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PART 2**

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# Deep infiltrating endometriosis: Evaluation and management

Deep endometriosis is successfully diagnosed with clinical signs and symptoms and specific MRI or TVUS protocols, and treatment options are available to relieve pain and optimize outcomes

Rosanne M. Kho, MD, and Mauricio S. Abrão, MD

**E**ndometriosis affects up to 10% of women of reproductive age or, conservatively, about 6.5 million women in the United States.<sup>1,2</sup>

There are 3 types of endometriosis—superficial, ovarian, and deep—and in the past each of these was assumed to have a distinct pathogenesis.<sup>3</sup> Deep infiltrating endometriosis (DIE) is the presence of one or more endometriotic nodules deeper than 5 mm. In a study at a large tertiary-care center, 40% of patients with endometriosis had deep disease.<sup>4</sup> DIE is associated with more severe pain and infertility.<sup>5</sup> In patients with endometriosis, diagnosis is commonly made 7 to 9 years after the initial pelvic pain presentation.<sup>6</sup> For these reasons, well-directed history taking and proper evaluation and treatment should be pursued to relieve pain and optimize outcomes.

## **CASE** Young woman with intensifying pelvic pain

Mary is a 26-year-old social worker who presents to her ObGyn with symptoms of worsening pain during as well as outside her periods. What additional information would you want to obtain from Mary, given her chief symptom of pain?

## Investigate the type of pain

It is important to ask the patient about her menstrual and sexual history, her thoughts regarding near- and long-term fertility, and the type and severity of her pain symptoms. The 5 pain symptoms specific to pelvic pain are dysmenorrhea, dyspareunia, dysuria, dyschezia, and noncyclic pelvic pain. A visual analog scale (VAS) for pain as well as pelvic pain questionnaires can be used to guide evaluation options and monitor treatment outcomes. In

*Dr. Kho and Dr. Abrão report that they are consultants to AbbVie.*

## Take-home points

- Specific MRI or TVUS protocols are highly accurate in making a nonsurgical diagnosis of deep infiltrating endometriosis (DIE).
- The combination of compelling clinical signs and symptoms and absence of imaging findings for DIE can be used to make a presumptive nonsurgical diagnosis of endometriosis.
- Empiric medical therapy may provide pain relief.
- Conservative treatment, including observation alone, may be considered in asymptomatic patients with DIE and in those with minimal pain.
- Before surgery, it is imperative to know lesion size, depth, circumferential bowel involvement, and location (or distance from the anal verge in cases of rectosigmoid lesion) to optimize surgical outcomes.

addition, it is of paramount importance to understand the differential diagnoses that can present as pelvic pain (TABLE, page SS4).

## **CASE Continued: Mary's history**

Mary reports that she always has had painful periods and that she was started on oral contraceptive pills for pain control and regulation of her periods soon after the onset of menses, when she was 12 years old. In college, she was prescribed oral contraceptive pills for contraception. Recently engaged, she is interested in becoming pregnant in 3 years.

A year ago, Mary discontinued the pills because of their adverse effects. Now she has severe pain during (VAS score, 8/10) and outside (VAS score, 7) her monthly periods. Because of this pain, she has taken time off from work twice within the past 6 months. She has pain during intercourse (VAS score, 7) and some pain with bowel movements during her menses (VAS

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**TABLE Differential diagnosis for pelvic pain**

| Organ system                          | Differential diagnosis  |   |
|---------------------------------------|---|---|
| Musculoskeletal                       | <ul style="list-style-type: none"> <li>• Abdominal wall pain</li> <li>• Myofascial pain</li> <li>• Fibromyalgia</li> <li>• Coccydynia</li> </ul>  | <ul style="list-style-type: none"> <li>• Pelvic floor tension myalgia</li> <li>• Osteitis pubis</li> <li>• Levator ani syndrome</li> <li>• Abdominal wall hernia</li> </ul> |
| Urologic                              | <ul style="list-style-type: none"> <li>• Interstitial cystitis</li> <li>• Nephrolithiasis</li> </ul>  |   |
| Gastrointestinal                      | <ul style="list-style-type: none"> <li>• Inflammatory bowel disease</li> <li>• Irritable bowel disease</li> <li>• Chronic constipation</li> </ul> | <ul style="list-style-type: none"> <li>• Chronic constipation</li> <li>• Chronic pseudo-obstruction</li> </ul>  |
| Psychologic                           | <ul style="list-style-type: none"> <li>• Sexual abuse history</li> <li>• Opiate dependency</li> </ul>   | <ul style="list-style-type: none"> <li>• Depression</li> <li>• Somatization</li> </ul>  |
| Gynecologic (excluding endometriosis) | <ul style="list-style-type: none"> <li>• Fibroid uterus</li> <li>• Ovarian remnant syndrome</li> <li>• Pelvic inflammatory disease</li> </ul>     | <ul style="list-style-type: none"> <li>• Adenomyosis</li> <li>• Pelvic adhesion</li> </ul>  |

