

SECTION I

Laparoscopic Skills

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1 Surgeons' Skills Training

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Adding Minimally Invasive Surgery to the Surgical Repertoire

Since the introduction of laparoscopy and thoracoscopy in small animal surgery in the mid 1970s, the main focus has been on the development of surgical techniques and equipment. Not until recently has veterinary medicine recognized the importance of skills development for surgeons who want to incorporate minimally invasive surgery (MIS) in their clinical practice.

Even for surgeons with considerable expertise in traditional open surgery, it will be readily apparent when approaching MIS that some laparoscopic skills are distinctly different from those of open surgery. The challenges and differences include the use of long instruments, which magnifies any tremor and limits tactile sensation, often referred to as haptic feedback. When the instrument movement is limited by a portal into the body cavity, the surgeon needs to handle the resulting fulcrum effect and the loss of freedom to simply alter an approaching angle. But even more important, the normal binocular vision becomes monocular; as a result, the associated depth perception is lost. Other challenges include the loss of a readily accessible bird's eye view of the entire body cavity. The advantage of magnification may be perceived as offset by a reduced field of view, and any instrument activity outside the view becomes a liability.

Understandably, a surgeon who has performed hundreds or more of any given procedure, with good success and minimal time expenditure, may initially be reluctant to take on the challenges of MIS. This may be especially conspicuous in small animal laparoscopy, in which the conventional surgical approach provides excellent and easy access to all intraabdominal organs. A budding small animal laparoscopic surgeon may meet resistance from referring veterinarians and even staff members when converting open procedures to laparoscopic because costs and surgery time, at least initially, tend to be higher. Educating the referral base, clients, and staff in the advantages of laparoscopy may alleviate but not remove the initial resistance.

The solution to minimizing the surgeon's pains of transitioning from open to laparoscopic surgery consists of pretraining. The basic laparoscopic skills of ambidexterity, optimizing instrument interaction; observing cues for depth perception; and precise, deliberate movements need to be achieved early in the skills development for the benefit of patient safety and surgeon's confidence in the operating room (OR).

Basic Laparoscopic Skills

The basic skills required for laparoscopic surgery include ambidexterity, hand–eye coordination, instrument targeting accuracy, and recognition of cues to provide a sense of depth.^{1,2}

Although these skills are used, and therefore trained, in clinical practice, the surgeon should not rely on caseload for training. The Institute of Medicine reported in “To Err Is Human” that approximately 100,000 humans die each year as a result of medical errors and that approximately 57% of these deaths are secondary to surgical mistakes.³ Despite efforts to prevent surgery-related human deaths, the cost of training one surgical resident in an OR throughout the course of his or her residency is estimated to cost nearly \$50,000.^{4,5} and this is becoming cost prohibitive for teaching institutions. In addition, medical surgery residents are now limited to working 80 hours per week,⁶ which further limits their exposure to clinical cases.

Although the number of surgical-related deaths in veterinary medicine in the United States is not known, they do occur. In addition, even though OR costs do not equal those of training a human surgical resident and we currently do not have limits on the work week of veterinary students or veterinary surgery residents, veterinary medicine has its own set of dilemmas. Veterinary training curricula are also faced with financial limitations, as well as increasing external and internal ethical concerns regarding the use of research animals for surgical training; increasing number of veterinary students being admitted to programs and subsequent decreased

exposure to laboratory and clinical cases; lack of sustainability of cadavers because of problems with availability, storage, and limited usefulness because of decay; and the drive to reduce errors made by inexperienced surgeons on actual patients.^{7,8} For these reasons, both human and veterinary educators are being compelled to develop innovative teaching methods for surgical skill instruction.

Beside the ethical and cost issues, it is likely that a training program built on practice in live patients becomes limited and inconsistent. Interestingly, we have noticed in our work that even experienced veterinary laparoscopic surgeons tend to lag in efficient use of their nondominant hands, something easily rectified by simulation training.⁹ In fact, the basic skills are most efficiently trained through simulation training.¹⁰ This has been recognized for more than a decade among medical doctors, and since 2008, laparoscopic simulation training curricula have been a requirement for surgery residency programs in the United States.¹¹ Robust evidence has been presented to demonstrate that skills developed by simulation indeed transfer into improved OR performance.¹²⁻¹⁶

Simulation Training Models

A number of simulation models have been presented and can currently be divided into three main categories: physical; virtual reality (VR); and hybrid, or augmented reality (AR), models.

