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ORIGINAL ARTICLE

Simulated management of urinary tract injury during robotic pelvic surgery utilizing the porcine model

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Abstract

Urologic injury is an infrequent but serious complication of pelvic surgery. Training in the assessment and management of this injury might be enhanced through animated simulation. Our objective was to assess the intraoperative management of urologic injury with robotic pelvic surgery using a simulated injury animal model. We used a female domestic pig to create three types of urologic injury, which we then managed with robotically assisted surgery. An edited video of the model was assessed by 14 senior learners and 10 attending faculty. The assessments included key competencies and domains of fidelity. A scale of poor, fair, or good was utilized. The defects and repairs simulated those seen in humans, both anatomically and surgically, although deficiencies were noted. Related to fidelity of the anatomy of the ureter and bladder, lower ratings were given for some of the key competencies (determining the relationship to the trigone, ureteral mobilization, repair of all 3 injuries). The porcine model for simulation of urologic injury during robotically assisted pelvic surgery may be useful for training purposes.

Keywords Porcine · Robotic · Urologic injury

Introduction

The urinary tract is intimately associated with other internal pelvic organs in a way that challenges the surgeon to minimize the risk of associated injuries [1]. Cystotomy and ureteral injury are well-recognized complications of gynecologic and colorectal surgery. The incidence of these injuries does not appear to be increased with laparoscopic approaches [2].

Laparoscopic surgery utilizing da Vinci robotic technology offers three-dimensional vision and ease of suturing, which may facilitate intraoperative recognition and management of urinary tract injury. The education and capability of pelvic surgeons in management of urinary tract injury have not been well-described. Few studies have been published describing utilization of the inanimate and/or open porcine model for bladder and ureteral injury [3–5]. Furthermore, the process of learning to perform robotically assisted repair of bladder and/or ureter has not been well-defined but likely includes graduate-level training, proctoring, attending advanced courses, observation of cases, and/or observation of videos. Specialty training exists in urology.

Post-graduate surgical training is becoming increasingly complex and yet increasingly time-restricted. In efforts to partially compensate for this and an often otherwise reduced volume of surgical training materials, as well as to improve outcomes, greater emphasis is being placed on use of simulation-based surgical training [6, 7]. This may be particularly

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important for uncommon but clinically highly significant scenarios such as bladder and ureteral injury.

Here, we describe and assess the intraoperative management of urologic injuries with robotic pelvic surgery using a simulated injury porcine model.

Materials and methods

Under approval of the University of South Florida Institutional Animal Care and Use Committee (IACUC) at the University of South Florida CAMLS (Center for Advanced Medical Learning and Simulation) da Vinci training center, we developed a model for assessment and repair of urinary tract injury utilizing the domestic pig. In our animal facility, pigs are properly kept and cared for under the close supervision of a veterinarian. For our objective of refining the technique and in association with a broader surgical simulation program, three female pigs were utilized (weight ranging from 30 to 40 kg). All surgeries were done under a carefully monitored general anesthesia protocol in conjunction with other aspects of the training curriculum, with each procedure ending in animal termination. The approximate total cost of each completed animal lab was $3500 US dollars.

Injury and repair procedures

We created three types of urologic injury (mid-ureteral transection, distal ureteral thermal injury, and cystotomy), which we then managed with robotically assisted surgery.

For ureteral transection, the right ureter was mobilized from the gonadal vessels to the bladder. Next, we used robotic scissors to partially transect the proximal pelvic ureter (our prior experience indicated that complete transection of the porcine ureter created two flimsy ends that lacked fidelity but that near-complete transection appeared to simulate human injury and repair). The ureter was repaired over a 5 F ureteral stent with interrupted 4–0 delayed absorbable sutures (video Online Resource 1).

For distal ureteral injury, the left ureter was first mobilized. We then used monopolar scissors to create an incidental thermal injury (video Online Resource 2). An occluding clip was applied distal to the injury, and the ureter was transected proximal to the thermal injury (suture ligation of the proximal ureter prior to transection was not done in the simulation). We then created an anterior fundal cystotomy (for purposes of this simulation, direct reimplantation was not demonstrated). Utilizing the cystotomy, we delivered the transected end of the proximal ureter into the bladder through a tension-free selected site (in the model, the potential tension seen in humans was not readily reproducible). Finally, the end of the ureter was spatulated, a transvesical ureteroneocystostomy was created with interrupted 4–0 delayed absorbable suture, and a 5 F ureteral stent was placed.

The cystotomy was previously created as described above for the ureteroneocystostomy. The repair was done in two layers (video Online Resource 3), with the first layer incorporating a running inverting technique and the second incorporating running imbricating stitches (3–0 delayed absorbable suture).

