TRAINING IN LAPAROSCOPIC SURGERY

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Abstract: *A structured training to teach and train laparoscopic skills lacks across continents. Halstead's approach "See one, do one, teach one" is not very effective for training laparoscopic surgery because a different set of skills are required. A preclinical teaching in the skills laboratory can help trainee to learn these basic skills. There are many methods of training available but the best method is not yet established. Training on animal organs integrated in to a special trainer provides a realistic view and the surgeon can practice repeatedly and obtain the training effect in a short time. All academic training institutes/hospitals should develop a surgical skills laboratory for training of residents in surgery.*
Key words: *Laparoscopic surgery, Residents training, Skills laboratory, Phantom trainer, Animal organs*

INTRODUCTION

Although laparoscopic surgery is being practised worldwide for the last 17 years, yet the opportunities for a structured training to teach and train laparoscopic skills lack across continents. The available training opportunities are deficient in developing levels of skill for safe performance of laparoscopic surgery since the training modules do not match the operating room scenario. Training in laparoscopic skills needs focus[1].

Training surgeons is an arduous and difficult task. With the widespread use of minimally invasive surgery this aspect has become even more demanding. Tactile based maneuvers that were performed with fingers and hands in direct contact with tissues are now performed at a considerable distance from them. Generations of surgeons have been trained in conventional surgery according to Halstead's concept of, "See one, do one, teach one" approach. This approach is not very effective for training of the laparoscopic surgeon because the assistant cannot easily mimic the movements of the surgeon and a different set of skills are required for safe performance of laparoscopic surgery[2,3,4].

The specific skills required for performing minimally invasive surgery include depth perception, translation of three-dimensional image into a 2D environment, loss of tactile sensation, hand-eye coordination, limited degrees of freedom, working with long instruments and the fulcrum effect of the long instruments. Until and unless the trainee has learnt these basic skills, it is not safe for him to perform laparoscopic surgery[5,6].

ACQUISITION OF LAPAROSCOPIC SKILLS

Surgical competence has two major components. The first one is cognitive competence, which requires cognitions mainly based on surgical, anatomical, and medical knowledge. The second one is technical skill in surgery, which is the result of a person's ability to perform a specific surgical task. There are numerous theories that explain the acquisition of technical skill. They emphasize the importance of modeling, repetitive practice, and formative feedback[7].

Fitts and Posner's three-stage theory of motor skill acquisition is the most accepted[8] (Table1). The three stages are cognitive stage, the integrative stage and the autonomous stage (Table2). In the cognitive stage, the learner intellectualizes the task; performance is erratic, and the procedure is carried out in distinct steps. For example, with a surgical skill such as tying a knot, in the cognitive stage the learner must understand the mechanics of the skill - how to hold the tie, how to place the throws, and how to move the hands. With practice, the learner reaches the integrative stage, in which knowledge is translated into appropriate motor behavior. The learner is still thinking about how to move the hands and hold the tie but is able to execute the task more fluidly, with fewer interruptions. In the autonomous stage, practice gradually results in smooth performance. The learner no longer needs to think about how to execute this particular task and can concentrate on other aspects of the procedure.

This model has obvious implications for surgical training. The earlier stages of teaching technical skills can take place outside the operating room; and with practice the skill can be mastered upto a point where the task is performed automatically. This allows the trainees to focus on more complex issues, both technical and nontechnical, in the operation theatre. To return to the example of knot tying, the learner who still new has to think about how to tie a square knot is much less likely to pick up on other teaching that occurs in the operating room than is the learner who has mastered this skill.

METHODS OF TRAINING FOR LAPAROSCOPIC SURGEY

Various methods of training for laparoscopic surgery which are available include; training on live animals, training on phantom models using animal organs, box trainers and computer simulation. The best method of training, however, has not yet been well established. Table 1 outlines the advantages and disadvantages of various training techniques.

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Table 1. Fitts–Posner Three-Stage Theory of Motor Skill Acquisition.*

Stage	Goal	Activity	Performance
Cognition	Understand the task	Explanation, demonstration	Erratic, distinct steps
Integration	Comprehend and perform mechanics	Deliberate practice, feedback	More fluid, fewer interruptions
Automation	Perform the task with speed, efficiency and precision	Continuous, fluid,adaptive	Automated performance requiring little cognitive input, focus on refining performance

*Adapted from Fitts and Posner [9]

Table 2. Advantages and disadvantages of various training techniques [8]