Physical Simulation Models: Box Trainers

Box trainers have in common that tasks are performed using regular laparoscopic instruments in a box containing a camera, which projects onto a computer or TV screen. A number of box trainers are commercially available (Figure 1-1) and carry the advantages of being portable and highly versatile. As web cam technology has improved within recent years, homemade trainers can be a very cost-effective alternative if portability is not a requirement. An example of a homemade trainer used in the author's Veterinary Applied Laparoscopic Training (VALT) laboratory is presented in Figures 1-2 to 1-4. Homemade versions are used solely for practice and not for skills assessments.

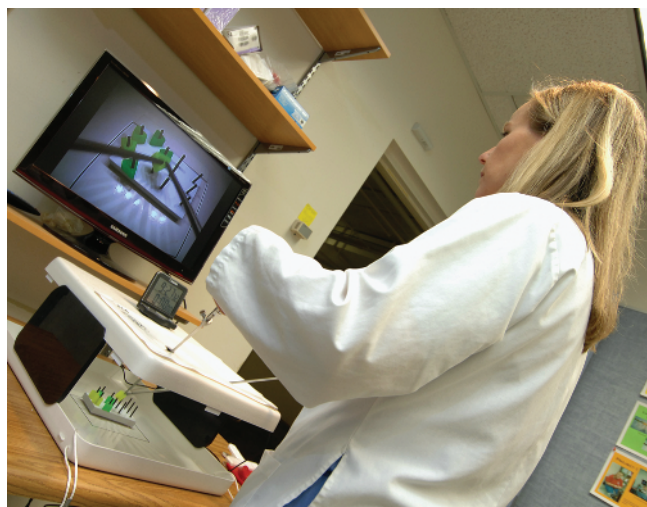


Figure 1-1 A number of laparoscopic skills training boxes are commercially available. Most are portable, and many have cameras that connect to a computer by USB connections. Some, including the official box for Fundamentals of Laparoscopic Surgery, require a TV screen. (Photo courtesy of Henry Moore, Jr., Washington State University, College of Veterinary Medicine.)

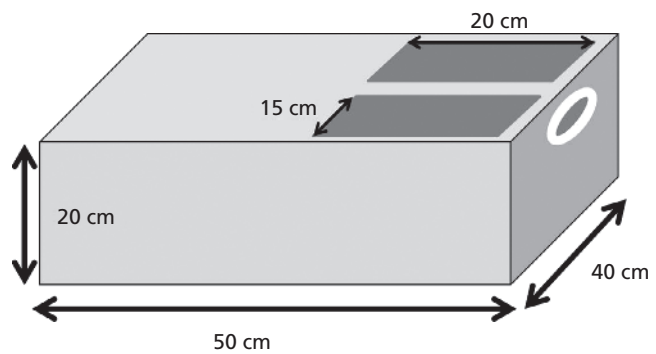


Figure 1-2 Commonly used dimensions in laparoscopic training boxes.

Box training can be considered low-fidelity simulation (i.e., less lifelike but nonetheless highly efficient training tools). A number of practice drills have been developed and validated. In the 1990s, several structured training tasks were described, including the Dr. Rosser's station tasks developed at Yale University, which are part of the popular "Top-Gun Shoot-Out" competition at national meetings for physicians. The physical training task system with the most solid validation to date is the McGill Inanimate Simulator for Training and Evaluation of Laparoscopic Skills (MISTELS).^{10,17-19} At present, MISTELS includes peg transfer, pattern cutting, ligature loop placement, and intra- and extracorporeal suturing. An additional cannulation task is currently being incorporated.²⁰

We have considerable experience of MISTELS-type training of veterinarians in our simulation training facility, the VALT laboratory

