Can Multi-Sensory Feedbacks Improve Laparoscopic Surgery Training?

Ninon CANDALH-TOUTA, Philippe POIGNET and Jérôme SZEWCZYK
ISIR - UMR 7222, Paris, France.
4 Place Jussieu - CC 173 - F-75005 Paris - Tel : +33 (0)1 44 27 62 09
Contact: candalh-touta@isir.upmc.fr

Laparoscopic surgery becomes a standard for many surgical procedures. Unfortunately for the surgeon and the student in medical school, this surgery is imparted with multiple problems. Students have to train outside of the operating room and the set-up is not giving enough information to the student and the teacher to have an efficient training. We expose in this paper a solution to improve these training sessions with the use of in-line multi-sensory feedbacks.

1 Introduction

Figure 1: *Laparoscopie Surgery Training scene*

Laparoscopic Surgery is a minimally invasive surgery of the abdominal region [1]. This type of surgery comes with mechanical, ergonomic and vision problems as lack of depth perception, a poor hand-eye coordination, an alteration of haptic feedback, a reduction of the movement to four degree of freedom, a fulcrum effect and musculoskeletal pains ([2][3]) which are both met by the surgeon and the student in medical school.

At the beginning of the training students can train outside of the operating room (OR) on simulators (pelvi-trainer (Figure 1) or virtual reality simulators). They repeat simple gestures or exercises defined by the *fundamental of laparoscopic surgery* program [4] until performing smooth and accurate movement. Unfortunatly, these training sessions are not sufficient and not effective enough because students miss time to train and there is no real active guidance from the teacher who can give only verbal advices. Furthermore, they cannot apply experts strategies due to the many problems and information that they have to deal with simultaneously. Additionally, the set-up and the practicing conditions cause musculoskeletal pain to the students.

We noticed that the training set-up is one of the major issues of the learning process. We proposed to improve it with the use of in-line multi-sensory feedbacks.

2 How can we improve the set-up?

2.1 Context

Because of a difficult training, a risk for the student is that he/she learns wrong gestures and bad postures. The teacher can correct the student and teach him the right way to do it but cannot instantaneously evaluate the performance quantitatively and automatically. By providing instantaneous information feedbacks, we could make the student more autonomous and reactive when practicing.

In [5], the authors make use of visual and tactile feedbacks to guide the gesture of the subject. The study showed that the use of a sensory feedback improved the performance in term of time and precision. This result, among others ([6][7]), incited us to study the use of multi-sensory feedbacks during a training program.

2.2 Protocol

Twelve novice subjects in laparoscopic surgery followed a training week on pelvi-trainer with daily sessions of 20 minutes.

They realized a cutting task from the *FLS* program. Only one information is provided to the students: the deviation of the tip of the instrument regarding the circle.

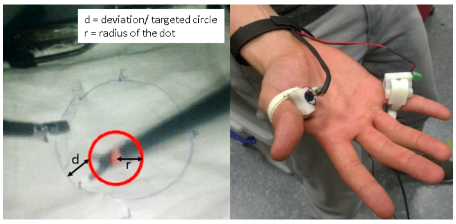

Figure 2: *left: visual feedback (r proportional to d); right: tactil feedback (2 vibrors)*

Students were divided into 4 groups:

- Control group (CG): no feedback;
- Visual feedback group (VG)(Figure 2, left): a moving color dot following the tip of the instrument: green when the tip is on the circle, red when it is inside and yellow when it is outside. The radius of the dot is proportionnal to the deviation;
- Tactile feedback group (TG)(Figure 2, right): two eccentric rotating mass motor (Precision microdrivesTMPico Vibe 307-100) strapped to the inner side of the thumb (external deviation) and little finger (internal deviation) of the hand holding the scissors. The amplitude of deviation is proportionnal to the deviation;
- Tacile-Visual feedabck group (TVG): both feedbacks.

At each session, the students started with a try without any feedback to define the baseline of the day, then continued with one or two tries with the feedback (VG, TG, VTG) and finished by one try without feedback for building the learning curve.

Subjects also responded to a questionnaire on the performance with and without the feedback: did the feedback help or disturb the performance? Did it help to better understand the task?, etc. The response was given by a number between 1 (strongly disagree) and 5 (strongly agree).

Total time (t), number of movements of the scissor hand, amplitude of deviation (AD), incorrected resected area (IRA) and result of the questionnaires have been evaluated.

