Title
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Journal
JSLS Journal of the Society of Laparoscopic & Robotic Surgeons, 8(2)

ISSN
1086-8089

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Publication Date
2004

CASE REPORT JSLS

Training and Assessment of Laparoscopic Skills

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ABSTRACT

Laparoscopic surgery is gaining popularity among the surgical community. While its prevalence expands, the need for reliable training and assessment tools is becoming increasingly important. Laparoscopic skills are not an innate behavior, nor can they be easily mimicked, and can only be acquired through hands-on training. A consensus exists among physicians that establishment and evaluation of technical skill in surgical training programs are inadequate and in need of improvement. A validated, reliable bench model that could train and assess could be standardized and provide numerous benefits including determination of which medical students should consider a career in surgery, valuable feedback to residents, a tracking mechanism of resident performance, a possible certification and recertification tool, and to allow for interinstitutional comparison. To this end, several potentially successful bench models testing dexterity, hand-eye coordination, and depth perception have been developed. A few models have been proven to be both valid and reliable indicators of technical skill. Although the future remains uncertain, enough groundwork has been laid to begin incorporating technical skill training and assessment into surgical training programs.

Key Words: Laparoscopy, Training, Assessment.

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BACKGROUND

Laparoscopic skill acquisition is an area of increasing interest. Not only is the prevalence of laparoscopic surgery due to its minimally invasive nature expanding but expanding also are the questions and concerns regarding necessary preparation for the next generation of surgeons. In general, the current evaluation techniques of technical skill are considered inadequate and in need of development. In most training programs, resident performance is judged by subjective faculty evaluations, which can be unreliable, and standardized tests, which only assess one aspect of clinical competence, namely knowledge base.[1-11] Physicians believe the current evaluations are lacking with regards to technical skill assessment.[3,5] Also a push is underway for improvement in the establishment of technical skill.[5] It is generally agreed that cognitive factors, innate dexterity, and personality are of prime importance in gauging a resident, and currently all lack reliable assessment modalities.[11] In addition, innate dexterity is believed to be the strongest contributor in the level of technical skill that could be attained with training and experience.[11] Despite the hype to improve technical skill assessment, it is agreed that an objective evaluation of technical skill should not replace, but should augment, the current subjective and cognitive tests used in evaluating a resident.[11] The above concerns point towards the necessity for improvements in technical skill acquisition and the objective assessment skills acquired.

DATABASE

Laparoscopic surgery has quickly become commonplace in general surgery and is often preferred over open surgery due to the benefits as seen by the patient: fewer complications, less pain, and quicker recovery. The skills required in laparoscopic surgery need to be acquired by hands-on training and are poorly learned from mimicry of a master surgeon or analysis of a written text due to their uniquely difficult and nonintuitive nature.[12-17] Laparoscopy is different from open surgery in that it is performed using long instruments, which can amplify tremor, inserted through a number of ports or openings made in the skin. Laparoscopy requires ambidexterity, manipulation from a 2-dimensional magnified image whose visual axis is often not aligned with the motor axes, working around the kinematic restrictions imposed by the instruments, and working with minimal tactile feedback.[4,7]

While the use of the operating room for skill acquisition and assessment seems ideal, difficulty standardizing operations, cost of the operative minute, and public expectations and awareness of the purpose of the operating room limit it as a viable option.[3] Animals are another venue for training and assessment but are costly, require highly trained personnel and are often surrounded with issues regarding appropriate use.[12,17] Cadavers are yet another avenue but can be costly and also have concerns regarding appropriate use. Many studies have proven that bench models can successfully train residents and surgeons with the skills necessary to perform laparoscopic surgery. Practice with the models allows an opportunity to increase skill, dexterity, and familiarity, all of which eventually lead to decreased operative time and complication rates.[17-21] Bench models can and have been successfully used as a training and assessment tool. Bench models are inexpensive, portable, can be used unsupervised, and can be used repeatedly providing unlimited practice.[2] Bench models have the potential if properly validated to identify residents with deficits, provide valuable feedback for further study, and possibly be used in promotional decisions. While several effective bench models are serving as trainers and objective assessors for laparoscopic skills, a standard, although desired by all, has yet to be agreed upon. Most models measure time as their primary endpoint and include points for specific errors particular to each task in the final score. While time does not correlate directly with an operative parameter, shorter times are indicative of familiarity and confidence with the instruments.[5] Models based on psychomotor performance also measure time as an endpoint but specifically measure the x, y, z, and q of each instrument along with instrument or task errors particular for each task. These psychometric data have been used more for developing and evaluating new instruments and ergonomic research than for evaluating a given resident's technical skill.[8] Instrument errors are used to catch what time alone cannot. For example, Hanna et al[7] test the movement accuracy of instrument placement for a 1-handed aiming task. An instrument is inserted through a random series of holes, and instrument error times are recorded as the amount of time the instrument is in contact with the perimeter of the hole.

