Chirurgia (2011) 106: 67-76
Nr. 1, Ianuarie - Februarie

Laparoscopic surgical education - the experience of the First Surgical Unit Iași

E. Târcoveanu[1], R. Moldovanu[1], C. Bradea[1], G. Dimofte[1], C. Lupașcu[1], Șt. Georgescu[1], D. Andronic[1], J.C. Lotz[2], N. Vlad[1], A. Vasilescu[1]

[1]First Surgical Unit, "St. Spiridon" Hospital, Research Center for Open and Laparoscopic Surgery
"Gr.T. Popa" University of Medicine and Pharmacy, Iași, Romania
[2]Staffordshire Hospital, Stafford, UK

Rezumat

Trainingul în chirurgia laparoscopică - experiența Clinicii I Chirurgie Iași

Învățământul chirurgical, după principiile clasice, se desfășoară în sala de operație sub coordonarea unui chirurg cu exeperiență. De-a lungul timpului și în special după introducerea tehnicilor de chirurgie minim invazivă ca abord standard pentru multe afecțiuni, au fost dezvoltate multiple metode care să asigure însușirea cunoștințelor. Din punct de vedere al comportamentului uman, se disting trei niveluri de cunoaștere: 1) comportament uman bazat pe abilități de bază; 2) comportament bazat pe reguli; 3) comportament bazat pe cunoaștere. Abilitățile necesare chirurgiei minim-invazive sunt dificil de însușit folosind modelul clasic de învățământ chirurgical, datorită a numeroase motive: etice, medico-legale și economice. De aceea, au fost dezvoltate multiple tipuri de simulatore destinate învățământului chirurgical minim-invaziv. Actualmente, simulatoarele sunt acceptate peste tot în lume pentru trainingul tehnicilor minim-invazive asigurând îmbunătățirea performanțelor tinerilor chirurgi. Simulatoarele folosite curent asigura însă numai însușirea abilităților practice de bază și, parțial, a comportamentului bazat pe reguli. Totuși, folosirea modelelor animale ca și a viitoarelor modele de simulatoare de realitate virtuală vor oferi posibilitatea însușirii și a comportamentului bazat pe cunoaștere. Cu toate acestea nu există o curriculă general acceptată pentru trainingul în chirurgia minim-invazivă. Lucrarea prezintă experiența de peste 10 ani a Clinicii I Chirurgie Iași și evoluția diverselor metode și tehnici de antrenament. De asemenea, s-a realizat un review al literaturii despre noile concepte și probleme ale învățământului chirurgical.

Cuvinte cheie: chirurgie minim-invazivă, învățământ medical, simulatoare, training laparoscopic, realitate virtuală

Corresponding author: Eugen Târcoveanu, MD, PhD
First Surgical Unit, "St. Spiridon" Hospital
700111, Bd. Independenței No.1, Iași
Romania
Tel. / Fax: 0232 218 272
E-mail: etarco@iasi.mednet.ro

Abstract

The classic apprenticeship model for surgical training takes place into the operating theater under the strict coordination of a senior surgeon. During the time and especially after the introduction of minimally invasive techniques as gold standard treatment for many diseases, other methods were developed to successful fulfill the well known three stages of training: skill-based behavior, rule-based behavior and knowledge-based behavior. The skills needed for minimally invasive surgery aren't easily obtained using classical apprenticeship model due to ethical, medico-legal and economic considerations. In this way several types of simulators have been developed. Nowadays simulators are worldwide accepted for laparoscopic surgical training and provide formative feedback which allows an improvement of the performances of the young surgeons. The simulators currently used allow assimilating only skill based behavior and rule-based behavior. However, the training using animal models as well as new virtual reality simulators and augmented reality offer the possibility to achieve knowledge-based behavior. However it isn't a worldwide accepted laparoscopic training curriculum. We present our experience with different types of simulators and teaching methods used along the time in our surgical unit. We also performed a review of the literature data.

Key words: minimally invasive surgery, education, simulators, laparoscopic training, virtual reality

Background

Minimally invasive surgery (MIS) has some well known advantages: minimum abdominal wall trauma, better aesthetic results, rapid recovery, short hospital stay, reduced hospital costs. (1) Much more, in the countries with high prevalence rate of human immune-deficiency virus infection, MIS has other important advantages: decreased risk of per operative infection and reduced postoperative patient immunosupression. (2) However, MIS has some disadvantages: inserting tools through keyhole incisions reduces the number of degrees of freedom, haptic perception, fulcrum effect with contra-intuitive (reverse motions), operating into a three-dimensional space while interacting with a bi-dimensional video interface. (3,4) That is why MIS requires specific psychomotor and cognitive skills: accurate instrument targeting in a three-dimensional environment using a video interface, non-dominant hand dexterity, two handed dexterity, surgical technique knowledge, knowledge of the laparoscopic anatomic particularities. (3,5,6,7,8) These skills are markedly different from those used in conventional open surgery and aren't directly derivative from open surgery skills (3,5). For these reasons as well as ethical, medico-legal and economic considerations, specialized training in MIS is mandatory. (9)

Material and Method

During the last 15 years, the surgical education in the First Surgical Unit Iași, and especially the training in MIS, has been continuously changed. From the point of view of laparoscopic education, our surgical unit staff made a successful transition from learning to teaching. Along this period of time, in our surgical unit, under the coordination of different lecturers 27 postgraduate courses and workshops for laparoscopic education were run. We retrospectively reviewed the data collected from these courses.

