

Evolution of Minimally Invasive Surgery and Its Impact on Surgical Residency Training

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2.1 Introduction

Upon reflection, it is remarkable how little has been written on the subject of the evolution of minimally invasive surgery (MIS). It is likely that history will judge the impact of MIS on patient-care practices and healthcare economics on par with the introduction of antibiotics for surgical patients.

As we are frequently reminded in the American popular press, the first wave of the approximately 79 million “Baby Boomers” turns 65 in 2011, thus becoming eligible for healthcare benefits under Medicare [1]. Imagine for a moment a scenario in which there had occurred no MIS revolution and, therefore, no MIS approaches to common surgical disorders existed. In this day of healthcare funding crises and limited hospital bed access, if cholecystectomy potentially still required a 4- to 6-day hospital stay and 4- to 6-week postoperative recuperation and paraesophageal hiatal hernia repairs occasioned a 7- to 10-day hospital stay and 6- to 8-week recovery period, our current volumes of patients – let alone the anticipated infusion of senior citizens – could not possibly be accommodated within such a strained system. The advent of MIS has been most fortuitous on many levels.

In its most recent incarnation, MIS is only about 20 years old. Despite laparoscopy having been described more than a century ago [2] and practiced to some degree over the intervening years, the introduction of

laparoscopic cholecystectomy (LC) by Phillip Mouret in 1987 is largely credited with launching the revolution in MIS with which most readers will be familiar [3]. The purist will insist that Muhe, in fact, performed the first truly minimally invasive cholecystectomy in 1985 [4].

These remarkable procedures were first reported on North American shores by 1988. Although many surgeons’ imaginations were captured by the possibilities that the new techniques promised, the response of the surgical “establishment” and “academic surgery” was largely that of viewing MIS as surgical heresy, to be spurned! Thus, LC was first learned and practiced and promulgated in the US by community or private practice surgeons. Patients soon took notice of LC and voted with their feet en masse to have the procedure done.

Such a manner of introduction of a new technique or technology into the surgical mainstream was a marked departure from historical practice. Whether or not advances in surgical care and practice can or should only originate in academic centers is not this chapter’s argument; however, the lack of effective, deliberate, coordinated oversight that accompanied the introduction of LC to North American practice brought with it many foreseeable problems.

More than a decade earlier, Fineberg had stated, “It is crucial that a process is identified by which the rate of diffusion of technologies is controlled by evidence related to their costs and benefits” [5]. It is certainly fair to say that no such evidence existed at the time that LC was being widely adopted in the United States (US). Historically, new techniques or technologies that had been developed in academic surgical centers emerged having been built on a foundation of basic research-derived knowledge and early clinical work that had occurred under the strict aegis of an

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institutional review board with its requisite accountabilities. Furthermore, these new techniques were taught or trained in the context of a surgical residency or fellowship where oversight through apprenticeship was the model.

Such a model of development and training through the failing of no particular party did not greet the dissemination of LC in the US. Private practice surgeons, referred to as the “early adopters” [6], had neither the resources nor the time to set up comprehensive training programs. The academic surgical establishment, for the most part, perceived both LC and MIS as “passing fads” over which they had little control and with which they had not been adequately engaged early enough to contribute significantly either in terms of training or dissemination of the techniques [6].

2.2 Recognizing the Need for Training, Proctoring, and Preceptoring

As a result, there arose in short order a great unmet need for training in LC and other MIS techniques. It is estimated that between 1990 and 1992, approximately 15,000 general surgeons in the US were trained in LC [2]. Most of the training was accomplished without any form of recognized oversight or accreditation by means of “short courses” involving animal labs. Predictably, there followed a spike of surgical misadventures and an increased rate of common bile duct injury [7]. It was soon apparent that the “weekend” or short course without ongoing proctoring was not the optimal training format for the adoption of these new techniques. The inadequacies of such a surgical educational model were well described by Rogers et al. [8]. There is, however, evidence that by adding a disciplined regimen of proctoring and preceptoring of cases to the successful completion of a short course, a surgeon could safely assimilate a new laparoscopic technique into his or her practice [9]. Even so, there remained further training challenges to address, such as who would fund such a labor-intensive process? Could proctors or preceptors perform their role via telesurgery? If so, how were issues of liability and licensing requirements to be addressed? Many of these questions remain unanswered.

2.3 Competency in Laparoscopic Training During Surgical Residency in the US

In time, academic surgical centers recognized that this new field of surgery was here to stay and began a process of “catch up” that is still underway. Clearly, the most ideal framework within which to teach and train MIS techniques was the surgical residency program. This, obviously, would not meet the needs of that large cohort of surgeons who were out in practice without the benefit of learning MIS during their residency training. More than a decade following the introduction of MIS techniques to North America, Park et al. conducted a national survey of MIS and surgical education leaders to determine how much progress had been made in residency training of MIS techniques [10]. It was determined that (over a range of 13 laparoscopic procedures) American surgical residency programs did not meet the MIS case volumes required for competency as determined by experts. Five years later in 2007, residents were still performing far fewer cases on average [11] than what was felt necessary for competence in a poll of 2006 MIS fellows [12]. In fact, with the exception of LC, in which residents had more than adequate case volumes (average 103.1 cases for a graduating chief in 2007, compared with the 35.6 thought needed for competency by 2006 MIS fellows), for no other procedures was the average resident exposure/case volume close to the required numbers set by the fellows themselves to attain competence. This was the case even for operations such as fundoplication for which a laparoscopic approach is undisputedly the standard of care – graduating chiefs in 2007 performed 4.6 on average, while the competence standard was estimated at 22.0 by fellows in 2006. Among the conclusions of these studies were proposals for the development of a national MIS skills curriculum and the development and recruitment of MIS expert faculty to train residents and identification of the need to move training out of the operating room (OR) through new methodologies and technologies such as simulation to address the ongoing deficit in resident training in MIS.