While each bench model uses different techniques for training and assessment, all focus on training of dexterity, ambidexterity, depth perception, instrument to target accuracy, hand-eye coordination, and adaptation to a magnified, 2-dimensional field. Most models focus on specific drills that mimic movements required in suturing. Handling of a length of rope, transferring of objects from one location to another, and picking up round objects and dropping them in a small opening produce movements that are closely correlated with suturing.[4] Many models focus on these and other tasks that train depth perception and manipulation of objects in the 2-dimensional field: placing hollow objects on a pegboard, passing a rope from 1 instrument to another along its length (rope pass), use of the nondominant hand to pick up and drop an object in a target hole (cup drop), and transferring objects between locations are all examples of this.[4,5,12-17] Some tasks are more operative in nature and practice placement and attachment of clips, pattern cutting, and mesh placement, and suturing/knot-tying.[2,4,12-17,19-21] Indeed, Chung and Sackier[17] identified that needle positioning was the most difficult and time-consuming maneuver in laparoscopic suturing and hence should be included if not the focus in laparoscopic training. Hanna et al[7-9] take a different approach and examine the psychomotor performance of 1-handed aiming and force production, and 2-handed task completion. Using their bench model, Hanna et al[7] were able to identify subjects that were not able to adjust to the 2-dimensional virtual field and hence incapable of performing laparoscopic procedures. Such a test could be used to screen prospective candidates for a surgical residency. Not attempting to mimic operative skills, they work with tasks, such as moving sliders, rotating dials, toggling switches, and positioning of a joystick, all of which are placed inside of a closed box with a spring lid. The nondominant hand holds the lid open while the dominant hand completes the different tasks. This is meant to simulate the grasping of tissue with the passive instrument while completing the task with the active instrument. Interestingly, few problem-solving exercises test the decision-making skills of residents in an operative situation.

Researchers have proven that bench models are indeed useful as training and evaluation tools. Heniford and colleagues[22] showed that surgeons gain more from hands-on experience than from pure course work. Mori and colleagues[19] support this, showing that hands-on training is an especially effective format for training of laparoscopic skills in which 2-handed coordination is required. Their group showed that needle mounting and knot tying improved steadily with hands-on training. Rosser and colleagues[5] showed that laparoscopic bench models can teach relevant laparoscopic skills regardless of prior surgical experience, sex, or age. They also demonstrate in their study that resident performance was roughly equal to that of trained, experienced open surgeons. Scott and colleagues[16] asked the questions: Who benefits the most from training and how much training is enough? Several studies[6,13,18] have investigated the learning curve and found that improvement is seen after 7 trials, but no plateau is reached, and a plateau could be reached after 10 to 15 repetitions using robotic surgical instruments. Scott et al[16] answer their own question by showing that the inexperienced benefit the most from the training and that at least 30 to 35 repetitions are required for maximal benefit. As stated previously, bench models have been successful in identifying individuals who are unable to adapt to the laparoscopic environment, which was a question raised by more than a few.[3-7,9] Surprisingly, no significant difference was found between 2-dimensional and 3-dimensional imaging modalities when endoscopic suturing was performed.[22] It is plausible that the current 3-dimensional systems are not yet perfected and still cause the user excessive visual strain.

