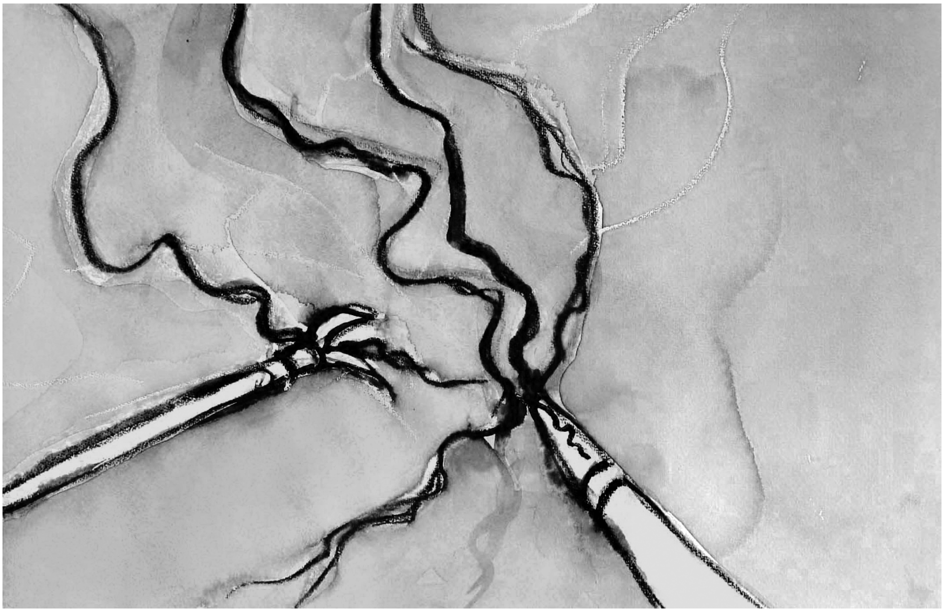
Acquiring minimally invasive surgical skills

Hiemstra, E.

CHAPTER 4

OPTIMIZING LAPAROSCOPIC SKILLS TRAINING: DOES A FIXED CAMERA COMPROMISE DEPTH PERCEPTION?



Ellen Hiemstra
Navid Hossein pour Khaledian
John van den Dobbelsteen
Jenny Dankelman
Frank Willem Jansen

Submitted

INTRODUCTION

In laparoscopic surgery, the image display system is the only visual interface between the surgeon and the operation field. Inherently, the three-dimensional (3D) operation field has to be perceived from a two-dimensional (2D) screen. Additionally, by looking at the monitor, the surgeon indirectly observes his hands manipulating the laparoscopic instruments. This may result in perceptual disturbances and distorted hand eye coordination [Heemskerk et al., 2006].

The camera is a substitute for the surgeon's eyes, and therefore, its position and navigation are of utmost importance. Many studies have been conducted to reveal the influence of camera and the operative setup on laparoscopic performance and the surgeon's workload in simulator settings[Ames et al., 2006; Conrad et al., 2006; Emam et al., 2002; Hanna et al., 1998; Haveran et al., 2007; Matern et al., 2005; Moschos et al., 2004; Omar et al., 2005; Smith et al., 2005; Zehetner et al., 2006]. The monitor should to be positioned in front of the surgeon, preferably in a gaze-down position[Hanna et al., 1998; Haveran et al., 2007; Matern et al., 2005; Omar et al., 2005; Zehetner et al., 2006]. Furthermore, a 0 degree scope results in the best performance during laparoscopy, and even the modest alteration in perspective results in a deterioration of performance[Ames et al., 2006; Omar et al., 2005]. The rotational angle of the laparoscopic image to the true horizon must be kept to a minimum to maintain a stable horizon, and for an optimal performance [Conrad et al., 2006]. Finally, it was found that the best place for a surgeon to stand is right in front of the laparoscopic instruments [Moschos & Coleman, 2004].

During the experiments described above, the camera was always placed in a fixed position. In laparoscopic practice, however, the camera is often navigated by either the surgeon who performs one-handed surgery, or by an assistant under direct oral instruction of the surgeon who performs two-handed surgery. Instable camera movements result in fatigue of the surgeon and delays in operative times [Bennett et al., 2011; Heemskerk et al., 2006], but in general, camera navigation provides the surgeon with 'depth cues'. For example, objects closer to the camera "move" faster as a result of navigation, than objects further away. The subsequent better understanding of the 3D operation field will facilitate hand-eye coordination and thereby efficient instrument-movements.