2.4 Fellowship Council and Advanced MIS Postgraduate Training

Fortunately, a great deal of intentional progress in the provision of minimally invasive training, as this chapter will specify, has been made over the subsequent

years. While much in terms of laparoscopic education has been instituted within residency programs, a telling and important development has been the emergence of the Fellowship Council (FC), dedicated to bring order to the chaos of postgraduate advanced gastrointestinal (GI) surgery and MIS training. As larger numbers of graduating general surgical residents began to pursue fellowship training to gain adequate exposure to and experience with MIS, there arose tandem efforts to bring standards, accreditation, and a “match” to that process [13]. These efforts came to maturity in the form of the FC, a coalescence to work toward the ends of the stake-holding surgical societies: The Society of American Gastrointestinal and Endoscopic Surgeons (SAGES), The Society for Surgery of the Alimentary Tract (SSAT), The American Hepato-Pancreato-Biliary Association (AHPBA), and the American Society for Metabolic and Bariatric Surgery (ASMBS). Currently, the estimate is that one quarter of all graduating general surgery residents engage in the application process for an FC-sanctioned GI/MIS fellowship [11, 14]. This suggests that American surgical residency programs have still not consistently bridged the deficit in MIS training; otherwise, surgical residents would not still be “voting with their feet” in such large numbers.

2.5 Development of Resident Education Guidelines for Basic and Advanced Laparoscopy

On a more positive note, it should be emphasized that a movement is afoot nationally to bring coherence and focus to the challenge of surgical training in the era of rapid technology development and technique progression. The benefits promised by this movement will accrue not just to surgical residents but also to practicing surgeons. The ultimate benefits, of course, will be to enhance patient safety and outcomes. Within this movement, the resources and efforts being directed toward a few initiatives in particular are worth examination: standardized curricular development, objective metrics establishment for surgical performance/competence assessment, transfer of training, and simulation’s role in surgical training. These will be the foci of the remainder of this chapter.

In 1998 (with a 2009 revision), the Resident Education Committee of SAGES published resident education

guidelines for basic and advanced laparoscopy. Intended to aid program directors in planning an educational curriculum, these guidelines recommended starting with the acquisition of a core group of technical skills. The safe learning and refinement of these skills prior to OR deployment would be accomplished through use of surgical trainers, animal models, virtual reality (VR) trainers, or other simulated operating conditions housed within skills laboratories, the recommended learning environment [15]. Simulation came to the fore, showing promise as a gateway technology in terms of providing both objective metrics and training transfer, characteristics that among others continue to secure its role as a primary tool in the armamentarium of minimally invasive surgical training [16].

2.6 Simulation Training

2.6.1 General Remarks

In laparoscopic skill acquisition, many of the initial challenges are related to a loss of depth perception, the fulcrum effect, and the use of new, unfamiliar instruments. Certainly, the first time one is faced with these challenges should not be when working on a living patient, and it seems reasonable that as much skill acquisition as possible should be moved out of the OR and into arenas where mistakes do not compromise patient safety.

At the mid-point of the 1990s, the view that simulation was a technology promising both as a tool for laparoscopic training and as a cornerstone of the OR of the future began to take hold [17–19]. Although objective evidence is relatively sparse, there is no question that simulation must be an important part of education for the future. What remains in question, however, is what type of simulator and what will simulation’s part in training be.

Simulators and training models, for the most part, fall into three broad categories:

- Virtual reality (VR) trainers
- Box or mechanical trainers
- Biological models

Use of animal models for skill acquisition allows the trainee to work with tissue prior to doing so surgically in a human. Few places, however, have either ready lab access or the monetary resources necessary to make

animal models a regular part of a training curriculum. Additionally, there are ethical considerations in regard to acquiring technical skills by regularly using live animals. For over 100 years, for instance, since the 1876 enactment of the Cruelty to Animals Act, the performance of surgical procedures on live animals has been prohibited in Great Britain.

2.6.2 Reliability and Validation

Although mechanical and VR trainers are increasingly relied on in surgical teaching programs, validation studies have been limited. Proving the value of a trainer means demonstrating the reliability of its associated tests and metrics. Reliability is the degree to which consistent results are obtained each time the test is used. Validation is the next step and it is here that surgical literature is most lacking. In its simplest form, validity refers to whether a test actually measures what it purports to do. The depths and breadths to which such assessments are proven subdivide validity into dozens of subcategories.

2.6.2.1 Face Validity

Face validity assesses only whether a test “looks” as if it will measure what it claims to – a basic and subjective measure at best.

2.6.2.2 Content Validity

Content validity ascertains if test content truly is representative of what a test claims to measure. A test capable of maintaining its results across varied settings, procedures, and participants is said to have external validity. Three validities – concurrent, construct, predictive – address actual participant skills in meaningful ways.

