Research paper

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Self-made transvaginal ultrasound simulator: new training equipment in ultrasound evaluation of controlled ovarian stimulation and oocyte retrieval

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Abstract

Aim: We sought to create and describe a self-made simulator designed and created for teaching purposes: a high-fidelity ultrasound phantom for demonstrating antral follicle count, ultrasound supervision of controlled of ovarian stimulation, and ultrasound-guided oocyte retrieval. **Materials and methods:** The uterus and ovaries of the ultrasound phantom were made from beef tongue, a male condom, latex gloves, cotton suture threads, bi-distilled water, and ultrasound gel. The components were placed in a pelvis created using three-dimensional (3D) printing. The phantom was presented to and evaluated by a group of 14 physicians pursuing a postgraduate course in reproductive medicine. Two training stations were structured: one to simulate antral follicle count and controlled ovarian stimulation and the other to simulate ultrasound-guided oocyte retrieval. Future specialists were requested to complete a feedback questionnaire evaluating the self-made simulator and the two practice stations. **Results:** The transvaginal ultrasound phantom was successfully created, making it possible to simulate antral follicle count, ultrasound control of ovarian hyperstimulation, and oocyte retrieval, and to capture ultrasound images. A review of the answers provided in the feedback questionnaire showed that the phantom had a good appearance and design, was realistic, helped to improve motor coordination, and could be a useful tool in the training of specialists in assisted reproduction. **Conclusion:** This phantom was designed to enable instruction and practice in the evaluation of ovarian follicles and ultrasound-guided oocyte retrieval in a supervised training environment. This self-made simulator is proposed as a training tool that could be included in the curricular structure of residency and postgraduate programs in reproductive medicine.

Introduction

The process of teaching and learning clinical and surgical procedures during medical practitioners' residencies or postgraduate training is complex and filled with ethical issues[1–3]. Future specialists traditionally acquire their new skills while assisting actual patients, under the direct supervision of a more experienced professional. However, this form of training may increase the patients' risks to injuries and it is associated with varied levels of treatment success; real-life training also requires a long period of mentoring, resulting in a slow learning curve and high training costs[4–6].

Simulation is a training method used in different areas of knowledge, including medicine, where it is known as “medical simulation” or “healthcare simulation” [7,8]. Using simulators to train future specialists in medical procedures offers the opportunity to acquire and practice technical skills in a safe, controlled, and reproducible environment without the risk of harming the patient[7]. Other benefits of using simulators in medical education include a reproducible curriculum for all students, immediate learning feedback, improvement of psychomotor skills, accuracy in clinical decision-making, and learning to work in a multidisciplinary team[9]. The earliest simulators in medical history were the obstetrical manikins introduced around 1700. Nowadays, simulators are frequently used to train doctors, nurses, and laypersons in such procedures as cardiopulmonary resuscitation[7,8].

Several medical societies currently recommend that training in a simulated environment should be part of the curriculum for resident physicians in several specialties. Computer technology advancements have made it possible to design virtual simulators that teach clinical and surgical skills with unlimited scenarios, simulation environments, and virtual patients[10–14].

Modern virtual simulators are widely used as an aid in the training of invasive and non-invasive ultrasound skills; however, the cost of acquiring and maintaining such equipment is still a limiting factor for many medical teaching centers, especially in developing countries[4,5,15,16]. Several training programs in ultrasound use self-made simulators that stand out for the realism of obtained images and low cost of production[17–21]. These simulators, also known as “phantoms,” are created from synthetic products, as well as other components of animal and plant origin, to simulate the anatomical relationships and echogenicity of different body organs and tissues. Their small size, ease of assembly, and durability, especially in ultrasound phantoms using “‘meat models,” are important characteristics for an ideal self-made simulator[22,23].

Practitioners involved in assisted reproduction technology and infertility fellowship programs must become proficient in ultrasound control for patients undergoing controlled ovulation stimulation and oocyte retrieval[11]. The number of oocyte retrieval procedures performed under supervision to acquire proficiency may vary among trainees, but it is estimated that half of the trainees in a typical fellowship program need at least 13 procedures. On the other hand, proficiency in transvaginal ultrasound for monitoring controlled ovulation stimulation is quite variable[11,24].

