The most interesting papers about endovascular simulation training

A paper summary by Professor Lars Lönn
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A COMMON QUESTION in clinic is: “How experienced and skilled are you and your team?”, and the team might even ask themselves: “How skilled are we really”? Although closely supervised and trained under a gradually-increasing responsibility principle, a time will come when there is no immediate available back-up in the catheterization lab. Furthermore, increased transparency and public awareness of medical errors has opened up a Pandora’s Box regarding a physician’s skill level and experience.

THE SCIENTIFIC EVIDENCE is sound and clear. Without a doubt, the best way to learn any motor skill, on the basis of solid theoretical and practical experience, is in a context where the curriculum embraces simulation technology, thus making the transition to live cases easier and ameliorating the pathway from theory to the endovascular suite.
INTRODUCTION

ACCORDING TO A recent publication in Catheterization and Cardiovascular Interventions, authorized by the Society for Cardiovascular Angiography and Intervention's (SCAI) Simulation Committee, the Society declares that, in future, simulation will take on a larger role in cardiovascular training and the maintenance of certification. However, the authors also conclude that, at present, there lacks a large body of evidence for its use. The papers described in this chapter focus mainly on assessment, economy, curriculum and transfer of skills, and are a response to Doctor Green’s sentence. There is already a large bulk of existing evidence out there in the community.

1. The current state of medical simulation in interventional cardiology: a clinical document from the Society for Cardiovascular Angiography and Intervention’s (SCAI) Simulation Committee
THE IMPORTANCE OF VALIDATION

VALIDATION OF A product is an essential quality assurance process. In medicine, validation studies need to establish evidence that provides a high degree of assurance that the system or service accomplishes its intended requirements. Validation is a process of evidence. In the end, this evidence should verify that the product does what it is intended and designed to do.

ENDOVASCULAR PROCEDURES HAVE replaced traditional open surgery in many vascular regions. This creates added pressure to educate more endovascular operators. The order and complexity of clinical procedures are often presented to the trainee in a random fashion, which gives sub-optimal and inefficient learning opportunities. Virtual reality offers potential for training, assessment and procedure rehearsal outside the operating room in a safe environment. Procedures can either be simulated, using cases supplied by the simulator, or by using real anatomy derived from imaging methods such as CTA or MRA.

In this way, simulation training will play an increasingly important role in medical education settings, certification and recertification.

CLINICAL PRACTICE CHANGES over time and needs differ between settings and regions. Virtual procedure rehearsal brings several advantages, including anticipation of complications, better informed selection of tools and techniques to be used, and a reduction in procedure time. These advances will result in higher procedure success rates and cost reductions.

SIMULATION-BASED TRAINING should be performed before operators perform any procedure on a real patient for the first time. However, a radical change is needed in how the curriculum is served and implemented in the future. A training vision with a clear end point, such as “proficiency level in endovascular work”, must be followed by the facilities and opportunities to meet this goal. Scientific and educational papers are a solid ground for this development.

“A RADICAL CHANGE IS NEEDED IN HOW THE CURRICULUM IS SERVED AND IMPLEMENTED IN THE FUTURE.”
THESIS RELATED TO MENTICE SOLUTIONS
A PhD is a higher degree which students from various fields as well as doctors may pursue if they have a particular research interest, in our case specific endovascular simulation. At the outset, a typical PhD must secure the funding required for all 4 years of study, which amounts to approximately 220,000 Euros. PhD studies usually follow a first basic year and a further three years of research leading to a PhD. The thesis consists of three to eight papers that are peer reviewed.

The most interesting papers about endovascular simulation training are listed in table 1.

The focus so far has been on coronary procedures (1, 5) and peripheral endovascular work (2, 4, 6, and 7). The work from Copenhagen also involves deeper assessment research (4, 5).

