The impact of aiding robotic-assisted surgery, simulation, virtual reality game-playing and seniority on novices' learning via skills simulator

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Research article

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Abstract

Background

Robotic-assisted surgery learning is highly self-governance, albeit its flourishing. Novices of robotic-assisted surgery are usually trained by virtual reality simulators. This study aims to evaluate whether novices' prior experiences of aiding robotic-assisted surgery, simulation on virtual reality or game-playing gives weight to their learning outcomes.

Methods

Novices' attitudes towards robotic-assisted surgery and video game-playing experiences were investigated using a questionnaire. Voluntary novices (n = 70) comprising surgical trainees (first-year to sixth-year residents) and surgeons were then examined on a VR simulator. The simulator automatically generated examination scores. Questionnaires and examination scores were analysed using SPSS.

Results

Participants' prior experiences of aiding robotic-assisted surgery ($p < .01$) and having robotic surgical simulation within six months ($p < .01$) was associated with significantly higher VR simulator performance, but not prior video game-playing ($p > .05$). Resident participant years 3–5 performed significantly better than resident participant years 1–2, and 6 and visiting staff ($p < .01$).

Conclusions

When formal robotic surgical training is lacking, novices' learning can be developed via both simulation and engaging in real cases. Formal robotic surgical training should be ideally introduced during the middle part of the residency period.

Background

Robotic-assisted surgery has become widely accepted in urology, gynaecology, cardiac surgery, otolaryngology, general surgery, colorectal surgery, thoracic surgery and orthopaedic surgery [1–8]. Despite it flourishing in these specialties, there is lack of exposure to robotic-assisted surgery during the surgical residency training period [9], with surgeons attending training programs by interrupting their practices or squeezing training programs in their hectic schedule. As such, training is highly self-governed [10]. Furthermore, due to the complexity of robotic-assisted surgery, skill acquisition is much slower than for conventional laparoscopy [11], resulting in lengthy training periods.

In order to learn robotic-assisted surgery, individuals are typically trained via virtual reality simulators [12]. Virtual reality comprises a 3-dimentional computer-generated world in which we can engage with by using specially developed headsets, gloves, consoles and even foot pedals. The similarity between robotic-assisted surgery and video game playing is that both use consoles to control, and both require control of hand-eye coordination during the activity. Kato [13] claims that the experiences of playing video games could reinforce the performance of hand-eye coordination, and develop better spatial visualization and reaction times, all of which have benefits for surgical skills. Other facilitators for robotic-assisted surgical skills training includes individuals' previous experience with laparoscopic surgery, in particular the development of intra-corporeal suturing [14].

This study aims to assess the potential factors associated with novices' learning robotic-assisted surgery by considering the following research questions (1) Does video-game playing experience enhance performance? (2) What other factors (e.g. aiding robotic assisted surgery practicing on a simulator, laparoscopic surgical simulation, and attitudes to robotic-assisted surgery) influence performance?

Methods

A questionnaire was developed to understand novice learners' relevant experiences and attitudes towards learning robotic-assisted surgery. Participants were then examined on two tasks using a virtual reality simulator to assess their learning. The scores of the two tasks comprise the outcome variable.

Research context

The research was set in a single branch of the largest group of teaching hospitals in Taiwan. The first two postgraduate years (first- and second-year residents) are focused on developing fundamental surgical skills. Between postgraduate years 3 and 5 (R3 to R5), trainees gain further training and become the first assistant in surgery. In postgraduate years 6 and 7+ (R6 and visiting staff), trainees become fellows of the hospital and are able to practice independently in their specialty.

Design of the Questionnaire

Physician educators and surgeons designed the questionnaire via discussion. The self-reported questionnaire included three sections. Section one comprises demographic questions (participants' department and seniority). Section two includes questions about their experiences of practicing on a simulator, laparoscopic surgical simulation, assisting in robotic-assisted surgery within the past six months and participants' attitudes to robotic-assisted surgery. Section three comprises questions around participants' video-game playing experiences: whether they had played any kind of video-game on any platform, whether they are still playing video games and the type of video-game they play.

Participants

Participants at the early stage of robotic-assisted surgery learning were recruited through online and bulletin board posters and department announcement during meetings. Voluntary novices (n=70) comprised 56 residents (Postgraduate Year 1-6) and 14 visiting staff (Postgraduate Years ≧7) from various departments (Table 1).

Examination Design

The examination comprised two tasks using the built-in software via the Skills Simulator for the da Vinci® Si™: stacking boxes and grabbing stones (see Table 2 for goals and purposes). These two tasks should be completed within 8 minutes during the examination. After the tasks had been completed, the simulator automatically revealed the scores of each task for the participant. Metrics of score consist of time to complete exercise, economy of motion, instrument collisions, excessive instrument force, master workplace range and drops.

