Our Early Experience Concerning an Assessment of Laparoscopy Training Systems

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Abstract. This papers describes the use of professional, commercial laparoscopic simulators to create a database of training results achieved by several groups of participants. The aim of this project was to create a common parameter database for two devices (LapSim and eoSurgical) to evaluate the trainees' performance. In order to deepen the statistical analyses and to draw conclusions, it is useful to identify additional parameters concerning the experience for the subjects studied. Such parameter will help to further evaluate training effectiveness.

Keywords: Simulation laparoscopic training assessment
Virtual reality · Laparoscopic surgery training · Endoscopic techniques

1 Introduction

Over the last decade, the ViMed laboratory at Wroclaw University of Technology has built a training curriculum for laparoscopic surgeons [4,14–16]. Numerous training sessions have been conducted with surgical residents, students and specialist surgeons. Using a combination of Virtual Reality-based, commercial simulators and pelvi-trainers, a training program along with scoring methods has been developed.

Laparoscopic surgery (one of most common minimally invasive procedures) has been in development since the 1980s and is currently the gold-standard in many operations, and is being introduced in new procedures [3]. Along with the obvious benefits to the patient, it is very demanding on the operating surgeons

R. Moreno-Díaz et al. (Eds.): EUROCAST 2017, Part II, LNCS 10672, pp. 372–379, 2018.
https://doi.org/10.1007/978-3-319-74727-9_44

and requires additional skills, which have not been developed as part of the classical surgical training in the past.

Several works have already confirmed the value of applying Virtual Reality (VR) based training at an early stage of laparoscopic education [5,6,9]. The work described in this paper relates to these findings.

2 Laparoscopy Training and Simulation Requirements

Laparoscopic surgery has far more advantages than conventional surgery when performed by professional surgeons. They minimize the complications associated with postoperative pain, blood loss, and scarring on large incisions. Its use allows the patient to return to home very quickly without any major complications. No sense of touch and limited movement in the work area require good hand eye coordination. This is a difficult technique that requires a lot of exercise to minimize the risk of surgery and prevent errors. The most important activities in a laparoscopic simulation laboratory consist of:

- Training using simulators.
- Development the techniques to improve outcomes.
- Enhancement of the assessment techniques.
- Development of devices that improve training outcomes.

Teaching on simulations and performed on laboratory models, offers trainees the opportunity to gain hands on experience in a non-patient based setting. New technologies, provide opportunities for introducing new, realistic training approaches. For instance, the effects of reconstruction algorithms for 3D scene based on images from the camera for operational training [7] are now research in the context of simulated medical environments. The key element of the system is a new approach to training [9], in which a 3D model of the operative field is the basis of the interaction between the trainees (veterinarians and surgeons) in the simulation system.

Using simulators, we can explore how to stimulate their effectiveness in training professionals and students and the effectiveness of the methodology used to perform the procedure. Considering the two phases of learning:

- basic skills learning,
- study of specific procedures,

we can distinguish the main activities of training for specialists as follows:

1. creating scenarios and roles,
2. training using simulators, without supervisor,
3. training with the supervision of a specialist,
4. review of obtained results and evaluation of training.

Concerning the last activity, the main features of the evaluation include:

- **WHAT** Score, Left/Right Instrument Path Length (m), Left/Right Instrument Angular Path (degrees), Left Instrument Outside View (number), Left Instrument Outside View (s),

– **WHERE** Left/Right Instrument Outside View (number), Left/Right Instrument Outside View (s),
– **WHEN** Total Time (s).

Comparative studies which investigate which instructional design features are especially important regarding to the specifications of learning objectives, learning groups and learning environments, are well justified.

For now, in the world of science, there are few publications that compare simulators for the acquiring basic skills of laparoscopic surgery. Because of that, the general aims and goals of our work was:

– What parameters are necessary to better analyze surgeon experience.
– How to incorporate all the training mechanisms required for the Fundamentals of Laparoscopic Surgery (FLS).
– How to design of metrics that will analyze better the performance of a trainee.
– How the simulators need to be modified for various levels of advancement of the student?

