Simulation in Surgical Education: Influences of and Opportunities for the Southern Surgical Association

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The Presidency of the Southern Surgical Association (SSA) has been held by many significant clinical innovators and educators. To be considered among such a group is truly one of the highest honors of my academic career and I am humbled by the opportunity to lead the Association for the last 12 months. My sincere and heartfelt thanks go to each and every member of the Association, as well as to surgical colleagues who have impacted my career.

Three members of the Association deserve my special gratitude as they have much to do with whatever successes I might have enjoyed in a surgical career. First, my medical school advisor at the University of Rochester, Dr Seymour Schwartz, has always been a model of intellect and grace, with abundant time for house officers and students. In my surgical residency at Duke, Dr David Sabiston demanded quality and accountability and whose pride in the accomplishments of his residents was never far below the surface. Finally, Dr Scott Jones, research mentor at Duke and Chair at Virginia, was an equally prominent role model for clinical excellence and integrity in research (Fig. 1).

All three of these scholars had their own successful methods of surgical education. However, an impressive quality that all 3 possessed was and is a willingness to embrace new paradigms or techniques. My intention to address an evolving methodology in surgical education will hopefully meet with their approval. I am confident, as with all outstanding teachers/mentors, that their commitment to excellence embraces novel approaches and they would support my comments.

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SIMULATION EDUCATION-A 21ST CENTURY TOOL FOR 20TH CENTURY ISSUES?

The rich history of surgical education repeatedly demonstrates the ability to adapt to change. Advances in pharmaceuticals, such as antibiotics, muscle relaxants, and vasopressors, have paralleled development of technology, such as cardiopulmonary bypass, imaging techniques, and laparoscopy. These advances have been associated with, if not required, rapid and efficient changes in surgical techniques, procedures, and decision making. Likewise, surgical education has adapted to rapid information access technology through computer learning, telemedicine, and adaptation to the technical advancements mentioned. Additionally, regulatory issues, such as the advent of the 80-hour work week and attending supervision have demanded a need for increasingly efficient and focused educational pathways for both the mentor and the student.

The use of simulation techniques have been part of surgical education at least for the last 20 years. The variety of techniques that can be simulated, as well as the models available for instruction, are nearly as numerous as the surgical procedures performed. Although it is understood that simulation is not a complete replacement for intraoperative experience, it clearly represents an important place in current surgical education.

An important goal of surgical education is the acquisition of skill and skill sets that can adapt to new technology during and, importantly, after resident training. The result of such increased skill should be improved clinical outcomes. This has been well documented by Birkmeyer and colleagues,[1] who evaluated graded performance skills of bariatric surgeons and compared these with patient outcomes. This group recruited 20 bariatric surgeons in Michigan to submit one videotape of their performance of a laparoscopic gastric bypass. A group of 10 different surgeons evaluated these tapes and rated various performance domains as skills assessment on a 1 to 5 scale. The evaluation was blinded as to the identity of the operating surgeon. The authors then compared these skill assessments with risk-adjusted complication data from their

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Abbreviations and Acronyms

AEI = Accredited Education Institute
CTA = cognitive task analysis
DP = deliberate practice
SSA = Southern Surgical Association
VR = virtual reality

prospective clinical outcomes database involving more than 10,000 patients. The best technical performing surgeons correlated with the best clinical outcomes and, by implication, patient safety. This study documents the need for procedural mastery and surgical skills as essential to quality surgical education. The question arises: can simulation training enhance the acquisition of surgical skill and, if so, how can simulation techniques prove themselves as relevant for such training? To understand how simulation can most effectively impact surgical education, it is necessary to understand how the wide range of available simulation techniques might be integrated into the current accepted paradigms of learning surgical skills. Therefore, although it is tempting to describe the multiple kinds of simulation devices and programs available, this presentation will focus more directly on how these emerging innovative methodologies fit appropriately and successfully into current teaching of surgical skills, and their effectiveness as an adjunct to intraoperative experience.

SURGICAL SKILL ACQUISITION AND LEARNING THEORY

For the capable student to acquire appropriate skills that allow him or her to obtain expert status, the 2 most important components are a solid, committed preceptor and up-to-date technology. These precepts have been understood in relation to surgical training, especially with regard to resident training, for at least the last 2 decades—and essentially since Halsted's time. Dr Ajit Sachdeva[2] (SSA member since 2013) described the importance of skilled preceptorship and health sciences education in 1996, and has been developing programs in the American College of Surgeons since then (Fig. 2). The understanding that simulation techniques could play an important part in surgical training was emphasized in the report of the Study Group of the American Surgical Association in 2009.[3] The report stressed the need for additional infrastructure to allow surgical skill acquisition and learning through simulation exercises. These programs would teach by breaking down procedures into

