American Journal of Emergency Medicine 35 (2017) 240–244

Contents lists available at ScienceDirect

American Journal of Emergency Medicine

journal homepage: www.elsevier.com/locate/ajem

Original Contribution

Success of ultrasound-guided versus landmark-guided arthrocentesis of hip, ankle, and wrist in a cadaver model☆

Kristin Berona, MD *, Amin Abdi, MD, Michael Menchine, MD, Tom Mailhot, MD, Tarina Kang, MD, Dina Seif, MD, MBA, Mikaela Chilstrom, MD [1]

Department of Emergency Medicine, Keck School of Medicine of USC, LAC + USC Medical Center, 1200 N. State Street, Room 1011, Los Angeles, CA 90033, United States

ARTICLE INFO

Article history:
Received 22 August 2016
Received in revised form 26 September 2016
Accepted 22 October 2016

Keywords:
Ultrasound
Diagnostic testing
Skills assessment/procedures
Education
Arthrocentesis

ABSTRACT

Purpose: The objectives of this study were to evaluate emergency medicine resident-performed ultrasound for diagnosis of effusions, compare the success of a landmark-guided (LM) approach with an ultrasound-guided (US) technique for hip, ankle and wrist arthrocentesis, and compare change in provider confidence with LM and US arthrocentesis.

Methods: After a brief video on LM and US arthrocentesis, residents were asked to identify artificially created effusions in the hip, ankle and wrist in a cadaver model and to perform US and LM arthrocentesis of the effusions. Outcomes included success of joint aspiration, time to aspiration, and number of attempts. Residents were surveyed regarding their confidence in identifying effusions with ultrasound and performing LM and US arthrocentesis.

Results: Eighteen residents completed the study. Sensitivity of ultrasound for detecting joint effusion was 86% and specificity was 90%. Residents were successful with ultrasound in 96% of attempts and with landmark 89% of attempts ($p = 0.257$). Median number of attempts was 1 with ultrasound and 2 with landmarks ($p = 0.12$). Median time to success with ultrasound was 38 s and 51 s with landmarks ($p = 0.23$). After the session, confidence in both US and LM arthrocentesis improved significantly, however the post intervention confidence in US arthrocentesis was higher than LM (4.3 vs. 3.8, $p < 0.001$).

Conclusions: EM residents were able to successfully identify joint effusions with ultrasound, however we were unable to detect significant differences in actual procedural success between the two modalities. Further studies are needed to define the role of ultrasound for arthrocentesis in the emergency department.

1. Introduction

Joint arthrocentesis is a necessary component of an emergency physicians' clinical practice. However, the procedure may be technically difficult, particularly in small (e.g. wrist) or deep (e.g. hip) joints. Unsuccessful arthrocentesis potentially exposes the patient to complications from the procedure (pain, infection, bleeding) and may contribute to diagnostic and treatment delays [1]. Ultrasound has been used to both diagnose joint effusions [2-4] and guide needle placement into the joint [5]. Studies in the rheumatology literature show improved accuracy of joint injection using ultrasound guidance. Cunnington et al. showed that a rheumatology fellow with only 9 months of rheumatology experience but specific ultrasound training had an accuracy of 83% with joint injection of shoulder, elbow, wrist, knee, and ankle compared to a 66% accuracy of landmark-based injection by a group of peers and attendings [6]. With regard to hip injections, a meta-analysis found that operators using ultrasound were 100% accurate while operators performing landmark-guided (LM) injections were 72% accurate (using fluoroscopy, computed tomography, magnetic resonance imaging, or direct visualization as the determinant of accuracy) [7].

Perhaps more relevant to emergency medicine (EM), Balint et al. showed that ultrasound improved success rates in *aspiration* of multiple joints (shoulder, hip, wrist, knee, ankle, and digits) by greater than 60% compared to LM techniques [8]. In the emergency medicine literature, there are multiple case reports of ultrasound-guided (US) arthrocentesis for the hip and ankle [9-13], but only one prospective study evaluating the utility of US arthrocentesis. Wiler et al. compared the success rate of US and LM arthrocentesis of the knee and found no difference, though patients reported less pain and providers found the procedure easier with ultrasound guidance [14].

We conducted a study whose goals were to: 1) estimate the accuracy of EM residents using ultrasound to detect hip, ankle, and wrist

☆ Prior presentations: SAEM Western Regional Meeting, April 1, 2016.

* Corresponding author.
E-mail address: berona@usc.edu (K. Berona).
[1] Present address: Department of Emergency Medicine, Emory University School of Medicine, 531 Asbury Circle, Annex Building Suite N340, Atlanta, GA 30322.

http://dx.doi.org/10.1016/j.ajem.2016.10.056
0735-6757/

effusions 2) compare success rates for US arthrocentesis and LM arthrocentesis among residents in a cadaver model and 3) examine the change in confidence for performing US and LM arthrocentesis after a brief teaching intervention and cadaver lab practicum.

2. Methods

This was a prospective, non-blinded study of EM resident physicians conducted using a cadaver model. The study was approved by the Institutional Review Board, and each study participant provided consent to participate in the study.

Residents participated in the study voluntarily and were given a gift card for $10 if they completed the study. Residents at our institution participate in a two-day comprehensive introduction to ultrasound course at the start of internship, and complete a two-week ultrasound rotation during both PGY1 and PGY2 years. Residents were primarily recruited to participate during their two-week ultrasound rotation and based on availability, however any resident PGY 1–4 could be enrolled. Residents were excluded if they participated in didactics but did not complete any of the cadaver lab practicum, or if they only performed the cadaver lab practicum without completing didactics.

