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ORIGINAL ARTICLE

A new affordable and easy-to-make pelvic model for training in complex urogynecological laparoscopic procedures

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Abstract

Introduction and hypothesis Our aim was to introduce a new affordable and easy-to-make pelvic model for training in complex urogynecological laparoscopic procedures.

Methods We modified a commercial female pelvic model consisting of sacrum, coccyx, two hip bones, the pubic symphysis, the fifth lumbar vertebra with intervertebral disc, and certain pelvic ligaments. We used sponge foam paper, felt fabric pieces, chenille stems, foam, plastic ties, fabric glue, and a thick, coated wire to create pelvic floor, uterus/vaginal cuff, bladder, both ureters, and anterior longitudinal and pectineal ligaments.

Results We created two different pelvic models: one with the uterus and one with the vaginal cuff. They enable training for laparoscopic pectopexy and hysteropexy/sacrocolpopexy. Trainees can practice proper mesh placement and suture the mesh to the corresponding anatomical structures. Because of the wire inserted in the uterus/vaginal cuff, it is possible to move the uterus/vaginal cuff in the anterior–posterior direction, thus mimicking the use of the manipulator during surgery. Besides the basic pelvis, all other parts of the model can be easily replaced when necessary.

Conclusions We believe that our pelvic model could provide a valuable tool for training complex urogynecological laparoscopic procedures and help to reduce the long learning curve of these procedures.

Keywords Laparoscopy · Training · Training model · Laparoscopic skills · Urogynecology

Introduction

One of the most common indications for gynecologic surgery is pelvic organ prolapse [1]. A woman who reaches 80 years of age has an 11% risk of surgical intervention because of pelvic organ prolapse and this percentage is expected to rise within the next 30 years [1, 2]. With recent advances in laparoscopic surgery and the increasing number of laparoscopic procedures performed, surgeons have to master a specific set of psychomotor and visuospatial skills [3]. Urogynecologists are not an exception here, as they have to overcome a lengthy and difficult learning process to obtain reasonable operation times and low conversion rates [4]. To reach these goals and achieve a favorable restoration of pelvic floor anatomy, they have to master laparoscopic surgical technique including laparoscopic suturing, and have a detailed knowledge of pelvic organs and pelvic floor anatomy [2].

Laparoscopic skills have therefore become essential for surgical trainees in surgery, gynecology, urology, urogynecology etc. Trainees can obtain these skills during training on physical simulators, various virtual reality simulators, or human and animal cadaver models [5, 6]. This kind of training has proven to be efficient in the acquisition of laparoscopic surgical skills and several studies have shown that technical skills learned in a simulation environment are transferrable to the operating room [3, 6, 7]. As many of these simulators are expensive and therefore not accessible in all environments, different affordable and easy-to-build laparoscopic trainers and models have been described [6, 8]. Our aim was to develop a new affordable and easy-to-make pelvic model for training in complex urogynecological laparoscopic procedures that can be put in a box simulator and be used as an additional training level between basic laparoscopic psychomotor skills training and performance of the procedure on a real patient.

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Materials and methods

As the present work did not include any human subjects, IRB approval was not required. Our pelvic model was made by modification of a commercial adult female pelvic model (3B Scientific, Hamburg, Germany), which was made of synthetic bone-like material and consisted of sacrum, coccyx, two hip bones, the pubic symphysis, and the fifth lumbar vertebra with intervertebral disc. Incorporated into the model were inguinal, pectineal, sacrospinous, sacrotuberous, anterior longitudinal, anterior sacroiliac, and iliolumbar ligaments, all made of a rubber-like material.

For modification of the model, we used sponge foam paper, felt fabric pieces, chenille stems (0.8 mm diameter, 50 cm length), foam, plastic ties, fabric glue, and a thick, coated wire (0.3 mm diameter of the wire; Fig. 1). First, we created a pelvic floor using red-colored sponge foam paper. A hole was cut out in the middle of the pelvic floor to create a space for the vaginal cuff or uterus, respectively. The pelvic floor was attached to the pelvis in three places (both sacrotuberous ligaments and pubic symphysis) using plastic ties. Next, we created a vaginal cuff and the uterus. The vaginal cuff was created using peach-colored felt fabric and a fabric glue. For the uterus, several sheets of black foam were glued together to create a block, then a uterus-shaped structure was sculpted out of the block using scissors or a knife. A thick, coated wire was inserted into the cuff or the uterus respectively to enable movement in an anterior–posterior direction, mimicking the use of a manipulator during the surgical procedure. The vaginal cuff/uterus was inserted into the pelvic floor through the previously created hole.