Assessment of simulated injury animal model

Videos from the operations (see Online Resource) were shown independently to 14 senior learners and 10 faculty members as follows: 5 gynecologic oncology fellows (3 with > 150 robotic cases each and the other 2 with > 50 robotic cases each, which included a lab fellow who had done a prior pelvic surgery fellowship), 5 board-certified gynecologic oncologists at 5, 7, 14, 14, and 35 years since fellowship (all 5 had extensive robotic surgical experience), 9 urology residents (with > 50 robotic cases each), and 5 urologists at 3, 3, 3, 6, and 21 years since residency (4 with > 150 robotic cases each and the senior with extensive laparoscopic experience).

Rating of video clips was a 2-step process. First, participants rated the model in terms of fidelity (relative to humans) as good, fair, or bad for selected characteristics. Next, participants rated the ability of the model to address selected key competencies. Fidelity and competency characteristics for each injury and repair procedure are listed in Table 1. Participants were also asked to comment on the limitations of the model.

Results

Some of the results, such as anatomy and repair, could be viewed across the three models. The fidelity of the model for ureteral anatomy, stent placement, and the various repairs were each rated as good by most participants. Two participants rated the fidelity of the uretero-ureterostomy repair as poor, with one citing tension and the other noting lack of spatulation. Two participants commented on lack of spatulation in evaluating the key competency of ureteral repair. Five participants commented on lack of demonstrated mobilization of the ureter in the edited videos, and 9 participants (35%) rated the anatomy and/or repair of the uretero-ureterostomy model as fair or poor, with the main criticism being lack of demonstrated ureteral mobilization. Four participants rated the fidelity of the bladder anatomy for the ureteroneocystostomy model as fair, mainly citing lack of retropubic location and mobility. For the cystotomy model, 7 participants (29%) rated the anatomy and/or repair as fair, commenting on lack of

Table 1 Characteristics used for fidelity and competency rating

	Fidelity	Competency
Ureteral repair	Ureteral anatomy Stent placement Anastomosis	Placement of stent Ureteral repair
Ureteroneocystostomy	Ureteral anatomy Bladder anatomy Stent placement Anastomosis	Mobilization of ureter Placement of stent Uretero-vesical anastomosis
Cystotomy	Anatomy Repair	Identify full extent of mucosal defect Determine relationship of cystotomy to trigone Repair of cystotomy

Table 2 Assessment of ureteral repair

	Fidelity			Key competencies	
	Anatomy	Stent placement	Anastomosis	Stent placement	Repair
GYOF	1 (1)	1 (1–2)	1 (1)	1 (1–2)	1 (1)
GYO	1 (1)	1 (1)	1 (1)	1 (1)	1 (1)
UR	2 (1–3)	2 (1–2)	2 (1–3)	1 (1–2)	1 (1–3)
U	1 (1–2)	1 (1–2)	1 (1–3)	1 (1)	1 (1–2)

Rating scale: 1 = good; 2 = fair; 3 = poor. Data in the table are expressed as the median (range)

GYOF gynecologic oncology fellow, *GYO* gynecologic oncologist, *UR* urology resident, *U* urologist

Table 3 Assessment of ureteroneocystostomy

	Fidelity				Key competencies		
	Ureteral anatomy	Bladder anatomy	Stent placement	Anastomosis	Mobilization of ureter	Stent placement	Anastomosis
GYOF	1 (1–2)	1 (1–2)	1 (1)	1 (1–2)	2 (1–3)	1 (1)	1 (1)
GYO	1 (1–2)	1 (1–2)	1 (1)	1 (1)	2 (2–3)	1 (1)	1 (1)
UR	1 (1)	1 (1–2)	1 (1–2)	1 (1–2)	2 (1–3)	1 (1)	1 (1–2)
U	1 (1)	1 (1–2)	1 (1)	1 (1)	2 (1–2)	1 (1)	1 (1)

Rating scale: 1 = good; 2 = fair; 3 = poor. Data expressed as the median (range)

GYOF gynecologic oncology fellow, *GYO* gynecologic oncologist, *UR* urology resident, *U* urologist

relationship to or distance from the trigone. All but one of the participants downgraded the ability of the model to address some of the related key competencies, indicating that bladder mobility mitigated the need for any significant mobilization of either the bladder or ureter or determining the relationship to the trigone. Furthermore, it was commented that identification and mobilization of the cystotomy were unrealistically straightforward. The ability of the model to address the remaining key competencies (stent placement, uretero-vesical anastomosis, cystotomy repair) was rated as good by most participants. Details of assessments are shown in Tables 2, 3 and 4.

Table 4 Assessment of cystotomy

	Fidelity		Key competencies		
	Anatomy	Repair	Identify defect	Cystotomy-trigone relation	Repair
GYOF	1 (1)	1 (1)	1 (1)	2 (1–2)	1 (1–2)
GYO	1 (1–2)	1 (1)	1 (1)	3 (2–3)	1 (1–2)
UR	1 (1–2)	1 (1–2)	1 (1)	3 (2–3)	1 (1–2)
U	1 (1)	1 (1–2)	1 (1)	3 (3)	1 (1–2)

Rating scale: 1 = good; 2 = fair; 3 = poor. Data expressed as the median (range)

GYOF gynecologic oncology fellow, *GYO* gynecologic oncologist, *UR* urology resident, *U* urologist

Discussion

Sophisticated simulators are being utilized for training in basic surgical skills and some straightforward operations [6–9]. Although simulators exist to teach some advanced surgical procedures, such as enteric and vascular anastomoses, they are financially prohibitive for most training programs (the live animal model may in fact be financially prohibitive as well) and lack the fidelity necessary to master such techniques in human patients. Other surgical training adjuvants include animal tissue, animal and human cadavers, and live animal models.