Statistical analysis

All n=70 participants completed both questionnaire and examination tasks. The results of the examination scores and questionnaires were analysed using Statistical Product and Service Solutions (SPSS 24). Descriptive statistics, *t*-test, one-way analysis of variance (ANOVA) and were employed for assessing the impact of experiences on participants' learning outcomes.

Results

Video-game playing experiences

Twenty participants never play video games, while fifty participants had prior experiences of video-game playing; 33 of whom had gradually ceased their video-game playing. In terms of playing frequency, the median was twice a week, and ranged from every two weeks to more than once per day. Actual median playing time (per game-playing session) was 20 minutes and raged from 10 minutes to more than 120 minutes.

Factors associated with the Skills Simulator tasks

To identify which experiences influenced participants' learning, a series of *t*-tests were conducted. The following five factors were assessed across the two scores for grabbing stones and stacking boxes: (1) assisting robotic-assisted surgery within six months, (2) having robotic surgical simulation within six

months, (3) video game-playing experience, (4) having laparoscopic surgical simulation within six months, and (5) positive attitude on robotic-assisted surgery.

Among all the studied factors, only assisting robotic-assisted surgery within six months, and having robotic surgical simulation within six months were found to be significantly associated with the stacking boxes scores: $t\,(49.47) = 2.94$, $p < .01$, and $t\,(68) = 3.247$, $p < .005$ respectively (see Tables 3). However, both have small effect sizes: $r = .074$, and $r = .067$.

Despite participants playing video games requiring higher motor-skills (e.g. action, action role-playing game, shooting, racing and fighting), we found no statistical evidence to support their better performance over other participants who lacked such experience. Video game-playing duration varied, ranged from 5 minutes per week to 420 minutes per week. Duration of playing was grouped into ‘never play’ and quartiles, and then examined against the two simulator scores via ANOVA. Video game-playing duration was not associated with neither the grabbing stone task scores ($F\ (2,67) = 0.68$, $p > .05$: see Table 4) or the stacking boxes task scores ($F\ (2,67) = 0.49$, $p > .05$: see Table 4).

Learning outcomes and seniority

Through one-way ANOVA, the level of seniority was examined against the two simulator scores (Table 5): seniority was significantly related to the stacking boxes task score (*Levene's* F test revealed that the heterogeneity of variances $F\ (2, 67) = 6{,}564$, $p < .005$; therefore, *Welch's* $F\ (2, 35.919) = 5.542$, $p < .01$: see Table 5). The R3-R5 group had significantly better performance than the R1-R2 group.

Discussion

In this study, we examined the association of video-game playing experience, aiding robotic assisted surgery, practicing on a simulator, laparoscopic surgical simulation, and attitudes to robotic-assisted surgery with novices’ learning outcome using a skills simulator for robotic assisted surgery. Participants’ with prior experiences in aiding robotic-assisted surgery and having robotic surgical simulation within six months were significantly associated with better scores for the task of stacking boxes. Participants’ laparoscopic surgical skills did not seem to influence their robotic-assisted surgery performance either. This is likely to be due to the basic skills selected for the examination being largely different to real-life skills: using needles in laparoscopic surgery, like intra-corporeal suturing, requires a more nuanced motion than the grabbing stones task.

Although previous research has found an association between video games playing experiences and robotic-assisted surgery skills [15], we failed to find such an association in our study. This was so despite the fact that our participants played high-skill video games (i.e. action, action RPG, shooting, racing, and fighting). Rosser et al. [16] found that when video game playing time is less than three hours per week, the impact on surgical skills performance is negated, compared to individuals who never play video

games. Given that most of the participants in our study only played video games on average every two weeks, it is unsurprising therefore, that this factor had no impact on their performance.

Our analysis regarding participants' level of seniority revealed an interesting non-linear association: the R3-R5 group scored significantly higher than the R1-R2 group with no difference between the R6-VS group and the other groups. Resident year three to resident year five are more mature than resident year one and two on basic surgical skills. We conjecture that Residents may have a more open learning mentality than visiting staff, owing to the fact that the adoption of a technology for visiting staff is highly self-governed and relates to their specialty [10]. Therefore, participants' attitudes toward robotic-surgery learning requires further investigation.

Limitations

There are some potential limitations in this study. We only recruited doctors who are from one branch of a single hospital group in one country; therefore, caution will need to be taken when generalising the results to a broader population. Additionally, the surgical skills measured in the tasks were basic and future studies might consider using advanced skills. Due to the convenience sampling approach we adopted, participants in our study did not display excessive game playing behaviours. Future research might employ a purposive sampling technique to recruit a group of participants who have regular video game-playing habits.