Simulation	Advantages	Disadvantages	Best Use
Bench models	Cheap, portable, reusable minimal risks	Acceptance by trainees; low fidelity basic tasks, not operations	Basic skills for novice learners, discrete skills
Live animals	High fidelity, availability, can practice hemostasis and, entire operations	Cost, special facilities and personnel required, ethical concerns, single use, anatomical differences	Advanced procedural knowledge, procedures in which blood flow is important, dissection skills
Cadavers	High fidelity, only "true" anatomy simulator currently, can practice entire operations	Cost, availability, single use, compliance of tissue, infection risk	Advanced procedural knowledge, dissection, continuing medical education Human performance
Simulators	Reusable, high fidelity, data capture, interactivity	Cost, maintenance, and downtime; limited "technical" applications	Team training, crisis management
Virtual reality surgical simulators	Reusable, data capture, minimal setup time	Cost, maintenance, and downtime; acceptance by trainees; three dimensions not well simulated	Basic laparoscopic skills, endoscopic and transcutaneous procedural skills

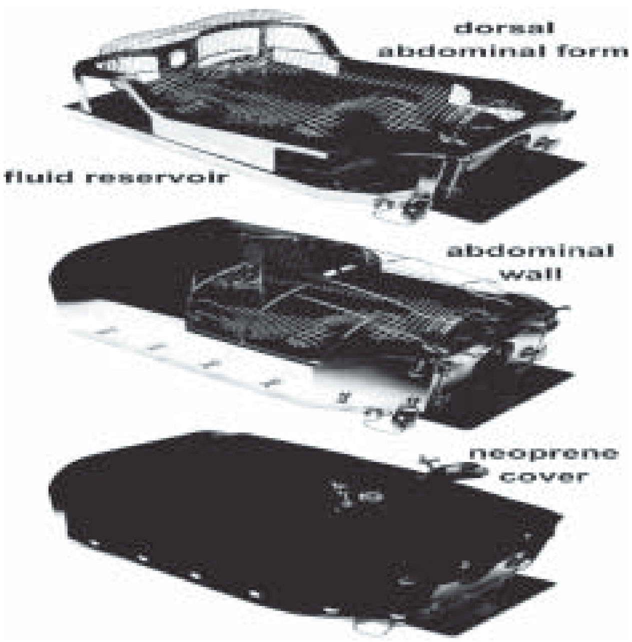

Figure 1. Tuebingen MIC Trainer

ANIMAL MODELS

Although training using live animals, such as pigs or dogs, has been performed for many years, it has become difficult in recent years due to restrictive legislation, public concern about the use of animals for training, and economic reasons[10,11]. Professor Buess and his colleagues at the University of Tuebingen, Germany have developed a special trainer for providing training in both basic and advanced laparoscopic surgery. More than 3000 surgeons have been trained in this centre at Tuebingen and recently they have set up similar centers in Havana, Cuba and AIIMS, New Delhi, India[12].

The Tuebingen MIC-Trainer was developed in cooperation with Richard Wolf GmbH (Knittlingen, Germany)[13]. This trainer consists of four parts: fluid reservoir, dorsal abdominal form, abdominal wall and neoprene cover (Figure 1). The form of this trainer was copied from a human body with gas insufflation; abdominal organs from the slaughterhouse can be integrated into this trainer (Figure 2). Surgeons can repeat operations such as laparoscopic cholecystectomy, appendectomy, fundoplication, colon resection and transanal endoscopic microsurgery (TEMS) in a realistic way and acquire a training effect in a short time[14].

The phantom trainer using animal organs has the following advantages[15]:

1. The cost of the phantom is comparatively low
2. Tissues from the slaughterhouse are inexpensive
3. No anesthesia is necessary
4. Normal laparoscopic instruments are used
5. Quick preparation of the training model
6. More realistic anatomy

Since a training center using phantoms does not need to be an operating room, the cost of establishing a training center is relatively low compared to a training system using live animals. Actually, the training center in Tuebingen and the training

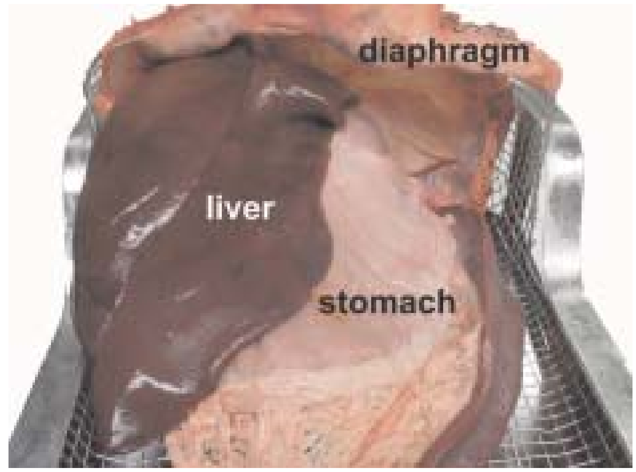

Figure 2. Animal organs integrated in the Tuebingen MIC Trainer

center in Havana, Cuba, and New Delhi, India are normal rooms. Since real internal organs are used, a participant can feel force feedback and dissection planes similar to those in human laparoscopic procedures. The most important advantage is that surgeons can practice repeatedly since it is possible to exchange the organs in the phantom[15]. They can obtain the training effect of surgical procedures in a short time.

