

SYSTEMATIC REVIEW

Role of simulation in open varicose veins surgery: A systematic review

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Abstract

Objective: To assess the types and effectiveness of simulators present for open varicose vein surgery.

Method: The systematic review was conducted at The Aga Khan University Hospital Karachi and comprised studies published from 1st January 2000 to 30th June 2020 related to open varicose vein surgical procedures done on simulators. Databases searched were PubMed, Medline, Google Scholar, Cochrane and Scopus using appropriate key words. The primary outcome of the review was to assess the effectiveness of different types of simulators used for varicose vein surgery.

Results: Of the 286 articles found, 6(2%) were included. A variety of simulators ranging from animal models, homemade simulators and commercially designed models with high fidelity options had been used. Technical competence was the major domain assessed in most of the studies 5(83.3%), while 1(16.6%) study focussed on self-assessment. Blinding was done in 4(66.6%) studies for assessment purpose, and videorecording of the trainees' performance was done in 5(83.3%) studies. Most studies 4(66.6%) found the use of simulation to be an effective tool in achieving technical competence.

Conclusion: The use of simulation in the training of surgical residents for open varicose vein surgery was found to be beneficial, but most studies were heterogeneous in terms of design, simulator types and study participants. This makes it difficult to establish the superiority of any one type of simulator over the rest. Further research is needed to develop and validate simulators in open varicose vein surgery procedures.

Keywords: Simulation training, Surgical education, Surgical training, Varicose vein surgery, Assessment, Saphenofemoral junction disconnection.

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Introduction

Acquiring operative skill proficiency is the most important aspect of surgical training. Recently the concept of

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residents; training on real patients has been seriously questioned.¹ The 80-hour-a-week regulation has decreased the operating exposure of the surgical trainees, making it imperative to maximise learning in limited time.² This has been further compounded by shortened duration of surgical residencies.³ Fear of potential lawsuits has also not helped the cause.⁴ Lastly, the widely popular approach of minimally invasive surgeries has resulted in endovascular training getting more attention than its open counterpart.⁵ This has opened an avenue to discuss the emerging role of simulation, particularly for open vascular surgical procedures.

A simulator is a model or a set of equipment designed specifically for training by replicating situations encountered in real life.⁶ Globally, there is a major shift in favour of simulation for safe training and fine-tuning of skills.⁷ Simulators, being cost-effective, readily available, easily commutable and with repeatability of usage, have an edge over other forms of training.⁸ It also avoids the ethical dilemma that the trainers might face in terms of putting a patient's safety at stake for training the trainees.⁹ Another challenge for the trainers is the assessment of a trainee's skill level. Direct observation in operating rooms (ORs) lacks objectivity and is associated with potential limitation of different interpretation between observers for a similar set of skills.¹⁰

Varicose veins (VVs) represent a common pathology¹¹ with reported worldwide prevalence ranging 10-30%.^{12,13} Khan et al. reported a prevalence of 34.8% for chronic venous insufficiency (CVI) in Pakistan.¹⁴ Traditional treatment has been surgery, which involves saphenofemoral junction disconnection (SFJD) in the groin.¹⁵ But now endovascular techniques are gaining popularity for the treatment of VVs.¹⁶ The trainees now are more used to the endovenous procedures, resulting in limited exposure to open SFJD. Even with all the advancements and frequent use of endovascular approach, there may be situations where open SFJD needs to be performed. Reluctance of health insurances to cover CVI forces patients to opt for open SFJD which is cheaper than endovenous procedures.¹⁷ VVs surgical procedures are associated with potential complications, like intraoperative bleeding, haematoma, groin infections and recurrence. If the operating surgeon has not been trained adequately and had limited exposure to SFJD

during training, the likelihood of having intraoperative and postoperative complication is increased. All of this makes it imperative that the skill of performing VVs surgery be mastered by the trainees.

Use of simulation for open vascular surgery procedures is widely reported. Although different types of simulators with varying fidelity are available but utility of any particular simulator over others is an unexplored area.¹⁸ This poses a problem for surgical educators in deciding the best approach and simulation technique that is cost-effective and ensures performance enhancement for VVs surgery.

The current systematic review was planned to assess literature on the type of simulators available and their effectiveness for technical performance of the trainees in VVs surgery.