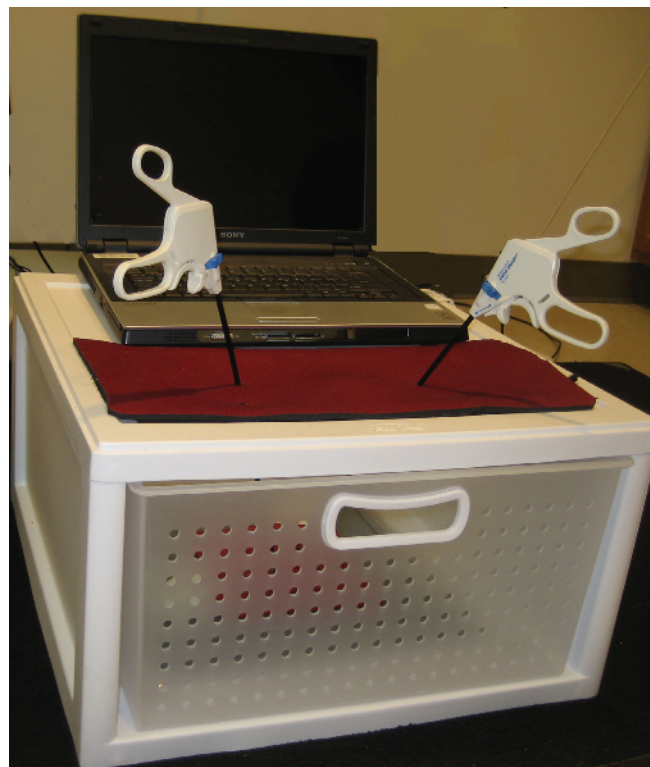


Figure 1-3 An example of a homemade training box.

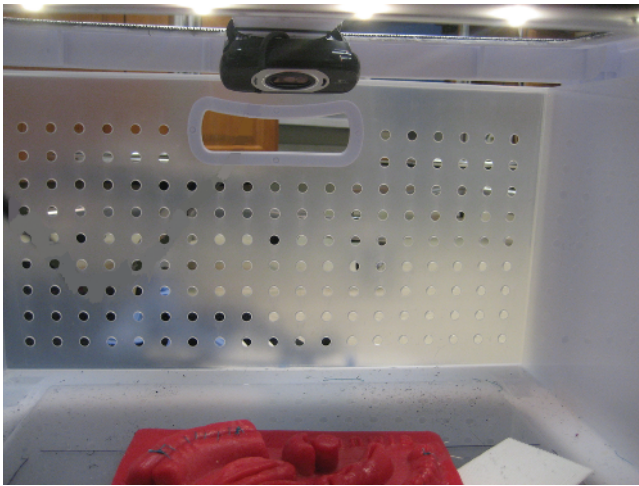


Figure 1-4 Recent advances in web cameras enable real-time imaging to a low cost.

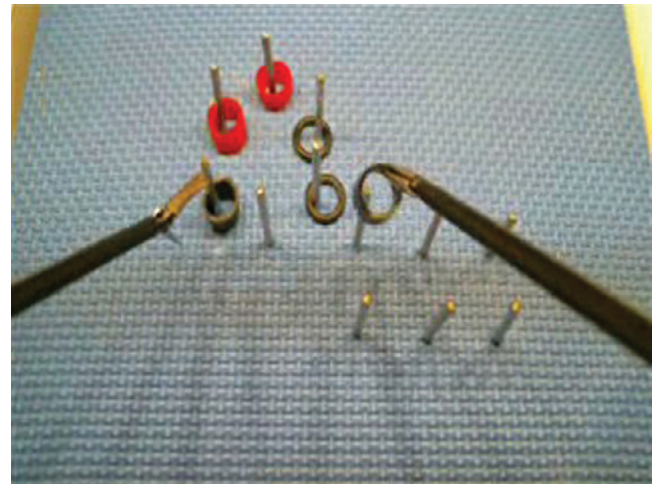


Figure 1-6 Peg transfer task. Six objects are lifted from the left-sided pegs with nondominant grasper, transferred midair to the dominant hand grasper, and then placed on a right-sided peg. The exercise is then reversed.

(Figure 1-5) at Washington State University. The adaptation of MISTELS for the VALT laboratory has been described in detail elsewhere,^{9,21} and currently, the tasks we use include:

- 1 **Pegboard transfer:** Laparoscopic grasping forceps in the non-dominant hand is used to lift each of six pegs from a pegboard, transfer them to a grasper in the dominant hand, place them on a second pegboard, and finally reverse the exercise (Figure 1-6).
- 2 **Pattern cutting:** This task involves cutting a 4-cm diameter circular pattern out of a 10 × 15-cm piece of instrument wrapping material or a gauze suspended between alligator clips (Figure 1-7).
- 3 **Ligature loop placement:** The task involves placing a ligature loop pretied with a laparoscopic slip knot over a mark placed on a foam appendix and cinching it down with a disposable-type knot pusher (Figure 1-8).



Figure 1-5 Logotype for the Veterinary Applied Laparoscopic Training laboratory at Washington State University.

4 **Extracorporeal suturing:** A simple interrupted suture using long (90-cm) suture on a taper point needle is placed through marked needle entry and exit points in a slitted Penrose drain segment. The first throw in the knot is tied extracorporeally with a slip knot and cinched down by use of a knot pusher. Thereafter, three single square throws are placed by use of laparoscopic needle holders and the suture is cut (Figure 1-9).

