Eur J Vasc Endovasc Surg (2016) 51, 441–451

REVIEW

Evidence for Endovascular Simulation Training: A Systematic Review

K.W.M. See, K.H. Chui, W.H. Chan, K.C. Wong, Y.C. Chan *

Division of Vascular and Endovascular Surgery, Department of Surgery, University of Hong Kong Medical Centre, South Wing, 14th Floor K Block, Queen Mary Hospital, Hong Kong

WHAT THIS PAPER ADDS

This systematic review has found that performance metrics within a simulator, namely procedure time and fluoroscopy time, improve with endovascular simulation training. There is evidence to show that there is translation of simulation to *in vivo* operations in patient specific rehearsal studies and in randomized controlled trials. The fluoroscopy angle can be affected significantly in patient specific rehearsals. Both global and procedure specific rating scales improve with endovascular simulation training. This review points out the lack of translational studies and studies comparing simulation and traditional surgical training.

Background: Simulation training in endovascular surgery provides opportunities for trainees to practice and learn from non-patient based experience. Several types of endovascular simulators are available commercially. Previous studies on endovascular simulation training can be categorized into trials in which only a simulator was used when measuring performance metrics or "trials within simulation"; patient specific procedure rehearsals; and randomized, controlled trials (RCTs) or translational studies.

Objectives: To examine whether endovascular simulation training can improve surgeon techniques and patient outcomes in real clinical settings.

Methods: A literature review was performed according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement. All searches were done via PubMed and Embase. Review articles, and papers that were not related to endovascular surgery and not within the scope of interest were excluded. References of review articles were further screened according to the exclusion criteria.

Results: In total, 909 records were identified and 290 duplicates were removed. Thirty-one were included in the qualitative analysis. Twenty-three were trials within simulation and most of them found statistically significant improvements in procedure time, fluoroscopy time, and contrast volume. Five were patient specific procedure rehearsals and showed that simulation significantly affected the fluoroscopy angle and improved performance metrics. Three were RCTs and revealed mainly positive results on a Global Rating Scale and procedure specific rating scale.

Conclusions: Contemporary evidence shows that performance metrics within endovascular simulations improve with simulation training. Successful translation to *in vivo* situations is observed in patient specific procedure rehearsals and RCTs on real procedures. However, there is no level I evidence to show that predictive validity of simulation can definitively improve patient outcomes. Current literature supports the idea that there is a beneficial role of simulation in endovascular training. Future studies are needed to confirm the efficacy of simulation in endovascular surgical training and to see if simulation is superior to traditional training in the operating theatre.

Article history: Received 19 May 2015, Accepted 18 October 2015, Available online 10 December 2015

Keywords: Endovascular procedures, Rating scale, Simulation, Simulator, Training, Virtual reality

* Corresponding author. Division of Vascular & Endovascular Surgery, Department of Surgery, University of Hong Kong Medical Centre, South Wing, 14th Floor K Block, Queen Mary Hospital, Pokfulam Road, Hong Kong. Tel: +852 2255 4962; fax: +852 2255 4961.

E-mail address: ycchan88@hkucc.hku.hk (Y.C. Chan).

http://dx.doi.org/10.1016/j.ejvs.2015.10.011

INTRODUCTION

Owing to its minimally invasive nature, together with a reduction in junior doctors' hours which may decrease clinical exposure, endovascular surgery is gaining popularity

in disciplines such as vascular surgery and neurosurgery.[1–3] Simulation provides training that allows repeated practice, and trainees may learn from their mistakes away from real patients.[4,5] Thus, simulation is an important adjunct to contemporary generic skills training, and can be defined as a technique to replace real patient experiences with artificially contrived and guided experiences that replicate substantial aspects of the real world in a fully interactive manner.[6] Several endovascular simulator models are currently available commercially, including: ANGIO Mentor (Simbionix, Cleveland, OH, USA), Vascular Intervention System Trainer (VIST) simulator (Mentice AB, Gothenburg, Sweden), and SimSuite (Medical Simulation Corporation, Denver, CO, USA) (Fig. 1).