Materials and Methods

The systematic review was conducted at The Aga Khan University Hospital Karachi from 30th June 2021 till 30th July 2021 and comprised studies published from January 2000 to June 2020 related to open VVs surgical procedures done on simulators. Using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement,¹⁹ studies were searched on

PubMed, Medline, Google Scholar, Cochrane databases and Scopus search engine. Studies, including case reports as well as observational and interventional studies, discussing the scope of simulation in VVs surgery were included. Studies related to simulation in vascular anastomosis or other non-VVs vascular procedures were excluded. Review articles, ongoing studies, unpublished articles and studies that were not published in the English language were also excluded.

The search strategy comprised the population, intervention and outcomes model.²⁰ Population was identified as physicians being trained in the discipline of vascular surgery. Both independent vascular surgeons and trainees were included. The terminologies used for this purpose were "vascular surgery trainees" OR "fellows of vascular surgery" OR "consultant vascular surgery" OR "attending vascular surgeons" AND "open vascular surgical procedures" OR "open vascular surgery". Various simulation models being used for open VVs surgery were considered as the aimed intervention. The terms included were "simulation models" OR "simulation tools" OR "simulation training" OR "simulation in open varicose vein surgery". The outcome was the effectiveness of different types of simulators used for open VVs surgery training. For such outcome, search terms included "effectiveness" OR "efficacy" OR "usefulness" OR "Impact" OR "benefits" OR "role" AND "simulator types" OR "simulation in open varicose vein surgery".

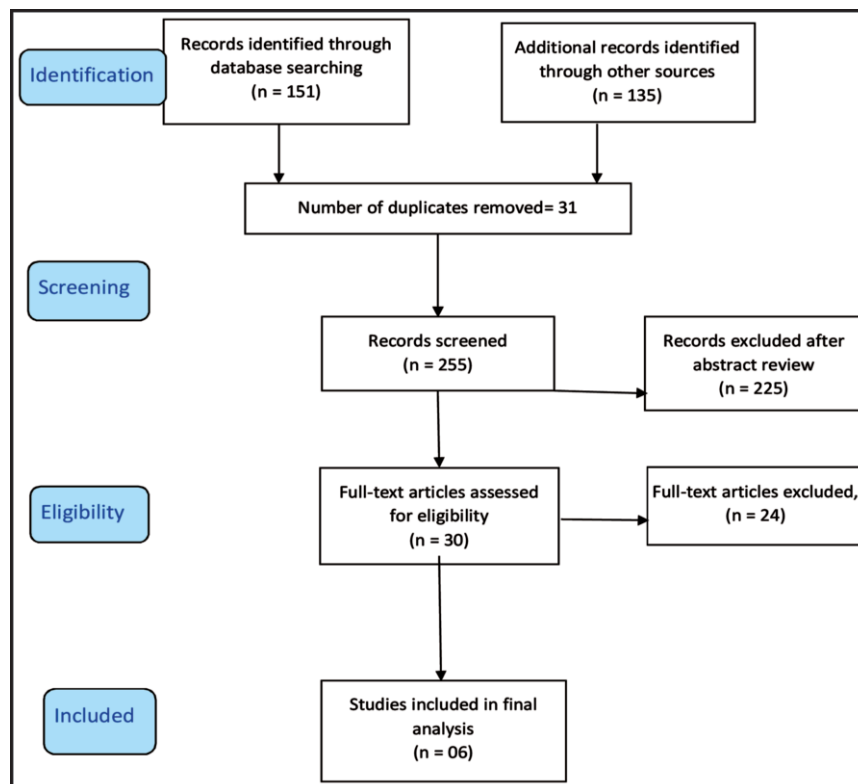


Figure: Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow-chart.

All studies mentioning the role of simulation in VVs surgery irrespective of the type of simulation used were included. Descriptive studies and review articles related to the role of simulation in VVs surgery were excluded. The identified studies using the above-mentioned criteria were reviewed by two independent investigators who thoroughly reviewed the search items. In case of disagreement between the reviewers, an independent third reviewer was invited to address the issue. For initial scanning, the titles of relevant studies were looked at and duplications were excluded. This was followed by rigorous evaluation of abstracts and manuscripts of the finalised studies to complete the process of inclusion. To avoid missing any relevant study, references of all the included studies were also reviewed.

The primary outcome was to assess the effectiveness of various simulation models used in VVs surgery training. Data noted on a predesigned template included publication year, details of the publishing journal and authors' names from the selected articles. Variables related to simulation, like the nature of simulator, details of the participants, including their number, training levels, assessment strategies and effectiveness of the simulation models, were also recorded.