Soave *et al.*[24] observed that using a virtual oocyte retrieval training simulator improved the procedure’s efficiency, speed, and accuracy both in a group of experienced practitioners and in another group of novice physicians. In another study, involving 46 residents from several French hospitals, Corroenne *et al.*[15] showed that a virtual oocyte retrieval simulator was a simple and efficient training method. Unfortunately, the cost of equipment and its delivery hinders access to the majority of commercially available virtual oocyte retrieval simulators.

This study aims to describe the creation of a self-made ultrasound simulation model for training practitioners in ultrasound control of ovulation induction and oocyte retrieval.

Materials and methods

Study design and settings

The authors collaborated to create a self-made simulator from February to June 2021. In the next step, the authors presented the phantom to a group of 14 future specialists in assisted reproduction from the Center for Teaching and Training in Ultrasound (CETRUS) at the unit in Recife, Pernambuco, Brazil.

Phantom preparation

Preparation of the ovaries

To simulate the ovarian parenchyma, minced beef tongue was used. To ensure the health and safety of those involved in the handling of biological material, the beef tongue was purchased from food establishments certified by local health vigilance authorities. To decontaminate the meat, it was placed in a basin with 10 ml of bleach and 1 liter of tap water for 5 to 10 seconds. Follicles of varying volumes and sizes (diameters ranging from 10 to 20 mm) were made from glove fingers filled with bi-distilled water; they were then inserted together with the pricked beef tongue inside a male condom (Fig. 1 and Fig. 2). Two sets of ovaries were made, each with different volumes and numbers of follicles, and positioned to the right and left of the pelvis, allowing for a greater number of evaluations. The final ovary had a cylindrical shape and was about 12 cm in length and 7 cm in diameter (Fig. 2). This size of the simulator ovary allows better visualization and fixing of the structure to the uterus.

Preparation of the uterus and vagina

We used a decontaminated beef tongue (the decontamination process is described in the previous section) to prepare the uterus. For the simulation of the endometrial line, we folded the animal tissue in its longitudinal direction. When visualized by ultrasound, the edges of the tissue appeared as hyperechogenic lines, simulating the anterior and posterior junctional zone, creating a thickness between 3 and 5 mm. The aim was to mimic the uterine texture, create a reference point for locating and scanning the ovaries, and make it possible to assess endometrial thickness. The final uterine measurements were around 10 cm in length, 8 cm in width, and 5 cm in depth (Fig. 1 and Fig. 2). This final size of the uterus simulator approaches the actual measurements and allows a good fixation of the structure to the 3D pelvis. The vaginal canal was constructed using a standard-size male condom.

Preparation of the pelvis

The phantom was mounted on a device shaped like a female pelvis, created by three-dimensional (3D) printing (Fig. 1). The 3D pelvis had two openings, one superior and one lateral. The upper opening was shaped as an oval with a lid, allowing access to the assembly of the pelvic structures (uterus and ovaries). The opening on one side was covered with a male condom to simulate the vaginal canal and provide access for the endovaginal transducer.

Fig. 1. *Components for preparing the homemade simulator.* **A.** *3D printed pelvis;* **B.** *Beef tongue folded into the shape of the uterus with sutures on the sides;* **C.** *Minced beef tongue;* **D.** *Glove fingers filled with bi-distilled water in different diameters*