score, 4). Pelvic examination reveals a normal-sized uterus and adnexa as well as a tender nodule in the rectovaginal septum.

What diagnostic tests and imaging would you obtain?

### Imaging's role in diagnosis

At many advanced centers for endometriosis, DIE is successfully diagnosed with specific magnetic resonance imaging (MRI) or transvaginal ultrasound (TVUS) protocols. In a recent review, MRI's pooled sensitivity and specificity for rectosigmoid endometriosis were 92% and 96%, respectively.<sup>7</sup> Choice of imaging for DIE depends on the skills and experience of the clinicians at each center. At a large referral center in São Paulo, Brazil, TVUS with bowel preparation had better sensitivity and specificity for deep retrocervical and rectosigmoid disease compared with MRI and digital pelvic examination.<sup>8</sup> In addition, at a center in the United States, we found that proficiency in performing TVUS for DIE was achieved after 70 to 75 cases, and the exam took an average of only 20 minutes.<sup>9</sup>

Despite recent advances in imaging, most gynecologic societies still hold that endometriosis is to be definitively diagnosed with histologic confirmation from tissue biopsies during surgery. Although surgery remains the diagnostic gold standard, it does not mean that all patients with

pelvic pain should undergo diagnostic laparoscopy with tissue biopsies.

The combination of compelling clinical signs, symptoms, and imaging findings (such as absence of findings for ovarian and deep endometriosis) can be used to make a presumptive nonsurgical (that is, clinical) diagnosis of endometriosis. Major societies recommend empiric medical therapy (for example, combination oral contraceptives) for the pain associated with superficial endometriosis.<sup>10,11</sup> When there is no response to treatment, or when a patient declines or has contraindications to medical therapy, diagnostic laparoscopy with excision of endometriosis should be considered.

### CASE Continued: Diagnosis

Mary undergoes TVUS with bowel preparation, which reveals a normal uterus and adnexa and the presence of 2 lesions, a 2×1.5-cm retrocervical lesion and a 1.8×2-cm rectosigmoid lesion 9 cm above the anal verge. The rectosigmoid lesion involves the external muscularis and compromises 30% of the bowel circumference.

How would you manage the bowel DIE?

### Management options: Factor in the variables

DIE can involve the ureters and bladder, the retrocervical and rectovaginal spaces, the appendix, and the bowel. Lesions can be single or multifocal.

Although our institutions' imaging with MRI and TVUS is highly accurate, we additionally recommend the use of colonoscopy (with directed biopsies if appropriate) to evaluate patients who present with rectal bleeding, large endometriotic rectal nodules, or have a family history of bowel cancer.

While many studies have found that surgical resection of DIE improves pain and quality of life, surgery can have significant complications.<sup>12</sup> Observation is adequate for asymptomatic patients with DIE. Medical treatment may be offered to patients with mild pain (there is no evidence of a reduction in lesion size with medical therapy). In cases of surgical treatment, we encourage the involvement of a multidisciplinary surgical team to reduce complications and optimize outcomes.

Patients with DIE, significant pain (VAS score, >7), and multiple failed in vitro fertilization treatments are candidates for surgery. When bowel endometriosis is noted on imaging, factors such as size, depth, number of lesions, circumferential involvement, and distance from the anal verge are all used to determine the surgical approach. Rectosigmoid lesions smaller than 3 cm can be treated more conservatively—for example, with shaving or anterior resection with manual repair using disk staplers. Segmental resection generally is indicated for rectosigmoid lesions larger than 3 cm, involvement deeper than the submucosal layer, multiple lesions, circumferential involvement of more than 40%, and the presence of obstructed bowel symptoms.<sup>13,14</sup>

In patients with DIE who present with both infertility and pain, antimüllerian hormone level and TVUS follicular count are used to evaluate ovarian reserve. As surgical treatment may further reduce

ovarian reserve in patients with DIE and infertility, we counsel them regarding assisted reproductive technology options before surgery.