The quality of studies was assessed using the validated National Institute of Health (NIH) tool.²¹

Results

Of the 286 articles found, 151(52.8%) were identified through the databases, while 135(47.2%) were found through other sources, like references of articles identified through database search. After the screening process, 6 (2%) studies were included for detailed review (See PRISMA diagram). Because of the difference in the reported outcomes and heterogeneity in the methodology in different studies, it was not possible to perform meta-analysis.

The mean NIH score of all the included studies was 7.3 ± 0.372 . The mean number of participants was 26.5 ± 9.725 . The level of training, technical capability and surgical experience varied widely^{18,22-26} (see Table). A variety of simulators ranging from animal models, homemade simulators and commercially designed models with high-fidelity options had been used. Technical competence

was the major domain assessed in most of the studies 5 (83.3%), while 1 (16.6%) study focussed on self-assessment. Blinding was done in 4 (66.6%) studies for assessment purpose, and videorecording of the trainees' performance was done in 5 (83.3%) studies. Most studies 4 (66.6%) found the use of simulation to be an effective tool in achieving technical competence. Overall, 3 (50%) studies grouped participants into junior residents, senior residents and consultants.^{18,24,25}

Moorthy et al.²⁴ created an artificial scenario leading to a crisis situation while dissecting the SFJ and the trainee's response in terms of handling the bleeding from the femoral vein was assessed. Performance was individually assessed and feedback was generated. Assessment was two pronged, analysing human factor skills and bleeding control skills. Time management was also considered. Blood loss was investigated as surrogate outcome measure. Two surgeons and a human factors expert assessed the trainees in a blinded manner. Trainees were grouped in two blocks, senior and junior trainees, depending upon the number of SFJDs performed previously.

Beard et al.²⁶ did not specify simulator details while evaluating 33 trainees from the General Surgery department. Five skills, including vessel ligation, were evaluated in a simulation setting. The operative skill of each participant was then investigated during SFJD on two or three occasions by a single surgeon observer. However, the exact nature and construct of the model

Table: Summary of articles included in the systematic review.

Paper	Year of Publication	Number of Participants	Type of Simulation Model	Domain Assessed	Assessment Done	Assessment Tool	Outcome	NIH Score
Hseino ²²	2012	12 Junior trainees	Bench model simulator	Technical skills	Yes (blinded)	Not reported	Beneficial	7
Pandey ²³	2008	42 Senior trainees (at the end of training)	Bespoke synthetic model	Technical skills	yes	Modified GRS	Not reported	7
Datta ²⁵	2004	Total 22 Consultants-4 Specialist- 14 Senior HO - 4	Inanimate synthetic model	Technical ability	Yes (blinded)	OSATS	Beneficial	8
Moorthy ²⁴	2006	Total-20 Senior trainee-10 Junior trainee-10	Silicone based synthetic model	Technical skills / crises management	Yes	GRS, NOTECHS rating scale	Beneficial	7
Pandey ¹⁸	2012	Total-30 Candidates-22 Examiner-8	Bespoke synthetic model	Technical ability	yes	OSATS, ICEPS	Not reported	7
Beard ²⁶	2005	33 General Surgery Trainees	Not known	Technical skills	Yes, blinded	Task specific checklist	Beneficial	7

GRS: Global rating scale, OSATS: Objective structured assessment of technical skills, NOTECHS: Non-technical skills, ICEPS: Imperial College Evaluation of Procedure-Specific Skill.

used for simulation was not explained. Pandey et al.^{18,23} in 2 (33.3%) studies used Bespoke synthetic groin models for SFJD.

Different types of validated and partially validated assessment tools were used, like the objective structured assessment of technical skills (OSATS), and the modified global rating scale (GRS).^{23,24} Beard et al.²⁶ used task-specific checklist for assessment purpose. Of the total, 3 (50%) studies^{22,25,26} reported assessors being blinded during assessment of the video recordings. Pandey et al.²³ identified significant variability in assessment between the independent observers and trainees assessing themselves as self-assessment. Therefore, the study recommended regular technical feedback during training to ensure improvement in technical performance of the trainees.²³

Pandey et al.^{18,23} did not highlight the usefulness of simulation, as the objective of both the studies was different and the focus was on participants' self-assessment and establishing comparison of relationship between technical and oral performances.

