



Trainee Factors Influencing Initial Performance in Single Incision Pediatric Endoscopic Surgery Simulation Training

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Abstract

Background: Studies of multi-port laparoscopy training have revealed multiple trainee factors exist that influence various components of simulated laparoscopy. Thorough identification of trainee factors influencing initial Single Incision Pediatric Endosurgery (SIPES) aptitude, and thus training requirements, has not been performed.

Materials and Methods: Performance during simulated single incision laparoscopic cholecystectomy was assessed in 12 participants. Total time for the procedure, path lengths of the instruments, economy of movements, minor and major adverse events were measured. Factors assessed by multivariate analysis for effects on performance were: age, gender, the approximate number of previously performed multiport laparoscopic surgeries, years of clinical experience doing multiport laparoscopic surgeries, previous multiport laparoscopic simulator training, and expertise in console gaming.

Result: Among assessed factors, male gender ($p=0.0072$), video game expertise ($p=0.0291$), and higher age ($p=0.0357$) correlated with overall performance. Previous laparoscopic simulator experience ($p=0.0904$) non-significantly correlated with simulated SIPES cholecystectomy execution. Comparing individual outcomes in males versus females, number of errors was significantly higher in females ($p=0.0431$), whereas time, path length and economy were not different between groups. Individual outcomes were not different comparing expert video gamers vs. non-expert gamers and comparing participants 30 years and older to participants below 30 years, respectively.

Conclusion: Gender, video game experience, and age affect performance of simulated single incision surgery.

Keywords: Single incision surgery; Pediatric; Simulation; Training factors

Introduction

Single incision pediatric endoscopic surgery (SIPES) describes an emerging endosurgical approach where the surgical procedure is performed through an abdominal trocar placed *via* a single incision [1], providing a better cosmetic result by removing the need for multiple port insertions [2,3]. SIPES has been demonstrated to have comparable safety and efficacy to multi-port laparoscopic surgeries [2,4]. However, the steep learning curve has discouraged many surgeons from adopting SIPES procedures [5,6]. Moreover, emphases on trainee work hours and performance-based outcomes have restrained the ability of house staff to master certain skills. This is of importance because previous work in multi-port laparoscopy has shown increased complications in the early learning phase [6,7]. To solve this problem in all forms of laparoscopic surgery, laparoscopic simulators are increasingly used to train residents and shorten their learning curve.

Previous study of multi-port simulation training has revealed that not all trainees are equally prepared to utilize the training. Psychomotor aptitude [5,8-10], spatial awareness [5,9], and perceptual speed [10] are all negatively correlated with the time required to reach proficiency. Previous experience with multi-port laparoscopic procedures has been shown to improve learning of new multi-port procedures [11].

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Table 1: Participant's data.

Participant	Gender	Age (y)	Influence factors				Outcomes					
			Laparoscopic Surgeries	Clinical Experience	Lap. Sim Training	Game Level	Time (min)	Path Length (mm)	Economy	Minor Events	Major Events	Overall Score
1	M	31	250	3	No	Expert	7.8	21928	900	0	0	53
2	M	28	20	2	Yes	n.a.	16.5	19494	755	2	0	43
3	M	31	130	3	Yes	Expert	11.7	39527	1499	1	0	42
4	M	23	0	0	No	Intermediate	16.2	31609	1578	1	0	41
5	F	31	20	3	Yes	Intermediate	17.8	34058	1482	1	0	38
6	M	30	2	2	Yes	Expert	14.2	47121	1606	1	0	37
7	F	31	10	5	Yes	None	21.1	27751	1947	2	0	30
8	M	28	20	1	Yes	Expert	14.5	41160	1778	3	0	29
9	F	24	0	0	No	Intermediate	17.6	32074	1739	6	2	22.5
10	M	24	0	0	No	Expert	23.2	76082	3633	2	0	21
11	M	23	0	0	n.a.	Intermediate	29.2	150063	4893	1	0	20
12	F	23	0	0	No	None	35	118909	4655	6	0	13.5

Individual participants' data (assessed influence factors for multivariate analysis and measured outcomes including the calculated Overall score) are given. For the outcomes Time, Path Length, and Economy a lower number reflects a 'better' performance. M: Male; F: Female; n.a.: Not Assessed

Knowledge of the impacts of previous experience and factors is not well established within SIPES simulation training. Some data indicate that previous multi-port experience may improve SIPES performance, without showing statistical significance [12]. Since SIPES skills have been shown to be more difficult to obtain and more difficult to retain than multi-port laparoscopy [13], it is of particular importance to establish what attributes indicate that a surgical trainee may need intensive vs. standard training opportunities.