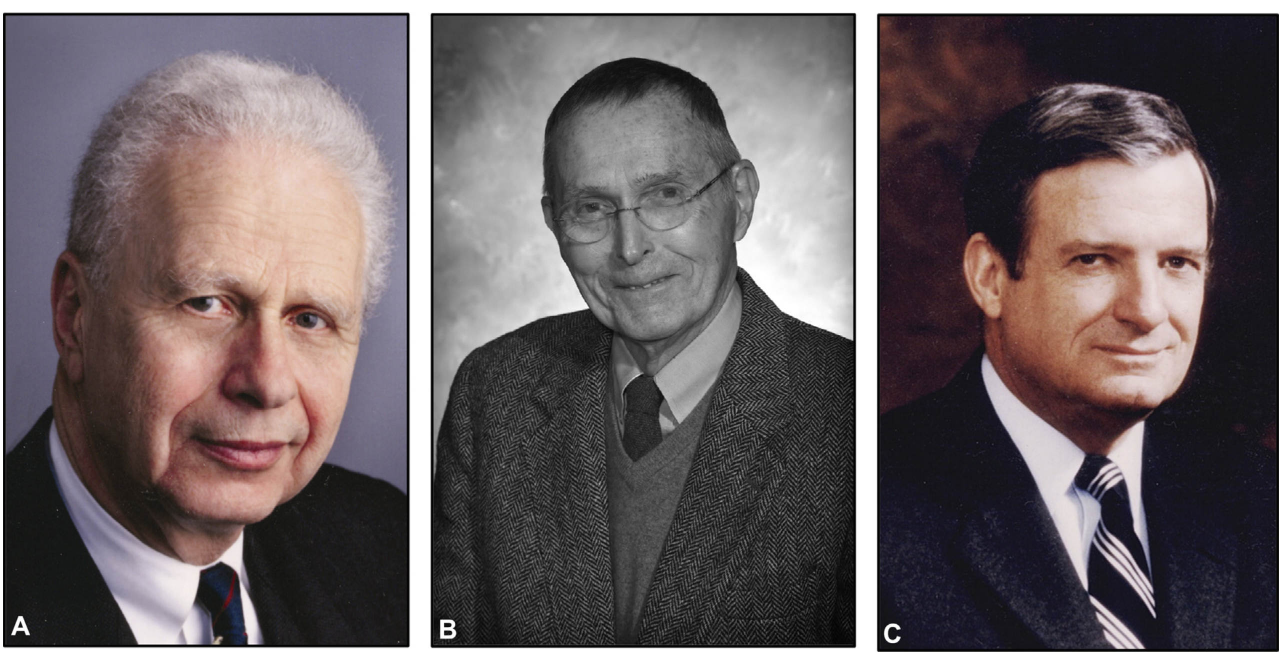

Figure 1. Mentors and educators whose contributions to a surgical career are deeply appreciated: (A) Seymour Schwartz, MD, FACS, University of Rochester Medical School Advisor. (Reprinted with permission from the Department of Surgery, University of Rochester School of Medicine and Dentistry.) (B) R Scott Jones, MD, FACS, University of Virginia Clinical and Research Advisor. (Reprinted with permission from the Department of Surgery, University of Virginia.) (C) David Sabiston, MD, FACS, Duke University, Chair of Surgery. (Reprinted with permission from the Duke University Department of Surgery Archives.)

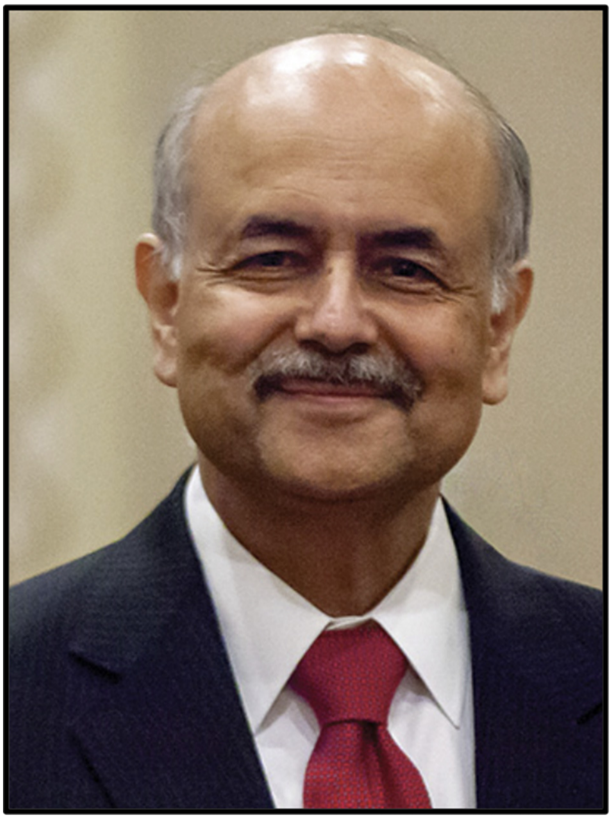

Figure 2. Ajit Sachdeva, MD, FACS, Director of Education, American College of Surgeons. Dr Sachdeva guided the implementation of American College of Surgeons-supported Simulation Centers, the Accredited Educational Institutes. (Reprinted with permission from the American College of Surgeons.)

measureable categories for which quantifiable metrics could be used to grade skill acquisition. Nine of the 11 authors of this report were members of the SSA.

While new and emerging simulation technology offered numerous exciting possibilities for surgical training, it was quickly realized that basic tenets of information transfer, technical skill acquisition, and standardization of assessment would need to have clear definition. As a result of these efforts, educators have looked to existing types of learning theory to evaluate how simulation programs fit with recognized learning techniques, goals, and results. Several types of learning theory seemed especially appropriate for simulation-based surgical education. The following discussion of several learning theories for surgical education, although not all-inclusive, presents several relevant issues that characterize the appropriateness of simulation as an important tool in gaining mastery of the discipline.