There are previous reports on utilization of the porcine model for surgical education in a variety of gynecologic cancer-related procedures and complications [3–5, 10, 11]. The present study provides evidence on the fidelity of this model for management of urinary tract injury during robotically assisted surgery. Furthermore, the study suggests that this model may be utilized to address some key competencies related to assessment and management of urinary tract injury during robotically assisted surgery. One of the main criticisms of the model was lack of mobilization of the ureter. In fact, this was done but unfortunately (inadvertently) edited out of the video. Although not offered as a criticism, the porcine anatomy would be quite conducive to the addition of a psoas hitch and/or Boari flap technique in adjunct to the ureteroneocystostomy. Modifying the model to include mobilization of the ureter (in the video clip), using a double-spatulated uretero-ureterostomy, and shortening the ureter together with moving the reimplantation site to the caudal posterior bladder, as well as adding a psoas hitch and/or Boari flap for the ureteroneocystostomy and moving the cystotomy repair to the caudal posterior bladder, would likely improve the fidelity of the model and the ability to better address some of the key competencies related to urinary tract injury.

The simulated urinary tract injury and associated management described were evaluated based on review of a video clip. It is the contention of the authors that the model performs substantially better in vivo. With the proposed enhancements to this simulation model as described above and the appropriate inclusion of these enhancements in an expanded video clip, it is anticipated that both the fidelity of the model and its ability to address the key competencies outlined would be substantially improved. The main drawback of the present study was the use of a live animal model (as has previously been discussed by us and others [4, 6]) with the associated expense, stress, and ensuing necessity for animal sacrifice.

In conclusion, a live simulation model for evaluation and management of urinary tract injury during robotically assisted surgery may be useful for training purposes.

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Compliance with ethical standards

Conflict of interest Dr. Mitchel Hoffman declares that he has no conflict of interest. Dr. Philippe Spiess declares that he has no conflicts of interest. All applicable international, national, and institutional guidelines for the care and use of animals were followed.

Ethical approval All applicable international, national, and institutional guidelines for the care and use of animals were followed. All procedures were performed in accordance with the ethical standards of the University of South Florida Institutional Animal Care and Use Committee

References

1. Hoffman MS (2008) How to safeguard the ureter and repair surgical injury. OBG Manage 20:16–28
2. Baggish M (2012) Major laparoscopic injuries: a review in two parts. J Gynecol Surg 28:315–332
3. Hammond I, Taylor J, Obermair A, McMenamin P (2004) The anatomy of complications workshop: an educational strategy to improve the training and performance of fellows in gynecologic oncology. Gynecol Oncol 94:769–773
4. Hoffman M, Ondrovic L, Wenham R, Sachin A, Murray S, Zervos E, William W, Roberts W (2009) Evaluation of the porcine model to teach various ancillary procedures to gynecologic oncology fellows. Am J Obstet Gynecol 201:116.e1–116.e3
5. Hoffman MS, Palmer J, Young C, Cobb A, Downes K (2014) Simulation of cystotomy repair utilizing fresh-frozen porcine bladder. J Gynecol Surg 30:141–146
6. Goff BA (2008) Changing the paradigm in surgical education. Obstet Gynecol 112:328–332
7. Hammoud MM, Nuthalapaty FS, Goepfert AR, Casey PM, Emmons S, Espey EL, Kaczmarczyk JM, Katz NT, Neutens JJ, Peskin EG (2008) To the point: medical education review of the role of simulators in surgical training. Am J Obstet Gynecol 199:338–343
8. Stefanidis D, Korndorffer JR Jr, Markley S, Sierra R, Scott DJ (2006) Proficiency maintenance: impact of ongoing simulator training on laparoscopic skill retention. J Am Coll Surg 202:599–603
9. McDougall EM, Corica FA, Boker JR, Sala LG, Stoliar G, Borin JF, Chu FT, Clayman RV (2006) Construct validity of a laparoscopic surgical simulator. J Am Coll Surg 202:779–787
10. Lanvin D, Elhage A, Henry B, Leblanc E, Querleu D, Delobelle-Deroide A (1997) Accuracy and safety of laparoscopic lymphadenectomy: an experimental prospective randomized study. Gynecol Oncol 67:83–87
11. Lentz GM, Mandel LS, Goff BA (2005) A six-year study of surgical teaching and skills evaluation for obstetric/gynecologic residents in porcine and inanimate surgical models. Am J Obstet Gynecol 193:2056–2061