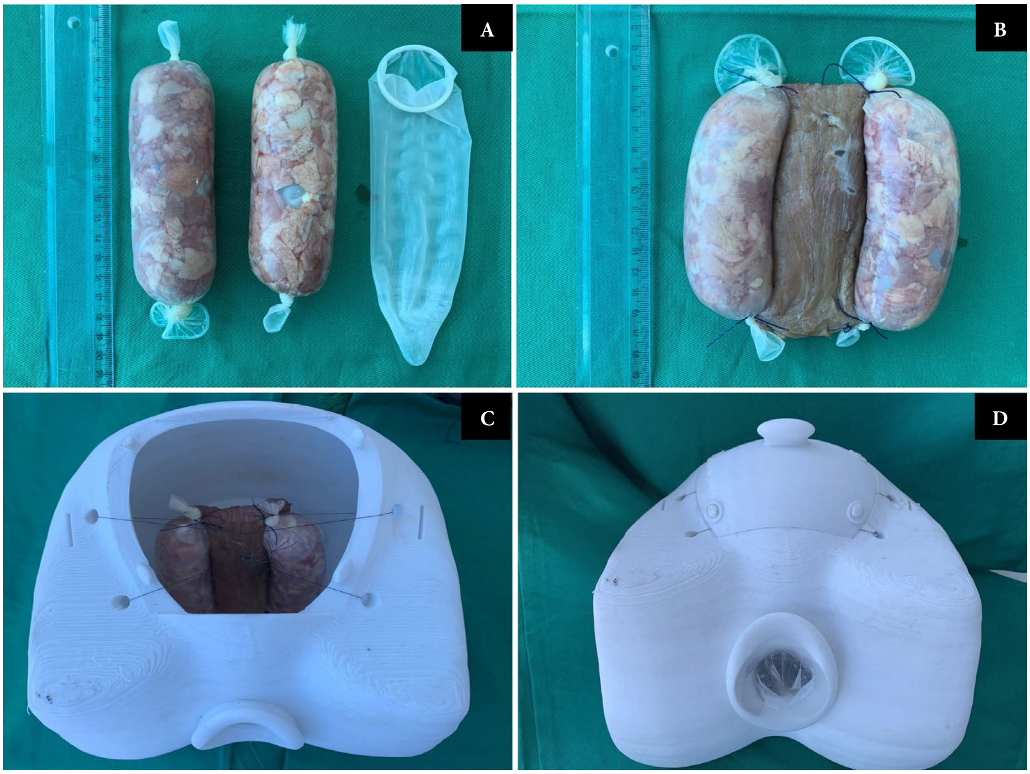

Fig. 2. *Assembly of the homemade simulator.* **A.** *Follicles of different diameters inserted together with the minced beef tongue inside a male condom;* **B.** *Ovaries attached to the sides of the uterus;* **C.** *Ovaries and uterus fixed inside the 3D pelvis;* **D.** *Final view of the homemade simulator after assembly, highlighting the vaginal canal*

As described above, the ovaries were fixed to the right and left sides of the uterus using cotton suture thread (size 0) and subsequently fixed inside the 3D pelvis. The anatomical piece (utero-ovaries) was attached to specific points (locking points created by 3D printing) inside the 3D pelvis through moorings, using cotton suture thread (size 0), which allowed the closest positioning to the anatomy of a female pelvis. Finally, the 3D pelvis was completely filled with ultrasound gel (approximately 5 liters), and the upper part was closed (Fig. 2). The average time to prepare and assemble the simulator was 40 minutes.

Universal precautions

To prevent any contamination of users during practice sessions, we encouraged the use of disposable gloves and plastic aprons. We put the phantom in disposable plastic trays to avoid contamination of the demonstration surface. The disposable trays and phantoms were placed on water-resistant blue sheets to prevent contamination of the surface due to dripping from the phantom (liquid that arises with the simulator heating).

Feedback questionnaire

The 14 physicians-in-training declared the absence of conflict of interest and were asked to complete a questionnaire to assess the realism and usefulness of the phantom for acquiring ultrasound skills. The questionnaire was divided into two sections and assessed the use of the phantom for ultrasound evaluation training in cycles of controlled ovarian stimulation and oocyte retrieval (Tab. 1).

Tab. 1. Feedback questionnaire

Section 1. Using the phantom for ovulation tracking training
1. What is your opinion of the appearance and design of the simulator? Possible answers: excellent, good, moderate, bad, terrible. 2. What is your opinion about the realism of the phantom? Possible answers: excellent, good, moderate, bad, terrible. 3. What is your opinion on the use of the phantom in ovulation control training? Possible answers: excellent, good, moderate, bad, terrible. 4. Could practicing with the phantom give you confidence to perform ovulation control? Possible answers: certainly, probably, not really, no.
Section 2. Using the phantom for oocyte retrieval training
1. What is your opinion about the realism of the phantom for follicular aspiration training? Possible answers: excellent, good, moderate, bad, terrible. 2. What is your opinion about acquiring basic skills in oocyte collection with the use of the phantom? Possible answers: excellent, good, moderate, bad, terrible. 3. What is your opinion about the usefulness of the simulator in improving hand-eye coordination? Possible answers: excellent, good, moderate, bad, terrible. 4. Could training with the phantom give you confidence to perform oocyte retrieval? Possible answers: certainly, probably, not really, no.
Note: Answers by beginners after the two training sessions, with multiple choice questions and possible answers.