3 Specific Background

One of the areas of research during the period of the last ten years in the ViMed laboratory at Wroclaw University of Science and Technology has been the application of virtual methods for laparoscopic surgery training [7,10,14,16]. The number of surgical advanced procedures using endoscopic techniques is growing steadily. As mentioned in the section above, endoscopic surgery requires special skills which are difficult to acquire in an operating room [3,11]. The simulation teaching performed on laboratory models offers opportunity to provide hands on experience. In addition, discussion has been made on effects of reconstruction algorithms for 3D scene based on images from the camera for operational training [8]. A key element of the system is a new approach to training [13], in which a 3D model of the operative field is the basis of the interaction between the trainees (veterinarians and surgeons) and simulation system. Presentation and discussion of the outline of the 3D processing algorithm and the results of a test for a group of 16 veterinary physicians and 20 surgeons is established. The tests were conducted on LapSim (http://www.surgical-science.com/lapsim-the-proven-training-system/) and eoSim SurgTrac (http://www.eosurgical.com/) simulators. The number of parameters assessed were 22 and 21, respectively.

1. LapSim - 22 parameters: Start Time, Score, Status, Total Time (s), Left and Right Instrument: Misses (%), Path Length (m), Angular Path (degrees), Outside View (#, s); Tissue Damage (#), Maximum Damage (mm), Grasper Collided with Left Box (#), Left Box Lifted (#), Left Box Min Exposure Angle (degrees), Grasper Collided with Right Box (#), Right Box Lifted (#), Right Box Min Expo-sure Angle (degrees).
2. eoSurgical - 21 parameters: time, left and right hand appliance of: distance between(cm), acceleration(mm/s2), distance(m), handedness(%), off screen(%), smoothness(mm/s3), speed(mm/s).

The quality of the training evaluation was very important, from our experience in the areas of performance assessment in computerized surgical training systems [12], as well as the assessment of education process management [1,2], along with additional methods developed in other centers [6,9].

4 ViMed - Center for Virtual Medical Technologies

Laboratory Programming Interfaces and Modeling Lab at the Faculty of Electronics of Wroclaw University of Science and Technology had been in operation for over a decade. In 2012, the laboratory became the Center of Virtual Medical Technology (http://vimed.pwr.edu.pl/). Since then, we prepared work on the applications, the latest research in the field of information technology, automation and robotics in the medical field. The basic aim is to use virtual reality to conduct simulated laparoscopic surgical operations for training purposes. The current scope of activities of the laboratory is:

– Modeling and simulation of laparoscopic operations;
– Wireless Sensor Networks (WSN);
– Modeling and recognition of human gait; and
– International project teams "7/24".

Students in the Medical University of Wroclaw utilize the lab in semester-long classes hone their skills in the theory and practice of laparoscopic surgery.

The main goals of such training are as follows:

– to learn the basic skills on simple simulators with the measurement of progress
– to re-train practicing surgeons after an extended leave of absence

5 Experiments and Performance Exercise

The objective was to assess the effectiveness of the course conducted on an animal model to improve the manual skills of surgeons performing endoscopic procedures. The rating was carried out before the course and after its completion. The conducted research consisted of 3 experiments among 2 groups of trainees. In total, 32 people were involved: males and females, between 17 and 33 years of age.

The first experiment was conducted during laparoscopic training for expert surgeons that took place at the Wroclaw University of Environmental and Life Sciences in September 2016. A total of 16 people underwent the training, which consisted of lectures, training on live animals under anesthesia and training verification using the LapSim surgical simulator. In order to objectively verify the results of training, every trainee had executed a set of exercises in the simulator before and after the training on live animals. The exercise set was comprised of:

– Instrument Navigation - touching a simulated gallstone 5 times with each hand
– Clip Applying - stretch the vessel to apply a clips, put a clip to two highlighted areas and cut vessel with scissors
– Grasping - stretch the object and move the object to the target - 5 times for each hand.

The results of the experiment are recorded in Table 1.

Table 1. Laparoscopic training on LapSim simulator for 16 expert surgeons.

