

# The most interesting papers about endovascular simulation training

A paper summary by Professor Lars Lönn

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# Introduction

**WITH THE ADVENT** of new endovascular devices and new procedural techniques, the question of clinical adoption and procedural proficiency for interventional specialties has become extremely relevant not only to residents and fellows but also to expert clinicians. The focus on patient safety and improved clinical performance has increased transparency and public awareness around medical errors with many patients seeking information about a physician's proficiency prior to therapy.

**OVER THE YEARS**, healthcare systems, professional societies, and academic institutions have developed curricula to enhance learning and help maintain the clinical proficiency of doctors across the spectrum of medicine. Institutions that have integrated simulation as part of their learning curriculum for acquisition of new skills or retaining proficiency of low volume therapies have shown an increased aptitude for learning and retention making the transition from simulation to live cases easier thus improving the pathway from theory to the daily clinical practice.



# Introduction

**RECENT REVIEWS PERFORMED** according to Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) show that, simulation is poised to take a larger role in Cardiovascular training and the maintenance of certification. The papers listed in the content of this document focus mainly on assessment, economic justification, curriculum, and transfer of skills supporting a large body of published evidence.



# 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 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 Research

**ENDOVASCULAR TRAINING IDEALLY** should have a simulation-based curriculum which is patient safe and less expensive than training procedures in the angiosuite.

**FOR EXPERIENCED ENDOVASCULAR** specialists simulation allows for a decreased learning curve of new techniques/procedures. Additionally rehearsal of rare cases is an advantage, i.e. patient specific rehearsal.

**LISTED HERE ARE** some of the many theses in the field demonstrating a historical focus shift from assessment to proficiency to patient specific rehearsal which ultimately extends to the daily clinical practice.

**Table 1: Published Theses on endovascular simulation**

#	Year	Institute and Country	Title	Author	Speciality
1	2021	Faculty of Health Sciences Copenhagen University DK	Competence in REBOA: Simulation training and assessment	Morten Engberg	Cardiology
2	2020	Faculty of Health Sciences Ghent BE	Safety in the hybrid angiography suite: Opening Pandora's Box	Bart Doyen	Vascular Surgery
3	2017	Faculty of Health Sciences Ghent BE	Patient-specific virtual reality simulation: a patient-tailored approach of endovascular aneurysm repair	Liesbeth Desender	Vascular Surgery
4	2017	Faculty of Health Sciences Copenhagen University DK	Competence in endovascular aortic repair: Development of assessment tools for proficiency testing	Michael Strøm	Vascular Surgery
5	2016	Faculty of Health Sciences Ghent BE	Simulation-based Endovascular Training: Ready for Prime Time?	Heidi Maertens	Vascular Surgery
6	2013	Karolinska Institute Stockholm, Sweden	The role of simulator training for skills acquisition in coronary angiography	Ulf Jensen	Cardiology
7	2012	Royal College of Surgeons Ireland	Proficiency-based simulation training in open and endovascular surgery	Hazem Hseino	Vascular Surgery
8	2011	Faculty of Health Sciences Ghent BE	Patient-specific virtual reality simulation for endovascular procedures*	W.J Willaert	Vascular Surgery
9	2011	Faculty of Health Sciences Copenhagen University DK	Endovascular Expertise, Aspects of Incorporating Virtual Reality Simulations	Bo Bech	Vascular Surgery
10	2011	Faculty of Health Sciences Copenhagen University DK	Aspects of Development and Assessment of Coronary Angiography Skills	Sune BEW Røder	Cardiology



# Assessment

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

**LISTED HERE YOU** will find papers relating to assessment in a variety of specialties. Several papers are free to download (i.e. open access).

## 1. Assessment of Competence in EVAR Stent Graft Sizing and Selection.

- Strøm M, Lönn L, Bech B, Schroeder TV, Konge L.
- Eur J Vasc Endovasc Surg. 2017 Jun;53(6):844-852.2.

## 2. Assessment of Competence in EVAR Procedures: A Novel Rating Scale Developed by the Delphi Technique.

- Strøm M, Lönn L, Bech B, Schroeder TV, Konge L; "EVARATE Delphi Panel".
- Eur J Vasc Endovasc Surg. 2017 Jul;54(1):34-41. 3.

