Simulation in Surgical Education: A Review of a Multi-Tiered Gynaecological Laparoscopy Workshop

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Abstract

Background: While minimally access approach has become the gold standard for many gynaecological procedures, laparoscopic surgery has a steep learning curve and many trainees face challenges acquiring the necessary skills. The aim of our study was to evaluate the effectiveness of a multi-tiered laparoscopy simulation workshop for gynaecology residents.

Approach: An observational study was conducted at SingHealth Duke-National University of Singapore (NUS) Institute of Medical Simulation Centre (SIMS) between November 2016 and November 2017. Gynaecology residents were recruited to attend two separate one-day workshops held in November 2016 and November 2017 respectively, involving didactic lectures, dry-lab simulation and animal training. Participants rated various learning domains of the training workshops using a five-point scale Likert in pre- and post-workshop surveys.

Findings: The study enrolled 16 residents in total. On a Likert scale from 1 to 5 (1 being poor and 5 being excellent), participants rated significant improvement in domains of general laparoscopy skills acquisition (1.7 $\pm$ 0.6 to 4.9 $\pm$ 0.4; $p<0.001$), dry lab simulation (1.9 $\pm$ 0.5 to 4.8 $\pm$ 0.4; $p<0.001$), confidence in laparoscopy suturing skills (1.1 $\pm$ 0.3 to 4.8 $\pm$ 0.4; $p<0.001$) and laparoscopy knowledge (2.1 $\pm$ 0.5 to 4.7 $\pm$ 0.5; $p<0.001$).

Conclusion: A combination of didactic lectures, dry-lab simulation and animal training under expert supervision and guidance dramatically improved surgical skills and confidence in gynaecology residents. Such a multi-tiered format allows for effective learning and acquisition of laparoscopic skills.

Keywords: Gynaecology, laparoscopy, simulation training

Introduction

In recent decades, pelvic laparoscopy and robotic-assisted procedures have progressed from simple diagnostic and therapeutic tools to a complex armamentarium of advanced surgical techniques. Laparoscopic surgery is important for gynaecological practice and has become the method of choice for many gynaecological procedures given relative advantages over open surgery, such as faster recovery, reduced post-operative pain and shorter hospitalisation stay (Johnson *et al.*, 2006; Walker *et al.*, 2009). The Royal College of Obstetricians and Gynaecologists' (RCOG's) Scientific Impact Paper *Enhanced Recovery in Gynaecology* also strongly supports the use of minimal access surgery to improve post-operative recovery (RAF Crawford, 2013). However, laparoscopic surgery has a steep learning curve that requires psychomotor skills different from those needed for open surgery. It poses many technical challenges including camera navigation, hand-brain coordination, limited range of motion of laparoscopic instruments and appreciation of depth and orientation using a two-dimensional screen.

The operating theatre can be highly stressful with complicated cases and may not be optimal for novice laparoscopic surgery training. The trainer often has a subconscious inclination to take control of the case to avoid complications from surgical errors and limit morbidity. Laparoscopic skills simulation programmes have been shown to refine the skills that are essential for minimally invasive surgical procedures in a controlled setting outside of the operating theatre (Houck *et al.*, 2013; Schwab *et al.*, 2017). Laparoscopy simulation training

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would allow residents to gain confidence in operative exposures and at the same time, master fundamental to advanced laparoscopic skills. Moreover, simulation has shown to not only reduce procedural duration, but also improves patient safety and offer better surgical outcomes (Samia *et al.*, 2013; Agha & Fowler, 2015).

However, many gynaecological training programmes do not incorporate laparoscopic simulation training as part of the syllabus for many reasons such as the lack of facilities, training specialists and cost (Wilson *et al.*, 2016; Fjortoft *et al.*, 2019). In the present world where patient safety is of paramount medico-legal concern, it would be useful to conduct laparoscopic training programmes prior to unsupervised surgeries.

The role of simulation with high fidelity equipment plays a very important part in the continued training for junior surgeons. A combination of simulators and laboratory animals prove to be a valuable source for such "realistic" training (La Torre and Caruso, 2013). Therefore, we implemented a combined training workshop with didactic lectures, box simulators and porcine simulation for gynaecological residents to enhance their laparoscopic skills as part of their training.

Approach

Workshop Design

A full-day hands-on workshop comprising dry-lab and wet-lab utilisation was conducted at our specialised procedural simulation laboratory at SingHealth Duke-National University of Singapore (NUS) Institute of Medical Simulation Centre (SIMS). The primary goal was to provide a training opportunity for OBGYN residents to gain exposure to both simulated daily advanced gynaecological laparoscopy procedures and instruments within an efficient and cost-saving environment.

