American College of Physicians - Internal Medicine Meeting 2025
New Orleans, LA

Ultrasound-Guided Lumbar Puncture

Faculty Information

Director:

Robert Nathanson, MD, FACP

Amir Begovic, MD, Member

Jacob B. Huston-Cravens, DO, MS, Member

Stephanie Ibrahim, MD

Terry J.S. Lund, MD, Member

Amanda Reeck, MD

Jonathan E. Selzman, DO, Member

Carolina Velez-Mejia, MD

Lara Voigt, MD, Member

Posted Date: February 24, 2025

Disclaimer: Specific product names may be included in this presentation/handout for the purposes of educational clarity and do not constitute an endorsement of those products.

FAQ about Lumbar Puncture

I. What agent should be used to cleanse the skin for lumbar puncture?

Currently chlorhexidine is not FDA approved to cleanse the skin for lumbar puncture or other neuroaxial procedures due to concern about chemical meningitis if chlorhexidine is introduced into the epidural space. However, the American Society for Regional Anaesthesia recommends use of chlorhexidine over povidone iodine for epidural catheters based on its superior antiseptic properties and the lack of clinical evidence of chemical meningitis from chlorhexidine. The New England Journal of Medicine videos state that either betadine or chlorhexidine is acceptable.

References:
Hebl JR. The importance and implications of aseptic techniques during regional anesthesia. Reg Anesth Pain Med. 2006 Jul-Aug;31(4):311-23.

II. Should a mask, hat, and gown be used in addition to sterile gloves?

Full sterile precautions are not required for lumbar puncture as the risk of infection is extremely low. There have been case reports of bacterial meningitis possibly due to mouth flora from the anesthesiologist managing epidural catheters for a prolonged period of time. This has led some experts to recommend use of a face mask during lumbar puncture and during procedures that require injection of substances (such as chemotherapy) into the epidural space. Only sterile gloves and the small sterile drapes provided in the LP kit are required for diagnostic LP; a mask is optional.

III. What type of needle is 'best' to perform an LP?

All lumbar puncture needles are hollow needles with a removable stylet. The needle should always be advanced and withdrawn with the stylet in place. Advancement without the stylet increased the risk of depositing an epidermal plug in the epidural space with eventual development of an epidermoid cyst. Withdrawal of the needle without the stylet increases the risk of post-puncture headache, presumably by causing dural fibers to get 'sucked into' the needle and trapped in the dural puncture site, resulting in a persistent CSF leak.

There are 2 issues in choosing an LP needle:
-The gauge of the needle
-The type of needle: 'Cutting' or traumatic needle (Quincke) vs. 'pencil point' or atraumatic needle (Whitacre or Sprotte).

A. Gauge of the needle:

Most standard LP trays have a 20 or 22 gauge 3.5" spinal needle. There is good evidence that the smaller the gauge, the lower the risk of post LP headache. Smaller gauge needles may reduce the success rate of the LP. Gauges smaller than 22 result in poor flow of spinal fluid.

B. Needle type
Standard LP trays have a 'traumatic' or 'cutting' (Quincke) needle. In contrast, atraumatic needles are blunt with a closed pencil point tip and a side port for injection/collection. In a recent 2018 systematic review and meta-analysis comparing atraumatic and conventional needles for lumbar puncture, atraumatic needles were associated with a decreased incidence of post-LP headache and need for patients to return to the hospital for additional therapy. The meta-analysis also showed similar efficacy between atraumatic and conventional needles. The American Academy of Neurology recommends use of the 'noncutting' needles to reduce post LP headaches.

References:
Nath S, Koziarz A, Badhiwala JH, et al. Atraumatic versus conventional lumbar puncture needles: a systematic review and meta-analysis. Lancet. 2018 Mar 24;391(10126):1197-1204.

Armon C, Evans RW; Therapeutics and Technology Assessment Subcommittee of the American Academy of Neurology. Addendum to assessment: Prevention of post-lumbar puncture headaches: report of the Therapeutics and Technology Assessment Subcommittee of the American Academy of Neurology. Neurology. 2005 Aug 23;65(4):510-2.

