

CLINICAL VIGNETTE

Ultrasound-Guided Lumbar Puncture

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Case Presentation

A 19-year-old female with migraines presented with three days of fever, headache, vomiting, and myalgias. The patient had a recent upper respiratory infection with spontaneous resolution of symptoms. She was evaluated at student health and tested negative for COVID-19, influenza, and group A *Streptococcus*. She was returning towards her usual state of health when her symptoms recurred with fever and myalgias. She also developed a frontal headache which felt different to her typical migraine headaches. This headache was associated with photophobia, phonophobia, nausea, and vomiting and prompted ED evaluation. She had one new unprotected sexual encounter two months prior to presentation. She denied sick contacts, recent travel, or intravenous drug use. She denied any neck stiffness, confusion, skin rashes, weakness, or vision changes.

Emergency department noted a fever of 102°F and a heart rate of 110. Laboratory results were notable for a leukocytosis with a white blood cell count of $13.94 \times 10^9/L$. The patient was treated for migraine with ibuprofen, metoclopramide, and magnesium with no improvement in her symptoms. Given concern for meningoencephalitis, a lumbar puncture (LP) was attempted three times by a resident and attending physician without success. The patient declined further LP attempts due to discomfort. She was started on intravenous antibiotics with vancomycin, ceftriaxone, and intravenous acyclovir to empirically treat for meningitis, and admitted to the medicine service. The infectious disease service discussed the risks and benefits of LP with the primary team and the patient. She agreed to one more LP attempt. The repeat LP was done under ultrasound guidance and was successful.

Meningitis was ruled out with normal cerebrospinal fluid (CSF) without pleocytosis. CSF WBC 1 cell/ μL (2% neutrophils, 12% lymphocytes), CSF protein 23 mg/dL, and CSF glucose 59 mg/dL. CSF HSV PCR was not detected. Her urinalysis was clear and blood cultures were negative. She was negative for *Coccidioides*, HIV, chlamydia, and gonorrhea. CT scan of her brain and sinuses only showed minimal mucosal thickening of the maxillary sinuses. Acyclovir and vancomycin were discontinued. The patient defervesced and her symptoms improved over several days. Ceftriaxone was continued for treatment of her fever and leukocytosis. The etiology of her infection remained unclear, with suspicion for a viral syndrome, perhaps gastroenteritis, leading to vomiting as well as possible sinusitis

and a superimposed migraine headache. Given her clinical improvement, the patient was discharged with amoxicillin-clavulanate to complete a 5-day total course of antibiotics.

Discussion

Lumbar puncture is a commonly performed invasive procedure in which the subarachnoid space is accessed to sample cerebrospinal fluid (CSF). LP is useful in diagnosing central nervous system (CNS) infections such as meningoencephalitis, neuroinflammatory diseases, and subarachnoid hemorrhage.^{1,2} The LP is a necessary step in the diagnostic work-up of bacterial meningitis, a condition associated with significant mortality which requires prompt treatment. Patients with meningitis may present with clinical features including fever, altered mental status, headache, and meningeal signs such as nuchal rigidity. CSF analysis through LP is necessary as the signs and symptoms alone are insufficient to diagnose meningitis and signs and symptoms cannot differentiate between bacterial versus viral CNS infections.³

Point-of-care ultrasound is a valuable tool to guide and facilitate bedside procedures, including LP. LPs are often performed successfully using anatomic landmarks alone. Ultrasound provides several advantages especially in patients with obesity with less palpable landmarks, as well as in pediatric patients.^{4,6} Ultrasound is utilized to assess the anatomy of the lumbar spine and identify the needle insertion site at the interspinous space with the highest chance of success. It also allows the clinician to determine the depth of the ligamentum flavum and the width of the interspinous spaces.^{4,5} The use of ultrasound to guide LPs has been reported to improve the rate of procedural success, reduce the number of insertion attempts and needle redirections, and reduce the risk of traumatic taps.^{5,7}

There are two major approaches to ultrasound LP guidance: ultrasound-guided site marking and real-time ultrasound guidance. We will discuss ultrasound-guided site marking, a static technique which is more common. This technique was employed in the case presentation, resulting in a successful LP after three failed attempts without ultrasound. The patient was noted to have smaller interspinous spaces on ultrasound, which posed a challenge performing LP by palpation alone.

