Development and validation of a low-fidelity, low-cost surgical simulation model to teach canine orchiectomy

Tatiana Motta, Benjamin Carter, Elena Sweazy, Abigail Taylor, Mary McLoughlin, Larry Hill
Department of Veterinary Clinical Sciences, College of Veterinary Medicine, The Ohio State University, Columbus, OH

Abstract

At The Ohio State University College of Veterinary Medicine, limited opportunity for hands-on experience during the first two years of academic study is often accompanied by lack of confidence regarding surgical skills, which can be associated with increased stress levels for students during the third and fourth years in a surgical setting. In this study, we aimed to test the hypothesis that a low-cost, low-fidelity surgical simulation model would improve surgical performance, increase student confidence and decrease anxiety. A surgical simulator for orchiectomy was created, and 24 volunteer students were recruited. The students were taught how to perform orchiectomy using lecture, video, and written material. Twelve students were assigned to the simulator and were provided surgical instruments and 30 minutes of training using the model. The other twelve students were provided surgical instruments and 30 minutes of basic training with surgical instruments and how to prepare for the surgical procedure. Seven days later, students were evaluated for surgical skills, knowledge and perceived confidence. A quiz was used to evaluate knowledge, a questionnaire was used to evaluate perceived confidence, and a cadaver orchiectomy was used to evaluate surgical skills. On the day of the surgery, all students answered a ten question quiz, completed a questionnaire, performed orchiectomy on a cadaver, and were graded using recorded video and a grading rubric. Students who had used the model performed better on the quiz and indicated in the questionnaire that practice with the model had improved their perceived performance, increased confidence, and decreased stress. Scores for the following surgical steps during the cadaver orchiectomy were significantly higher for students who had used the model compared to those who had not: spermatic fascia disruption ($p=0.041$) as well as clamping and ligation of both the first ($p=0.0032$) and second ($p=0.024$) spermatic cords. Surgical time to clamp and ligate the first spermatic cord also was significantly decreased in students who had used the model ($p=0.0086$). Our findings suggest that use of a low-fidelity surgical model can help students develop surgical skills during early stages of training and may improve surgical performance.

Keywords: Surgical simulation, veterinary, validation, orchiectomy, model training, skill training

Introduction

One of the current challenges facing veterinary education is the ability to adequately prepare students to meet the expectations of practitioners for surgical competency in new graduates. In a recent survey, over half of veterinarians polled considered general surgical skills to be the most important area of knowledge for a new graduate.[1]

Although didactic presentation of surgical procedures is an important part of the veterinary curriculum, creating opportunities for hands-on experience has become increasingly difficult with decreased teaching of surgery using cadavers and live animals. Financial and ethical concerns have caused most veterinary colleges to discontinue non-survival animal laboratories. Ethical, practical and economic considerations also limit the use of recovery surgeries because resources to manage the animals postoperatively often are not available. Increased numbers of enrolled veterinary students and a shift away from performing elective surgical procedures at veterinary teaching hospitals have decreased the number of simple surgical procedures available to third and fourth year veterinary students.[2]

Several low-fidelity models have been developed and used in various surgical training programs in veterinary medicine to replace live animal or cadaver instruction. Information regarding the validity of these models however is limited, and additional studies correlating psychological preparedness with qualitative assessment of outcome are needed.[3] Simulators provide students an opportunity for safe and practical hands-on learning early in the academic curriculum while avoiding the ethical and practical limitations described above. These models also allow students to repeat procedures without concerns about cost, animal welfare, and laboratory or instructor availability. Simulators can be used by students outside scheduled classroom time. With adequate availability of educational tools, simulators can be used to enhance self-directed learning and provide an opportunity for repeated practice of skills at the student's own pace. Additionally, these models allow for skill acquisition by providing tactile, dimensional, visual, and situational similarities to surgical procedures. As a supplement to the regular curriculum, hands-on simulators add an element of 'skill-oriented' instruction that can teach students fundamental skills transferable to many surgical procedures.[4,5] Some students also may experience decreased anxiety and increased confidence after using simulation models.[6] A more complete educational and positive emotional experience potentially may be attained by use of surgical simulation models, thus contributing to an overall higher standard of learning.[3] We aimed to develop and validate a low-fidelity simulation model that could be used to teach veterinary students surgical skills needed to perform orchiectomy in dogs.

Orchiectomy in dogs can be performed in various ways, but we taught and evaluated pre-scrotal closed orchiectomy. A pre-scrotal incision is made over a testicle advanced cranially under the skin in the subcutaneous tissues, and the testicle is exteriorized leaving the vaginal tunic intact. Spermatic fascia that surrounds the testicle and cord is manually disrupted to free the testicle and allow for further exteriorization. After the spermatic cord has been adequately freed and tension has been released from the cord, three Carmalt clamps are placed on the cord approximately 5 millimeters apart. The cord is transected between the distal and middle clamps to remove the testicle. The most proximal clamp then is removed and a circumferential ligature placed over the clamped tissue. Next, a transfixing ligature is placed just proximal to the remaining (middle) clamp. The cord then is gently grasped with hemostats or thumb forceps and the middle clamp removed. The pedicle is checked for bleeding before being released back into the incision. The same technique is used on the second testicle. A two-layer closure is performed with separate closure of the subcutaneous tissue and skin.[7] All procedures were performed using 2-0 chromic gut for the ligatures on the spermatic cord, 3-0 chromic gut for subcutaneous closure using a simple continuous pattern, and 4-0 nylon for skin closure using an interrupted cruciate pattern.