## 3. Assessment of EVAR Competence: Validity of a Novel Rating Scale (EVARATE) in a Simulated Setting.

- Strøm M, Lönn L, Konge L, Schroeder TV, Lindgren H, Nyheim T, Venermo M, Bech B.
- Eur J Vasc Endovasc Surg. 2018 Jul;56(1):137-144.

## 4. Evidence for Endovascular Simulation Training

- K W M See, K H Chui, W H Chan, K C Wong, Y C Chan.
- Eur J Vasc Endovasc Surg. 2016 Mar;51(3):441-51. doi: 10.1016/j.ejvs.2015.10.011. Epub 2015 Dec 10.
- PMID: 26684597 [PubMed – indexed for MEDLINE] **Free article**

## 5. Technical skills assessment in a coronary angiography simulator for construct validation.

- Jensen UJ, Jensen J, Olivecrona GK, Ahlberg G, Tornvall P.
- Simul Healthc. 2013 Oct;8(5):324-8. doi: 10.1097/S1140.0b013e31828fdeac.
- PMID: 23598862 [PubMed – indexed for MEDLINE]

## 6. Recent advancements in medical simulation: patient-specific virtual reality simulation.

- Willaert WJ, Aggarwal R, Van Herzele I, Cheshire NJ, Vermassen FE.
- World J Surg. 2012 Jul;36(7):1703-12. doi: 10.1007/s00268-012-1489-0. Review.
- PMID: 22532308 [PubMed – indexed for MEDLINE]

## 7. Construct validity and reliability of structured assessment of endovascular expertise in a simulated setting.

- Bech B, Lönn L, Falkenberg M, Bartholdy NJ, Räder SB, Schroeder TV, Ringsted C.
- Eur J Vasc Endovasc Surg. 2011 Oct;42(4):539-48. doi: 10.1016/j.ejvs.2011.05.003. Epub 2011 Jun 15.

## 8. 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.
- Eur J Vasc Endovasc Surg. 2010 Sep;40(3):292-302. doi: 10.1016/j.ejvs.2010.04.022. Epub 2010 Jun 8. Review.
- PMID: 20807686 [PubMed – indexed for MEDLINE] **Free article**
- Related citations: [http://www.ncbi.nlm.nih.gov/pubmed?linkname=pubmed\\_pubmed&from\\_uid=20807686](http://www.ncbi.nlm.nih.gov/pubmed?linkname=pubmed_pubmed&from_uid=20807686)



# Case Rehearsal

**PATIENT CASE REHEARSAL** improves an operator's procedural skills and transfers those skills to performance of the procedure on the actual patient. Simulation training must be more than just simulated experience and should offer the opportunity to rehearse a case using real patient data, allowing the clinician to make mistakes and receive immediate feedback. This means that the physician is given proximate formative as well as summative performance feedback enhancing and accelerating the learning process.

**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. On the following page is a selected group of papers on this subject.





# Case Rehearsal

## 1. Simulation-Based Virtual-Reality Patient-Specific Rehearsal Prior to Endovascular Procedures: A Systematic Review

- Caroline Albrecht-Beste Nielsen, Lars Lönn, Lars Konge and Mikkel Taudorf. Diagnostics (Basel). 2020 Jul 20;10(7):E500. doi: 10.3390/diagnostics10070500
- PMID: 32698437 [PubMed – indexed for MEDLINE] [Free Article](#)
- Related citations: [https://pubmed.ncbi.nlm.nih.gov/?linkname=pubmed\\_pubmed&from\\_uid=32698437](https://pubmed.ncbi.nlm.nih.gov/?linkname=pubmed_pubmed&from_uid=32698437)

## 2. Role of patient-specific virtual reality rehearsal in carotid artery stenting.

- Willaert WI, Aggarwal R, Van Herzele I, Plessers M, Stroobant N, Nestel D, Cheshire N, Vermassen F. Br J Surg. 2012 Sep;99(9):1304-13. doi: 10.1002/bjs.8858.
- PMID: 22864891 [PubMed – indexed for MEDLINE]
- Related citations: [https://www.ncbi.nlm.nih.gov/pubmed/?linkname=pubmed\\_pubmed&from\\_uid=22864891](https://www.ncbi.nlm.nih.gov/pubmed/?linkname=pubmed_pubmed&from_uid=22864891)

## 3. Improving results for carotid artery stenting by validation of the anatomic scoring system for carotid artery stenting with patient-specific simulated rehearsal.