One of the earliest trials on endovascular simulation training was performed in 2006 by Aggarwal et al., who showed that simulations led to improvement in procedure time (PT) and contrast volume (CV) usage in renal artery procedures.[7] Later, Kessel et al. argued that mere improvement in performance metrics within simulation could not be translated into clinical efficacy in endovascular training.[8] In 2008, Tsang et al. reviewed seven trials and showed that simulators had a role in competency based, structured training of vascular interventionalists and improved patient safety.[9] In a review by Desender et al.,[6] most studies were found to have had good face validity, which is the extent to which the simulation resembles real life situations. However, there are only limited translation studies, and these did not include studies on patient specific procedure rehearsal, a recent simulation method that incorporates patient specific image data into the simulation for rehearsal and the real procedures are performed subsequently.[10]

The aim of this systematic review is to determine whether simulation training can be beneficial in real clinical settings in terms of generic skills training and patient outcomes.

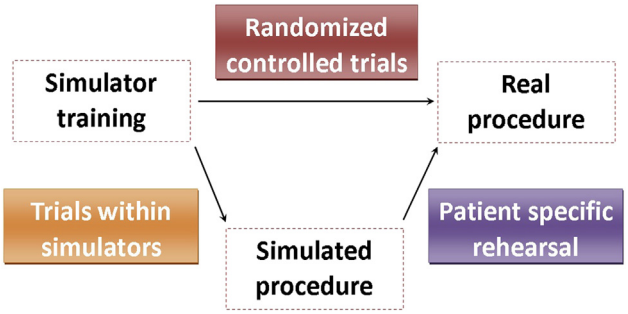

Figure 2. Relationship of study categories on reaching the conclusion of this review.

MATERIALS AND METHODS

Studies on endovascular simulation training can be categorized as: (i) trials on performance metrics, such as PT, fluoroscopy time (FT), and CV, within a simulation; (ii) patient specific procedure rehearsals that incorporate patient specific image data into simulation for rehearsal and the real procedures are then performed subsequently; and (iii) randomized, controlled trials (RCTs) or translation studies that look for a translation of performance from simulation into real procedures. The first category of studies could prove the effect of simulation training on performance in simulated procedures. The second category could provide predictive validity for simulation into *in vivo* procedures. The last category could directly translate simulation training into real procedures. The effect of simulation training on real clinical outcome is summarized in Fig. 2.

This systematic review was designed following the Preferred Reporting Items for Systematic Reviews and

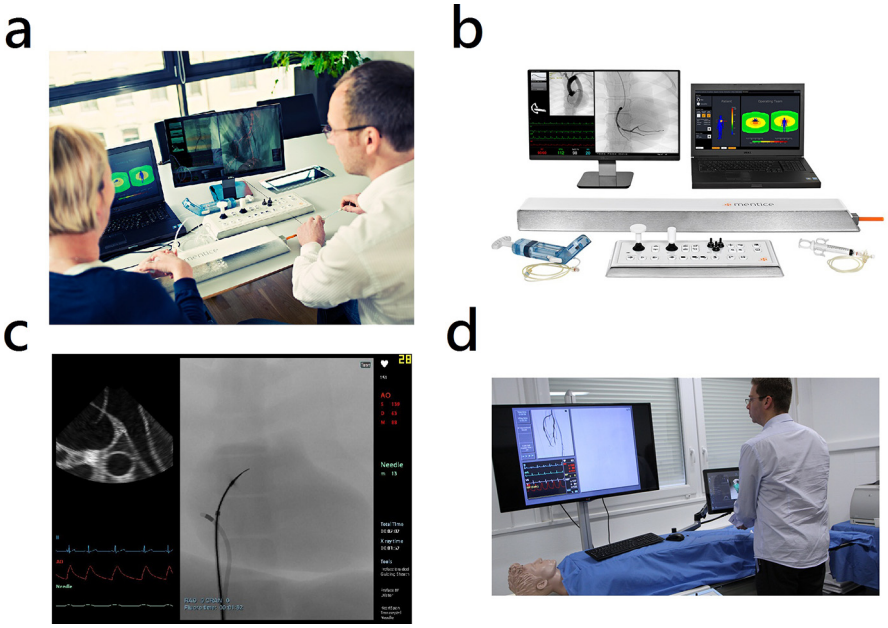

Figure 1. Different simulators. (a, b) Mentice; (c, d) Simbionix. *Note.* Permission received from Mentice and Simbionix to reproduce the images.