The present study aimed to evaluate trainee factors correlating with performance in single incision surgery. Hence factors such as past laparoscopic experience, proficiencies console gaming; gender, age, and training level were correlated with simulated SIPES cholecystectomy.

Materials and Methods

Setting

All study participants attended the same presentation on the basics of SIPES and gallbladder anatomy a few hours prior to the study. Questionnaires investigating participant attributes were distributed. Participants were given a set amount of time to practice single incision peg transfer and rope tracing prior to evaluation. Total time, path length, and economy of movement during the simulation were calculated by the laparoscopic simulator (Simsei Organ Models and Skill Exercises from Applied Medical) (Figure 1a and 1b). Minor and major events were counted by one non-blinded author of the present study (RNV).

Outcomes

Five different metrics were assessed during the study:

- (i). Total time to perform the procedure (Calot's triangle dissection, cystic duct and artery clipping and ligation, and gallbladder removal)
- (ii). Total path length
- (iii). Economy of movement (with a lower number being 'better')
- (iv). Number of minor events during surgery
- (v). Number of major events during surgery.

Events were considered minor when they could be easily corrected or repaired during real-time procedure, e.g. bile spillage, stone spillage, laceration of the cystic artery. Events were considered major if they could not be easily corrected during real-time cholecystectomy and included lacerations to the left hepatic artery or common bile duct injuries (Table 1).

Analysis

The following factors were assessed by multivariate analysis for effects on performance: age, gender, the approximate number of previously performed multiport laparoscopic surgeries, years of clinical experience doing multiport laparoscopic surgeries, previous multiport laparoscopic simulator training, and expertise in console gaming. Participants' performances on the five-different metrics were independently ranked from best performance to worst. Thereafter the five rankings were added, creating one single ranking. This final ranking, considered an overall score, was used for multivariate analysis.

For the three outcomes affecting overall performance score (gender, age, and proficiency in console gaming), individual outcomes (total time, path length, economy, and number of errors) were compared between groups. Participants' proficiency in console gaming was divided into experts and non-experts for comparison. Since the median age of all twelve participants was 28 years, participants were divided arbitrarily in the two age groups ≥ 30 years and <30 years. Furthermore, numbers of minor and major events were summed for analysis, with major events counting double.

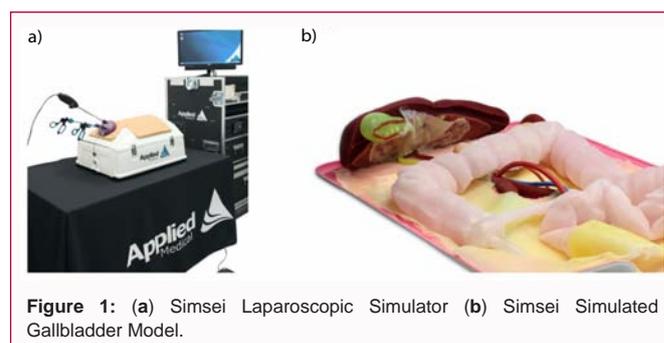


Figure 1: (a) Simsei Laparoscopic Simulator (b) Simsei Simulated Gallbladder Model.