All simulation companies have published scientific papers on validity and the transfer of skills. Below is a table of the most important theses published recently (table 1). In addition, there are two theses in progress from Ghent in Belgium. These are Doctor Heidi Maertens’s study on transferability and cost-effectiveness of a proficiency-based stepwise endovascular curricular training program (PROSPECT) and Doctor Liesbeth Descender’s focus on patient-specific virtual reality simulation: a patient-tailored approach to endovascular aneurysm repair.

### TABLE 1: PUBLISHED THERSES ON ENDOVASCULAR SIMULATION

<table>
<thead>
<tr>
<th>#</th>
<th>YEAR</th>
<th>INSTITUTE AND COUNTRY</th>
<th>TITLE</th>
<th>AUTHOR</th>
<th>SPECIALTY</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2013</td>
<td>Karolinska Institute Stockholm Sweden</td>
<td>The role of simulator training for skills acquisition in coronary angiography</td>
<td>Ulf Jensen</td>
<td>Cardiology</td>
</tr>
<tr>
<td>2</td>
<td>2012</td>
<td>Royal College of Surgeons Ireland</td>
<td>Proficiency-based simulation training in open and endovascular surgery</td>
<td>Hazem Hseino</td>
<td>Vascular Surgery</td>
</tr>
<tr>
<td>3</td>
<td>2011</td>
<td>Faculty of Health Sciences Ghent BE</td>
<td>Patient-specific virtual reality simulation for endovascular procedures*</td>
<td>W.I Willaert</td>
<td>Vascular Surgery</td>
</tr>
<tr>
<td>4</td>
<td>2011</td>
<td>Faculty of Health Sciences Copenhagen University DK</td>
<td>Endovascular Expertise, Aspects of Incorporating Virtual Reality Simulations</td>
<td>Bo Bech</td>
<td>Vascular Surgery</td>
</tr>
<tr>
<td>5</td>
<td>2011</td>
<td>Faculty of Health Sciences Copenhagen University DK</td>
<td>Aspects of Development and Assessment of Coronary Angiography Skills</td>
<td>Sune BEW Ræder</td>
<td>Cardiology</td>
</tr>
<tr>
<td>6</td>
<td>2009</td>
<td>Faculty of Health Sciences Ghent University BE</td>
<td>Virtual Reality Endovascular Simulation: Ready for Training</td>
<td>Isabelle Vanherzeele</td>
<td>Vascular Surgery</td>
</tr>
<tr>
<td>7</td>
<td>2007</td>
<td>Sahlgrenska Academy Göteborg Sweden</td>
<td>Virtual Reality Simulations and Interventional Radiology</td>
<td>Max Berry</td>
<td>Radiology</td>
</tr>
</tbody>
</table>

The most interesting papers about endovascular simulation training

ASSESSMENT IN GENERAL terms means the act of making a judgement about something.

Here below, you will find the most important papers on the subject in each category and specialty in respect of developing assessment tools. Several papers are free to download (i.e. open access). Note that paper no 3 is a review of patient specific rehearsal in more general terms.

1. Capturing the essence of developing endovascular expertise for the construction of a global assessment instrument.
   - Bech B, Lönn L, Schroeder TV, Räder SB, Ringsted C.

2. Technical skills assessment in a coronary angiography simulator for construct validation.
   - Jensen UJ, Jensen J, Olivecrona GK, Ahlberg G, Tornvall P.
   - PMID: 23598862 [PubMed – indexed for MEDLINE]

   - Willaert WI, Aggarwal R, Van Herzeele I, Cheshire NJ, Vermassen FE.
   - PMID: 22532308 [PubMed – indexed for MEDLINE]

   - Bech B, Lönn L, Falkenberg M, Bartholdy NJ, Räder SB, Schroeder TV, Ringsted C.
CASE REHEARSAL

VIRTUAL REALITY TRAINING improves operator’s procedural skills and transfers those improved skills to performance of the new procedure on actual patients.

