Chapter 9

Discussion

Due to the introduction of laparoscopy in gynecological, urological and abdominal surgery training in surgery is changing. A 'See one, do one, teach one' approach whereby feedback is directly provided during surgery in the operating room (OR) is no longer accepted. As early as in 1999 Kauffman et al. proposed a 'See one, do multiple in a skills lab, do one for real' approach[1]. Ethical concerns, necessity of a high volume of surgical procedures, availability of skilled mentors and reduced working hours are the main limitations in employing the operating theatre as a primary learning environment[2]. Skills can be described as an individual's learned capability to perform specific acts[3]. Despite the introduction of simulators designed specifically to train characteristic MIS skills (i.e. hand-eye coordination, remote handling of instruments with reduced tactile feedback) and compelling evidence to support simulator-based training in MIS, the acknowledgement and implementation of such simulators in surgical training programs is lacking. This thesis provides a scientific foundation for the implementation of simulation based MIS training in a surgical training program.

Acquirement of laparoscopic skill

It is important to understand the methodology of skill acquirement prior to implementation of a training method. In the early 1970's Malcolm Knowles laid out the basic principles of what came to be known as the adult learner theory; 'the principles of adult learning'[4]. The approach became popular with liberal medical educators. According to this theory motivation to learn is based on a trainees experience with the task and personal- or work related problems. Motivation would be more responsive to internal- than to external motivators. These principles have long determined the construction of medical curricula[5]. Using a prospective observational cohort study we investigated the extent to which residents are able to identify their own limitations **(chapter 2)** and motivators to persist in voluntary and autonomous (MIS) training **(chapter 3)**. We found that training facilities were not adequately utilized if practice was considered voluntary[6]. In contrast to Knowles' theory, we found that main motivators to participate in voluntary autonomous MIS training included constructive feedback, a structured skills curriculum and protected training time.

We found little to no relationship between externally generated assessment scores and self-confidence scores. Self-assessment might consequently be potentially hazardous since overestimation of own skill may cause regrettable errors[7]. This confirms once again that groups of residents do not represent the adult learner and that a medical curriculum should be structured, competency based, and inclusive of several mandatory simulation based training components with rigorous assessment procedures.

A laparoscopic training curriculum

As described, a successful laparoscopic skills curriculum is dependent on many factors. Obvious factors include participant motivation, resource and personnel availability, and trainee and faculty commitment. To increase motivation, a curriculum should include goal-oriented training, objective performance metrics and assessment, appropriate methods of instruction and feedback, and a cognitive component. Several studies have demonstrated that learning curves on simulators vary between individuals at the same level of differences in training[8;9]. Therefore a

MIS curriculum should be a dynamic process with the possibility of individual tailoring and continuous optimization based on accumulated evidence and experience and should include team-training and maintenance training. Based on the results of the first two studies - a systematic literature search including available MIS-simulators and training methods **(chapter 5)** and the results of a study on a laparoscopic training course **(chapter 4) -** we propose a MIS curriculum divided into four phases as described below (figure1). Since no simulator yet provides the ability to train the entire set of required psychomotor skills in MIS, a multiyear training curriculum combining various simulators for multiple-level training, including team training and assessment protocols should be constructed. Simulation based training should be combined with adequately planned and dosed exposure to MIS in the OR combined with structured feedback.

Figure 1:

Suggested MIS curriculum. BT, box trainer. VR, virtual reality trainer.

In this thesis we focused mainly on the first stage of MIS skill acquisition; basic laparoscopic skill, such as hand–eye coordination and bimanual coordination. A critical aspect in the initial MIS learning curve is guided training; critical errors are immediately corrected to ensure that they are not repeated[10]. In our opinion this crucial first stage in acquiring MIS skills is best achieved on a low-cost box trainer with a tracking device and regular supervision by a senior laparoscopic surgeon. Examples of surgical curricula implementing such an approach are the Fundamentals of Laparoscopic Surgery (FLS) and Advanced Suturing Course (ASC) as organized by our research group **(chapter 4)**[11;12].

During the second stage of training, the trainee should participate in a theoretical course of procedural performance in MIS. Fitting for this stage would be a Box Trainer (BT) or Virtual Reality (VR)- device including a tutorial on various MIS procedures **(chapter 5)**. Hereafter, improvement of cognitive and interpersonal skills which are needed to manage a procedure within the OR should be trained. Team training has become an essential driving force in reducing medical errors by increasing communication in the operating room[13]. Therefore a team-training program should be developed and implemented in MIS curricula. Some of the new generations of VR and AR simulators made the first steps toward procedural and team training within their simulating options, partially replacing complex and human resources. The last stage would contain guided transition to the OR. Finally a program for maintained training during residency and further career should be implemented.

