Influence of Proficiency on Eye Movement of the Surgeon for Laparoscopic Cholecystectomy

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Abstract. In this study, a training system of laparoscopic cholecystectomy combined surgical instrument simulation and eye movement analysis was established. The surgical tool usage also was recorded by video cameras during the whole training process. The eye track information and utilization information of surgical tool were provided to interns as a study reference. The expert's information also was showed to interns in order to make a comparison after practice. The system had been shown to be effective in a variety of practices.

Keywords: Eye movement · Laparoscopic cholecystectomy · Surgeon · Expert · Non-expert

1 Introduction

In the field of a surgical operation technology has been developing in recent years. Moreover, since the acquisition method of the technology in a surgical operation has the main system with "studies technique by seeing" it requires long time for an expert's training. Furthermore, when there is little an advising doctor's number, or when an advising doctor's instruction capability is low, it further delays during an expert's rearing period. Operation under laparoscopy has many advantages such as the point and duration of hospitalization because operative wound is smaller than a laparotomy and end are comparatively short. These reasons are mostly desired by the patient. Since it is necessary to do the operation by only the information acquired from the image of a laparoscope while making full use of a special machine and instrument to relian, the operation technique should have high difficulty, and then the operated should have advanced technique [1, 2]. Although it can also train by using a simulator for the technical acquisition method besides the method of "studies technique by seeing" in

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order to raise a level of skill, it is indispensable to train repeatedly and to gain much experiences [3].

In this research, eye movement measurement was performed for the process of the operation under laparoscopy to two or more persons. The knack of advanced technique was understood through numerical method and the difference in technology were evaluated, and it aimed at showing the influence of years of experience on eye movement by comparing the operation for the operators with different level of skill. The target operation was laparoscopic cholecystectomy. We decided to carry out under the same conditions using a simulator, and the subject was taken as two experts and one unskilled operator from which years of experience differ so that comparison between two or more subjects might be attained. According to the procedure in which it is most worked by the whole operation by actual laparoscopic cholecystectomy, it classified into five items and measured the factor about working hours and a view at each process. As a result, when its attention was paid to the gaze rate to the internal organs and the surgical instrument at the time of inserting a surgical instrument and a surgical instrument was inserted, the look of unskilled operator from operating part was separated in many cases. And the look was repeated frequently between internal organs and a surgical instrument from the start of an operation before the end. Therefore, it is in the tendency to require many working hours. On the other hand, the expert is gazing at operating part in most operation processes, even if he is a time of operating the instrument, a look does not separate him from the operating part. This is the reason of shorten working hours in well trained operated case.

It became clear from this result that the working hours of an operation differ greatly by the difference in operator level of skill.

2 Experiment

2.1 Participants

Three doctors who work at department of gastroenterological surgery from Shiga University of Medical Science were selected as experts and non-expert in this study. Among of them, three doctors were divided into two groups, two experts, and one non-expert. The non-expert (female, right-handed) had six years of clinical experience with 29 years old. One of experts (male, right-handed) had fourteen years of clinical experience with 36 years old. Another expert was 47 years old (male, right-handed), who had 22 years of clinical experience.

2.2 Experimental Process

The simulative surgery of laparoscopic cholecystectomy based on a virtual reality endoscopic surgical training simulator (LapVR, manufactured Gadelius Medical Corporation) was focused on this research. The training system of virtual reality endoscopic surgical training simulator was aim to provide a training platform for laparoscopic cholecystectomy surgery and cultivate user's basic skills, such as three-dimensional space cognitive ability, eye-hand coordination ability and monitoring both hands and

feet during endoscopic surgery. This system was consisted of 20 inches flat LCD monitor, haptic (tactile) devices, surgery forceps handle, and a camera. The camera illuminates the surgical location and sends a real-time picture from inside the body to the monitor, giving the surgeon a close-up view of the organs and tissues. The surgeon watches the monitor and performs the operation by manipulating the surgical instruments through the operating ports.

The characteristics of eye movement track during the whole training process were measured by eye movement measuring device with 60 Hz sampling frequency (Talk Eye, manufactured by Takei equipment Industrial Co., Ltd.). The experimental landscape of eye movement measurement was illustrated on Fig. 1.