- Willaert WI, Cheshire NJ, Aggarwal R, Van Herzele I, Stansby G, Macdonald S, Vermassen FE; European Virtual Reality Endovascular Research Team (EVERest). J Vasc Surg. 2012 Dec;56(6):1763-70. doi: 10.1016/j.jvs.2012.03.257. Epub 2012 Jun 27.
- PMID: 22743018 [PubMed – indexed for MEDLINE] [Free Article](#)
- Related citations: [https://www.ncbi.nlm.nih.gov/pubmed/?linkname=pubmed\\_pubmed&from\\_uid=22743018](https://www.ncbi.nlm.nih.gov/pubmed/?linkname=pubmed_pubmed&from_uid=22743018)

## 4. Simulated procedure rehearsal is more effective than a pre-operative generic warm-up for endovascular procedures.

- Willaert WI, Aggarwal R, Daruwalla F, Van Herzele I, Darzi AW, Vermassen FE, Cheshire NJ; European Virtual Reality Endovascular Research Team EVERest. Ann Surg. 2012 Jun;255(6):1184-9. doi: 10.1097/SLA.0b013e31824f9dbf.
- PMID: 22566016 [PubMed – indexed for MEDLINE]
- Related citations: [https://www.ncbi.nlm.nih.gov/pubmed/?linkname=pubmed\\_pubmed&from\\_uid=22566016](https://www.ncbi.nlm.nih.gov/pubmed/?linkname=pubmed_pubmed&from_uid=22566016)

## 5. Recent advancements in medical simulation: patient-specific virtual reality simulation.

- Willaert WI, Aggarwal R, Van Herzele I, Cheshire NJ, Vermassen FE. World J Surg. 2012 Jul;36(7):1703-12. doi: 10.1007/s00268-012-1489-0. Review
- PMID: 22532308 [PubMed – indexed for MEDLINE]
- Related citations: [https://www.ncbi.nlm.nih.gov/pubmed/?linkname=pubmed\\_pubmed&from\\_uid=22532308](https://www.ncbi.nlm.nih.gov/pubmed/?linkname=pubmed_pubmed&from_uid=22532308)

## 6. Efficient implementation of patient-specific simulated rehearsal for the carotid artery stenting procedure: part-task rehearsal.

- Willaert W, Aggarwal R, Harvey K, Cochenne F, Nestel D, Darzi A, Vermassen F, Cheshire N; European Virtual Reality Endovascular Research Team (EVERest). Eur J Vasc Endovasc Surg. 2011 Aug;42(2):158-66. doi: 10.1016/j.ejvs.2011.03.032. Epub 2011 May 25.
- PMID: 21612950 [PubMed – indexed for MEDLINE] [Free Article](#)
- Related citations: [https://www.ncbi.nlm.nih.gov/pubmed/?linkname=pubmed\\_pubmed&from\\_uid=21612950](https://www.ncbi.nlm.nih.gov/pubmed/?linkname=pubmed_pubmed&from_uid=21612950)

## 7. Patient-specific endovascular simulation influences interventionalists performing carotid artery stenting procedures.

- Willaert WI, Aggarwal R, Van Herzele I, O'Donoghue K, Gaines PA, Darzi AW, Vermassen FE, Cheshire NJ; European Virtual Reality Endovascular Research Team EVERest. Eur J Vasc Endovasc Surg. 2011 Apr;41(4):492-500. doi: 10.1016/j.ejvs.2010.12.013. Epub 2011 Jan 26.
- PMID: 21276738 [PubMed – indexed for MEDLINE] [Free Article](#)
- Related citations: [https://www.ncbi.nlm.nih.gov/pubmed/?linkname=pubmed\\_pubmed&from\\_uid=21276738](https://www.ncbi.nlm.nih.gov/pubmed/?linkname=pubmed_pubmed&from_uid=21276738)

## 8. Patient-specific simulation in carotid artery stenting.

- Willaert W, Aggarwal R, Bicknell C, Hamady M, Darzi A, Vermassen F, Cheshire N; European Virtual Reality Endovascular Research Team (EVERest). J Vasc Surg. 2010 Dec;52(6):1700-5. doi: 10.1016/j.jvs.2010.08.015. Epub 2010 Oct 25.
- PMID: 20974522 [PubMed – indexed for MEDLINE] [Free Article](#)
- Related citations: [https://www.ncbi.nlm.nih.gov/pubmed/?linkname=pubmed\\_pubmed&from\\_uid=20974522](https://www.ncbi.nlm.nih.gov/pubmed/?linkname=pubmed_pubmed&from_uid=20974522)