In ultrasound-guided site-marking, we start with traditional surface landmarks and determine the superior points of the iliac crests. The transducer is placed transversely to visualize the spinous processes as well as to mark the midline of the spine (Figure 1). Without ultrasound the midline may be challenging to determine in patients with abnormal spinal curvature or obesity.⁵ The high-frequency linear array transducer produces higher resolution images and can be used in lean patients and when training learners; however, the curvilinear transducer is more often used as it provides penetration to visualize deeper structures.⁴

Once the midline and the L2, L3, L4, and L5 spinous processes are identified, the transducer is rotated longitudinally 90°. From this view, the spinous processes appear as tombstones with the hyperechoic bone tip casting a deeper shadow (Figure 2). By sliding the transducer along the marked midline, the widest

interspinous space can be identified and marked. The intersection of the markings at L3-L4 or L4-L5 intervertebral spaces is the point of entry of the spinal needle.⁴ Ultrasound facilitates the accurate identification of a particular intervertebral space. Studies show two-thirds of cases clinicians correctly identified the lumbar intervertebral levels with ultrasound compared to only one-third using palpation alone.⁸

Conclusion

Ultrasound is a technique that is quick to perform and allows visualization of the relevant anatomy to supplement anatomical palpation in LPs. It provides greater accuracy and reliability to the LP procedure. The use of ultrasound can increase success rates, decreasing the number of needle passes, redirections, and traumatic taps.