2.6.2.3 Concurrent and Construct Validity

Concurrent validity establishes that a test is able to measure accurately the skill level of a test-taker at the time of the test, and construct validity presents proof that a test is able to differentiate subjects by their skill levels. Demonstrating correlation with performance

in the real world – predictive validity – is in terms of training usefulness, the most important while also the most difficult to determine and least reported.

2.6.3 Mechanical or Box Trainers

For basic and demanding skills associated with MIS, a variety of simple to complex physical objects, referred to as mechanical trainers, can be used for the purpose of simulated learning (Fig. 2.1). Another common method for introducing such skills to trainees is that of using a simple box-trainer comprising essentially the same equipment as would be found in the OR. These trainers come in various forms, but the basic components are the same – an enclosure with integrated skill

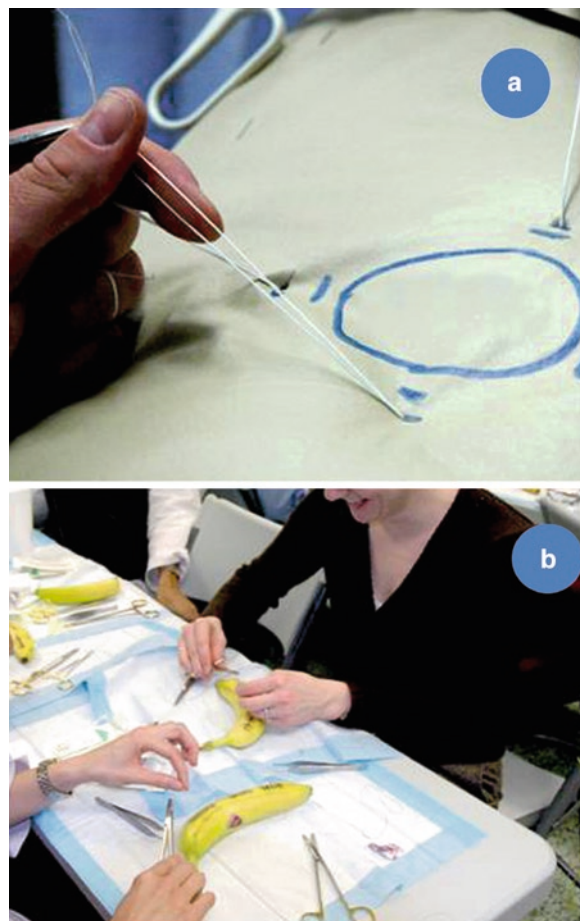


Fig. 2.1 Two instances of mechanical model use: (a) Physical abdominal model used for training the technique of placing transfascial sutures. (b) Students trained in open suturing using bananas

or task components, a camera system, and a light source. The cheapest and simplest of these training options are constructed from a simple plastic or cardboard box, a webcam, and a computer display [20–22]. On the high end, some mechanical trainers consisting of an actual laparoscope with accompanying fiber-optic light source and display are available (Fig. 2.2). Tasks to be practiced and perfected with the use of simulators can be as simple as moving laparoscopic instruments along a piece of rope in a fashion similar to that practiced with bowel or as sophisticated as actual procedural mock-ups.

2.6.3.1 Reliability and Validation

Demonstrations of the validities and reliability of box trainers are commonplace in clinical literature. One of the earliest examples demonstrating validity in surgical education is the Objective Structured Assessment of Technical Skill (OSATS). OSATS, developed initially

for use in the open surgical environment, utilizes bench tasks, the performance of which surgeon-observers using task-specific checklists rate and also assign a global rating to. Its reliability and construct validity were initially established in 1996 [23]. OSATS and other variants that rely on procedure-related checklists have become common teaching tools in the assessment of surgical trainees [24, 25].

2.6.3.2 McGill Inanimate System for Training and Evaluation of Laparoscopic Skills (MISTELS)

The best studied of the mechanical box trainers designed specifically for laparoscopic surgery, the McGill Inanimate System for Training and Evaluation of Laparoscopic Skills (MISTELS) now also forms the basis of the Fundamentals of Laparoscopic Surgery (FLS) training and assessment system (Fig. 2.3). In a trainer-box environment, MISTELS allows performance practice and acquisition of five basic laparoscopic exercises, scored for both efficiency (time) and precision. The validity of MISTELS has been demonstrated on multiple levels. Two 1998 reports introducing MISTELS provided evidence of the simulator's construct validity [26] and substantiated it with additional research [27]. Studies confirming MISTELS' construct and establishing its concurrent validities have also appeared [28–32] as has evidence of its predictive and face validity [33]. Additionally, the reliability of MISTELS has been described [34].



Fig. 2.2 The ergonomically designed Park training stand and box (San Jose, USA)



Fig. 2.3 Performance of FLS in a traditional laparoscopic box skills trainer

2.6.3.3 Limitations of Box Trainers

Box trainers in comparison to VR trainers are relatively cheap with both providing similar access to basic skills practice (Fig. 2.4). Box trainers do necessitate some ongoing costs as they use consumable materials and require maintenance. The complexity of tasks performable in a box trainer is limited since tasks requiring cutting, clipping, or suturing generally damage these models irreversibly, making them mostly single-use only. The limitations in regard to single usage and inability to accommodate practice of complex tasks dictate the impracticality of high-cost box trainers. When box trainers are low-cost overall, use very inexpensive consumables, are reusable, and are primarily for practice of simple tasks, they make satisfactory single-use models.