Conclusion

This study suggests that the learning outcomes of robotic-assisted surgery are related to participants' previous experiences in simulated practices or assisting robotic surgery. Experiences of playing video games does not seem to significantly influence their learning outcome. The result of R3-R5 performing better suggests this might be the optimal timing for simulator learning of robotic-assisted surgery.

Abbreviations

VR: virtual reality; SPSS: Statistical Product and Service Solutions; ANOVA: analysis of variance; R1: resident year one; R2: resident year two; R3: resident year three; R5: resident year five; VS: visiting staff

Declarations

Ethics approval and consent to participate

Ethical approval for this study was obtained from the Chang Gung Medical Foundation Institutional Review Board (IRB No. 104-3216B1), and written informed consent was obtained from all participants.

Consent of publication

Not applicable.

Availability of data and materials

The study data are kept at the Chang Chung Medical Education Research Centre, Chang Chung Memorial Hospital, Linkou, Taiwan. The data are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

YYC contributed to data analysis, data interpretation and manuscript drafting. YKC contributed to conception and research design. YCH contributed to collection and sampling of the data. CHC contributed to data analysis and interpretation. MJH contributed to conception and research design and administrative support. All authors have written and approved the final version of the manuscript.

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Tables

Table 1. Study participants by specialties

Department	Residents	Visiting staff	Total	Percentage (%)
Colon & Rectal Surgery	7	3	10	14.29
Cardiovascular& Thoracic Surgery	3	2	5	7.14
Otolaryngology	12	3	15	21.43
General Surgery	18	2	20	28.57
Neurosurgery	2	2	4	5.71
Gynaecology	5	2	7	10
Urology	5	0	5	7.14
General	4	0	4	5.71
Total	56	14	70	100

Table 2. Tasks in the examination

Task	Goals	Purpose
Grabbing stones	Operating the camera to target the stone.	Evaluating use camera with clutch.
	Picking up the stone and placing it in an appointed basket.	Evaluating ability of stereo depth sensitivity. Evaluating camera targeting skills.
Stacking boxes	Stacking boxes as high as possible within a limited time.	Evaluating EndoWrist adroitness. Evaluating camera control skills.

Table 3. *t*-test Results for Comparing Learning Experiences (n=70)

	Grabbing stone task			Staking box task		
	Yes	No	p-value	Yes	No	p-value
Assisting robotic-assisted surgery within six months (yes, n=36)	37.69 (11.0)	34.12 (20.7)	0.375	71.83 (14.0)	56.85 (26.4)	0.005**
Having robotic surgical simulation within six months (yes, n=53)	36.83 (14.4)	33.24 (21.9)	0.436	69.11 (19.7)	50.35 (23.3)	0.002**
Video game-playing experience (yes, n=50)	37.32 (17.8)	32.55 (12.3)	0.276	66.14 (21.8)	60.60 (22.9)	0.347
Having laparoscopic surgical simulation within six months (yes, n=31)	38.10 (21.6)	34.26 (10.8)	0.370	62.48 (24.5)	66.21 (20.2)	0.488
High skill Video game-playing experience (yes, n=34)	37.85 (18.9)	35.31 (13.5)	0.633	62.68 (22.3)	68.25 (15.3)	0.309
Positive attitude on robotic-assisted surgery (yes, n=50)	36.2 (16.5)	35.35 (12.3)	0.847	65.88 (21.0)	61.25 (24.9)	0.433

*p<.05. **p<.01.

Table 4. Descriptive and ANOVA Results for video game-playing duration (n=70)

	Grabbing stone task			Staking box task		
			p-value			p-value
(1) Never play(n=20)	32.55	(12.26)	0.5098	60.60	(22.88)	0.6128
(2) Less than 10 mins (n=20)	36.15	(9.77)		64.90	(23.02)	
(3) 10 mins and more (n=30)	38.10	(21.64)		66.97	(21.36)	

*p<.05. **p<.01.

Table 5. Descriptive and ANOVA Results for Seniority(n=70)

	Grabbing stone task			Staking box task			
			p-value			p-value	Dunnett T3 post-hoc test
(1) R1-R2(n=26)	34.92	(22.9)	0.423	55.38	(25.26)	0.008*	(2)>(1)
(2) R3-R5 (n=27)	37.70	(12.1)		73.74	(14.4)		
(3) R6-VS (n=17)	34.76	(9.8)		64.00	(22.3)		

*p<.01