Box trainers are designed for basic laparoscopic skills training. However, many box trainers are supplied with fixed camera systems, despite the theoretical importance and the practical application of a navigated camera. To our knowledge, no research has been conducted on whether a camera navigation setup influences the proficiency gaining process. Therefore, this study compares a fixed camera to a navigated camera during laparoscopic skills training in this study. We try to answer the question whether a fixed camera position compromises depth perception during laparoscopic skills training.

MATERIAL AND METHODS

The study was conducted at the skills laboratory of the Leiden University Medical Center (LUMC) in the Netherlands. An inanimate box trainer was used with a separate monitor and an endoscope with 0 degree camera In this box trainer, a validated beads placing task [Kolkman et al., 2008] had to be performed (Figure 1). To fulfil this task, the beads had to be placed in a designated position using a laparoscopic grasper with the (dominant) right hand. For this exercise a correct interpretation of the 3D operation field is indispensable.

Participants

Right-handed medical students, in the preclinical phase of their study, and without prior experience with laparoscopic surgery or training (novices) were recruited to the study. Participation was on a voluntary basis. After enrolment, all participants completed a questionnaire providing demographic information (i.e. gender, self-perceived dexterity, and computer gaming experience) in order to compare baseline characteristics.

Study design (Figure 2)

Each novice was randomly assigned to eight beads placing tasks in one of the following three camera navigation setups, thereby testing the influence of camera navigation on laparoscopic skills acquisition:

- I: Assistant navigated camera: the task was performed with the dominant right hand while the camera was navigated by an assistant who was positioned on the left side of the participant.
- II: Self navigated camera: the task was performed with the dominant right hand while the camera was navigated by the participant's left hand.
- III: Fixed camera: the task was performed with the right hand while the camera was fixed in a standardized position.

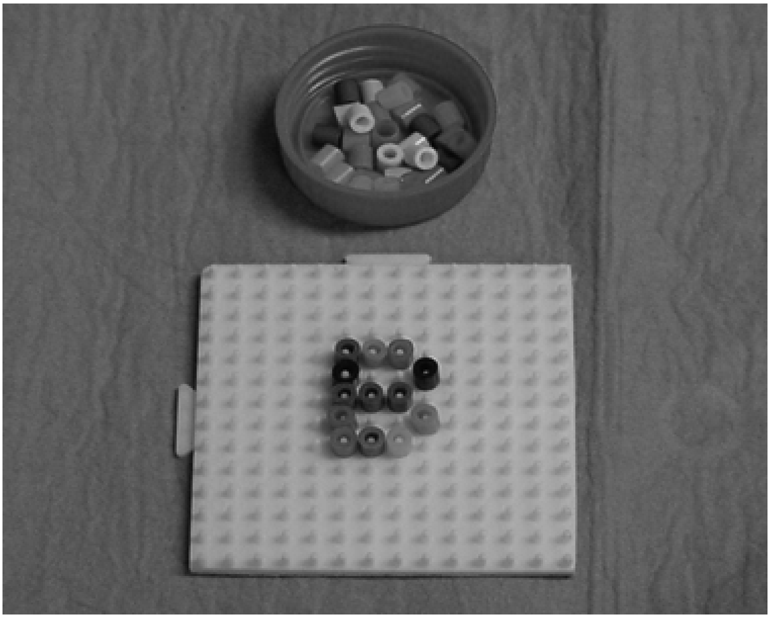


Figure 1. Beads placing task.

Randomization was done by using the website www.randomization.com, with an equal distribution of the participants to the three groups. Regarding setup III, camera navigation was performed only on demand, and always by the same assistant (NH). Possible commands were*: centre the work field, zoom in,* and *zoom out*. Instructions were given in advance.

Each participant performed the beads placing task eight times in order to gain insight in the learning curves over time with the different camera setups, instead of only comparing the performance at the start of the skills training. The eight trials were distributed over two sessions of four trials with approximately one week in between. This distributed training was chosen in order to prevent a worse performance due to fatigue.