Results

Training in antral follicle count and controlled ovarian stimulation
The phantom can be used for 24 hours (conservation time of biological material) for training in antral follicle count and to count and measure follicles in the simulation of controlled ovarian stimulation. A transvaginal ultrasound probe at a frequency of 8–13 MHz was used to capture images (Fig. 3). The ultrasound probe should be covered with a condom for protection. During training with the phantom, the ultrasound technique is the same as that used in vivo: performing longitudinal and/or transverse scanning of each ovary and calculating the average diameter of each follicle based on the measurement of two axes. The superior opening of the 3D pelvis allows the repositioning of the ovaries in different locations, changing the degree of difficulty of the training (Fig. 3).

Training in ultrasound-guided oocyte retrieval

The training in ultrasound-guided follicular aspiration was performed using one regular, sterile single lumen oocyte retrieval needle attached to a sterile collection tube to capture the "follicular fluid," and a 20 ml sterile syringe that exerted the aspiration pressure. Pairs of participants went through the training session together. One of the members was the ultrasound operator, responsible for generating the image, identifying the uterus and ovaries, and designing the strategy to puncture all follicles with the minimum number of punctures without moving the needle too much. The other member was responsible for performing suction through the syringe, monitoring the presence or absence of the follicular fluid in the collection tube, and changing it when it was full. The resistance offered for the progression of the needle by biological tissues is similar to that experienced in real patients. Containers for the disposal of sharps and biohazardous materials should be readily available for participant safety and training site hygiene (Fig. 3).

Feedback questionnaire

Figure 4 summarizes the answers provided by 14 physicians after the training sessions with the phantom. A review of the responses to the questionnaire showed that the phantom had a good appearance and design, is was realistic, helped to improve motor coordination, and could be a useful tool in the training of specialists in assisted reproduction.

Discussion

During their training, specialists in reproductive medicine should acquire, among others, ultrasonographic skills of antral follicle counting, evaluating the number and size of ovarian follicles during controlled ovarian stimulation, and guiding oocyte retrieval procedure. To achieve this end, the European Society of Human Reproduction Embryology (ESHRE) recommends that the curriculum structure provide simulation training for future specialists[11]. However, the reduced number of simulator models and the high cost of their acquisition and maintenance are limiting factors for implementing the recommended practice in residency and graduate programs.

Derr *et al.*[6] observed that emergency physicians needed at least 25 exams in point-of-care ultrasound training to acquire proficiency in adequate preparation and insertion of the endovaginal transduc-