Hypothesis

Surgical competency can be enhanced and perceived situational anxiety can be decreased by using a low-fidelity surgical simulator to teach inexperienced veterinary students basic surgical skills needed to perform closed orchiectomy in dogs.

Specific aims

1. To develop a low-fidelity, low-cost, multiple-use canine orchiectomy model to be used as a surgical simulator for teaching purposes.

2. To validate the model by evaluating surgical competency in inexperienced veterinary students trained to use the surgical simulator (test group) as compared to students who not did not use the simulator (control group).

3.To evaluate perception of stress, quality of surgical performance, and confidence in students who trained using the simulator as compared to students who did not (controls).

Materials and methods

Simulator development

A low-fidelity surgical simulator for orchiectomy in dogs was developed using low-cost materials including a wooden board, polyvinyl chloride (PVC) pipe, balloons, craft pom-poms, cable ties, spun-bond material, and neoprene. Spun-bond material is commonly used to make disposable bouffant surgical caps and is made from long fibers bonded together by a hot press. A list of fundamental skills required to accurately perform orchiectomy was compiled by one of the authors (TM) in consultation with two experienced veterinary surgeons (LH and MM) using cognitive task analysis principles. The model was developed to test the identified skills. Simulator use is most beneficial when used to augment the didactic curriculum and increase accuracy in newly developed tactile skills.[8] The model was designed to allow students to practice the following surgical skills: approach and pre-scrotal skin incision; manual disruption of spermatic fascia; placement of 3 clamps; placement of circumferential and transfixing ligatures on the spermatic cord; and, closure of subcutaneous tissue and skin (Figure 1). The model could be reused (up to 20 times) by rotating the neoprene sleeve (representing skin) and replacing model components that represented the testicle, visceral vaginal tunic, and spermatic fascia.

Student involvement

Institutional review board (IRB) approval allowed for recruitment of 24 veterinary students to participate in the study. Students volunteered without provision of any financial or academic incentives, and each participant was a first or second year veterinary student with minimal or no surgical experience. This cohort of students has not taken any surgery courses at Ohio State University's College of Veterinary Medicine because surgery is taught in the third year of the curriculum. All participating students attended a lecture and had unlimited online access to a podcast of the lecture, supplemental materials, and instructional videos created for the study. Furthermore, all students were scheduled for a 30-minute meeting with a trained instructor who was not a surgeon or grader. During this meeting, students received surgical instruments and instructions on how to access the online training material. In addition to the logistical instructions and surgical instrument kit, students assigned to the "test group" (12 students) received a surgical simulator model and sufficient suture material to practice the procedure up to ten times During this meeting, students in the "test group" were exposed to the simulator and the anatomical representations of each part of the model were described. There was no instruction on how to perform the surgical procedure itself.

Data collection

Seven days after receiving instructional materials and the simulators, students were evaluated for surgical skills, knowledge and perceived confidence. Four digit codes were assigned to each participant as an anonymous identifier for the scoring process. A multiple-choice quiz evaluating retention of the surgical procedure for canine orchiectomy was given to each student before he or she performed orchiectomy on a cadaver in the Small Animal Operating Practice laboratory of the Ohio State University College of Veterinary Medicine. Each procedure was video-recorded using a digital camera mounted above the surgical table. Only the hands of the students were recorded to maintain anonymity, and no faculty member involved in the scoring process was present at the surgeries. Each student worked with a trained surgical assistant who was instructed to refrain from answering questions or intervening unless a clear mistake was made and documented or the procedure was completed. Two surgical assistants participated in this study and both were trained by the grading surgeon. The surgical assistants had a list of mistakes that should be addressed if they occurred. If one of these listed mistakes was made during the procedure, it was documented, and the assistant used a signaling system to notify the grader of the video if assistance or intervention was required. In addition to being documented and graded, each mistake was addressed by the assistant to ensure the student would leave the surgery with a better understanding of the procedure and necessary techniques. Once surgery had been completed, each participant was given a survey to record his or her own experience and evaluate the model; this survey included self-evaluation of learning style and the perceived benefits of the simulator.

The results of the quiz and questionnaire were recorded, and the data collected were used to determine the influence of the model on knowledge retention and surgical skill development as well as each student's perception of the effectiveness and impact of the model. Each one of the 24 recorded surgeries was scored for times: scores were obtained from two faculty surgeons and two registered veterinary technicians using a rubric created for the study (Appendix). The veterinary technicians grading the surgeries had four to six years of experience working as teaching technicians in the small animal operative practice course offered to third year veterinary students. In addition, the two technicians were closely involved in the preparation of the teaching materials used for this study and were very familiar with the procedure.