5 **Intracorporeal suturing:** A simple interrupted suture is placed using short (12- to 15-cm-long) suture on a taper point needle through marked needle entry and exit points in a slitted Penrose drain segment. Three throws are placed, the first being a surgeon's (double) throw, by use of laparoscopic needle holders. The exercise is completed when the suture is cut (Figure 1-10).

In addition to the MISTELS exercises, we have found important benefits in the VALT laboratory of a variety of exercises, which have been presented.⁹ We find that exercises performed in a simulated canine abdomen (Mayo Endoscopy Simulated Image, Sawbones,

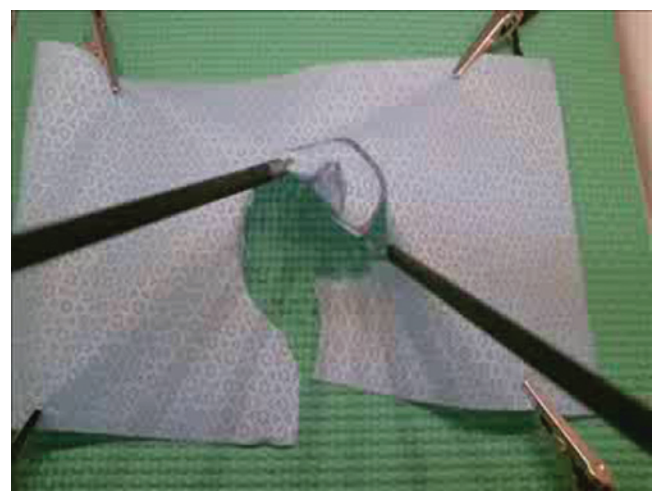


Figure 1-7 Pattern cut task. A 4-cm circle is cut, with a penalty applied if the cut is outside the mark.



Figure 1-8 Ligature loop application task.

Vashon, WA; Figure 1-11) can be helpful in practicing camera manipulation and mirroring situations (i.e., camera facing surgeon) and can help prepare the surgeon for the confines of a canine abdomen.

The one major disadvantage with box training is the lack of instant feedback. Without automated feedback, an experienced surgeon needs to be available to critique the performance of the trainee, which becomes an important limitation because of the busy schedules of most surgeons. However, proficiency goals have been defined for MISTELS such that the trainee can monitor his or her progress by simple metrics such as time and errors.²² With these goals in mind, the trainee can practice independently for the basic tasks of peg transfer, pattern cutting, and ligature loop placement. Laparoscopic suturing requires instructive sessions with an experienced surgeon. When suturing technique has been learned, the trainee can continue to practice independently to reach an expert level of performance, as defined by the proficiency goals.

Another disadvantage of box training is the current lack of veterinary high-fidelity surgery procedural models. Physical models



Figure 1-9 Extracorporeal suture task.



Figure 1-10 Intracorporeal suture task.

for cholecystectomy, appendectomy, and so on are commercially available, but they are all fairly expensive. In addition, they are all based on human anatomy and physiology and thus are less relevant for veterinary surgeons. A physical model, which can often be used only once, may not be feasible for most residency training programs if the cost is more than \$100/each. Research into construction of low-cost yet higher fidelity physical models is ongoing at our institution, which may provide increased access to veterinary procedure models in the future.

Virtual Reality Simulation

Highly realistic VR simulation (Figure 1-12) is commercially available for both basic skills as well as entire simulated surgical procedures. In fact, one of the main advantages with VR training is realistic simulation of surgical procedures, which is hard to achieve to a reasonable cost in box training. For veterinarians, this advantage is somewhat limited, though, because anatomy and surgical procedures are all based on human anatomy.

Basic task simulations give the trainee opportunity to experience a variety of surgical complications, such as bleeding, dropping clips, and reperfusion from rough tissue handling while benefiting from

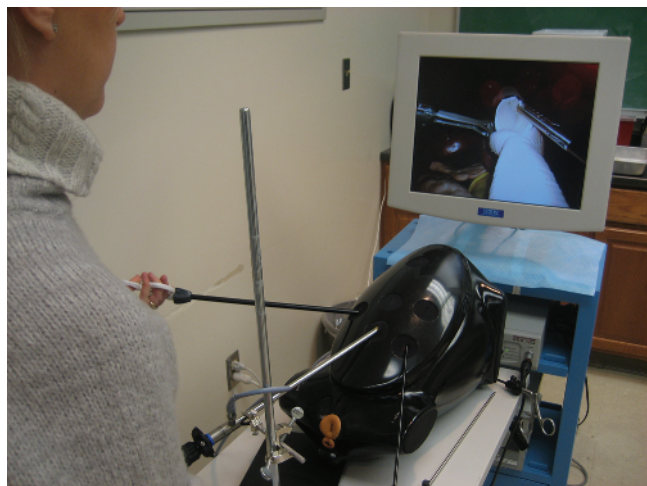


Figure 1-11 The Mayo Endoscopic Simulated Image (MESI) canine model (Sawbones, Vashon, WA) for laparoscopic and endoscopic practice.



