

# Ultrasound in Emergency Medicine



## LEARNING CURVES FOR ULTRASOUND ASSESSMENT OF LUMBAR PUNCTURE INSERTION SITES: WHEN IS COMPETENCY ESTABLISHED?

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**Abstract—Background:** Ultrasound (US) can be used to improve lumbar puncture (LP) success. How to achieve competency in LP US has not been defined. Cumulative sum statistics (CUSUM) characterized competency acquisition in other skills. **Objectives:** Identify the learning curve for 80% success rate in LP US insertion site (IS) identification among pediatric emergency medicine fellows. **Methods:** This prospective study took place in a single pediatric emergency department. Fellows with limited ultrasound experience received didactics, training, and three proctored examinations. Skills were evaluated in three 2-h sessions: using US, subjects identified LP ISs on a convenience sample of patients ages 0–20 years old. Subjects' IS markings were compared to markings by an expert, an emergency US fellowship-trained attending. Successful IS identification was defined as markings within 2 mm or 5 mm of the expert mark in infants and older children, respectively. A second expert marked 17 cases for interrater agreement. CUSUM was used to analyze individual learning curves. **Results:** Five fellows evaluated 72 patients (mean age 11.4 years [SD = 4, range 3–20], mean body mass index 20.5 [SD = 4.4, range 13.1–37.7]) over a 3-month period. Mean number of attempts per fellow was  $14.4 \pm 3.1$  (R 11–19); mean time to landmark identification was  $72 \pm 46$  s (R 27–240). The two experts demonstrated 100% observed agreement. Aggregate success rate for all fellows was 75% (54/72). Four fellows showed learning curves that trended toward, but did not achieve, the acceptable success rate of

80%. **Conclusions:** Nineteen attempts are insufficient among fellows to achieve competency in US-guided LP IS identification. © 2016 Elsevier Inc. All rights reserved.

**Keywords—**procedural competency; ultrasound; lumbar puncture

### INTRODUCTION

Procedural competency is essential in emergency medicine to decrease complication rates and improve patient care. Lumbar puncture (LP) is routinely performed in emergency departments (EDs). However, 30–50% of neonatal and infant LPs are traumatic or unsuccessful (1,2). Unsuccessful LPs may create increased anxiety for patients and families, and can lead to unnecessary hospitalizations and prolonged courses of intravenous antibiotics. Procedural ultrasound has been shown to improve LP success rates in adults (3,4). Ultrasound has been shown to increase procedural confidence among pediatric residents (5). Two interim analyses regarding procedural ultrasound and pediatric LP show conflicting results regarding the effect of ultrasound on LP success (6,7). Prior to investigating how ultrasound can affect LP success, primary importance should be placed on understanding the feasibility of the procedure, the best

methods for skill acquisition, and the amount of training and experience necessary to achieve competency with ultrasound-assisted LP.

Whereas most training programs require tracking and documentation of procedural experience, both the American Board of Emergency Medicine and the American Academy of Pediatrics do not outline specific procedural competency criteria. Quality of procedural experience is difficult to determine and is not standardized across training programs. Cumulative sum (CUSUM) is a type of control chart used to monitor individual performance against an acceptable target rate and determine achievement of competency (8). Our goal is to determine the number of attempts needed to achieve 80% success rate with identification of insertion sites (ISs) for ultrasound-assisted LP among pediatric emergency medicine (PEM) fellows, using CUSUM.

## METHODS

### *Study Design, Setting, and Population*

This was a prospective observational study, which took place in a single urban pediatric ED with an annual census of 76,000 visits and an eight-member PEM fellowship. Study subjects included five PEM fellows (3 postgraduate year [PGY]-4, 1 PGY-5, 1 PGY-6) with limited ultrasound experience. The institutional review board approved the study protocol.

### *Study Protocol*

PEM fellows received a 30-min lecture including a short instructional video, followed by a 1-h hands-on practice session scanning healthy volunteers. Upon completion of this initial training, each fellow completed three proctored examinations on healthy volunteers with real-time instructional feedback.

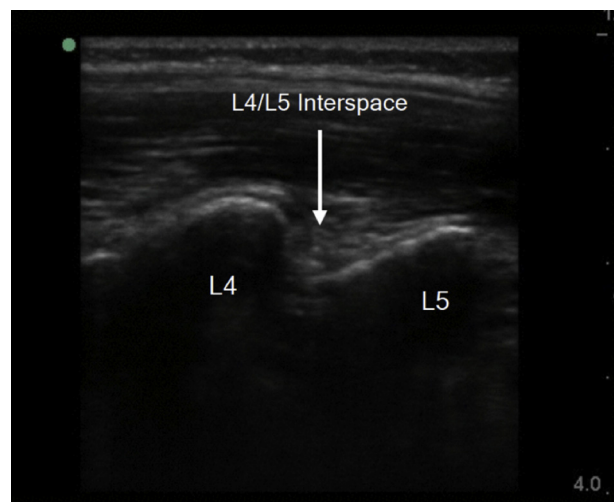
After training, successful identification of ISs was evaluated in three 2-h sessions in which each fellow attempted IS identification with ultrasound guidance on a convenience sample of patients from ages 0–20 years old presenting to the ED for evaluation for any reason. We excluded patients who could not sit in an upright position secondary to age or pain, and unstable patients needing immediate resuscitative measures. Age and body mass index (BMI) were collected for each patient by the expert sonographer (primary investigator). Verbal consent was obtained from each patient/guardian and a study information sheet was provided.

Comparisons were made between expert sonographer (PEM attending who completed a 1-year Emergency Ultrasound fellowship) and PEM fellow markings for IS identification. Ultrasounds were obtained with patients

in the sitting position, using either a 13-6-MHz high-frequency linear or 5-2-MHz curvilinear transducer (Sonosite, Bothell, WA). The sacrum was located using a paramedian sagittal approach. The transducer was then moved cranially to identify the L3/L4 and L4/L5 interspaces (Figure 1). The interspace was centered on the screen and a horizontal line was drawn from the middle of the probe to mark each interspace. The transducer was then turned in a transverse orientation, with the directional indicator pointed toward the patient's left to find the true midline. The spinous process was identified and placed in the middle of the screen (Figure 2). A vertical line was drawn from the center of the transducer to indicate the true midline. The intersection of these lines indicated IS for LP.

The expert sonographer used ultrasound to mark the L3/L4 and L4/L5 ISs with an ultraviolet (UV)-light marking pen. A large, clear, sterile adhesive dressing (Tegaderm™, 3M, Saint Paul, MN) was placed over the patient's lower back. Immediately after, the PEM fellow entered the examination room and repeated the procedure over the Tegaderm using ultrasound and a standard marking pen (Figures 3 and 4). The PEM fellow was instructed to mark either the L3/L4 or L4/L5 IS and report the intended site. Time taken to complete the procedure was recorded in seconds by the primary investigator and was defined as the time from the moment the ultrasound transducer touched the patient until the IS was marked. As the previous site was marked with a UV light pen, the PEM fellow was blinded to the location selected by the ultrasound expert.

The primary investigator then used a UV light to compare the absolute distances between the expert and trainee mark. Distances were recorded in mm. Successful identification of IS was defined as PEM fellow markings within 2 mm of the expert benchmark in infants and 5 mm



**Figure 1.** Sagittal view lumbar spine; paramedian approach.

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