The rubric evaluated the procedure by identifying eight skills: initial approach; disruption of spermatic fascia of the first testicle; clamping and ligation of the first spermatic cord; approach to the second testicle; disruption of spermatic fascia of the second testicle; clamping and ligation of the second spermatic cord; subcutaneous closure; and, skin closure. These skills were further characterized by specific steps, each of which was given an assigned point value based on difficulty and severity of consequence for error (Figure 2). To determine the difficulty and severity of consequence for error for each step, a board-certified surgeon (MM) and two other surgeons in the study (TM and LH) individually ranked each step. The average rank for the difficulty and severity of each step was incorporated into the rubric. The amount of time taken to complete all of the steps in each skill also was recorded and evaluated. The grading rubric was developed by the two expert surgeons who graded the surgeries. The two technician graders were trained to use the grading rubric by one of the experienced surgeons. The training included a detailed discussion of each item included in the grading rubric. In addition, one randomly recorded video was selected for grader training. The graders scored the video and commented on each step about which they had uncertainty.

Statistical analysis

Data from the grading rubric were compared between groups using a two-tailed t-test assuming equal variance. Time taken to complete each step also was compared between groups using a two-tailed t-test assuming equal variance. An intraclass correlation coefficient (ICC) was used to determine the level of agreement among the total scores provided by each rater.[9]

Results

Quiz

Scores from the multiple-choice quiz were compared between the test and control groups. All of the students from the test group scored 100%, with 0.00% standard deviation. The control group scored on average 90% with a 15.95% standard deviation. The p-value for these scores was 0.05.

Surgical scores

Students who utilized the orchiectomy simulator scored higher in 3 of 8 skills when compared to the control group. Scores from the rubric (Table 1) were significantly higher in the areas of dissection of spermatic fascia of the first testicle (p=0.041), clamping and ligation of the first spermatic cord (p=0.0032), and clamping and ligation of the second spermatic cord (p=0.024). The amount of time taken to complete each skill, obtained from the recording of the procedure, was evaluated using the same method (Table 2). A significant decrease in time for the test group was identified for clamping and ligation of the first spermatic cord (p=0.0086).

The ICC was utilized to determine the level of agreement among the total scores provided by each rater. The scores were analyzed using a single measurement, absolute agreement, two-way mixed model, which found an ICC of 0.764 with 95% confidence interval of 0.585-0.882. Values > 0.75 represent excellent agreement between raters.[9]

Questionnaire

Data from the questionnaire recorded by the students in the test group showed that of the total time each student spent studying with all of the materials provided (average, 9.07 hours) an average of 5.45 hours (55% of total) was spent using the model (Figure 3). The utilization of each of the other resources provided ranged between 0.45 and 1.30 hours (4.6-13.1%).

Data also were collected from the questionnaire regarding perceived usefulness of each teaching aid involved in the study as well as perceived impact of the model on each student. The perceived usefulness of each teaching aid available was ranked by students on a scale from 1 (most useful) to 6 (least useful). All of the students who used the model ranked it and training in its use as the most helpful of all resources offered (Figure 4).

Participants also rated the perceived effect of the model on their surgical performance, stress level, and confidence level on a scale of 1 (agreed strongly that the model was helpful) to 6 (model did not help at all). Seventy-five percent of students (9/12) agreed strongly, and 25% (3/12) agreed somewhat, that the model helped improve their performance and confidence and decreased their stress level. No student felt that the model did not have a positive impact on his or her performance or emotional state.

Discussion

The primary purpose of our study was to investigate the impact of low-cost, low-fidelity surgical simulation to train first- and second-year veterinary students. Students in our study who were given a simulation model to practice orchiectomy scored higher on the associated quiz than those who were not. The consistency of the scores suggests that knowledge retention was increased by addition of the model as compared to conventional resources incorporated in the curriculum. Although, statistically, test performance was significantly different, whether or not this difference has practical relevance is uncertain because both groups had excellent grades on the examination.

Although other studies have shown positive emotional impact with the use of models,[2,10] few have attempted to quantify the corresponding impact on performance. The use of recorded video, in conjunction with a grading rubric, allowed for quantitative assessment of the individual skills required to perform orchiectomy successfully. The potential for grading bias for the recorded procedures was minimized by maintaining anonymity with undisclosed identification numbers and restricting the recording window to include only the hands of the student and surgical field. Obtaining scoring data from two surgeons as well as two experienced registered veterinary technicians further limited the potential for grading bias.

Students in the test group scored higher than those in the control group in three of the eight skills assigned to the procedure. The skills with significantly higher scores were disruption of spermatic fascia and clamping and ligation of the spermatic cord, both of which are specific to orchiectomy in dogs and received most focus during development of the model. Although the model was developed to provide a skills-oriented approach[6] and teach basic surgical skills transferable to any procedure, participants from both groups also may have had previous exposure to more generalized skills evaluated (such as skin closure).