In order to simulate the anatomy of the female pelvis, we made a two-dimensional model of a bladder and a model of both ureters. The bladder was cut out of a yellow-colored sponge foam paper as a circular-shaped structure. For both ureters, one yellow chenille stem was used. We attached a chenille stem to the iliolumbar ligament on one side of the pelvis, and then directed it toward the bladder, which was placed right in front of the vaginal cuff/uterus and attached to the pubic symphysis using a plastic tie. We threaded the chenille stem through the two punctures in the lateral sides of the bladder and then back up toward the iliolumbar ligament on the other side, where it was again attached. For an additional challenge, the left common iliac vein and hypogastric nerves can be created using red felt and a white thread.

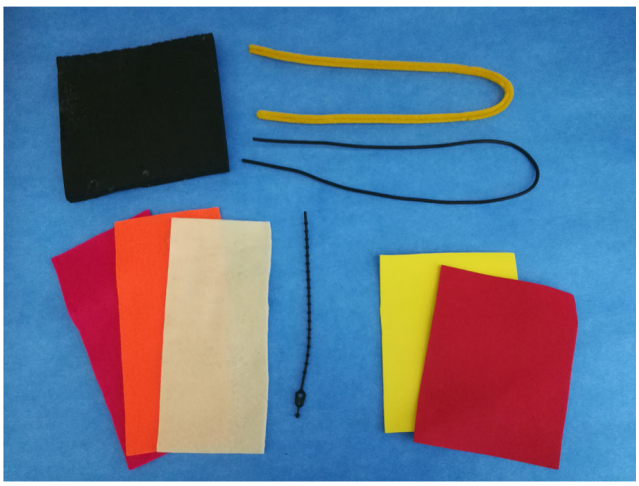

Fig. 1 Materials needed for the pelvic model set-up. *Top left*: black foam. *Top right*: chenille stem and coated wire. *Bottom left*: felt fabric pieces. *Bottom right*: sponge foam paper. *Bottom center*: plastic tie

In the final step of the process, we created anterior longitudinal and pectineal ligaments using felt fabric pieces of different colors. We cut out strips of fabric, which we attached to corresponding anatomical structures using plastic ties. The attachment had to be very tight to enable suturing without movement of the underlying ligaments.

Results

The result of our modification of a basic commercial female pelvic model are two different pelvic models for complex urogynecological laparoscopic procedures training; one with the uterus and one with the vaginal cuff (Figs. 2, 3). For training purposes, they can be put in a box simulator and attached to the box using a wire (Fig. 4). In our case, a Szabo–Berci–Sackier laparoscopic box trainer with a suturing top plate was used. Otherwise, any other box trainer of appropriate size can be utilized. The first model with the uterus enables training of both laparoscopic hysteropexy and pectopexy. Trainees can practice proper mesh placement and suture the mesh to the uterus and the anterior longitudinal or pectineal ligament respectively. The second model with the vaginal cuff enables training of laparoscopic sacrocolpopexy and laparoscopic pectopexy, again with the proper mesh placement and suturing of the mesh to the cuff and the anterior longitudinal or pectineal ligament. Because of the wire in the uterus/vaginal cuff, it is possible to move the uterus/vaginal cuff in an anterior–posterior direction, thus mimicking the movement of the uterine/vaginal manipulator during surgical procedure. The pelvic floor, pelvic bones, ligaments, bladder, and the ureters are very similar to real-life pelvic anatomy and give trainees the opportunity to work and suture in a limited space, just as they would in real surgical procedure.

Except for the basic pelvis, all components of the model are reusable, inexpensive, and can be simply replaced when necessary (Table 1). Although the basic pelvic model was bought from the manufacturer for approximately 210 EUR, all of the other components were bought in a specialized art supplies store for less than 15 EUR per model. In this manner, the model can be simply renewed and used for a long period of time with relatively low costs.