Figure 1-12 The ProMis augmented reality trainer is a combination of a physical box trainer and a virtual reality overlay used in many surgical exercises. (Photo courtesy of CAE Healthcare, © 2014 CAE Healthcare.)

instant feedback and suggestions on how to proceed. Other advantages of VR simulation are that modules contain detailed instruction for performance of all tasks and summative feedback comparing the overall performance with an expert level. The summative performance is also broken down into a number of performance metrics, such as time, instrument path length for the dominant and non-dominant hands, and errors, giving objective information about the performance. Therefore, the provided feedback of VR gives the trainee opportunity to practice without the need for an instructor. We have found that this instant feedback also serves as motivation because most surgeons and residents have competitive personalities and enjoy the comparison with expert level.

At present, a number of VR simulators are commercially available, but they all carry the disadvantage of being expensive. For example, a haptic LapSim (Surgical Science, Minneapolis, MN) unit currently cost a little over \$90,000 (personal communication, Tony Rubin, VP, Surgical Science, Inc., September 2013), and software updates are also expensive. Another disadvantage is that, as mentioned, all VR simulation is based on human anatomy, and developing software for veterinary simulation is expensive; such models may not become available, at least not in the near future.

Because of the high cost of VR training, investigations have tried to determine if VR training can be justified by being more effective than box training. A recent systematic review through the Cochrane Institute found that VR procedural training shows some advantage over box training in operating time and performance.²³ Some controversy seems to exist: a similar review concluded that VR and box training both are valid teaching models and that both methods are recommended in surgical curricula but with no definitive superiority of VR.²⁴ Important for veterinary conditions, VR procedural training may not be superior unless it is procedure specific,²⁵ and thus it likely needs to be species specific.

Currently, the VALT laboratory group is studying the effects of incorporating VR basic skills or surgical procedural skills into the



Figure 1-13 The LapSimHaptic system virtual reality trainer is combining high-technological virtual reality exercises with haptic feedback. (© Surgical Science Inc. Reproduced with permission from Surgical Science Inc.)

physical training curriculum, and this information will be available in the near future. Preliminary data do not support that VR cholecystectomy training translates to performance on a physical cholecystectomy model.

Hybrid Training Models: Augmented Reality

Virtual reality simulation has been criticized for the lack of realistic haptic feedback²⁶; therefore, hybrid, or AR, simulators were developed that combine a live and a virtual environment. A number of AR simulators are commercially available.²⁷ To date, the most validated system is the ProMIS simulator (CAE Healthcare, Montreal, Quebec; Figure 1-13), which has been used in the VALT laboratory since 2010. Tasks are performed in a box trainer using real instruments, but a virtual interface can be placed over the image of the camera. Three cameras are used for motion tracking of the physical instruments in three planes. Therefore, objective metrics such as instrument path and economy of movement (i.e., velocity and directional changes over time, also expressed as motion smoothness) are provided. The metrics used have showed construct validity in suturing tasks and in the ability to separate expert colorectal surgeons from experienced laparoscopic, but novice colorectal, surgeons.^{28,29}

In our experience, the use of surgical instruments adds realism to the simulation, which is in agreement with a study comparing AR with VR simulation.³⁰ However, an even bigger advantage for veterinary surgery is the ability to use novel physical models for simulation. Species-specific models can be custom made and used in the ProMIS, obtaining motion metrics feedback. Until species-specific simulation in VR is developed, this will likely be the most

useful procedural simulation training device. The VALT laboratory is currently working on development of realistic simulation models made from materials of reasonable costs. Unfortunately, availability of the ProMIS simulator is currently reduced because the manufacturing company recently changed, and production is temporarily on hold.

