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IUJ VIDEO

A live porcine model for robotic sacrocolpopexy training

Khushabu Kasabwala[1] · Ramy Goueli[1] · Patrick J. Culligan[1]

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Abstract

Introduction and hypothesis Robotic sacrocolpopexy is an effective and durable technique for pelvic organ prolapse repair. However, the learning curve for this procedure has underscored the need for an effective surgical training module. Given the cost, infection risk, poor tissue compliance, and scarcity of human cadavers, the live porcine model represents a realistic, available, and cost-effective alternative. This article describes a live porcine model for teaching robotic sacrocolpopexy to determine whether it teaches key aspects of live human robotic sacrocolpopexy to the learner.

Methods This robotic sacrocolpopexy model was created using the Da Vinci Xi or Si robotic system on domestic pigs under general anesthesia. The main steps of the model include: (1) creating the porcine "cervix" and (2) performing robotic sacrocolpopexy. The model was evaluated with a survey given to 18 board-certified surgeons who attended the training course between December 2016 and April 2018.

Results All of the participants reported improvements in their economy of motion, tissue handling ability, suturing efficiency, and overall performance of robotic sacrocolpopexy. Furthermore, a majority of participants were likely to incorporate aspects of the model into their practice (88.8%) and recommend the model to colleagues (94.2%).

Conclusions The porcine model provides a feasible tool for teaching robotic sacrocolpopexy to physicians.

Keywords Pelvic organ prolapse · Porcine model · Robotic sacrocolpopexy · Robotic surgery · Surgical training

Introduction

One of the main surgical approaches to correction of apical prolapse is abdominal sacrocolpopexy. In the last 2 decades, the morbidity of open abdominal techniques has led to an increase in laparoscopic cases, either with or without robotic assistance [1]. However, there is a significant learning curve associated with robotic sacrocolpopexy, underscoring the urgency to identify a realistic and accessible training model for teaching this complex procedure [2].

Fresh cadavers can be very useful when learning robotic sacrocolpopexy techniques, but widespread use of the cadaveric model remains challenging because of cost and availability [3]. In addition, the cadaveric model cannot reproduce the same live tissue interactions and bleeding potential of the actual surgery. The live porcine model has been previously used for teaching surgical techniques to gynecological trainees [4]. Here, we describe our porcine model for teaching robotic sacrocolpopexy and report its utility as described by surgeons enrolled in an educational course.

Conference presentation Part of this work was presented at the American Urological Association 2018 Meeting (San Francisco, CA), May 2018

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✉ Patrick J. Culligan
pjc9007@nyp.org

[1] Department of Urology, Weill Cornell Medical College, New York Presbyterian Hospital, 525 E 68th St, F9 West, 9th floor, New York, NY 10065, USA

Materials and methods

We developed and refined our teaching model for robotic sacrocolpopexy in this video using the domestic pig (*Sus scrofus domesticus*) in 2009 with permission from the Institutional Animal Care and Use Committee (IACUC) of the University of Houston (UH). The teaching model was created to simulate a robotic sacrocolpopexy immediately following a supracervical hysterectomy. The steps of our model are outlined below.

1. **Cervical model creation, to accurately simulate the bulkier human cervix.** Both ureters are sealed ensuring no urine will be delivered into the bladder. The superior aspect of the bladder is amputated and a gauze is inserted and sewn into the remaining bladder. Next, the right horn of the bicornuate uterus is removed and the remaining uterus is sutured to the previously created bladder stump completing the "cervix" model, simulating the bulky human cervical remnant after a supracervical hysterectomy. After creating the "model cervix," the surgeon trainee uses the robotic tenaculum to manipulate it during dissection and graft placement.
2. **Anterior dissection, to create the "anterior vagina."** The space anterior to the "cervix" is developed. Distally, this dissection is on top of the pig urethra.
3. **Posterior dissection, to create the posterior vagina.** The posterior cul-de-sac peritoneum is divided, and the rectovaginal space is developed caudally to the pig perineum.
4. **Sacral dissection**. The peritoneum overlying the sacral promontory is opened along the right paracolic gutter caudally to the previous cul-de-sac incision. The presacral tissue is dissected while navigating around the middle sacral vessels. The anterior longitudinal ligament is exposed to the right of these vessels.
5. **Vaginal mesh placement.** A graft material of choice is then sewn first to the posterior and then to the anterior "vaginal" walls using an interrupted technique with polytetrafluoroethylene (PTFE) sutures. The posterior arm of the graft is sewn from the perineum to the "cervix," and the anterior portion is sewn to a length that would be analogous to the level of the trigone in a human. During this part, the graft can be removed and resewn using other techniques and sutures such as a barbed suture.
6. **Sacral fixation:** Before fixing the proximal arm of the graft, various techniques and approaches are used to make needle throws adjacent to the middle sacral vessels. It can also be instructive to place the needle into structures that should not be sutured in a human (e.g., vertebrae and intervertebral disc) to better understand improper stitch placement. Once the trainee is comfortable with all of these needle approaches, the proximal arm of the graft is sewn to the anterior longitudinal ligament just distal to the promontory.
7. **Closure of the peritoneum.** The peritoneal edges are closed over the mesh using a continuous purse-string suture.