The AD and the IRA were determined by post-processing of the compresses (figure 3).

Subjects were asked to be fast and precise. That is why we defined a score that regroups the total time, AD and IRA (1). The average scores (t_0, AD_0, IRA_0) of the first trials for all the subjects served as a reference value for normalizing the data.

$$score = \frac{t_n + AD_n + IRA_n}{3} \quad (1)$$

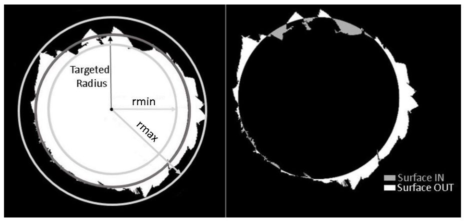

Figure 3: *left: AD=(60-2*r_{min})+(2*r_{max}-60) ; right: IRA =S_{in} + S_{out}*

2.3 Preliminary Results

Preliminary results show that there is an improvement in performance across all groups, each score decreases (figure 4). Nevertheless, even if TG is the best at the end, the differences between the groups are not statistically significant to infer if the feedback helps during the training. Moreover, if we look at the score of the tries with feedbacks, VG was the less accurate. This can be explained by the fact that the feedback disturbed the subject. Indeed, we got an average subject answer of 4 to the question "did the feedback disturb?" whereas the tactile group answered 1.8 on average.

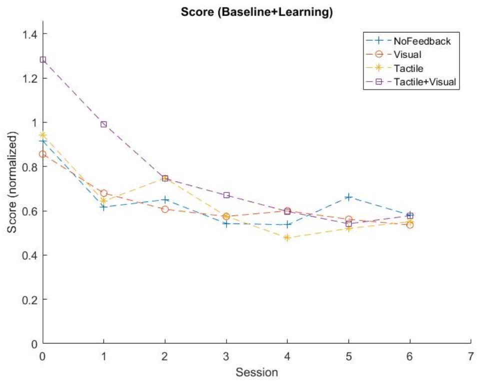

Figure 4: *Score on the average of the baseline and learning tries*

3 Conclusion

We were not able to conclude on the relevance of using multi-sensory feedbacks during the training of laparoscopic surgery because of a too highly cognitive load task, an inappropriate visual feedback and inhomogeneous groups.

We proprose to remake the protocol on a different task. We design a virtual trajectory that the subjects have to follow. There will be 3 groups. The visual group will have the trajectory display on the screen and the tactile group will have vibrations when the tip of the instrument deviates from the trajectory. The feedback will be on demand.

We hope that, with an easier task and better design of the feedbacks, we would be able to observe differences between groups.

References

[1] Westebring-Van Der Puten, E. P., Goossens, R. H. M., Jakimowicz, J. J. and Dankelman, J. (2008). Haptics in minimally invasive surgery - a review. *Minimally Invasive Therapy and Allied Technologies*, 17(1), 3-16.

[2] Xin, H., Zelek, J. S. and Carnahan, H. (2006). Laparoscopic surgery, perceptual limitations and force: A review. *First Canadian student conf. on biomedical computing*, (Vol. 144).

[3] Hemal, A. K., Srinivas, M. and Charles, A. R. (2001). Ergonomic problems associated with laparoscopy. *Journal of endourology*, 15(5), 499-503.

[4] FLS Manual Skill Written Instructions and Performance (2014). Fundamentals of Laparoscopic Surgery. *(http://www.flsprogram.org/wp-content/uploads/2014/03/ Revised-Manual-Skills-Guidelines-February-2014.pdf)*

[5] Howard, T. and Szewczyk, J. (2014). Visuo-haptic feedback for 1-D Guidance in laparoscopic surgery. *5th IEEE RAS/EMBS International Conference on Biomedical Robotics and Biomechatronics*, (pp. 58-65).

[6] Botden, S. M., de Hingh, I. H. and Jakimowicz, J. J. (2009). Suturing training in augmented reality: gaining proficiency in suturing skills faster. *Surgical endoscopy*, 23(9), 2131-2137.

[7] Van Der Linden, J., Schoonderwaldt, E., Bird, J. and Johnson, R. (2011). Musicjacketcombining motion capture and vibrotactile feedback to teach violin bowing. *IEEE Transactions on Instrumentation and Measurement*, 60(1), 104-113.