Fig. 2.4 The same basic laparoscopic skill performed in (a) Basic trainer box and (b) VR simulator

2.6.4 Virtual Reality

VR simulation has been made possible by ongoing advances in computer power and technology. In comparison to even the simplest biologic system, man-made machines such as automobiles and airplanes have proven easy to model accurately. Vehicle VR simulators are increasingly realistic, while VR simulators in surgery still provide very crude approximations of life in most cases. The first VR surgical simulators had limited or absent tactile (haptic) feedback, and this type of simulator continues to have a strong presence today. MIST-VR (Mentice, Göteborg, Sweden), built on the Virtual Laparoscopic Interface hardware platform from Immersion Medical Inc (Gaithersburg, USA), is one of the first and probably the most widely known of these simulators. The Virtual Laparoscopic Interface continues to be the platform for several simulators currently in use today, such as LapSim (Surgical Science, Göteborg, Sweden) – which was recently investigated by Aggarwal et al. [35] in a study that demonstrated that its proficiency-based curriculum of basic tasks at varying difficulties shortened the learning curve of a laparoscopic procedure, specifically a porcine cholecystectomy.

2.6.4.1 Limitations and Challenges of Virtual Reality Simulation

While VR simulations are visually becoming increasingly life-like, with image-quality approaching photo-realism (Fig. 2.5), the development of interface

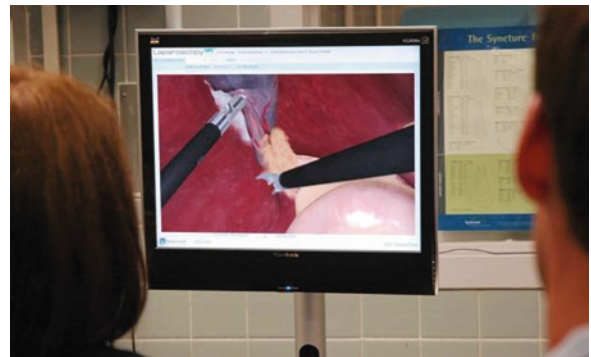


Fig. 2.5 Screen shot of students performing a cholecystectomy in a VR trainer

technology that provides users with haptic feedback lags. Haptics do not yet convey well the real anatomic situation [36]. Challenges to creating a realistic virtual environment include the modeling of tissue properties, rendering of the flow dynamics of hemorrhage and smoke, and simulating the operating environment on a larger scale including components such as patient physiology, personnel, and equipment. [37] Additionally, although the technological developments being made are exciting, true scientific evidence in support of VR simulators is still lacking overall. For this reason, VR simulation, though it holds great promise for the future, is not yet ready for wholesale incorporation into mainstream surgical curricula.

2.6.4.2 Comparison Between Virtual Reality, Box Trainer, and Their Impact in Clinical Practice

Whatever claims – positive or not – are bandied about in terms of types or models of simulators, the ultimate considerations must be how effectively and successfully they contribute to the acquisition of laparoscopic or other surgical skills. To date, no single type of trainer has been demonstrated to be superior to the other. In fact, one recent systematic review of the spectrum of surgical simulators, covering VR, video simulation (defined as box trainers with simple tasks), and model simulation (defined as box trainers with anatomic models) by Sutherland et al. [38] ultimately concluded that no single training method was consistently superior to the others. Their review, however, was limited by the tremendous heterogeneity of the current published literature. Nonetheless, a few trends emerged. VR training was found to be superior to no training and to standard training, although the benefits over the latter were less pronounced. Compared to training on a video simulator (box trainer with simple tasks), VR was neither consistently better nor worse. Surprisingly, video simulation did not show a consistent advantage over either no training or standard training. Again however, this heterogeneity is likely due to the broad range of simulators and training standards currently in use. Similarly, model simulation also had mixed results. No “gold standard” has been established in laparoscopic training; therefore, the methodologies compared in studies tend to be chosen arbitrarily. No research has yet established a relationship between simulation

training and improved patient outcomes. For the time being, their educational contributions must be measured in terms of their capabilities to provide objective performance metrics and to assure that simulated training once acquired is transferable to the OR.

2.7 Objective Metrics

Objective metrics, when obtainable, provide certainty toward assessment of progress of trainee proficiency and competency in addition to the continuance of acquired skills. In little more than a decade, interest and research have considerably expanded and improved reliable, objective metrics. A measure of success has been enjoyed by two similarly computer-controlled objective evaluation tools.

2.7.1 ICSAD and ADEPT

- Imperial College Surgical Assessment Device (ICSAD)
- Advanced Dundee Endoscopic Psychomotor Tester (ADEPT) [39–42]

The evaluative data accumulated by ICSAD, for example, are focused on the time taken and the distance covered by a surgeon’s hands as they are engaged in the performance of basic surgical tasks or an actual procedure. Additionally, ICSAD has claimed the number of hand movements in surgical performance as a qualitative objective performance measurement although that has been challenged [43]. Other systems of metric acquisition include the Blue Dragon and its successor the Red Dragon, which in addition to instrument movement measure the torque and force applied by a surgeon during laparoscopic tasks [44, 45].

