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Use of equine cadaver limb models to enhance veterinary student self-efficacy during arthrocentesis

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OBJECTIVE
To determine if equine cadavers modified with joint distension would yield higher fluid volumes, require fewer needle redirects, and improve student self-efficacy.

SAMPLE
19 third-year veterinary students.

METHODS
Voluntary participation was sought during 4 sessions of an equine arthrocentesis and diagnostic analgesia laboratory. Half of the sessions were provided with unmodified cadavers and half were provided with cadavers modified with joint distention. Prior to and after the laboratory, participating students completed surveys regarding their self-efficacy with arthrocentesis of the metacarpophalangeal and distal interphalangeal joints. During the study, the number of needle redirects and the volume of fluid obtained was recorded.

RESULTS
Increased fluid volumes were obtained from the modified metacarpophalangeal and distal interphalangeal joints. No difference was identified in number of needle redirects between cadaver types for either joint. Self-efficacy scores increased at the end of the laboratory for arthrocentesis of the metacarpophalangeal joint in both modified and unmodified groups. Self-efficacy scores increased at the end of the laboratory for arthrocentesis of the distal interphalangeal joint for the modified but not unmodified groups.

CLINICAL RELEVANCE
Modified equine cadavers provided a higher fluid yield following arthrocentesis compared to unmodified cadavers, but despite this, multiple attempts were required for proper needle placement. Performing equine arthrocentesis improved student self-efficacy with the task. Given our results, the model used for introduction to performing equine arthrocentesis may be less important than practice with the skill. In order to improve proficiency and self-efficacy, equine arthrocentesis should be provided multiple times throughout the veterinary curriculum.

Keywords: arthrocentesis, equine, self-efficacy, veterinary, student

Arthrocentesis remains a common procedure performed by equine veterinarians and the ability to perform arthrocentesis is expected of veterinary graduates entering equine practice.[1,2] A stakeholder survey regarding new veterinary graduate abilities found 71% of small, large, and mixed animal practitioners and 91% of small, large, and mixed animal clinical faculty expect that new graduates are proficient in performing arthrocentesis at 1 of 3 levels: with guidance, adequately, or smoothly.[3] Despite these expectations, only 13% of students reported exposure to arthrocentesis during any phase of their veterinary curriculum.[4]

In most veterinary schools, frozen-thawed cadavers are utilized for teaching laboratories as fresh cadavers are difficult to obtain reliably. In both canine and equine frozen-thawed cadavers used for arthrocentesis, joint fluid volume is often low and more difficult to obtain.[5,6] Modified canine cadaver models for arthrocentesis were found to yield higher fluid volumes upon aspiration compared to unmodified cadavers.[6] When using both the modified and unmodified canine cadaver models in a group of students, the modified model resulted in a greater volume of fluid recovered which the authors felt simulated a more realistic experience when compared to the unmodified model.[7] The presence of fluid in the hub of a needle or the ability to aspirate fluid is important for students who have yet to develop the tactile sense for when they have entered a joint and can provide real-time positive feedback of successful completion of this skill during the learning process. Currently no studies exist evaluating a modified cadaver for teaching equine arthrocentesis, despite the high demands for this skill in the equine veterinary profession.

Positive, performance-related feedback is important in the learning process and has been shown to improve intrinsic motivation[8] and motor skills learning.[9] Positive feedback also has an impact on self-efficacy, or the belief in one's ability to perform specific behaviors relative to specific performance outcomes.[10] Possessing knowledge and skills related to performing a task is important, but some degree of self-efficacy, or the belief that one can perform the task, is needed to be successful.[11] Enactive mastery experiences, such as the act or practice of performing a task, remain one of the most influential sources of self-efficacy.[12] It is important to note that while positive experiences can increase self-efficacy, performance failures can also decrease self-efficacy. Therefore, educators must focus on providing opportunities for authentic practice experiences that are likely to deliver performance success.[10,13]

In our experience, students practicing equine arthrocentesis on thawed cadaver limbs often become frustrated and discouraged at the lack of feedback and minimal indications of success during the activity. Because of this, our goal was to assess the use of an equine cadaver limb modified with joint distension compared to an unmodified equine cadaver limb during an equine arthrocentesis laboratory in a veterinary teaching setting. We hypothesized that a cadaver limb modified by joint distension would have a higher fluid yield following arthrocentesis and would require fewer needle redirects to obtain fluid compared to an unmodified cadaver limb. Our second hypothesis was that students using a modified equine cadaver limb for performing equine arthrocentesis would have an increase in self-efficacy scores compared to students using an unmodified cadaver limb.

