Is the aptitude of manual skills enough for assessing the training effect of students using a laparoscopy simulator?

Ist die alleinigemanuelle Begabung der Medizinstudenten zur Beurteilung des Lerneffektes am Laparoskopie-Simulator ausreichend?

Abstract

**Background:** The aim of this study was to determine if students are suitable candidates to assess the learning effect through a virtual reality laparoscopy simulator (LapSim®).

**Materials and methods:** 14 medical students in their final year without any previous experience with a virtual reality simulator were recruited as subjects. In order to establish a "base line" all subjects were instructed into the “clip application” task - a basis module of the laparoscopy simulator - at the beginning of the study. They were then randomized into two groups. Group A (n=7) had parameter adjusted to an easy level of performance, while group B (n=7) was adjusted to a difficult level. In both levels, errors simulated clinically relevant situations such as vessel rupture and subsequent bleeding. Each participant had to repeat the clip application task ten times consecutively.

**Results:** The mean time for completion ten repetitions was 15 min pro participant in group A and 20 min in group B. From the first to the fifth repetition group A improved significantly the task completion time from 238.9 s to 103.3 s (p<0.007) consecutively and also improved the error score from 312 to 177 (p<0.07). At the tenth repetition they increased the task completion time from 103.3 s to 152.2 s (p<0.09) and increased their error score from 177 to 202 (p=0.25). From the first to the fifth repetition group B also improved the task completion time from 131.6 s to 104.5 s (p<0.31) consecutively and improved the error score from 235 to 208 (p<0.32) but at the tenth repetition they increased the task completion time from 104.5 s to 142.4 s (p<0.45) and clearly increased their error score from 208 to 244 (p<0.38).

**Conclusion:** These results suggest that medical students, who lack clinical background, may be not suitable candidates for assessing the efficiency of a training model using a laparoscopy simulator. If medical students are appointed for such studies, they should receive didactic sessions in the context of a clinical curriculum prior to manual training.

**Keywords:** virtual reality, laparoscopy simulator, learning, minimal-invasive surgery, surgical training

Zusammenfassung

**Hintergrund:** Das Ziel dieser Studie war es zu überprüfen, ob Medizinstudenten eine geeignete Prüfpopulation sind, um Lerneffekte durch einen Laparoskopie-Simulator abzubilden.

**Materialien und Methoden:** 14 Medizinstudenten im praktischen Jahr ohne Laparoskopie-Erfahrung nahmen an dieser Studie teil. Die Einschätzung laparoskopischer Fertigkeiten erfolgte mit dem Laparoskopie-Simulator LapSim®. Alle Probanden führten - nach vorheriger Einführung in den Simulator - zu Beginn der Studie die Übung "Klipapplikation", ein Basismodul des Laparoskopiesimulators virtueller Realität (LapSim®), welches vor kurzem beschrieben wurde, einmal durch. Anschließend
wurden die Teilnehmer in zwei Gruppen randomisiert. Gruppe A (n=7) führte eine leichte Einstellung der Klippapplikation durch, während Gruppe B (n=7) eine schwere Einstellung der Klippapplikation hatte. Fehlerereignisse simulierten klinisch relevante Situationen wie beispielsweise Gefäßrupturen und Blutungen. Jeder Teilnehmer wiederholte die Übung zehnmal hintereinander. **Ergebnisse**: Die Zeit zur Durchführung von 10 Wiederholungen lag im Mittel bei 15 min pro Teilnehmer für Gruppe A und 20 min pro Teilnehmer für Gruppe B. Gruppe A konnte eine Verbesserung der Durchführungszeit in der fünften Wiederholung 103,3 s im Vergleich zur ersten Durchführung 238,9 s erzielen (p<0,007) und zeigte ebenfalls eine Verminderung der Fehlerrate von 312 auf 177 (p<0,07). In der zehnten Wiederholung hatte Gruppe A allerdings eine längere Durchführungszeit 152,2 s im Vergleich zur fünften Wiederholung 103,3 s (p=0,009) und auch eine Zunahme der Fehlerrate von 177 auf 202 (p>0,05). Gruppe B konnte eine Verbesserung der Durchführungszeit in der fünften Wiederholung 104,5 s im Vergleich zur ersten Durchführung 131,6 s erzielen (p<0,31) und zeigte ebenfalls eine Verminderung der Fehlerrate von 235 auf 208 (p<0,32). In der zehnten Wiederholung hatte Gruppe A allerdings eine längere Durchführungszeit 142,4 s im Vergleich zur fünften Wiederholung 104,5 s (p=0,45) und auch eine Zunahme der Fehlerrate von 208 auf 244 (p=0,38). **Schlussfolgerung**: Die Ergebnisse dieser Studie weisen darauf hin, dass Medizinstudenten ohne ausreichenden klinischen Hintergrund möglicherweise zur Einschätzung des Trainingseffektes von VR-Laparoskopie-Simulatoren nicht geeignet sind. Vor solchen Studien sollte zusätzlich zu den praktischen Übungen im Rahmen von angepassten Curricula die klinischen Hintergründe vermittelt werden. **Schlüsselwörter**: virtuelle Realität, Laparoskopie-Simulator, minimal-invasive Chirurgie, chirurgisches Training, Lernkurve