Video Games in Laparoscopic Skills Training

Bench-top models, VR simulators, medical simulators, and robotic surgical systems have been investigated extensively in the human medical field. Although these systems have proven effective, they can be costly and time consuming to set up and maintain. Video gaming is a multi-billion dollar industry. In 2014, it was estimated that 59% of Americans play video games, with 52% of gamers being male and 42% of gamers being female. Twenty-nine percent of gamers are younger than 18 years old, 32% are 18 to 35 years old, and 39% are older than 36 years old.³¹ This surge in the availability and the creation of new video games that have motion-sensing interfaces that allow gamers to move the controllers through three dimensions have led to an increasing interest in the usability of video games to aid in surgical training. Video games are portable, do not necessitate the use of a specialized skills laboratory, are easy to set up and use, and can be used within small spaces, and no consumables are associated with their use.

Contemporary video game consoles use similar skills as laparoscopic surgery in that they improve precision and accuracy of hand movements, two-hand coordination, and conversion of three-dimensional movements to a two-dimensional screen.³² They require depth perception, timing, visual-motor dexterity, and quick reflexes.³³ Studies have shown that individuals who grew up playing video games have faster reaction times and improved performance on hand-eye coordinative tasks, spatial visualization tasks, and neuropsychological tests.^{6,34-37} Video games have also been proven to enhance visual selective attention capacity³⁷ and to increase response time to visual stimuli.³⁸ Green and Bavalier³⁷ found that gamers have improved abilities to take in peripheral detail while still focusing on the specific task at hand; this is called “flanker compatibility task.” Compared with nongamers, they also found that gamers have greater attention to detail as task difficulty increases and an increased ability to perform better at task switching and enumeration tasks. Green and Bavelier questioned if students who played video games had a natural inclination toward these skill sets or if playing video games actually increased performance. To test this, they had nongamers play video games for 1 hour per day for 10 days. Nongamers were able to improve their visuospatial task scores, thus rejecting the notion that video gamers do better because of a natural aptitude.³⁷ Last, video games have the added benefit of reducing stress among students while also being competitive and entertaining.^{8,38}

Proof of Utility of Video Games

The positive correlation of performance with laparoscopic box trainers and surgical simulators to improved operative laparoscopic performance has been demonstrated repeatedly in human medicine.^{14,22,33,39} Although hands-on training is ultimately required for complete training, video games may provide a useful precursor or adjunct to laparoscopic box trainers and surgical simulators. However, proof of the utility of video games must be demonstrated before incorporating video games into surgical training programs. Within the past decade, the human field has also published numerous studies demonstrating the positive correlation between video

game performance and laparoscopic box trainers, surgical simulators, and actual OR performance. Few studies currently exist in veterinary medicine. The following studies are just a glimpse of the benefits of using video games.

Badurdeen *et al.*⁴⁰ recruited 20 medical students and junior doctors with minimal laparoscopic surgical or video game experience. They found a positive correlation with video game scores and laparoscopic box-training skills ($r = 0.78$). In fact, participants scoring in the top tertile for video games scored 60.3% higher on laparoscopic box trainers than the bottom tertile ($P < 0.01$).

Boyle *et al.*⁴¹ recruited 22 medical students without previous laparoscopic or video game experience. Baseline laparoscopic box-training skills were obtained. Then half of the students were allocated to continue to not play video games while the other half was allocated to play for 3 hours. All participants then returned in 5 to 7 days to retest their laparoscopic skills. Those with just 3 hours of video game experience scored better than those that did not play.

Adams *et al.*⁶ obtained baseline laparoscopic simulator scores and then randomly allocated 31 surgical residents to 6 weeks of practice on a laparoscopic simulator, XBOX 360 (Microsoft Corp., Redmond, WA) or Nintendo Wii (Nintendo of America, Redmond, WA). At the end of the 6 weeks, all participants were retested on the laparoscopic simulator. Quite interestingly, participants who played the XBOX 360 or Nintendo Wii improved the most.

Grantcharov *et al.*⁴² surveyed 25 surgical residents with and without past video game experience. Those with past video game experience of varying levels made fewer errors than nonusers in the OR ($P = 0.035$).

Shane *et al.*⁴³ found that fourth-year medical students who played more than 3 hours of video games per week had improved laparoscopic simulator scores and shorter learner curves than nongamers.

Rosser *et al.*⁴⁴ found that surgeons who play video games for more than 3 hours each week were 27% faster, made 37% fewer errors, and scored 42% better overall than surgeons who had no video game exposure with laparoscopic operative skills and suturing. Current video game players were 24% faster, made 32% fewer errors, and scored 26% better overall than their nonplayer colleagues. Past and current video game skill not only increased speed but also decreased errors.