2.7.2 Measuring Performance in the Operating Room – GOALS

Measuring performance in the OR in a reliable, unobtrusive fashion can be done using assessment instruments such as the Global Operative Assessment of

Laparoscopic Skills (GOALS) rating scale described by Vassiliou et al. [46]. Developed for the assessment of cholecystectomy performance, GOALS utilizes a combination of a five-item global rating scale, a ten-item task checklist, and two visual analogue scales (one for competence and the other for difficulty). GOALS has been successfully used to differentiate novices from more experienced surgeons [47] and is potentially adaptable to other laparoscopic procedures.

2.8 Transfer of Training

Transfer of training refers to whether acquiring proficiency in one task is of benefit in developing proficiency in another related, possibly more complex task. Issues of transfer of training are particularly germane in two aspects of teaching MIS. The first relates to whether open surgical skills carry over to laparoscopic skills. Figert et al. [48] found no correlation between the amount of open surgical experience and laparoscopic suturing performance in residents. This highlights the importance of training specifically targeting laparoscopic skills.

Transfer of training is again an important consideration when examining the benefit of various simulators currently in use. Studies tying simulator practice to skills transferable to the OR have steadily proliferated though the need for such proof is far from satisfied. Transfer of training has been seen in regard to both box trainers (Fig. 2.6) and VR simulators [37, 49–52]. The endpoints for these studies are heterogeneous, ranging from tasks in a live animal model to

performance in a real human OR. This highlights the lack of a consensus metric or technique of assessing “real” operative performance – a significant challenge yet to be overcome.

2.9 Work-hour Restrictions

Medical work-hour restrictions are becoming increasingly enforced around the world. Surgical trainees in the US are now limited to working 80 h per week. Although the literature on this topic continues to grow, thus far the 80-h work week has been found to have no measurable impact on the quality of patient care [53]. Concerns persist, however, that trainee education will be hampered by the 80-h regulation. Diminishment of exposure to real clinical scenarios increases the importance of considering and proving simulation training as a viable alternative. Still, residents must be motivated to use their own time in simulator practice as it may fall outside of the 80-h work week. In a survey of resident perception of simulator training, Boyd et al. [54] found that a majority of residents felt that such training should be mandatory (though it should be considered that this was the answer given by 75% of the junior residents and only 27% of the senior residents). Furthermore, junior residents ranked simulation training as the best way to learn new skills, whereas seniors preferred proctorship.

2.10 Cost Considerations

Surgical training costs money, space, and time. Money must be available to purchase simulators, there must be space to train and practice, and surgical instructors must make time for their trainees. Mounting evidence supporting the efficacy of laparoscopic skills training outside of the OR should encourage improved support resulting in increased amounts of educational resources. Ideally, the specific advantages and disadvantages of each type of simulator suggest that some exposure to each would likely be of benefit to the trainee. When working with limited resources, however, simulator training of basic laparoscopic skills can be provided cost-effectively through creative and frugal use of materials. In fact, low-tech (and relatively inexpensive)

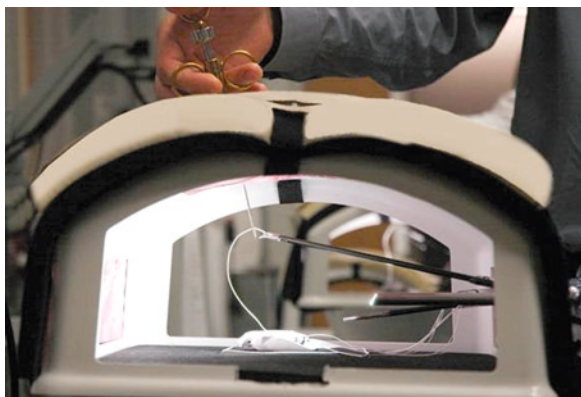


Fig. 2.6 Example of simulation aimed to improve transfer of suture passing technique to OR

simulators are at this date the best studied. Low costs make these simulators accessible and easily incorporated into most training programs. Berg et al. [55] described a yearly laparoscopic training cost of \$982 per resident that included the price of constructing simulators by using combined materials of the type that could be found in research labs and retail stores or donated by industry. Similarly, Adrales et al. [56] described anatomic models constructed from inexpensive materials such as elastics for vessels and crinoline fabric for hernia mesh. Mirrors have also been described as low-cost alternatives to both cameras and monitors [57].

2.11 Value and Relevance of Simulator Training

The success of simulation training hinges on residents, in particular whether they trust its educational value and future relevance and believe that they will have opportunities to use the skills thus acquired in the OR during residency and practice. Trusting and believing thus are crucial attitudes in terms of determining whether residents will be motivated, as many believe they must use their own time for simulator practice. Few residents will see the benefit of mastering laparoscopic suturing in a training box, if they are never given the chance to suture in the OR. With limited time available, most residents will need to be able to reap the rewards of practice and training in the OR to realize the worth of their time spent in the simulation environment.

2.12 Cognitive Skills

In MIS, the process of decision-making occurs from the moment a patient is encountered, and continues as a diagnosis is made and surgical or other treatment is selected and performed. In the OR, as a surgeon proceeds through a case, many moment-to-moment decisions, including whether to convert to laparotomy, must be made. Tissues and planes must be identified, respected, and manipulated in an appropriate fashion. While there is a growing complement of educational tools for teaching the purely technical aspects of

surgery (simulation exercises have in the majority been based on tasks most notable for their potential development of the basic hand–eye coordination necessary for performing laparoscopic procedures), surgery is more than simple technical skills. Indeed, it has been argued that learning is best facilitated when training in technical skills takes place in tandem with development of cognitive skills [42]. The cognitive aspects of decision-making, however, have largely been unaddressed in surgical training; when they have been, they are learned almost solely through patient care. In this instance, it is fortunate that risks to patients may be minimized by the careful supervision of an expert, who can correct unsound or poor decisions before the possibility of any adverse patient effects. Clinic discussions of a patient or active feedback presented in the OR are two of many ways that corrections can be offered. Learning as much as possible prior to or outside of direct clinical contact, one must remember, is of benefit to trainees as it allows them to optimize their time spent with patients.