In contrast to previous studies that have not found significant differences in surgical performance after simulator use,[11] development and utilization of a more detailed rubric with a larger point spread allowed for detailed evaluation of individual skills and identification of significant differences between groups. Our study included 12 students per group, whereas a larger student pool likely would have provided greater power to evaluate surgical performance.

Participants in the test group also completed one of the eight skills in significantly less time than those in the control group. Also, decreased time for completion was observed in three of the eight skills, but this difference was not significant ($p \leq 0.2$). The significant decrease in time corresponded to clamping and ligation of the spermatic cord and, in combination with the significantly higher performance scores in this area, suggested that use of the model effectively taught this skill and improved both the competence and speed of the students.

The responses collected from the questionnaire indicated that use of the model positively impacted the perceived performance and confidence of students while simultaneously decreasing the perceived stress level associated with the surgical procedure. In a qualitative study evaluating the emotions of veterinary students by Langebaek et al,[2] the main source of positive emotions listed by students was the ability to prepare well, and the most common source of negative emotion reported was lack of self-confidence.[2] By creating a low-fidelity model that was designed for multiple use, we were able to provide students additional opportunities for preparation, which resulted in an increase in positive and decrease in negative emotional states. Both the positive perceived performance responses from students as well as the increased surgical scores supported previous findings that encouraging positive emotional states, along with repetitive practice, can improve the performance of veterinary students during newly learned procedures.

Lastly, a surgical simulator model that can be used safely by inexperienced veterinary students early in the curriculum can provide simulated surgical exposure to students over a longer period of time during the course of their education. As has been demonstrated, practice of a new skill distributed over shorter, more frequent episodes of learning as compared to a single longer exposure ultimately provides better development and long-term retention of new skills.[12,13] Additionally, repetitive training using models has been shown to increase skill retention over longer time periods.[14] Providing students with safe, early access to surgical simulators over the entire 4-year curriculum hopefully will produce more capable surgeons upon graduation.

Although data from our study support the use of low-cost, low-fidelity surgical simulators, several limitations must be acknowledged. Our study was performed during the summer, which limited the number of students available to participate and added variability to the amount of time students were able to dedicate to the study. Also, students participating in our study had not yet been introduced to surgical techniques in the regular curriculum. Because there was no grade or academic credit associated with the project, participant engagement also varied. Another limitation is the fact that the students in the study were not blinded. Students in the simulator group clearly knew they were part of the simulator group. This potentially could have influenced their responses on the questionnaire. Furthermore, students in the test group received instruction regarding anatomical considerations of the simulator. The additional exposure to anatomical knowledge may play a role in knowledge retention and performance. In the areas in which statistical differences were not observed between groups, lack of significance potentially could have been addressed by increasing the participant pool and further refining the grading rubric.

In conclusion, our findings indicate that use of low-cost, low-fidelity surgical simulators can be beneficial in the development of fundamental surgical skills during the early stages of veterinary training. By continuing to improve the simulator and further investigating its impact, low-fidelity surgical simulation has the potential to alleviate many issues currently facing veterinary curricula and could become a fundamental component in the education of veterinary students.

Future work

To further evaluate the benefits of surgical simulation in veterinary education, the current model should be revised to address areas in which significant improvement was not identified. The rubric also should be revised to improve specificity regarding the fundamental skills investigated to further minimize variation among graders. A larger student pool should be incorporated to collect additional data more representative of the entire veterinary class, and methods to quantitatively measure stress and anxiety should be investigated.

Acknowledgments

We thank the Merial Veterinary Scholars Program for financial support, Linda Bednarski and Erin Waggoner for assistance in the laboratories, and the veterinary students who participated in the study.