### CASE Resolved

After thorough discussion, Mary opts to try a different combination oral contraceptive pill formulation. The pills improve her pain symptoms significantly (VAS score, 4), and she decides to forgo surgery. She will be followed up closely on an outpatient basis with serial TVUS imaging.

### Individualize management based on patient parameters

Imaging has been used for the nonsurgical diagnosis of DIE for many years, and this practice increasingly is being accepted and adopted. A presumptive nonsurgical diagnosis of endometriosis can be made based on the clinical signs and symptoms obtained from a thorough history and physical examination, in addition to the absence of imaging findings for ovarian and deep endometriosis.

According to guidelines from major ObGyn societies, such as the American College of Obstetricians and Gynecologists and the European Society of Human Reproduction and Embryology, empiric medical therapy (including combination oral contraceptives, progesterone-containing formulations, and gonadotropin-releasing hormone agonists) can be considered for patients with presumed endometriosis presenting with pain.<sup>15</sup>

When surgery is chosen, the surgeon must obtain crucial information on the characteristics of the lesion(s) and involve a multidisciplinary team to achieve the best outcomes for the patient. ■

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# What's new in simulation training for hysterectomy

Here's a rundown on hysterectomy simulation trainers that can be helpful for polishing skills and teaching (and evaluating) residents

Alicia Scribner, MD, MPH, and Christine Vaccaro, DO

**D**ue to an increase in minimally invasive approaches to hysterectomy, including vaginal and laparoscopic approaches, gynecologic surgeons may need to turn to simulation training to augment practice and hone skills. Simulation is useful for all surgeons, especially for low-volume surgeons, as a warm-up to sharpen technical skills prior to starting the day's cases. Additionally, educators are uniquely poised to use simulation to teach residents and to evaluate their procedural competency.

In this article, we provide an overview of the 3 approaches to hysterectomy—vaginal, laparoscopic, abdominal—through medical modeling and simulation techniques. We focus on practical issues, including current resources available online, cost, setup time, fidelity, and limitations of some commonly available vaginal, laparoscopic, and open hysterectomy models.

Simulation directly influences patient safety. Thus, the value of simulation cannot be overstated, as it can increase the quality of health care by improving patient outcomes and lowering overall costs. In 2008, the American College of Obstetricians and Gynecologists (ACOG) founded the Simulations Working Group to establish simulation as a pillar in education for women's health through collaboration, advocacy, research, and the development and implementation of multidisciplinary simulations-based educational resources and opportunities.

Refer to the ACOG Simulations Working Group Toolkit online to see the objectives, simulation, and videos related to each module. Under the "Hysterectomy" section, you will find how to construct the "flower pot" model for abdominal and

vaginal hysterectomy, as well as the AAGL vaginal and laparoscopic hysterectomy webinars. All content is reaffirmed frequently to keep it up to date. You can access the toolkit, with your ACOG login and passcode, at <https://www.acog.org/About-ACOG/ACOG-Departments/Simulations-Consortium/Simulations-Consortium-Tool-Kit>.

For a comprehensive gynecology curriculum to include vaginal, laparoscopic, and abdominal approaches to hysterectomy, refer to ACOG's Surgical Curriculum in Obstetrics and Gynecology page at <https://cfweb.acog.org/scog/>. This page lists the standardized surgical skills curriculum for use in training residents in obstetrics and gynecology by procedure. It includes:

- the objective, description, and assessment of the module
- a description of the simulation
- a description of the surgical procedure
- a quiz that must be passed to proceed to evaluation by a faculty member
- an evaluation form to be downloaded and printed by the learner.

