We surgeons have always had a lifelong commitment to learning. From the first day that we were dropped off at the kindergarten door until well into our retirement from clinical practice, we are constantly on a quest for new knowledge and skills. Like you, most of the procedures and techniques I perform in my surgical practice today I did not learn during my residency training program. The growth of medical knowledge and application of technological advances has occurred exponentially in the past decade. Medicine and surgery are much more complex, and our patients' expectations are much higher because of these amazing advances.

Although the Halstedian unregulated apprenticeship served training surgeons well 100 years ago, the surgical technology of the 21st century has placed increased demands on the surgical education of today. Traditional open surgery utilizes 3-dimensional visualization and tactile sensation, but this has been radically changed with the introduction of minimally invasive surgery. Basic transluminal endoscopy has resulted in monocular visualization along with reduced tactile sensation for the surgeon. Laparoscopy has further challenged the surgeon by creating a 2-dimensional working environment with fixed-site access, counterintuitive movements, and reduced tactile sensation. Although the recent introduction of robot-assisted laparoscopy has returned the 3-dimensional image and enhanced it with 12x magnification, the complete absence of tactile or haptic feedback has created yet another challenge in the learning curve of this newest form of minimally invasive surgery.

Being prepared to perform an operation no longer simply means reading the appropriate pages of a surgical atlas. The clinical environment has ceased to be an acceptable milieu for residents to develop the surgical skills required for highly complex minimally invasive surgery, due to the devastating complications that can occur in the early learning curve of these techniques. The cost of operating room time and the technical complexity of many modern procedures demand training in a repetitive fashion before clinical application. Before entering the operating room, the basic skills for open, and particularly for minimally invasive procedures, must be developed. The institution of the 80-hour work week directive for physicians in training, financial pressures to increase productivity, JACHO requirements regarding “attending” participation, and economic restraints on the number of physicians trained by a program have all combined to reduce the opportunity of the surgical resident to learn and master surgical skills in the operating room. A variety of training formats have been developed and include high-tech and low-tech means of education. While pelvic trainers can provide the necessary basic skills training for surgeons, it is usually necessary to incorporate live animal practice to more fully train in the complex surgical techniques of laparoscopy and robot-assisted laparoscopy. However, live animal surgery requires highly skilled personnel, the increased expense of the animal, inexact anatomy compared to that of the human, and then only a one-time experience with the surgical procedure. Concerns over bovine spongiform encephalopathy (mad cow disease) have actually eliminated the animal laboratory training from countries like Britain and Canada, because of possible contamination of medical personnel. Cadaveric surgical training incurs greater expense and, while providing true anatomic depiction, may not give as realistic an experience as that of living, blood-perfused tissue. It also provides only a one-time surgical experience for the trainee. All of these limitations have led to the development of the realm of surgical simulation.

Surgical simulators may be considered model-based, computer-based, or hybrid. Model-based simulation recreates isolated parts of the body. The advances in materials technology have created dramatically realistic physical simulation of various body structures. These simulators may be relatively inexpensive and can be adapted to a wide-range of disciplines in a single skills center where trainees can regularly and repetitively practice specific skills or tasks. The procedures commonly taught by these simulators include venapuncture, urinary catheterization, wound closure, and intravenous infusion. These inanimate models are unable to provide feedback or objective
measures of performance unless an educator or expert clinician is in attendance during the practice session. Computer-based simulation is more complex and accordingly more expensive and less readily available. However, computer-based simulation provides a much more impressive level of realism than model-based simulators. The most sophisticated of the computer-based simulation models are those that provide the student with a virtual reality (VR) experience. VR is a collection of technologies that allow people to interact efficiently with 3-dimensional, computerized databases in real time, using their natural senses and skills. These simulators can provide a convincing representation of the organ or system, and through complex, haptic devices nearly replicate the real clinical experience, albeit still in a cartoon-like environment. They can require both diagnostic and treatment planning by the trainee, while simultaneously providing objective measures of performance and skill. It is hypothesized, and as yet unproven, that training with this combination of features may ultimately result in the reduction of surgical errors while improving clinical outcomes. The hybrid simulators combine the 3-dimensional physical models with the computerized simulators. This provides a clinically realistic interface to connect the mannequin with the computer. Thus, the realistic feel of the instruments and human tissue can be combined with the ability of the computer to tabulate objective measures of performance and skill.

While surgical simulation is advancing quickly in the new technology development, validity testing of these devices is still needed before they are accepted as reliable educational devices. Basic face and content validity is needed to make sure that a simulator does teach what it is supposed to teach, that it represents what it is supposed to represent, and that it is an effective educational modality. The ultimate validity testing will be that of predictive validity and construct validity. True construct validity will demonstrate that the simulator can take inexperienced surgeons and give them the same skills as experienced surgeons. Accordingly, the simulator must be able to reliably allow the trainee to acquire the skills and techniques of an expert surgeon within a defined training time and program on the simulator. In other words, this would be an opportunity to enable the surgeon to safely proceed through the learning curve effect of any new procedure without placing any human at risk. As such, the simulator must be able to distinguish between the inexperienced surgeon and the experienced or expert surgeon; without corroboration of construct and predictive validity, the simulator remains a very expensive, entertaining video game. With proven validity, it becomes a powerful tool to teach, train, and test.