References

1. Hill LN, Smeak DD, Lord LK: Frequency of use and proficiency in performance of surgical skills expected of entry-level veterinarians by general practitioners. J Am Vet Med Assoc 2012;240:1345-1354.
2. Langebaek R, Berendt M, Pedersen LT, et al: Features that contribute to the usefulness of low-fidelity models for surgical skills training. Vet Rec 2012;170:361.
3. Langebaek R, Eika B, Tanggaard L, et al: Emotions in veterinary surgical students: a qualitative study. J Vet Med Educ 2012;39:312-321.
4. Smeak DD: Teaching surgery to the veterinary novice: the Ohio State University experience. J Vet Med Educ 2007;34:620-627.
5. Feins RH, Burkhart HM, Conte JV, et al: Simulation-based training in cardiac surgery. Ann Thorac Surg 2017;103:312-321.
6. McMillan HJ, Writer H, Moreau KA, et al: Lumbar puncture simulation in pediatric residency training: improving procedural competence and decreasing anxiety. BMC Med Educ 2016;16:198.
7. Tobias KM, Johnston SA: Veterinary surgery : small animal. St. Louis: Elsevier; 2012.
8. Khamis NN, Satava RM, Alnassar SA, et al: A stepwise model for simulation-based curriculum development for clinical skills, a modification of the six-step approach. Surg Endosc 2016;30:279-287.
9. Fleiss J L, Levin B, Paik MC: The measurement of interrater agreement. Statistical methods for rates and proportions. 3rd ed. Hoboken:John Wiley & Sons, Inc;2003.
10. Langebaek R, Eika B, Jensen AL, et al: Anxiety in veterinary surgical students: a quantitative study. J Vet Med Educ 2012;39:331-340.
11. Smeak DD, Hill LN, Beck ML, et al: Evaluation of an autotutorial-simulator program for instruction of hollow organ closure. Vet Surg 1994;23:519-528.
12. Moulton CA, Dubrowski A, Macrae H, et al: Teaching surgical skills: what kind of practice makes perfect?: a randomized, controlled trial. Ann Surg 2006;244:400-409.
13. Spruit EN, Band GP, Hamming JF: Increasing efficiency of surgical training: effects of spacing practice on skill acquisition and retention in laparoscopy training. Surg Endosc 2015;29:2235-2243.
14. Madani A, Watanabe Y, Vassiliou MC, et al: Long-term knowledge retention following simulation-based training for electrosurgical safety: 1-year follow-up of a randomized controlled trial. Surg Endosc 2016;30:1156-1163.

Table 1. Average scores with standard deviation and p-value for each skill set as scored on the rubric. Statistical power and sample size needed were calculated for the skill sets there were not significantly different.

Surgical Skill	Students with Model	Students without Model	P-value	Statistical Power	Sample Size Needed (each treatment group)
Approach to the 1st Testicle	81.6% ± 19%	79.6% ± 19%	0.61	0.06	709
Disruption of Spermatic Fascia of the 1st Testicle	90.2% ± 10%	71.7% ± 23.7%	0.041		
Clamping and Ligation of the 1st Testicle	95.6% ± 3.9%	80.6% ± 16%	0.0032		
Approach to the 2nd Testicle	91.8% ± 11.8%	92.8% ± 9.2%	0.91	0.05	785
Disruption of Spermatic Fascia of the 2nd Testicle	93.9% ± 9.2%	84.3% ± 13.7%	0.17	0.73	15
Clamping and Ligation of the 2nd Testicle	98.2% ± 3.0%	90.6% ± 9.9%	0.024		
Subcutaneous Closure	86.9% ± 10.0%	80.3% ± 11.4%	0.28	0.55	22
Skin Closure	88.1% ± 11.2%	90.0% ± 11.7%	0.51	0.09	264

Table 2. Average surgical time and standard deviation with p-value for each skill set.

Surgical Skill	Students with Model	Students without Model	P-value
Approach to the 1st Testicle	2 min 33.18 sec	2 min 18.33 sec	0.74
Disruption of Spermatic Fascia of the 1st Testicle	2 min 37.36 sec	3 min 54.25 sec	0.066
Clamping and Ligation of the 1st Testicle	5 min 4.45 sec	7 min 13.75 sec	0.0086
Approach to the 2nd Testicle	1 min 29.27 sec	2 min 4.08 sec	0.84
Disruption of Spermatic Fascia of the 2nd Testicle	2 min 9.09 sec	2 min 47.08 sec	0.30
Clamping and Ligation of the 2nd Testicle	4 min 42.06 sec	5 min 21.08 sec	0.16
Subcutaneous Closure	9 min 40.73 sec	11 min 38.92 sec	0.18
Skin Closure	8 min 45.27 sec	6 min 33.42 sec	0.97