Laparoscopic Simulation

As illustrated in the previous paragraph, simulation based training provides unique opportunity to educate and assess MIS skills. Simulators use standardized metrics in a safe and controllable environment for assessment and feedback. Currently available laparoscopic simulators can be divided into three categories: traditional box trainers, virtual reality (VR) and augmented reality (AR) simulators[14]. Box trainers (Figure 2) provide realistic haptic feedback - which is especially important during the early phase of psychomotor skill acquisition[15] - but lack automated objective feedback and assessment. They allow for many simulated tasks, depending on used materials. VR simulators provide task-oriented modules; feedback and objective assessment but lack haptic feedback and have limited predefined skill trainings. AR simulators combine the benefits of traditional box trainers and VR simulators but are (relatively) expensive and complex, limiting use in group- or home training settings. A simple and broad implementation is not easily feasible today. Virtual and augmented simulators in combination with serious gaming are a good training option and testing method[16;17].

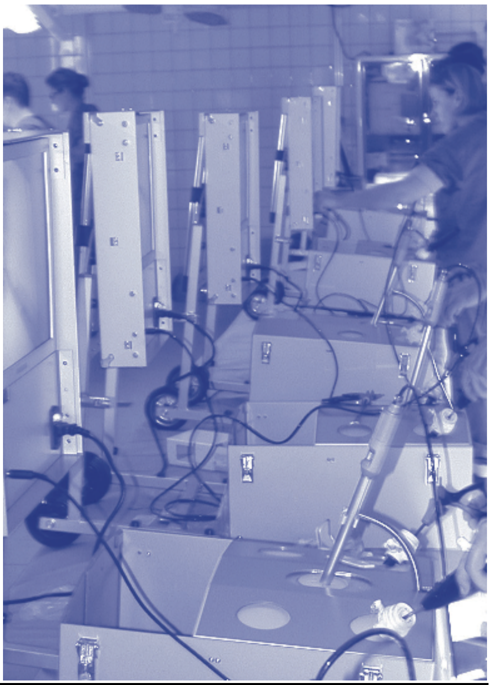

Figure 2: Box trainer:

Relatively inexpensive
Genuine haptic feedback
Actual laparoscopic instruments
Practice on genuine cadaveric tissue
Suitable for groups training and practice ‘at home’
Opportunity to add a tracking device

The *TrEndo* laparoscopic tracking system for implementation on a standard laparoscopic box trainer

A motion tracking system during laparoscopic task performance provides feedback on time for a task, smoothness of motion and instrument path length. A tracking system could also be used for examination purposes, possibly combined with the Objective Structured Assessment of Technical Skills (OSATS) scoring system. In this thesis we investigated the validity of the TrEndo tracking device implemented on a traditional box trainer **(chapter 6)**. Previous studies investigating face-, content-, construct- and concurrent validity of the TrEndo demonstrated positive results, suggesting the applicability of this device for training in MIS[18]. Laparoscopic skill assessment was traditionally and is currently mainly based on the subjective OSATS[19]. As a supervisor evaluates performance, the OSATS is subjective and subject to inter-observer bias. In this thesis we demonstrated that an objective assessment method of a basic laparoscopic task by means of the TrEndo laparoscopic simulator globally correlated with the subjective gold standard by means of the OSATS. However, the TrEndo might be more effective at recording individual progress **(chapter 8)**. t is important that the assessment of MIS skill is not based on one parameter only but several parameters combined[20]. Tracking devices like the TrEndo record time and 4 MAPS for each hand including path length, insertion distance, angular area and volume. However these parameters do not provide information on the quality and strength of the performed knot. Therefore, simulator based results in combination with expert judgment of learner performance using the OSATS is still necessary.

Competency-based training

A globally accepted example of a format in Competency-based training (CBT) is the CanMEDS framework[21]. CBT according to CanMEDS organizes physician practice around the central medical expert role and six intrinsic roles: Communicator, Collaborator, Manager, Health Advocate, Scholar, and Professional. According to the CanMEDS framework, competency-based training incorporates more or less global assessment of all pre-defined roles and competencies. The research in this thesis is mainly focused on the medical expert role. To enhance the transfer of simulator-acquired skills to professional performance in real patients, it is important to set and assess the targets to which simulator based training must meet; creating expert benchmark levels of proficiency is essential in the development of a competency- based curriculum[22]. In our studies, we set an expert competency level for a MIS task on a laparoscopic box trainer and demonstrated that MIS skill of laparoscopic trainees as recorded by the TrEndo laparoscopic simulator increased toward an expert level during a laparoscopic training course **(chapter 7)**. Feedback and assessment on time, precision and economy of movement may be sufficient in assessing several laparoscopic exercises on the initial learning curve. These metrics however provide no information on tissue handling[23;24]. To train and objectively assess tissue-handling skills a force-sensing training system providing feedback about forces could be implemented[24].