## 9. Patient-specific simulation for endovascular procedures: qualitative evaluation of the development process.

- Willaert WI, Aggarwal R, Nestel DF, Gaines PA, Vermassen FE, Darzi AW, Cheshire NJ; European Virtual Reality Endovascular Research Team, EVERest. Int J Med Robot. 2010 Jun;6(2):202-10. doi: 10.1002/rocs.307.
- PMID: 20506441 [PubMed – indexed for MEDLINE]
- Related citations: [https://www.ncbi.nlm.nih.gov/pubmed/?linkname=pubmed\\_pubmed&from\\_uid=20506441](https://www.ncbi.nlm.nih.gov/pubmed/?linkname=pubmed_pubmed&from_uid=20506441)

## 10. Patient-specific rehearsal prior to EVAR: a pilot study.

- Desender L, Rancic Z, Aggarwal R, Duchateau J, Glenck M, Lachat M, Vermassen F, Van Herzele I; EVEREST (European Virtual Reality Endovascular REsearch Team). Eur J Vasc Endovasc Surg. 2013 Jun;45(6):639-47. doi: 10.1016/j.ejvs.2013.03.006. Epub 2013 Apr 10.
- PMID: 23582342 [PubMed – indexed for MEDLINE] [Free Article](#)
- Related citations: [https://www.ncbi.nlm.nih.gov/pubmed/?linkname=pubmed\\_pubmed&from\\_uid=23582342](https://www.ncbi.nlm.nih.gov/pubmed/?linkname=pubmed_pubmed&from_uid=23582342)

## 11. Simulation case rehearsals for carotid artery stenting.

- Hislop SJ, Hedrick JH, Singh MJ, Rhodes JM, Gillespie DL, Johansson M, Illig KA. Eur J Vasc Endovasc Surg. 2009 Dec;38(6):750-4. doi: 10.1016/j.ejvs.2009.08.011. Epub 2009 Oct 3.
- PMID: 19801196 [PubMed – indexed for MEDLINE] [Free Article](#)
- Related citations: [https://www.ncbi.nlm.nih.gov/pubmed/?linkname=pubmed\\_pubmed&from\\_uid=19801196](https://www.ncbi.nlm.nih.gov/pubmed/?linkname=pubmed_pubmed&from_uid=19801196)

# 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 rehearsal (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.

- Hseino H, Nugent E, Lee MJ, Hill AD, Neary P, Tierney S, Moneley D, Given M.
- Simul Healthc. 2012 Oct;7(5):274-81. doi: 10.1097/SIH.0b013e31825b6308.
- PMID: 22801255 [PubMed – indexed for MEDLINE]
- Related citations: [http://www.ncbi.nlm.nih.gov/pubmed?linkname=pubmed\\_pubmed&from\\_uid=22801255](http://www.ncbi.nlm.nih.gov/pubmed?linkname=pubmed_pubmed&from_uid=22801255)



# Concurrent Validity

**CONCURRENT VALIDITY CAN** be demonstrated if there is a high concordance between two tests that measure the same thing. For this reason, we would expect an endovascular specialist who is highly experienced in endovascular procedures to perform well on a full physics simulator setup to simulate a familiar procedure. The Karolinska Institute researches conclude that the Mentice VIST simulator can distinguish between trainees and experts in coronary angiography using the simulation metrics and therefore proves the concept of concurrent validity.

## 1. Technical skills assessment in a coronary angiography simulator for construct validation.

- Jensen UJ, Jensen J, Olivecrona GK, Ahlberg G, Tornvall P. Simul Healthc. 2013 Oct;8(5):324-8. doi: 10.1097/SIH.0b013e31828fdedc.
- PMID: 23598862 [PubMed - indexed for MEDLINE]
- Related citations: [http://www.ncbi.nlm.nih.gov/pubmed?linkname=pubmed\\_pubmed&from\\_uid=23598862](http://www.ncbi.nlm.nih.gov/pubmed?linkname=pubmed_pubmed&from_uid=23598862)