Deliberate practice

The concept of deliberate practice (DP) holds that expert performance can result from deliberately choosing learning programs that maintain high performance. The learner is deliberately taken out of his or her "comfort zone" to acquire skills they desire, but have yet to master. The important principle of DP is the theory that deliberate engaging in activities that maintain and improve high performance will most effectively lead to expert performance. This program requires more than doing repeated tasks in a fixed time schedule. Although some learners can proceed on their own, most would need ongoing mentorship to guide the process. The end result of a DP program would be that all learners attain mastery (with earlier understood metrics) with minimal variation in outcomes. All learners would have the time necessary to complete the tasks to be learned. The goal of DP then, is not just skill acquisition, but skill improvement. The willingness of the learner and the commitment of the preceptor are all important. McGaghie and colleagues[4] reported a meta-analysis of literature and reported that the uses of simulation-based DP methods have superior results to traditional medical education in achieving specific clinical skill acquisition goals, including cardiac life support, laparoscopic surgical techniques, central venous catheter insertion, cardiac auscultation and thoracentesis. Hashimoto and colleagues[5] reported a randomized trial evaluating DP vs control methods of resident training for laparoscopic cholecystectomy. After completion of the training, the DP group reached 100% of designated quality of performance compared with 30% of the control group (Fig. 3). Crochet and colleagues[6] also reported the significant improvement in laparoscopic skills in a randomized study of "inexperienced" surgeons. Those who underwent DP instructional activities had significantly better global rating scores for quantitative and qualitative measures. It appears that the extent of DP performed is key: the student repeats the skill task not for a set number of repetitions, or within a certain time constraint, but until the task is mastered.

Cognitive task analysis

Deliberate practice methodology appears effective in allowing the novice learner to advance to mastery of techniques. However, surgical trainees also need to master awareness of unpredictable situations that require strategies for unforeseen situations that require alteration of operative plans. How does the master hepatobiliary surgeon deal with aberrant vascular anatomy resulting in intraoperative life-threatening hemorrhage? The difference between skilled or experienced surgeons ("experienced non experts" and "advanced experts") can be the

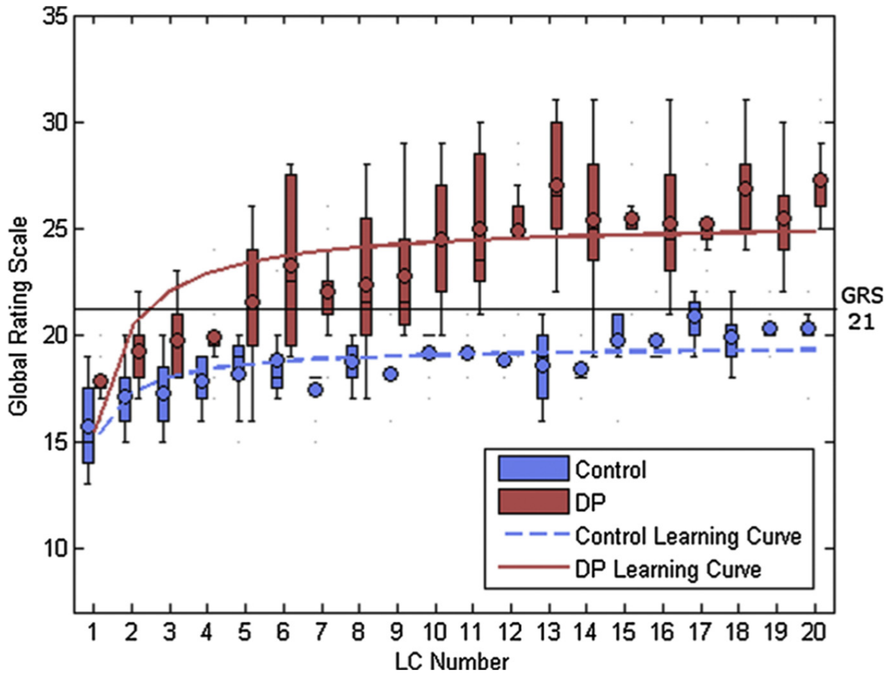

Figure 3. Deliberate practice methodology significantly improves surgical resident performance for laparoscopic cholecystectomy technique. (Reprinted from Hashimoto and colleagues[5] with permission from Springer Nature.)

ability of the latter to recognize and deal with unforeseen problems. Cognitive task analysis (CTA) is a learning system that can assess the steps required to attain expert task performance.[7] Cognitive task analysis was developed by industry and used in the military with the goal of creating job expertise in complex tasks in a short period of time. The impetus for using CTA lay with the realization that the "apprentice" model and/or use of DP did not completely address the learner acquiring situational awareness requiring expert judgment. In the arena of clinical surgery, poor situational awareness can result in poor judgment, increased chance of technical error, and poor outcomes. These situations might be too infrequent, and are instructor-dependent, therefore, poorly transferrable. The goal of CTA is to provide a set of methods and techniques that specify the processes needed for successful task performance. Agreeing on these processes can be laborious, as multiple experts must be queried to agree on the metrics to be learned and also critique the performance of learners.[8]

Simulation education has developed programs using CTA and is continually refining these programs. In 2012, the Society for Surgery of the Alimentary Tract developed a "virtual surgical patient" on which a series of clinical scenarios were encountered. Clinical decision making was presented via videos, text, and images. Options were presented to the student and management skills could be assessed. Options for management were presented through a "branching" design, thereby allowing "wrong" decisions. At completion of the exercise a "score" can be generated that reflects the user's proficiency of judgment for the exercise. The Society for Surgery of the Alimentary Tract is in the process of evaluating the future of this effort, recognizing that the initial effort might need to be more adaptable to a wider range of learners.