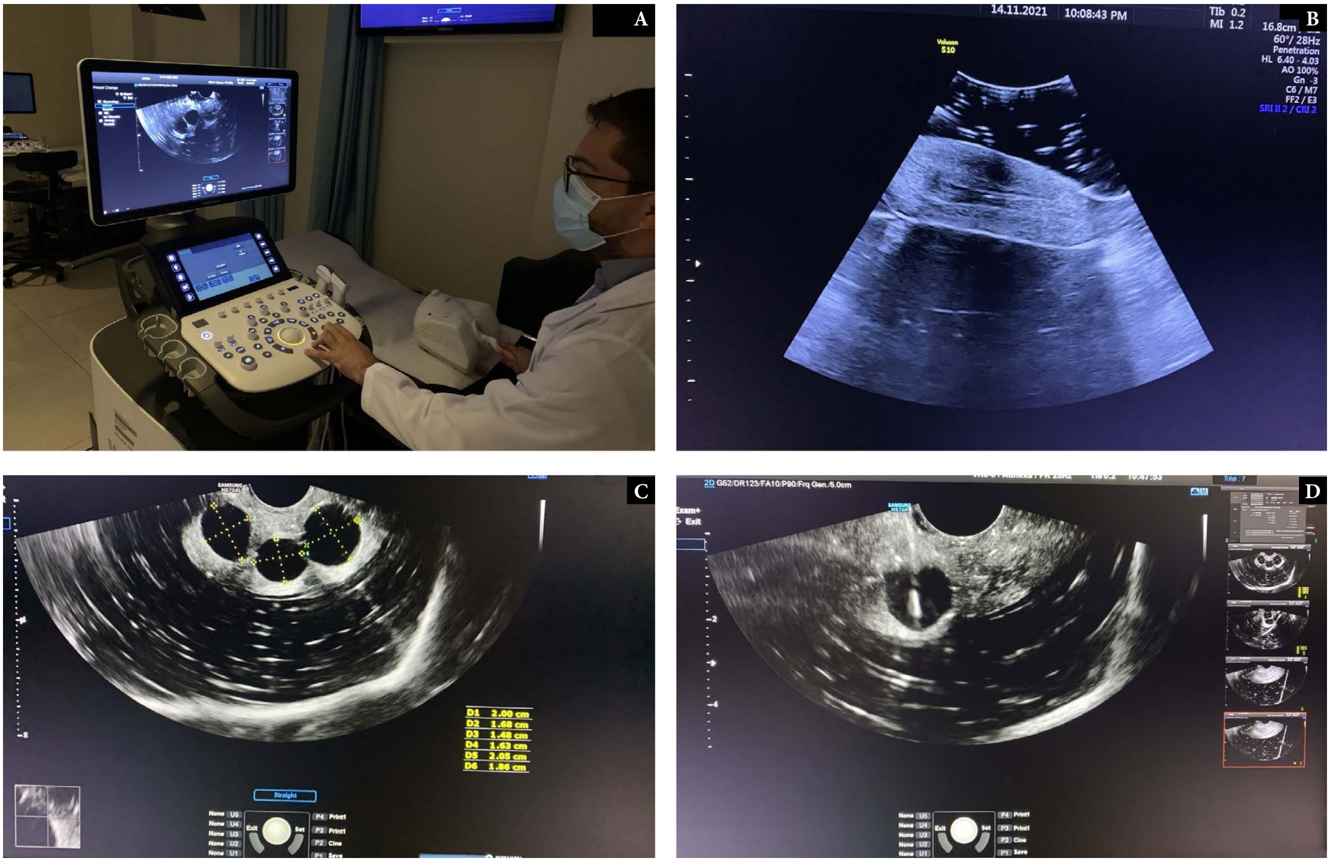

Fig. 3. *Training session with the homemade simulator.* **A.** *Overview of a student during a training session;* **B.** *Transvaginal ultrasound image showing a longitudinal section of the uterus (sagittal view);* **C.** *Transvaginal ultrasound image during an ovarian follicle count and measurement in an ovary simulating hyperstimulation;* **D.** *Transvaginal ultrasound image during simulation of oocyte retrieval, highlighting the needle in the center of the follicle*

er, identification of the bladder and uterus, and anatomic relationships of pelvic organs. However, the authors found that emergency physicians still had difficulty identifying the ovaries after this initial training, suggesting that a learning curve persisted after 25 exams[6]. Several authors have highlighted the importance of simulator training to improve ultrasound skills in obstetrics and gynecology. Chao *et al.*[25] observed that virtual simulator training considerably improved the skills of performing transvaginal ultrasound among first-year gynecology and obstetrics residents. Byford *et al.*[26] found that incorporating virtual simulator training into an obstetrics and gynecology residency program improved confidence and ability to perform transvaginal ultrasounds.
There are no clear guidelines on the minimum number of oocyte retrievals needed under the supervision of an expert to acquire competence in this procedure. ESHRE suggests that competency in oocyte retrieval is achieved with at least 30 procedures, and that a minimum of 50 oocyte pick-up (OPU) procedures would be required to achieve adequate qualifications[11].

Proficiency in oocyte retrieval should be evaluated not only by performing the procedure but by the results obtained, using the following variables: absolute number and rate of oocytes collected (number of oocytes collected/number of follicles), number of ovarian punctures, procedure duration, and number of short- and long-term complications[11]. ESHRE suggests that, where possible, simulators should form part of the structured training for beginners wishing to perform OPU. Simulators make it possible to monitor basic skills and reach a predefined level of performance in a safe and controlled environment before performing the procedure on actual patients[11].