HOWEVER, ON A cautionary note, not all companies’ simulations are equal. Simulation training must be more than just simulated experience supplanting repeated in vivo practice. Quality virtual reality simulation training should afford the trainee the opportunity to engage in deliberate practice while making mistakes and giving immediate “proximate” feedback when mistakes are made. This means that trainees are given proximate formative as well as summative performance feedback which enhances and accelerates the learning process.

THE CURRENT TECHNOLOGY permits patient-specific rehearsal of endovascular procedures. Current scientific studies aim at evaluating how effectively real interventions are replicated by patient-specific rehearsal technology and assessing its value as a preparatory tool for the operating team. The conclusions can be generalized to Mentice VIST as well as other companies. Thus this scientific data can be used by the whole global endovascular simulation industry. On the next page is a selected group of papers on the subject for your perusal.
1. Role of patient-specific virtual reality rehearsal in carotid artery stenting.
   - PMID: 22864891 [PubMed – indexed for MEDLINE]

2. Improving results for carotid artery stenting by validation of the anatomic scoring system for carotid artery stenting with patient-specific simulated rehearsal.
   - PMID: 22566016 [PubMed – indexed for MEDLINE]

   - Willaert W, Aggarwal R, Van Herzeele I, Cheshire NJ, Vermassen FE.
   - PMID: 22532308 [PubMed – indexed for MEDLINE]

   - PMID: 22532308 [PubMed – indexed for MEDLINE]

5. Patient-specific simulation in carotid artery stenting.
   - PMID: 21276738 [PubMed – indexed for MEDLINE]

   - PMID: 23582342 [PubMed – indexed for MEDLINE]

7. Simulation case rehearsals for carotid artery stenting.
   - PMID: 20506441 [PubMed – indexed for MEDLINE]

8. Simulation case rehearsals for carotid artery stenting.
   - PMID: 19945932 [PubMed – indexed for MEDLINE]

   - PMID: 23582342 [PubMed – indexed for MEDLINE]

10. Simulation case rehearsals for carotid artery stenting.
    - PMID: 19945932 [PubMed – indexed for MEDLINE]

The most interesting papers about endovascular simulation training.
The most interesting papers about endovascular simulation training

Transfer of Skills

The most crucial validation test of a simulator is to determine whether skills training on the simulator transfers to the in vivo operating environment. One-to-one correspondence assessment of patient-specific data (e.g., mission rehearsal) is the ultimate assessment of transfer of training. The paper below concludes that basic endovascular skills acquired using proficiency-based simulation training do, in fact, translate to real-world performance.

1. Skills transfer after proficiency-based simulation training in superficial femoral artery angioplasty.
   - PMID: 22801255
CONCURRENT VALIDITY

THIS CAN BE said to have been demonstrated if there is a high concordance between two tests that purport to measure the same thing. For example, we would expect an endovascular specialist who is highly experienced in endovascular procedures to perform well on a full-physics virtual reality simulator set up to simulate the same procedures. The Karolinska Institute researchers conclude that the Mentice VIST simulator can distinguish between trainees and experts in coronary angiography in the metrics extracted from the computer and, therefore, proves the concept of construct validity.

1. Technical skills assessment in a coronary angiography simulator for construct validation.
   • Jensen UJ, Jensen J, Olivecrona GK, Ahlberg G, Tornvall P.
   • PMID: 23598862 [PubMed - indexed for MEDLINE]
SIMULATION-BASED EDUCATION and training appears to be a promising path to meet most of the current challenges. The skills training centers are of immense help in realizing the full potential of a new way of education training the medical workforce of tomorrow. The simulated angiosuite allows for risk-free, hands-on training to a criterion where it is safe to begin to perform part task procedures on patients. To the right are listed papers based on Mentice machines presenting data on endovascular simulation and courses.

PROFESSOR GALLAGHER, University College of Cork, Ireland is the world’s most renowned expert on structured simulation training within healthcare. His method is based on the principles of objective assessment and training towards proficiency. Anthony Gallagher has published multiple papers in the field. In the list you will find a few of the studies within the endovascular context.

