IJoHS International Journal of Healthcare Simulation Vol.1, Issue no.2

ESSAY

Novel do-it-yourself low-cost abdominal laparoscopy entry simulator for gynaecology trainees

Kamalaveni Soundararajan[1], Karthikadevi Sivakumar[2], Andrew Blackmore[1], Marina Flynn[2]

[1]*Hull Institute of Learning and Simulation, Hull University Teaching Hospitals NHS Trust, Kingston Upon Hull, Anlaby Road, HU3 2J, UK*
[2]*School of Obstetrics and Gynaecology, North /East Yorkshire and Humber, Health Education England, Health House, Grange Park Lane, Willerby, Hull HU10 6DT, UK*

Corresponding author: Kamalaveni Soundararajan, kamhull21@gmail.com

https://ijohs.com/article/doi/10.54531/EEIC5466

ABSTRACT

Introduction
The COVID-19 pandemic has affected gynaecology trainees in the United Kingdom by reducing operating theatre experience. Simulators are widely used for operative laparoscopy but not for practising laparoscopic-entry techniques. We devised a low-cost simulator to help trainees achieve the skill. Our aim was to pilot this low-cost simulator to perform Royal College of Obstetricians and Gynaecologists (RCOG) supervised learning events.

Methods
A single-centre pilot study involving six gynaecology trainees in a structured training session. Interactive PowerPoint teaching was followed by trainees' demonstration of laparoscopic entry for a supervised learning event and personalized feedback. Participants completed pre- and post-course questionnaires.

Results
All the trainees found the training useful to the score of 10 (scale of 1–10) and recommended this to be included in Deanery teaching. Personalized feedback was described as the most useful. The simulator was rated as good as a real-life patient relative to the skill being taught.

Discussion
Gynaecology trainees are affected by lack of hands-on experience in the operating theatre for performing laparoscopic entry. A low-cost abdominal laparoscopy entry simulator can help deliver the RCOG curriculum, enabling trainees to achieve required competencies.

What this study adds

- Gynaecology trainees are affected by lack of hands-on experience in the operating theatre for performing laparoscopic entry.
- To date, there has been no published validated simulator available for practising laparoscopic-entry techniques in the literature.
- This do-it-yourself (DIY) low-cost abdominal laparoscopy entry simulator will help deliver the RCOG curriculum, enabling trainees to achieve required competencies during the pandemic and beyond.
- We recommend the use of this low-cost DIY model for teaching and learning laparoscopy entry across all surgical specialties.
- We acknowledge that this session cannot be used to replace real patient experience; however, this session will boost trainees confidence and knowledge in laparoscopic entry techniques.

Introduction

With the COVID-19 pandemic changes and the elective operative procedures being cut down to a bare minimum for more than a year, gynaecology and surgical trainees continue to struggle to get the required operating theatre experience to meet their curriculum requirements in the UK [1–5]. The trainees in the UK are under intense pressure affecting them in a multitude of ways, including psychological well-being [6]. There is a need for innovating and embracing novel methods of training and curriculum delivery at this challenging time [4,7].

In the UK, competence in diagnostic laparoscopy is expected at the end of 4 years of specialty training (ST4) in gynaecology [8]. Trainees at the end of ST4 need to complete a minimum of three assessments of their diagnostic laparoscopy procedural skill to prove their competence. These assessments are called Summative Objective Assessment of Surgical and Technical Skills (OSATS). This is essential to achieve Outcome 1 in their Annual Review of Competency Progression (ARCP) [8]. Outcome 1 is the desired outcome confirming successful completion of the training year.

The specialty trainees from years 1 to 3 (ST1-3) are encouraged to have formative OSATS [9] (supervised learning event) that provides evidence of continued engagement in training. However, as discussed, trainees struggle to get hands-on laparoscopy entry experience in theatre and hence to get formative OSATS.

RCOG has produced a revised COVID-19 matrix of progression 2020–2021 to guide ARCP outcomes [8]. RCOG also actively promotes the use of other methodologies employing innovative teaching opportunities to assess trainees and perform OSATS for curriculum delivery in situations when clinical exposure is limited [10]. The use of simulation in delivering laparoscopic training has been well recognized by the British Society for Gynaecological Endoscopy (BSGE) and the Royal College of Surgeons (RCS), and programmes of simulation curriculum delivery exist. However, there has not been an abdominal laparoscopy entry simulator model used in this way before.

