Simulation of a Laparoscopic Major Vessel Injury in a Live Animal Model

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ABSTRACT

Objective: Iatrogenic injury to major vessels is a rare but potentially life-threatening complication during laparoscopic hepato-pancreato-biliary surgery. This experimental study aimed to assess the usefulness of an *in-vivo* animal model for the management of such injuries.

Methods: During three editions of advanced live animal laparoscopy courses 12 participants were exposed to 19 intraoperative iatrogenic vessel injuries. The participants were free to control the bleeding using maneuvers of their choice. The participants' heart rate was measured, and their movements were video recorded. The study was evaluated by all participants using a Visual Analogue Scale at the end of the course.

Results: Temporary vessel control was obtained in all cases. One animal died due to relapse of bleeding. Heart rate (HR) of participants ranged from 52 to 97 per minute before the task and from 75 to 120 per minute during the task. Eleven participants gave this exercise a 5/5 score and one gave it a score of 3/5. The HR was higher in experienced surgeons vs. inexperienced residents although this difference did not reach statistical significance.

Conclusion: *In-vivo* pig and sheep model can be used for training in major bleeding control during HPB surgery. It is highly appreciated by trainees. It seems that stress level during advanced exercises is higher in experienced surgeons than in beginners.

Introduction

Iatrogenic injury to major vessels with the ensuing bleeding is a rare but potentially life-threatening complication during laparoscopic major HPB surgery. The most commonly injured vessels are aorta, the iliac vessels, and the inferior vena cava [1]. Contrary to traditional approach suggesting immediate conversion to open surgery it is suggested nowadays that this kind of injury and bleeding should be approached laparoscopically [2]. An obvious requirement for such an approach is an appropriate training [3]. Advanced laparoscopy training currently includes box-trainers [4], virtual reality training [5], live animal training [6] and training that combines all of the above [7]. Unfortunately, the majority of training modalities in laparoscopy concentrate on purely technical

knowledge not considering psychological burden of a major intraoperative disaster. While obtaining and maintaining technical skills is clearly important [8] the possibility of testing these skills in a stressful environment imitating operating room disaster could be the way to prepare surgeons to adequately react to the unexpected [9]. In this study we have tried to create an environment as similar to real life laparoscopic disaster as possible and observe trainees' reactions and their ability to use technical skills to control the situation.

Materials and Methods

During three editions of advanced laparoscopic training course 12 participants faced a task of controlling a major vessel damage. Training course was designed for both experienced surgeons and novices in advanced laparoscopy. Each course lasted for two days. At the beginning of the first day the tutors explained the methods of laparoscopy bleeding control with a video footage. Each day of the course there were 7 hours of live animal laparoscopy training. The first part of the training was designed to achieve technical abilities in various steps of advanced laparoscopy procedures depending on the level of experience of each participant. In the second part of the training during the last 60 minutes of each day the participants were exposed to iatrogenic injury of a major vessel performed with an electrocautery on an area of approximately 1cm and were asked to control the bleeding and repair the damage. During these maneuvers their Heart Rate (HR) was monitored, and their reactions were video recorded. After successfully completing the task and if time permitted the same animal was used for another iatrogenic injury with another participant operating. Animals used for training were pigs and sheep. During the whole procedure the animals were taken care of by an experienced veterinary anesthesiologist. At the end of each course participants were asked to evaluate their experience in controlling the bleeding in a stressful environment using Visual Analogue Scale from 1 (very bad experience with no value for training) to 5 (the best type of training one can imagine).

Results

Altogether there were 19 episodes of iatrogenic injury in 10 animals controlled by 12 participants. One animal died after exsufflation due to relapse of bleeding after non-complete hemostasis. There were no conversions to open procedure. Temporary vessel control was obtained with a grasper, gauze, intraabdominal pressure elevation or temporary clip application. For final hemostatic purposes participants used Vicryl 2.0 or PDS II 3.0 suture. Heart rate of participants before the injury, during the repair and after obtaining a haemostasis is shown in Table 1. HR ranged from 52 to 97 per minute before the task and from 75 to 120 during the repair of injury. There was a tendency towards higher HR values before and during the task in experienced surgeons than in novices although this difference did not reach statistical significance. When evaluating this approach to training in disaster control eleven participants gave the exercise 5 points on a VAS scale and one participant gave it 3 points resulting in a total of 4.8 points for the whole group.