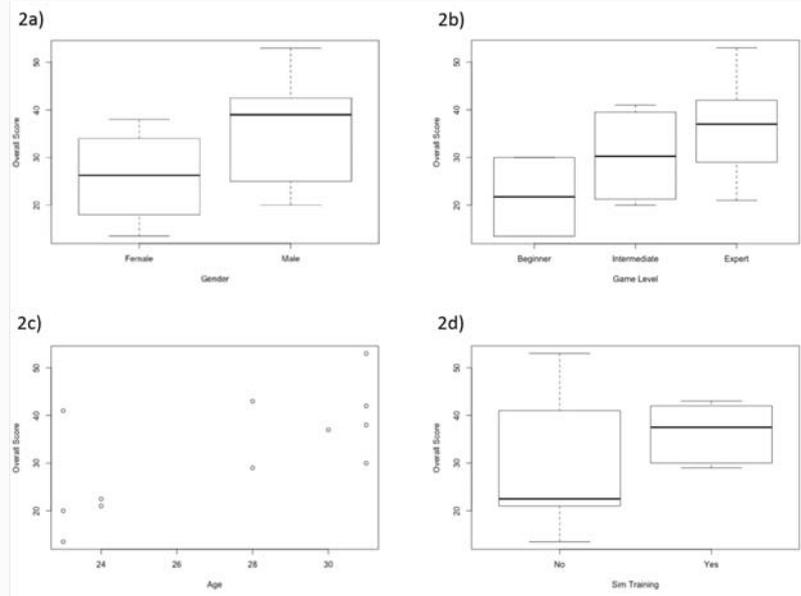


Figure 2: (a) Comparison of the overall score by gender, (b) Game level experience, (c) Age and (d) Previous laparoscopic simulation training. Box plots show the 25th, 50th (median) and 75th percentiles. Whiskers reflect +/- 1.5x inter quartile range markings.

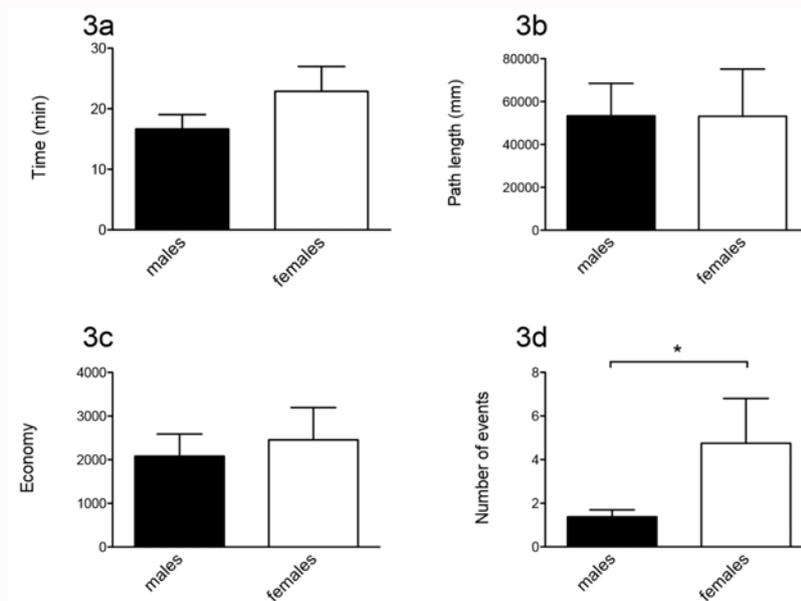


Figure 3: (a). Time (min), (b). Path length (mm), (c). Economy and (d). Number of errors in males (black bars) vs. females (white bars). Mean values ± SEM. *p<0.05.

Statistics

Results were represented as mean and SEM (standard error of the mean). P-values of less than 0.05 were considered significant. Unpaired two-tailed T-tests were performed to assess individual outcomes in two groups of participants (e.g. males vs. females). Trainee factors for SIPES performance were assessed using linear regression analysis. The open source statistical program R (<http://www.R-project.org/>) and the software Graphpad Prism (www.graphpad.com) were used for analysis.

Ethics

The study protocol was reviewed and approved by the Colorado Multiple Institutional Review Board.

Results and Discussion

Fourteen participants were included in the present study. Thereof, two were excluded due to non-functioning simulators. Demographic information can be found in Table 1. Median years of clinical experience were 1.5, ranging from 0 [five (42%) participants were medical students] to 5. Six participants (50%) had previous multi-port simulator training, and the median number of previously performed laparoscopic cases was six (range 0 to 250). Only three participants had performed actual SIPES cases previously (less than three each). Participant-reported previous video game experience ranged from expert (42%) to intermediate (33%), to beginner (17%). One participant did not answer this question.