The differences between this trainer and a real patient are as follows. There is no blood loss in this trainer. Although the perfusion system can be used for training for Trans anal endoscopic microsurgery (TEMS) and colorectal resection, the bleeding is not realistic. Using this system, large vessels show a quite natural bleeding situation, but there is no bleeding from the bowel wall or the mucosal layer itself. Pneumoperitoneum is not required. The form and the size of organs differ from that of patient. Although the anatomical position of organs can be adjusted, it is not completely equivalent to human anatomy. Since organs are not connected with other structures, the circumference organs next to an object do not exist[16].

Cadavers

The advantages of a cadaveric model include, easy availability and less cost of establishing such training centre. Unembalmed cadavers give a real feel of the anatomy. Moreover the same body can be used for other field of surgical training such as sinus endoscopy, temporal bone surgery, micro neurosurgery and arthroscopy[17]. The disadvantage of this training module is less availability of cadavers, no bleeding. This model teaches residents specific training in the handling and manipulation of tissue as well as practice in surgical techniques for adnexal surgery, pelvic dissection, laparoscopic hysterectomy, and dissection within the space of Retzius that is not possible with mechanical trainers. In a study carried out at one centre, to estimate if cadaver training program significantly and relatively rapidly taught residents laparoscopic surgical skills. 96.9% of the enrolled students expressed a general satisfaction. The cadaver surgical training program appeared to significantly improve laparoscopic surgical techniques in PGY 2 and PGY 3 obstetric/gynecology residents in a relatively short time[18].

BOX TRAINERS

The box trainers are simple inexpensive and easy method of learning laparoscopic surgery. There are various types of box trainers available.

The Mirror trainer consists of a flat working field with two upright plastic fields. Two angled mirrors facing each other on the inside of the box create an indirect vision. The inside front mirror reflects the image of the operating field onto the inside back wall mirror, which is viewed by the trainee. The front side prevents the trainee from viewing the working field directly. Laparoscopic instruments are introduced into the box through two 10mm ports in the front upright side. The mirror trainer is inexpensive and can be used anywhere; not only in the environment of a "high tech" skills laboratory but also in an office or even at home[19]. Keyser et al. [20] validated the capacity of the Mirror Trainer to discriminate between surgeons with different expertise in laparoscopy.

Pelvic trainer consists of a black box covered by an opaque rubber mat enabling introduction of trocars, instruments and a scope. The scope is connected to the camera and a light source. The image is visualized on monitor. Scope is fixed with a custom made fixator to work independently.

VIRTUAL REALITY SIMULATORS

There are two categories of simulators: physical simulators (video trainers) and computer-based simulators ('virtual reality'). Video trainers consist of a trainer box and a videoscopic imaging system. Tasks are performed within the confines of the box using actual laparoscopic surgical instruments. The metrics used to assess performance in a video trainer are relatively simple (time to complete a task, predefined errors). Computer-based simulators vary in their sophistication but generally involve the performance of a task in a 'virtual' environment. The metrics in a computer-based simulator are typically more complex (motion analysis). Computer-based simulators are significantly more expensive than video trainers. Virtual reality simulation plays a key role in training of the personnel for high-risk industries such as the military and pilots for aircraft[21]. There is a growing awareness of the potential applications of such technology to training in laparoscopic surgery[22]. In 1989, Joseph Rosen MD and Scott Delp PhD[23] from NASA built the first surgical simulator which was followed up by Dr Richard Stava and Jaron Lanier (who coined the term virtual reality)[24]. Dr. Christof Kaufmann has introduced simulators in anesthesia for training in ATLS for carrying out task such as endotracheal intubations, intravenous line access, cardiac massage, chest tube placement[25]. Simulators for laparoscopic surgery training are available from the following companies; *Immersion, Mentice, Surgical Science AB, Simbionix Ltd, Reachin Technologies AB, SeSurgical Science AB, and Lect IT VEST Systems AG.*

An effective simulator must have

1. A user friendly interface
2. Measure multiple parameters of performance and error
3. Accurately reproduce the key aspects of laparoscopic skills
4. Have added force feedback mechanisms to provide tactile sense

Simulators can provide basic skills training without supervision in a controlled environment and free of pressure of operating on real patients. This training can consist of tasks that directly relate to the operative task or that are sufficiently related to improve performance in the operation theatre (Table 3). The use of simulators also provides an objective certification/ recertification to determine the surgical skills of surgeons in practice. Simulation labs provide an opportunity to assess technical skills of the residents. Scott has reported that laparoscopic suturing training results in improved suturing in a porcine model and, that laboratory training results in improved operative performance[26,27].

