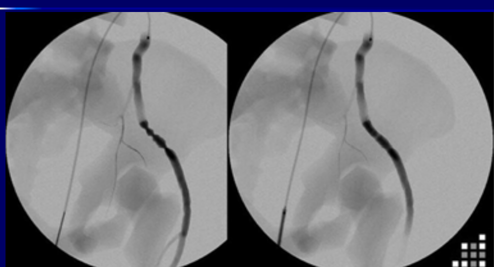
Catheter manipulation errors over time



Metric	Mean Difference Trial 1–Trial 5	Scheffe F-Test	p Value
Procedure time (min)	3.53	36.4	0.001
Contrast volume (ml)	5.58	6.24	0.02
Fluoroscopy time (min)	1.9	13.48	0.002
Number of cine loops	−0.22	0.12	0.78
Composite catheter errors	2.39	4.69	0.04
Catheter vessel errors	1.22	3.02	0.1
Catheter movement errors	0.22	0.34	0.57

Patel AD et al J Am Coll Cardiol 2006;47:1796-802

Peripheral Vascular Intervention- VR to OR



Chaer R et al Ann Surg 2006;243:343-52

Validation Study in PAD

- 20 surgical residents included with randomization to simulation based training versus standard
- Performance of two simulated cases with consecutive mentored catheter-based interventions for lower extremity occlusive disease in an OR/angiography suite.
- Resident performance was graded by attending surgeons blinded to the resident's training status, using 18 procedural steps as well as a global rating scale.

Chaer R et al Ann Surg 2006;243:343-52

PAD Simulation Training

TABLE 4. Mean Checklist Scores on Individual Measures of Performance for Simulator- and Non–Simulator-Trained Residents

	Procedure 1			Procedure 2		
	Simulator-Trained	Non–Simulator-Trained	P	Simulator-Trained	Non–Simulator-Trained	P
Advance femoral wire	2.4	1.4	NS	2.6	2.0	NS
Advance wire atraumatically	2.6	1.8	0.05	2.8	2.0	0.03
Constantly visualize wire tip	2.9	1.4	0.005	3.1	1.9	0.001
Mount and advance catheter over wire	2.9	2.0	0.01	3.1	2.9	NS
Position imaging catheter	2.1	1.2	0.04	2.4	1.8	0.03
Knowledge of anatomy	2.4	1.3	NS	2.5	1.6	0.04
Walk catheter back over wire	2.9	2.0	NS	3.4	2.7	0.05
Advance balloon over wire	3.1	2.2	0.006	3.4	2.6	0.02
Center balloon over stenosis	3.0	2.0	0.009	2.9	1.9	0.003
Balloon inflation	3.0	2.0	0.003	3.0	1.7	0.003
Balloon pressure	2.6	1.3	0.003	2.3	1.1	0.002
Walk balloon back over wire	3.0	2.2	NS	3.3	2.0	0.006
Image after PTA	2.5	1.8	NS	2.6	1.9	NS
Advance stent over wire	3.0	2.3	NS	3.4	2.2	0.01
Center stent over stenosis	2.6	2.1	NS	2.9	1.8	0.01
Accurately deploy stent	2.6	1.4	NS	3.0	1.7	0.01
Walk stent shaft out over wire	3.0	2.4	NS	3.3	2.0	0.006
Completion angiogram	2.2	1.9	NS	2.7	1.7	0.04

NS indicates not significant; PTA, percutaneous transluminal angioplasty.
Details of the checklist scoring sheet available in appendix A.