Methods

To perform this study, participation was sought from third-year veterinary students at the North Carolina State University College of Veterinary Medicine and study approval was obtained by the university Institutional Review Board (#24608). As part of the Advanced Principles of Surgery course, students were advised of the study and the opportunity to participate through email messaging provided through the open-source learning platform (Moodle). Participation in the study was strictly voluntary with no incentives (academic or monetary) offered. Informed consent forms were provided electronically and prior to the laboratory to students participating in the study. Forms were collected either via the online learning platform or in person during the laboratory. Students participating in the study were given a pre-laboratory self-efficacy survey prior to starting the laboratory activities and an identical, post-laboratory self-efficacy survey after completion of the laboratory activities **(Supplementary Figures S1 and S2)**. Briefly, students were asked to rate their ability to identify landmarks and perform arthrocentesis of the distal interphalangeal and metacarpophalangeal joints on a scale from 0 to 100. Half of the laboratory sessions were randomly assigned to use unmodified equine cadaver limbs and half of the laboratory sessions were randomly assigned to use modified equine cadaver limbs. Prior to the start of their laboratory session, students were provided with instructional notes, a PowerPoint presentation, and additional educational media (diagrams and video) on arthrocentesis techniques for the equine distal limb through an open-source learning platform (Moodle). Prior to the equine arthrocentesis laboratory, all students were required to review the provided materials and complete an online quiz. At the beginning of the laboratory session, a review of basic technical skills of equine arthrocentesis was performed by a board-certified large animal surgeon. The students were instructed to perform arthrocentesis of the dorsal aspect of the distal interphalangeal and metacarpophalangeal joints with the joints in an extended position. This was demonstrated by either holding the limb upright as if it were in a weight-bearing position or extending the joints by elevating the toe of the hoof while the limb was lying on a surgical table. Throughout the laboratory session, a PowerPoint presentation of arthrocentesis techniques was projected on a screen at each student workstation. Students worked in groups of 2 to 3 students per limb and were unaware of what type of cadaver they were using. Following the laboratory sessions conducted as part of the study, the students were given the opportunity to work with the cadaver group that they did not use during their laboratory session to provide students with equal opportunity to both experiences.

Cadaver limbs in the modified group had the distal interphalangeal and metacarpophalangeal joints distended with saline approximately 20 to 30 minutes prior to the laboratory session. The distal interphalangeal joints were distended with 10 mL of saline solution, and the metacarpophalangeal joints were distended with 20 mL of saline solution. The amount of fluid used to distend the joints was chosen to mimic distension as would be seen in cases with joint pathology. Following joint distention, the joints were placed through 15-20 flexion and extension cycles. The cadaver limbs in the unmodified group were placed through 15-20 flexion and extension cycles. This protocol was based on that used for canine cadavers[5] and modified by the authors for equine joints in an unpublished, preliminary study to compare fluid obtained from modified and unmodified equine cadaver joints.

During the laboratory, students performed arthrocentesis and diagnostic analgesia techniques of various sites on the limb. Students participating in the study were asked to record the number of needle redirects required to obtain joint fluid and the amount of fluid obtained when performing the dorsal approach of arthrocentesis of the distal interphalangeal and metacarpophalangeal joints. A needle redirect was considered to be removal of the needle from the original site of placement followed by redirection or new placement of the needle. Arthrocentesis was considered successful when fluid was present in the hub of the needle or able to be aspirated from the joint.

Prior to the study, the experimental sample size was calculated using G*Power and indicated that the minimum sample size to yield a statistical power of at least 0.8 using a 95% CI and a 0.8 effect size is 12. Following the laboratory sessions, the number of needle redirects, the amount of fluid obtained, and the pre- and post-laboratory self-efficacy scores were compared between students in the unmodified and modified cadaver groups. Statistical analyses were performed using commercially available software (GraphPad Prism; GraphPad Software) with a *P* value of < .05 used for significance. The Wilcoxon rank sum test was used to compare the number of needle redirects, the amount of fluid obtained, and the changes in self-efficacy scores between treatment groups.

Results

A total of 19 students participated in the study with 13 students in the modified laboratory sessions and 6 in the unmodified laboratory sessions.

Fluid volume

An increased volume of fluid was obtained following arthrocentesis of the metacarpophalangeal joint with use of the modified cadaver (1.7 mL) compared to the unmodified cadaver (0.1 mL; *P* = .004; **Table 1**). An increased volume of fluid was obtained following arthrocentesis of the distal interphalangeal joint with use of the modified cadaver (0.5 mL) compared to the unmodified cadaver (0 mL; *P* = .029; Table 1). Fluid was obtained and arthrocentesis considered successful in 4/6 (66%) unmodified metacarpophalangeal joints and in 2/6 (33%) distal interphalangeal joints. Fluid was obtained and arthrocentesis considered successful in 13/13 (100%) of modified metacarpophalangeal joints and in 12/13 (92%) of modified distal interphalangeal joints.