Pugh and colleagues[9] have used CTA to evaluate intraoperative decision making on 4 open surgical procedures, including pancreatic jejunostomy, ventral hernia repair, and stoma creation. They described the use of expert instruction and direct feedback using CTA principles during simulated procedures. The group used low-cost ($10.00 per) modules for each scenario and developed a CTA framework for decision making. Faculty-level participants showed improved decision making. They also advocated that such scenarios could be an important part of resident training.

Proficiency-based training

An obvious goal of any training paradigm is mastery of the relevant skills. Classical education programs have been given over a fixed time and a grade given that evaluates "proficiency" (2 semesters of organic chemistry in premed). More recently, emphasis has been placed more directly on programs that define metrics of proficiency regardless of the time spent attaining them. Surgical educators have broken this concept into several parts. "Skills generalization" and "skills transfer" are important concepts in what has been referred to as proficiency-based training. Using baseball as an example, one can believe that swinging a bat is a fairly easy task. That would be an example of "skills generalization." However, the more specific task of laying down a perfect bunt or hitting behind the runner must be practiced repeatedly until a degree of confidence can allow predictable results in competition. This is an example of "skills transfer" and these specific tasks are practiced repeatedly by athletes who desire optimal results in game situations. Gallagher and colleagues[10] have reported their experience with "proficiency-based progression" using the concept of skills generalization and skills transfer. The program starts with pretesting of performance, followed by a simulation-based scenario that is repeated until a defined benchmark is achieved.

Gallagher and colleagues[11] have used proficiency-based progression in virtual reality (VR) simulation training for laparoscopic skill acquisition. In a randomized, prospective blinded study, expert and novice groups received either VR simulation pretraining or conventional training programs and then were evaluated on similar surgical skills. Both experts and novices demonstrated improved performance with VR pretraining. Procedure error reduction was reduced by 32% to 42%. Interestingly, the largest proportion of performance improvement was observed in the VR pretrained novice group.

APPLICATION OR "VALUE" OF SIMULATION-BASED PROGRAMS TO SURGICAL EDUCATION

It appears that simulation-based programs fit with established learning theory at least for certain defined technical skills. A larger question exists: where can such programs logically and feasibly integrate in the broad spectrum of the education of the clinical surgeon?

Resident (or "novice") education

Several pressures have forced significant changes in surgical resident education during the last 25 to 30 years. The effects of the 80-hour work week and attending supervision throughout all years of training have had a major impact. It would appear that the application of DP and/or proficiency-based training paradigms using simulation-based training would fit nicely into surgical resident training programs.[12] As mentioned previously, Gallagher's group[10] is among several that have shown demonstrable skills acquisition by residents using such programs. Seymour and colleagues[13] reported a randomized, double-blind study to assess surgical resident skills performing laparoscopic cholecystectomy with or without virtual reality simulator pretraining. The non-simulator-trained residents were 9 times more likely to "fail to make progress" and 5 times more likely (Fig. 4) to injure the gallbladder or burn nontarget tissue. This and other studies emphasize several aspects of learning theory that enhance resident education: ability to repeat practice scenarios, lack of pressure, ability to work with a skilled mentor, and ability to quantitate results and gauge improvement. Dr Dana Andersen (SSA member since 1992) has written extensively about these efforts.[14] He is