Outcome measures

The movements of the tip of the laparoscopic grasper, used for picking up and transporting the beads, were tracked using a built-in tracking system, the TrEndo. The TrEndo, developed at the Delft University of Technology, allows realistic movements of the laparoscopic instrument in four degrees of freedom and real-time recording of the instruments movements [Chmarra et al., 2006]. Time (seconds) to a successful completion of the task was recorded and used as outcome measure. Additionally, two kinematic parameters were calculated using the recorded movements: the total path length (meters), and the motion in depth (meters). Total path length was defined as the total distance the tip of the instrument travelled, and motion in depth is defined as the total distance travelled by the instrument along its axis. The latter parameter was chosen as it might be indicative for a trainee's depth perception[Cotin et al., 2002].

Statistical analysis

Data were recorded and analysed in SPSS 16.0 software package (SPSS, Chicago, IL, USA). The time and the motion in depth were plotted for each trial. For comparison of baseline characteristics of the three groups, a Student t-test was used for normally distributed continuous variables, and a Pearson's Chi-square to test dichotomous data. A mixed design ANOVA was used in order to compare the effect of camera navigation setup and skills training. The model contained a between-subject factor for the difference in camera setup and a within-

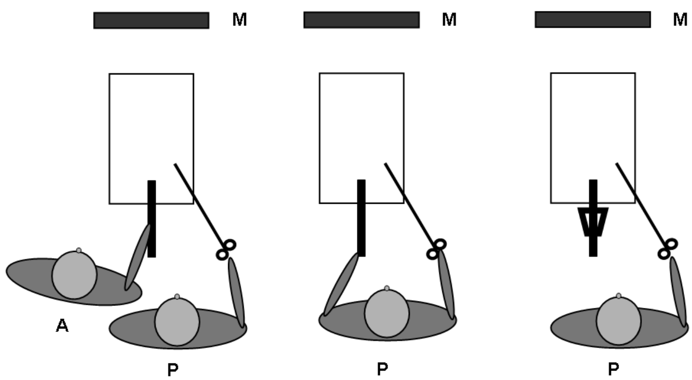


Figure 2. Study Design. I: Assistant navigated camera, II: Self navigated camera III: Fixed camera. (A = assistant, P = person, M = monitor).

subject factor for the repeated measurements (i.e. trials) for each participant. We determined the effects of these independent variables on the outcome measures time, path length and motion in depth. Bonferroni post-hoc tests were performed to determine whether there were significant differences between the trials. A p-value less than .05 was considered statistically significant, 95 per cent confidence intervals (95%CI) were calculated.

RESULTS

In total, 69 right-handed novices were enrolled in the study. None of them had prior surgical experience. They were equally distributed among the camera setups: a self-navigated camera (n=23), a researcher-navigated camera (n=23) and a fixed camera (n=23). They all completed the entire study protocol of eight trials. Among the participants, 21 were male and 48 were female, 15 among them did frequently play video games. No variance with respect to these parameters was observed among the three groups. Also with respect to self-perceived dexterity, participants had been equally distributed among the three groups.

The box plots for each of the three camera setup groups are displayed. (Figure 3) Time, path length and motion in depth improved for all three groups of participants within the eight trials ($p<.001$ for all three parameters). Post-hoc testing showed that the performance significantly improved in the first three trials but that performance was about equal for the following trials.