IV. What other measures may reduce post LP HA?

Orientating the bevel of the standard LP needle parallel vs. perpendicular to the fibers of the cauda equina has been shown to reduce the risk of post-procedure headache. This basically means orienting the bevel towards one of the patient's hips. The reason is not well understood. Bedrest after an LP does not reduce the incidence of post LP headache.

References:
Straus SE, Thorpe KE, Holroyd-Leduc J. How do I perform a lumbar puncture and analyze the results to diagnose bacterial meningitis? JAMA. 2006 Oct 25;296(16):2012-22.

Thoennissen J, Herkner H, Lang W, Domanovits H, Laggner AN, Müllner M. Does bed rest after cervical or lumbar puncture prevent headache? A systematic review and meta-analysis. CMAJ. 2001 Nov 13;165(10):1311-6.

V. Is there an advantage to a sitting vs. lateral recumbent position in performing LP?

Studies of the intervertebral distance show that the space is increased slightly (by about .2 cm) when the patient is in the sitting position, with the feet supported, compared to the lateral recumbent position. However, a 2017 meta-analysis suggested that lateral recumbent position may be associated with reduced incidence of post-dural puncture headache compared to the sitting position, without any difference in successful placement of the needle at first pass. More studies are needed to compare the success rates and outcomes of lateral recumbent vs sitting position. Opening pressure cannot be accurately measured when the patient is sitting.

References:
Sandoval M, Shestak W, Stürmann K, Hsu C. Optimal patient position for lumbar puncture, measured by ultrasonography. Emerg Radiol. 2004 Feb;10(4):179-81.

Zorrilla-Vaca A, Makkar JK. Effectiveness of Lateral Decubitus Position for Preventing Post-Dural Puncture Headache: A Meta-Analysis. Pain Physician. 2017 May;20(4):E521-E529.

VI. How much fluid should be removed during an LP?

The usual total amount of CSF removed for diagnostic purposes is 10-12 cc. This amount is sufficient for cell counts, cultures, chemistry, and more detailed studies such as those required to evaluate for Guillain Barre or multiple sclerosis. The body can replace this amount of CSF in approximately one hour. Total CSF volume is approximately 150 cc in women and 200 cc in men. Volume of CSF removed does not appear to be a factor in the risk of post procedure headache.

Removal of larger volumes (30-50 cc or 5-10 ml/hr using a temporary catheter) has been used to assess clinical response to CSF drainage in patients suspected of having normal pressure hydrocephalus, a condition of excess CSF due to impaired drainage of CSF. Serial large volume LPs to remove CSF to relieve symptoms associated with pseudotumor cerebri is not appropriate as the CSF will re-accumulate within 6 hours with return of symptoms.

Removal of larger volumes of CSF may be required to lower intracranial pressure in patients with cryptococcal meningitis. Guidelines suggest lowering the intracranial pressure to <20 mmH20, or by 50% if the initial pressure is very high. Daily LPs to drain CSF should be continued until the pressure is consistently < 20 mmH2O.

VII. What factors increase the risk of spinal hematoma after LP?

Bleeding disorders may increase the risk of spinal hematoma related to lumbar puncture. Spinal hematoma may in turn result in spinal cord compression and permanent paralysis. Most of the literature on the risks of spinal hematoma after lumbar puncture come from case reports and case series in patients receiving spinal or epidural anesthesia. Because of the variability in the cases and procedures reported in the literature, many experts refrain

from specific recommendations about levels of platelets or INR that are 'safe' for lumbar puncture.

Additional risk factor for spinal hematoma and neurologic compromise include patient factors (female sex, increased age, ankylosing spondylitis or spinal stenosis, renal insufficiency), factors related to technique (traumatic needle/catheter placement), dosing factors ('high' or 'low' dose LMWH, timing of LMWH, concomitant antiplatelet or anticoagulants). There are some guidelines, described below, for specific situations.