Lectures on advanced laparoscopy techniques were first conducted by the faculty. The dry-lab component then involved the use of laparoscopy model boxes with laparoscopic equipment and video systems. After the dry-lab session, the wet-lab component ensued. This involved practice using advanced laparoscopy equipment on anaesthetized laboratory pigs. Specific advanced laparoscopic procedures were performed under direct supervision by faculty during the wet-lab session. A summative sharing exercise (between participants and faculty), coupled with formal feedback evaluation, was conducted at the end of the workshop.

The workshop employed the use of advanced surgical instruments and equipment, including high resolution video-camera systems, which were supported by institution-approved technicians.

Participants

The set-up included the workshop director, faculty (four consultants with expertise in minimally invasive gynaecology surgery), eight OBGYN residents and four nurses. There were four stations, each with one nurse, one porcine animal and one set of simulation equipment.

During the workshop, two participants were assigned to each station, which had one laboratory animal and one faculty member. The participants received direct supervision and guidance from the faculty member. By sharing one laboratory animal during the entire workshop, the participants and the faculty member also gained full mutual access and exposure to operating on the animal.

Didactic lectures

Apart from covering the steps of basic laparoscopic procedures (cystectomy, total hysterectomy, salpingo-oophorectomy), the lectures also covered important basics of laparoscopy including equipment, patient consideration, patient positioning, abdominal access, trochar placement, establishment of pneumoperitoneum, and post-operative care.

Dry-lab

The dry-lab component involved the use of laparoscopy model boxes with laparoscopic equipment and video systems. The laparoscopy training model box provided a platform for participants to assess their fundamental skills in laparoscopy. This included laparoscopic suturing, dissection (using balloons filled with dye to simulate cysts) and hand-eye coordination (using rubber rings for left-to-right transfer and precision pointing). Participants were assessed based on performance of specific tasks using the model boxes such as hand-eye coordination and three-dimensional appreciation with the video systems. The objective of this transition was to provide participants with a warm-up and revision of basic principles in laparoscopy prior to performing hands-on complex procedures on

the laboratory animals. This was also in concordance with the SingHealth Institutional Animal Care and Use Committee (IACUC) prerequisite for animal-handlers to demonstrate respect to the animals by avoiding "unnecessary mutilation".

Wet-lab
The workshop focused on extensive hands-on experience on live anaesthetised pigs supported by the veterinary services from the SingHealth Experimental Medicine Centre. Official approval was obtained from SingHealth Centralised Institutional Review Board (CIRB) and the SingHealth Institutional Animal Care and Use Committee (IACUC) to conduct this workshop involving the handling of laboratory animals. Several procedures were selected for the participants to complete during the wet-lab session.

Innovative Concept of Group Sharing
At the end of the hands-on sessions, there was a group sharing session between the participants and the faculty. This was an open discussion to give feedback to participants and for the faculty to share their experiences and tips. A monologue was avoided as the participants also had the opportunity to ask questions and share their own experiences with the faculty and the rest of their peers. The objective of this two-way interaction was to encourage both participants and the faculty to engage in a non-judgmental and non-paternalistic sharing of ideas amongst each other. Such group sharing discussions were not common during academic courses.

Nursing Support
The involvement of nurses was the first-of-its-kind in such simulation workshops whereby doctors and nurses trained together simultaneously, enhancing the learning value and efficiency of such workshops. Four nurses from the Singapore General Hospital Major Operating Theatre were engaged as part of the supporting members for this workshop.

Data Collection and Analysis

Participants were asked to rate various learning domains of the training workshop using a five-point Likert scale from 1 to 5 (1 being poor and 5 being excellent) in the pre- and the post-workshop surveys.

Learning domains evaluated were that of laparoscopy knowledge, laparoscopic skills, previous dry-lab exposures and confidence in laparoscopic suturing. Additional comments from participants and faculty members were also invited through the open 'Written Comments' section.

Statistical Analysis
Comparisons of the pre- and post-workshop mean scores of all four domains (laparoscopy knowledge, laparoscopy skills, dry-lab exposure and confidence in laparoscopy suturing) were made using the paired samples t-test, with $p<0.05$ considered statistically significant.

Findings

The results of our pre-workshop and post-workshop questionnaires are summarised in Table 1 and Table 2 respectively. There was a total of 16 participants for the workshop across two sessions. 15 residents completed our pre-workshop questionnaire while all 16 completed our post-workshop questionnaire.

