Summary

Minimally Invasive Surgical skills training,

Learning, Assessment & Validation

This thesis is focused on medical doctors learning to become laparoscopic surgeons. Until recently residency programs were based on self-directed master apprenticeship training and mainly consisted of on the job learning, wherein residents progressively take on more responsibility in patient care, with decreasing supervision by attending physicians. Present-day innovations in laparoscopic surgery, reduced working hours and concerns about preventable medical errors moves training programs towards more competency-based outcomes. This thesis reports on research projects based on training in laparoscopic surgery in the Netherlands and Belgium between 2008 and 2010.

In minimally invasive surgery (MIS) or laparoscopic surgery **(chapter 1)** the surgeon performs a procedure with long instruments through small incisions in the abdominal wall while observing a 2D screen. This type of surgery has important benefits for patients compared to conventional open surgery such as reduced postoperative pain, cosmetic advantages, reduced hospital stay and quicker return to normal physical activities. To take advantage of this minimally invasive approach, skilled and well-trained surgeons should perform MIS procedures. However, laparoscopic surgery is more difficult to master and is associated with a longer learning curve than conventional open surgery. Depth perception is reduced, hand-eye coordination is distorted and haptic feedback is reduced. Multiple laparoscopic simulators are

available to train MIS skills outside the operation room (OR) including box trainers (BT), Virtual Reality- (VR) and Augmented Reality (AR) simulators. Haptic feedback is naturally present in box trainers whereas most VR system still lack haptic feedback. VR systems incorporate automated and objective feedback on procedural performance. AR devices combine both benefits are relatively expensive and therefore not suitable for group and home training.

It is known that simulation based training results in increased OR performance. However, a fully integrated surgical curriculum including predefined goals, proctoring, protected training time and objective assessment of skills with predefined accomplishment scores is necessary before training on a surgical simulator is effective. A scientific basis on the aspects of learning and the organisation of skill training is often lacking. Therefore, these aspects are discussed in the current thesis.

Before constructing a curriculum it is necessary to know how residents obtain skill. In **chapter 2** of this thesis residents' self-confidence of a basic skill (open-knot tying), required for laparoscopic surgery has been studied in a prospective observational cohort study. Residents appeared to be unaware and unable to adequately estimate their open knot tying skills. We emphasized the need of repeated training of (basic) surgical skills and continuous assessment and feedback of skills.

Chapter 3 reports on a qualitative study that obtained residents' time-log during MIS training and their perspectives on a six weeks period of autonomous home-training on a BT. In a focus group, experiences with, and ideas on obtaining MIS skills were explored. It was evident that residents felt to spend insufficient time on laparoscopic simulator based training. Main confounders included a lack of time or a lack of interest in MIS. Residents stated that autonomous practice should be structured including adequate and sufficient feedback points. A minimally required practice time should be set. Voluntary exercise only works if targets and exams are used as a motivator.

In **chapter 4** we evaluated the effects of a two-day surgical training program in MIS that we developed at our medical department. In this study we assessed residents at the beginning of a laparoscopic training course, at the end of the first training day and after six weeks of voluntary autonomous home-practice. We concluded that the construction of our MIS training program was successful, however as stated in chapter 2 and 3 more powerful stimulants should be implemented and examined in order to stimulate and motivate residents to train and maintain MIS skills.

An overview of the currently available simulators in MIS is given in **chapter 5**. Several simulators are evaluated on their strength and weaknesses. We found that no simulator yet provides the ability to train the entire set of required psychomotor skills or procedures required in MIS. A multiyear training program combining various simulators for multiple-level training, including team training, should be constructed. Based on the knowledge we obtained in the first chapters of this thesis we also proposed a surgical curriculum in MIS. In our opinion, a curriculum should provide the trainee with a competency based training program that provides full attention to not only technical skill but also to critical steps such as procedural decision-making and interpersonal management, which integrally will allow performing entire MIS procedures on patients in the operating room. A validated curriculum embedding technical skill training, assessment and team training will still be subject to an ever-changing environment. Taking into consideration that an AR system provides realistic haptic feedback but is considerably more expensive than other devices and that team training, including serious gaming, is still in its infancy, we suggest a curriculum based on the laparoscopic box trainer including a low-cost motion-tracking device to cover the early learning curve. A VR system containing serious gaming would fit perfectly in one of the last stages before entering the OR.

Before implementing MIS simulators into a curriculum, validation studies must be conducted. In **chapter 6** the TrEndo, a VR simulator, was subjectively evaluated by a group of experienced laparoscopic surgeons and a group of surgical trainees (face and content validation). Both groups considered the TrEndo as a realistic and useful simulator for training basic laparoscopic skills. We also established construct validity. The TrEndo was able to distinguish groups with different levels of laparoscopic skill. In **chapter 7**, we demonstrated a learning curve on the TrEndo. Laparoscopic skill of trainees increased significantly toward an expert level during a laparoscopic training course in a large and heterogeneous study group. We concluded that the TrEndo holds real potential as a (home) training and assessment device.

Most laparoscopic training programs are not evidence-based and there is still no global consent on an objective assessment of MIS skill. Current assessment relies on subjective evaluation based on a supervisor’s recollection. In our final study (**chapter 8**) we demonstrated that an objective assessment method of a basic laparoscopic task by means of the TrEndo globally correlated with the subjective gold standard of MIS skill, the Objective Structured Assessment of Techincal Skills (OSATS).

However, the TrEndo was more responsive than the OSATS, and might be more effective at recording individual progress.

In our general discussion (**Chapter 9)** we combines the results of the aforementioned chapters in a broader perspective. We focus on the role of learning, and the design of a cost-effective MIS curriculum which aims for a safe and well-grounded transfer from simulator based competency to procedural performance in MIS. In conclusion, a competency-based structured curriculum in which MIS trainees are educated and evaluated is indispensible during MIS training. We discuss our findings and conclude with suggestions for future research.