In terms of teaching decision-making, simulators currently are hindered by their design, which specifically focuses on “how” rather than “why.” We have a limited example of “why” decision-making incorporated into the mock-ups of real operative procedures described by Adrales et al. [56] where items such as appropriate respect for tissues is part of the trainee’s evaluation. There is the promise that VR simulators will one day better incorporate the unpredictability that typifies the decision-making necessary in real surgical scenarios and will contain also the capacity to model larger portions of procedures. At this point, however, the fidelity of VR simulators is not adequate to capture the often very fine and subtle cues that generate inputs leading to surgical decision-making.

2.12.1 Maryland Virtual Patient (MVP)

There has been the development of a novel high-level simulation approach to teaching clinical decision-making – cognitive modeling. This type of simulation models the clinical pathways that are involved in disease presentation and management. An example of this type of simulation, which based on input from expert sources fosters trainee decision-making, is the Maryland Virtual Patient (MVP). The MVP simulates

disease states in a patient and allows the user to perform diagnostic tests as well as interventions [58]. At the core of the MVP is an engine built around a unique ontology that organizes medical knowledge into a form that can be processed by a computer. A natural-language, artificial-intelligence-driven user interface creates an intuitive, realistic experience – albeit through a computer monitor and keyboard. This simulator has the potential to be combined with other simulators to create a larger, even more complete simulation. For example, combination with a VR trainer would allow trainees to not only medically diagnose and treat a patient but also simulate the appropriate surgery.

2.13 Laparoscopic Training: Current Status and Future Direction

Within residency training programs, there is a significant variability in available equipment and training practices, a disparity perhaps reflective of time and money limitations. Recent surveys by Kapadia et al. [59] and Gould [60] found that 80–90% of programs possessed skills labs. These numbers likely represent a very broad spectrum of what the training programs across the country possess. However, interpretation of their findings should be tempered by the fact that these were self-reporting, voluntary surveys and that their definitions of what constituted a “skills lab” were not necessarily consistent. Still, these studies hopefully reflect increasing awareness of and resource allocation to training labs.

Another promising undertaking is the accelerated effort to bring some standardization to both the teaching and simulation processes. A combined American College of Surgeons (ACS) and Association of Program Directors in Surgery (APDS) task force is currently in the midst of rolling out a standard national curriculum for residents in surgery. Scott and Dunnington recently published a description of this program [61]. This curriculum is conceptualized in three phases.

- *Phase I:* Focuses on basic skills ranging from asepsis and instrument handling to fashioning an anastomosis
- *Phase II:* Focuses on procedures (and is still under development)

- *Phase III:* Focuses on team-based training (and is still under development)

This curriculum is promising as a comprehensive whole as its incorporation of concepts in regard to teaching and assessing judgment augments technical skill acquisition.

Throughout this chapter, it has hopefully been apparent that the advent of MIS has not only revolutionized surgical patient care but has also ushered in a new era and focus on surgical training and residency training in particular. Considerations that include surgical simulation, the development of objective measures of surgical performance, and the way in which both will come together in a standard surgical curriculum should leave little doubt of the significant impact MIS has had on surgical residency training. The actual business of training surgeons and the related surgical research that will accompany these efforts promise to be compelling endeavors for the foreseeable future.

References

1. Cauchon, D.: Senior benefit costs up 24%: ‘health care crisis’ leads to 8-year rise. USA Today, pp. 1A–2A (February 14, 2008)
2. Soper, N.J., Brunt, L.M., Kerbl, K.: Laparoscopic general surgery. N. Engl. J. Med. **330**, 409–419 (1994)
3. Cuschieri, A., Dubois, F., Mouiel, J., et al.: The European experience with laparoscopic cholecystectomy. Am. J. Surg. **161**, 385–387 (1991)
4. Harrell, A.G., Heniford, B.T.: Minimally invasive abdominal surgery: lux et veritas past, present, future. Am. J. Surg. **190**, 239–243 (2005)
5. Cuschieri, A.: Whither minimal access surgery: tribulations and expectations. Am. J. Surg. **169**, 9–19 (1995)
6. Rogers, E.M.: Diffusions of Innovations, 5th edn. Free Press, New York (2003)
7. The Southern Surgeons Club: A prospective analysis of 1518 laparoscopic cholecystectomies. N. Engl. J. Med. **324**, 1073–1078 (1991)
8. Rogers, D.A., Elstein, A.S., Bordage, G.: Improving continuing medical education for surgical techniques: applying the lessons learned in the first decade of minimal access surgery. Ann. Surg. **233**, 159–166 (2001)
9. Heniford, B.T., Backus, C.L., Matthews, B.D., et al.: Optimal teaching environment for laparoscopic splenectomy. Am. J. Surg. **181**, 226–230 (2001)
10. Park, A., Witzke, D., Donnelly, M.: Ongoing deficits in resident training for minimally invasive surgery. J. Gastrointest. Surg. **6**, 501–509 (2002)
11. Department of Applications and Data Analysis: General surgery case logs: national data report. Accreditation Council