For a better exposure and understanding, the data were managed using the human behavior model described by Rasmussen. (10) This model has been successfully applied in laparoscopic training and allows a better and easier definition of the training objectives, needs and means. (11)

According to this model, there are three levels of human behavior: (4,10,11)

- Skill based behavior (SBB) – during the normal activities different movements and instruments handlings are executed without conscious control; the achievement of skill based behavior is reflected in the correct automatic handling of the instruments. From point of view of MIS, this means a good eye-hand coordination and bi-manual dexterity.
- Rule based behavior (RBB) – as in "classical" surgical approach, the laparoscopic surgical procedures are performed respecting a sequence of steps and rules; that is why the RBB can be easily transferred from open surgery to MIS. However the RBB in MIS has some particularities (e.g. the critical view during the dissection of the gallbladder infundibulum and cystic duct). Due to these features, the classical residency program is not sufficient to achieve the RBB level and intensive training is mandatory. (4)
- Knowledge based behavior (KBB) – means the higher level of human behavior. From surgical point of view that means the possibility to solve complex and unexpected intraoperative situations (e.g. bleeding from aberrant vessels, abnormal biliary anatomy, technical problems). The achievement of KBB level means the use of different resources: lectures, attendance to live surgical procedures and commented surgical procedures, multimedia resources (internet, surgical procedures movies). We think that for a surgeon the achievement of the KBB means a continuous education during all the life.

Results

In Romania, the minimally invasive surgery era, has begun in 1992 when the first laparoscopic cholecystectomies were performed by Prof. V. Sârbu and Prof. S. Duca from Constanța and Cluj-Napoca, respectively. A few months later (March 31st, 1993), in the First Surgical Unit from Iași University of Medicine, was performed the first laparoscopic cholecystectomy from Moldavia region, by a Romanian-Belgium team. From then the laparoscopic education became a constant priority for our surgical staff.

The First Surgical Unit apprenticeship model in laparoscopic education is common for some surgical centers from the first years of the MIS and consists in the staff's skills transfer from learning to teaching. (12,13,14)

Retrospectively analysed, the laparoscopic education from our Surgical Unit could be described as a three stages process:

1. first stage (the beginning), from 1993 until 1995 – our staff acquired SBB, RBB and KBB for basic MIS procedures: cholecystectomy, appendectomy, surgical ablation of ovarian cysts;
2. the second stage, from 1996 until 1999 – characterized by continuous training of our surgical staff until the achievement of the KBB level for basic MIS procedures and training for other operations (laparoscopic treatment of the groin hernias, eso-gastric surgery, bariatric surgery) and the teaching of the residents and the surgeons from Moldova region to achieve SBB and RBB for basic MIS procedures;
3. the third stage, from 2000 until present – characterized by a continuous improvement of the surgical teams'

laparoscopic skills for different procedures, and developing a modern curricula for laparoscopic education.

First stage (1993-1995)

The laparoscopic surgery began in 1993 with knowledge and logistic support of a Franco-Belgium team (Dr. W. Cornette, Prof. C. Gouillat, Dr. M. van Baden).

The goal of this stage was to train, as soon as possible, a surgical team to achieve the KBB level for laparoscopic cholecystectomy and laparoscopic appendectomy.

The trainees from that period had some unique characteristics: they were senior surgeons highly trained in open surgery, but without any MIS experience. In fact they had no SBB and RBB but they had some RBB and KBB "imported" from their previous experience in open surgery.

The training methods were: lectures, postgraduate courses and scholarships in France and Belgium (IRCAD, Strasbourg, C.H.U. Lyon, Zaventem Hospital,), attendance to live surgical procedures performed by experts from abroad, training using a "box trainer" to achieve SBB and RBB (simple exercises for eye-hand coordination and bimanual dexterity, dissection of a porcine liver-gallbladder model), animal experiment (in fact, the first laparoscopic cholecystectomy has been performed in a live pig model).

Experts from abroad were involved to evaluate the surgical skills.

The second stage (1996-1999)

The primary goal of the second stage was to start the development of an education program in MIS to train the residents and surgeons from the hospitals from Moldavia region until the KBB level for basic laparoscopic surgical procedures (cholecystectomy, appendectomy). The secondary objective was the continuous training of the own surgical team for different other procedures (laparoscopic treatment of the perforated ulcer, eso-gastric surgery, laparoscopic treatment of inguinal hernia, bariatric surgery).

The characteristics of this period were a heterogeneous group of trainees and a team of lectures from our surgical unit already trained in MIS. There were two categories of trainees: the residents with no SBB, RBB and KBB and the surgeons from the hospitals from Moldavia region (Suceava, Onești, Bârlad, Neamț, Focșani, Galați, Buzău) who already had experience in open surgery.

The training tools consisted in lectures, attendance to live surgical procedures, commented videos during the postgraduate courses and workshops. The "box trainer" was extensively used and different tasks were designed (peg transfer, rope pass, rope cutting etc.) for the achievement of the SBB. Others important "box trainer" tasks were the exercises designed for suturing and intracorporeal knot tying. The dissection of a porcine liver-gallbladder model was also used for training and, associated with others methods (lectures, commented videos, attendance to live surgical procedures) provided the achievement of the RBB. Unfortunately, due to the financial problems, the live pig model was used only for two courses.

Experts and trainers evaluated the trainees' performances during the "box trainer" exercises. The theoretic knowledge was tested using questionnaires and multiple choice questions.

The third stage (2000 until the present days)

The primary goal of the third stage was to develop a modern curriculum for MIS education for residents in general surgery until they achieve the KBB level for basic MIS procedures. During the time we also designated other objectives for MIS education: 1) to start a selection program for the students with high surgical abilities and guide them to start residency in surgical specialties; 2) the implementation in the surgical department of a new concept – the preoperative warm-up.

The unique features of this period were the use of the ultimate methods of surgical education – virtual reality simulators and multimedia resources. The multimedia support (live transmission from operating room, commented videos, CDs and DVDs with different techniques, online internet libraries, journals and sites) is extensively used and is absolutely necessary for the achievement of RBB and especially for KBB level. (15)

The training methods used during this period consisted of lectures, attendance to the surgical procedures, commented operations (during the courses and workshops), training using VR simulators and "box trainer". Unfortunately, the live pig model wasn't anymore available.