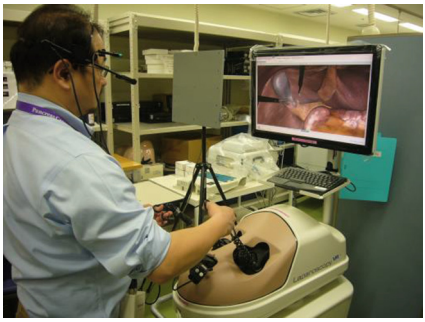


Fig. 1. Experimental landscape of eye movement measurement

2.3 Surgical Process

Laparoscopic cholecystectomy requires at least two small incisions in the abdomen to allow the insertion of operating ports, through which surgical instruments and the laparoscope camera are put into the abdominal cavity with around 30 degrees outward from patient's body (simulator).

The whole process of laparoscopic cholecystectomy surgery was divided into five steps as following:

(Step.1), Strip the cystic duct and cystic artery from the gallbladder neck.
(Step.2), Cut and clean cystic duct.
(Step.3), Cut and clean cystic artery.
(Step.4), Strip the gallbladder from the side cholecystopathy part.
(Step.5), Cleaning the operative field, (Based on procedural requirements).

Above surgical steps was the most popular procedure in the world based on clinical experience. The characteristics of working time and visual field for each step were measured in this research.

3 Results and Discussions

3.1 Results of Eye Movement

Both expert and non-expert's proportion time of gaze location during the whole process was illustrated in Fig. 2. According to Fig. 2, the gaze location focused the effective part of organs and surgical instruments were represented at black areas against time series. In case of non-expert, the gaze location was switched between organs and surgical instruments frequently during the whole surgery process. However, in case of expert, (An example of expert 2 was shown in Fig. 2), subject's gaze location didn't transform between target elements frequently.

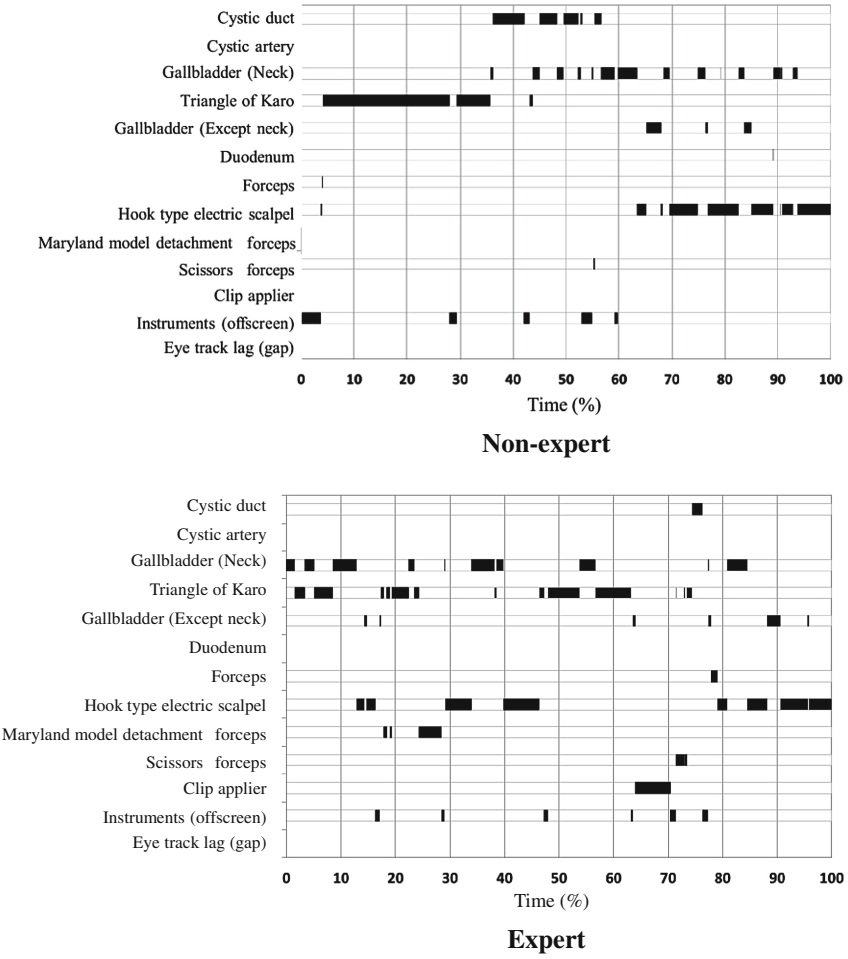
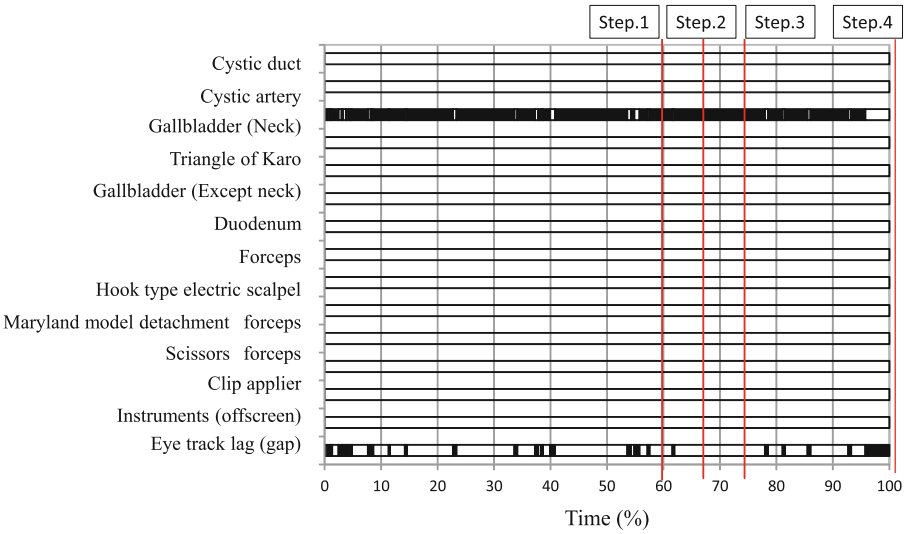