- for Graduate Medical Education. http://www.acgme.org/acWebsite/RRC_440/reports/GSNatData0607.pdf (2007). Accessed 05 Nov 2010
12. Park, A., Kavic, S.M., Lee, T.H., et al.: Minimally invasive surgery: the evolution of fellowship. *Surgery* **142**, 505–513 (2007)
 13. Swanstrom, L.L., Park, A., Arregui, M., et al.: Bringing order to the chaos: developing a matching process for minimally invasive and gastrointestinal postgraduate fellowships. *Ann. Surg.* **243**, 431–435 (2006)
 14. The Fellowship Council Newsletter: Latest accreditation & match statistics. Fellowship Council. https://fellowship-council.org/documents/FC_news_fall07_web.pdf (2007). Accessed 05 Nov 2010
 15. Resident Education Committee: SAGES curriculum outline for resident education. Society of American Gastrointestinal and Endoscopic Surgeons. www.sages.org/publications/publication-pdf.php?id=28 (2009). Accessed 05 Nov 2010
 16. Segan, R.D., Park, A.E.: Training competent minimal access surgeons: review of tools, metrics, and techniques across the spectrum of technology. In: Szabo, Z., Coburg, A.J., Savalgi, R.S., et al. (eds.) *Surgical Technology International XIII*, pp. 25–32. Universal Medical Press, San Francisco (2004)
 17. Ota, D., Loftin, B., Saito, T., et al.: Virtual reality in surgical education. *Comput. Biol. Med.* **25**, 127–137 (1995)
 18. Satava, R.M.: Medical applications of virtual reality. *J. Med. Syst.* **19**, 275–280 (1995)
 19. Satava, R.M.: Virtual reality, telesurgery, and the new world order of medicine. *J. Image Guid. Surg.* **1**, 12–16 (1995)
 20. Beatty, J.D.: How to build an inexpensive laparoscopic webcam-based trainer. *BJU Int.* **96**, 679–682 (2005)
 21. Chung, S.Y., Landsittel, D., Chon, C.H., et al.: Laparoscopic skills training using a webcam trainer. *J. Urol.* **173**, 180–183 (2005)
 22. Pokorny, M.R., McLaren, S.L.: Inexpensive home-made laparoscopic trainer and camera. *ANZ J. Surg.* **74**, 691–693 (2004)
 23. Reznick, R.R., Regehr, G., MacRae, H., et al.: Testing technical skill via an innovative “bench station” examination. *Am. J. Surg.* **172**, 226–230 (1996)
 24. Martin, J.A., Regehr, G., Macrae, H., et al.: Objective Structured Assessment of Technical Skill (OSATS) for surgical residents. *Br. J. Surg.* **84**, 273–278 (1997)
 25. Szalay, D., MacRae, H., Regehr, G., et al.: Using operative outcome to assess technical skill. *Am. J. Surg.* **180**, 234–237 (2000)
 26. Derossis, A.M., Fried, G.M., Abrahamowicz, M., et al.: Development of a model for evaluation and training of laparoscopic skills. *Am. J. Surg.* **175**, 482–487 (1998)
 27. Derossis, A.M., Bothwell, J., Sigman, H.H., et al.: The effect of practice on performance in a laparoscopic simulator. *Surg. Endosc.* **12**, 1117–1120 (1998)
 28. Derossis, A.M., Antoniuk, M., Fried, G.M.: Evaluation of laparoscopic skills: a 2-year follow-up during residency training. *Can. J. Surg.* **42**, 293–296 (1999)
 29. Feldman, L.S., Hagarty, S.E., Ghitulescu, G., et al.: Relationship between objective assessment of technical skills and subjective in-training evaluations in surgical residents. *J. Am. Coll. Surg.* **198**, 105–110 (2004)
 30. Fried, G.M., Derossis, A.M., Bothwell, J., et al.: Comparison of laparoscopic performance in vivo with performance measured in a laparoscopic simulator. *Surg. Endosc.* **13**, 1077–1081 (1999)
 31. Ghitulescu, G.A., Derossis, A.M., Feldman, L.S., et al.: A model for evaluation of laparoscopic skills: is there correlation to level of training? *Surg. Endosc.* **15**(Supp 1), S127 (2001)
 32. Ghitulescu, G.A., Derossis, A.M., Stanbridge, D., et al.: A model for evaluation of laparoscopic skills: is there external validity? *Surg. Endosc.* **15**(Supp 1), S128 (2001)
 33. Fried, G.M., Feldman, L.S., Vassiliou, M.C., et al.: Proving the value of simulation in laparoscopic surgery. *Ann. Surg.* **240**, 518–528 (2004)
 34. Vassiliou, M.C., Ghitulescu, G.A., Feldman, L.S., et al.: The MISTELS program to measure technical skill in laparoscopic surgery. Evidence for reliability. *Surg. Endosc.* **20**, 744–747 (2006)
 35. Aggarwal, R., Ward, J., Balasundaram, I., et al.: Proving the effectiveness of virtual reality simulation for training in laparoscopic surgery. *Ann. Surg.* **246**, 771–779 (2007)
 36. Picod, G., Jambon, A.C., Vinatier, D., et al.: What can the operator actually feel when performing a laparoscopy? *Surg. Endosc.* **19**, 95–100 (2005)
 37. Seymour, N.E., Rotnes, J.S.: Challenges to the development of complex virtual reality surgical simulations. *Surg. Endosc.* **20**, 1774–1777 (2006)
 38. Sutherland, L.M., Middleton, P.F., Anthony, A., et al.: Surgical simulation – a systematic review. *Ann. Surg.* **243**, 291–300 (2006)
 39. Hanna, G.B., Cuschieri, A.: Influence of the optical axis-to target view angle on endoscopic task performance. *Surg. Endosc.* **13**, 371–375 (1999)
 40. Hanna, G.B., Drew, T., Clinch, P., et al.: A microprocessor controlled psychomotor tester for minimal access surgery. *Surg. Endosc.* **10**, 965–969 (1996)
 41. Hanna, G.B., Drew, T., Clinch, P., et al.: Computer-controlled endoscopic performance assessment system. *Surg. Endosc.* **12**, 997–1000 (1998)
 42. Poulin, E.C., Gagne, J.P., Boushey, R.P.: Advanced laparoscopic skills acquisition: the case of laparoscopic colorectal surgery. *Surg. Clin. N. Am.* **86**, 987–1004 (2006)
 43. Lee, G., Lee, T., Dexter, D., et al.: Methodological infrastructure in surgical ergonomics: a review of tasks, models, and measurement systems. *Surg. Innov.* **14**, 153–167 (2007)
 44. Brown, J.D., Rosen, J., Chang, L., et al.: Quantifying surgeon grasping mechanics in laparoscopy using the Blue DRAGON system. *Stud. Health Technol. Inform.* **98**, 34–36 (2004)
 45. Gunther, S., Rosen, J., Hannaford, B., et al.: The red DRAGON: a multi-modality system for simulation and training in minimally invasive surgery. *Stud. Health Technol. Inform.* **125**, 149–54 (2007)
 46. Vassiliou, M.C., Feldman, L.S., Andrew, C.G., et al.: A global assessment tool for evaluation of intraoperative laparoscopic skills. *Am. J. Surg.* **190**, 107–113 (2005)
 47. Vassiliou, M.C., Feldman, L.S., Fraser, S.A., et al.: Evaluating intraoperative laparoscopic skill: direct observation versus blinded videotaped performances. *Surg. Innov.* **14**, 211–216 (2007)