	[I N]		[L & G]		[C A]	
	Aver.	Var.	Aver.	Var.	Aver.	Var.
Score	77	15	74	15	67	27
Total time (s)	48	20	158	40	221	153
Left instrument path length (m)	1	0	3	1	2	2
Left instrument angular path (degrees)	182	60	622	206	483	343
Right instrument path length (m)	1	0	3	1	3	2
Right instrument angular path (degrees)	208	52	621	169	533	323
Left instrument outside view (#)	0	0	11	7	1	1
Left instrument outside view (s)	0	1	13	9	7	13
Right instrument outside view (#)	0	1	8	6	1	2
Right instrument outside view (s)	0	1	4	1	3	5

The second experiment has been conducted among a group of 16 students of the Wroclaw Medical University who had limited previous contact with surgery during theoretical courses and internships. Firstly, the group had been trained

Table 2. Laparoscopic training on eoSurogical simulator for 16 student surgeons.

n = 16	17 September 2017			20 September 2017		
	Aver.	Var.	Med.	Aver.	Var.	Med.
Total time (s)	175	75	173	74	25	67
Total distance between (cm)	6	1	6	6	1	6
Total acceleration (mm/s2)	1	1	1	1	0	1
Total distance (m)	5	7	2	1	0	1
Total speed (mm/s)	3	5	2	2	1	2
Left instrument acceleration (mm/s2)	1	0	1	1	0	1
Left instrument distance (m)	1	0	1	1	0	1
Left instrument handedness (%)	42	18	48	49	10	48
Left instrument outside View (%)	18	12	15	14	10	14
Left instrument speed (mm/s)	1	0	1	2	1	2
Right instrument acceleration (mm/s2)	1	2	1	1	0	1
Right instrument distance (m)	4	7	1	1	0	1
Right instrument handedness (%)	58	18	52	51	10	52
Right instrument outside View (%)	10	8	7	10	10	7
Right instrument speed (mm/s)	5	10	2	2	1	2

using the eoSurgical simulator and the Thread Transfer exercise, where a thread has to be passed through several loops using a laparoscopic instrument in minimal time. Table 2 gathers the results of the trainees in this group. Each of the trainees had repeated the exercise after three days.

After such preparation, the students were trained using the LapSim simulator and exercised using a set of tasks: grasping, clip application, and cutting. The results of this training session are gathered in Table 3.

Table 3. Laparoscopic training on LapSim simulator for 16 student surgeons.

	[Grasping]		[Cutting]		[Clip applying]	
	Aver.	Var.	Aver.	Var.	Aver.	Var.
Score	10	14	10	14	0	0
Total time (s)	189	78	189	78	225	127
Left instrument path length (m)	4	2	4	2	4	3
Left instrument angular path (degrees)	637	411	637	411	426	260
Right instrument path length (m)	2	1	2	1	4	3
Right instrument angular path (degrees)	539	303	539	303	609	513
Left instrument outside view (#)	2	1	2	1	5	6
Left instrument outside view (s)	1	1	1	1	5	7
Right instrument outside view (#)	1	1	1	1	3	4
Right instrument outside view (s)	1	1	1	1	12	21

6 Conclusions and Final Remarks

The results confirm that laparoscopy simulation training permits to learn the basic skills sufficiently in simple simulators and allows us to measure the progress. We also found that every laparoscopic surgeon after an extended leave should again test his or her skills in the simulator to determine the level of proficiency. The results show that the multiplicity of exercise has had a positive effect.

By contrast, reducing the time spent on exercises had a negative impact We are also expecting to increase significantly the size of our data base; this seems to be necessary to further develop our assessment system. The aim of the work was to create a common parameter database for different devices (here: LapSim and eoSurgical) to evaluate the exercise.

Our Vimed Laboratory is based on the experience of the ASTEC Laboratory (University of Arizona, Tucson, AZ, USA) and the Laboratorio de Simulacion y Formacion basada en Tecnologia (Universidad de Las Palmas de Gran Canaria, Spain) We plan to extend our cooperation with the Multimedia Network Lab (National Cheng-Kung University, Taiwan and the Remote Labs (University of Technology Sydney (Australia).

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