VR simulators

MIST VR

The use of VR simulators started in 2000 using a MIST VR (Minimally Invasive Surgery Trainer - Virtual Reality) simulator. The MIST VR system was developed in the last years of the 20-th Century in order to facilitate the access to the Basic Surgical Skills Course (BSSC) imposed by The Royal College of Surgeons of England. (16) The MIST VR system consists in a hardware platform (200 MHz Pentium® PC with 64 Mb RAM and 16 Mb video-card, running a Windows NT operating system and a Virtual Laparoscopic Interface (VLI) (Immersion Inc., San Jose, CA, USA), which includes a jig with two endoscopic handles with 6 degree of freedom but without force feedback and a software which translated the instruments movements as a real-time graphical display of the instruments. The operating volume is represented as a three-dimensional cube on the computer screen. The overall image size and the sizes of the target objects (small balls and a cylinder) can be varied for different skill levels.Targets can be grasped, manipulated and coagulated according to the task design. Six tasks have been designed to simulate some of the basic manoeuvres performed during a laparoscopic cholecystectomy. The software recorded the accuracy, errors and time to completion. These data allow an objective assessment method for the trainees' performances. However the cut-off point is difficult to establish. The tasks are relatively easy to be completed, especially when factory settings is used. In this way, both trainer as well as trainees considered the MIST VR tasks as being boring. However, we tested the trainees before and after the training of MIST VR using experts and Global Rating Score (17) to evaluate the performances and we found a significant improvement of all the scores.

LapSim

We had the opportunity to use one of the most powerful system for laparoscopic education – LapSim VR Simulator. The hardware consists in a 2000 MHz processor Pentium IV computer running Windows XP, equipped with a GeForce graphic card and a 17 inches TFT monitor, and the same Virtual Laparoscopic Interface (VLI) hardware (Immersion Inc., San Jose, CA, USA) used for MIST VR. The software was LapSim Basic Skills 3.0 (Surgical Science Ltd., Göteburg, Sweden) which had a basic skill training module consisting in the following six tasks: camera navigation, instrument navigation, lifting and grasping, cutting, clip applying and suturing. The software also included an advance module which allowed the training until the RBB level for laparoscopic cholecystectomy and adnexectomy.

The software also recorded different parameters which allow an objective evaluation: time, misses, drift, trajectory and angular path of the instruments, tissue damage (total times and maximum depth), missing clips, badly placed clips, blood loss volume. The recorded Lap Sim parameters were interpreted as: higher parameters scores mean a poorer virtual laparoscopic performance and the best performance was designated as the task performed in the shortest time with lowest score from point of view of tissue damage. Our previous work showed that LapSim VR simulator can evaluate the surgeons' performances, especially the parameters of the instrument navigation and lifting and grasping modules, which require a higher degree of eye-hand coordination, but the suturing module is less influenced by surgeons' experience, result probably explained by a lack of the transfer of training and the absence of the of the force feed-back. (18)

However we'd like to emphasize that the laparoscopic cholecystectomy dissection module is very well designed, especially related to the "critical view" and allows the possibility to achieve the RBB level.

Lap Mentor

From 2008 we used Lap Mentor for VR laparoscopic training. This device is one of the most recent VR simulators on the market. The system comprises a powerful PC running Windows XP and a console which simulates a patient's abdomen with three trocars already inserted. The most important feature of the console is the force feed-back (haptic console). The software is very complex and is structured as a library with different modules. We used only the basic skills module and laparoscopic cholecystectomy module. The basic skills module includes the following tasks: camera navigation, instrument navigation, grasping, clipping, grasping and clipping, cutting, coagulation. During these tasks the instruments can be changed to choice the appropriate tool. The Lap Chole - Procedural Tasks Module is designed as a step by step tutorial focused on the key points of laparoscopic cholecystectomy. The module helps surgeons to identify the anatomic landmarks clues (and especially the critical view) associated with tissue handling. In our opinion the modules allow the achievement of the RBB level for laparoscopic cholecystectomy. The system allows a variety of clinical cases with different biliary and vascular abnormalities which, in fact, insures training until the KBB level. The software recorded a large number of kinematics parameters for assessing trainees' performances. Lap Mentor has a good construct validity providing the possibility to distinguish between subjects with varying laparoscopic experience. (19)

Box trainer

We used the box trainer (pelvitrainer) even from the beginning. It was demonstrated in different studies that box trainer allows the achievement of SBB and, using specialized models or animal models (e.g. porcine liver-gallbladder model), the achievement of the RBB for some basic surgical procedures, like laparoscopic cholecystectomy. (4,20,21) The box trainer also allows the achievement of the knots and suturing skills. Nowadays, we use a box trainer system and a training program which permit the achievement of SBB level and even the RBB level for laparoscopic cholecystectomy.

The actual box trainer consists in a laparoscopic system, a "black box" and a digital system of video recording (DELL notebook + Pinnacle USB video capture system + Pinnacle Studio software). The actual educational program consists in three modules - basic skills module, dissection module and suturing module. The training modules were designed to be completed during short practical courses to give a maximum concentration for maximum performances.

The basic skills module has the following tasks *(Fig. 1)*:

- peg drop – picking up a peg with a grasper and dropping it into a cup (alternative with dominant and non-dominant hand). There were twenty pegs to be handled.
- peg transfer – picking up a peg with a grasper then transfer in the other hand and then dropping it into a cup; there were also twenty pegs to be handled.
- peg pass – using both hands a match must be pass through 3 ringlets.
- rope pass and cutting – the task consists in running a rope and then cutting it in pieces of about 5 cm length.
- dissection and cutting – cutting a circle shape from a surgical glove.

The dissection module has the primary goal to allow the achievement of SBB level and even RBB level for laparoscopic cholecystectomy. In this way, we used a porcine liver-gallbladder model to train the traction / exposure maneuvers, the dissection of the cystic duct and artery and, the complete dissection of the cholecystectomy.