1. Mentored simulation training improves procedural skills in cardiac catheterization: a randomized, controlled pilot study.
   - Bagar A, O’Brien S, Al Lawati H, Goyal P, Ball W, Grantcharov T, Farn N.

2. The importance of expert feedback during endovascular simulator training.
   - Boyle E, O’Keeffe DA, Naughton PA, Hill AD, McDonnell CO, Moneley D.

3. Endovascular simulator is of benefit in the acquisition of basic skills by novice operators.
   - Coates PJ, Zealley IA, Chakraverty S.
   - PMID: 19931470 [PubMed – indexed for MEDLINE]

4. Four-year experience with a regional program providing simulation-based endovascular training for vascular surgery fellows.
   - Dawson DL, Lee ES, Hedayat N, Pevec WC.
   - PMID: 20142130 [PubMed – indexed for MEDLINE]

5. Impact of an assistant on the technical skills of the primary operator in superficial femoral artery angioplasty.
   - Hsieh H, Nugent E, Cantwell C, Lee MJ, Given M, Hill AD, Moneley D.
   - PMID: 23002121 [PubMed – indexed for MEDLINE]

6. Basic endovascular skills for trauma course: bridging the gap between endovascular techniques and the acute care surgeon.
   - Brenner M, Hoehn M, Pasley J, Dubose J, Stein D, Scalea T.
   - PMID: 25058255 [PubMed – indexed for MEDLINE]

7. Simulator based angiography education in neurosurgery: results of a pilot educational program.
   - PMID: 22015637 [PubMed – indexed for MEDLINE]

8. The future of simulation technologies for complex cardiovascular procedures.
   - Cates CU, Gallagher AG.

9. Face and content validation of virtual reality simulation for carotid angiography: results from the first 100 physicians attending the Emory NeuroAnatomy Carotid Training (ENACT) program.
   - Simul Healthc. 2006 Fall;1(3):147-50.
   - PMID: 19088583 [PubMed – indexed for MEDLINE]

EDUCATIONAL PAPERS
ECONOMY & RANDOMIZED CONTROLLED STUDIES (RCT)

ECONOMY

THERE ARE GOOD pedagogic grounds on which to believe that simulation training will become increasingly important. The present comparison of the direct costs suggests that VR training is less expensive than live animal training.

1. Endovascular training with animals versus virtual reality systems: an economic analysis.
   - Berry M, Hellström M, Göthlin J, Reznick R, Lönn L.
   - PMID: 18341955 [PubMed – indexed for MEDLINE]

RANDOMIZED CONTROLLED STUDIES (RCT)

SUBJECTS ARE ALLOCATED at random to receive one of a number of special interventions. One is the standard of comparison or control. The control is the standard practice or no intervention at all. These studies are quantitative, comparative, controlled experiments in which investigators study two or more interventions in a series of individuals who receive them in random order. The RCT is one of the most powerful tools in clinical research.

1. Simulation improves resident performance in catheter-based intervention: results of a randomized, controlled study.
   - PMID: 16926560 [PubMed – indexed for MEDLINE]
   - Free PMC Article
   - Related citations:

2. Porcine transfer study: virtual reality simulator training compared with porcine training in endovascular novices.
   - Berry M, Lystig T, Beard J, Klingesterna H, Reznick R, Lönn L.
   - PMID: 17225971 [PubMed – indexed for MEDLINE]
   - Related citations:
IN MEDICINE, VALIDATION studies need to establish evidence that provides a high degree of assurance that a product, service or system accomplishes its intended requirements. Validation of a product is an essential quality assurance process, particularly for products that will be used for medical purposes such as training. Below is a short description of the definitions of validity.

FACE VALIDITY
A type of preliminary validation to evaluate whether a device looks, feels, behaves, teaches, trains and assesses as intended. In the early days of simulation, these types of “interviews” were published. Today, there is little if any interest for journals to publish face validity papers due to the huge development within the industry of more sophisticated machines. Face validity is self-evident in today’s context of simulators.