Towle Millard *et al.*⁸ published the first veterinary study correlating video game performance and laparoscopic skills. Twenty-nine third-year veterinary students volunteered to participate in the study; they all had varying levels of past video game experience. However, none of the participants had previous experience with the three test video games or the three laparoscopic box-trainer tasks. The study clearly demonstrated a positive correlation between video game proficiency and laparoscopic box-trainer proficiency ($rs = +0.40$, $P = 0.031$).⁸

Future Incorporation of Video Games Into Training Programs

The studies just discussed are just a few of the many studies that demonstrate the positive correlation between past and current video game experience and improved scores on laparoscopic box trainers, laparoscopic surgical simulators, and laparoscopic operative performance. Additional veterinary studies are needed, but one could surmise that the results will likely be similar to those in the human medical field. Now that the link has been made, educators can explore methods to incorporate video games into helping students discover natural aptitudes and advancing surgical training before they enter the OR.

Kennedy *et al.*³⁶ recently proposed that video games may be useful for identifying and assessing natural aptitudes. Studies have been conducted on high school students, medical students, medical surgery residents, and veterinary students. Video games may be a method to help direct students into discovering hidden talents and help direct them to future career paths. Towle Millard and Freeman⁴⁵ surveyed 68 third-year veterinary students. They found that the 38 students with a higher interest in surgery had higher video game scores ($P = 0.023$) than the 30 students with a higher interest in internal medicine. Interestingly, Fanning *et al.*⁴⁶ found that teenagers with video gaming experience performed better on laparoscopy simulators than medical surgery residents with no gaming experience. Kennedy *et al.*³⁶ found that medical students who average 7 hours of video gaming per week had better psychomotor skills than those who did not play regularly. Shane *et al.*⁴³ found that medical students and first-year surgery residents with previous and current video gaming experience took fewer trials to gain proficiency on a laparoscopic simulator than did nongamers. Badurdeen *et al.*⁴⁰ suggested that the surgical residents who perform better on video games could be viewed more positively when selecting suitable surgery candidates to advance to laparoscopic training programs.

Besides helping identify promising young students and incorporating video games into training programs before entering the OR, video games may also be used as a “warm-up” method before starting surgeries to decrease the number of OR complications. Gallagher *et al.*⁴⁷ and Gallagher and Satava⁴⁸ demonstrated that 15 to 20 minutes of warm-up with simulators resulted in fewer OR errors in both fresh and fatigued surgeons. Rosser *et al.*³⁴ demonstrated that the use of video games just before performing surgery resulted in faster surgeons who made fewer errors versus surgeons who did not warm up. Using video games as a warm-up method is just another benefit of this cost-effective, motivational, and highly available resource.

Conclusion

Medical and veterinary educators are compelled to develop innovative methods to teach surgery as they are faced with expanding curricula, more students, financial constraints, limited time, and increasing ethical concerns of inexperienced students and surgeons operating on actual patients. The traditional approach of “learning by doing” in a clinical arena is falling out of favor in both human and veterinary surgery.⁴⁹ The current social climate in human medicine is that novices should not gain their basic skills on actual patients, and this is extending to veterinary medicine as more and more veterinary owners think of their small animal pets as family members.

Although box trainers and surgical simulators are obvious training modalities, video games are an underused modality that is inexpensive and has been shown to directly correlate with box trainers, surgical simulators, and OR performance. As the technology advances, video games can be designed that directly simulate laparoscopic surgery. These modalities will not completely replicate actual OR experiences, but using them could be part of the solution of improving patient outcomes and addressing the dilemmas faced by teaching institutions.

The Optimal Training Program

Extensive amounts of research have provided comprehensive information on training program design. What follows is a brief discussion of current evidence-based information, with

comparative aspects with our experience of veterinary training in the VALT laboratory.

Ideally, training initially focuses on basic skills task training before progressing to specific surgical procedure training. More important than the type of simulation model one has access to is that the practice is deliberate.⁵⁰ Expertise is not gained by simply spending time practicing but by engaging in a specific type of practice. The concept of deliberate practice⁵⁰ outlines the critical elements of optimal learning, that is, tasks with (1) well-defined goals, (2) motivation to learn, (3) feedback, and (4) opportunities for repetition and refinement.