The curriculum as designed above would encourage the use of competency-based outcome parameters as opposed to solely the number or length of performed procedures. Competency levels should also be defined for procedural competencies, visual perception, knowledge of anatomy, pathology and team performance.

Teach the teacher

Performance of MIS in the OR should only be sanctioned once trainees have achieved and completed predefined skills levels. The goals contained within this curriculum should be based on international expert consensus.

A generally accepted curriculum is developed based on educational knowledge, motivated supervisors and residents who are motivated to learn. It is crucial to maintain focus on the trainee, however established goals should also be achieved by the instructor. Simulators alone will never suffice to assess and turn residents into competent surgeons. Therefore to encourage trainee motivation, objective- and validated subjective peer-group assessment plays an important role. The role of teacher training has thus become an important issue[25]. For trainees to attain an identical level of training, qualification programmes for instructors should be implemented.

Future perspectives

In response to the report of the Dutch Health Care (inspectorate (IGZ)[26], which found an unacceptable amount of serious complications in common laparoscopic procedures and stated that patient safety in MIS should improve, we focused our studies on basic laparoscopic skill training and the initial learning curve in MIS. As mentioned, a curriculum in MIS should not only attend to technical skill but also to other critical steps and CanMED competency's such as procedural decision-making, communication skills, interpersonal management and OR knowledge. Various studies have shown that non-technical factors strongly influence the appropriate performance of procedural skills and are crucial for successful OR performance and patient care[27;28]. We stress the importance of non-technical (human) factors in team training to be subject of research as well.

Learning curves differ in individuals[4;29]. Future research should investigate average learning curves and extremes. The number of required training sessions per procedure should be investaged. Examining a learning curve is a difficult yet challenging and necessary step in optimizing MIS training. Defining reasonable training goals on MIS simulators, and the identification of adequate benchmarks to allow procedural performance in the OR should be subject of future research. Also, it is unknown how many recurrent training sessions should be implemented to retain adequate skill. It is known that laparoscopic skill may to deteriorate in a period of 6 to 18 months without training. Fine motor skills, required to perform more difficult tasks, deteriorates more than skills needed for easier tasks[30-32].

In this thesis we relatively focused on basic skills training in a MIS curriculum and the validation of the TrEndo tracking device to assess MIS skill. Although the TrEndo is a useful and validated device to train and assess task efficiency and instrument handling in MIS on the basis of time and motion tracking parameters there is still room for improvement on the face and content validity of this device. Currently TrEndo data are difficult to interpret. A visual combination of the TrEndo outcomes and instructors (peer-grouped) assessment should be designed.

Current training programs are mainly based on a resident's own responsibility. There should be a balance between a resident's personal responsibility and requirements of an excellent training program. Educators are responsible for the development, implementation and quality of a residents training[33]. The trainee's are responsible for monitoring the time to gain the steps of a MIS curriculum and collect the achieved results in a personal portfolio. A curriculum in MIS should be competency based with objective measurable theoretical and practical skills, closely linked to efficiency in the OR and patient safety. To prepare residents for the OR a stepwise training program provided by qualified trainers should enclose a quality cycle in which each achievable step and final goal is continuously checked and if necessary adjusted. To be successful implemented, laparoscopic training programs for all surgical disciplines should become aligned to (European) accreditation systems. To train and assess essential laparoscopic psychomotor skills, the European Academy of Gynaecological Surgery (EAGS) already developed the Laparoscopic Skills Testing and Training (LASTT) model[34]. However, like the FLS this trainings program only focused on the basic MIS skills of the medical expert whereas the ASC teaches a more advanced task (e.g., suturing and knot tying) assessed not only on time but also 4 (TrEndo) MAPS. A future laparoscopist should first train basic laparoscopic skills (e.g., hand-eye coordination) prior to more advanced laparoscopic tasks[35]. The relationship between performance on box trainers and assessments need to be improved in terms of procedure outcome and patient safety. In order to complete a comprehensive MIS curriculum conforming to current educational theories such as the CanMED's competency-based training strategy educators will have to reach an international consensus in all disciplines.

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