# Educational Papers

**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 products 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.

- Bagai A, O'Brien S, Al Lawati H, Goyal P, Ball W, Grantcharov T, Fam N.
- Circ Cardiovasc Interv. 2012 Oct;5(5):672-9. doi: 10.1161/CIRCINTERVENTIONS.112.970772. Epub 2012 Oct 9.
- PMID: 23048053 [PubMed – indexed for MEDLINE] [Free Article](#)
- Related citations: [http://www.ncbi.nlm.nih.gov/pubmed?linkname=pubmed\\_pubmed&from\\_uid=23048053](http://www.ncbi.nlm.nih.gov/pubmed?linkname=pubmed_pubmed&from_uid=23048053)

## 2. The importance of expert feedback during endovascular simulator training.

- Boyle E, O'Keeffe DA, Naughton PA, Hill AD, McDonnell CO, Moneley D.
- J Vasc Surg. 2011 Jul;54(1):240-248.e1. doi: 10.1016/j.jvs.2011.01.058. Epub 2011 Jun 2.
- PMID: 21636241 [PubMed – indexed for MEDLINE] [Free Article](#)
- Related citations: [http://www.ncbi.nlm.nih.gov/pubmed?linkname=pubmed\\_pubmed&from\\_uid=21636241](http://www.ncbi.nlm.nih.gov/pubmed?linkname=pubmed_pubmed&from_uid=21636241)

## 3. Endovascular simulator is of benefit in the acquisition of basic skills by novice operators.

- Coates PJ, Zealley IA, Chakraverty S.
- J Vasc Interv Radiol. 2010 Jan;21(1):130-4. doi: 10.1016/j.jvir.2009.09.013. Epub 2009 Nov 20.
- PMID: 19931470 [PubMed – indexed for MEDLINE]
- Related citations: [http://www.ncbi.nlm.nih.gov/pubmed?linkname=pubmed\\_pubmed&from\\_uid=19931470](http://www.ncbi.nlm.nih.gov/pubmed?linkname=pubmed_pubmed&from_uid=19931470)

## 4. Four-year experience with a regional program providing simulation-based endovascular training for vascular surgery fellows.

- Dawson DL, Lee ES, Hedayati N, Pevec WC.
- J Surg Educ. 2009 Nov-Dec;66(6):330-5. doi: 10.1016/j.jsurg.2009.07.004.
- PMID: 20142130 [PubMed – indexed for MEDLINE]
- Related citations: [http://www.ncbi.nlm.nih.gov/pubmed?linkname=pubmed\\_pubmed&from\\_uid=20142130](http://www.ncbi.nlm.nih.gov/pubmed?linkname=pubmed_pubmed&from_uid=20142130)

## 5. Impact of an assistant on the technical skills of the primary operator in superficial femoral artery angioplasty.

- Hseino H, Nugent E, Cantwell C, Lee MJ, Given M, Hill AD, Moneley D.
- Vasc Endovascular Surg. 2012 Nov;46(8): 635-9. doi: 10.1177/1538574412460771. Epub 2012 Sep 20.
- PMID: 23002121 [PubMed – indexed for MEDLINE]
- Related citations: [http://www.ncbi.nlm.nih.gov/pubmed?linkname=pubmed\\_pubmed&from\\_uid=23002121](http://www.ncbi.nlm.nih.gov/pubmed?linkname=pubmed_pubmed&from_uid=23002121)

## 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.
- J Trauma Acute Care Surg. 2014 Aug;77(2):286-91. doi: 10.1097/TA.0000000000000310.
- PMID: 25058255 [PubMed – indexed for MEDLINE]
- Related citations: [http://www.ncbi.nlm.nih.gov/pubmed?linkname=pubmed\\_pubmed&from\\_uid=25058255](http://www.ncbi.nlm.nih.gov/pubmed?linkname=pubmed_pubmed&from_uid=25058255)

## 7. Simulator based angiography education in neurosurgery: results of a pilot educational program.

- Fargen KM, Siddiqui AH, Veznedaroglu E, Turner RD, Ringer AJ, Mocco J.
- J Neurointerv Surg. 2012 Nov;4(6):438-41. doi: 10.1136/neurintsurg-2011-010128. Epub 2011 Oct 20.
- PMID: 22015637 [PubMed – indexed for MEDLINE]
- Related citations: [http://www.ncbi.nlm.nih.gov/pubmed?linkname=pubmed\\_pubmed&from\\_uid=22015637](http://www.ncbi.nlm.nih.gov/pubmed?linkname=pubmed_pubmed&from_uid=22015637)