Our literature review did not find any mention of other self-made simulators being used in reproductive medicine to train practitioners in ultrasound skills. The strong points of our phantom include its low cost, ease of assembly, reproducibility, and the possibility of training many times by beginners. Practice with the phantom can help trainees in reproductive medicine to acquire basic ultrasonographic skills such as image construction, orientation in the sagittal and coronal planes, identification of the uterus and ovaries, counting and measuring ovarian follicles, and invasive procedures such as oocyte retrieval. Another strength of the phantom is the possibility of additional training for professionals who are already qualified but do not perform a sufficient annual number of OPUs to maintain their skills or need to refresh their existing ones.

The durability of the simulator and the lack of possibility to evaluate the rate of recovered eggs – an essential criterion in competence evaluation – were the main limitations associated with this self-made simulator. The same simulator allows multiple assessments of ovarian follicles, but only a single OPU. Another downside of the phantom is the absence of structures that simulate the pelvic vessels, intestine, and rectum, which is relevant, as injuries to these organs are responsible for the rare complications observed in OPU.
The feedback questionnaire shows that the self-made ultrasound simu-

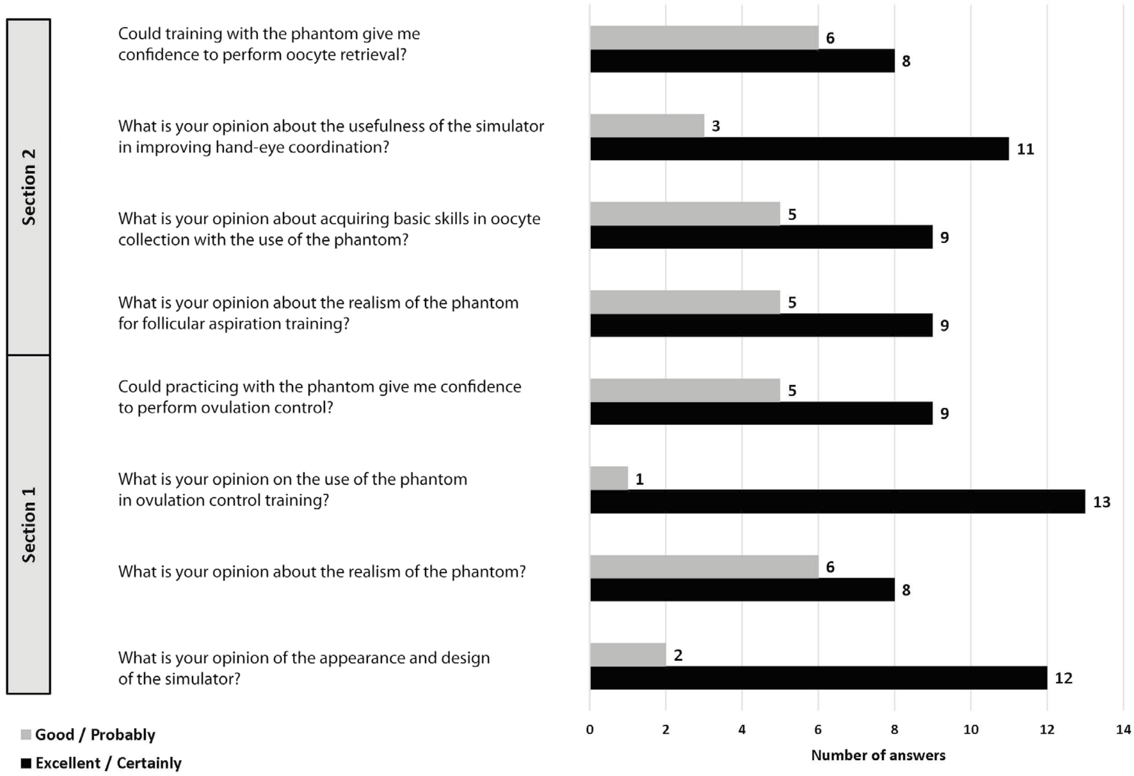

Fig. 4. *Feedback questionnaire. Answers provided by 14 physicians after the training sessions with the homemade simulator*

lator produces ultrasound images that correspond to those obtained from an actual patient, especially of the uterus and ovaries with follicles of different sizes. The use of the ultrasound simulator allows the practices of counting, measuring, and follicular aspiration. However, an intervention study is needed to assess the impact of phantom-based training on the acquisition of ultrasound skills by OPU beginners.