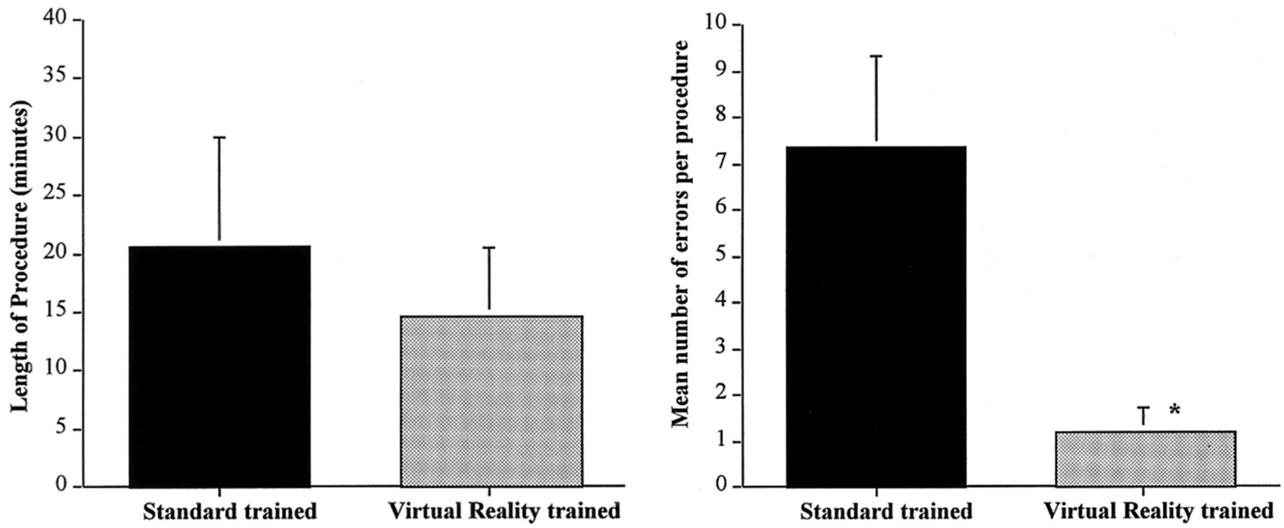

Figure 4. Using virtual-reality simulator pretraining, surgical residents reduced the mean operating time (left figure) and reduced the number of intraoperative "errors" (right figure). (Reprinted from Seymour and colleagues[13] with permission from Wolters Kluwer.)

currently working with the NIH to support and evaluate support for research into the efficacy and further potential of simulation as an education tool.

Skills acquisition by practicing surgeons

A successful career in surgery requires a commitment to lifelong learning. However, the acquisition of new skills or adapting to new technology at mid-career requires a different learning experience. The advent of laparoscopic cholecystectomy is a prime example of a sea change in technical skills that required a rapid learning curve at all levels, but mostly with practicing surgeons to remain competitive. Gallagher and colleagues[11] have reported that "experienced laparoscopic surgeons" benefitted from virtual reality-based simulation training in prospective randomized studies. Other studies have emerged with data strongly suggesting simulation techniques can be used at "novice" and "experienced" levels with results showing improvement in skills and psychometer development.[14-16]

The American Surgical Association recognized the importance of training (and credentialing) surgeons during the course of their careers, addressing specifically the issues of new technology and maintenance of skills.[3] The American Surgical Association Study Group advocated for new and revised educational programs using simulation techniques to allow learning and maintaining skills with agreed metrics of performance. As a direct result of the report, new programs, such as Fundamentals of Laparoscopic Surgery and Fundamentals of Endoscopic Surgery were developed.[17] The Baylor College of Medicine has developed the Methodist Institute for Technology, Innovation and Education in partnership with industry, which specifically provides access to practitioners to teach new skills and procedures through various simulation programs.[18] Dr Barbara Bass (SSA member since 1995) has been a leader in this program. Clearly, there is widespread interest in developing accessible, reproducible programs for practicing physicians to gain new skills as well as improve their existing ones.[19]

Interprofessional, professional, and "team" development

Almost a decade ago, the ACGME mandated documentation of professional competency learning in surgical residency training. Program directors have wrestled with quantitating such "learning" or developing meaningful metrics in these areas. Simulation might well offer interprofessional team training that would allow participants to acquire, practice, and refine technical skills as well as communication and efficiency of team performance. Video recordings of team assessment have been used for nearly 20 years for trauma education in the emergency setting. The American Association of Medical Colleges has supported the use of multidisciplinary simulation for team training involving patient care, interpersonal communication, and critical thinking.[20] Video tapes are critically reviewed and feedback is immediate and directed to issues where improvement is needed. As the broader applications of simulation are explored and developed, the obvious relevance to issues of patient safety and optimal outcomes increasingly presents itself. Dijkman and colleagues[21] reported in obstetrics a nearly 100% rate of maternal mortality in near-term pregnancy from cardiac arrest if not addressed within 5 minutes of onset. Because this rare circumstance requires emergency cesarean section, the delay appeared insurmountable. His report describes a team training program using simulation techniques—Managing Obstetric Emergencies and Trauma, which was established in The Netherlands in 2004. Rigorous protocols were practiced and agreed on. A preprogram maternal mortality rate of 100% for near-term cardiac arrest was reduced to 83% by rapid evaluation and bedside cesarean section.

Simulation training impact on clinical outcomes and patient safety

Although significant advances have been made in simulation training's impact on professional skills, it is reasonable to propose that the lay public would be most interested in knowing whether this translates to improved clinical outcomes and patient safety. Seymour's group,[13] mentioned previously, reported that residents trained by VR simulation in a randomized double-blind study reduced procedure errors 6 times more than their control group. In 2011, Zendejas and colleagues[22] reported a study of surgical residents training using web-based modules and a procedure simulator for totally extraperitoneal inguinal hernia repair. Intraoperative complications, postoperative complications, and hospital length of stay were all reduced in the group using the simulation curriculum.

In 2015, Cox and colleagues[23] reported a literature search to investigate the impact of simulation training on clinical outcomes. They refer to the 4 levels described by Kirkpatrick and colleagues[24] for evaluating the impact of simulation on the learner[25] (Table 1). The Fourth Level, the highest, attempts to document specifically if the training program directly resulted in improved patient outcomes. Cox and colleagues reviewed more than 1,300 articles and could find only 12 that satisfied the Level 4 criteria—mainly reports in the reduction of site infections after central venous line placement as a result of rigorous training. Cox and colleagues stressed the need for continued efforts to document the effect of simulation

Table 1. Kirkpatrick Levels of Learning

Level One	Reaction	Did the learner perceive value in simulation training?
Level Two	Learning	Did the learner's knowledge, skill, or attitude improve as a result of simulation training?
Level Three	Behavioral change	Did these acquired skills or knowledge transfer to the clinical environment (bedside and/or operating room)?
Level Four	Results	Did the simulation training lead to improved clinical outcomes?

not only to improve parameters of surgeon performance, but to demonstrate direct effects on patient safety and outcomes. Wider appeal to and support from the lay public (and future patients) can only come as a result of rigorous studies showing such results.

