Efficacy of a cadaver-based procedural skills lab for internal medicine residents
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Abstract: Cadaver-based simulation has been used in many surgical and subspecialty fields to teach procedural skills. We developed a cadaver-based simulation curriculum to enhance internal medicine residents’ comfort with arthrocentesis. 29 internal medicine residents in postgraduate years 1–3 participated in the cadaver-based simulation session. Multidisciplinary faculty precepted the course, with assistance from rheumatology fellows. Landmark-based and ultrasonography-guided injections were performed on cadaver shoulder and knee joints. Residents reported an average of 1.63 arthrocentesis procedures performed prior to the simulation session. They reported a comfort level of 1.74 on the pre-simulation session survey. This comfort level improved by 70.11% to 2.94 following the simulation session. The effect was sustained at 4–6-week follow-up, with residents reporting a comfort level of 2.94. Cadaver-based procedural skills sessions increased self-reported trainee comfort with arthrocentesis. We recommend that such simulation sessions should be adopted into formal internal medicine residency training.

Keywords: education; patient-simulation; ultrasound; internal medicine

1. Introduction
Cadaver-based simulation has been employed by various subspecialties to teach procedural skills to postgraduate trainees. The efficacy of a cadaver-based simulation format has been well studied in various fields including surgery, emergency medicine and subspecialties within internal medicine (rheumatology) (Berman et al., 2012; Kay et al., 2016; Tabas, 2005; Tschabitscher & Di Ieva, 2013). Not only do the simulations improve self-reported confidence but they have also been verified to improve trainee skills and diminish error (Ruparel et al., 2017; Sharma et al., 2018). Moreover, simulations with cadavers have been reported to be superior at improving trainee confidence in skills, beyond other simulation formats that use synthetic anatomic models or lecture alone (Torralba et al., 2015).

With this in mind, we designed a cadaver-based simulation to train internal medicine residents in arthrocentesis. The course consisted of a lecture component, followed by a cadaver lab teaching landmark-based and ultrasound-guided arthrocentesis of the shoulder and knee joints. We wanted to ascertain if this course would enhance trainee comfort and, if so, would the effect last beyond the simulation session.
2. Methods

2.1. Study population
Participants were internal medicine residents, ranging between postgraduate years 1 and 3. Participants completed pre-participation surveys to assess confidence levels with performing landmark-based and ultrasound-guided arthrocentesis of the shoulder and knee joints. Participants then attended a lecture on arthrocentesis, followed by a cadaver-based procedural skills session. Immediately following the session, they were given another survey assessing confidence levels with performing the same procedures. To assess retention of the skills and ongoing comfort level with the procedures, 4–6 weeks later, participants were asked to complete an additional post-training session survey. The data from these surveys were collected and analyzed for statistical significance. The survey consisted of 10 questions regarding prior experience with arthrocentesis, as well as comfort level with performing the procedure on a Likert scale from 1 to 5 (see Table 1). The Institutional Review Board at our program determined that this research was exempt and given protocol number 300002781.

2.2. Survey questions
Each survey consisted of 10–11 questions asking participants to rate their comfort level with performing specific procedures using the Likert scale reported in Table 1. In the initial survey, prior to the skills camp, participants were asked to report the average number of supervised and logged arthrocentesis performed prior to the lecture and simulation lab. In every survey, participants were asked to report post-graduate level, as well as comfort level with obtaining ultrasound windows and performing arthrocentesis for various joints and through different approaches. These include obtaining ultrasound windows for the glenohumeral joint as well as the patellofemoral joint; performing glenohumeral joint arthrocentesis via anatomic landmarks lateral approach, via anatomic landmarks posterior approach, and via ultrasound guidance; and performing patellofemoral joint arthrocentesis via anatomic landmarks suprapatellar approach, via anatomic landmarks infrapatellar approach, and via ultrasound guidance. In the immediate post-session survey, participants were also asked to give any feedback regarding the session (see Appendix A).

2.3. Study design
Internal medicine residents were given a lunch-time auditorium-based lecture, which reviewed anatomic landmarks and procedural approaches for an hour. Six days later, they presented for a 2-hour cadaveric simulation lab. There were 29 resident attendees. There were five attending physician faculty members from backgrounds including emergency medicine, critical care, sports medicine and internal medicine. There were also two rheumatology fellows who assisted in precepting.