**Takeaway.** Value of Simulation = Quality (Improved Patient Outcomes) ÷ Direct and Indirect Costs.

## Simulation models for training in vaginal hysterectomy

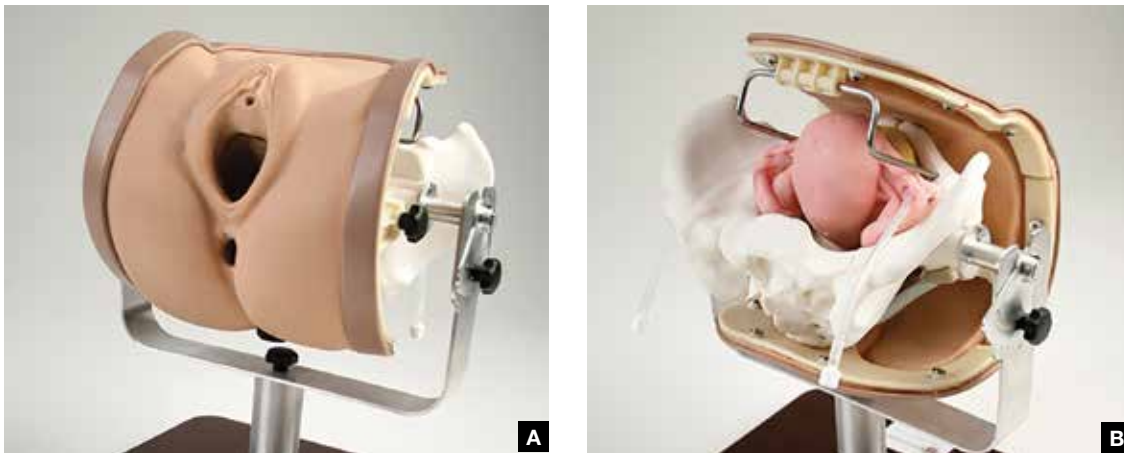
According to the Accreditation Council for Graduate Medical Education (ACGME), the minimum number of vaginal hysterectomies is 15; this number represents the minimum accepted exposure, however, and does not imply competency. Exposure to vaginal hysterectomy in residency training has significantly declined over the years, with a mean of only 19 vaginal hysterectomies performed by the time of graduation in 2014.<sup>1</sup>

A wide range of simulation models are available

*The authors report no financial relationships relevant to this article.*

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**FIGURE 1** Front view (A) and back view (B) of the Miya Model Pelvic Surgery Training Model



Used with permission from Miyazaki Enterprises, Winston-Salem, North Carolina.

that you either can construct or purchase, based on your budget. We discuss 3 such models below.

### The Miya model

The Miya Model Pelvic Surgery Training Model (Miyazaki Enterprises) consists of a bony pelvic frame and multiple replaceable and realistic anatomic structures, including the uterus, cervix, and adnexa (1 structure), vagina, bladder, and a few selected muscles and ligaments for pelvic floor disorders (FIGURE 1). The model incorporates features to simulate actual surgical experiences, such as realistic cutting and puncturing tensions, palpable surgical landmarks, a pressurized vascular system with bleeding for inadequate technique, and an inflatable bladder that can leak water if damaged.

Mounted on a rotating stand with the top of the pelvis open, the Miya model is designed to provide access and visibility, enabling supervising physicians the ability to give immediate guidance and feedback. The interchangeable parts allow the learner to be challenged at the appropriate skill level with the use of a large uterus versus a smaller uterus.

New in 2018 is an “intern” uterus and vagina that have no vascular supply and a single-layer vagina; this model is one-third of the cost of the larger, high-fidelity uterus (which has a vascular supply and additional tissue layers).

The Miya model reusable bony pelvic frame has a one-time cost of a few thousand dollars.

Advantages include its high fidelity, low technology, light weight, portability, and quick setup. To view a video of the Miya model, go to [https://www.youtube.com/watch?time\\_continue=49&v=A2RjOgVRclo](https://www.youtube.com/watch?time_continue=49&v=A2RjOgVRclo). To see a simulated vaginal hysterectomy, visit [https://www.youtube.com/watch?time\\_continue=13&v=dwiQz4DTyy8](https://www.youtube.com/watch?time_continue=13&v=dwiQz4DTyy8).

The gynecologic surgeon and inventor, Dr. Douglas Miyazaki, has improved the vesicouterine peritoneal fold (usually the most challenging for the surgeon) to have a more realistic, slippery feel when palpated.

This model’s weaknesses are its cost (relative to low-fidelity models) and the inability to use energy devices.

**Takeaway.** The Miya model is a high-fidelity, portable vaginal hysterectomy model with a reusable base and consumable replacement parts. It can be tailored to the learner’s desired level of difficulty.