The suturing training module has three tasks: knot tying task to train the intracorporeal knots; needle pass and suturing which consists in passing a curve needle through a piece of sponge covered with natural leather which mimicked the suturing of a perforated ulcer; intracorporeal suturing consists

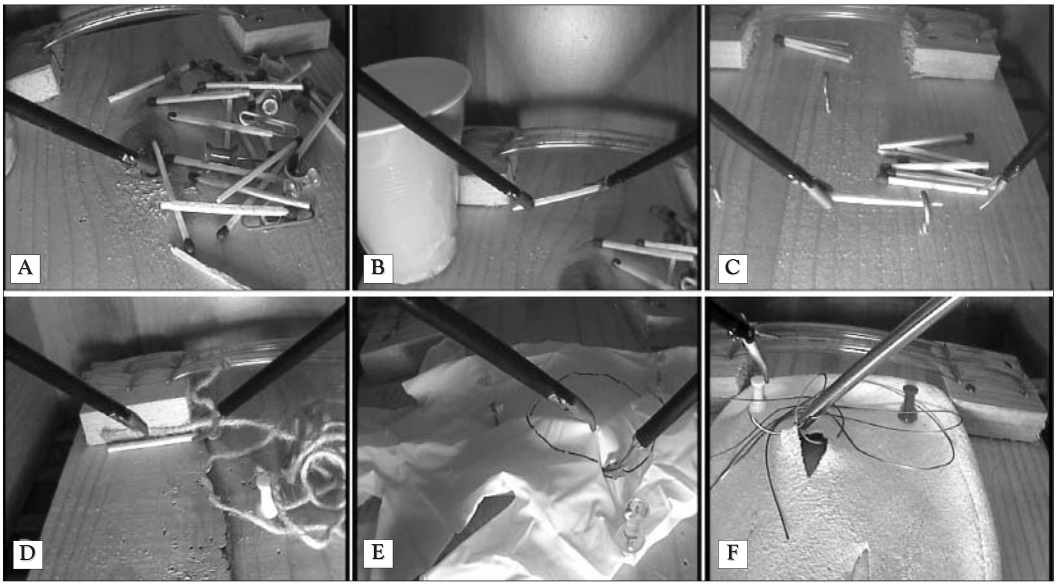

Figure 1. *Box trainer – basic skills and suturing modules.* ***A.*** *Peg drop task;* ***B.*** *Peg transfer task;* ***C.*** *Peg pass task;* ***D.*** *Rope pass and cutting;* ***E.*** *Dissection and cutting;* ***F.*** *Needle pass and suturing*

in performing a running sutures through a piece of sponge covered with natural leather.

All the trainees are tested initially, and at the end of the training program, and their performances are recorded and evaluated by the trainers using a Lykert type scale [Global Rating Score (17)] *(Fig. 2)*.

The training program

The actual education program for MIS consisted of lectures, surgical demonstrations, proctorships which are already included in the residency curriculum (from 2000). We also organized for our residents the hands-on courses to allow the achievement of the SBB and RBB level for basic MIS. The actual hands-on courses were designed as workshops with a few lectures to emphasize the key points of the surgical procedures and recorded procedures commented by experts. The trainees are initially tested using the box trainer in basic skills module; their performances are digitally recorded. The next step is the

Figure 2. *Global Rating Score used for trainees assessment*

WORKSHOP TEHNCI DE BAZĂ ÎN LAPAROSCOPIE **Date ....**
Global Rating Score
First name .... Last Name ....; age ....; student ☐ rezident ☐ consultant ☐
Group .... Round .....

	1	2	3	4	5	Score Task 1	Score Task 2	Score Task 3	Score Task 4	Sore Task 5
Respect for „tissue"	Frequent unnecessary force on tissue or caused damage by inappropriate use of instruments	→	Careful handling of tissue but occasionally caused inadvertent damage	→	Consistently handled tissue appropriately with minimal damage to tissue					
Time & Motion	Many unncessary moves	→	Efficient time / motion but some unnecessary moves	→	Clear economy of movement . Maximum efficiency					
Instrument handling	Tentative moves / inappropriate use	→	Competent use of instruments / occasionaly inappropriate	→	Fluid moves with instruments					
Depth perception	Constantly overshoots, swings wide, slow correction	→	Some overshooting but quick to correct	→	Accurately directs instruments in correct plane					
Bimanual dexterity	Uses only one hand, poor coordination between hands	→	Uses both hands but does not optimize their interaction	→	Expertly uses both hands to provide optimal exposure					
Overall impression	Novice	→	Experienced	→	Expert					
Missing targets										
Time sec										

working with simulators (MIST VR, Lap Mentor and finally, the box trainer modules with complex procedures). At the end of the hands-on course, the trainees are tested again using the same box trainer basic skills module and their performances are recorded and evaluated by the experts.

One of the latest goals of our education program in MIS is to select the students with high surgical abilities; in this way we organized three days courses for students in the last two years of study. The students are initially tested and then they work with different simulators, as in the hands-on courses for residents. Then they are tested at the end of course and the students with performances higher then the 50% cut-off value of the residents are advised to follow a surgical carrier.

The last objective was inspired from the recent works from the literature data – the preoperative warm-up. (22) We tested the efficiency of the preoperative warm-up using the LapMentor VR simulator. Partial results about this work revealed that performing simple exercises using VR simulators before the surgical procedure, even highly trained surgeons may become more prepared both in terms of psychomotor and cognitive skills. These results were recently presented. (23)

Discussions

Surgery is constantly evolved from the Ancient Age until the Computer Age. (24) During the last decades of the Industrial Age, a new approach has been developed – minimally invasive surgery. If, in the open surgery, the surgeon has a direct contact with the patient and directly visualizes the operative field, and directly manipulate the specific tools, during the minimally invasive approach the surgeon has a limited contact with the patient. He continues to directly manipulate the special designed tools, but visualize the operating field using a video bi-dimensional interface. (25) The latest technological level allowed, in the last years, the development of robotic surgery. In this surgical approach the surgeon operates and manipulates specific tools without direct contact with the patient. (24,25) In this way it could be better described by a term imported from aviation industry: surgeon operates by wire. (9)

Because surgery is a domain in which the surgeon's performance is a crucial determinant of outcome (26) a characteristic apprenticeship model has been developed along the history. This classical training model was defined and theorized by William Stewart Halsted (1852-1922) known by own trainees as "The Professor". (27) He changed the training of surgeons from a disorganized apprenticeship to the residency training programs. (27) His aphorism, "see one, do one, teach one", is probably the best description of the classical training model. (27) According to this model, the surgical training takes place into the operating theater under the coordination of a senior surgeon, "Le Grand Patron". (28) This master needed certain qualities: a well based and very broad knowledge, a strong-willed character and an imposing personality with quite good surgical performances. (28) However, his knowledge were not technological based and his performances were not fully evaluated. (28)