Needle redirects

A difference in number of needle redirects was not identified (*P* = .58; Table 1) between unmodified (2.5) and modified (2) cadaver groups when performing arthrocentesis of the metacarpophalangeal joint. With arthrocentesis of the distal interphalangeal joint, there was no difference (*P* = .534; Table 1) in the number of needle redirects between the unmodified (3) and modified (2) cadaver groups.

Self-efficacy scores

Identification of landmarks—No difference was present in pre-laboratory self-efficacy scores for identification of landmarks for arthrocentesis of the metacarpophalangeal joint (*P* = .825) or the distal interphalangeal joint (*P* = .563) between unmodified or modified cadaver groups.

A significant increase was identified in the post-laboratory scores for identification of landmarks of the metacarpophalangeal joint for students using both the modified (score = 70; *P* = .003; **Table 2**) and unmodified cadavers (score = 70; *P* = .034; Table 2), however there was not a significant difference in post-laboratory scores between students using the modified and unmodified cadavers (*P* = 1). A significant increase was identified in the post-laboratory scores for identification of landmarks of the distal

Table 1—Median amount of fluid obtained and needle redirects required to obtain fluid during arthrocentesis of the distal interphalangeal and metacarpophalangeal joints in both modified and unmodified cadaver groups.

Joint	Measured	Modified	Unmodified	*P* value
Distal interphalangeal joint	Fluid obtained (mL)	0.5	0	.029*
	Needle redirects	2	3	.534
Metacarpophalangeal joint	Fluid obtained (mL)	1.7	0.1	.004*
	Needle redirects	2	2.5	.580

*P value of < .05.

Table 2—Median self-efficacy scores for identification of landmarks and performance of arthrocentesis for the distal interphalangeal and metacarpophalangeal joints in both modified and unmodified cadaver groups.

Group	Measured	Pre-lab score	Post-lab score	*P* value
Distal interphalangeal joint unmodified	ID landmarks	30	65	.058
	Perform arthrocentesis	30	60	.058
Distal interphalangeal joint modified	ID landmarks	40	70	.007*
	Perform arthrocentesis	30	60	.025*
Metacarpophalangeal joint unmodified	ID landmarks	30	70	.034*
	Perform arthrocentesis	25	65	.036*
Metacarpophalangeal joint modified	ID landmarks	40	70	.003*
	Perform arthrocentesis	30	70	.01*

*P value of < .05.

interphalangeal joint for students using the modified (score = 70; *P* = .007; Table 2) but not the unmodified cadavers (score = 65; *P* = 0.058; Table 2), however there was not a significant difference in post-laboratory scores between students using the modified and unmodified cadavers (*P* = .753).

Performance of arthrocentesis—No difference was present in pre-laboratory self-efficacy scores for performance of arthrocentesis of the metacarpophalangeal joint (*P* = .533) or the distal interphalangeal joint (*P* = .594) between unmodified or modified cadaver groups.

A significant increase was identified in the post-laboratory scores for performance of arthrocentesis of the metacarpophalangeal joint for students using both the modified (score = 70; *P* = .01; Table 2) and unmodified cadavers (score = 65; *P* = .036; Table 2), however there was not a significant difference in post-laboratory scores between students using the modified and unmodified cadavers (*P* = .965). A significant increase was identified in the post-laboratory scores for performance of arthrocentesis of the distal interphalangeal joint for students using the modified (score = 60; *P* = .025; Table 2) but not the unmodified cadavers (score = 60; *P* = .058; Table 2), however there was not a significant difference in post-laboratory scores between students using the modified and unmodified cadavers (*P* = .622).

Discussion

Our goal was to determine if modification of equine cadaver limbs with joint distention would result in higher fluid yields and decreased needle redirects while increasing self-efficacy with equine arthrocentesis among veterinary students. The results of our study partially support our 2 hypotheses. First, we found a higher fluid yield from the metacarpophalangeal and distal interphalangeal joints following modification. Retrieving fluid from a joint shortly after being distended seems intuitively obvious; however, to assess feasibility of the modification for teaching where success was measured by obtaining fluid, we needed to confirm this. Studies using canine cadavers for teaching arthrocentesis found similar results where modified cadavers had a higher fluid yield following arthrocentesis compared with unmodified cadavers.[5,7]

As stated in the methods, the amount of fluid used to modify joints was chosen to mimic cases with joint pathology and joint distension. The amounts were chosen based on the authors clinical experience with amount of fluid required to distend the distal interphalangeal and metacarpophalangeal joints when determining synovial communication with wounds. To the authors' knowledge, there are no clinical reports describing the amount of synovial fluid within normal or abnormal equine joints. When performing intra-articular diagnostic analgesia, the recommended volume of anesthetic to be injected varies between sources. To perform intra-articular analgesia of the distal interphalangeal joint, the minimum amount of fluid to be injected is reported as 4 mL with a maximum of 10 mL.[14,15] For the metacarpophalangeal joint, the range of anesthetic that can be injected is reported as 8 to 12 mL.[14,15] When performing intra-articular analgesia for lameness localization, the volumes used should not cause significant distension of the joint as this can lead to diffusion and analgesia of structures outside the joint.