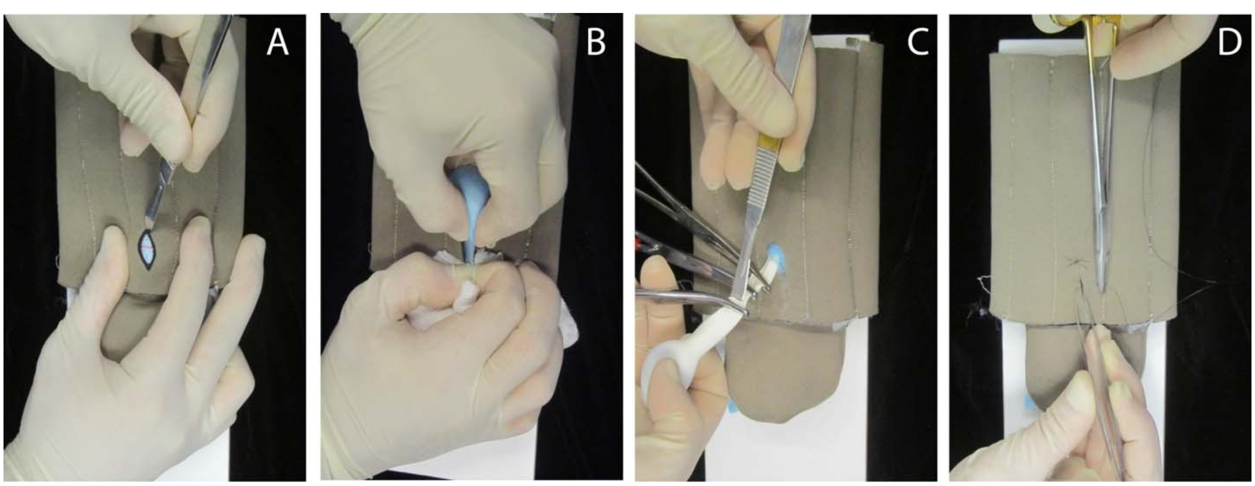

Figure 1. (A) Approach and incision, (B) tearing of spermatic fascia, (C) three clamp technique, (D) closure of skin.

Difficulty Level: Hard (H); Medium (M); Easy (E)
Consequences to the Patient: Minimal (M); Significant (S); Catastrophic (C)

	H	M	E
M	1	3	5
S	3	5	7
C	5	7	9

A skill or step that is hard and results in minimal consequences, weights 1 point
A skill or step that is hard and results in catastrophic consequences, weights 5 points
A skill or step that is easy and results in catastrophic consequences, weights 9 points

Figure 2. Grading scale used to assign rubric point values based on levels of difficulty for the surgeon and consequences to the patient or the surgeon.

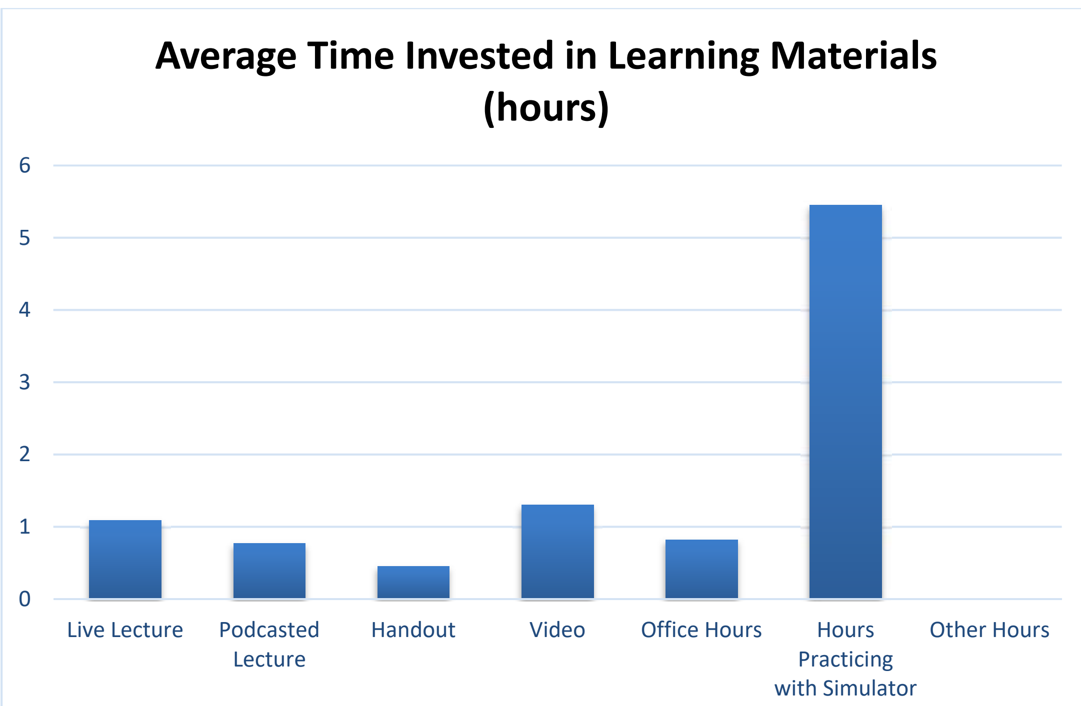

Figure 3. Average time each student spent with each individual learning material. Office hours represent time invested in simulator training offered by trained students.