## 8. The future of simulation technologies for complex cardiovascular procedures.

- Cates CU, Gallagher AG.
- Eur Heart J. 2012 Sep;33(17):2127-34. doi: 10.1093/eurheartj/ehs155. Epub 2012 Jun 24. Review.
- PMID: 22733836 [PubMed – indexed for MEDLINE] [Free Article](#)
- Similar articles: [http://www.ncbi.nlm.nih.gov/pubmed?linkname=pubmed\\_pubmed&from\\_uid=22733836](http://www.ncbi.nlm.nih.gov/pubmed?linkname=pubmed_pubmed&from_uid=22733836)

## 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.

- Nicholson WJ, Cates CU, Patel AD, Niazi K, Palmer S, Helmy T, Gallagher AG.
- Simul Healthc. 2006 Fall;1(3):147-50.
- PMID: 19088583 [PubMed – indexed for MEDLINE]
- Similar articles: [http://www.ncbi.nlm.nih.gov/pubmed?linkname=pubmed\\_pubmed&from\\_uid=19088583](http://www.ncbi.nlm.nih.gov/pubmed?linkname=pubmed_pubmed&from_uid=19088583)

# 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.
- J Vasc Interv Radiol. 2008 Feb;19(2 Pt 1):233-8. doi: 10.1016/j.jvir.2007.09.004. Erratum in: J Vasc Interv Radiol. 2008 Jun;19(6):959.
- 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.

- Chaer RA, Derubertis BG, Lin SC, Bush HL, Karwowski JK, Birk D, Morrissey NJ, Faries PL, McKinsey JF, Kent KC.
- Ann Surg. 2006 Sep;244(3):343-52.
- 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, Klingestierna H, Reznick R, Lönn L.
- Cardiovasc Interv Radiol. 2007 May-Jun;30(3):455-61.
- PMID: 17225971 [PubMed – indexed for MEDLINE]
- Related citations:





# Appendix

**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 solutions. 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.

## Concurrent Validity

Concurrent validity can be demonstrated if there is a high concordance between two tests that measure the same thing. For this reason, we would expect an endovascular specialist who is highly experienced in endovascular procedures to perform well on a full physics simulator setup to simulate a familiar procedure.



# Additional Resources

## State of the Evidence on Simulation-Based Training for Laparoscopic Surgery: A Systematic Review.

- Ann Surg 2013;257(4):586-93

## Surgical Skills Simulation: A Shift in the Conversation.

- Selzer DJ, Dunnington GL
- Ann Surg 2013 257(4):594-95

## COMMISSION RECOMMENDATION of 24 September 2013 on the audits and assessments performed by notified bodies in the field of medical devices.

- COMMISSION TE.
- Official Journal of the European Union 25.9.2013 ed, 2013.

## Fine-motor skills testing and prediction of endovascular performance.

- Bech B, Lönn L, Schroeder TV, Ringsted C.
- Acta Radiol. 2013 Jun 26. [Epub ahead of print] PubMed PMID: 23803752.

## Objective simulator-based evaluation of carotid artery stenting proficiency (from Assessment of Operator Performance by the Carotid Stenting Simulator Study [ASSESS]).

- Weisz G, Smilowitz NR, Parise H, Devaud J, Moussa I, Ramee S, Reisman M, White CJ, Gray WA.
- Am J Cardiol. 2013 Jul 15;112(2):299-306. doi:10.1016/j.amjcard.2013.02.069. Epub 2013 Apr 18. PubMed PMID: 23601579.

## A pilot study of video-motion analysis in endovascular surgery development of real-time discriminatory skill metrics.

- Rolls AE, Riga CV, Bicknell CD, Stoyanov DV, Shah CV, Van Herzele I, Hamady, M Cheshire NJ.
- Eur J Vasc Endovasc Surg. 2013 May;45(5):509-15. doi: 10.1016/j.ejvs.2013.02.004. Epub 2013 Mar 1. PubMed PMID: 23465454.

## Simulator training on pulsatile vascular models significantly improves surgical skills and the quality of carotid patch plasty.