Table 1: Pre-course questionnaire results

Pre-workshop (15 Subjects, Missing 1)	**Mean**	**Lowest Score**	**Highest Score**
Laparoscopy knowledge	2.1	1	3
Laparoscopy skills	1.7	1	3
Dry lap exposure	1.9	1	3
Confidence in laparoscopy suturing	1.1	1	2

Table 2: Post-course questionnaire results

Post-workshop (16 subjects)	Mean	Lowest Score	Highest Score
Laparoscopy knowledge gained	4.7	4	5
Laparoscopy skills gained	4.9	4	5
Dry lap exposure adequacy	4.8	4	5
Confidence in laparoscopy suturing	4.8	4	5

Figure 1 shows the comparison of mean scores of all four learning domains between pre- and post-workshop based on a five-point Likert Scale with one being poor and five being excellent

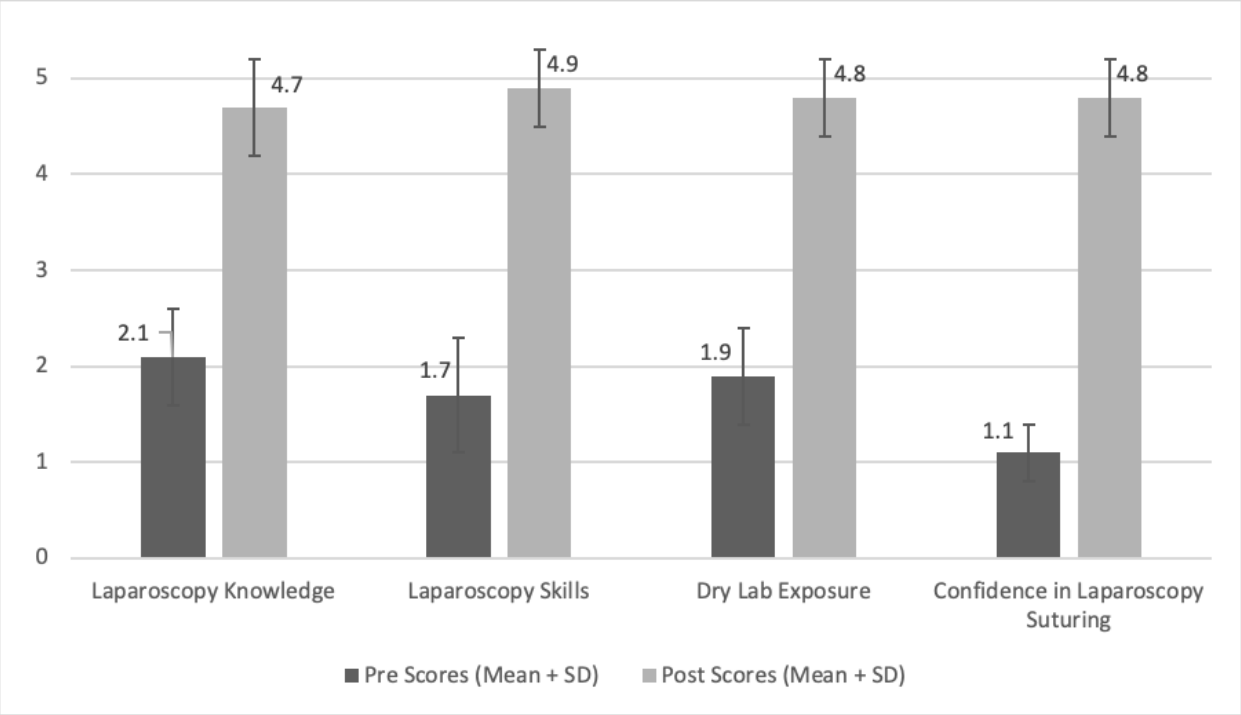

Figure 1: Comparison of Pre and Post workshop knowledge/skills domain scores based on a 5-point Likert Scale

Comparisons of the residents' mean scores for laparoscopic knowledge exhibited a statistically significant improvement, from a pre-workshop mean score of 2.1 to a post- workshop mean score of 4.7 ($p < 0.001$). Their laparoscopy skills also showed a statistically significant improvement, from a pre-workshop mean score of 1.7 to a post workshop mean score of 4.9 ($p < 0.001$. Dry-lab exposure also had a significant improvement from a pre-workshop mean score of 1.9 to a post-workshop mean score of 4.8 ($p < 0.001$). Most significantly, their confidence in laparoscopy suturing increased from a mean pre-workshop score of 1.1 to 4.8 post-workshop ($p < 0.001$).

Discussion

Value of Surgical Simulation

Minimally invasive surgery is rapidly becoming a standard surgical technique for many procedures and an important surgical skill for gynaecological trainees to master. However, the traditional Halstedian apprenticeship model of 'See One, Do One, Teach One' where the trainee is expected to be able to perform the procedure after observation and thereafter be

capable of training another may not be very applicable to laparoscopic surgery. Laparoscopic surgery involves working with images on a screen and manipulation of instruments that are outside the line of vision. Trainees are not able to observe the surgeon's hands and the procedures simultaneously as in open surgery. Consequently, simulators are becoming widely accepted as an adjunct for laparoscopic surgical training.