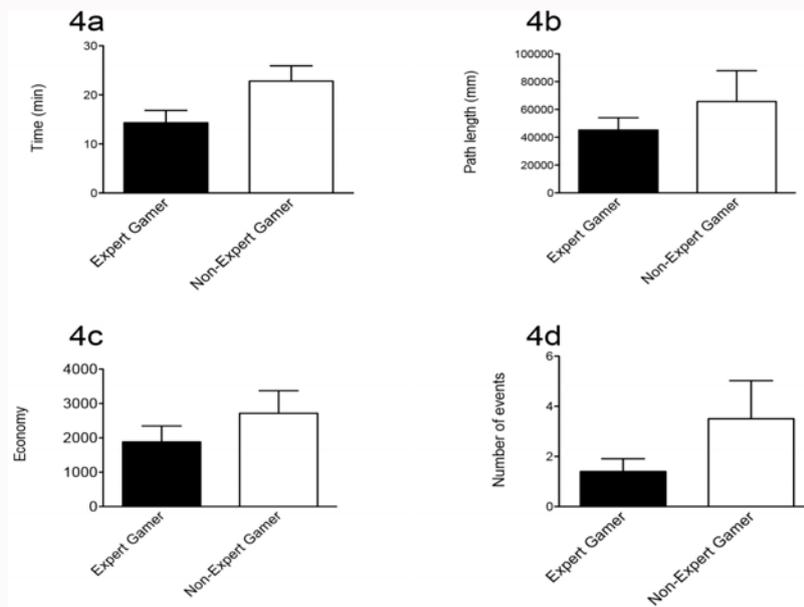


Figure 4: (a) Time (min), (b) Path length (mm), (c) Economy and (d) Number of errors in expert gamers (black bars) vs. non-expert gamers (white bars). Mean values \pm SEM. * $p < 0.05$.

The overall performance score was significantly higher in males ($p=0.0072$) (Figure 2a), in older participants ($p=0.0357$) (Figure 2b), and in participants with higher proficiencies in console gaming ($p=0.0291$) (Figure 2c). Previous laparoscopic simulator experience ($p=0.0904$) non-significantly correlated with simulated SIPES performance (Figure 2d). The number of previously performed multi-port laparoscopic surgeries, and years of experience with multi-port laparoscopic surgeries were found to have no statistically significant correlation with overall performance score.

Comparing individual outcomes in males vs. females, number of errors was significantly higher in females ($p=0.0431$), whereas time, path length and economy were not different between groups (Figure 3). Individual outcomes (number of errors, time, path length, economy) were not different comparing expert video gamers vs. non-expert gamers (Figure 4). Comparing participants ≥ 30 years old to participants younger than 30 years, there was no significant difference in individual outcomes (number of errors, time, path length, economy) (Figure 5).

Since the first laparoscopic cholecystectomy was performed in 1985 by Mühe of Böblingen in Germany [14], surgery has continued to develop and transition towards minimally invasive procedures as technology allows. Single incision endoscopic surgery could be viewed as a next step in this development. More complications occur during the early part of the learning curve for laparoscopic procedures [5]. Furthermore, single incision appendectomy has been shown to be associated with a higher technical failure rate and a longer operative time when compared to multiport appendectomy [15]. Hence, surgical training programs are increasingly utilizing laparoscopic simulation training to shorten the time to operative proficiency, especially in centers, where single incision procedures are performed. Given the known factors correlating with trainee aptitude in multi-port training, it is important to establish what factors are important in single incision training. Furthermore, dedicated single incision laparoscopic training appears to develop competencies for single incision and multiport laparoscopic procedures [16].

The present study aimed to evaluate trainee factors correlating with simulated SIPES performance. Among the six factors assessed, male gender, higher proficiency in console gaming, and age correlated with overall performance.