### The Gynesim model

The Gynesim Vaginal Hysterectomy Model, developed by Dr. Malcolm “Kip” Mackenzie (Gynesim), is a high-fidelity surgical simulation model constructed from animal tissue to provide realistic training in pelvic surgery (FIGURE 2, page SS8).

These “real tissue models” are hand-constructed from animal tissue harvested from US Department of Agriculture inspected meat processing centers. The models mimic normal and abnormal abdominal and pelvic anatomy,



**FIGURE 2** Abdominal view of the Gynesim Vaginal Hysterectomy Model

Used with permission from Gynesim, Boston, Massachusetts.

providing realistic feel (haptics) and response to all surgical energy modalities. The “cassette” tissues are placed within a vaginal approach platform, which is portable.

Each model (including a 120- to 240-g uterus, bladder, ureter, uterine artery, cardinal and uterosacral ligaments, and rectum) supports critical gaps in surgical techniques such as peritoneal entry and cuff closure. Gynesim staff set up the entire laboratory, including the simulation models, instruments, and/or cameras; however, surgical energy systems are secured from the host institution.

The advantages of this model are its excellent tissue haptics and the minimal preparation time required from the busy gynecologic teaching faculty, as the company performs the setup and breakdown. Disadvantages include the model's cost (relative to low-fidelity models), that it does not bleed, its one-time use, and the need for technical assistance from the company for setup.

This model can be used for laparoscopic and open hysterectomy approaches, as well as for vaginal hysterectomy. For more information, visit the Gynesim website at <https://www.gynesim.com/vaginal-hysterectomy/>.

**Takeaway.** The high-fidelity Gynesim model can be used to practice vaginal, laparoscopic, or open hysterectomy approaches. It offers excellent tissue haptics, one-time use “cassettes” made from animal tissue, and compatibility with energy devices.

**The milk jug model**

The milk jug and fabric uterus model, developed by Dr. Dee Fenner, is a low-cost simulation model

and an alternative to the flower pot model (described later in this article). The bony pelvis is simulated by a 1-gallon milk carton that is taped to a foam ring. Other materials used to make the uterus are fabric, stuffing, and a needle and thread (or a sewing machine). Each model costs approximately \$5 and takes approximately 15 minutes to create. For instructions on how to construct this model, see the Society for Gynecologic Surgeons (SGS) award-winning video from 2012 at <https://vimeo.com/123804677>.

The advantages of this model are that it is inexpensive and is a good tool with which novice gynecologic surgeons can learn the basic steps of the procedure. The disadvantages are that it does not bleed, is not compatible with energy devices, and must be constructed by hand (adding considerable time) or with a sewing machine.

**Takeaway.** The milk jug model is a low-cost, low-fidelity model for the novice surgeon that can be quickly constructed with the use of a sewing machine.

**Simulation models for training in laparoscopic hysterectomy**

While overall hysterectomy numbers have remained relatively stable during the last 10 years, the proportion of laparoscopic hysterectomy procedures is increasing in residency training.<sup>1</sup> Many toolkits and models are available for practicing skills, from low-fidelity models on which to rehearse laparoscopic techniques (suturing, instrument handling) to high-fidelity models that provide augmented reality views of the abdominal cavity as well as the operating room itself. We offer a sampling of 4 such models below.

**The FLS trainer system**

The Fundamentals of Laparoscopic Surgery (FLS) Trainer Box (Limbs & Things Ltd) provides hands-on manual skills practice and training for laparoscopic surgery (**FIGURE 3**). The FLS trainer box uses 5 skills to challenge a surgeon's dexterity and psychomotor skills. The set includes the trainer box with a camera and light source as well as the equipment needed to perform the 5 FLS tasks (peg transfer, pattern cutting, ligating loop, and intracorporeal and extracorporeal knot tying). The kit does not include laparoscopic instruments or a monitor.

**FIGURE 3** FLS Trainer system (A) components (minus the monitor and instruments) and (B) the unit in use



Used with permission from Limbs & Things Ltd, Savannah, Georgia.

The FLS trainer box with camera costs \$1,164. The advantages are that it is portable and can be used to warm-up prior to surgery or for practice to improve technical skills. It is a great tool for junior residents who are learning the basics of laparoscopic surgery. This trainer's disadvantages are that it is a low-fidelity unit that is procedure agnostic. For more information, visit the Limbs & Things website at <https://www.fls-products.com>.