48. Figert, P.L., Park, A.E., Witzke, D.B., et al.: Transfer of training in acquiring laparoscopic skills. *J. Am. Coll. Surg.* **193**, 533–537 (2001)
49. Hyltander, A., Liljegren, E., Rhodin, P.H., et al.: The transfer of basic skills learned in a laparoscopic simulator to the operating room. *Surg. Endosc.* **16**, 1324–1328 (2002)
50. Korndorffer, J.R., Dunne, J.B., Sierra, R., et al.: Simulator training for laparoscopic suturing using performance goals translates to the operating room. *J. Am. Coll. Surg.* **201**, 23–29 (2005)
51. Stefanidis, D., Korndorffer, J.R., Markley, S., et al.: Closing the gap in operative performance between novices and experts: does harder mean better for laparoscopic simulator training? *J. Am. Coll. Surg.* **205**, 307–313 (2007)
52. Youngblood, P.L., Srivastava, S., Curet, M., et al.: Comparison of training on two laparoscopic simulators and assessment of skills transfer to surgical performance. *J. Am. Coll. Surg.* **200**, 547–551 (2005)
53. Haluck, R.S., Marshall, R.L., Krummel, T.M., et al.: Are surgery training programs ready for virtual reality? a survey of program directors in general surgery. *J. Am. Coll. Surg.* **193**, 660–665 (2001)
54. Boyd, B.K., Olivier, J., Salameh, J.R.: Surgical residents' perception of simulation training. *Am. Surg.* **72**, 521–524 (2006)
55. Berg, D.A., Milner, R.E., Fisher, C.A., et al.: A cost-effective approach to establishing a surgical skills laboratory. *Surgery* **142**, 712–721 (2007)
56. Adrales, G.L., Chu, U.B., Witzke, D.B., et al.: Evaluating minimally invasive surgery training using low-cost mechanical simulations. *Surg. Endosc.* **17**, 580–585 (2003)
57. Bruynzeel, H., de Bruin, A.F.J., Bonjer, H.J.: Desktop simulator: key to universal training? *Surg. Endosc.* **21**, 1637–1640 (2007)
58. Jarrell, B., Nirenburg, S., McShane, M., et al.: An interactive, cognitive simulation of gastroesophageal reflux disease. *Stud. Health Technol. Inform.* **125**, 194–199 (2007)
59. Kapadia, M.R., DaRosa, D.A., MacRae, H.M., et al.: Current assessment and future directions of surgical skills laboratories. *J. Surg. Educ.* **64**, 260–265 (2007)
60. Gould, J.C.: Building a laparoscopic surgical skills training laboratory: resources and support. *JSLS* **10**, 293–296 (2006)
61. Scott, D.J., Dunnington, G.L.: The new ACS/APDS skills curriculum: moving the learning curve out of the operating room. *J. Gastrointest. Surg.* **12**, 213–221 (2008)

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