Cost-effectiveness of simulation

Very few reports deal with the true cost or "value" of simulation. Cost, of course, can be defined in numerous ways, for example, dollars spent, time by learners, time by mentors invested, and space available. In the 2012 meeting of the American College of Surgeons Accredited Education Institutes, Pentiak and colleagues[26] reported that the initial cost for their center to start their simulation center was $4.5 million. Approximate costs per resident to complete the entire American College of Surgeons/Association of Program Directors in Surgery skills curriculum was $30,000.

A wide range of "simulation tools" are available, from $250,000 computer-equipped manikins, to simple box

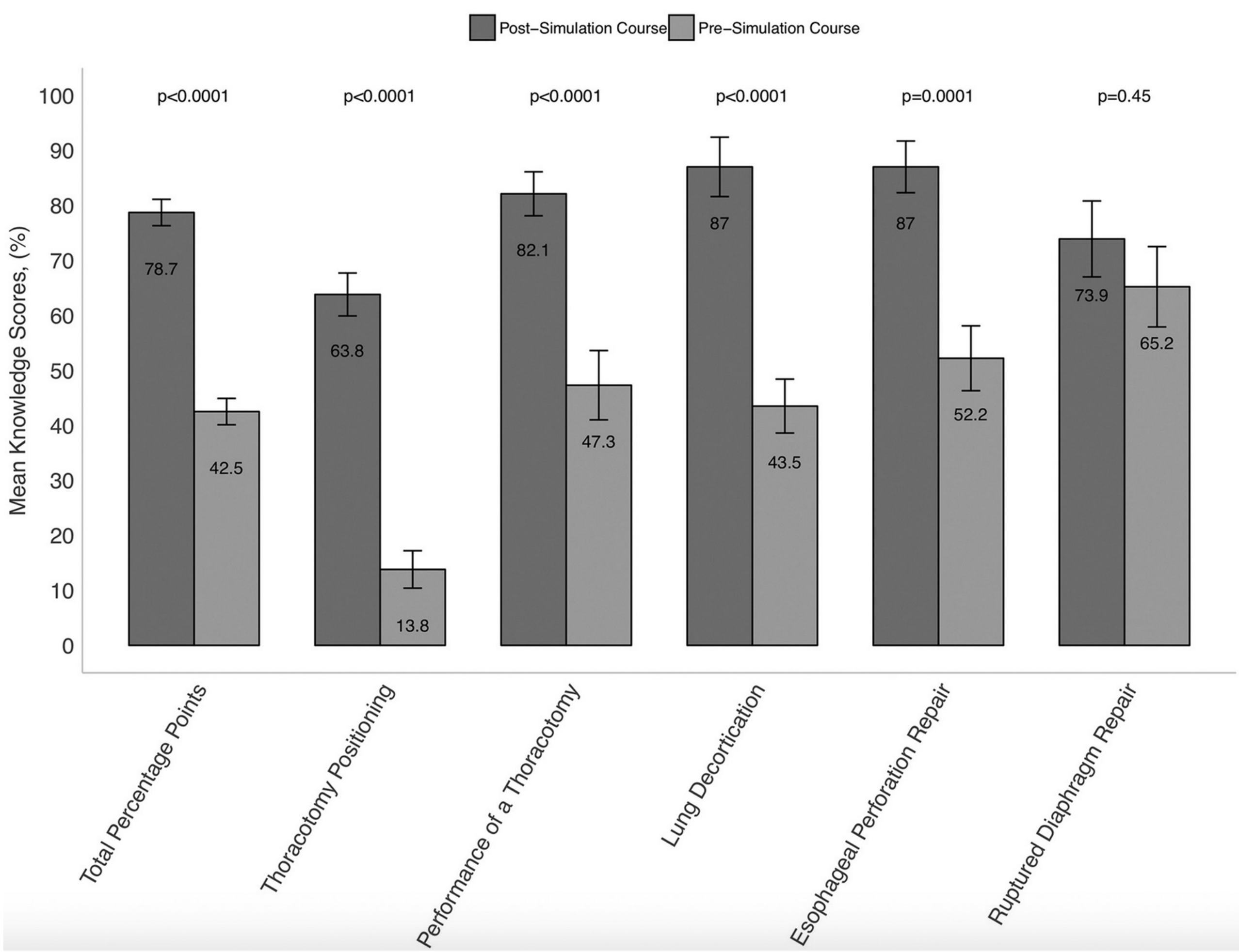

Figure 5. Using simulation models in a resource limited environment (Rwanda). Ramirez and colleagues showed measureable positive impact on skills learning for basic thoracic procedures. (Reprinted from Ramirez and colleagues[28] with permission from Elsevier.)