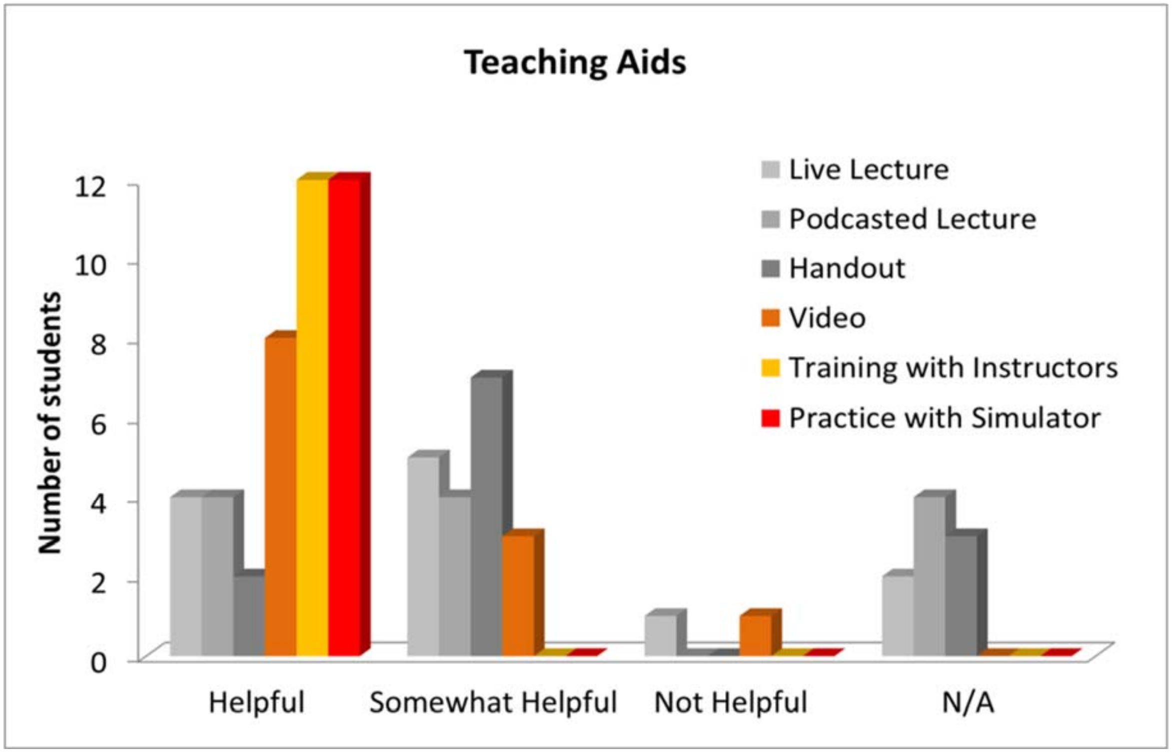

Figure 4: Participant responses from the test group regarding the perceived benefit of each teaching aid.

(Editor's Note: Figures in this manuscript are available in color in the online edition of Clinical Theriogenology.)

Appendix

Surgical Simulation Research Project's Grading Rubric

Student ID

<table>
<tr><td colspan="5">Hypothesis: Surgical performance can be influenced by implementing basic skills training exercises using a low-fidelity surgical simulation models to teach canine orchiectomy and celiotomy.

Specific Aims: (1) To develop two low-fidelity, low cost, multiple use surgical models to be used as a surgical simulator. (2) To validate the newly developed models by evaluating surgical performance of inexperienced professional veterinary students trained with and without the use of surgical simulation. (3) To evaluate students' perception regarding their stress level, quality of surgical performance, and confidence level.

Instructions: Each student should be evaluated based on tasks listed. Different tasks have different point values, based on level of difficulty and harmful consequences. If all tasks are completed adequately, student receives 394 points.</td><td>Weight (1, 3, 5, 7 or 9)</td></tr>
<tr><td></td><td>Yes</td><td>No</td><td>Yes</td><td>No</td><td></td></tr>
<tr><td>Orchiectomy Approach:</td><td colspan="2">1st testicle</td><td colspan="2">2nd testicle</td><td></td></tr>
<tr><td>Appropriate surgical landmarks for pre-scrotal incision (2nd testicle: median raphe incised?)</td><td>☐</td><td>☐</td><td>☐</td><td>☐</td><td>7</td></tr>
<tr><td>☐ Off midline (5) ☐ Too caudal (7) ☐ Too cranial (7)</td><td>☐</td><td>☐</td><td>☐</td><td>☐</td><td></td></tr>
<tr><td>Urethra protected before incision</td><td>☐</td><td>☐</td><td>☐</td><td>☐</td><td>9</td></tr>
<tr><td>Appropriate incision. If no, why not?</td><td>☐</td><td>☐</td><td>☐</td><td>☐</td><td>5</td></tr>
<tr><td>☐ Short (5) ☐ Long (3) ☐ Deep (5) ☐ Superficial (5)</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Appropriate technique for exteriorizing testicle. If no, why not?</td><td></td><td></td><td></td><td></td><td>5</td></tr>
<tr><td>☐ Harsh tissue handling (5) ☐ Excessive time (5)</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="6">Approach Time: 1st testicle____________________ / 2nd testicle_____________________</td></tr>
<tr><td>Disruption of Gubernaculum and Spermatic Fascia:</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>At caudal surface of testicle</td><td>☐</td><td>☐</td><td>☐</td><td>☐</td><td>7</td></tr>
<tr><td></td><td>☐</td><td>☐</td><td>☐</td><td>☐</td><td></td></tr>
<tr><td>Spreading out the fascia to facilitate disruption</td><td>☐</td><td>☐</td><td>☐</td><td>☐</td><td>3</td></tr>
</table>