- Duschek N, Assadian A, Lamont PM, Klemm K, Schmidli J, Mendel H, Eckstein HH.
- J Vasc Surg. 2013 Apr;57(4):1148-54. doi: 10.1016/j.jvs.2012.08.109. Epub 2013 Jan 9. PubMed PMID: 23312831.

## Technical skills measurement based on a cyber-physical system for endovascular surgery simulation.

- Tercero C, Kodama H, Shi C, Ooe K, Ikeda S, Fukuda T, Arai F, Negoro M, Kwon G, Najdowski Z.
- Int J Med Robot. 2012 Nov 28. doi:10.1002/rcs.1467. [Epub ahead of print] PubMed PMID: 23192938.

## Impact of an assistant on the technical skills of the primary operator in superficial femoral artery angioplasty.

- Hseino H, Nugent E, Cantwell C, Lee MJ, Given M, Hill AD, Moneley D.
- Vasc Endovascular Surg. 2012 Nov;46(8):635-9. doi:10.1177/1538574412460771. Epub 2012 Sep 20. PubMed PMID: 23002121.

## Procedural virtual reality simulation in minimally invasive surgery.

- Våpenstad C, Buzink SN.
- Surg Endosc. 2013 Feb;27(2):364-77. doi:10.1007/s00464-012-2503-1. Epub 2012 Sep 7. Review. PubMed PMID: 22956001.

## Role of patient-specific virtual reality rehearsal in carotid artery stenting.

- Willaert WI, Aggarwal R, Van Herzele I, Plessers M, Stroobant N, Nestel D, Cheshire N, Vermassen F.
- Br J Surg. 2012 Sep;99(9):1304-13. doi:10.1002/bjs.8858. PubMed PMID: 22864891.

## Skills transfer after proficiency-based simulation training in superficial femoral artery angioplasty.

- Hseino H, Nugent E, Lee MJ, Hill AD, Neary P, Tierney S, Moneley D, Given M.
- Simul Healthc. 2012 Oct;7(5):274-81. doi:10.1097/SIH.0b013e31825b6308. PubMed PMID: 22801255.

## Simulated procedure rehearsal is more effective than a pre-operative generic warm-up for endovascular procedures.

- Willaert WI, Aggarwal R, Daruwalla F, Van Herzele I, Darzi AW, Vermassen FE, Cheshire NJ; European Virtual Reality Endovascular Research Team EVEResT.
- Ann Surg. 2012 Jun;255(6):1184-9. doi:10.1097/SLA.0b013e31824f9dbf. PubMed PMID: 22566016.

## Impact of endovascular simulator training on vascular surgery as a career choice in medical students.

- Markovic J, Peyser C, Cavoore T, Fletcher E, Peterson D, Shortell C.
- J Vasc Surg. 2012 May;55(5):1515-21. doi:10.1016/j.jvs.2011.11.060. Epub 2012 Mar 29. PubMed PMID: 22464708.

## Simulated diagnostic cerebral angiography in neurosurgical training a pilot program.

- Spiotta AM, Rasmussen PA, Masaryk TJ, Benzel EC, Schlenk R.
- J Neurointerv Surg. 2013 Jul;5(4):376-81. doi: 10.1136/neurintsurg-2012-010319. Epub 2012 May 10. PubMed PMID: 22576472.

## Virtual evaluation of stent graft deployment a validated modeling and simulation study.

- De Bock S, Iannaccone F, De Santis G, De Beule M, Van Loo D, Devos D, Vermassen F, Segers P, Verhegghe B.

- J Mech Behav Biomed Mater. 2012 Sep;13:129-39. doi: 10.1016/j.jmbbm.2012.04.021. Epub 2012 May 12. PubMed PMID: 22842656.

## Patient-specific rehearsal prior to EVAR a pilot study.

- Desender L, Rancic Z, Aggarwal R, Duchateau J, Glenck M, Lachat M, Vermassen F, Van Herzele I; EVEREST (European Virtual Reality Endovascular REsearch Team).
- Eur J Vasc Endovasc Surg. 2013 Jun;45(6):639-47. doi: 10.1016/j.ejvs.2013.03.006. Epub 2013 Apr 10. PubMed PMID: 23582342.

## Mentored simulation training improves procedural skills in cardiac Catheterization a randomized, controlled pilot study.