Table 3 *Training task for virtual reality*

1. Acquire and place
2. Transfer and place
3. Transversal
4. Withdraw and insert
5. Diathermy
6. Manipulate and diathermy

There are various types of simulators which are available – low fidelity (realistic) to high-fidelity simulators, which vary in degree of similarity with actual clinical procedures[28]. Technical skills can be taught in the practice of part tasks, for beginners to simplify a complex procedure, of whole tasks, for those who have mastered the component skill sets. Low-fidelity tasks and part tasks are better suited to beginners. This lesson has been borne out in aviation training. Beginning pilots are more likely to learn effectively within a simple simulation training environment than to be placed in an actual cockpit to fly, where the complexity of instrumentation and the pressure to perform perfectly can be overwhelming[21]. Examples of low-fidelity laparoscopic surgery simulation include the basic skills of transferring pegs to a pegboard or simple cutting exercises within a laparoscopic trainer. These fundamental tasks orient the learner to the perceptual adaptations that must be made in the course of performing laparoscopy. Mastery in the acquisition of these basic skills has been shown to correlate with learning more complex tasks, such as laparoscopic suturing[29].

MIST VR

Low-fidelity virtual reality simulators with combined metric systems, such as the early MIST VR, are used to provide feedback to trainees during practice[30,31]. MIST-VR is a computer based virtual reality trainer designed to simulate basic laparoscopic tasks. It consists of a video monitor and a console that has instrument handles which the trainee uses to perform a virtual abstract task intended to simulate the skills needed to perform a laparoscopic surgery. This system demonstrates construct, predictive, and concurrent validity, and offers the additional advantage of providing immediate feedback of performance to the trainee subject [32, 33,34]. Research done by Jordan et al.[35] has demonstrated that training on the MIST-VR simulator leads to faster adaptation of the psychomotor issues encountered in MIS. These findings suggest that acclimatizing subjects to the fulcrum effect on the simulator results in improved performance in the operation theatre.

The MISTVR simulator provides continuous, real-time feedback to the subject during training by the use of visual cues (i.e., the task target turns red to indicate an error). Van Sickle et al[31] studied whether medical students who had received exclusively simulation-based training could perform laparoscopic suturing and knot-tying as well as senior surgery residents. Simulators were used to train 11 fourth-year medical students with no previous suturing experience to perform intracorporeal suturing and to tie a free-hand intracorporeal knot. Students' skills were assessed by the performance of the fundal suturing portion of a Nissen fundoplication in a porcine model. Their operative performance was evaluated for time, needle manipulations, and total errors. Results were compared to those of 11 senior-level surgery residents performing the same task. The study concluded that trainees could learn advanced technical skills such as laparoscopic suturing and knot tying by using simulation exclusively. The trainees and senior level surgery residents had a similar number of needle manipulations.

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

This system was developed to assess laparoscopic skills and to score them objectively and has been adapted into the SAGES Fundamentals of laparoscopic surgery (FLS) course. The simulator consists of a laparoscopic trainer box measuring 40x30x19.5cm^3 covered by an opaque membrane (USSC Laptrainer; United States Surgical Corporation, Norwalk, CT, USA). Two 12-mm trocars are placed at convenient working angles on either side of the 10-mm 0 degree telescope. Alligator clips are used to suspend materials for the exercises. The laparoscope and camera are mounted on a stand at a fixed height, distance, and working angle relative to the position of the objects being manipulated. The video monitor is placed in line with the operator. Following tasks are required to be performed; Peg transfer, Pattern cutting, Endoloop, Extracorporeal knotting and intracorporeal knotting. Various tasks have predefined cut off time and scores are assigned on the basis of performance[36,37].

Fraser et al[38] conducted a study to see the effect of MISTELS on training in non competent medical students. The non competent group consisted of medical students and surgical residents in their first 2 years of training (n= 83). The competent group consisted of chief general surgical residents in their last year of training, laparoscopy fellows, and practicing laparoscopic surgeons (n=82). They concluded that there was a significant difference in total scores and individual MISTELS task scores between the non competent and competent laparoscopic surgeons (189 vs 372.5; $p < 0.0001$) and competent surgeons can be discriminated from non competent surgeons.

CONCLUSIONS

Laparoscopy is a difficult and often frustrating task to learn and teach. There is enough evidence in the literature to suggest that training improves performance in the operation theatre. Preclinical teaching in the skills laboratory can cover part of the learning curve for laparoscopic surgery. There are many methods of training available, but the best method is not yet established. All surgical residents must be given basic training in laparoscopic surgery in the skills laboratory. Training on phantom animal organs integrated into a special trainer provides a realistic view and the surgeon can practice repeatedly and obtain the training effect in a short time.

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