Discussion

The current review identified some interesting facts regarding the role of simulation in VVs surgery. The development, advancement and use of simulators in endovascular interventions has surpassed the simulation in open vascular surgical procedures.⁴ The findings point toward the fact that despite VVs surgery being one of the most performed procedures, the work on simulation for residents' training is limited and is further complicated by the fact that almost all the present studies are heterogeneous in nature with different types of simulators used in a limited number of participants.

The objective of a simulator is to create an environment with certain element of fidelity for the behavioural, emotional and cognitive engagement to ensure effective participation, resulting in desirable outcomes.²⁷ The types of simulators ranged from a simple plastic-based synthetic model²⁵ to a more complex Bespoke model²³ and finally to a very complex simulated operating theatre (SOT).²⁴ The effectiveness of training on simulators of varying fidelity is still a matter of debate.²⁸ Moorthy et al. used SOT with the involvement of an anaesthetist, and focus on blood-loss, realisation of calling for help along with the procedural technicalities showed indirect benefit of simulation. Majority of participants in the study thought of simulation as useful for skill acquisition.²⁴ However, other studies^{25,26} also reported simulation as a positive catalyst for the improvement in surgical skills

while using comparatively low-fidelity models. Different types of simulation models were used across all studies. This limitation along with quite a low number of studies on this subject limit the ability to conclude any one model being superior to the others. It can be assumed that the experience of simulation in VVs surgery can be enhanced by using cadaveric models with intact perfusion. These models have been used in certain institutions to enhance the simulation experience for open vascular surgery procedures.²⁹

All the studies included had a wide variation of participants. Even though the numbers ranged from 12 to 42, the experience and designation of these participants were quite variable, ranging from surgical trainees at different years of training from the first year to candidates for European Board Fellowship to consultants already practising independently. With each year of training, the learning needs of the trainees differ and the complexity of the procedures also do not remain the same.¹⁷ Low-fidelity simulators, such as bench top plastic models, may appear to be highly useful for junior trainees in the first or second year of their training, but for the senior group of trainees, incorporation of more complex aspects of surgical skills is needed. As of now, there is not enough evidence to ascertain the advantage of high-fidelity over low-fidelity simulators for senior trainees.

Prior exposure to VVs surgery before becoming a part of simulation is another factor to consider in terms of effectiveness of training. Again, there is heterogeneity where Hseino et al.²² inducted 12 participants in the first and second year of training with no prior exposure to VVs surgery, while Moorthy et al. included only those participants who had done at least 20 cases of SFJD before.²⁴ The trainee's previous exposure can substantially enhance the effectiveness of a simulation, as shown by Moorthy et al.²⁴ who included more experienced trainees. Similar-level surgical trainees may have different learning experience and variable skill improvement based on the level of familiarity and previous knowledge about VVs surgical procedures.

Almost all the studies considered technical skills improvement as the primary objective and major domain taught and assessed on the simulator. Other than the technical aspect of training, there are other soft skills that are required to ensure optimal performance of surgeons in training, like communication skills, ethical considerations, team dynamics, leadership, task delegation, professionalism, mutual respect, constructive feedback, crises management, realisation of limitations and ability to call for help. Moorthy et al. focussed on these variables.²⁴ Ideally, a simulator should be designed

in a way that beside addressing the surgical skill component, it should also be able to cater to the requirement of human-factor skills. Realistically though achieving this task has significant technical, financial and logistical challenges. A simulated OR, as used by Moorthy et al.,²⁴ with multiple simulators of varying fidelity specialised in addressing different skills can be a possible answer to this.

Assessment tools also varied among the studies. Majority of the studies used tools for assessment, most frequently OSATS and the Imperial College Evaluation of Procedural Skill (ICEPS), for the evaluation of the participants. GRS was used by most of the studies, which lacks the specificity of evaluating individual procedures.³⁰ Even though a few procedure-specific checklists and OSATS have been developed for VVs surgery, they are not yet validated. Combining GRS and procedure-specific checklists are usually considered to be more valid and reliable assessment tools to improve surgical skills.³¹

All the studies reported the use of simulation models to be an effective learning tool, but the generalisability of this effectiveness is still debatable. Reported skill improvement should be approached with caution because of non-validated tools being mostly used. The low number of participants with varied experience, different types of simulator models and assessment tools also limits the generalisability of simulator effectiveness.

One of the other limitations of the current review was the fact that most of the studies identified were not very recent, which points towards the need of having more focussed research on the topic. Despite relatively low number of old studies, the quality of the studies was found to be good as suggested by a good NIH score.