While we did see an increase in fluid obtained, we did not see a difference in the number of needle redirects that it took students to obtain this fluid between the modified and unmodified cadaver for either the metacarpophalangeal or distal interphalangeal joints. This is the first time in this curriculum where students are introduced to the clinical skill of equine arthrocentesis. This skill requires recall of previously learned knowledge of anatomy in addition to knowledge regarding direction and depth of needle placement, which they are likely unfamiliar with. Increasing the amount of fluid in the metacarpophalangeal and distal interphalangeal joints increases the fluid volume obtained, however, does not immediately translate to proficiency in the clinical skill of arthrocentesis. A study examining veterinary student proficiency development with basic and advanced robotic simulator tasks found a median of 8 attempts was needed to reach proficiency with the basic task while the advanced task required 22 attempts.[16] Clinical skill development and proficiency requires practice, and it seems plausible that students require more than a single practice session to improve upon the skill of arthrocentesis.[17]

Prior to the laboratory, students in the unmodified and modified cadaver groups had no difference in scores for self-efficacy. In the post-laboratory assessment, we did find increases in student self-efficacy with use of both the modified and unmodified cadavers for the metacarpophalangeal joint when identifying landmarks and when performing arthrocentesis. When identifying landmarks and performing arthrocentesis of the distal interphalangeal joint, we saw significant increases with self-efficacy scores in the students using the modified but not the unmodified cadavers. When comparing self-efficacy scores from the students using the modified and unmodified cadavers, however, no significant difference was found and the lack of significant increase in the students using the unmodified cadavers is likely due to the lower number of students in this group.

We expected to see a greater increase in self-efficacy with the use of modified cadavers as positive feedback, in this case in the form of increased fluid volume from the joint, has been shown to impact learner's self-efficacy.[18,19] Despite a greater amount of fluid obtained from the modified cadaver joints, the increases seen in self-efficacy at the end of the laboratory were similar between groups using modified and unmodified cadavers. Of the 4 major sources of self-efficacy, mastery experiences are one of the most influential sources and the increases in self-efficacy following practice with unmodified and modified cadavers in our study corroborate this.[10,12] And while positive experiences can increase self-efficacy, we must remember that performance failures can also decrease self-efficacy.[9,18,20] Therefore, it is important for educators to focus on providing opportunities for authentic practice experiences likely to deliver performance success. Given our results, the model used for initial introduction to performing equine arthrocentesis may be less important than the act of practicing the skill. Further studies evaluating the effect of different model types over multiple practice on proficiency and self-efficacy with equine arthrocentesis are warranted. Multiple opportunities to practice equine arthrocentesis on both cadaver limbs and in live patients throughout the veterinary curriculum are likely necessary to develop proficiency in this skill prior to graduation.

Limitations of our study include a low number of participants and measuring only student self-efficacy and not including subjective questions regarding their experience related to the laboratory. Because the laboratory is part of the normal curriculum that all veterinary students have to take, voluntary participation was sought. Incentives and encouragement from the instructor (who was also the researcher) were considered a conflict of interest through the IRB and could not be performed to increase participation. Given the low number of participants within the study, the findings should be corroborated by a similar study including a greater number of participants to increase the power. Other ways to increase participation and the number of subjects in the study could have included using students in different stages of the curriculum (first-, second-, or fourth-year veterinary students) or potentially recruiting students from other universities. The difficultly with this is that subjects would not be homogenous in their stage or experience provided at that point in their veterinary curriculum, which may have affected the results. Ideally, we also would have measured student self-efficacy over multiple practice sessions rather than a singular practice session. The lameness and joint pathology history of the cases that donated cadaver limbs was unknown. If significant joint pathology existed in the distal interphalangeal or metacarpophalangeal joints, this may have affected the student's ability and experience with arthrocentesis.

Future studies would include evaluating student proficiency and self-efficacy with equine arthrocentesis over multiple practice sessions and in a larger group of students. Ideally, studies would also compare student proficiency and self-efficacy with equine arthrocentesis using both modified and unmodified cadavers in addition to live animals.

In conclusion, results of this study found that modified cadavers provided a higher fluid yield following arthrocentesis compared to unmodified cadavers. Despite increased fluid yield with modified cadavers, multiple attempts were still required for proper needle placement which suggests that proficiency with equine arthrocentesis requires additional practice sessions. And finally, regardless of the cadaver model used, performing equine arthrocentesis in our group of students improved self-efficacy with the task.

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Disclosures

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Supplementary Materials

Supplementary materials are posted online at the journal website: avmajournals.avma.org