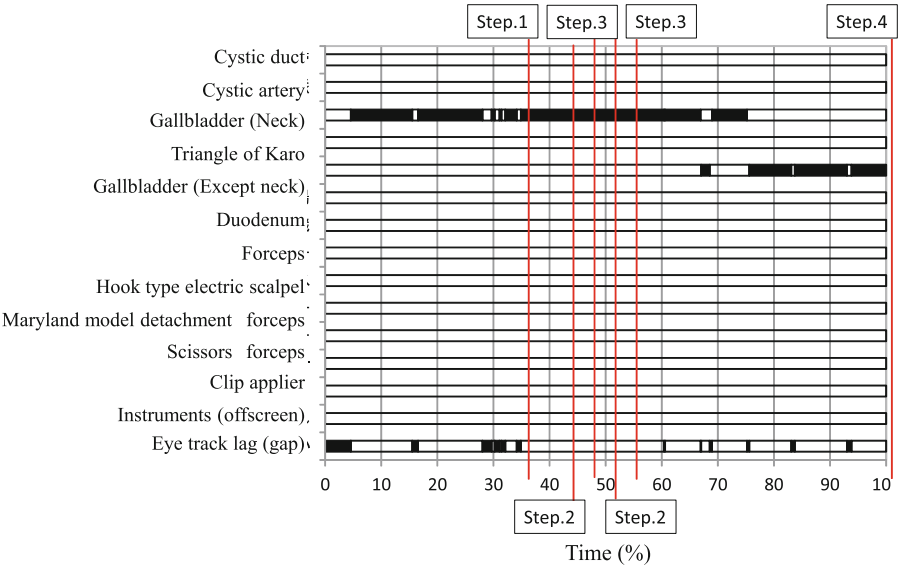
Fig. 2. Gaze location comparison between expert and non-expert

3.2 Results of Forceps Movement

The forceps movements also was summarized and presented at black areas against time series in Fig. 3. The forceps movement was defined as the moment of forceps touching organ while organ was occurring deformation according to image from eye movement's monitor.