Table 1: Changes in participants' heart rate before, during and after the vessel injury.

Participant #	HR before Injury	Immediately after the injury	After Obtaining Full Bleeding Control
1	78	102	90
2	67	107	100
3	85	120	78
4	84	112	87
5	78	85	77
6	65	92	57
7	85	117	61
8	55	89	78
9	65	112	99
10	52	75	50
11	61	82	83
12	68	108	98
13	70	99	100
14	98	106	82
15	82	108	86
16	87	97	82
17	97	104	100
18	79	98	90
19	86	100	98

Discussion

With growing number of advanced laparoscopic HPB surgery worldwide there is a clear need for a structured laparoscopy training [3]. In order to prepare surgeons for these demanding procedures a variety of simulation models have been proposed so far. Advanced laparoscopy techniques can be taught in a simple box-trainer. The box trainer however, apart from giving the opportunity to learn purely technical skills is much less effective in preparing for conditions in real life surgery [4]. A Virtual Reality (VR) training offers interesting approach to teaching without the need for the use of animal tissue and creating close to real life conditions. Unfortunately, at its current level of performance, it does not meet expectations. No additional benefit is observed from VR training in a multimodality laparoscopy training program [5]. A very interesting model with perfused pig liver can simulate almost life-like conditions [7]. It is one of the few training modalities to offer trainees a highly simulated bleeding in order to acquire advanced laparoscopic suture skills and train under the pressure of bleeding [10]. The setting of such a training modality seems however too complex to be widely used for teaching laparoscopy. Also, contrary to the model described herein it does not offer the trainee the possibility to observe the effect of bleeding on a general status of the patients, concentrating only on the bleeding itself. In this sense, it seems closer to a box-trainer concentrating merely on a technical control of bleeding without the stress of observing worsening vital signs that clearly simulates real-life disaster.

The closest to life experience can probably be achieved in live animal models [11]. It has been successfully used in creating a model for the intravascular treatment of IVC injury. In live anesthetized pigs after iatrogenic IVC injury a bleeding was controlled successfully by trainees using balloon insertion via femoral vein [12]. Live animal laparoscopy training using pigs has been shown to be useful in acquiring advanced liver laparoscopy skills [6]. While the benefits of this model over other approaches in teaching purely technical skills can be discussed it offers unique opportunity to create a simulation for a life-threatening intraoperative event. There are much less reports on the use of sheep as a model for advanced surgical training [12]. It is however known to be an interesting model for advanced colon resections [13]. During our study we have observed a higher level of stress measured as a rise in HR in more experienced trainees. While it was a bit surprising it can be explained by the fact that more senior surgeons are well aware of the potentially fatal complications of a major vessel injury during laparoscopy. Almost all participants including experienced and inexperienced surgeons agreed that this training modality was close to perfect in creating a stressful environment simulating real-life disastrous intraoperative event.

Conclusion

In-vivo pig and sheep models can be used for training in the management of major bleeding during HPB surgery. It is a modality that is highly appreciated by trainees. It seems that stress level during advanced exercises is higher in experienced surgeons than in newcomers.

Funding Statement

None.

Conflicts of Interest

All authors have no conflicts of interest to declare.

Ethical Statement

The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. Experiments were performed under a project license Reference code: 001/20/Cert granted by "The Ethics Committee in Animal Experimentation of the "Jesús Usón" Minimally Invasive Surgery Center", in compliance with compliance with existing laws for the use of experimental animals (Royal Decree 53/2013, of February 1st)" for the care and use of animals.

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