PAD Simulation Training

Mean Global Rating Scores for Procedure 2
Simulator Trained 33±6 vs Standard 21±6, p<0.005

TABLE 5. Mean Endovascular Global Rating Scale Scores on Individual Measures of Performance for Simulator- and Non–Simulator-Trained Residents

	Procedure 1			Procedure 2		
	Simulator-Trained	Non–Simulator-Trained	P	Simulator-Trained	Non–Simulator-Trained	P
Time and motion	2.3	1.4	NS	2.6	1.7	0.01
Wire and catheter handling	2.8	1.6	0.002	3.0	1.9	0.009
Awareness of wire position	2.6	1.7	0.005	3.0	1.8	0.01
Wire stability	2.6	1.9	NS	3.0	2.1	0.04
Fluoroscopy usage	1.5	1.1	NS	2.0	1.1	0.003
Precision of wire/catheter technique	2.8	1.7	0.03	2.8	1.7	0.005
Flow of operation	2.4	1.4	NS	2.8	1.2	0.002
Knowledge of procedure	2.0	1.4	NS	2.4	1.1	0.005
Quality of final product	3.6	3.0	0.03	3.3	3.2	NS
Ability to complete the case	2.4	1.4	0.03	2.6	1.4	0.01
Need for verbal prompts	2.3	1.0	0.03	2.4	1.4	0.01
Attending takeover	2.6	1.4	0.003	2.9	1.7	0.006

NS indicates not significant.
Details of the global rating scale scoring sheet available in Table 3.

Chaer R et al Ann Surg 2006;243:343-52

ABIM Validation Study—Coronary Angioplasty

A Technical and Cognitive Skills Evaluation of Performance in Interventional Cardiology Procedures Using Medical Simulation

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Introduction: Interventional cardiology, with large numbers of complex procedures and potentially serious complications, stands out as an obvious discipline in which to apply simulation to help prevent medical errors. The objective of the study was to determine whether it is feasible to develop a valid and reliable evaluation approach using medical simulation to assess technical and cognitive skills of physicians performing coronary interventions.
Methods: Clinical case scenarios were developed by a committee of subject matter experts, who defined key decision nodes, such as stent positioning, and introduced unanticipated complications, such as coronary perforation. Subjects were 115 physicians from 10 U.S. healthcare institutions at three levels of expertise: novice, skilled, or expert. Subjects completed a questionnaire, one practice case and six test cases on a SimSuite simulator (Medical Simulation Corporation, Denver, CO), and an opinion survey. Clinical specialists rated subjects' procedural skills.
Results: A technical and cognitive skills evaluation of performance in interventional cardiology procedures using medical simulation yielded results that distinguished between a novice group and skilled or expert groups ($P < 0.001$) and scores

Lipner RS et al *Sim Healthcare* 5:65–74, 2010

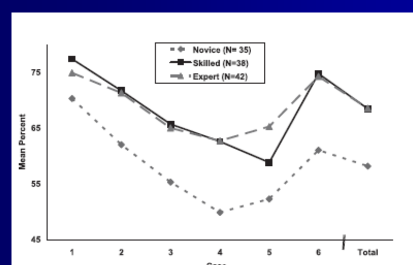
Study Design

- 6 interventional simulations created by the ABIM Interventional Committee
- Broad range of cases/skills tested
- Scoring system focusing on technical and cognitive aspects of interventional cardiology developed
- Recruitment of subjects from 10 hospitals around the US