CONSTRUCT VALIDITY
Probably best summarised by the question “are we measuring or assessing what we think we’re measuring?” This type of validation is based on the accumulation of evidence from numerous studies confirming the identification and differentiation of levels of performance, skill, experience or ability. There are many papers on the subject and these can be displayed upon request.

CONCURRENT VALIDITY
This can be said to have been demonstrated if there is a high concordance between two tests that purport to measure the same thing. For example, we would expect an endovascular specialist who is highly experienced in endovascular procedures to perform well on a full-physics virtual reality simulator that simulates the same procedures. There are many papers on the subject and these can be displayed upon request.
THE AUTHOR

“LARS LÖNN, CLINICAL PROFESSOR in the Faculty of Health Sciences, University of Copenhagen, is an active CIRSE member. He serves on the Membership Committee. A member of the EBIR Council (Oral Examination) in 2012, of the Vascular Division of the Foundation Advisory Council 2009-2011, and the Rules Committee (2011-2013). Professor Lönn has also given presentations at several CIRSE annual meetings. Local organizer in Gothenburg 2001 and Copenhagen 2008. At CIRSE 2013, he organized sessions on Emergency EVAR and led a session on the essentials of femoral artery access/haemostasis. Professor Lönn has published more than 150 papers and several book chapters. His passion is to enhance the education and training of all endovascular specialists. Moreover, he encourages collaborative working relationships with other clinical specialties where possible and promotes the interests of simulation training”.

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WE BELIEVE IN CHANGING THE PARADIGM FOR IMPROVEMENT IN HEALTHCARE

FOUNDED IN 1999. Mentice is the world leader in endovascular medical simulation, providing qualified solutions for training and assessment of medical professionals. With a focus on minimally invasive techniques and procedures, Mentice enables training in a realistic, risk-free environment.

MENTICE INTRODUCED the world’s first endovascular simulator in 2001 – the VIST® – and has since been the market leader with the world’s largest install base of simulators for endovascular intervention.

MENTICE SIMULATORS ARE the most validated endovascular training systems. The advantages are well documented and include, enhancing clinical performance, reducing cost, and, ultimately, improving patient safety.
ABOUT MENTICE

Medical Simulation Versatility
Due to their flexibility Mentice VIST® simulators provide an ideal simulation solution which covers mobile and stationary setups, individual and team training, from learning to assessment and from basic motor skills to procedural competence – all in an individually customizable set of procedural modules.

VIST® Simulation Systems
The VIST®-Lab and the VIST®-C systems share unique advantages in terms of the highest fidelity, clinical realism and use of actual clinical devices.

VIST®-LAB
Full body mannequin, with two removable virtual reality simulators, adjustable table, one 4K-UHD screen and a HD touch — VIST®-LAB.

VIST® G5
Virtual reality simulator with laptop and extra screen — VIST® G5.

MOBILITY: Mentice simulators are available in a stationary (VIST®-Lab) and a portable (VIST® G5) setup. This provides an unmatched versatility covering any kind of training setup (see next page).

MODULE CHOICES: Customers can choose from a large number of endovascular modules covering all endovascular specialties: radiology, cardiology, vascular surgery, cardiovascular surgery, neuroradiology, electrophysiology, oncology - with new modules being added all the time.

VIST® Training Modules
A structured and comprehensive suite of modules with clearly defined learning objectives, giving trainees exposure to a wide range of patient scenarios and anatomical variations.

Neuro Intervention
Carotid Intervention
Coronary PRO
Cardiac Rhythm Management
Transseptal Puncture
Peripheral Angiography
Renal Intervention
Endovascular Aortic Repair
Vascular Trauma Management

Uterine Artery Embolization
Iliac/SFA Intervention
BTK Intervention
Acute Stroke Intervention
Aortic Valve Implantation
Thoracic Endovascular Aortic Repair
Left Atrial Appendage Occlusion
Renal Denervation
Radiation Safety