Need for a novel abdominal laparoscopy entry model

Laparoscopic procedures are widely performed worldwide, and incidence of serious complications is 1 in 1000 in laparoscopic cases [11]; the serious complications include bowel injury and blood vessel injury. The period of greatest risk in laparoscopy is during the blind insertion of the Veress needle and trocars through the abdominal wall [11]. Gynaecology trainees have traditionally learnt the blind Veress needle insertion and trocar insertions during operating theatre experiences directly on a real-life patient. Reduced access to operating theatre training, redeployment, staff shortages and reduced elective cases have all been contributing to reduced training opportunities and poor confidence in trainees. In our training session, only one in three trainees in the first 2 years of training has performed diagnostic laparoscopy under supervision in the last 12 months. All trainees felt that they would benefit from a diagnostic laparoscopy course on a score of 8 to 10, with a median of 10 (scale of 1–10), and none of them had OSATS before for operative or diagnostic laparoscopy in their training.

Our literature search for a laparoscopy entry simulator did not identify any published literature. However, we found information on social media on the use of a DIY model [12], which has informed the development of our model in this study.

Instructions for making the laparoscopy entry model

Our models are do-it-yourself (DIY) models with low-cost supplies such as cardboard box, plastic sheet, tapes, thermocol, sponge and plastic containers as reservoirs for simulating bowel/blood vessel injury, and we used manikin skin (Figure 1). The cost of this simulator was $8 without manikin skin and $28 with mannikin skin. We used leftover skin in our clinical skills institute and hence costs were minimum (Table 1):

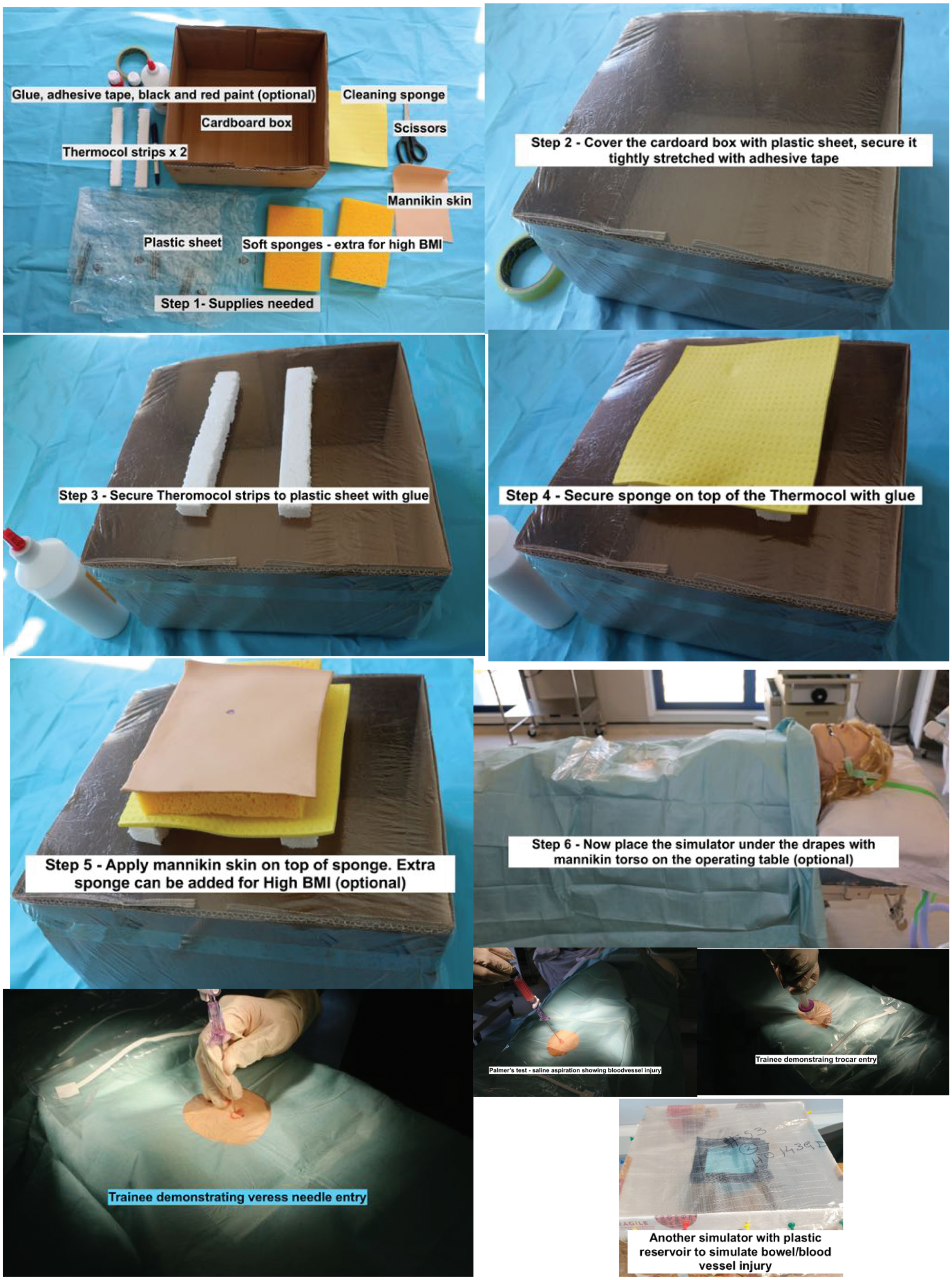
Step 1: Collect the materials required: cardboard box, cleaning sponge, scissors, glue adhesive tape, black and red paint, plastic sheet, soft sponges and mannikin skin (optional).