devices, or even readily available articles, such as discarded suture packs, or even soda straws for anastomosis procedure instruction. Therefore, true analysis of cost is hard to define or quantitate. Using a narrow definition of cost for simulation training, Zendejas and colleagues[22] report a defined cost benefit for inguinal hernia repair. This group has also reported that literature search for cost analysis reveals that only 1% to 2% of articles report cost effectiveness with any rigor.[27]

Cost-effectiveness must necessarily take into account a wide range of definition. As mentioned previously, the far end of the spectrum can require significant cash outlay for sophisticated equipment and systems, such as VR simulators and computer-driven manikins, which can present changing clinical scenarios in response to learner interventions. However, many simulation teaching programs can use almost cost-free procedure teaching elements, such as outdated operating room supplies, fruit, paper, straws, and/or meat products available in grocery stores or slaughter houses. It appears that if learners master technical skills initially on low-cost simulators, they can advance more efficiently to master decision making and clinical awareness scenarios, thereby decreasing time spent and increasing cost-effectiveness.[20] Cost-effectiveness is an important consideration, especially for third-world or resource-limited countries. Ramirez and colleagues[28] from the University of Virginia demonstrated the feasibility of simulation training for residents and attendings of general thoracic procedures at university hospitals in Rwanda. Five procedure models using only local materials or animal parts, none of which required electricity or external power, showed quantifiable improvement in physician understanding and performance (Fig. 5). Material cost was negligible. Clearly, mentor time and dedication were significant. Dr Tom Daniel, the project leader in Rwanda and a co-author with Ramirez and colleagues, has been a member of SSA since 1986.

Unfortunately, there appears to be a lack of consensus as to the real cost-benefit parameters for which simulation programs can be uniformly evaluated. Much more credible evaluations of return on investment could be made across a larger group of training programs or simulation centers if such standards were recognized and agreed on universally. Understanding the needs of the learner, the skill of the mentor, and the appropriateness of the education simulation tool are critical for any program. Only then can the true value of the process be appreciated and evaluated critically for ongoing improvement. Such an effort would clearly be the most cost-effective strategy, aimed at reasonable prices for the program with measureable cost-reduction on savings in the clinical areas and, ultimately, through optimal patient outcomes.

AMERICAN COLLEGE OF SURGEONS-ACCREDITED EDUCATION INSTITUTES

As mentioned previously, the American College of Surgeons has sponsored and supported simulation-based surgical training by the creation of Accredited Education Institutes for 15 years. Each program is evaluated for teaching capability and program relevance for initial evaluation and ongoing maintenance of relevant teaching efforts. In 2018, ninety-three such centers were accepted by the College for accreditation, 80 of which are in the US.

A questionnaire was sent to the principal investigator of each of the 80 US sites about their experience with simulation-based surgical education. A 43% response rate at 3 weeks was received from 34 centers. The responses brought out several interesting points (Table 2). From the answers received from these established centers invested in simuation education, it is apparent that: 1) simulation can be effectively taught to medical students and surgical residents by an enthusiastic faculty; 2) these centers can find intramural and extramural support for funding; and 3) there is a sincere interest in collaborative efforts in the future with national organizations to establish agreement for protocols and data acquisition for documenting impact on skills assesssment and clinical outcomes.

SIMULATION TRAINING AND SURGICAL EDUCATION: WHERE TO NEXT?

There is little doubt that, used in a time-efficient, cost-effective manner, simulation techniques and programs can play an important part in surgical education of the future. What needs to be done by the broad field of surgical education to make sure this advancement takes place in timely and meaningful ways?

Define the learners

It appears that there are at least 4 levels of "learners" for which simulation programs aid advancement of technical skills, as well as interpersonal communication.

Surgical residents

In 2007, the Residency Review Committee of Surgery required programs to offer training paradigms assessing surgical skills outside of the operating room environment. The questionnaire responses from the Accredited Education Institutes (AEIs) have showed definite enthusiasm

Table 2. Responses to Questionnaire on Experience with Simulation-Based Surgical Education

Response	n	%
Longevity of center		
>5 y	29/34	85
>10 y	17	50
Longevity as accredited program		
>5 y	21	61
>10 y	8	24
Offered programs shared by other clinical departments at their institutions	29	85
Programs for the following learner groups were offered		
Surgical residents	34	100
Medical students	32	94
Allied health professionals	32	94
Practicing clinicians	31	91
Practicing surgeons	30	88
Nurses	30	88
Which group benefits most from the programs?		
Surgical residents	—	38
Medical students	—	26
Practicing clinicians	—	6
Practicing surgeons	—	6
Nurses	—	6
Allied health professionals	—	3
Barriers		
What are the largest barriers to achieving the educations goals of your program?		
Student/resident participation due to time constraint	20	59
Lack of support/participation by faculty	20	59
Lack of support by hospital or medical school	13	38
Student/resident participation due to lack of interest	5	15
Lack of support by department chair	4	12
Financial support		
How much financial support do you receive from your medical school or hospital?		
None	5	15
0-$10,000/y	3	9
$10,000-$100,000/y	8	24
>$100,000/y	18	53
How much financial support do you receive from outside the medical school or hospital?		
None	2	6
0−$10,000/y	12	35
$10,000−$100,000/y	10	29
>$100,000/y	10	29
Program effectiveness		
Strongly agreed with the statement: "Providing simulation-based education to surgical residents is worth the time and effort."	25/34	74
Strongly agreed with the statement: "Providing simulation-based education to medical students is worth the time and effort."	27/34	79
National collaboration: Primary investigators who would be interested in national collaboration programs of simulation-based education initiated by surgical associations such as ACS, SSA, or ASA	33/34	97
Had at least 1 instructor who was a member of the SSA	18	55

