

Simulation-Based Learning Strategies to Teach Undergraduate Students Basic Surgical Skills: A Systematic Review

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OBJECTIVE: We aimed to identify and critically appraise all literature surrounding simulation-based learning (SBL) courses, to assess their relevance as tools for undergraduate surgical education, and create a design framework targeted at standardizing future SBL.

METHODS: We performed a systematic review of the literature using a specific keyword strategy to search at MEDLINE database.

RESULTS: Of the 2371 potentially eligible titles, 472 were shortlisted and only 40 explored active interventions in undergraduate medical education. Of those, 20 were conducted in the United States, 9 in Europe and 11 in the rest of the world. Nineteen studies assessed the effectiveness of SBL by comparing students' attributes before and after interventions, 1 study assessed a new tool of surgical assessment and 16 studies evaluated SBL courses from the students' perspectives. Of those 40 studies, 12 used dry laboratory, 7 wet laboratory, 12 mixed, and 9 cadaveric SBL interventions. The extent to which positive results were obtained from dry, wet, mixed, and cadaveric laboratories were 75%, 57%, 92%, and 100%, respectively. Consequently, the SBL design framework was devised, providing a foundation upon which future SBL interventions can be designed such that learning outcomes are optimized.

CONCLUSIONS: SBL is an important step in surgical education, investing in a safer and more efficient generation of surgeons. Standardization of these efforts can be accelerated with SBL design framework, a comprehensive guide to designing future interventions for basic surgical training at the undergraduate level. (J Surg Ed ■■■■■. © 2018 Association of Program Directors in Surgery. Published by Elsevier Inc. All rights reserved.)

KEY WORDS: simulation, in vivo, ex vivo, undergraduate, wet, dry

COMPETENCIES: Patient Care, Medical Knowledge, Practice-Based Learning and Improvement

INTRODUCTION

Surgical education is emerging as an important element of the undergraduate medical curricula, and an increasing number of medical schools are incorporating simulation-based learning (SBL) to cover this ground. In addition, several recent challenges in postgraduate surgical training including the European Working Time Directive (EWTD),¹ increasing litigation,² as well as the increasing need to maintain continuity of care through a shift-based service provision, have affirmed the need for an augmented training matrix. Current evidence shows that incorporating the use of either animal tissue or other simulation methods in educational programs can be catalytic for the advancement of surgical education. Most of these SBL initiatives achieve reasonable skill and confidence improvement.³

In an era of restricted training time, one should question whether future surgeons receive adequate teaching and

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preparation. For example, Parsons et al.⁴ reported a drift to spending less time attaining basic surgical skills in general surgery, and a cross-sectional survey by Rodrigues et al.⁵ revealed that only half the trainees believe that they receive adequate exposure upon completion of their surgical training. In contrast, Mahesh et al.⁶ suggest that the quality and quantity of training improved following full implementation of the EWTD, indicating the possibility that surgical education is “suffering” from much broader issues than solely singular factors such as the EWTD. This necessitates the creation and implementation of a structured surgical training program earlier on at the undergraduate level. Nevertheless, recent manifestation of obstacles such as a steep learning curve for minimally invasive surgery and the stronger ethical implications of learning on patients,⁷ have rendered the traditional “See one, Do one, Teach one” rationale problematic.⁸

SBL is a term that includes a branch of different teaching modalities and materials, which aims to “simulate” simple steps (basic surgical skills) or even more complex surgical procedures in live animal tissue (in vivo), isolated tissue flaps (ex vivo), cadaveric tissue, or technology-based tools. The use of animal tissue is generally conceived as “wet lab” simulation, while nonanimal, hardware-based devices are conceived as “dry lab” simulation. Regardless of wet, dry or cadaveric simulation, different fidelity levels can be achieved to adjust expectations of surgical teaching. In other words, lower fidelity SBL is targeted for basic surgical training (BST) while higher fidelity modules are reserved for advanced postgraduate teaching. Although there is considerable evidence that early implementation of SBL in the undergraduate curriculum promotes patient safety, teamwork, communication,⁹ and the credible method of trainee assessment,¹⁰ there are no previous systematic literature reviews confirming such validity.

In the context of these challenges, by identifying all published efforts to incorporate SBL in surgical education, this review primarily aimed to:

- (1) Describe the context within which BST research is evolving.
- (2) Review the assessment methods and outcome frameworks used by SBL studies.
- (3) Identify important parameters of SBL courses and incorporate these into a comprehensive design framework to act as a guide for future SBL interventions and secondarily to:
- (4) Assess the relevance of SBL interventions as tools in surgical education.

METHODS

Search Strategy

Following an iterative process, an appropriate nonexclusive search methodology was adopted to allow for a systematic

search of the MEDLINE database. [Appendix 1](#) presents our full search strategy including any limits used, such that it could be repeated. Advanced initial keyword searches yielded a total of 2371 candidate records.

Selection Criteria

Inclusion and exclusion criteria for the 2371 records were identified by 2 reviewers, who marked titles or abstracts as potentially relevant for full-text retrieval. Full texts of the shortlisted articles were then retrieved and independently assessed by both reviewers against the inclusion criteria (I.T. and M.N.). Any conflict between reviewers was resolved by one of the senior authors (M.S.). Initial screening focused on identifying any nonrelevant titles. Titles not published in English and without available translations, or not accessible full texts were also excluded. Following that, careful selection of studies was performed based on our PICO criteria.

- (1) *Population*: undergraduate medical students.
- (2) *Intervention*: any wet or dry laboratory or cadaveric course offered by Medical School or other provider (experimental research laboratory or scientific/students’ society, etc. published on MEDLINE).
- (3) *Comparison*: different modalities of simulation: wet laboratory, dry laboratory, cadaveric, and high or low fidelity simulation.
- (4) *Outcomes*: performance improvement/motivation effect to pursue a career in surgery/overall perception of students.

The use of an objective assessment tool such as the aforementioned PICO protocol was crucial in maximizing homogeneity within the final list of studies. To robustly apply the methodology, all three reviewers rescreened all included sources through a secondary thorough read of the selected articles. In cases of disagreement between the researchers as to whether a source should be included/excluded, the source was included by default. Manual search of known conference proceedings for unpublished/non-indexed research was also conducted.

Data Extraction

Data was initially extracted by 2 independent reviewers (I.T. and M.N.) using a pilot modified worksheet structured around the PICO framework. Subheadings of the PICO framework enabled a more thorough extraction of data and greater insight into the selected studies. Examples of the spreadsheet’s extracted fields are shown in [Table 1](#). Upon completion of the first round of extraction, a third reviewer confirmed the validity of the data (M.S.).

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