**Introduction**

Technical skills in the field of surgery have been commonly taught using the apprenticeship model. The advent of minimally invasive surgery brought about the use of simulation as a training tool. Such simulations make it possible to design a wide range of repeatable surgical situations, and thus to design assessments based on direct observation of performance [1]. Laparoscopic simulation has been proven effective in providing skills which are transferable to the operating room [2], [3], [4]. Computer environments are free of ethical considerations but tend to be expensive and are currently incompletely developed [5]. However, training in computer simulated laparoscopic environments has become increasingly popular in the last years despite a little evidence regarding the efficacy of these techniques. In a recent study a total of 29 medical students were randomized into two groups. One group received preoperative training with a virtual reality laparoscopy simulator (MIST-VR). Both groups then performed a simulated laparoscopic appendectomy in a pig. The operations were videotaped and examined by three independent observers. There was no significant difference in performance between the two groups [6]. This result suggests that either the MIST-VR did not improve the surgical skills of the subjects, or students are not suitable to show the training effect of the laparoscopy simulator because they lack background for laparoscopic surgery. The current study was designed to establish whether or not the medical students are suitable to assess the efficiency of a training model using two different degrees of difficulty of virtual reality task during training sessions with the laparoscopy simulator LapSim®.

**Material and methods**

**The simulation model**

The simulator used in this study (LapSim®, Surgical Science Ltd., Goeteborg/Sweden) creates a virtual laparoscopic system using a computer (Windows XP®), a video monitor and laparoscopic interface containing two pistol-grip instruments and a diathermy pedal (Figure 1). The LapSim® software contains the basic module referred to as "Clip application", in which the level of complexity and difficulty can be adjusted as previously described [1], [5]. The "Clip application" module in the LapSim® skills set represents a surgical manoeuvre during laparoscopic operations and was adjusted to different levels of procedural complexity by increasing the level of difficulty to accomplish the task.
For the purpose of this study, the task was adjusted to an easy level (group A) and a difficult level (group B). For each individual, as well as for the entire group the following parameters were obtained: Time needed to complete the task (min); and error score comprised of amount of blood loss (ml); dropped clips (n); badly placed clips (n); incomplete target areas (n); stretch damage (percent).

**Study groups**

The study groups comprised of fourteen medical students in their final year were recruited as subjects (six women and eight men). The entire group was divided into two groups each comprised of seven students. Group A had parameter adjusted to an easy level of performance, while group B was adjusted to a difficult level. None of the subjects had any previous experience with a virtual reality simulator. All students were briefly instructed regarding the virtual reality technique of the clip application. The use of the laparoscopic instruments was demonstrated and the students were given time to practice until they felt comfortable. Then both groups performed the clip application task on their level and completed ten consecutive repetitions.

**Statistics**

The data was imported by the simulator's computer directly into an MS Excel® worksheet. With the help of a statistic program (SPSS) the data was analyzed descriptively. The error score was calculated using the sum of total errors (badly placed clips, dropped clips, incomplete target areas, stretch damage and loss of blood). The difference in performance between the two groups was analyzed by using the nonparametric Mann-Whitney-test. The level for statistical significance was set at p<0.05.

**Results**

Study subjects comprised of six women and eight men, ranging in age from 25 to 30 years. All 14 subjects completed the ten consecutive repetitions of the "Clip application" task. The mean time for the completion of ten repetitions was 15 min per participant in group A and 20 min in group B.

**Performance of group A (easy level)**

The participants of this group achieved a significant improvement of the completion time of task 5 compared to baseline assessment in task 1. From the first to the fifth repetition group A improved significantly the task comple-
Table 1: Medians of performance parameters of the "Clip application" task during first, fifth and tenth repetition

| Clip application       | Group A (easy level) | Group B (hard level) |
|------------------------|----------------------|----------------------|
|                        | Task 1               | Task 5               | Task 10              | Task 1               | Task 5               | Task 10              |
| Loss of blood (ml)     | 0 (0-470)            | 0 (0-110)            | 0 (0-570)            | 2000 (910-570)       | 570 (200-680)        | 460 (150-1940)       |
| Dropped clips (n)      | 0 (0-9)              | 0 (0-2)              | 0 (0-2)              | 0 (0-1)              | 1 (1-2)              | 0 (0-1)              |
| Badly placed clips (n) | 0 (0-2)              | 0 (0-3)              | 0 (0-11)             | 0 (0-2)              | 1 (0-2)              | 1 (0-1)              |
| Incomplete target areas (n) | 0 (0)             | 0 (0-2)              | 0 (0-12)             | 2 (1-2)              | 2 (1-2)              | 0 (0-1)              |
| Stretch-damage in %    | 59 (4-100)           | 24 (0-100)           | 52 (0-100)           | 100 (100-100)        | 100 (100-100)        | 100 (100-100)        |

Figure 2: The course of time to complete the task (s) for easy (Group A) and hard level (Group B) during the first, fifth and tenth repetition of the clip application task

Figure 3: The course of error score for easy (Group A) and hard level (Group B) during the first, fifth and tenth repetition of the clip application task
tion time from 238.9 s to 103.3 s (p<0.007) consecutively and also improved the error score from 312 to 177 (p<0.07). At the tenth repetition they increased the task completion time from 103.3 s to 152.2 s (p<0.09) and declined their error score from 177 to 202 (p=0.25) (Figure 2, Figure 3). The other parameters are shown in Table 1.