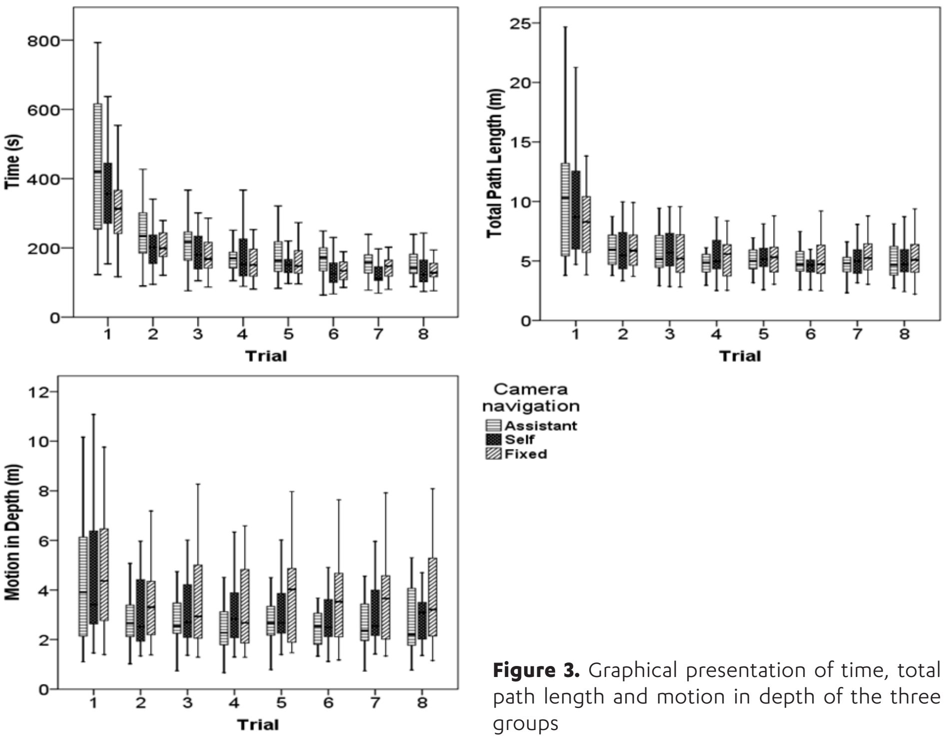


Figure 3. Graphical presentation of time, total path length and motion in depth of the three groups

The camera setup was not a significant factor. Despite this lack of difference of camera setup on performance, the group with the assistant navigated camera tended to need more time for completion of the task during the first trial than the group with the self-navigated and the fixed camera position. Additionally, the motion in depth tended to be longer for the fixed camera group during the last four trials than for the other two setups. In other words, the fixed camera group tended to travel a longer path along the instruments axis.

DISCUSSION

The camera setup does not influence the performance of a task requiring hand-eye coordination, with respect to time, path length or motion in depth. As a result, the hypothesis is not confirmed that a fixed camera position compromises depth perception.

However, motion in depth tends to be longer in the fixed camera group compared to the self- and the assistant navigated camera group during the last four trials. Therefore, it is possible that the camera setup plays a role during basic laparoscopic skills training, although this was not apparent from our study. It has to be considered that the beads placing task is relatively simple. Repetitive movements from the basket to the pegboard have to be carried out. Possibly, this has helped all groups to correctly interpret the 3D operation field. On the other hand, it is a validated task in which proper hand-eye coordination is of utmost importance, because every bead should be placed in the exact indicated position, without causing the beads already placed to fall over. As a consequence, this task seemed appropriate for answering our research question. Maybe, an influence of camera navigation setup will be revealed during more complex tasks, like intracorporeal knot tying. That is in accordance with the findings of Omar et al. who proved that a better monitor stance leads to more improvement in performance of more complex tasks [Omar et al., 2005].

Inherently to the absence of difference between the three groups, no difference was observed between camera navigation by the trainee and by an assistant. However, a tendency was present that the participants whose camera was navigated by the assistant required more time during the first trial. A theoretical explanation is that the participants needed time to instruct the assistant, combined with getting familiar with the exercise.

In laparoscopy, a surgeon needs to be proficient in camera navigation and in giving clear instructions to the assistant who navigates the camera. In both ways he should be able to interpret the 3D operation field. As a consequence, it is worthwhile to train camera navigation skills in a simulator setting. A box trainer model and a virtual reality trainer both have been validated and found to be effective training tools for that purpose [Bennett et al., 2011; Korndorffer, Jr. et al., 2005b]. Despite the importance of being able to perform surgery with a navigated camera system, also standards are being used in order to fix the camera position. The major advantage of a standard is the stability of the view. The decision for a system will depend on the surgeon’s preference and the required changes of the operation field during a procedure. For example, during a long lasting laparoscopic nephrectomy the required stability of the image may outweigh the need to change the camera position frequently, whereas it is the other way around during the laparoscopic removal of an adnexal cyst.

In conclusion, the influence of camera navigation is either absent or too small to be observed during a basic laparoscopic skills task. A fixed camera setup allows solitary training without clearly compromising depth perception, while training with a navigated camera will lead to enhanced navigation skills, and to training of communication skills with an assistant. Therefore, both ways of training have their own benefits and from a clinical point of view the combination seems superior.