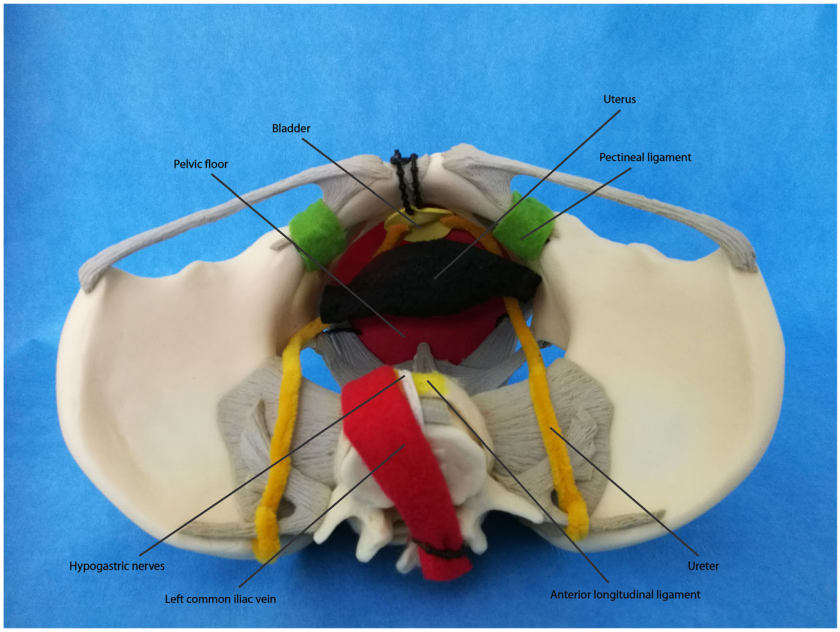

Fig. 2 Pelvic model with uterus

Discussion

During laparoscopy, surgeons have to deal with some unique challenges compared with open surgical procedures: altered hand–eye coordination, loss of depth perception because of the two-dimensional video image, limited tactile feedback, the fulcrum effect, and working with elongated instruments [3]. To overcome these challenges, simulation training has become an indispensable part of the learning process for trainees and novice surgeons, as it helps them to progress along the early part of the learning curve before entering the operation [3, 5–7]. A resident survey from 2014 showed that 95.5% of trainees believe that simulation training improved their laparoscopic skills. Most of them also believed that skills learned during simulation were transferrable to the operating room [3]. Moreover, it has been shown that training outside the operating room objectively improves residents' operative performance and that learning of laparoscopic skills can be enhanced by independent practice on simulators, either at home or on site [9]. Laparoscopic suturing skills, which are usually most difficult to master, require even more coaching and access to advanced models compared with basic laparoscopic psychomotor skills [10, 11].

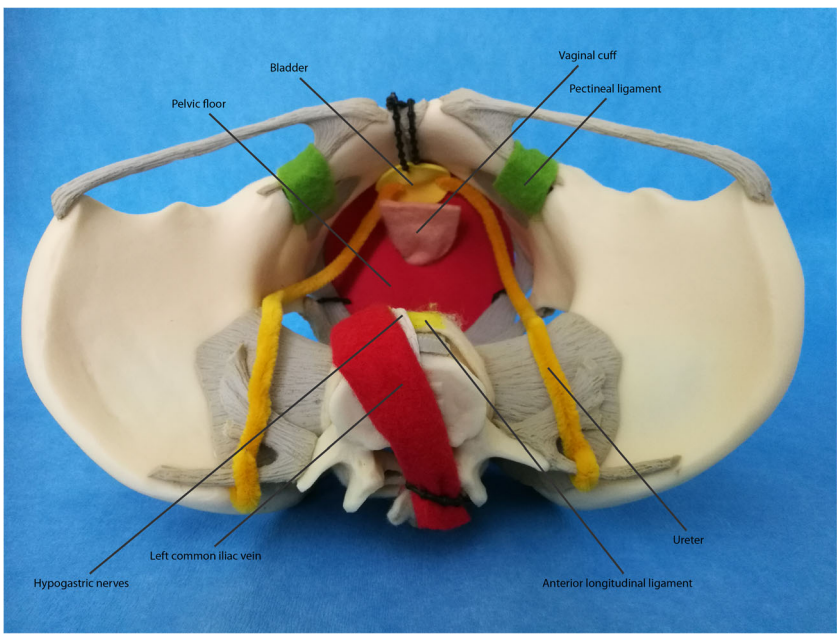

Fig. 3 Pelvic model with vaginal cuff

Fig. 4 Pelvic model in a box simulator with attached mesh after practice of advanced urogynecological laparoscopic skills

To achieve good anatomical results, reasonable operation times, and low conversion rates, urogynecologists need to master laparoscopic surgical skills and have a detailed knowledge of pelvic anatomy [2, 4]. As in other surgical fields, they too have to progress along the learning curve, which varies greatly because of differences in surgeons' baseline skills, patient population, and participation of trainees in the learning process [10]. Establishment of a learning curve in laparoscopic urogynecological procedures has been most extensively studied in laparoscopic sacrocolpopexy (LSCP). LSCP is a complex surgical intervention, first described in 1994, with a low complication rate, but specific complications and a long learning curve, and therefore requires appropriate training [12–14]. In 2009, Claerhout et al. found out that a single experienced surgeon has to perform 60 LSCPs to overcome the learning curve. Operative time declined rapidly during the first 30 procedures and reached a steady state after 90 surgeries with an unchanged complication rate during the series [14]. Two more studies have also investigated learning curves of senior urogynecological surgeons. A study by Akladios et al. analyzed the first 48 LSCPs performed by the same surgeon. They discovered a linear decrease in the duration of surgery with a turning point after 18–24 procedures and no increased morbidity during the learning curve [2]. Another retrospective study by Mustafa et al. compared results of 47 consecutive women in whom LSCP was performed. They found that after the first 15 cases of one surgical team, operative time significantly decreased and that 30–40 procedures were necessary to master the LSCP technique [1]. Similarly, Kantartzis et al. found a decrease in mean operative time with each group of ten cases until cases 31–40 in their retrospective analysis of the first 180 LSCPs performed by four experienced surgeons [10].