Due to the specific capabilities required in MIS the halstedian model of apprenticeship is no longer available. (29) These capabilities can only be gained through extensive training. (30) It was demonstrated that the specialized training for MIS is absolutely necessary to avoid or to minimize the intraoperative errors. (31,32) In this way we quoted Mr. R. Satava "Among the many attributes of simulation, one of the most important is that it permits exploration and repeated practice in a setting that fosters "permission to fail" - the opportunity to learn from owns mistakes". (33)

However, until now, is no training curriculum for MIS gained universal acceptance. To efficiently design a training program is necessary to establish the goals, the needs and the means of the training. (4,11) The goals represent the level of proficiency required (SBB, RBB or KBB). (11) The needs are defined as the difference between the initial level of competence and the required level of competence of the trainees and the means are represented by the methods of training. (11) The objectives, the needs and means of our training program have been changed over the time according to our staff experience in MIS, the evolving of the technology and the social needs. During 90' the concept of accreditation for MIS appeared in the majority of Western countries especially due to the medico-legal implication. (21,34) During that time, consultants and seniors surgeons with high experience in open surgery graduated hands-on courses which allowed the achievement of the SBB and RBB level for basic laparoscopic procedures in order to transfer the experience from open surgery in MIS. (21) Our teaching program had the same features in the first stage. During the next years, many countries and medical societies developed guidelines and training programs for MIS and some training programs for MIS were included in residency curriculum. (34,35,36,37,38,39,40,41) The constant goal of our training program, for all the trainees and especially for the residents, was to achieve the RBB and even KBB level for basic laparoscopic procedures (cholecystectomy, appendectomy, treatment of the ovarian cysts). The actual program designed for residents integrating into the residency curriculum the training in MIS because at the end of the residency, the surgeons have the accreditation for basic laparoscopic procedures. (42)

Even if this program is not covered in any official documents of the Ministry of Health or National Center for Continuous Education for Physicians and Pharmacists, we advise our residents to participate and to graduate at least two hands-on courses and workshops during the residency to achieve SBB and RBB level, as in other experiences presented in literature. We also noted during the hands-on courses and workshops the different tasks became a challenge and enhance the competence between the trainees and allow a maximum performance and proficiency. (43) The regular organization of hands-on course and workshops, solve another important problem of the residency training – the limited weekly working time at 48 hours due to the The European Working Time Directive. (28,44) Another important advantage is the laparoscopic skills improvement of our own staff. (45) Due to the complexity of the problem, we consider the term of MIS education more appropriate that MIS training, as Prof. Schiappa already stated. (28) In our opinion, the acceptance of

Rasmussen model about the human behavior, (4,10,11) allows a mathematical definition of the objectives and needs and is the first step to a standardized worldwide curriculum for MIS education. In aviation this model has been already successfully applied to pilots. (10)

There are many data in the literature about the different methods of training in MIS. The actual techniques used worldwide are: lectures, courses, live surgical demonstrations, live or recorded commented videos, online resources, hands-on courses and workshops using simulators (box trainer / pelvitrainer, VR simulators), proctorships. (4,21) The access to different resources can pose problems; even in the United States, a recent evaluation revealed that only 55% from 253 hospitals have not training facilities for MIS and 46% have not VR simulators. During the last ten years we used almost all the methods cited in literature for MIS education, from the simplest box trainer until the most performing VR simulators with haptic console and live animal experiments. Unfortunately, even though the live animal experiment is the best possibility to achieve the KBB level for different types of laparoscopic procedures (47), we used this method only in the first years. The VR simulator is a very efficient method for MIS training and easily accepted by the trainees. (4,32,33,48,49) However VR simulators have some limitations: the video simulation of the operative environment and the force feed-back. (4) Even if the computer modeling reached high performances, these aspects remain far from realistic. Along the time, both the trainees and trainers noted that the box trainer is superior to the VR simulators especially when animal models (e.g. porcine liver gallbladder model) are used. This fact is explained especially by the realistic force feed-back of the laparoscopic instruments. We demonstrated in a previous work that the lack of force feed-back is one of the most important disadvantages especially when suturing and knot tying are trained. (18) These data are in concordance with other studies from literature. (7,50,51) During the time we used different tasks for the box trainer: peg drop, peeling the grapes or chicken skin, needle pass through different materials. The actual modules consist in 6 tasks (peg drop, peg transfer, peg pass, rope pass and cutting, dissection and cutting a glove) and other three additional tasks to train the knots and sutures (knot tying, needle pass and suturing and intracorporeal suturing through a piece of sponge covered with natural leather). These exercises were designed according to other data from the literature. (6,52,53)

Munz Y et al. compared the training using VR simulators (LapSim) vs box trainer and noted that both modalities are effective means of teaching and improving basic psychomotor skills, and that these skills are transferable to a relatively complicated real task. (20) However, the authors didn't study the suturing or knot tying tasks. A promising type of simulator is augmented reality simulator which combines the realistic haptic feed-back with computer generated objects. (54) These future simulators are already tested and will offer the possibility to achieve the RBB and KBB levels.

The multimedia resources are continuously developing. Different online libraries and sites (e.g. www.websurg.com, www.sls.org) are now available and offer a real support to achieve the KBB level for different laparoscopic procedures. Other concepts as telementoring and telepresence were developed in the last years and offer unlimited possibilities of surgical education. (55,56)

Every training method is efficient in the concept of Rasmussen human behavior. In this way, we agree with Dankelman J (4) who classified the training methods according to the human behavior: 1) the achievement of SBB level using pelvitrainers and VR simulators; 2) the achievement of RBB level using courses, literature, internet resources, VR simulators; 3) the achievement of KBB level using animal experiments, some VR simulators, live surgical demonstrations.

