Effects of Simulation-Based Training in Gastrointestinal Endoscopy: A Systematic Review and Meta-analysis

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BACKGROUND & AIMS: Simulation-based training (SBT) in gastrointestinal endoscopy has been increasingly adopted by gastroenterology fellowship programs. However, the effectiveness of SBT in enhancing trainee skills remains unclear. We performed a systematic review with a meta-analysis of published literature on SBT in gastrointestinal endoscopy.

METHODS: We performed a systematic search of multiple electronic databases for all original studies that evaluated SBT in gastrointestinal endoscopy in comparison with no intervention or alternative instructional approaches. Outcomes included skills (in a test setting), behaviors (in clinical practice), and effects on patients. We pooled effect size (ES) using random-effects meta-analysis.

RESULTS: From 10,903 articles, we identified 39 articles, including 21 randomized trials of SBT, enrolling 1181 participants. Compared with no intervention (n = 32 studies), SBT significantly improved endoscopic process skills in a test setting (ES, 0.79; n = 22), process behaviors in clinical practice (ES, 0.49; n = 8), time to procedure completion in both a test setting (ES, 0.79; n = 16) and clinical practice (ES, 0.75; n = 5), and patient outcomes (procedural completion and risk of major complications; ES, 0.45; n = 10). Only 5 studies evaluated the comparative effectiveness of different SBT approaches; which provided inconclusive evidence regarding feedback and simulation modalities.

CONCLUSIONS: Simulation-based education in gastrointestinal endoscopy is associated with improved performance in a test setting and in clinical practice, and improved patient outcomes compared with no intervention. Comparative effectiveness studies of different simulation modalities are limited.

Keywords: Simulation; Gastrointestinal Endoscopy; Outcomes; Education.

Traditional training in gastrointestinal endoscopy is based on the apprenticeship model (ie, trainees learn basic endoscopic skills under the supervision of experienced endoscopists in clinical practice). However, in light of ethical and medicolegal concerns for patient comfort and safety, as well as the negative short-term financial impact of teaching endoscopy to trainees, there is an increasing shift to simulation-based training (SBT) in gastrointestinal endoscopy.[1] SBT is an attractive alternative for teaching psychomotor and perceptual skills, offering an environment that avoids time pressures and patient safety risks and enables systematic variation of the clinical scenario. In fact, current guidelines from the American Council for Graduate Medical Education mandate the incorporation of SBT in all gastroenterology fellowship programs.[2]

Previous reviews have offered some insights into the effectiveness of SBT in gastrointestinal endoscopy, but these reviews have been limited by the lack of a systematic search, incomplete assessment of study quality, and an absence of quantitative pooling to derive best estimates of effect of these interventions on the trainees' endoscopic skills.[3,4] A recent review from the Cochrane Collaboration focused only on randomized controlled trials of computed-based endoscopy training, and included only 13 trials with 278 participants.[5] Nonrandomized studies, single-arm pre- vs postintervention comparisons, and on ex vivo animal models and mechanical simulation models were not included, and hence the review did not synthesize the available evidence comprehensively. A comprehensive review and

synthesis would allow an objective assessment of the effectiveness of SBT, as compared with no intervention, in improving procedural skills and effects on patients, enable identification of appropriate instructional design features, and identify areas in simulation-based education that require further investigation.

Hence, we sought to identify and summarize, both quantitatively and qualitatively, all comparative studies of SBT in gastrointestinal endoscopy (diagnostic and therapeutic esophagogastroduodenoscopy [EGD], colonoscopy, flexible sigmoidoscopy, endoscopic retrograde cholangiopancreatography [ERCP], and endoscopic ultrasound) through a systematic review and meta-analysis of published literature.

Methods

This study was a planned subanalysis of data collected as part of a comprehensive review of simulation-based education.[6] The study was planned, conducted, and reported in adherence to Preferred Reporting Items for Systematic Reviews and Meta-Analysis standards of quality for reporting meta-analyses.[7] Our general methods have been described in detail previously[6]; we summarize them briefly later.

Questions

We sought to answer the following questions: (1) what is the effectiveness of technology-enhanced simulation for training in gastrointestinal endoscopy on trainee knowledge, procedural skills in a simulation/training environment, performance skills with actual patients, and effects on patient outcomes, and (2) what instructional design features are associated with improved outcomes in trainee performance? We defined technology-enhanced simulation as an educational tool or device with which the learner physically interacts to mimic an aspect of clinical care.[6]

Study Eligibility

We included studies involving health professional learners at any stage in training or practice that investigated the use of technology-enhanced simulation to learn gastrointestinal endoscopy, in comparison with the following: (1) no intervention (ie, a control arm or pre-intervention assessment), (2) a nonsimulation training activity, or (3) an active alternative SBT modality. Both single-group pretest-posttest and 2-group randomized and nonrandomized studies, focusing on the educational outcomes of SBT in therapeutic EGD, colonoscopy, flexible sigmoidoscopy, ERCP, and endoscopic ultrasound, were included. We did not exclude studies based on outcome, year, or language of publication. However, studies that focused only on simulation-based assessment (ie, a model's ability to assess procedural skills) were excluded.

Study Identification

We performed a systematic literature search of MEDLINE, EMBASE, CINAHL, PsycINFO, ERIC, Web of Science, and Scopus, from inception to May 11, 2011, with the help of an experienced librarian. Our full search strategy has been published previously.[6] We searched for omitted articles by reviewing the reference lists of all included articles, technical reviews from the American Society of Gastrointestinal Endoscopy,[8] the September 2006 edition of *Gastrointestinal Endoscopy Clinics of North America*, which was dedicated to Endoscopy Simulators for Training and Assessing Skills (which included the consensus statement of the First International Conference on Endoscopy Simulation),[4,9–14] and several published reviews of health professions simulation.[3,5,15] Finally, we searched the full table of contents of 2 journals devoted to health professions simulation (*Simulation in Healthcare* and *Clinical Simulation in Nursing*).

During the peer-review phase, we identified recently published articles by searching PubMed using the terms simulat* AND (egd OR endoscopy OR colonoscopy OR ercp) from a date range of January 11, 2011, to December 19, 2013. We retrieved 765 articles. A single author reviewed all of these studies, applying the inclusion criteria noted earlier and extracting key information from eligible studies.

Study Selection

Study selection was performed in 2 stages. In the first stage, we identified all studies of technology-enhanced simulation for health professional education using the search described earlier. Two reviewers independently screened all titles and abstracts to exclude studies that did not address the research question of interest. The full texts of the remaining articles were reviewed for definitive inclusion or exclusion, again independently and in duplicate. We resolved conflicts by consensus. Chance-adjusted interrater agreement for study inclusion at the first step was substantial (intraclass correlation coefficient, 0.69).[16] In the second stage, 2 investigators trained in gastroenterology reviewed the studies addressing technology-enhanced simulation to specifically identify studies focused on gastrointestinal endoscopy training; the κ-coefficient of agreement between the 2 investigators at this stage was 0.95.

Data Extraction

We abstracted information independently and in duplicate for all variables in which reviewer judgment was required, and resolved conflicts by consensus. Foreign-language articles were translated before data abstraction. By using a data abstraction form, we abstracted information on the training level of learners, clinical topic, method of group assignment, outcomes