Confidence in Laparoscopy Surgery

Through our surveys, all residents collectively agreed that the workshop has led to improvement in their knowledge, skills and confidence as shown in Figure 1 above. Pre-workshop, participants rated a higher mean score of 2.1 in laparoscopy knowledge in comparison to mean score of 1.1 confidence in laparoscopy suturing. The disparity between knowledge and confidence was reduced after workshop as the mean scores for confidence improved to 4.8, slightly higher than laparoscopy knowledge mean score of 4.7. This data demonstrates the efficacy of this workshop and the impact of simulation on residents' confidence in laparoscopic surgery.

Holistic Training Programme

We conceived this workshop taking into consideration Fitts and Posner's theory of complex motor skill acquisition (Fitts & Posner, 1967). According to Fitts and Posner (1967), complex motor skills are acquired in three stages: a cognitive stage, an associate stage and an autonomous stage. Several authors have also then proposed and popularised similar surgical curricula closely resembling Fitts' three-stage progression (Gallagher *et al.*, 2005; McClusky & Smith, 2008). These surgical skill education models have in common a sequential and progressive approach to the training of surgical skills – providing knowledge on the tasks followed by simulator-based training to translate cognition into motor behaviour. Only after these two stages can trainees progress into the autonomous stage of learning.

Many laparoscopy simulation workshops often only include either a box-model or animal model. Our three-part programme from lecture to dry- and wet-lab simulation during the same setting allows participants to apply knowledge from the lectures and psychomotor skills learnt from the box trainers directly to the realistic porcine models. It provides high fidelity in laparoscopy training and in many studies have proven to be effective whilst encouraging enthusiasm and realism (Hoffman *et al.*, 2009; Torricelli *et al.*, 2016). Video-based education before training was also shown to enhance the acquisition of surgical skills on simulators (Eisenhofer *et al.*, 2011). We incorporated an initial dry-lab phase which had our participants performing basic tasks using the laparoscopic box model as it trains our participants to adapt to two-dimensional vision and handling of the laparoscopy surgical tools. The tasks focus on developing their hand-eye coordination, camera navigation as well as appreciation of depth and orientation. Manual skills learnt during dry-lab simulation has also been demonstrated to improve performance in porcine animal simulators (Stelzer *et al.*, 2009).

Feedback and Guidance

Feedback is the single most important constituent of simulation-based surgical education. Only through prompt feedback and dedicated coaching during and after the course by expert facilitators, trainees can better identify areas of weakness and be offered useful guidance on specific techniques. Individualised performance feedback and debriefing by trainers has been shown to improves trainees' cognitive understanding of the skills and procedure, translating to better performance (Ahlborg *et al.*, 2015).

Simulation as a Pre-Requisite

Many have also sparked the debate on whether laparoscopy simulation training and objective assessment ought to be made mandatory for gynaecology trainees (Larsen *et al.*, 2009). The fact remains that inadequate and inequitable operative exposure makes laparoscopy simulation training essential. In our opinion, dedicated and mandatory training should be part of training curriculum. The prevalence of medico-legal cases also meant reduced opportunities for trainees to engage in real-life operations. It could also well be viewed as a prerequisite before trainees can become primary surgeons on real patients.

Interprofessional collaboration with nurses

The involvement of nursing colleagues in the workshop was also beneficial as it provided them with opportunities to assist the surgeons and familiarize themselves with the advanced state-of-the-art instruments, as well as the procedures that are performed on a daily basis in clinical practice. Feedback from the nurses were positive in terms of good personal learning experience and better understanding of the challenges faced by doctors during surgeries.

Limitations of our training model and Future Improvements

Due to time constraints, we did not offer more objective surveys pertaining to each module performed. However, these should be reviewed and considered as part of further analysis of the workshop's usefulness. Skills assessment could be made via OSATS to determine the transference of skills from the training programme to actual clinical practice. In fact, virtual reality simulators like SIMlap have been reported to be very effective in quantifying dexterity improvements during training courses (Larsen *et al.*, 2009; Torricelli *et al.*, 2016). Hence, there is scope in the near future for its utility as an objective assessment to gauge dexterity prior to the conduct of clinical practical surgery, with the supplementary employment of OSATS for the monitoring of training progress.

Conclusion

In conclusion, simulation is crucial in the education of laparoscopic surgery. The combination of didactic lectures, dry-lab simulation and animal training under expert supervision and guidance has shown to dramatically improve surgical skills and confidence in gynaecology residents. Such multi-tiered format allows for effective learning and acquisition of laparoscopic skills.

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