One of the most important aspects of laparoscopic education is the evaluation of the trainees. The primary objective of the evaluation is to establish the trainees' level of proficiency after MIS education. (4) The secondary objectives are to reveal the level of proficiency of the surgeons and how this level is influence by different factors [fatigue (57), self-belief (58), psychological and social factors] and if the surgeon's accreditation for MIS is still valid. (59,60) These last goals will be more and more important due to the medico-legal implications. The process of trainees' evaluation motivated the trainees and especially the residents, and the hands-on courses and workshops become more challenging. (4) There are different assessment tools used for MIS education. VR simulators are in fact devices specialized to provide a formative feed-back and an objective evaluation of the recorded kinematics data. (6,33) Evaluation consists in accurate measurement of path length and angles as well as time and errors. The results are interpreted as follows: higher parameters scores mean a poorer virtual laparoscopic performance and the best performance was designated as the task performed in the shortest time with lowest score from point of view of tissue damage. (18) However the results and the level of proficiency are difficult to be interpreted and statistical analysis to establish the cut-off points are necessary. (61,62) The measurements of kinematics data are sufficient to evaluate the achievement of SBB level. (4) However the evaluation of the RBB level's achievement is more difficult and kinematics data are not sufficient. In this way, the VR simulators recorded and reported adjacent data as volume of blood loss, badly placed clip, billiary injuries, and tissue damage. (63,64)

Another important assessment method is the performances evaluation using global scales. One of the simplest and effective scale is Global Rating Score (GRS) (17,65) which has the advantages to be correlated with kinematics data. (62) Actually we recorded the trainees' tasks and then experts evaluated their performances using GRS. The method could be used for self evaluation to identify and to correct the errors. It could be also used as preoperative assessment tool. (17)

The KBB level is difficult to be evaluated. The theoretical data could be assessed using tests and multiple choice questions. However, the real operative possibilities to solve different unusual situations are almost impossible to be evaluated. Checklists and global score were proposed. (3) We think only evaluation of the recorded videos using experts and telementoring systems could assure an efficient evaluation.

Another important fact about the assessment methods is the number of surgical procedures to be performed during residency to become proficient. (28,30,34) This method is used in many countries as a powerful tool for MIS accreditation. Future possibilities, already used in different studies to be used to establish the training level as well as the current proficiency are assessment using electromagnetic tracking devices (66) or video tracking devices. (67) The interpretation of kinematics data associated with a global score or checklist will provide a better assessment for MIS education.

Because 8-10% from all the surgeons can't achieve laparoscopic skills (28) we also begin to develop a program to assure a selection for the students with high surgical abilities. There are the same tendencies in the literature data. (68) The warm up concept is very new and the literature data are a few. However, it was demonstrated that a 15 to 20 minutes warm-up led to a 33% overall reduction in errors on a series of exercises that simulated surgical skills. (22)

Conclusions

The training model of the First Surgical Unit evolved as a three stages process (from the learning to teaching). Along the time we used almost all the training methods world wide available, from box trainer to VR simulators, animal experiments and multimedia resources. Our experience demonstrates good results using a combination of training modules which allowed acquiring: SBB level - VR simulator (MIST VR) and box trainer; SBB level (suturing module) - box trainer; RBB – VR simulator (LapMentor, dissection module) and box trainer (liver-gallbladder porcine model); KBB level – VR simulator (LapMentor), multimedia resources, live operation.

Future goals are to reimplement the live pig model and the use of tracking motion devices for assessment of intraoperative and box trainer skills. Further studies are necessary to establish the transfer the preoperative warm-up concept in surgical practice.

Acknowledgements

The authors thank Romanian Association for Endoscopic Surgery and especially to Prof. dr. M. Beuran, Prof. dr. I. Popescu, Dr. C. Copăescu and Dr. V. Tomulescu for their help to acquire VR simulators and to VIREAL Craiova (Mr. E. Ionescu and Mr. P. Popescu) for technical support.

This study was performed by objective researchers who have no attachments with the industry.

References

1. Fuchs KH. Minimally invasive surgery. Endoscopy. 2002; 4(2): 154-159.
2. Okrainec A, Smith L, Azzie G. Surgical simulation in Africa: the feasibility and impact of a 3-day fundamentals of laparoscopic surgery course. Surg Endosc. 2009; 23(11):2493-8. Epub 2009 Apr 3.
3. Cristancho SM, Hodgson AJ, Panton ON, Meneghetti A, Warnock G, Qayumi K. Intraoperative monitoring of laparoscopic skill development based on quantitative measures. Surg Endosc. 2009;23(10):2181-90. Epub 2008 Dec 31.
4. Dankelman J. Surgical simulators design and development. W J Surg. 2008;39:149-155.
5. Andreatta PB, Woodrum DT, Birkmeyer JD, Yellamanchilli RK, Doherty GM, Gauger PG, et al. Laparoscopic skills are improved with LapMentor training: results of a randomized, double-blinded study. Ann Surg. 2006;243(6):854-60; discussion 860-3.
6. Black M, Gould JC. Measuring laparoscopic operative skill in a video trainer. Surg Endosc. 2006;20(7):1069-71. Epub 2006 May 26.
7. Figert PL, Park AE, Witzke DB, Schwartz RW. Transfer of training in aquiring laparoscopic skills. J Am Coll Surg. 2001; 193(5):533-7.
8. Târcoveanu E, Bradea C, Moldovanu R, Vasilescu A. Anatomia laparoscopică a regiunii eso-gastrice. Jurnalul de chirurgie. 2008;4(2):114-126.
9. Târcoveanu E, Moldovanu R, Bradea C, Dimofte G, Lupașcu C, Lotz JC, et al. Laparoscopic surgical training – a ten years experience. The 21-st International Conference of Society for Medical Innovation and Technology, Abstract Book; 2009. p. 80.
10. Rasmussen J. Skills, rules and knowledge; signals, signs and symbols, and other distinctions in human performance. IEEE Tran Syst Man Cybern B Cybern. 1983;13:257-266.
11. Wentink M, Stassen LP, Alwayn I, Hosman RJ, Stassen HG. Rasmussen's model of human behavior in laparoscopy training. Surg Endosc. 2003;17(8):1241-6. Epub 2003 Jun 13.
12. Furka I, Gamal EM, Mikó I, Metzger P, Sándor J, Rózsa I, et al. The history and the future of teaching and training of laparoscopic surgery in Hungary. Acta Chir Hung. 1999; 38(2):159-61.
13. Târcoveanu E. Training in laparoscopic surgery. The problem of competence and responsibility. Chirurgia (Bucur). 1995; 44(2):17-27. [Article in Romanian]
14. Zucker KA, Bailey RW, Graham SM, Scovil W, Imbembo AL. Training for laparoscopic surgery. World J Surg. 1993;17(1):3-7.
15. Târcoveanu E, Moldovanu R. Rezidențiatul în chirurgie - probleme noi, soluții vechi. Decalogul pregătirii rezidenților. Jurnalul de chirurgie 2009;5(2):109-114.
16. Wilson MS, Middlebrook A, Sutton C, Stone R, McCloy RF. MIST VR: a virtual reality trainer for laparoscopic surgery assesses performance. Ann R Coll Surg Engl. 1997;79(6):403-4.
17. Doyle JD, Webber EM, Sidhu RS. An universal global rating scale for the evaluation of technical skills in the operating room. Am J Surg. 2007;193(5):551-5; discussion 555.
18. Moldovanu R, Târcoveanu E, Lupașcu C, Dimofte G, Filip V, Vlad N, Vasilescu A. Training on a virtual reality simulator – is it really possible a correct evaluation of the surgeons' experience ? Rev Med Chir Soc Med Nat Iasi. 2009;113(3):780-7.
19. Zhang A, Hünerbein M, Dai Y, Schlag PM, Beller S. Construct validity testing of a laparoscopic surgery simulator (Lap Mentor): evaluation of surgical skill with a virtual laparoscopic training simulator. Surg Endosc. 2008;22(6):1440-4. Epub 2007 Oct 31.
20. Munz Y, Kumar BD, Moorthy K, Bann S, Darzi A. Laparoscopic virtual reality and box trainers: is one superior to the other? Surg Endosc. 2004;18(3):485-94. Epub 2004 Feb 2.
21. Royston CM, Lansdown MR, Brough WA. Teaching laparoscopic surgery: the need for guidelines. BMJ. 1994;308(6935):