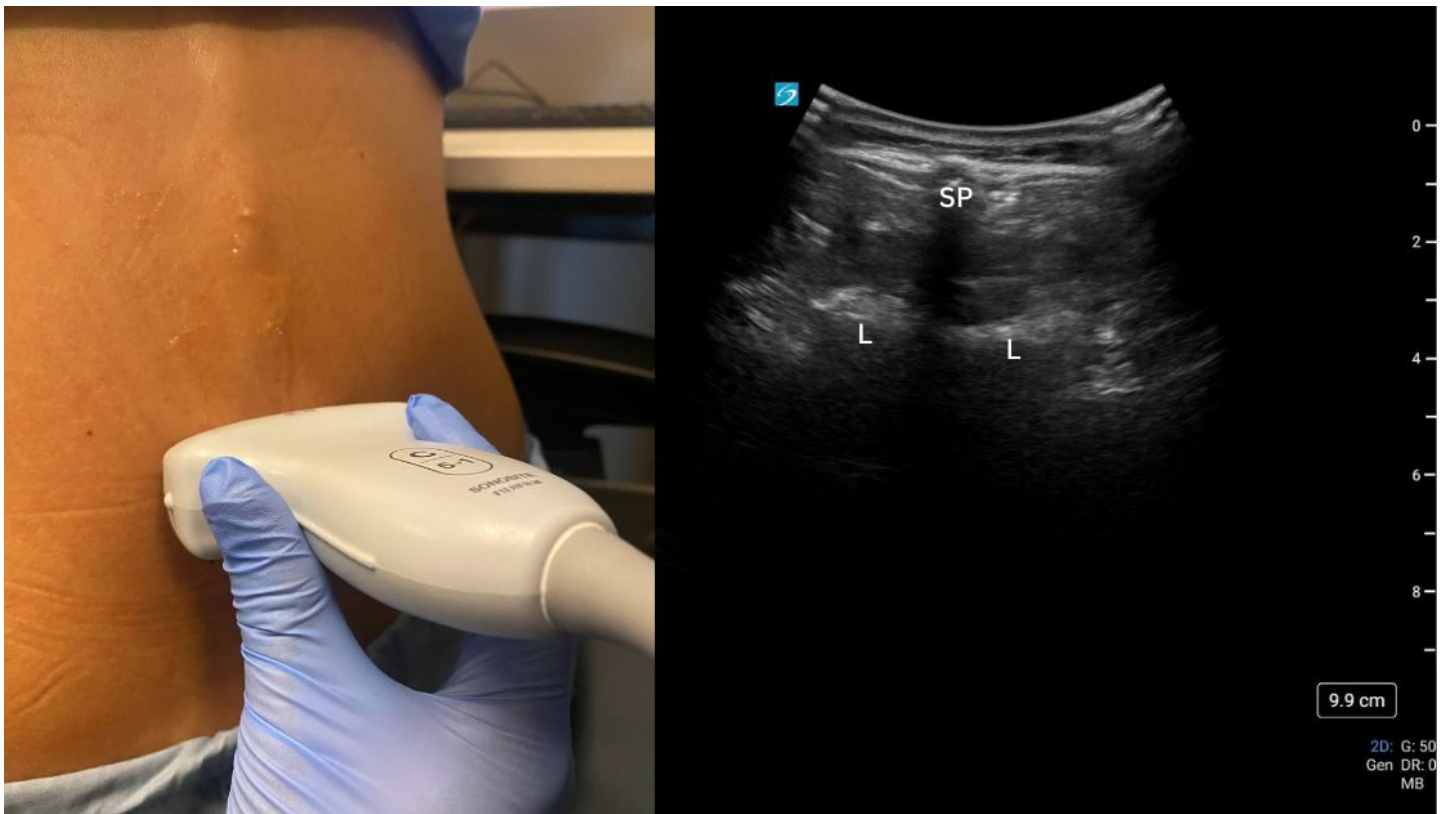


Figure 1. View of the transverse plane. Spinous processes (SP), lamina (L). Figure 1 represents an image similar to our case taken from a healthy patient.