The cadavers were obtained and prepared through our institution’s cadaver donation program. Cadavers were lightly embalmed. There were four cadaveric shoulders and four cadaveric knee joints available for injection. Two portable ultrasound machines (GE) were used for the ultrasound-guided injections. The trainees formed groups of three to five with a preceptor. They were encouraged to perform landmark-guided and ultrasound-guided injections consecutively to enhance anatomic comprehension. They were further encouraged to attempt a variety of approaches to the arthrocentesis. See Figure 1 for protocol and study design.

| Table 1. Likert scale for responses |
|------------------------------------|
| Scale | 1 | 2 | 3 | 4 | 5 |
| Self-reported comfort | Zero comfort | Comfort with maximal supervision | Comfort with moderate assistance | Comfort with independent performance | Expert level comfort |

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2.4. Statistical analysis
Continuous variables were reported using means, standard deviations and interquartile ranges. Categorical variables were reported using percentages. Comparisons of the average comfort rating score across the three time points (pre-session, post-session and 4–6-week post-session) were performed using analysis of variance and general linear models, including simultaneous pairwise comparisons using the Tukey test. All analyses were performed using SAS software version 9.4 of the SAS System for Windows.

3. Results
Twenty-nine residents participated in the cadaver-based skills session. Eighteen residents (62%) responded to the immediate post-simulation survey. Twenty-two residents (76%) responded to the survey sent at 4–6-week follow-up.

The average number of arthrocentesis performed prior to the skills session was 1.63. Participants reported a mean comfort level of 1.74 with performing ultrasounds of both the shoulder and knee joints. They also reported a mean comfort level of 1.74 with performing shoulder arthrocentesis via posterior and lateral landmark approaches and knee arthrocentesis via suprapatellar and infra-patellar landmark approaches.

Following the skills session, participants reported an average comfort level of 2.94 with performing the same procedures. They reported a comfort level between 2 and 3.
At 4–6-week follow-up, participants continued to report an average comfort level of 2.96, indicating a comfort level similar to that immediately following the skills session. Thus, the overall confidence level increased by 70.11% from before the skills session to the 4–6-week post-session feedback point (see Figure 2).

Prior to the skills session, 60.87% of the participants reported an average comfort level between 1 and 2 for all of the arthrocentesis procedures, with 36.96% averaging a score between 2 and 3, 2.17% reporting a score between 3 and 4 and 0% averaging a score of 4–5.

Immediately following the skills session, only 5.56% of the participants reported a comfort level 1–2, 38.89% averaging a comfort level between 2 and 3, 55.56% with a score between 3 and 4 and 0% with a comfort level between 4 and 5.

After 4–6 weeks following the skills session, comfort levels remained higher than pre-skills session quantities, with 4.55% of the participants reporting a comfort level between 1 and 2, 40.91% with a comfort level between 2 and 3, 50.00% with between 3 and 4 and 4.55% averaging a score between 4 and 5. The average comfort level comparisons between the various questions and feedback points are noted in Figure 3, with the average percentage of residents reporting comfort levels between 1-5 are noted in Figure 4.

4. Discussion

54.4 million adults have doctor-diagnosed arthritis, according to the National Health Interview Survey (NHIS) (Barbour et al., 2017). By 2040, that number is expected to grow to 78.4 million adults aged 18 years and older (Hootman et al., 2016). Currently, options for treatment include weight management, physical therapy, arthrocentesis and joint replacement.

It follows then that primary care providers will see increasing numbers of patients with musculoskeletal (MSK) complaints. One study reported that MSK complaints currently account for up to 60% of primary care visits (Wiitavaara et al., 2017).

However, data also suggest that graduates of internal medicine programs may not feel adequately prepared to care for these patients. One study reported that up to 52% of internal medicine program directors felt that arthrocentesis was not adequately taught at their respective programs (Goldenberg et al., 1985).

There is an abundance of data that demonstrate that internal medicine residents who receive arthrocentesis training are more likely to report feeling comfortable with performing these procedures (Bakewell & Gardner, 2011; Berman et al., 2012; Kay et al., 2016; Torralba et al., 2015). Trainees who receive this education are also more likely than controls to perform arthrocentesis once they enter independent clinical practice.