VIII. Can LP be performed safely in patients with thrombocytopenia?

A recent extensive review concluded with the recommendation that LP may be safely performed in patients with a platelet count $\geq$40K, as long as the patient is not receiving antiplatelet agents or anticoagulants, there are no other coagulopathies, the platelets are functioning normally, and the platelet count is stable. This is consistent with the recommendations of the American National Red Cross (http://www.redcross.org/www-files/Documents/WorkingWiththeRedCross/practiceguidelinesforbloodtrans.pdf)

References:

van Veen JJ, Nokes TJ, Makris M. The risk of spinal haematoma following neuraxial anaesthesia or lumbar puncture in thrombocytopenic individuals. Br J Haematol. 2010 Jan;148(1):15-25.

Dodd KC, Emsley HCA, Desborough MJR, Chhetri SK. Periprocedural antithrombotic management for lumbar puncture: Association of British Neurologists clinical guideline. Pract Neurol. 2018 Dec;18(6):436-446.

IX. Can LP be performed safely in patients on antiplatelet agents (aspirin and clopidogrel)?

Traditional guidelines have recommended discontinuing antiplatelet agents before lumbar puncture due to potential risks of hematoma. However, most diagnostic LPs are performed emergently and termination of the antiplatelet agent 7 days prior to the procedure is generally not possible. Traumatic LP is an additional risk factor in these patients. Fluoroscopically guided LP reduces the risk of a traumatic tap and should be considered in this population, particularly when additional risk factors (spinal stenosis, elderly, renal dysfunction) are present. Although more studies are needed, recent retrospective studies suggest that use of aspirin or clopidogrel does not increase hemorrhagic complications in lumbar puncture, regardless of when the drugs were held relative to the time of the procedure.

GP IIb/IIIa receptor antagonists (abciximab, eptifibatide, tirofiban) may be used in combination with aspirin. The risk of spinal hematoma with these agents is unknown, but in combination with aspirin, they appear to have profound effects on platelet aggregation. Lumbar puncture is not recommended until platelet function normalizes. Platelet function

will normalize in 8 hours after discontinuation of tirofiban, and 24-48 hours with the other agents. There is no specific test to verify normalization of function.

NSAIDs do not increase the risk of spinal hematoma.

References:
Layton KF, Kallmes DF, Horlocker TT. Recommendations for anticoagulated patients undergoing image-guided spinal procedures. AJNR Am J Neuroradiol. 2006 Mar;27(3):468-70.

Horlocker TT, Vandermeuelen E, Kopp SL, Gogarten W, Leffert LR, Benzon HT. Regional Anesthesia in the Patient Receiving Antithrombotic or Thrombolytic Therapy: American Society of Regional Anesthesia and Pain Medicine Evidence-Based Guidelines (Fourth Edition). Reg Anesth Pain Med. 2018 Apr;43(3):263-309.

Nash M, Bloch S, Golan D. Safety of lumbar puncture for people who are treated with ADP receptor antagonists. J Neurol. 2023 Jun;270(6):3052-3057.

Lee PW, Levy M. Risk of Hematoma From Aspirin or Clopidogrel Owing to Lumbar Puncture. Mayo Clin Proc. 2019 Aug;94(8):1552-1555.

X. Can LP be performed safely in patients receiving prophylactic heparin or low molecular weight heparin?

Low molecular weight heparin increases the risk of spinal hematoma sufficiently to warrant a ‘black box warning’ about use of neuraxial (spinal or epidural) anesthesia in patients on LMWH. Practitioners are urged to ‘consider risk vs. benefit’ and observe the patient closely for bleeding and signs of neurological impairment if therapy is administered during or immediately following lumbar puncture.

Published guidelines recommend that prophylactic LMWH be held for at least 12 hours prior to LP and resumed 24 hours after the procedure. Therapeutic doses of LMWH should be held for 24 hours and may be resumed after 24 hours. Intravenous infusions of unfractionated heparin should be stopped for 2-4 hours, until aPTT is normalized, and can be restarted 1 hour after the procedure.