Conclusion

In conclusion, the phantom described above has been designed for the purposes of instruction and practice in ultrasound-guided oocyte retrieval and evaluation of ovarian follicles in a supervised training environment. In addition, its realism and portability allow students to use it as a stand-alone repetitive practice station at their own pace and convenience. Thus, this self-made simulator is proposed as a training tool that could be included in the curricular structure of residency and postgraduate programs in reproductive medicine.

Conflict of interest

The authors do not report any financial or personal connections with other persons or organizations which might negatively affect the contents of this publication and/or claim authorship rights to this publication.

Author contributions

Original concept of study: MBC, AAF. Writing of manuscript: EAJ. Analysis and interpretation of data: MBC, PHAS. Final approval of manuscript: MBC, SMZF, WBNCO, MMPC, PHAS, AAF, CRP, EAJ. Collection, recording and/or compilation of data: WBNCO, MMPC. Critical review of manuscript: SMZF, CRP, EAJ.

References

1. Ruiz-Gómez JL, Martín-Parra JI, González-Noriega M, Redondo-Figuero CG, Manuel-Palazuelos JC: Simulation as a surgical teaching model. Cir Esp (Engl Ed) 2018; 96: 12–17. DOI: 10.1016/j.ciresp.2017.09.005.
2. Leape LL, Brennan TA, Laird N, Lawthers AG, Localio AR, Barnes BA *et al.*: The nature of adverse events in hospitalized patients. Results of the Harvard Medical Practice Study II. N Engl J Med 1991; 324: 377–384. DOI: 10.1056/nejm199102073240605.
3. Burgess A, van Diggele C, Roberts C, Mellis C: Tips for teaching procedural skills. BMC Med Educ 2020; 20(Suppl 2): 458. DOI: 10.1186/s12909-020-02284-1
4. Stather DR, Maceachern P, Rimmer K, Hergott CA, Tremblay A: Assessment and learning curve evaluation of endobronchial ultrasound skills following simulation and clinical training. Respirology 2011; 16: 698–704.

5. Stather DR, Chee A, MacEachern P, Dumoulin E, Hergott CA, Gelberg J *et al.*: Endobronchial ultrasound learning curve in interventional pulmonary fellows. Respirology 2015; 20: 333–339. DOI: 10.1111/resp.12450.

6. Derr C, Shteyman A, Jackson SA, Lu Y, Campbell T, De Lucia A *et al.*: Determination of endovaginal ultrasound proficiency and learning curve among emergency medicine trainees. J Ultrasound Med 2022; 41: 1741–1752. DOI: 10.1002/jum.15857.

7. Ayaz O, Ismail FW: Healthcare simulation: a key to the future of medical education – a review. Adv Med Educ Pract 2022; 13: 301–308. DOI: 10.2147/amep.s353777.

8. Al-Elq AH: Simulation-based medical teaching and learning. J Family Community Med 2010; 17: 35–40. DOI: 10.4103/1319-1683.68787.

9. Abas T, Juma FZ: Benefits of simulation training in medical education. Adv Med Educ Pract 2016; 7: 399–400. DOI: 10.2147/amep.s110386.

10. Milburn JA, Khera G, Hornby ST, Malone PS, Fitzgerald JE: Introduction, availability and role of simulation in surgical education and training: review of current evidence and recommendations from the Association of Surgeons in Training. Int J Surg 2012; 10: 393–398. DOI: 10.1016/j.ijsu.2012.05.005.

11. ESHRE Working Group on Ultrasound in ART, D'Angelo A, Panayotidis C, Amso N, Marci R, Matorras R *et al.*: Recommendations for good practice in ultrasound: oocyte pick up. Hum Reprod Open 2019; 2019: hoz025. DOI: 10.1093/hropen/hoz025.

12. Penneçot C, Gagnayre R, Ammirati C, Bertin É, Capelle D, Cheraitia E *et al.*: Consensus recommendations for the use of simulation in therapeutic patient education. Simul Healthc 2020; 15(1): 30–38. DOI: 10.1097/sih.0000000000000401.