1023-5. Comment in: BMJ. 1994;308(6941):1435. BMJ. 1994; 309(6950):342.
22. Kahol K, Satava RM, Ferrara J, Smith ML. Effect of short-term pretrial practice on surgical proficiency in simulated environments: a randomized trial of the "preoperative warm-up" effect. J Am Coll Surg. 2009;208(2):255-68. Epub 2008 Dec 4.
23. Moldovanu R, Târcoveanu E, Bradea C, Dimofte G, Lupașcu C, Lotz JC, Vlad N, Vasilescu A. The Preoperative warm-up using virtual reality simulator. 21-st International Conference of Society for Medical Innovation and Technologies (SMIT), Sinaia, Romania, 7-9 October 2009, Abstract Book, OP 096; p. 80.
24. Satava RM. How the future of surgery is changing: robotics, telesurgery, surgical simulators and other advanced technologies. Jurnalul de chirurgie. 2009;5(4):311-325.
25. Satava RM. Information age technologies for surgeons: overview. World J Surg. 2001;25(11):1408-11.
26. Maschuw K, Osei-Agyemang T, Weyers P, Danila R, Bin Dayne K, Rothmund M, et al. The impact of self-belief on laparoscopic performance of novices and experienced surgeons. World J Surg. 2008;32(9):1911-6.
27. Osborne MP. William Stewart Halsted: his life and contributions to surgery. Lancet Oncol. 2007;8(3):256-65.
28. Schiappa JM. Which way shall we take for traning and education in surgery? Jurnalul de chirurgie 2009;5(4):399-405.
29. Darzi A, Smith S, Taffinder N. Assessing operative skill needs to become more objective. BMJ. 1999;318(7188):887-8.
30. Aggarwal R, Moorthy K, Darzi A. Laparoscopic skills training and assessment. Br J Surg. 2004;91(12):1549-58.
31. MacFadyen BV Jr, Vecchio R, Ricardo AE, Mathis CR. Bile duct injury after laparoscopic cholecystectomy: the US experience. Surg Endosc. 1998;12(4):315-21.
32. Rosenthal R, Gantert WA, Hamel C, Metzger J, Kocher T, Vogelbach P, et al. The future of patient safety: Surgical trainees accept virtual reality as a new training tool. Patient Safety in Surgery. 2008; 2:16.
33. Satava RM. Historical review of surgical simulation - a personal perspective. World J Surg. 2008;32(2):141-8.
34. Haluck RS, Satava RM, Fried G, Lake C, Ritter EM, Sachdeva AK, et al. Establishing a simulation center for surgical skills: what to do and how to do it. Surg Endosc. 2007;21(7):1223-32. Epub 2007 Apr 24. Comment in: Surg Endosc. 2008;22(2):564.
35. ***. Integrating advanced laparoscopy into surgical residency training. Society of American Gastrointestinal Endoscopic Surgeons (SAGES). Surg Endosc. 1998;12(4):374-6.
36. Jakimowicz JJ. The European Association for Endoscopic Surgery recommendations for training in laparoscopic surgery. Ann Chir Gynaecol. 1994;83(2):137-41.
37. Carter FJ, Schijven MP, Aggarwal R, Grantcharov T, Francis NK, Hanna GB, et al. Consensus guidelines for validation of virtual reality surgical simulators. Surg Endosc. 2005;19(12): 1523-32. Epub 2005 Oct 26. Comment in: Surg Endosc. 2005;19(12):1521-2.
38. Keeley FX Jr, Eden CG, Tolley DA, Joyce AD. The British Association of Urological Surgeons: guidelines for training in laparoscopy. BJU Int. 2007;100(2):379-81.
39. Khan S, Ahmede J, MacFie J. Guidelines on the number of times a procedure should be performed by trainees. Ann R Coll Surg Engl. 2009;91(4):353; author reply 354. Comment on: Ann R Coll Surg Engl. 2008;90(7):577-80.
40. Schijven MP, Jakimowicz JJ, Broeders IA, Tseng LN. The Eindhoven laparoscopic cholecystectomy training course - improving operating room performance using virtual reality training: results from the first E.A.E.S. accredited virtual reality trainings curriculum. Surg Endosc. 2005;19(9):1220-6.
41. Mariette C. Apprenticeship in laparoscopic surgery: Tools and methods for the surgeon in trening. J Chir (Paris). 2006; 143(4):221-5. [Article in French]
42. ***. Curricula rezidențiatului în chirurgie. Available online at http://www.umfiasi.ro/atdoc/ cursuri _ rez _CHIRURGIE_GENERALA.pdf
43. Ali MR, Mowery Y, Kaplan B, DeMaria EJ. Training the novice in laparoscopy. More challenge is better. Surg Endosc. 2002;16(12):1732-6. Epub 2002 Jul 29.
44. Waurick R, Weber T, Bröking K, Van Aken H. The European Working Time Directive: effect on education and clinical care. Curr Opin Anaesthesiol. 2007;20(6):576-9.
45. Powers TW, Murayama KM, Toyama M, Murphy S, Denham EW 3rd, Derossis AM, et al. Housestaff performance is improved by participation in a laparoscopic skills curriculum. Am J Surg. 2002;184(6):626-9; discussion 629-30.
46. Korndorffer JR Jr, Stefanidis D, Scott DJ. Laparoscopic skills laboratories: current assessment and a call for resident training standards. Am J Surg. 2006;191(1):17-22.
47. Copăescu C, Dragomirescu C. The pig model for the laparoscopic antireflux surgery training. Chirurgia (Bucur). 2009;104(3): 309-15. [Article in Romanian]
48. Tomulescu V, Popescu I. The use of LapSim virtual reality simulator in the evaluation of laparoscopic surgery skill. Preliminary results. Chirurgia (Bucur). 2004;99(6):523-7. [Article in Romanian]
49. Bruynzeel H, de Bruin AF, Bonjer HJ, Lange JF, Hop WC, Ayodeji ID, et al. Desktop simulator: key to universal training? Surg Endosc. 2007;21(9):1637-40. Epub 2007 Feb 9.
50. Rosser JC, Rosser LE, Savalgi RS. Skill acquisition and assessment for laparoscopic surgery. Arch Surg. 1997;132(2):200-4.
51. Panait L, Akkary E, Bell RL, Roberts KE, Dudrick SJ, Duffy AJ. The role of haptic feedback in laparoscopic simulation training. J Surg Res. 2009;156(2):312-6. Epub 2009 May 14.
52. Dayan AB, Ziv A, Berkenstadt H, Munz Y. A simple, low-cost platform for basic laparoscopic skills training. Surg Innov. 2008;15(2):136-42.
53. Robert G, Calvet C, Lapouge O, Vallee V, Emeriau D, Ballanger P. Development and validation of a model of training at home to the laparoscopy. Prog Urol. 2006;16(3):352-5. [Article in French]
54. Botden SM, de Hingh IH, Jakimowicz JJ. Suturing trening in augmented reality: gaining proficiency in suturing skills faster. Surg Endosc. 2009;23(9):2131-7. Epub 2008 Dec 6.
55. Rosser JC Jr, Herman B, Giammaria LE.Telementoring. Semin Laparosc Surg. 2003;10(4):209-17.
56. Rosser JC Jr, Young SM, Klonsky J. Telementoring: an application whose time has come. Surg Endosc. 2007;21(8):1458-63. Epub 2007 May 5.
57. Kahol K, Leyba MJ, Deka M, Deka V, Mayes S, Smith M, et al. Effect of fatigue on psychomotor and cognitive skills. Am J Surg. 2008;195(2):195-204.
58. Maschuw K, Osei-Agyemang T, Weyers P, Danila R, Bin Dayne K, Rothmund M, et al. The impact of self-belief on laparoscopic performance of novices and experienced surgeons. World J Surg. 2008;32(9):1911-6.
59. Kahol K, Satava RM, Ferrara J, Smith ML. Effect of short-term pretrial practice on surgical proficiency in simulated environments: a randomized trial of the "preoperative warm-up" effect. J Am Coll Surg. 2009;208(2):255-68. Epub 2008 Dec 4.
60. Sinha P, Hogle NJ, Fowler DL. Do the laparoscopic skills of trainees deteriorate over time? Surg Endosc. 2008;22(9):2018-