There is no contraindication to LP in patients receiving prophylactic unfractionated heparin as long as the total 24-hour dose is $\leq$10,000 units.

References:
Layton KF, Kallmes DF, Horlocker TT. Recommendations for anticoagulated patients undergoing image-guided spinal procedures. AJNR Am J Neuroradiol. 2006 Mar;27(3):468-70.

Blank JA, Peters KK, O'Donnell MA, Mansoor AM. Clinical Progress Note: Consolidated Guidelines on Management of Coagulopathy and Antithrombotic Agents for Common Bedside Procedures. J Hosp Med. 2021 Nov;16(11):675-679.

XI. Can LP be performed safely in patients with elevated INR due to coumadin use? Can LP be performed safely in patients with elevated INR due to their underlying medical condition (eg liver disease)?

The American National Red Cross recommends using fresh frozen plasma to treat multiple coagulation deficiencies (such as liver disease) prior to an invasive procedure, including lumbar puncture. The goal is an INR $\leq$1.5. FFP may also be used to correct INR in patients on coumadin if urgent reversal of anticoagulation is needed. The usual dose to provide 30% of plasma factor concentrate is 10-20 ml/kg. A 'unit' of FFP is approximately 250cc, though the volume may vary. In a 70 kg patient, 3-6 units of FFP is recommended to correct INR sufficiently. Complete normalization of INR is often not possible in patients with liver disease.

Patients with hemophilia or von Willebrand's disease should have factors normalized prior to lumbar puncture.

References:
Armon C, Evans RW; Therapeutics and Technology Assessment Subcommittee of the American Academy of Neurology. Addendum to assessment: Prevention of post-lumbar puncture headaches: report of the Therapeutics and Technology Assessment Subcommittee of the American Academy of Neurology. Neurology. 2005 Aug 23;65(4):510-2

Williams J, Lye DC, Umapathi T. Diagnostic lumbar puncture: minimizing complications. Intern Med J. 2008 Jul;38(7):587-91.

XII. Can LP be performed safely in patients receiving DOACs?

All available DOACs carry a black box warning regarding their use in the setting of neuraxial anesthesia or procedures for concern of potential spinal or epidural hematoma. Guidelines developed by the American Society of Regional Anesthesia and Pain Management recommend discontinuing a DOAC prior to neuraxial procedures (4-5 days for dabigatran and 3-5 days for factor Xa inhibitors), with re-initiation 24 hours post-procedure.

References:
Doherty JU, et al. 2017 ACC Expert Consensus Decision Pathway for Periprocedural Management of Anticoagulation in Patients with Nonvalvular Atrial Fibrillation: A Report on the American College of Cardiology Clinical Expert Consensus Document Task Force. J Am Coll Cardiol. 2017 Feb 21;69(7):871-898

XIII. What is the role of ultrasound in diagnostic lumbar puncture?

A 2013 meta-analysis of articles comparing use of ultrasound vs. landmarks to identify the site for diagnostic lumbar puncture or epidural catheterization concluded that use of ultrasound significantly improves success rates for the procedure. The combined results of fourteen studies were 44 failed procedures out of 610 in the control group, (approximately 7% failure) vs. 6 failed procedures out of 624 in the ultrasound-assisted group (approximately 1% failure rate). Ultrasound imaging reduced the risk of failed procedures (RR= 0.21 (95% CI= 0.10 to 0.43), p=<0.001). Ultrasound imaging also significantly reduced the risk of traumatic procedures (RR=0.27 (0.11 to 0.67), p=0.005), the number of insertion attempts (mean difference -0.44 (95% CI= -0.64 to -0.24), p=<0.001), and the number of needle redirections (mean difference -1.00 (95% CI= -1.24 to -0.75), p=<0.001).