Step 2: Cover the cardboard box with a plastic sheet and secure it tightly stretched with adhesive tape. This will form the fascial/peritoneal layer and give the second click during Veress needle entry at the umbilical area.

Step 3: Secure thermocol strips parallel to each other in the centre of the plastic sheet. It is to create space for the layer between the rectus sheath and peritoneum.

Step 4: Secure sponge on top of the thermocol with glue. This layer will simulate the rectus sheath and will give the first click during entry with Veress needle in the umbilical point.

Figure 1: Instructions for making the simulator



Step 5: Apply a soft sponge on top of the cleaning sponge to mimic subcutaneous fat layer. Then, apply manikin skin on top of the sponge which will be the skin layer. In a lower-cost alternative, skin can be replaced by any thin rubber sheet.

Step 6: Now place the simulator under the drapes with mannikin torso on the operating table. This step is optional and the simulator is functional even without this step.

Table 1: Supplies needed for the simulator

	Material	Cost ($)
1	Card board box	1.00
2	Thermocol strips	1.00
3	Glue	1.00
4	Sellotape	1.00
5	Scissors	1.00
6	Cleaning sponge	1.00
7	Plastic sheet	1.00
8	Soft sponge	1.00
9	Mannikin skin	20.00
	Total	28.00

Variations in simulator

1. Palmer's point entry: This is preferred in situations such as morbidly obese patients and suspected bowel adhesions in the umbilical site to avoid organ injury. Here, the Veress needle is introduced through the left hypochondrium, 2 cm below the left sub-costal margin in the mid-clavicular line. The abdominal wall layers encountered vary from the umbilical site as there will be three clicks produced by two layers of fascia and the layer of peritoneum. This is simulated by repeating steps 3 and 4 in the above instructions (additional fascial layer) after step 4. The sponge layer (step 5) should be thin as the subcutaneous fat layer is minimal in this plane.
2. Open entry – Hassan's entry: This can be performed at the umbilical site as in real life. Using a canvas sheet or white plastic sheet (Step 2) will better replicate the fascial layer.
3. Aortic injury: Trainees can practise identifying and managing blood vessel injury by the following modification to the simulator. A small plastic cup filled with water mixed with red paint is attached under the centre of the plastic sheet (Step 2); this can be easily achieved by glue or adhesive tape. Then, Steps 3 to 6 are completed as above. When the trainee inserts the Veress needle and performs Palmer's test to aspirate, this will reveal red aspirate mimicking blood (Figure 1). At this point, trainee's response can be studied and feedback given about the management of blood vessel injury during laparoscopic entry. The ideal response would be not to move the Veress needle, to alert the theatre team including anaesthetists, scrub nurses and assistants about the blood vessel injury and to get prepared for laparotomy and repair of vascular injury. A senior-most surgeon should be called for help. Major haemorrhage should be anticipated and blood cross-matched for transfusion. Vascular surgeon should be immediately called for help. While awaiting the arrival of vascular surgeon, in a collapsed patient, manual pressure should be applied on the bleeding vessel after laparotomy and location of injury with resuscitation.
4. Bowel injury: This can be simulated by using black paint instead of red paint in the above model of aortic injury. The ideal response would be not to remove the Veress needle to help locate the site of injury, alert theatre team, call bowel surgeons for help with laparotomy for identification and repair of injury and administer antibiotics.