Nine enrollment sessions were held, with 1 cadaver per session and a maximum of 3 participants during each session. Cadavers were prepared in advance by a study investigator (KB, AA, TK, DS, MC). Saline was injected into joints under ultrasound guidance until a detectable effusion was noted (approximately 30–60 mL for hip, 10–20 mL for ankle, and 10 mL for wrist) by the study investigators, all of whom were ultrasound fellowship trained, similar to prior studies [15-16]. (Fig. 1) The laterality of each effusion was randomized prior to preparation of the cadaver for each enrollment session using an online randomizer (www.random.org), except in the case of open joints from surgical procedures (the available fresh tissue cadavers were shared with surgical specialties). The study investigator visualized all joints with ultrasound to ensure only one side had an effusion and that fluid was only present inside the joint. This investigator assessment served as the 'gold standard' for whether an effusion was present or absent in the joint. Multiple superficial needle punctures were created in the skin overlying each of the bilateral joints so that residents were unable to identify the side with the effusion based on the presence of needle marks introduced during the injection of saline. Immediately before the cadaver lab, resident participants watched a pre-recorded, 30-minute instructional video on how to diagnose hip, ankle, and wrist effusions using ultrasound and how to perform arthrocentesis of each joint using both a LM and US technique. Demographics collected from participants included year in training, self-reported number of arthrocenteses performed for each of the joints being studied, and number of ultrasounds correctly performed and interpreted based on a query of our image archiving database.

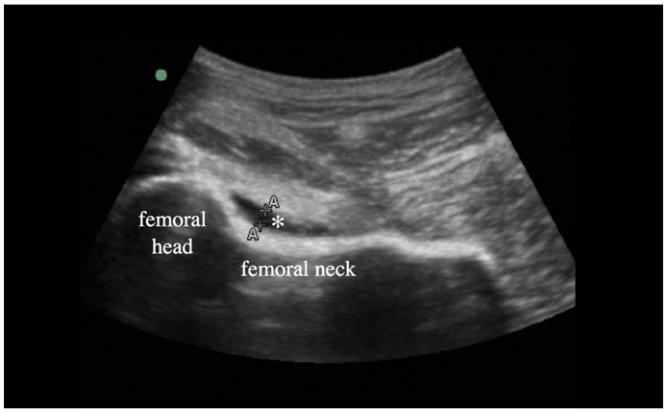

Fig. 1. Artificially created hip effusion in a cadaver model (asterisk denotes effusion).

Subjects were then brought to the cadaver lab and asked to use ultrasound to identify whether an effusion was present or absent in each cadaver hip, ankle, and wrist. Subjects did not know how many joints contained effusions. Participants used either a curvilinear (5–2 MHz) or linear (13–6 MHz) transducer for the hips and a linear transducer for the ankle and wrist. An M-Turbo (SonoSite™, Bothell, WA) ultrasound machine was used.

After identifying the effusions, or being directed to the side with the effusion by the study investigator if identified incorrectly, participants attempted arthrocentesis of the hip, ankle, and wrist. Participants were randomized to start either with US or LM technique for each joint to mitigate familiarity with the cadaver model improving success (e.g. they performed both methods in the same joint, but were randomized to do US or LM arthrocentesis first).

Outcome measures of the study were 1) sensitivity and specificity of ultrasound for diagnosis of joint effusion 2) whether the subject successfully aspirated joint fluid (defined as >1 mL of fluid aspirated) from joints with confirmed effusion 3) number of attempts to success (attempt defined as needle withdrawal from skin and reinsertion) and 4) time to aspiration (defined as time from insertion of needle into skin to successful aspiration). When participants were not successful after 5 min from the initial skin puncture, they were assigned a time of 300 s and instructed to move on. A study investigator (KB, AA, TK, DS, MC) recorded the key outcome measures for each participant.

Confidence before and after the session was assessed using a five-point Likert scale of agreement with 1 being strongly disagree and 5 being strongly agree. Questions included "I am comfortable identifying a joint effusion using ultrasound for (hip/ankle/wrist)"; "I am comfortable with the landmark approach to arthrocentesis for (hip/ankle/wrist)"; and "I am comfortable with the ultrasound-guided approach to arthrocentesis for (hip/ankle/wrist)." We then assessed the change in confidence before and after the training intervention and compared the change in confidence in the LM approach with the change in confidence with the US approach.

2.1. Data Analysis

Prior rheumatology literature described a difference of 65% between successful US and LM arthrocentesis (97 vs. 32%) [8], however an emergency medicine study showed no difference between US and LM knee arthrocentesis (94% vs. 93%) [14]. Given the wide estimates of success across the different modalities and the fact that we planned on studying a different set of joints, we did not believe a formal sample size calculation was in order. Rather we sought to perform a preliminary study to obtain a more accurate projection of success of EM residents with US and LM arthrocentesis and based our sample size on the number of residents rotating through the ultrasound rotation and the number of cadavers we could obtain.

Diagnostic sensitivity and specificity of resident-performed ultrasound for effusion were calculated. Successful arthrocentesis rates were compared with McNemar's test for matched pairs. Median number of attempts and time were compared using Wilcoxon signed rank test for matched pairs. Confidence was compared with Wilcoxon signed rank test. All statistics were performed by STATA (College Station, Texas).

3. Results

Twenty participants were enrolled, 2 were subsequently excluded because they did not complete the study procedures. In the final analysis we included 3 PGY1, 11 PGY2, 3 PGY3 and 1 PGY4, who had performed an average of 161 ultrasounds. Collectively, the group had performed 2 hip, 19 ankle, and 3 wrist arthrocentesis (self-reported, Table 1). Due to cadaver limitations (fluid leaking out, open joints) not all participants scanned each bilateral joint to identify the presence of an effusion, nor did all participants perform arthrocentesis at each of