Between December 2016 and April 2018, 21 surgeons attended multiple 2-day sacrocolpopexy training courses at an Intuitive Surgical robotic surgery training facility in Houston, Texas, and Atlanta, Georgia. Of the attendees, 18 were board-certified in their respective specialties, 3 (16%) in urology and the remaining 15 (84%) in obstetrics and gynecology. The 2-day laboratory cost was covered by Intuitive Surgical, and all other costs including transportation and housing were paid for by participants.

Day 1 of the course consisted of didactics about the laparoscopic and robotic surgery in general and sacrocolpopexy in particular. Day 2 was the surgical portion of the laboratory session using the Xi or Si version of the da Vinci Surgical System (Intuitive Surgical Inc., Sunnyvale, CA, USA) with a ratio of two trainee surgeons per pig. The schedule included a laboratory session with the creation of the pig model by the trainees from 8:00 to 9:00 a.m. followed by robotic sacrocolpopexy dissection techniques from 9:00 until 11:30 a.m. After lunch, the surgeon trainees completed the vaginal and sacral mesh attachment and finally covered the mesh with peritoneum by approximately 3:30 p.m. Throughout the module, the surgical trainees were offered nuanced instruction and challenged to try a variety of surgical techniques. All nine pigs remained alive during the surgery and were humanely killed after the course at by onsite veterinary services.

After the course, the 18 board-certified trainees were asked to complete a two-page questionnaire for skill self-evaluation derived from the Objective Skills Assessment Test (OSAT) with additional questions regarding past and future training model use (Appendix). The OSAT has previously been validated for use in various gynecology simulators [5–7]. The study was

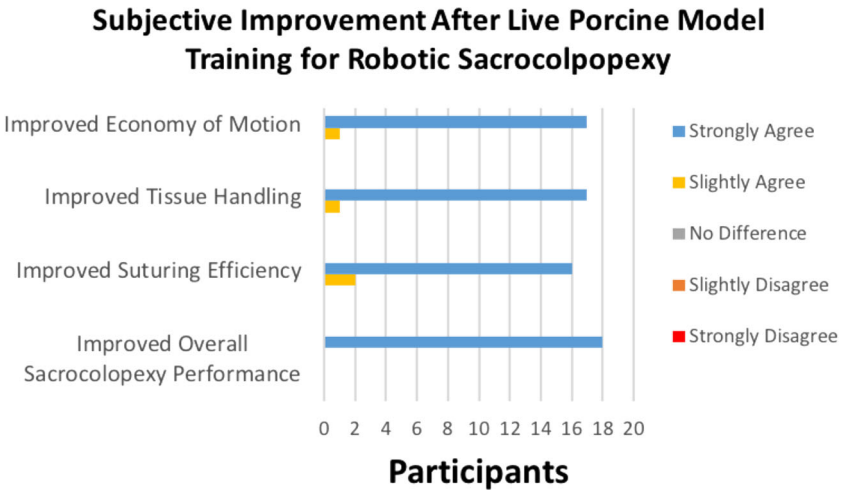

Fig. 1 This graph shows the distribution of subjective improvement in four surgical domains of 18 trainees who attended a 2-day training course using the porcine model for robotic sacrocolpopexy

exempt per the Weill-Cornell Medicine Institutional Review Board (IRB).