Table 1 Components and tools required for pelvic model set-up

	Description	Quantity
Components	Adult female pelvic model	1 piece
	Sponge foam paper—red	1 sheet
	Sponge foam paper—yellow	1 sheet
	Chenille stems—yellow	1 piece
	Foam	3–4 sheets
	Felt fabric—peach	1 sheet
	Felt fabric—optional colors	2 sheets
	Plastic ties	7 pieces
	Thick, coated wire	1 piece
Tools	Fabric glue	1 tube
	Knife	1 piece
	Scissors	1 piece

In our opinion, our pelvic model for complex urogynecological procedures training could help to overcome the learning curve for these procedures. First, it enables practice of mesh handling, which can sometimes be difficult for a novice surgeon. Furthermore, a trainee can practice suturing of the mesh to the uterus/vaginal cuff and the ligaments while simultaneously holding the mesh in place, which represents an additional challenge. Because of the surrounding pelvic floor, pelvic bones, ligaments, bladder, and the ureters, the trainee has the opportunity to work and suture in a limited space, just as he or she would in a real surgical procedure. The limitation of the model is that it does not enable the practice of nerve-sparing dissection of the retroperitoneal space or the dissection of different planes in the vesicouterine and rectouterine pouch. According to the results of certain studies, the rate-limiting steps of LSCP are the determination of correct planes for safe dissection and the high number of sutures [1, 10]. Claerhout et al. found that the dissection phase represents the most challenging step for a trainee [4]. However, in our opinion dissection is only the most challenging step in LSCP. In laparoscopic hysteropexy, where there is no scar tissue after previous surgery, the dissection is relatively simple. In this case, laparoscopic suturing is usually the most time-consuming step of the procedure.

To date, there have been only a few commercial surgical female pelvic models that enable practice of advanced urogynecological laparoscopic procedures. For example, the Surgical Female Pelvic Trainer Mk2 (Limbs and Things, Bristol, UK) enables practice of several gynecological procedures including hysterectomy, myomectomy, salpingectomy etc. In this model, dissection down to and location of ureters can be achieved and insertion of a uterine manipulator can be performed. It is also compatible for use with a harmonic scalpel, which enables even more realistic simulation of procedures. Although urogynecological procedures are not listed as possible procedures that can be practiced in this model, we believe that with creation of the anterior longitudinal ligament with an additional pad, this model would also be suitable

for training in laparoscopic sacrocolpopexy or hysteropexy. On the other hand, the high cost and the necessity of replacing the soft tissues after training limit its use in everyday practice [15]. An individually constructed model for LSCP was also described by Tunitsky-Bitton et al. in 2014. The model is constructed using a Fundamentals of Laparoscopic Surgery (FLS) box trainer, uterine manipulation system, sacrocolpopexy tip, tip cover, and a bracket. A cover for the tip was made from a swim-suit material to simulate the vaginal apex. The price of the model set-up was approximately 150 EUR (without the FLS box trainer). The model enables mesh handling and suturing. Similar to our model, peritoneum dissection is not possible [16].

In our opinion, the main advantages of our model are the low cost and that it enables acquisition of several laparoscopic skills such as bimanual dexterity, depth perception, efficiency, mesh handling and suturing. As mentioned previously, it does not enable dissection of the peritoneum, vesicouterine fold and rectouterine fold. However, we believe that with appropriate training on a model like ours, residents would have the opportunity to practice their laparoscopic skills and become familiar with the procedures that are usually not performed on an everyday basis. It can also be useful for experienced surgeons to practice and renew their laparoscopic skills. Moreover, the model is affordable, easy to make, and can be renewed simply with only minimal costs.

Since the development of the model, it has been tested and used at one local urogynecological meeting and at two international urogynecological laparoscopic workshops. There has been positive feedback from the participants and the instructors, who found the models very useful.

Laparoscopic procedures are taking a leading role in central compartment prolapse management, because they provide good anatomical support and are generally safer than transvaginal mesh surgery. This is why we need to aim to establish good training programs to properly educate future surgeons. It would be reasonable to include training of the procedure on a pelvic model as an additional training level between basic laparoscopic skills training and performance of the procedure on a real patient.

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Compliance with ethical standards

Conflicts of interest None.

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