Conclusions

The utility of simulation in acquiring and enhancing surgical skills for VVs surgery were noted, but the absence of standardised simulation models, variability in participants' surgical experience and level of training along with the varied assessment strategies make the generalisability of the finding questionable. With the currently available literature, it is difficult to consider any particular type of simulator as a standard against which other simulators can be compared. All current simulators have their advantages and disadvantage, and, thus, development, advancement and validation of more simulators along with the predesigned curriculum are required for training surgeons for open VVs surgery. Similarly, validation of assessment strategies by the development of procedure specific checklists is also the

need of the hour.

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References

1. Davis SS Jr, Husain FA, Lin E, Nandipati KC, Perez S, Sweeney JF. Resident participation in index laparoscopic general surgical cases: impact of the learning environment on surgical outcomes. *J Am Coll Surg* 2013;216:96-104. doi: 10.1016/j.jamcollsurg.2012.08.014.
2. Hutter MM, Kellogg KC, Ferguson CM, Abbott WM, Warshaw AL. The impact of the 80-hour resident workweek on surgical residents and attending surgeons. *Ann Surg* 2006;243:864-71; discussion 871-5. doi: 10.1097/01.sla.0000220042.48310.66.
3. Duschek N, Assadian A, Lamont PM, Klemm K, Schmidli J, Mendel H, et al. Simulator training on pulsatile vascular models significantly improves surgical skills and the quality of carotid patch plasty. *J Vasc Surg* 2013;57:1148-54. doi: 10.1016/j.jvs.2012.08.109.
4. Lawaetz J, Skovbo Kristensen JS, Nayahangan LJ, Van Herzele I, Konge L, Eiberg JP. Simulation Based Training and Assessment in Open Vascular Surgery: A Systematic Review. *Eur J Vasc Endovasc Surg* 2021;61:502-9. doi: 10.1016/j.ejvs.2020.11.003.
5. Dua A, Koprowski S, Upchurch G, Lee CJ, Desai SS. Progressive shortfall in open aneurysm experience for vascular surgery trainees with the impact of fenestrated and branched endovascular technology. *J Vasc Surg* 2017;65:257-61. doi: 10.1016/j.jvs.2016.08.075.
6. Valentine R, Padhye V, Wormald PJ. Simulation Training for Vascular Emergencies in Endoscopic Sinus and Skull Base Surgery. *Otolaryngol Clin North Am* 2016;49:877-87. doi: 10.1016/j.otc.2016.02.013.
7. Stefanidis D, Sevdalis N, Paige J, Zevin B, Aggarwal R, Grantcharov T, et al. Association for Surgical Education Simulation Committee. Simulation in surgery: what's needed next? *Ann Surg* 2015;261:846-53. doi: 10.1097/SLA.0000000000000826.
8. Martin JA, Regehr G, Reznick R, MacRae H, Murnaghan J, Hutchison C, et al. Objective structured assessment of technical skill (OSATS) for surgical residents. *Br J Surg* 1997;84:273-8. doi: 10.1046/j.1365-2168.1997.02502.x.
9. Issenberg SB, McGaghie WC, Hart IR, Mayer JW, Felner JM, Petrusa ER, et al. Simulation technology for health care professional skills training and assessment. *JAMA* 1999;282:861-6. doi: 10.1001/jama.282.9.861.
10. Ahmed K, Miskovic D, Darzi A, Athanasiou T, Hanna GB. Observational tools for assessment of procedural skills: a systematic review. *Am J Surg* 2011;202:469-80.e6. doi: 10.1016/j.amjsurg.2010.10.020.
11. Campbell B. Varicose veins and their management. *BMJ* 2006;333:287-92. doi: 10.1136/bmj.333.7562.287.
12. Proebstle T, van den Bos R. Endovenous ablation of refluxing saphenous and perforating veins. *Vasa* 2017;46:159-66. doi: 10.1024/0301-1526/a000610.
13. Callam MJ. Epidemiology of varicose veins. *Br J Surg* 1994;81:167-73. doi: 10.1002/bjs.1800810204.
14. Khan AF, Chaudhri R, Ashraf MA, Mazaffar MS, Zawar-ul-Imam S, Tanveer M. Prevalence and presentation of chronic venous disease in Pakistan: a multicentre study. *Phlebology* 2013; 28:74-9. doi: 10.1258/phleb.2012.011122.
15. Recek C. Significance of Reflux Abolition at the Saphenofemoral Junction in Connection with Stripping and Ablative Methods. *Int J Angiol* 2015; 24:249-61. doi: 10.1055/s-0035-1546439.