Performance of group B (hard level)

From the first to the fifth repetition group B also improved the task completion time from 131.6 s to 104.5 s (p<0.31) consecutively and improved the error score from 235 to 208 (p<0.32) but at the tenth repetition they increased the task completion time from 104.5 s to 142.4 s (p<0.45) and clearly declined their error score from 208 to 244 (p<0.38) (Figure 2, Figure 3). The other parameters are shown in Table 1.

Discussion

The increasing use of minimally invasive surgery emphasizes the necessity to develop training programs for the improvement of laparoscopic skills, so that the risk for the patient can be reduced to a minimum. The learning of psychomotoric skills to master laparoscopic procedures requires more than passive observation [7]. That is the reason why the practice of acquiring skills in minimal invasive surgery through a camera holder role is inferior to active training. However, the operating room is not suited to serve as a classroom, because of factors such as safety of the patient, time constraints and costs. Training outside the operating room offers a structured educational opportunity with stress modulation, which reduces the trainees' stress in the operating room.

That such training can improve laparoscopic surgical skills has previously been demonstrated. For instance Rosser et al. [8] described a structured training method for enhancing skills, with 150 trainee surgeons performing a series of three simple standardized laparoscopic drills on a box simulation. At the end of each drill their skill at performing an intracorporeal stitch was assessed by time taken. After only one series of tasks, the time taken to complete an intracorporeal stitch improved significantly, with further significant improvement at the end of ten repetitions. A similar programme with MIST-VR® as the training tool revealed significant improvements in knotting times after a 5-day training period [9]. As these new simulators for skills enhancement are developed and implemented, one important question obviously is "how much training is enough?"

Recent studies have suggested that performance plateaus can be reached after only 2-7 repetitions [5], [10]. Ahlberg et al. reported that the virtual laparoscopy simulator (MIST-VR) did not improve the surgical skills of the students during laparoscopic appendectomy in a porcine model [6]. Ögan et al. concluded in their study about the value of VR training for urerectomy that VR training is unable to override the impact of clinical training by medical students [11].

If the learning effect of virtual reality simulator would indeed be unclear, it may not be worthwhile to invest in expensive virtual reality training systems. The aim of this study was therefore, to establish, whether medical students lacking laparoscopic background are suited for assessment of the learning effect using virtual reality simulator or if the learning effect of such a training system is dependent on the degree of difficulty of the training task. Although most experts of laparoscopic surgery would agree that the learning curve of a more difficult procedure would most likely be longer than that of an easy task, such information has not been available as of yet.

In this preliminary current study, we have demonstrated that a stable optimum performance of laparoscopic skills for medical students using the laparoscopy simulator was not reached. Furthermore, the performance depended only conditionally on the level of complexity. Even when the task was easy to perform, neither a stable time for performance nor a stable error score was reached.

This finding clearly indicates that all of the participants did have some learning effect through the simulator that was independent from the level of the task. But, and more importantly, during both trainings, a stable optimum performance was not achieved at the end of the training although such a plateau can be abode. This study has thus important practical implications. By identifying a difference in plateaus of the different levels of difficulty for training laparoscopic skills on the LapSim® - simulator, we have shown, that like in the operating room, difficult tasks take longer to be mastered on VR simulators because participants are more focused on reducing complication like loss of blood, whereas easy tasks without directly identifiable complication take shorter to be mastered on VR simulators however worsening trauma parameter like stretch damage as a result of carelessness. One of the criticisms of laparoscopic trainers has been that they are abstract, with tasks being too simple and not related to real procedures.

We have now shown, that virtual reality simulators, if appropriately used, may in fact be closer to real procedures than previously thought. The second important finding is the value and necessity of carefulness for identifying the suited participants to assess laparoscopic skills. We have demonstrated that even after the participants had achieved a good performance level in the fifth training session, they achieved no stable optimum performance at the tenth repetitions, maybe because they lack background or comprehension for laparoscopic surgery. This finding is relevant for surgical education, because medical students may receive theoretical lecture in surgery concomitantly to the manual instruction of the task to develop adequate background before the implementation of such procedures. It is to be expected, that such performance-based curricula may significantly enhance the efficiency and efficacy of skills training by means of VR laparoscopic training.
Conclusion

These preliminary results suggest that medical students, who lack clinical background and comprehension for laparoscopic surgery may be not suitable for assessing the efficiency of a training model like this of virtual reality laparoscopy simulator. If medical students are appointed for such studies, they should receive didactic sessions in the context of a curriculum prior to manual training.

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