- Bagai A, O'Brien S, Al Lawati H, Goyal P, Ball W, Grantcharov T, Fam N.
- Circ Cardiovasc Interv. 2012 Oct;5(5):672-9. doi:10.1161/CIRCINTERVENTIONS.112.970772. Epub 2012 Oct 9. PubMed PMID: 23048053.

## Technical Skills Assessment in a Coronary Angiography Simulator for Construct Validation.

- Jensen UJ, Jensen J, Olivecrona GK, Ahlberg G, Tornvall P.
- Simul Healthc. 2013 Apr 17. [Epub ahead of print] PubMed PMID: 23598862.

## How can educators use simulation applications to teach and assess surgical judgment?

- Andersen DK.
- Acad Med. 2012 Jul;87(7):934-41. doi: 10.1097/ACM.0b013e3182583248.

## The future of simulation technologies for complex cardiovascular procedures.

- Cates CU, Gallagher AG.
- Eur Heart J. 2012 Sep;33(17):2127-34. doi: 10.1093/eurheartj/ehs155. Epub 2012 Jun 24.

## The use of fluoroscopy to construct learning curves for coronary angiography.

- Jensen UJ, Lagerquist B, Jensen J, Tornvall P.
- Catheter Cardiovasc Interv. 2012 Oct 1;80(4):564-9. doi: 10.1002/ccd.23298. Epub 2011 Dec 12.

## Virtual reality simulation training in a high-fidelity procedure suite: operator appraisal.

- Lonn L, Edmond JJ, Marco J, Kearney PP, Gallagher AG.
- J Vasc Interv Radiol. 2012 Oct;23(10):1361-6.e2. doi: 10.1016/j.jvir.2012.06.002. Epub 2012 Jul 31.

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**LARS LÖNN, CLINICAL PROFESSOR** in the Faculty of Health Sciences, University of Copenhagen, is an active CIRSE member. He has served at the membership committee but current is in the Scientific Programme Committee of CIRSE. 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 cirse organiser 2001, 2008 and 2017 in Copenhagen. 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 over 250 papers and several book chapters and tutored over 20 PhD students in vascular cardiology, surgery and radiology. 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”.



# About Mentice

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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.

**MOBILITY:** Mentice simulators are available in a stationary (VIST®-Lab) and a portable (VIST® G7 setup). This provides an unmatched versatility covering any kind of training setup.

**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® Simulation Systems

The VIST®-Lab and the VIST®-G7 systems share unique advantages in terms of the highest fidelity, clinical realism and use of actual clinical devices.



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



Virtual reality simulator with laptop and extra screen – **VIST® G7**.

## VIST® Simulation Systems

### Coronary Intervention

- Coronary Advanced
- Coronary Essentials
- Coronary Intermediate
- Transradial Approach

### Structural Heart

- Aortic Valve Implantation
- Atrial Septal Defect & Patent Foramen Ovale Occlusion
- Left Atrial Appendage Occlusion
- Transseptal Puncture

### Electrophysiology

- Cardiac Rhythm Management

### Embolotherapy

- Prostatic Artery Embolization
- Transarterial Chemoembolization
- Uterine Artery Embolization

### Trauma

- Vascular Trauma Management

### Neuro Intervention

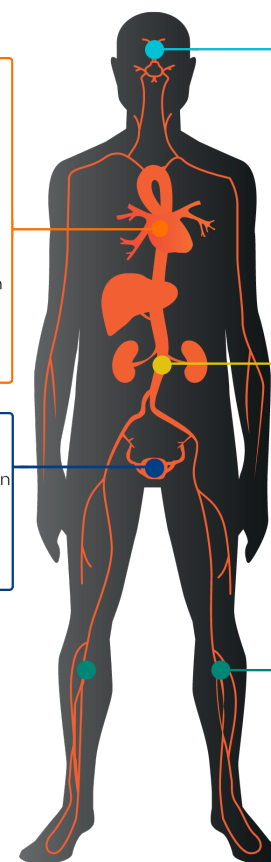
- Acute Ischemic Stroke Intervention
- Carotid Intervention
- Neurovascular Coiling
- Neurovascular Thrombectomy
- Transradial Approach

### Aortic

- Endovascular Aortic Repair
- Thoracic Endovascular Aortic Repair

### Peripheral Intervention

- Below-the-knee Intervention
- Iliac/SFA Intervention
- Peripheral Angiography
- Renal Denervation
- Renal Intervention
- Transradial Approach



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