Pilot study

In our pilot study, we included six gynaecology trainees in the first 2 years of training (three in each group), and the session lasted 3 hours. The aims of the workshop were that at the end of this workshop, participants should be able (1) to identify surface landmarks of the abdomen specific to laparoscopy entry, (2) to identify laparoscopic anatomy and landmarks in gynaecology diagnostic laparoscopy, (3) to identify common problems during laparoscopic entry and how to avoid them, (4) to identify the complications that can happen during laparoscopic entry and how to immediately manage them, (5) to demonstrate safe laparoscopic entry with Veress needle and trocar in a laparoscopic simulator and (6) to demonstrate diagnostic laparoscopic approach in a laparoscopic simulator.

Our training session started with an interactive lecture on the relevant laparoscopic anatomy, landmarks and entry techniques followed by the discussion of management of complications. We also included a slide show of spot diagnosis of common diagnostic laparoscopy conditions (e.g. endometriosis, peri-hepatic adhesions of Fitz-Hugh-Curtis syndrome, ectopic pregnancy and torted ovarian cyst). This was then followed by operating theatre simulation scenarios, where each trainee was given the opportunity to be the surgeon demonstrating laparoscopy entry with a Veress needle and trocar. The scenarios we included were low body mass index, morbid obesity, palmers point entry, bowel injury and blood vessel injury.

Trainees demonstrated safety checks such as testing spring action, patency of Veress needle, choosing the base of the umbilicus for skin incision, angle of entry of 90°, listening for clicks during abdominal entry and palmers saline test which can all be performed in the simulator that gave them a realistic feel of the situation. Then, the trainees performed trocar insertion at a 90° angle, demonstrating a safe technique with guarded entry, at the correct intra-peritoneal gas insufflation of 20–25 mmHg, and checked the location of trocar. Each trainee was given immediate objective structured personalized feedback as part of the OSATS.

Results

In our small group of trainees, confidence in performing diagnostic laparoscopy pre-course varied from a score of 1 to 5 (on a 10-point scale), with a median of 2. This increased to a score of 3 to 7 (on a 10-point scale), with a median of 6, post-course. Confidence in Veress needle entry and trocar insertion pre-course varied from a score of 1 to 5 (on a 10-point scale), with a median of 3, to a post-course score of 4 to 9 (in a 10-point scale), with a median of 8. Trainees feedback included 'it was a safe and realistic way to practice Veress needle entry and trocar entry under expert supervision' and 'the course was incredibly valuable as an introduction to laparoscopy as we do not have any training currently like this'. Further comments included 'I feel confident to ask the consultant and do it in theatre after that hands-on experience' and, 'It was

Table 2: Cost analysis of laparoscopy entry simulators

	Model	Cost	Advantage	Disadvantage
1	Do-it-yourself model	$8 to $28	• Low cost • Easy to make in 10–15 min • Available any time of day or year • Portable, lightweight • Can have obese, thin, palmers point versions • Can have simulated visceral injury (e.g. bowel injury, blood vessel injury) • Can use Veress needle, palmers saline test, Hassan entry • Can create pneumoperitoneum	• Will need new model after 2–3 entries as the tension in the sheet will be lost • Not validated universally
2	Surgery & Laparoscopy Torso without Diathermy: Medisave	$2900	• Portable, lightweight • Can be easily cleaned by flushing out through a large airtight drain plug • Available any time of day or year	• Will need a new replacement part for entry after few uses • Not validated universally
3	Virtual reality – Haptic surgery simulations	$25,000 to $80,000	• Haptic feedback and computer program gives an analysis of performance	• High cost • Not widely available • Requires maintenance and dedicated team for software troubleshooting with maintenance expenses
4	Animal model – porcine	$200	• Anatomically similar to human	• Ethically challenging • Needs new cadaver for every session • Tissues are not similar to human • Needs specialized set-up for use and disposal of tissue
4	Human cadaver	$10,000	• Closest to real-life patient • Widely validated by surgical specialties	• Not widely available • High cost • Only accessible in licensed courses • Not affordable in a low-resource setting/trainees with low educational fund