Recently, a 2020 meta-analysis of articles comparing ultrasound-assisted and landmark-based lumbar puncture yielded similar findings. The combined results of 28 studies and 2813 patients showed that ultrasound-guided lumbar punctures were associated with a reduced risk of failed procedures (risk ratio 0.58 (95% CI= 0.39 to 0.85), p=0.005). Ultrasound-assistance was also associated with decreased first attempt to failure (RR=0.43 (95% CI= 0.30 to 0.62), p=<0.00001), mean attempts to success (SMD= -0.61 (95% CI= -0.80 to -0.43), p=0.00001), and incidence of complications of headache and backache (RR= 0.63 (95% CI= 0.46 to 0.85), p=0.003).

The reference by R. Strony below explains the technique for US identification of the landmarks.

References:

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.

Strony R. Ultrasound-assisted lumbar puncture in obese patients. Crit Care Clin. 2010 Oct;26(4):661-4.

Shu L, Huang J, Liu JC. Efficacy of ultrasound guidance for lumbar punctures: a systematic review and meta-analysis of randomised controlled trials. Postgrad Med J. 2021 Jan;97(1143):40-47.

Lumbar Puncture Procedure Checklist

		yes	no	comment
1.	Wash hands x 30 seconds before palpating patient.			
2	'Time Out' to verify: - the patient's identity with name, DOB - the procedure that is being done - whether consent has been obtained - the site			
3	Verify that lumbar puncture tray, nonsterile and sterile gloves (correct size), are present. Consider extra lidocaine and facemask (optional).			
4	Palpate the superior aspects of the iliac crests and identify the intersection at the L4 spinous process. Use ultrasound to identify needle insertion site as described in the "US-Guided Lumbar Puncture Mapping Checklist." Use a skin-marking pen or a pen cap to indicate the proper position at the L3/L4 or L4/L5 interspace.			
5	Clean the overlying skin with BETADINE x 3 in widening concentric circles, or chlorhexidine (30 second scrub). Allow to dry.			
6	Open the LP tray before placing sterile gloves.			
7	Put on FACE MASK (optional).			
8	Put on sterile gloves with proper technique.			
9	Applies sterile drapes.			
10	Arrange tubes in order of proper collection.			
11	Assemble manometer with 3-way stopcock. Do not contaminate tip of manometer.			
12	Verify the contents of the anesthetic before drawing it up. Draw up the provided anesthetic in the 5cc syringe. Warn the patient about the administration of local anesthesia. Using the smallest provided needle, make a wheal of local anesthesia at the previously marked site.			NOTE: may not be able to inject anesthetic into mannequin. Learner should verbally announce task
13	Change from the smaller to the larger needle, then administer anesthesia in the anticipated tract of spinal needle placement 1. superior aspect of the inferior spinous process 2. in the midline			

	3. approximately 15 degrees cephalad, as if aiming at the umbilicus 4. Horizontal plane perpendicular to patient's back			
14	Insert the LP needle with stylet in place at the marked site. The bevel of the needle should be pointed to the patient's hip. Advance in the orientation as described above.			
15	Advance through the anatomic structures until the subarachnoid space is reached. May experience a popping sensation as the ligamentum flavum is crossed.			
16	Advance in 2mm intervals. Withdraw the stylet completely after each incremental advance to check for fluid return and replace the stylet before further advancement.			
17	If attempt is unsuccessful (bone encountered, no CSF flow, etc.), withdraw the needle to the subcutaneous tissue (without exiting the skin) and redirect the needle.			
18	Once CSF is free flowing, measure the opening pressure.			
19	Once the measurement is taken, collect 10-12cc of CSF (note: can collect the fluid from the manometer OR remove manometer to collect fluid directly from needle hub).			
20	Replace the stylet BEFORE removing the needle.			
22	Clean skin and apply a bandage.			
23	Dispose of all sharps and biohazard material appropriately. Remove the draping and observe the patient for any complications (NOTE: AS WE ARE REUSING NEEDLES, disposal will be a designated open tray).			