ACS, American College of Surgeons; ASA, American Surgical Association; SSA, Southern Surgical Association.

for this level of program support. Additionally, Fundamentals of Endoscopic Surgery and Fundamentals of Laparoscopic Surgery courses are good examples of this effort. A wide range of teaching tools ranging from box trainers to cadavers and computerized manikins are increasingly possible. Development of quantifiable metrics can and should be addressed for decision making, operation independence, ethics, team training, and professional behavior. Such programs would be most effective if standardized across as many programs as possible. Additionally working within the 80-hour time frame will be challenging.

Post-residency skills acquisition

The introduction of laparoscopic cholecystectomy is a prime example of rapid assimilation of new technology in a very unstructured fashion. Many practicing surgeons were required to learn a new technique in a short time frame and with virtually no agreed on metrics of skill acquisition. More uniform programs can and should be developed to introduce emerging technology and standardize methodologies, assuring good clinical outcomes. As with resident training, standardization of programs and time constraints are important considerations.

Team training

There has been good success, as mentioned previously, with trauma team training where communication and delineation of responsibilities is defined and critically reviewed. A broader application could use intraoperative emergencies, patient resuscitation protocols, and perhaps difficult patient (and physicians?) behavioral challenges.

Coaching

The American College of Surgeons has supported efforts by "senior" surgeons, nearing or in retirement, to train as "coaches" for their younger colleagues. Several programs have established courses using simulation models—most notably Dr Richard Feins'[29] program at the University of North Carolina. These programs, especially the University of North Carolina program, have been very well received and speak to an untapped resource of surgical educators.

Develop standards for quantifiable skills assessment, protocols, and outcome measurements

To garner realistic support (and financial backing), the programs put in place for any of the leaner programs described will need more universal agreement as to what is taught, how it is graded, and what definable outcomes (especially patient safety) can be demonstrated. The lay public, if it is to be approached for recognition of clinicians' efforts to provide the best possible clinical results, will demand no less than protocol and data-driven results.

Develop more centralized programs

It is always challenging to offer medical educators, especially in the surgical world, the concept of "centralized" educational or clinical programs. The loss of proximity or local control is often met with considerable resistance. However, with the sophistication of telemetry, Internet, and other "distance learning" techniques, the world of surgical educators must re-evaluate how a larger audience can be reached. Additionally, the impact of centralized learning "institutes" or "academies" should be recognized. In the latter area, the American College of Surgeons has established innovative programs to provide regional support for simulation-based surgical education by supporting a consortium of AEIs.[30] As mentioned previously, these regional centers offer programs at the basic or comprehensive level depending on the needs of the learners and resources available. The AEIs have as shared goals several objectives: development of innovative curricula, peer review of new educational products and programs, collaborative research of outcomes, and sharing of limited resources. The questionnaire sent to AEI principal investigator shows overwhelming enthusiasm for multi-institutional collaboration in developing programs for simulation-based training. It appears that "centralization" of simulation education is not only reasonable, but has taken place successfully. Continued support from national and local sources will be critical for sustaining programs. It is time for surgical societies, such as the SSA, the American Surgical Association, The Central Surgical Association, and others to put forth their ideas for development and support of robust, data-driven, and outcomes-oriented surgical education programs.

The endgame

Any surgeon today would most likely state that it is hard to duplicate important skills that were learned in the operating room. Most likely, that impression remains true today and in the future. However, significant changes, such as work hour restrictions, have forced surgeon educators to look at realistic alternatives to real-time intraoperative skill acquisition and decision making.

Simulation training offers innovative and rewarding possibilities for the future of surgical educators and learners. There are many stakeholders, including students, residents, practitioners, but also administrators and, most importantly, patients. With the increasing sophistication of devices, cost-effectiveness becomes more important. What appears most necessary is the identification of the appropriate learners and to use the most relevant, goal-oriented simulation programs or technique for that group. Most importantly, quantifiable and reproducible results should be agreed on and evaluated, particularly in a robust and longitudinal fashion. The overall goal must necessarily be a demonstrable increase in the skills that are being evaluated in concert with definable results on improvement in clinical outcomes.

The SSA has enjoyed more than a century in the forefront of reporting advances in surgical education through innovations in operative techniques and, importantly, the effects of surgical leaders on learning. The SSA now has the opportunity to support the growth of simulation techniques and programs in the same fashion. Opportunities are now in place for the SSA to identify and support the members who are now fully invested in simulation education, with a goal of identifying the programs and learners who would embrace and benefit by such programs.

I sincerely hope that the SSA will look to and fully support the promising future of simulation with specific recommendations, support, and even creation of SSA-supported efforts. With the remarkable vitality and creative genius of its members, the SSA should have as a goal to be an innovative and recognized leader in supporting and defining the future of simulation education in surgery.

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