Results

In the post-course survey, all participants reported improvements in their economy of motion, tissue handling ability, suturing efficacy, and overall performance of robotic sacrocolpopexy (Fig. 1). Furthermore, 88.8% of participants reported they were very likely to incorporate aspects of the model into their practice and 94.2% would recommend the model to colleagues.

Fourteen participants had previously trained on a fresh cadaveric model, and all stated that the porcine model was superior in comparison. All participants agreed that the porcine model was a good simulation of the surgery given the realistic tissue dissection. Six of the participants specifically stated that the bleeding possibility was a benefit compared with the cadaveric model. The most commonly stated weakness of the model was the difference in anatomy and tissue integrity of the porcine model compared with humans ($n = 6$).

Discussion

This study demonstrates that our porcine model is a feasible and subjectively effective tool for teaching robotic sacrocolpopexy to physicians. All participants reported increased comfort in performing a robotic sacrocolpopexy procedure and increased proficiency in three key surgical principles (economy of motion, tissue handling ability, suturing efficacy).

The limitations of our model must be interpreted in the context of the study design. First, porcine anatomy is inherently different from that of a human. However, several modifications in our model optimize the porcine pelvis in mimicking a human pelvis. Second, the questionnaire captured the participant's self-assessed skills at the completion of the course. While the survey obtained immediate subjective input from participants, we did not use any objective measures to determine the impact of the training module or durability of the skills learned. Additionally, our survey instrument was not validated, but was based on the OSAT, which has previously been described as a tool used to objectively measure trainees' surgical performance. Furthermore, there was no OSAT determination by an independent rater. Despite study limitations, the porcine model provides a feasible tool for teaching robotic sacrocolpopexy to physicians.

Funding Intuitive Surgical covered porcine laboratory cost. No other funding was provided.

Compliance with ethical standards

Consent No patients were part of this work—there were only the pig used in the video and the surgeons who filled out anonymous ratings of the model.

Conflicts of interest Patrick Culligan is a consultant and paid instructor for Intuitive Surgical and Coloplast and a stockholder in Origami Surgical. The remaining authors, Khushabu Kasabwala and Ramy Goeuli, have no disclosures.

Appendix

Robotic sacrocolpopexy training course (post-test)

Thank you for attending our robotic training course. The goal of this course was to improve your surgical technique for the robotic sacrocolpopexy using a live pig model. With regards to this model for the robotic sacrocolpopexy, please answer the following questions.

1. The porcine model improved **my economy of motion and efficiency of instrumentation**

--------1----------2----------3----------4----------5----------

Strongly Disagree | Somewhat Disagree | No Difference | Somewhat Agree | Strongly Agree

2. The porcine model improved **my suturing efficiency**

--------1----------2----------3----------4----------5----------

Strongly Disagree | Somewhat Disagree | No Difference | Somewhat Agree | Strongly Agree

3. The porcine model improved **my tissue handling and dissection of surgical spaces**

--------1----------2----------3----------4----------5----------

Strongly Disagree | Somewhat Disagree | No Difference | Somewhat Agree | Strongly Agree

4. The porcine model improved **my overall performance of the robotic sacrocolpopexy**

--------1----------2----------3----------4----------5----------

Strongly Disagree | Somewhat Disagree | No Difference | Somewhat Agree | Strongly Agree

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5. **How likely are you to incorporate aspects of this training model in your surgical practice?**

--------1----------2----------3----------4----------5----------

Very Unlikely | Unlikely | Equivocal | Likely | Very Likely

1. **How likely would you be to recommend this model to a friend and colleague?**

--------1----------2----------3----------4----------5----------

Very Unlikely | Unlikely | Equivocal | Likely | Very Likely

2. **What is at least one strength of the model?**

3. **What is at least one weakness of the model?**

4. **Have you ever operated on a fresh tissue cadaveric model?**

Yes **No**

1. **If yes, how does the porcine model compare cadaveric model?**

----------1----------2----------3----------4----------5----------

Cadaveric model clearly better | Cadaveric model somewhat better | Equivalent | Porcine model somewhat better | Porcine model clearly better

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