Ultrasound Mapping for Lumbar Puncture Checklist

		Yes	No	Comments
1.	**Prepare the ultrasound machine**			
	A. Connect appropriate ultrasound transducer to machine ➢ Low, Normal, or Overweight (BMI<30): Use high-frequency (5-10 MHz), wide (3-4cm) linear array transducer. See Table 1. ➢ Obese or Morbidly Obese (BMI>30): Use low-frequency (2-5 MHz) curved or phased array transducer. See Table 1.			
	B. Clean ultrasound machine AND transducers with anti-septic wipes per local protocol			
	C. Power "on" ultrasound machine, enter patient information, and select "Exam" type: ➢ Linear Transducer-select "Small parts" exam ➢ Curved Transducer-select "Abdomen" exam			
	D. Position ultrasound machine to operator's left (for right-handed persons) or right (for left-handed persons) on long side of bed from where LP will be performed.			
2.	**Wash hands** x 30 seconds (or sanitize hands with alcohol-based hand gel) before touching patient.			
3.	Perform procedure **"Time Out"** - Verify patient's identity using 2 identifiers (name, DOB) - Restate procedure to be performed - Confirm consent has been obtained			
4.	**Position the patient**: Opening/closing pressures should only be measured in lateral decubitus position, but operators may prefer sitting position for patient with difficult anatomy, including obese patients. Observational data suggest greater success rate in sitting position. Patient should be comfortable to stay in position for ~20 minutes. See Figure 1. ➢ Lateral decubitus position: Position patient in center of bed in left or right lateral decubitus position with hips and shoulders perpendicular to floor. Tuck head and knees towards chest ("fetal position"). ➢ Sitting position: Have patient sit in center of bed and lean over a table with legs handing from side of bed. Provide leg support with chair/stool on side of bed. ***Note: If the patient is repositioned prior to performing lumbar puncture, then the operator should re-scan and mark the patient just prior to starting the procedure.***			
5.	Palpate the **posterior, superior iliac crests** and using a skin marker, make a small mark on the superior aspect of the iliac crests. The level of the posterior superior iliac crests identifies the L_3-L_4 interspace and serves as a general guide to start ultrasound scanning at the L_3-L_4 level. See Image 1.			

6.	Scan the lumbar spine in transverse and longitudinal planes to **identify the midline and interspaces** of the lumbar spine.			
	A. Transverse Plane: The purpose of scanning in a transverse plane is to identify the midline of the spine. Starting at the level of the posterior superior iliac crests, place the transducer in the midline of the back with the notch on the transducer pointed to the patient's left. Slide the transducer caudally and rostrally in the midline of the back and identify the spinous processes. The spinous processes will appear as pointed, bony structures with hyperechoic rims and distal shadowing (See Image 2). Center the transducer over a spinous process and make a mark perpendicular to the transducer to mark the midline. Consider making a mark lateral to the transducer to mark the level of the spinous process. Slide the transducer over 2-3 spinous processes to mark the midline. Connect the marks to create a line over the true midline of the spine			
	B. Longitudinal Plane: The purpose of scanning in a longitudinal plane is to identify the interspaces of the spine. Place the transducer on the midline of the back with the notch on the transducer pointed to the patient's head. Slide the transducer caudally and rostrally in the midline of the back and identify the spinous interspaces in a longitudinal plane (See Image 3). The spinous processes will appear as oval or rectangular shaped bony structures with hyperechoic rims and distal shadowing. Center the transducer over the spinous interspace and make a mark perpendicular to the transducer to mark the level of the interspace. Identify the ligamentum flavum deep in the interspace and measure the distance from the skin to the ligamentum flavum (Average distance in normal BMI is 44mm and 64mm in obese). The length of the spinal needle should be at least 5mm longer than the distance from the skin to the ligamentum flavum to assure an adequate needle length. Slide the transducer over 2-3 spinous processes and mark the interspaces. Connect the lateral marks identifying the interspaces at each level and the lines will cross the midline of the spine. The intersection of the lines demarcating the midline and interspaces will create an "X" where the spinal needle should be inserted. Prior to sterilizing the skin, use the back end of a capped needle or pen cap to make a circular skin indentation over the "X" where the spinal needle will be inserted.			
7.	The patient should not be repositioned after he/she has been marked. Consider placing a sterile probe cover over the transducer prior to starting the procedure to have the ultrasound available during the procedure to re-evaluate the lumbar spine anatomy.			
8.	Proceed with performance of the lumbar puncture using the "Lumbar Puncture Checklist"			