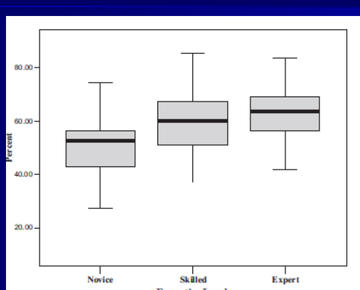
Study Population

	Total (n = 115)	Novice (n = 35)	Skilled (n = 38)	Expert (n = 42)	Sig.†
Male (%)	88	84	81	97	NS
Mean years since medical school	13.2 (8.7)	6.3 (2.2)	10.7 (5.0)	21.5 (8.1)	$P < 0.01$
Cardiovascular disease certificate (%)	53	3	50	100	$P < 0.01$
Interventional cardiology certificate (%)	42	0	22	97	$P < 0.01$
Mean practice years as cardiologist	5.7 (8.1)	0.3 (1.1)	2.0 (3.9)	13.8 (8.1)	$P < 0.01$
Mean practice years as interventional cardiologist	4.8 (7.4)	0.0 (–)	0.6 (0.8)	12.9 (7.1)	$P < 0.01$
Mean no. therapeutic procedures in past year	110.9 (123.7)	0.2 (0.9)	124.0 (124.3)	200.1 (100.5)	$P < 0.01$
Mean number therapeutic procedures/career	875.2 (1379.4)	2.7 (14.1)	193.3 (198.6)	2256.9 (1504.0)	$P < 0.01$
Prior simulator experience (%)					
None	45	72	41	25	$P < 0.01$
<1 h	26	6	38	33	
1–3 h	20	16	16	28	
>4 h	9	6	6	14	
Time currently spent on therapeutic procedures as primary operator (%)					
0–10	39	97	25	0	$P < 0.01$
11–25	9	0	6	19	
26–50	19	0	25	31	
>50	33	3	43	50	
Typical complexity of therapeutic procedures (%)					
Simple	24	69	6	0	$P < 0.01$
Moderate	35	22	53	31	
Complex	37	0	38	69	
Not applicable	4	9	3	0	

Case and Total Score Performance by Experience Level



Cognitive Skills / Decision Making by Experience



ABIM Study--Conclusions

- Physician evaluation using high-fidelity medical simulation to assess technical and cognitive skills can be used to identify physicians who are poor performers in interventional cardiology
- The use of a high-fidelity simulator incorporating situations with multiple events, immediate feedback, and high sensory load would complement the results of traditional written examinations of medical knowledge to provide a more comprehensive assessment of physician ability in interventional cardiology.

Lipner RS et al *Sim Healthcare* 5:65–74, 2010

ABIM MOC Training

Earn 20 points of MOC credit and up to 2*AMA PRA Category 1 Credits*™ by completing a medical simulation, which provides hands-on opportunity to perform cases that mirror what a physician would typically face in daily practice.

Simulations are completed on-site at one of Medical Simulation Corporation's SimSuite® education centers, and are also offered at several meetings and conferences throughout the year.

Simulations currently offered by ABIM

Interventional Cardiology – Four ABIM-developed cases

Locations

Medical Simulation Corporation SimSuite® Centers at:

•Duke University Medical Center, Durham, NC
•University of California at Davis Medical Center, Sacramento, CA
•Riverside Methodist Hospital, Columbus, OH
•University of South Florida at Tampa General Hospital
•Medical Simulation Corporation headquarters, Denver, CO (part time)

Accreditation Council for Graduate Medical Education | Resident Services | Program Directors & Coordinators | DIOs | Public | ACGME

IV.A.2) Systems-based Practice

Fellows must demonstrate an awareness of and responsiveness to the larger context and system of health care, as well as the ability to call effectively on other resources in the system to provide optimal health care.

IV.A.3. Curriculum Organization and Fellow Experiences

a) All 12 months must include clinical experiences and appropriate protected time for research.
b) **Fellows must participate in training using simulation.**
c) The core curriculum must include a didactic program based upon the core knowledge content in the subspecialty area.

**In effect 7/2012 for Cardiovascular Disease and Interventional Cardiology

Simulation of Interventional Procedures--TAVR

Advancement of Percutaneous Valve

Evaluation of Errors

Training in Complex Device Use--TAVR

Current Status of Simulation in Interventional Cardiology

- Collaborative evaluation of the current state of simulation
  - ABIM
  - Society of Cardiovascular Angiography and Intervention
  - American College of Cardiology
- Survey of simulation use in interventional cardiology training
- White paper on Simulation in IC

Challenges

- Funding
- Integration of simulation with a didactic curriculum
- Standardizing and validating metrics
- Broad dissemination of simulation training

Unanswered Questions

- What is the value?
  - Does simulation training improve clinical outcomes?
- Will this continue as part of maintenance of certification?
- How do we best incorporate this into training from a cardiology societal perspective?
- What is the role is testing?

Summary

- Simulation training (and testing) is available for interventional cardiology but needs further investigation
- The simulated procedures have expanded dramatically in the last several years with limited evaluation
- There needs to be a societal and accreditation approach to guide the use and incorporation of simulation in interventional cardiology

Questions