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Update on Simulation-Based Surgical Training and Assessment in Ophthalmology

A Systematic Review

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Topic: This study reviews the evidence behind simulation-based surgical training of ophthalmologists to determine (1) the validity of the reported models and (2) the ability to transfer skills to the operating room.

Clinical Relevance: Simulation-based training is established widely within ophthalmology, although it often lacks a scientific basis for implementation.

Methods: We conducted a systematic review of trials involving simulation-based training or assessment of ophthalmic surgical skills among health professionals. The search included 5 databases (PubMed, EMBASE, PsycINFO, Cochrane Library, and Web of Science) and was completed on March 1, 2014. Overall, the included trials were divided into animal, cadaver, inanimate, and virtual-reality models. Risk of bias was assessed using the Cochrane Collaboration's tool. Validity evidence was evaluated using a modern validity framework (Messick's).

Results: We screened 1368 reports for eligibility and included 118 trials. The most common surgery simulated was cataract surgery. Most validity trials investigated only 1 or 2 of 5 sources of validity (87%). Only 2 trials (48 participants) investigated transfer of skills to the operating room; 4 trials (65 participants) evaluated the effect of simulation-based training on patient-related outcomes. Because of heterogeneity of the studies, it was not possible to conduct a quantitative analysis.

Conclusions: The methodologic rigor of trials investigating simulation-based surgical training in ophthalmology is inadequate. To ensure effective implementation of training models, evidence-based knowledge of validity and efficacy is needed. We provide a useful tool for implementation and evaluation of research in simulation-based training. *Ophthalmology 2015;■:1–20 © 2015 by the American Academy of Ophthalmology.*

Misconceptions of key aspects in surgical training and assessment can lead to suboptimal research and training programs within the area. An evidence-based approach to new training models is paramount to deliver satisfactory patient outcomes, and we are far behind in developing such an approach.

Although simulation has a long history in training programs in various domains, such as the aviation industry, the use of simulation in surgical training is more recent. "See one, do one, teach one" has been the dominating paradigm in surgical education for decades, but legal and ethical concerns about using patients for training purposes have led to increasing interest in simulation-based training, including in ophthalmology. The apprenticeship model using patients as teaching cases is associated with increased complication rates[1–12] and worse patient outcomes.[13,14] Furthermore, training surgical residents in the operating room increases costs because of increased operating times.[15–17] Generally, concerns have been raised regarding the number of residents who struggle with surgical competency,[18] and several studies have reported significant perceived deficiencies in surgical training of residents.[19–21] Therefore, alternative training models are needed, and simulation models may be the answer because they offer standardized, controlled training scenarios without endangering patients.

Besides the need for alternative training models, there is also a need for objective assessment tools with which to evaluate surgical competency in ophthalmology.[22] Programs typically require residents to complete a minimum number of procedures before graduating (Accreditation Council for Graduate Medical Education and Royal College of Ophthalmology), although performing a required number of surgeries does not ensure competency. However, the use of simulation models can ensure a basic level of competency.[23]

Different categories of simulation models are used for assessment and training purposes, including animal, cadaver, inanimate, and virtual-reality models. The Accreditation Council for Graduate Medical Education mandates access to a surgical simulation model (wet lab or virtual-reality simulator [VRS]),[24] and several curricula emphasize the use of simulation-based training and

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Table 1. Applied Frameworks for Quality Assessment of Included Trials*

Framework	Description	Items	Definition	Examples	Score
Messick	Validity of assessment tools	Content	Relevance of test content when compared to domain of interest	Ensuring representative assessment using review by experts	0−3
		Response process	Evidence of data integrity (all sources of error associated with test administration are controlled or eliminated)	Controlled assessment environment; e.g., standardized written instructions	0−3
		Internal structure	Reproducibility and generalizability of the test	Reliability of the assessment tool; e.g., intermodule reliability analysis using intraclass correlation coefficients	0−3
		Relations with other variables	Correlation to external, independent measures	Assessment results related to previous surgical experience	0−3
		Consequences	Consequences of test use	Considerations on passing rates including documentation of the method used to establish a pass/fail score	0−3
Kirkpatrick	Efficacy of training programs	Reaction	Trainees' satisfaction with the training model	Response survey	Level 1
		Learning	Extent to which the training led to an increased level of knowledge or skill	Comparison of the effect of 2 different simulation-based training programs on subsequent wet-lab performance	Level 2
		Behavior	Transfer of skills to the operating room	Effect of training on OR video-assessed performance	Level 3
		Results	Improvement of patient-related outcomes	Effect of training on patient complication rates	Level 4
OCEBM†					

OCEBM = Oxford Centre for Evidence-Based Medicine Levels of Evidence; OR = operating room.
*From Downing and Yudkowski,[35] Ghaderi et al.,[36] Kirkpatrick and Kirkpatrick.[37]
†OCEBM are used for general quality assessment based on study design and cannot be categorized into items.

assessment.[25,26] A survey published in 2011 by Ahmed et al[27] reported that a VRS was included in 23% of residency training programs in the United States. The simulator was used for quantitative evaluation of resident surgical skills in 50% of the programs, whereas 21% of the programs without a VRS reported unproven validity of the simulator as a limiting factor.

The results of this survey provided a good impression of the problem. The empirical basis for the great increase in simulation-based training in ophthalmology has not been well established,[27−29] and in particular, the link between task-based simulation and clinical practice is missing. Using simulation models without knowledge of reliability, validity, and efficacy may compromise patient safety, especially if the trained skills do not correlate with the skills needed for real-life performance. At the same time, ineffective training on often expensive simulation models are costly for departments. When used for assessment purposes, such as certification, important decisions cannot be appropriately made if the validity of the model's or instrument's measurements are questionable.[30] Therefore, an overview of the empirical background for available simulation models in ophthalmology is needed to make informed decisions on which models to use and to guide future research.

In this review, we used state-of-the-art frameworks for assessing the quality of the included trials. Validity is a key issue in simulation, especially when considering models or instruments for assessment purposes, including competency-based training. In medical education, validity is the degree to which an instrument measures what it sets out to measure.[31] The classical framework including construct, content, and criterion validity has been replaced by a modern, unified framework, introduced by Messick, consisting of 5 sources of validity evidence (the American Educational Research Association also uses this framework).[32−35] The evidence from each of these 5 sources can be ranked (0−3).[36] Trials measuring the efficacy of training programs can be stratified according to Kirkpatrick's 4 levels of evidence (1−4).[37,38] For a more detailed description of the applied frameworks, see Table 1.

The research questions for this study were: What types of ophthalmic surgical training models have been described in the literature? To what extent has validity evidence been established? Has efficacy (cf. Kirkpatrick's model) been investigated (especially transfer to the operating room)? Thus, we mapped the current knowledge about surgical training models within ophthalmology based on a qualitative, systematic literature review. The aims of the study were to provide ophthalmologists with a tool for selecting models for surgical training and assessment and to present recommendations for prioritizing future research.

Methods

Eligibility Criteria for Considering Trials for This Review

We included all trials dealing with simulation-based training or assessment of ophthalmic surgical skills among health professionals. We excluded trials dealing only with cognitive surgical