Table 1: Transducer Types

Linear Array Transducer	Curved Array Transducer	Phased Array Transducer
		

From Point-of-care Ultrasound, 1st ed, 2014

Figure 1: Lateral Decubitus & Sitting Position

(from http://apps.med.buffalo.edu/procedures/lumbarpuncture.asp)

The lateral decubitus position for performing lumbar puncture. **Note** assistant is "curling" the patient to maximally flex the spine open.

The sitting position for lumbar puncture. Note the patient is curled over a bedside table to maximally flex the spine open.

Image 1: Iliac Crest and Lumbar Spine

(from http://www.sci-recovery.org/images)

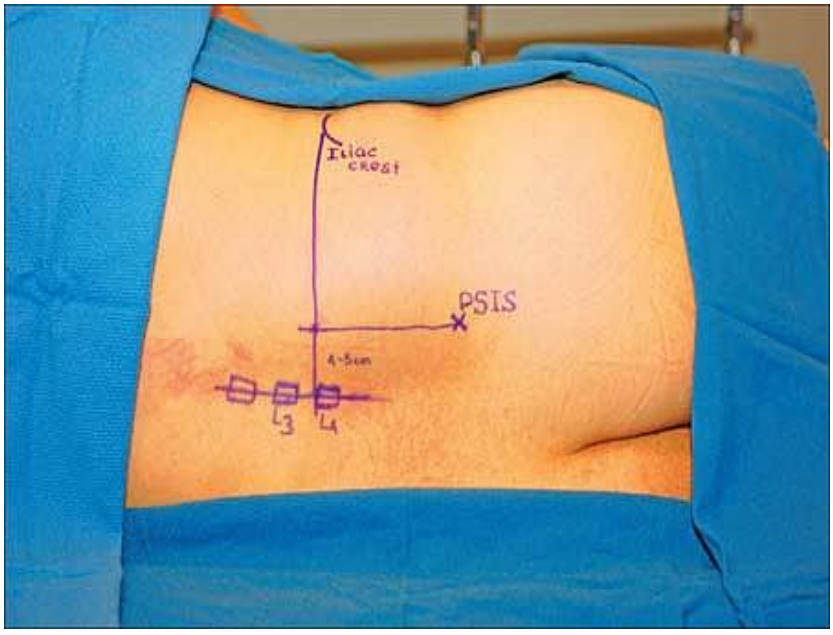

Image 2: Spinous Process in Transverse Plane

(From Point-of-care Ultrasound, 1st ed, 2014)