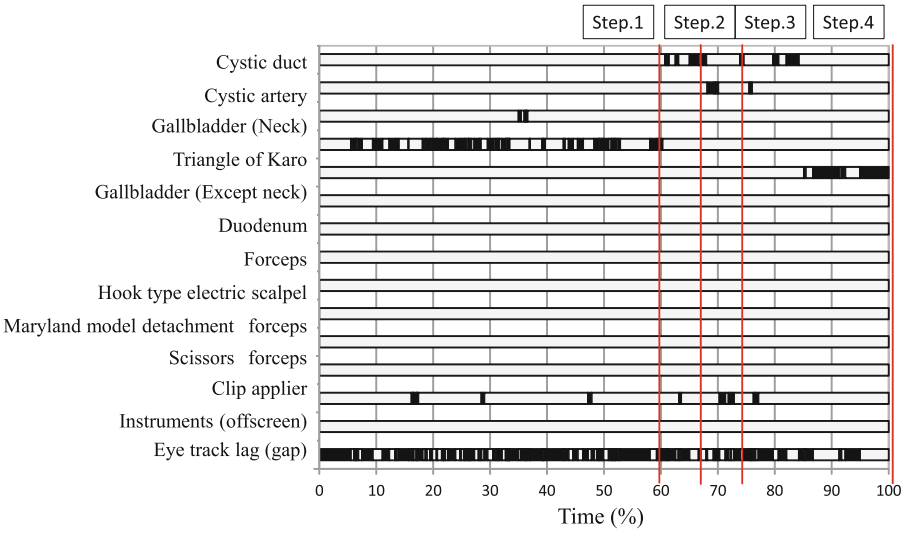


(a). Left hand forceps movement for non-expert

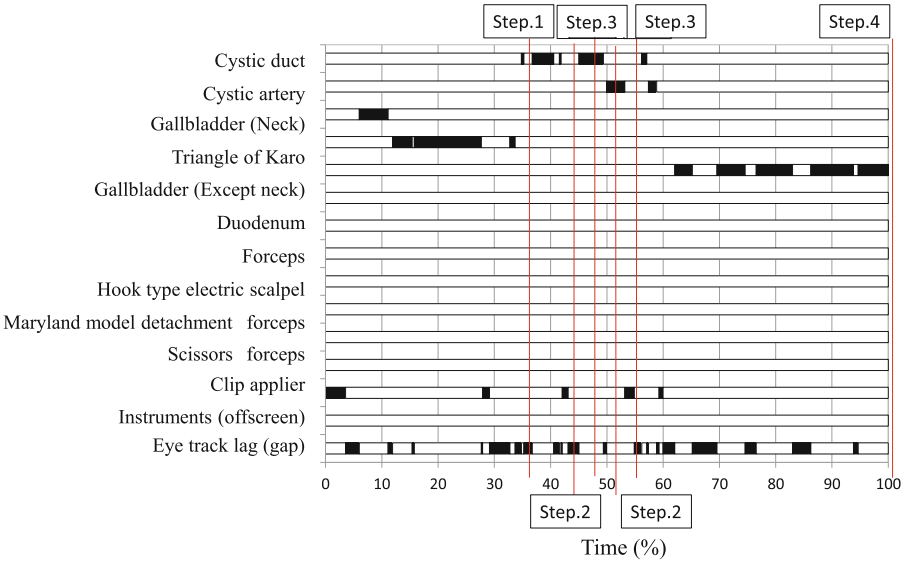


(b). Left hand forceps movement for expert

Fig. 3. (Continued)



(c). Right hand forceps movement for non-expert



(d). Right hand forceps movement for expert

Fig. 3. Forceps movement

The Fig. 3 was shown the characteristics of the forceps movements held on left hand and right hand between non-expert and expert 2. (Fig. 3(a), Non-expert, left hand; Fig. 3(b), Expert, left hand; Fig. 3(c), Non-expert, right hand; Fig. 3(d), Expert, right

hand). According to Fig. 3, normally, the gallbladder was clamped by left hand. The non-expert always clamped the gallbladder neck from step1 to step4. However, the non-expert clamped the gallbladder neck before the first half of stage4, afterwards clamped other parts of gallbladder. On the other hand, focused on right hand, the non-expert had unstable movements compared with expert. It was revealed that forceps held on right hand was always repeated or non-touch the organs during the whole process.

3.3 Collaboration Application of Eye Movement and Surgical Instrument

Additionally, the non-expert's sight always followed the surgical instruments. The eye move track focused the surgical instruments more than organs. However, eye move track of expert 2 main focused on the organs. Even eye movement track stop on organs when change surgical instruments. The expert will jump back to organs immediately.

4 Conclusions

In a word, the correct way of eye movement focused on five steps was clarified in this paper, which had a great influence on the whole process of laparoscopic cholecystectomy. The eye move way of expert can provide a reference, which had been suggested to be effective in the early learning process of laparoscopic surgery. Further work on collaboration application will comprise based on greater amounts of data of eye move track and surgical instrument movement, the achievement of training improvements in order to establish a effective teaching and learning system.

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