13. Frykholm P, Pikwer A, Hammarskjöld F, Larsson AT, Lindgren S, Lindwall R *et al.*: Clinical guidelines on central venous catheterisation. Swedish Society of Anaesthesiology and Intensive Care Medicine. Acta Anaesthesiol Scand 2014; 58(5): 508–524. DOI: 10.1111/aas.12295.

14. Society of Thoracic Surgeons Task Force on Resuscitation After Cardiac Surgery: The Society of Thoracic Surgeons expert consensus for the resuscitation of patients who arrest after cardiac surgery. Ann Thorac Surg 2017; 103(3): 1005–1020. DOI: 10.1016/j.athoracsur.2016.10.033.

15. Corroenne R, Legendre G, Riethmuller D, El-Hachem H, Zhu KH, Dreux C *et al.*: Benefits of an oocyte pickup simulation training program using a high-fidelity simulator (PickUpSim™) for obstetrics and gynaecology residents: an observational survey study. J Obstet Gynaecol 2021; 41(4): 631–636. DOI: 10.1080/01443615.2020.1789951.

16. Frère A, Samba E, Lejus-Bourdeau C: SonoSim ultrasound simulator training for novice residents: a randomised study. Eur J Anaesthesiol 2021; 38(7): 791–792. DOI: 10.1097/eja.0000000000001481.

17. Al-Hadidi A, Amine M, Batman A, Hakmeh W: Homemade cardiac and vein cannulation ultrasound phantoms for trauma management training in resource-limited settings. Avicenna J Med 2021; 11(1): 42–45. DOI: 10.4103/ajm.ajm_196_20.

18. Novaes AKB, Dalamura R, Menon T, Pazeli JM Jr, Bastos MG: Homemade ultrasound phantom for simulation of hydronephrosis. J Bras Nefrol 2018; 40(2): 206–208. DOI: 10.1590/2175-8239-jbn-3916.

19. Lo MD, Ackley SH, Solari P: Homemade ultrasound phantom for teaching identification of superficial soft tissue abscess. Emerg Med J 2012; 29(9): 738–741. DOI: 10.1136/emermed-2011-200264.

20. James V, Kee CY, Ong GY: A homemade, high-fidelity ultrasound model for simulating pneumonia with parapneumonic effusion and empyema. J Emerg Med 2019; 56(4): 421–425. DOI: 10.1016/j.jemermed.2018.12.015.

21. Di Domenico S, Santori G, Porcile E, Licausi M, Centanaro M, Valente U: Inexpensive homemade models for ultrasound-guided vein cannulation training. J Clin Anesth 2007; 19(7): 491–496. DOI: 10.1016/j.jclinane.2007.05.002.

22. Giannotti E, Jethwa K, Closs S, Sun R, Bhatti H, James J *et al.*: Promoting simulation-based training in radiology: a homemade phantom for the practice of ultrasound-guided procedures. Br J Radiol 2022; 95(1137): 20220354. DOI: 10.1259/bjr.20220354.

23. Izhar R, Husain S, Tahir MA, Kausar M, Sana T, Ghalib F: Antral follicle count and anti-Müllerian hormone level as predictors of ovarian hyperstimulation syndrome in women with polycystic ovarian syndrome undergoing controlled ovarian stimulation. J Ultrason 2021; 21(86): e200–e205. DOI: 10.15557/jou.2021.0032.

24. Soave I, D'Angelo A, Piva I, Marci R: A pilot study on oocyte retrieval simulator: a new tool for training? J Med Syst 2019; 43(7): 202. DOI: 10.1007/s10916-019-1340-3.

25. Chao C, Chalouhi GE, Bouhanna P, Ville Y, Dommergues M: Randomized clinical trial of virtual reality simulation training for transvaginal gynecologic ultrasound skills. J Ultrasound Med 2015; 34(9): 1663–1667. DOI: 10.7863/ultra.15.14.09063.

26. Byford S, Janssens S, Cook R: Implementing the transvaginal ultrasound simulation training (TRUSST) programme for obstetric registrars. Adv Simul (Lond) 2021; 6(1): 1. DOI: 10.1186/s41077-020-00152-y.