very helpful, as we can actually feel like real-life situation'. All trainees recommend this to be a part of deanery teaching.

Discussion

The other available methods of laparoscopy teaching include box simulators, Virtual Reality-haptic feedback simulators, animal models and human cadaveric courses, the cost of which vary greatly [12–16]. The advantages and disadvantages of other options for laparoscopy entry teaching are discussed in Table 2. There has been a recent study conducted by the Department of Electronics, Information and Bioengineering, Milan, of a virtual reality simulator for laparoscopy entry with 14 volunteers of experienced urologists and students, which concluded that this simulator has shown potential to be an important resource for training [17]. However, the authors have mentioned that they have not validated the simulator.

The main advantage of virtual haptics in surgical training is the computer system-based feedback and record of use. However, the cost of running and acquisition is very high, and a recent systematic review into the use of virtual haptics as an education tool was not convincing of haptics being a truly surgical necessity [18]. A cadaveric training programme was found to be useful to significantly improve operative laparoscopic surgical techniques in 21 Obstetrics and Gynaecology residents in a study in Canada [19]. However, cadavers are not widely available for training in all institutions because of cost, facilities and ethico-legal aspects related to their use.

Small group teaching and providing structured feedback have been shown to improve individual and team performance team [20,21]. Creating a safe and supportive learning environment, interactive discussion of clinical anatomy followed by reinforcement using a hands-on simulator with immediate structured feedback forms the basis of the success of this session that helps to deliver the RCOG curriculum by other methodologies. We believe that this is a practical, economical and efficient simulator-based method of teaching. This can be created and used by all healthcare educators for the training of core trainees in the basic laparoscopy entry techniques. We acknowledge that this session cannot be used to replace real clinical patient experience; we believe that this simulator is a valuable teaching aid in teaching the techniques of laparoscopic entry.

Limitations

We acknowledge that the simulator used is not yet validated internationally. There are no specific validated laparoscopy entry simulators available even though operative laparoscopy models are widely used. Our pilot study included only a small number of gynaecology trainees, and even though the feedback was 100% positive, we need more trainees and institutions evaluating this model as a global assessment tool. We plan to include this simulator in our laparoscopy teaching sessions across the whole deanery for gynaecology trainees. Further feedback from trainees and trainers will give more information and gather more evidence on the long-term viability of this model.

Conclusions

This DIY laparoscopy entry simulator complemented by a small group lecture and hands-on workshop session can be a promising mode of acquiring laparoscopy entry skills.
Declarations

Acknowledgements

We are grateful to our trainees who participated in this session and provided feedback and also to the Hull Institute of Learning and Simulation team who helped with the project.

Authors' contributions

K. Soundararajan: concept, design of the study, execution of the project, data collection, data analysis, and manuscript writing; K. Sivakumar: support with the execution of the project and manuscript editing; AB: supervision of the study and technical support, and manuscript editing; MF: project lead, supervision of study and support, and manuscript editing.

Funding

No funding was received for this project.

Availability of data and materials

None.

Ethics approval and consent to participate

This study was registered with Hull Institute of Learning and Simulation and confirmed not to require ethical approval.

Competing interests

No conflict of interest was declared by all four authors.