Adequate disruption of fascia, with gauze or fingers. If no, why not?	☐	☐	☐	☐	7
☐ Hemostats (5) ☐ Scissors (7) ☐ Scalpel (7) ☐ Thumb forceps (5)	☐	☐	☐	☐	
Cord properly exteriorized. If no, why not?					5
☐ Not far enough (5) ☐ Too far (3) ☐ Too much pull/harsh tissue handling (5)					
Cord adequately dissected before clamp placement					7
Dissection Time: 1st testicle___________________ / 2nd testicle____________________					
Placement of Clamps:					
Greater curvature toward animal and tips away from animal	☐	☐	☐	☐	5
Using the tips of the clamps	☐	☐	☐	☐	7
Entire cord is clamped	☐	☐	☐	☐	7
Adequate distance between each clamp (5 to 10mm)	☐	☐	☐	☐	7
Correct clamp location on spermatic cord. If no, why not?	☐	☐	☐	☐	9
☐ Distal (includes pampiniform plexus) ☐ Extremely proximal (touching skin)	☐	☐	☐	☐	
Spermatic cord incised between middle and distal clamps. If no, why not?					7
☐ Above distal (3) ☐ Above proximal (5) ☐ Below proximal (7)					
Circumferential Cord Ligation:					
First throw for circumferential is prepared	☐	☐	☐	☐	5
Proximal clamp is removed before suture is tightened	☐	☐	☐	☐	5
Circumferential ligature placed on crushed tissue	☐	☐	☐	☐	5
Ligature is properly tightened	☐	☐	☐	☐	7
Two square knots are used	☐	☐	☐	☐	7
Transfixation Cord Ligation					
Safely insert needle through spermatic cord	☐	☐	☐	☐	5
Transfixation is placed distal to the circumferential ligation	☐	☐	☐	☐	7
Needle is handled with thumb forceps or needle holders while in tissue	☐	☐	☐	☐	5
One or two throws on one side	☐	☐	☐	☐	5
Two square knots on opposite side	☐	☐	☐	☐	7
Ligature is properly tightened	☐	☐	☐	☐	7
Clamping and Ligation Time: 1st testicle___________________ / 2nd testicle____________________					

	Yes	No	
Subcutaneous Closure			
Simple continuous or interrupted pattern	☐	☐	5
Adequately starts a buried knot (DSN to SDF). If no, why not?	☐	☐	3
☐ SDF to DSN (3) ☐ Knots not buried (3)	☐	☐	
Suture is tightened by pulling parallel to the incision	☐	☐	3
Two square knots are used	☐	☐	7
Adequate skin apposition achieved (<2mm, if planning percutaneous suture). If no, indicate which:	☐	☐	3
☐ 2 to 5mm (1) ☐ >5mm (3)			
Needle is handled with thumb forceps or needle holders while in tissue	☐	☐	5
Adequate/gentle tissue handling			5
Subcutaneous Closure Time:____________________			
Skin Closure:			
Satisfactory suture placement (5mm from incision)	☐	☐	5
Satisfactory interval (8 to 10mm between sutures)	☐	☐	5
Two square knots are used	☐	☐	7
Square knots firmly tightened	☐	☐	7
Enough space for tissue swelling	☐	☐	5
Needle is handled with thumb forceps or needle holders while in tissue	☐	☐	5
Adequate/gentle tissue handling	☐	☐	5
Skin Closure Time:____________________			

Instrument Handling:			No points
Adequate scalpel grip (pencil or fingertip). If not, how often?	☐	☐	
☐ Once ☐ 2 to 5 times ☐ > 5 times	☐	☐	
Adequate thumb forceps grip (pencil). If not, how often?	☐	☐	
☐ Once ☐ 2 to 5 times ☐ > 5 times	☐	☐	
Adequate scissors grip (thumb & ring finger tips). If not, how often?			
☐ Once ☐ 2 to 5 times ☐ > 5 times	☐	☐	
Adequate needle holder grip (thumb & ring finger tips). If not, how often?			
☐ Once ☐ 2 to 5 times ☐ > 5 times			
Adequate Carmalt hemostats forceps grip (thumb & ring finger tips)			
Additional remarks:			No points
Always keep hands between waist and shoulders	☐	☐	
All instruments are maintained above the table and below shoulder level	☐	☐	
Face/mask is maintained at a minimal distance of 12in from surgical wound	☐	☐	
No instruments collected on the surgery table during procedure	☐	☐	

Open Comments:

____

Difficulty Level: Hard (H); Medium (M); Easy (E)

Harmful Consequences: Minimal (M); Significant (S); Catastrophic (C)

	H	**M**	**E**
M	1	3	5
S	3	5	7
C	5	7	9

A skill or step that is <u>hard</u> and results in <u>minimal</u> consequences, weights 1 point

A skill or step that is <u>hard</u> and results in <u>catastrophic</u> consequences, weights 5 point

A skill or step that is <u>easy</u> and results in <u>catastrophic</u> consequences, weights 9 point