Notably, ObGyn residents who graduate after May 31, 2020, will be required to successfully complete the FLS program as a prerequisite for specialty board certification.<sup>2</sup> The FLS program is endorsed by the American College of Surgeons and is run through the Society of American Gastrointestinal and Endoscopic Surgeons. The FLS test is proctored and must be taken at a testing center. **Takeaway.** The FLS trainer box is readily available, portable, relatively inexpensive, low-tech, and has valid benchmarks for proficiency. The FLS test will be required for ObGyn residents by 2020.

### The SimPraxis software trainer

The SimPraxis Laparoscopic Hysterectomy Trainer (Red Llama, Inc) is an interactive simulation software platform that is available in DVD or USB format (FIGURE 4). The software is designed to review anatomy, surgical instrumentation, and specific steps of the procedure. It provides formative assessments and offers summative feedback for users.

The SimPraxis training software would make a useful tool to familiarize medical students and interns with the basics of the procedure before advancing to other simulation trainers. The software costs \$100. For more information, visit <https://www.3-dmed.com/product/simpraxis%20C3%82%20AE-laparoscopic-hysterectomy-trainer>.

**Takeaway.** The SimPraxis software is ideal for

**FIGURE 4** Screenshot of the SimPraxis Laparoscopic Hysterectomy Trainer software program demonstrating pelvic structures



Used with permission from Red Llama, Inc, Seattle, Washington.

CONTINUED ON PAGE SS10

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**FIGURE 5** The LapSim simulator (A) and the LapSim hysterectomy module (B) in action

Used with permission from Surgical Science, Göteborg, Sweden.

novice learners and can be used on a home or office computer.

**The LapSim virtual reality trainer**

The LapSim Haptic System (Surgical Science) is a virtual reality skills trainer. The hysterectomy module includes right and left uterine artery dissection, vaginal cuff opening, and cuff closure (FIGURE 5). One advantage of this simulator is its haptic feedback system, which enhances the fidelity of the training.

The LapSim simulator includes a training module for students and early learners and modules to improve camera handling. The virtual reality base system costs \$70,720, and the hysterectomy software module is an additional \$15,600.

For more information, visit the company's website at <https://surgiscience.com/systems/lapsim/>. For an informational video, go to <https://surgiscience.com/systems/lapsim/video/>.

**Takeaway.** The LapSim is an expensive, high-fidelity, virtual reality simulator with enhanced haptics and software for practicing laparoscopic hysterectomy.

**The LAP Mentor virtual reality simulator**

The LAP Mentor VR (3D Systems) is another virtual reality simulator that has modules for laparoscopic hysterectomy and cuff closure (FIGURE 6). The trainee uses a virtual reality headset and becomes fully immersed in the operating room environment with audio and visual cues that mimic a real surgical experience.

The hysterectomy module allows the user to manipulate the uterus, identify the ureters, divide

the superior pedicles, mobilize the bladder, expose and divide the uterine artery, and perform the colpotomy. The cuff closure module allows the user to suture the vaginal cuff using barbed suture. The module also can expose the learner to complications, such as bladder, ureteral, colon, or vascular injury.

The LAP Mentor VR base system costs \$84,000 and the modules cost about \$15,000. For additional information, visit the company's website at <http://symbionix.com/simulators/lap-mentor/lap-mentor-vr-or/>.

**Takeaway.** The LAP Mentor is an expensive, high-fidelity simulation platform with a virtual reality headset that simulates a laparoscopic hysterectomy (with complications) in the operating room.

**Simulation models for training in robot-assisted laparoscopic hysterectomy**

All robot-assisted simulation platforms have highly realistic graphics, and they are expensive (TABLE). However, the da Vinci Skills Simulator (backpack) platform is included with the da Vinci Si and Xi Systems. Note, though, that it can be challenging to access the surgeon console and backpack at institutions with high volumes of robot-assisted surgery.

Other options that generally reside outside of the operating room include Mimic's FlexVR and dV-Trainer and the Robotix Mentor by 3D Systems (FIGURES 7-11, page SS11.e1). Mimic's new technology, called MaestroAR (augmented reality), allows trainees to manipulate virtual robotic instruments to interact with anatomic regions within augmented 3D surgical video footage, with narration and instruction by Dr. Arnold Advincula.

Newer software by Symbionix allows augmented reality to assist the simulation of robot-assisted hysterectomy with the da Vinci Xi backpack and RobotiX platforms.