Bench models are wonderful training tools to practice with, but can they be used as assessment tools as well? For any test to be used with confidence, it must be feasible, cost-effective, valid, and reliable.[3,7] Validity ensures that the test is measuring what it is designed to measure, and in the case of laparoscopic surgical training, this is the measurement of technical skill. A valid test should successfully differentiate between inexperienced residents and highly proficient master surgeons. Many of the models claim face validity because they are modeled after fundamental laparoscopic procedures and often use the identical tools, instruments, and vision systems seen in the operating room.[13,24,25] Reliability refers to the precision of a test and its ability to consistently measure from one test to the next. The Advanced Dundee Endoscopic Psychomotor Tester (ADEPT) has been proven both a valid and reliable system of bimanual endoscopic task performance.[8,25] Its predecessor, DEPT, has also been proven reliable for objective assessment of single-handed endoscopic performance.[7] Derossis and colleagues,[13] utilizing the McGill Inanimate System for Training and Evaluation of Laparoscopic Skills (MISTELS) program, demonstrated construct validity by measuring significant improvement in performance with increasing training.

Bench models have been proven to produce significant improvements among trainees when trainees are assessed on the models, but what about actual transfer to operative performance? Anastakis and colleagues[2] showed that bench models and cadaver models were equivalent when performance was evaluated on a cadaver model. Reznick and group[3] showed equivalent psychometric performance between live animal platform and bench model simulations. The Fried and Derossis research team[14] verified this, concluding that performance in an in vitro laparoscopic simulator correlated significantly with performance in an in vivo animal model. Performance on the bench model has yet to be closely correlated with actual clinical performance in the operating room due to obvious difficulties in standardization of procedures, but the guess can safely be made that bench model performance is an excellent predictor of technical skill.

It is overwhelmingly agreed that standardization of bench model testing should become a reality. Both the public and surgical communities are concerned with effective training and evaluation of ability.[3,11,17,24] The airline industry also relies on technical performance and requires training pilots to master drills in realistic simulators before taking flight in actual planes. Some wonder why it should be different for those practicing to become surgeons.[3,13] Once verified as valid and reliable, not only can bench models be used for practice, training, and objective assessment, but their role in final certification, revalidation, and institutional comparisons becomes possible. Model results could be used to follow the progress of residents during training providing valuable feedback and setting expectations for surgical residents. The model could also play a part in an exit clinical examination.[11] Although physicians have agreed that revalidation or competence checks are needed, only the goals of revalidation, not an actual mechanism, have been established. The 4 goals of revalidation decided upon are improve patient care, set standards for the practice of medicine, encourage continued medical education, and reassure patients that doctors remain competent throughout their careers.[11] A consensus on a standard measure of clinical competence has yet to be agreed upon.

As a note to the not too distant future, laparoscopic robotic surgery is a safe and effective alternative to conventional laparoscopic surgery.[18] The da Vinci Robotic System restores hand-eye coordination by returning to a more intuitive approach and restores a 3-dimensional view. In addition, the system is capable of motion scaling, tremor elimination, field magnification, and allows surgeon-control over the camera. Although no training or assessment regimes have been tested using this robotic technology, one wonders if the robot, which could be made to automatically record psychometric parameters, could be used to both train and assess future surgeons.

CONCLUSION

Until the advent of the "information age" and the perfection of camera technology, the actions of the open surgeon could neither be quantitated nor judged. Today, with many procedures being performed "on camera," all instrument activity can be recorded and stored. In addition, the advent of robotic surgery provides another dimension allowing for more precise and ongoing evaluation of the movement of the surgeon's instruments. Accordingly, we are only now at a point in time where "raw" surgeon skill can now be accurately assessed; the next step is to move from the measurement itself to constructing valid and reliable testing parameters. The integration of these tests into the surgical realm is essential to provide a means for selection, certification, and postgraduate examination of the functional aspects of each surgeon's skills. The third and final step is to develop tests that combine both cognitive and practical skills in the form of virtual reality simulators providing surgical situations in which the interplay of judgment and function are essential to achieve a successful result. The creation of these testing apparatuses is essential to ensuring the safety and competence of surgeons, present and future. With these developments, the entire practice of surgery will be brought out of the subjective, apprenticeship system that has been its hallmark since the Middle Ages and into a more objective, measurable, and reproducible system to the benefit of both patient and surgeon alike.

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