Despite this, arthrocentesis simulation education remains sporadic and not widely integrated into the internal medicine curriculum. For this reason, we sought to develop and assess a cadaver-based simulation program that could be adopted widely. Our cadaver-based simulation was effective at improving resident comfort with the procedures, and the effect was lasting.

Our study demonstrates statistically significant improvement in self-reported comfort levels in residents who participated in the cadaver-based simulation session, with continued high comfort levels 4–6 weeks following the session. This strongly supports the use of such simulation sessions within the internal medicine resident population to increase comfort level with performing such procedures.

There are several limitations to this study. Participants were de-identified, and therefore, individualized familiarity with arthrocentesis could not be assessed. Adopting the simulation session into the formal, required curriculum and tracking resident progress through procedure logs and
Figure 2. Average comfort levels reported per session with performing the various procedures reviewed during the procedural skills session.
Figure 3. Average score per question compared between survey feedback points.
Figure 4. Percentage of residents reporting various comfort levels compared between the survey feedback points.
evaluations could overcome this limitation. Another limitation to this study is the lack of long-term follow-up of trainees. It would be helpful to re-survey residents once they enter independent clinical practice to assess if the intervention had an impact on the prevalence of arthrocentesis in their independent practice. This study also did not statistically address the accuracy of performing the procedures. During the skills session, residents were observed for accuracy; however, this was not measured or analyzed in this study. Finally, results in this study are limited to the follow-up responses of the participants. The number of these responses varied at each feedback point, as noted previously, and the variability in response rate constitutes another limitation. These limitations could be overcome by adopting the skills sessions into the formal education curriculum. This would allow for attending physician oversight to monitor technique, as well as mandatory self-evaluations.

In summary, we report that a cadaver-based procedural skills session increased self-reported trainee comfort with arthrocentesis. We recommend that such simulation sessions should be adopted into formal internal medicine residency training.

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Appendix A Survey questions

Pre-session survey

(1) What is your PGY level?
(2) How many supervised and logged arthrocentesis have you performed during residency?
(3) Rate your comfort level from 1 to 5 scale below with obtaining ultrasound windows for the glenohumeral joint. 1 (zero comfort), 2 (max supervision), 3 (moderate assistance), 4 (can usually perform on my own), 5 (expert).
(4) Rate your comfort level from 1 to 5 scale below with obtaining ultrasound windows for the patellofemoral joint. 1 (zero comfort), 2 (max supervision), 3 (moderate assistance), 4 (can usually perform on my own), 5 (expert).
(5) Rate your comfort level from 1 to 5 scale below with performing glenohumeral joint arthrocentesis via anatomic landmarks lateral approach. 1 (zero comfort), 2 (max supervision), 3 (moderate assistance), 4 (can usually perform on my own), 5 (expert).
(6) Rate your comfort level from 1 to 5 scale below with performing glenohumeral joint arthrocentesis via anatomic landmarks posterior approach. 1 (zero comfort), 2 (max supervision), 3 (moderate assistance), 4 (can usually perform on my own), 5 (expert).
(7) Rate your comfort level from 1 to 5 scale below with performing glenohumeral joint arthrocentesis via ultrasound guidance. 1 (zero comfort), 2 (max supervision), 3 (moderate assistance), 4 (can usually perform on my own), 5 (expert).
(8) Rate your comfort level from 1 to 5 scale below with performing patellofemoral joint arthrocentesis via anatomic landmarks suprapatellar approach. 1 (zero comfort), 2 (max supervision), 3 (moderate assistance), 4 (can usually perform on my own), 5 (expert).
(9) Rate your comfort level from 1 to 5 scale below with performing patellofemoral joint arthrocentesis via anatomic landmarks infrapatellar approach. 1 (zero comfort), 2 (max supervision), 3 (moderate assistance), 4 (can usually perform on my own), 5 (expert).
(10) Rate your comfort level from 1 to 5 scale above with performing patellofemoral joint arthrocentesis via ultrasound guidance. 1 (zero comfort), 2 (max supervision), 3 (moderate assistance), 4 (can usually perform on my own), 5 (expert).

Additional questions included in the post-session and 4–6-week post-session surveys.

(1) Did you attend the arthrocentesis practice session?
(2) What did you like about the practice session? How can we make the session better?