**Models for training in abdominal hysterectomy**

In the last 10 years, there has been a 30% decrease in the number of abdominal hysterectomies

**FIGURE 6** The LAP Mentor VR simulation unit (A) and the Lap Mentor VR operating room (B) experienced via a headset



Used with permission from 3D Systems, Airport City, Israel.

There are not many simulation models available for teaching abdominal hysterectomy, but here we discuss 2 that we utilize in our residency program.

### Adaptable task trainer

The Surgical Female Pelvic Trainer (SFPT) (Limbs & Things Ltd), a pelvic task trainer primarily used for simulation of laparoscopic hysterectomy, can be adapted for abdominal hysterectomy by removing the abdominal cover (FIGURE 12, page SS11.e2). This trainer can be used with simulated blood to increase the realism of training. The SFPT trainer costs \$2,190. For more information, go to [https://www.limbsandthings.com/us/our-products/details/surgical](https://www.limbsandthings.com/us/our-products/details/surgical-female-pelvic-trainer-sfpt-mk-2)

-female-pelvic-trainer-sfpt-mk-2.

**Takeaway.** The SFPT is a medium-fidelity task trainer with a reusable base and consumable replacement parts.

performed by residents.<sup>1</sup> Because of this decline in operating room experience, simulation training can be an important tool to bolster residency experience.

**TABLE Simulation platforms for robot-assisted laparoscopic hysterectomy**

| Simulator  | Company, website   | Evaluation tools and software capabilities  | Video demonstration   |
|--|--|---|---|
| FlexVR   | Mimic<br><a href="http://www.mimic-simulation.com/flexvr2/">http://www.mimic-simulation.com/flexvr2/</a>   | MScore, <sup>a</sup> MaestroAR  | <a href="https://www.youtube.com/watch?time_continue=37&amp;v=5Va47qVmQNo">https://www.youtube.com/watch?time_continue=37&amp;v=5Va47qVmQNo</a> |
| dV-Trainer   | Mimic<br><a href="http://mimicsimulation.com/dv-trainer/">http://mimicsimulation.com/dv-trainer/</a>   | MScore, <sup>a</sup> MaestroAR  | <a href="https://www.youtube.com/watch?v=qTsX1jOs3jl">https://www.youtube.com/watch?v=qTsX1jOs3jl</a>   |
| da Vinci Skills Simulator (backpack) for Si and Xi platforms | Intuitive Surgical; Mimic<br><a href="https://www.intuitive-surgical.com/products/skills_simulator/index.php">https://www.intuitive-surgical.com/products/skills_simulator/index.php</a> | MScore <sup>a</sup> for Si platform with procedure-agnostic software by Mimic<br><br>Xi platform with procedure-specific modules with software by Symbionix | <a href="https://www.youtube.com/watch?v=utb-8YCvCHY">https://www.youtube.com/watch?v=utb-8YCvCHY</a>   |
| RobotiX Mentor   | 3D Systems<br><a href="http://symbionix.com/simulators/robotix-mentor/robotix-platform/">http://symbionix.com/simulators/robotix-mentor/robotix-platform/</a>                            | Augmented reality with software by Symbionix  | <a href="https://vimeo.com/216811228">https://vimeo.com/216811228</a> (hysterectomy demo plays up to the 1:10 minute mark)                      |

<sup>a</sup>Mimic's MScore is a proficiency-based skills assessment that tracks metrics over time.

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**FIGURE 7** FlexVR simulator with 3D glasses



Used with permission from Mimic Technologies, Inc, Seattle, Washington.

**FIGURE 8** dV-Trainer simulator with MaestroAR (augmented reality)



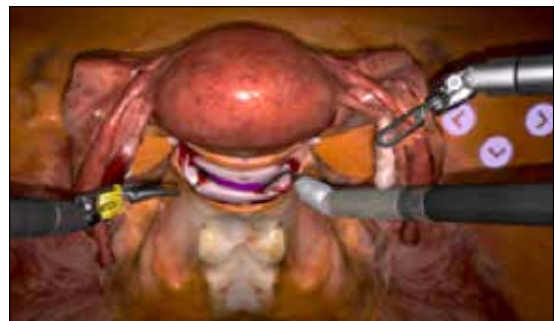
Used with permission from Mimic Technologies, Inc, Seattle, Washington.