References

1. Ellison EC, Spanknebel K, Stain SC, Shabahang MM, Matthews JB, Debas HT, et al. Impact of the COVID-19 pandemic on surgical training and learner well-being: report of a survey of general surgery and other surgical specialty educators. Journal of the American College of Surgeons. 2020 Sep 12;231(6):613–626.
2. Fonseka TR, Ellis RJ. The personal impact of covid-19 on trainees. British Medical Journal. 2020 Dec 1;371:m4688.
3. Khan KS, Keay R, McLellan M, Mahmud S. Impact of the COVID-19 pandemic on core surgical training. Scottish Medical Journal. 2020 Aug 9;65(4):133–137.
4. Hope C, Reilly JJ, Griffiths G, Lund J, Humes D. The impact of COVID-19 on surgical training: a systematic review. Techniques in Coloproctology. 2021 Jan 28; 25(5):505–520.
5. Munro C, Burke J, Allum W, Mortensen N. Covid-19 leaves surgical training in crisis. British Medical Journal. 2021 Mar 12;372:n659.
6. Walton M, Murray E, Christian MD. Mental health care for medical staff and affiliated healthcare workers during the COVID-19 pandemic. European Heart Journal Acute Cardiovascular Care. 2020 Apr 28;9(3):241–247.
7. Dedeilia A, Sotiropoulos MG, Hanrahan JG, Janga D, Dedeilias P, Sideris M. Medical and surgical education challenges and innovations in the COVID-19 Era: a systematic review. In Vivo. 2020 Jun;34(3 Suppl):1603–1611.
8. RCOG. Matrix of progression. 2020–2021. https://www.rcog.org.uk/en/careers-training/about-specialty-training-in-og/assessment-and-progression-through-training/training-matrix/ [Accessed 3 December 2021].
9. Royal College of Obstetricians and Gynaecologists. Formative OSATS. 2021. Available from: https://www.rcog.org.uk/en/careers-training/about-specialty-training-in-og/assessment-and-progression-through-training/workplace-based-assessments/osats/ [Accessed 3 December 2021].
10. RCOG. Sign-off by 'other methodologies' (OM). 2021. https://www.rcog.org.uk/en/careers-training/about-specialty-training-in-og/assessment-and-progression-through-training/sign-off-by-other-methodologies/ [Accessed 3 December 2021].
11. BSGE R. Prevention of entry related gynaecological laparoscopic injuries. 2008. https://www.bsge.org.uk/wp-content/uploads/2016/03/GtG-no-49-Laparoscopic-Injury-2008.pdf [Accessed 3 December 2021].
12. Simpson JS. An economical approach to teaching cadaver anatomy. The American Biology Teacher. 2014 Jan;76(1):42–16.
13. Abbasi H, Abbasi A. Using porcine cadavers as an alternative to human cadavers for teaching minimally invasive spinal fusion: proof of concept and anatomical comparison. Cureus. 2019 Nov 14;11(11):e6158.
14. 3B Scientific. VR laparoscopy simulator. 2021. Available from: https://www.3bscientific.co.uk/lap-x-hybrid-laparoscopy-simulator-1020117-medical-x-lap-x-hybrid,p_1456_28147.html?searchinput=laparoscopy&searchword=laparoscopy. [Accessed 3 December 2021].
15. Medisave UK Ltd. Surgery & laparoscopy torso without diathermy. 2021. Available from: https://www.medisave.co.uk/surgery-laparoscopy-torso-without-diathermy.html. [Accessed 3 December 2021].
16. Surgical Science Sweden AB. [LAP SIM]. 2021. Available from: https://surgicalscience.com/simulators/lapsim/. [Accessed 3 December 2021].
17. Di Vece C, Luciano C, De Momi E. Psychomotor skills development for Veress needle placement using a virtual reality and haptics-based simulator. International Journal of Computer Assisted Radiology and Surgery. 2021 Mar 12;16(4):639–647.
18. Rangarajan K, Davis H, Pucher PH. Systematic review of virtual haptics in surgical simulation: a valid

educational tool? Journal of Surgical Education. 2016 Sep 26;77(2):337–347.
19. Levine RL, Kives S, Cathey G, Blinchevsky A, Acland R, Thompson C, et al. The use of lightly embalmed (fresh tissue) cadavers for resident laparoscopic training. Journal of Minimally Invasive Gynecology. 2006 Jun 9;13(5):451–456.
20. Tannenbaum SI, Cerasoli CP. Do team and individual debriefs enhance performance? A meta-analysis. Human Factors. 2012 Jun 4;55(1):231–245.
21. Burgess A, van Diggele C, Roberts C, Mellis C. Facilitating small group learning in the health professions. BioMed Central Medical Education. 2020 Dec 3;20(suppl 2):457.