Tasks and Goals

Training tasks can be selected based on construct validity (i.e., tasks in which performance has been demonstrated to correlate with higher skill levels). However, face value is also important (i.e., experienced surgeons confirming that a training task is using the same skill sets as those required in clinical practice). All tasks need to be demonstrated clearly and effectively for superior learning. Ideally, trainees have unlimited access to high-quality video tutorials and demonstrations, complementing and significantly decreasing the need for expert instructor involvement.⁵¹

Training goals in form of performance targets are generally accepted as superior to time-based training because individuals may differ considerably in how fast the target is reached. For MISTELS-based training, performance goals have been clearly defined.²² For other practice tasks, speed, accuracy, or even motion metrics have shown severe limitations, and appropriate training goals for trainees at different levels of training remain work in progress.⁵¹ A training study in the VALT laboratory failed to document advantages of proficiency goals compared with time control,⁹ and this observation has also been made by others.⁵² Perhaps as the medical field learns more about simulation training, we will become increasingly successful in setting appropriate goals. Despite our experiences in the VALT laboratory, we consider proficiency goals valuable because we have noted that training goals appear to add motivation to practice.

Motivation

Internal motivation is a prerequisite for learning but cannot be relied on as the sole driving source for a successful training program. Surgical residents and practicing surgeons are affected by long working hours, limited free time, and seemingly endless clinical responsibilities. Not surprisingly, studies on voluntary participation of skills training in a busy residency showed the participation rate as between 6% and 14%.^{53,54} These studies showed that providing dedicated regular time for mandatory training, known ahead of time to trainees and their faculty, greatly improved participation. For a laboratory with limited resources, this may be hard to accomplish. In the VALT laboratory, we have had success with mandatory training sessions but with timing flexibility through an online sign-up policy, so each trainee can choose the time that works best for him or her without affecting the clinic or crowding the laboratory. The importance of dedicated laboratory personnel, keeping track of the trainees' sessions, and the commitment from faculty in supporting the training cannot be stressed enough. In addition, external motivation can be gained from training feedback and scheduled skills assessments. Further external motivation may be gained by performance requirements on simulators before OR participation,⁵¹ but we have not yet felt a need for that at the VALT laboratory. Importantly, we have found an inverse relationship between

motivation for simulation training and clinical experience,⁹ underscoring the importance of initiating simulation training early in a laparoscopic surgeon's career.

Feedback

Regular feedback during simulation training is not only a tool for motivation but is also essential for skills acquisition and retention. As already discussed, motion metrics serve as instant feedback during VR training and are likely one of the most important advantages to that type of simulation training. However, verbal feedback from experts has been shown more effective than motion metrics.⁵⁵ Specific and individualized feedback and subsequent training tailored to address that feedback have recently been shown to greatly improve OR performance.⁵⁶

Opportunity to Practice

Currently, the opportunity for simulation training is severely limited for veterinary surgeons and residents. Hopefully, veterinary surgery will show a similar development to that occurring over the past decade among MD surgeons. In 2006, only 55% of residency programs had training laboratories,⁵⁷ but by 2008, such laboratories became a requirement.¹¹ Currently, the VALT laboratory offers training for external DVMs, but ideally, residents should have easy access to simulation training at their home institutions and practices. This preference is based on the fact that distributed practice leads to better skills acquisition compared with intense extended practice.⁵¹ The optimal distribution is presently considered to be 1-hour sessions with a maximum of two sessions per day interspersed by a rest period, allowing the brain the opportunity to internalize the learning.⁵⁸ Approximately 10 hours of practice has been demonstrated to lead to fundamentals of laparoscopic surgery (FLS) competency,²² but mastery within any given field requires approximately 10,000 hours of deliberate practice.⁵⁸ Skill decay will ensue after rigorous training, but with ongoing practice in small amounts at 6-months intervals, performance has been shown to be maintained at a high level.⁵⁸

Self-training

Most veterinarians in practice do not and will not have easy access to simulation training curricula. Fortunately, MISTELS type exercises lend themselves well to self-study because there are well-defined training goals that are easy to monitor. Self-study guidelines based on performance time have been demonstrated, showing that reliable achievement of 53-s peg transfer, 50-s pattern cut, 87-s ligature loop, 99-s extracorporeal suturing, and 96-s intracorporeal suturing times are associated with an 84% chance of passing the FLS test,⁵⁹ thus demonstrating basic skills competency. Laparoscopic suturing will likely require training proctored by experienced surgeons, and we encourage self-study trainees to seek instruction for those exercises. Presently, there is a move to make video-tutorial training material and a manual skills test, Veterinary Assessment of Laparoscopic skills (VALS), also available for veterinarians. The VALS program is based on the rigorously validated MISTELS program for training and assessment of skills. The goal is to create a readily available training program for all veterinary surgeons, leading to improved OR performance. A 5-week systematic video game training program showed a positive impact on subsequent performance on complex surgical simulator tasks.⁶⁰ Such a rigorous video gaming program could be readily available to surgeons, and if routinely incorporated into VALS, constitute an inexpensive precursor or concurrent training modality.

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