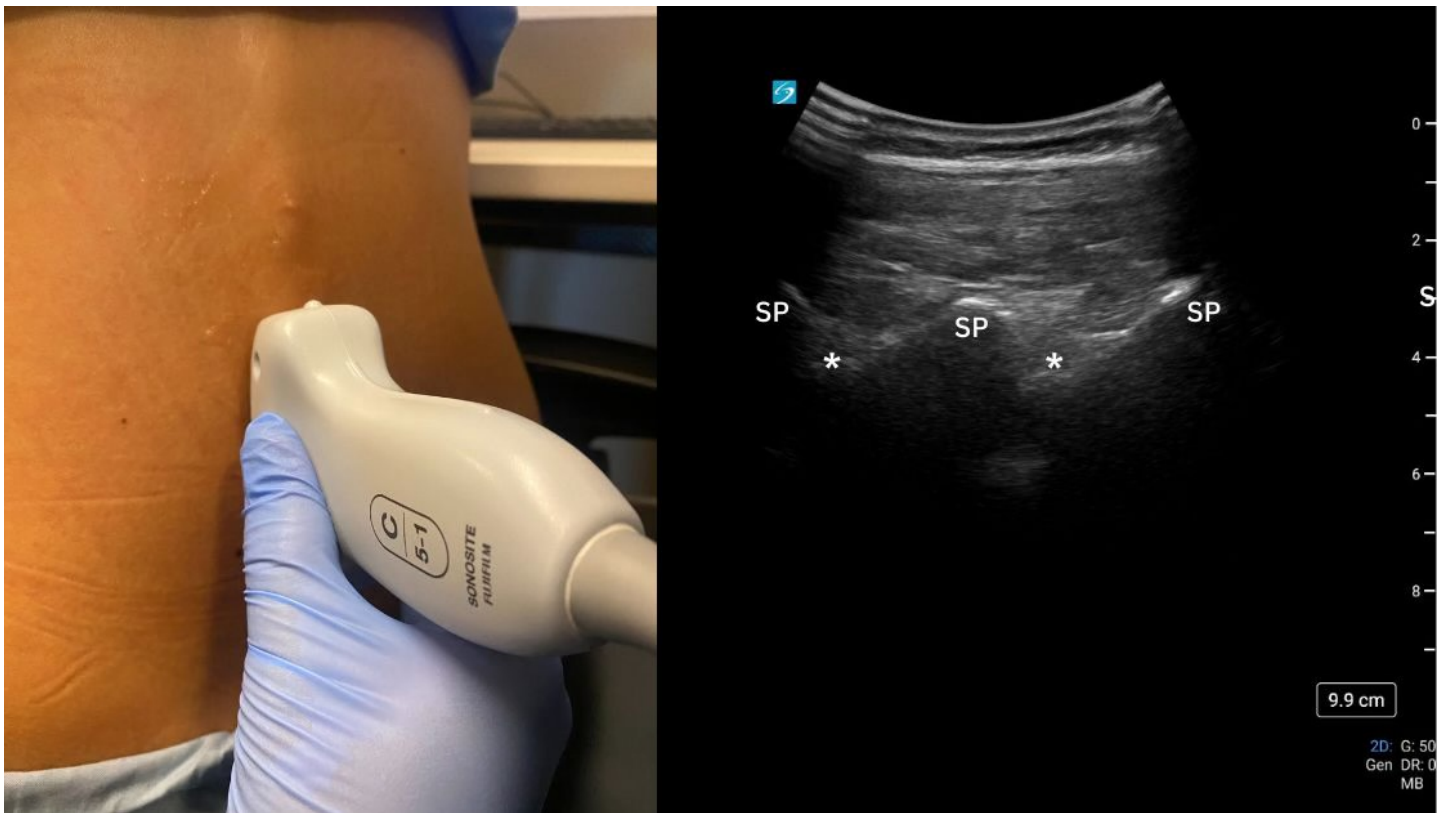


Figure 2. View of the longitudinal plane. Spinous processes (SP), interspinous spaces (*). Figure 2 represents an image similar to our case taken from a healthy patient.

REFERENCES

1. **Doherty CM, Forbes RB.** Diagnostic Lumbar Puncture. *Ulster Med J.* 2014 May;83(2):93-102. PMID: 25075138; PMCID: PMC4113153.
2. **Wright BL, Lai JT, Sinclair AJ.** Cerebrospinal fluid and lumbar puncture: a practical review. *J Neurol.* 2012 Aug;259(8):1530-45. doi: 10.1007/s00415-012-6413-x. Epub 2012 Jan 26. PMID: 22278331.
3. **Young N, Thomas M.** Meningitis in adults: diagnosis and management. *Intern Med J.* 2018 Nov;48(11):1294-1307. doi: 10.1111/imj.14102. PMID: 30387309.
4. **Soni NJ, Franco-Sadud R, Schnobrich D, Dancel R, Tierney DM, Salame G, Restrepo MI, McHardy P.** Ultrasound guidance for lumbar puncture. *Neurol Clin Pract.* 2016 Aug;6(4):358-368. doi: 10.1212/CPJ.000000000000265. PMID: 27574571; PMCID: PMC4987119.
5. **Millington SJ, Silva Restrepo M, Koenig S.** Better With Ultrasound: Lumbar Puncture. *Chest.* 2018 Nov;154(5):1223-1229. doi: 10.1016/j.chest.2018.07.010. Epub 2018 Jul 20. PMID: 30036497.
6. **Pierce DB, Shivaram G, Koo KSH, Shaw DWW, Meyer KF, Monroe EJ.** Ultrasound-guided lumbar puncture in pediatric patients: technical success and safety. *Pediatr Radiol.* 2018 Jun;48(6):875-881. doi: 10.1007/s00247-018-4091-2. Epub 2018 Feb 3. PMID: 29397406.
7. **Shaikh F, Brzezinski J, Alexander S, Arzola C, Carvalho JC, Beyene J, Sung L.** Ultrasound imaging for lumbar punctures and epidural catheterisations: systematic review and meta-analysis. *BMJ.* 2013 Mar 26;346:f1720. doi: 10.1136/bmj.f1720. PMID: 23532866.
8. **Furness G, Reilly MP, Kuchi S.** An evaluation of ultrasound imaging for identification of lumbar intervertebral level. *Anaesthesia.* 2002 Mar;57(3):277-80. doi: 10.1046/j.1365-2044.2002.2403_4.x. PMID: 11892638.