Five different outcomes (time, path length, economy of movements, minor, and major adverse events) were assessed in the present study. In order to avoid multiple analyses, those outcomes were ranked, and an overall performance score was calculated. The overall performance score was higher in males in the present study. Similarly, multiport laparoscopic simulator performance has previously been shown to be better in males, with greatest differences in speed and visuospatial abilities [17,18]. When assessing each individual outcome in males versus females in the present study, numbers of errors were higher in females, and there was a slight tendency to increased time to accomplish the task in females. Path length and economy of movements were similar between males and females. Gender differences in multiport laparoscopic performance have been shown to be more pronounced in medical students and seem to offset in residents. This likely due to an increased initial self-confidence in males, leading to a shorter reaction time and a riskier behavior [18]. Nevertheless, the lower amount of error rates in males in the present study does not reflect the suspected riskier behavior. Video game experience has been shown to correlate with initial multiport simulator performance with a decreasing strength of correlation with increasing complexity of the task [17,19,20]. Similarly, higher proficiency in video console gaming correlated with better SIPES performance (overall score) in the present study. Comparing the different outcomes individually in participants describing themselves as 'expert gamers' compared to non-expert gamers, no significant difference was detected, but a trend to lower error rates and less time to perform the task was seen. Whereas a steeper learning curve of simulated laparoscopic performance in younger trainees has been shown previously [21], higher age correlated with better performance in the present study. This likely rather reflects the bigger laparoscopic experience in older participants, that has been shown by others to correlate with the familiarization on the simulator [12,22]. Similarly,

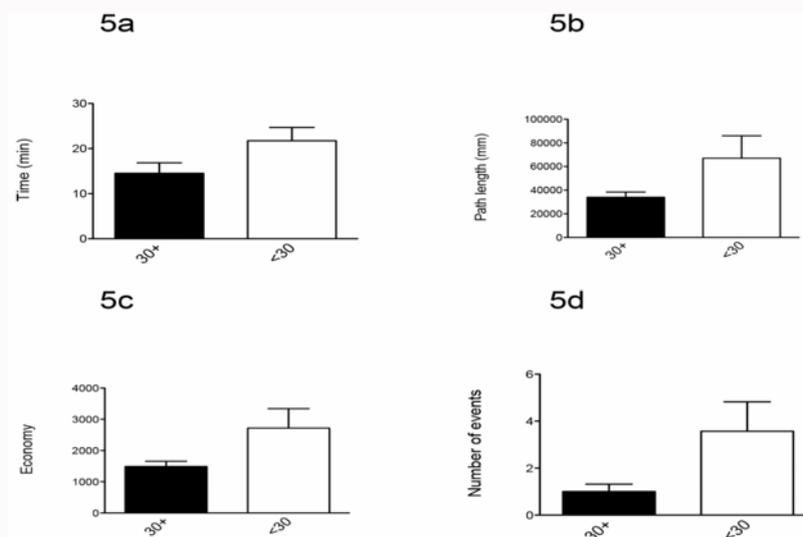


Figure 5: (a) Time (min), (b) Path length (mm), (c) Economy and (d) Number of errors in patients with previous simulator experience (black bars) vs. patients without prior experience (white bars). Mean values \pm SEM. * $p < 0.05$.

previous multiport simulator training showed a non-significant trend to better SIPES performance in the present study. Nevertheless, the number of previously performed multi-port surgeries and years of clinical experience did not correlate with overall performance in the present study.

The strengths of this study are the prospective study design and the fact that all participants were almost complete novices in performing SIPES cases (with a maximal number of 3 SIPES cases performed previously per participant).

An obvious limitation of the current study is the low number of participants and their heterogeneity (*i.e.* medical students and residents). To address this issue, the impact of clinical experience was included in the multivariate analysis, and was shown not to affect overall performance.

Future studies of SIPES simulator training should examine the relation of these factors to participants' psychomotor proficiency using validated measures, time to proficiency across multiple rounds of training, and skill retention timeline. Increased sample size may uncover less prominent factors and remove the need for a composite score, thus allowing for more precise conclusions to be reached. Factors identified as independent predictors of trainee aptitude, once adequately identified, could be used to develop a parsimonious screening tool to identify trainees who may need more time or resources.

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