**FIGURE 9** The da Vinci Skills Simulator with MScore



Used with permission from Intuitive Surgical, Sunnyvale, California.

**FIGURE 10** Sionix software for hysterectomy available for use on the da Vinci Xi System



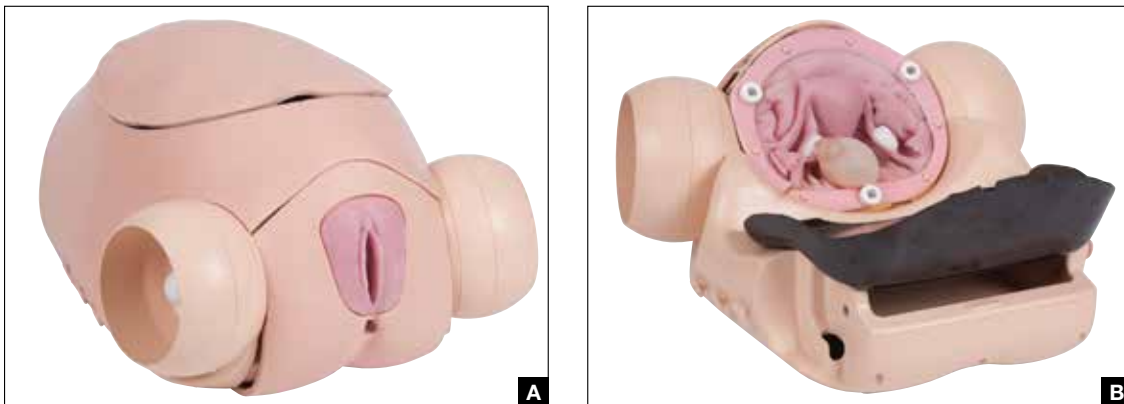
Used with permission from 3D Systems, Airport City, Israel.

**FIGURE 11** RobotiX Mentor surgeon console and monitor with Sionix software for hysterectomy



Used with permission from 3D Systems, Airport City, Israel.

**FIGURE 12** Surgical Female Pelvic Trainer model (A) and model (B) with abdominal cover removed



Used with permission from Limbs & Things Ltd, Savannah, Georgia.

### ACOG's do-it-yourself flower pot model

The flower pot model (developed by the ACOG Simulation Working Group, Washington, DC) is a comprehensive educational package that includes learning objectives, simulation construction instructions, content review of the abdominal hysterectomy, quiz, and evaluation form.<sup>3</sup> ACOG has endorsed this low-cost model for residency education.

Each model costs approximately \$20, and the base (flower pot) is reusable (FIGURE 13). Construction time for each model is 30 to 60 minutes, and learners can participate in the construction. This can aid in anatomy review and familiarization with the model prior to training in the surgical procedure.

The learning objectives, content review, quiz, and evaluation form can be used for the flower pot model or for high-fidelity models.

**FIGURE 13** ACOG's flower pot model (A) assembled and (B) model materials



Images courtesy of Kristiina Altman, MD; Dayna Burrell, MD; Grace Chen, MD; Betty Chou, MD; and Tola Fashokun, MD; Johns Hopkins University School of Medicine, Department of Obstetrics and Gynecology, Baltimore, Maryland.

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The advantages of this model are the low cost and that it provides enough fidelity to teach each of the critical steps of the procedure. The disadvantages include that it is a lower-fidelity model, requires a considerable amount of time for construction, does not bleed, and is not compatible with energy devices. This model also can be used for training in laparoscopic and vaginal hysterectomy. For more information, visit ACOG's Surgical Curriculum website at <https://cfweb.acog.org/scog/>.

**Takeaway.** ACOG's flower pot model for hysterectomy training is a comprehensive, low-cost, low-fidelity simulation model that requires significant setup time.

### Simulation's offerings

Simulation training is the present and future of medicine that bridges the gap between textbook learning and technical proficiency. Although in this article we describe only a handful of the simulation resources available, we hope that you will

incorporate such tools into your practice for continuing education and skill development. Utilize peer-reviewed resources, such as the ACOG curriculum module and evaluation tools for abdominal, laparoscopic, and vaginal hysterectomy, which can be used with any simulation model to provide a comprehensive and complimentary learning experience.

The future of health care depends on the commitment and ingenuity of educators who embrace medical simulation's purpose: improved patient safety, effectiveness, and efficiency. Join the movement! ■

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