25. Epub 2008 Apr 25.
61. Fried GM, Feldman LS. Objective assessment of technical performance. World J Surg. 2008;32(2):156-60.
62. Pellen M, Horgan L, Roger Barton J, Attwood S. Laparoscopic surgical skills assessment: can simulators replace experts? World J Surg. 2009;33(3):440-7.
63. Yamaguchi S, Konishi K, Yasunaga T, Yoshida D, Kinjo N, Kobayashi K, et al. Construct validity for eye-hand coordination skill on a virtual reality laparoscopic surgical simulator. Surg Endosc. 2007;21(12):2253-7. Epub 2007 May 4.
64. van Dongen KW, Tournoij E, van der Zee DC, Schijven MP, Broeders IA. Construct validity of the LapSim: can the LapSim virtual reality simulator distinguish between novices and experts? Surg Endosc. 2007;21(8):1413-7. Epub 2007 Feb 9.
65. Reznick R, Regehr G, MacRae H, Martin J, McCulloch W. Testing technical skill via an innovative "bench station" examination. Am J Surg. 1997;173(3):226-30.
66. Hance J, Aggarwal R, Moorthy K, Munz Y, Undre S, Darzi A. Assessment of psychomotor skills acquisition during laparoscoic cholecystectomy courses. Am J Surg. 2005;190(3):507-11.
67. Aggarwal R, Grantcharov T, Moorthy K, Milland T, Papasavas P, Dosis A, et al. An evaluation of the feasibility, validity, and reliability of laparoscopic skills assessment in the operating room. Ann Surg. 2007;245(6):992-9.
68. Salgado J, Grantcharov TP, Papasavas PK, Gagne DJ, Caushaj PF. Technical skills assessment as part of the selection process for a fellowship in minimally invasive surgery. Surg Endosc. 2009;23(3):641-4. Epub 2008 Sep 24.