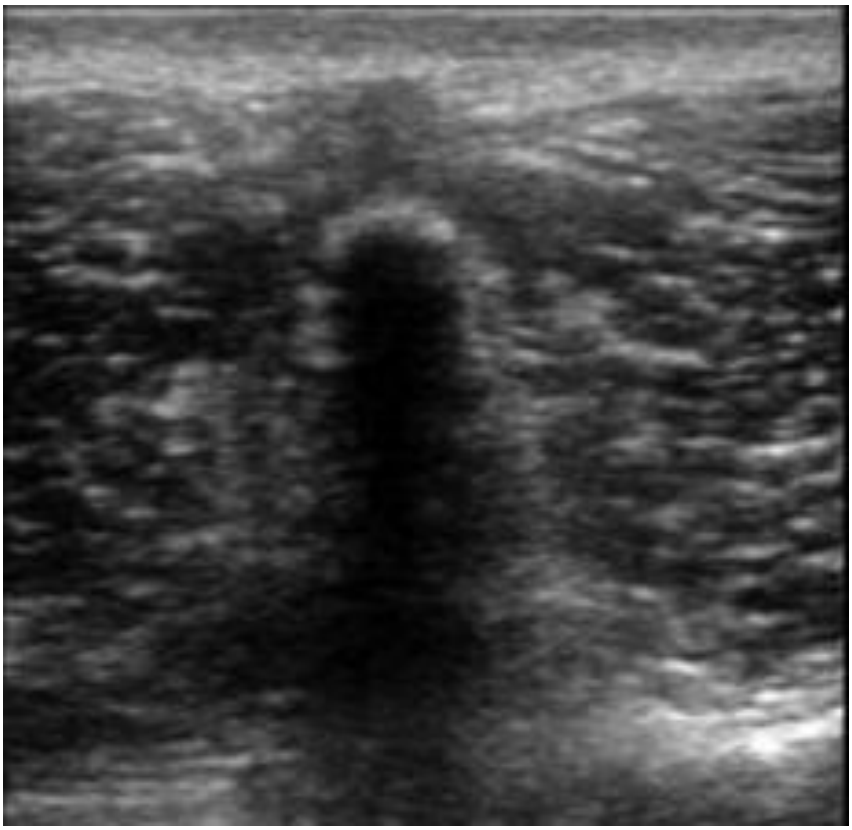

Image 3: Spinous Processes in Longitudinal Plane

(From Point-of-care Ultrasound, 1st ed, 2014)

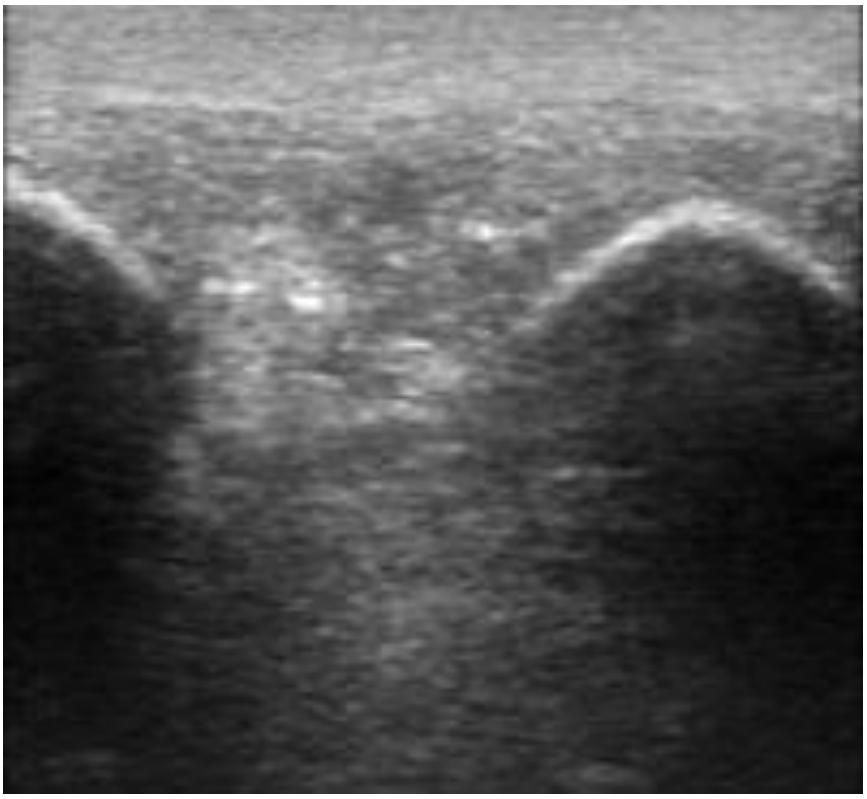

Image 4: Ligamentum Flavum in Longitudinal Plane
(from Tirado A, et al. Emerg Med Clin N Am. 2013)