16. Rasmussen JL, Kristensen J, Nayahangan LJ, Sillesen H, van Herzele I, Konge L, et al. A Systematic Review on Simulation-based Education in Open Vascular Surgery Providing-An Overview of The Literature Including Recommendations for Effective Future Training-Programs. *Eur J Vasc Endovasc Surg* 2019; 58:e712-3.
 17. Schul MW, King T, Kabnick LS. Inequalities of health insurance guidelines for the treatment of symptomatic varicose veins. *Phlebology* 2014;29:236-46. doi: 10.1177/0268355513479589.
 18. Pandey VA, Wolfe JH. Expanding the use of simulation in open vascular surgical training. *J Vasc Surg* 2012; 56:847-52. doi: 10.1016/j.jvs.2012.04.015.
 19. Moher D, Liberati A, Tetzlaff J, Altman DG; PRISMA Group. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *PLoS Med* 2009;6:e1000097. doi: 10.1371/journal.pmed.1000097.
 20. Methley AM, Campbell S, Chew-Graham C, McNally R, Cheraghi-Sohi S. PICO, PICOS and SPIDER: a comparison study of specificity and sensitivity in three search tools for qualitative systematic reviews. *BMC Health Serv Res* 2014;14:579. doi: 10.1186/s12913-014-0579-0.
 21. Migliavaca CB, Stein C, Colpani V, Munn Z, Falavigna M. Quality assessment of prevalence studies: a systematic review. *J Clin Epidemiol* 2020;127:59-68. doi: 10.1016/j.jclinepi.2020.06.039.
 22. Hseino H, Nugent E, Lee MJ, Hill AD, Neary P, Tierney S, et al. Skills transfer after proficiency-based simulation training in superficial femoral artery angioplasty. *Simul Healthc* 2012;7:274-81. doi: 10.1097/SIH.0b013e31825b6308.
 23. Pandey VA, Wolfe JH, Black SA, Cairols M, Liapis CD, Bergqvist D. Self-assessment of technical skill in surgery: the need for expert feedback. *Ann R Coll Surg Engl* 2008; 90:286-90. doi: 10.1308/003588408X286008.
 24. Moorthy K, Munz Y, Forrest D, Pandey V, Undre S, Vincent C, et al. Surgical crisis management skills training and assessment: a simulation[corrected]-based approach to enhancing operating room performance. *Ann Surg* 2006;244:139-47. doi: 10.1097/01.sla.0000217618.30744.61.
 25. Datta V, Bann S, Beard J, Mandalia M, Darzi A. Comparison of bench test evaluations of surgical skill with live operating performance assessments. *J Am Coll Surg* 2004;199:603-6. doi: 10.1016/j.jamcollsurg.2004.05.269.
 26. Beard JD, Jolly BC, Newble DI, Thomas WE, Donnelly J, Southgate LJ. Assessing the technical skills of surgical trainees. *Br J Surg* 2005;92:778-82. doi: 10.1002/bjs.4951.
 27. van Joolingen WR, de Jong T. Characteristics of simulations for instructional settings. *Comput Educ* 1991;6:241-62. doi: 10.1016/0167-9287(91)80004-H
 28. Doozandeh P, Ritter FE. Does simulation fidelity affect training? A lesson from a brief review of literature. In: *SBP-BRiMS: International Conference on Social Computing, Behavioral-Cultural Modeling and Prediction and Behavior Representation in Modeling and Simulation*. Pennsylvania, USA: Pennsylvania State University, 2019; pp 1-9.
 29. Carey JN, Minneti M, Leland HA, Demetriades D, Talving P. Perfused fresh cadavers: method for application to surgical simulation. *Am J Surg* 2015;210:179-87. doi: 10.1016/j.amjsurg.2014.10.027.
 30. In: Stefanidis D, Korndorffer Jr JR, Sweet R, eds. *Comprehensive healthcare simulation: surgery and surgical subspecialties*. Geneva, Switzerland: Springer International Publishing; 2019.
 31. Vassiliou MC, Feldman LS, Andrew CG, Bergman S, Leffondré K, Stanbridge D, et al. A global assessment tool for evaluation of intraoperative laparoscopic skills. *Am J Surg* 2005;190:107-13. doi: 10.1016/j.amjsurg.2005.04.004.
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