The new challenges of surgical education are affecting both residents and practicing surgeons. The mandated 80-hour work week invoked in July 2003 by the Accreditation Council of Graduate Medical Education and the Residency Review Committee have inspired some to suggest that sufficient time is no longer available to train highly effective and skilled surgeons, and that a whole year may have to be added to residency training programs to achieve this level of proficiency. However, to place this into perspective, although Americans work hard, averaging 43 hours of work per week, only 1 in 5 Americans works more than 50 hours per week. Work-hour limits for residents and physicians have been resonating internationally for some time. The European Union has legislated a maximum of 48 hours for all of its member countries. Also, in the global economy, it is more important what you produce rather than how hard you work. Although Americans work longer hours, our productivity is less than that of workers in France, Belgium, and Norway. It would seem reasonable to focus our efforts on making surgical education more productive, rather than defining the training program by the number of hours worked. Educational programs should strive to allow residents to engage in meaningful and beneficial activities for their educational benefit. The random opportunities of our current apprenticeship system need to be replaced by a curriculum or learning system that meets the needs of our residents and their future. Surgical simulation, whether model- or computer-based, provides a unique opportunity for repetitive skills training with the exploration of possible outcomes in a risk-free environment that can maximize the educational experience and reduce the time of training for surgeons in complex surgical techniques. However, like exercise equipment, purchase does not equate to fitness unless one takes the time to “workout.” Whether this time should be included or excluded from the 80-hour limit is an area of further discussion; for in the overall scheme, patient care must always come first.

Similarly, for practicing urologists, the technical advances are happening so quickly that it is not uncommon for surgeons 10 years from their training program to lack the skills for many of the minimally invasive surgical techniques. Indeed, for the average surgeon, who is a decade or a score beyond residency, the strong likelihood exists that less than 50% or 20% respectively, of his or her daily activities revolve around procedures learned during residency training. As such, learning how to learn surgery may well be the most important lesson we can impart to our residents during their training, for this will more than anything else equip them for the future. To this end, the
model- and simulator-based training will allow surgeons in a postgraduate educational format to learn a new set of skills that can then be combined to complete a task, which in turn can be combined to allow for the mastering of a new procedure; through repetitive practice surgeons can acquire the confidence and competency necessary to safely introduce a new procedure into their practice. This is particularly pertinent in urologic surgery where, due to a lack of high-volume cases in laparoscopic procedures such as nephrectomy, the ability to maintain skills by practice on a simulator may be very appealing, or in point, essential. Indeed, many procedures for which one is credentialed may only be performed rarely; when hospital reprivileging arises, the individual may not have performed a sufficient number of these procedures to be viewed as “competent” and thus their practice may be curtailed. Documenting proficiency on a validated simulator could well substitute for the paucity of cases. The concept of repetitive practice in an environment that provides the opportunity to fail without real life-threatening consequences suggests an enhancement of the acquisition of complex surgical skills and tasks. This is likened to the practice required to learn to play a complicated musical instrument, master a difficult dance routine, or to fly a complex airplane.

The development of centers of excellence in surgical education will provide surgeons with the opportunity to practice and maintain their surgical skills. With proper validation and integration into educational programs, these virtual reality and other training modalities will eventually transition from training tools to testing modalities. In this regard, they will become invaluable in board exams, certification processes, and recertification. At long last, chirurgie, or the “hand work” that we all do, will be evaluated for both the cognitive and manual aspects that are essential to the successful completion of all surgical procedures. Surgery will become of a higher quality and safer.

The growth of knowledge and the integration of technology into the surgical disciplines makes it harder to master a resident, to stay current as a practicing surgeon, and to provide the full range of the discipline as a residency training program. It is clear that surgical education must change and adapt to the 21st century. However, change is difficult, especially for a profession that traditionally prides itself on having been taught by following the preceding generation’s example. As surgeons, we have a passion for what we do, and we strive to make it the best. But it is time for us to take surgical education out of the realm of tradition and into the light of a planned curriculum. With diligence and proper tools, each discipline of surgery can offer its trainees a well-planned 4- or 5-year course of study in which both cognitive and manual abilities are taught and honed in a logical and then assessable manner. Surgical education requires this same passion and desire for excellence as we strive to develop these new concepts. I am confident that we will meet this challenge and that we will all strive to keep American surgical education in its preeminent position. It is progressive organizations, such as the Society of Laparoendoscopic Surgeons, that will help shape and hopefully lead us into this new frontier of “quantifiable” cognitive and manual surgical education. Tradition in all its hoary headed glory needs to take a back seat to the scientific technology of this millennium and the benefits it will bring to our students and the multitudes of people they will treat. To quote Alvin Toffler, “The illiterate of the 21st century will not be those who cannot read and write, but those who cannot learn, unlearn, and relearn.”

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