



University of Calgary and University of Alberta

General Internal Medicine

Procedural Manual

Lumbar Puncture

This script is intended for Personal Study Only.

Please send all feedback to corresponding author: ima@ucalgary.ca

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Useful Online Lumbar Puncture Videos

1) Three useful videos from Harrison's Principles of Internal Medicine, 20e. Clinical Procedure Tutorial, available via Access Medicine®: Go to Multimedia>Procedural Videos > Neurology

For learners at the University of Calgary:

Video CP06-1: **Lumbar Puncture**. ~16 minutes. Authors: Rapaport B, Krieger S, McGraw C.
<https://accessmedicine-mhmedical-com.ezproxy.lib.ucalgary.ca/MultimediaPlayer.aspx?MultimediaID=17670479>

Video 175-3. **Lumbar Puncture Sitting Position**. ~3 minutes. Author: Ladde JG.
<https://accessmedicine-mhmedical-com.ezproxy.lib.ucalgary.ca/MultimediaPlayer.aspx?MultimediaID=17965166>

Video 175-2. **Lumbar Puncture Landmark Identification by Ultrasound**. ~6 minutes. Author: Ladde JG.
<https://accessmedicine-mhmedical-com.ezproxy.lib.ucalgary.ca/MultimediaPlayer.aspx?MultimediaID=17965165>

2) 11-minute video from The New England Journal of Medicine Videos in Clinical Medicine series (available to subscribers):¹
<https://www.nejm.org/doi/full/10.1056/NEJMvcm054952>

3) 9-minute video "Ultrasound-Guided Lumbar Puncture" Ma I:
<https://sites.google.com/site/calgaryimus/home/procedures/lumbar-puncture>
You can also get to it here: www.cimus.ca > Procedures tab on the left

4) 6-minute video, useful for patient consents: "What to Expect for Your Lumbar Puncture Appointment"
Kapadia R:
[What to Expect for Your Lumbar Puncture Appointment - YouTube](#)

Pre-Procedure Checklist

The Canadian Internal Medicine Ultrasound (CIMUS) pre-procedural checklist is: *pending, not currently available*.

Notes below are intended for refresher and Personal Study Only. Not for Distribution.

Patient Preparation

Ensure procedure indicated	<ul style="list-style-type: none"> • Diagnostic:² Cerebrospinal fluid (CSF) analysis for central nervous system (CNS) infections and other pathologies (e.g. CNS malignancies, demyelinating diseases, Guillain-Barré syndrome, suspected subarachnoid hemorrhage but negative computed tomography (CT) scan, autoimmune encephalitis, dementia syndromes, idiopathic intracranial hypertension) • Therapeutic: in certain disease states (e.g. normal pressure hydrocephalus, idiopathic intracranial hypertension, and cryptococcus meningitis if elevated CSF pressures) or intrathecal administration of drugs including chemotherapy, local anesthetics and opioids, although intrathecal drug administration is not commonly performed in internal medicine
Ensure no contraindication	<ul style="list-style-type: none"> • Intracranial space-occupying lesion with mass effect³ • Posterior fossa mass³ • Increased intracranial pressure (ICP) due to increased CSF pressure or Arnold-Chiari malformation³ • Non-communicating hydrocephalus • Brain or spinal cord developmental abnormalities • Overlying infection, suspected epidural abscess at puncture site⁴ • Anticoagulants (see coagulation section below) or bleeding diathesis • Uncooperative patient (depending on degree of uncooperativeness, may be a relative contraindication) • Patient refusal • <i>Note: Hematology and/or neurosurgery consultation may be warranted in select cases of bleeding disorders and anatomical abnormalities, respectively</i>
CT before LP considerations	<ul style="list-style-type: none"> • If focal neurological deficits (<i>cannot follow 2 consecutive commands, cannot answer 2 consecutive questions, abnormal visual fields, arm or leg drift, gaze palsy, facial palsy, abnormal language: aphasia, dysarthria, extinction</i>), immune compromised patient, prior CNS disease (mass, stroke, focal infection), recent seizure(s), impaired consciousness, or papilledema on fundoscopy, consider CNS imaging to rule out findings that would contraindicate a lumbar puncture (LP)^{3,5-7}
Coagulation <i>Note – refer to latest guidelines for recommendations</i>	<ul style="list-style-type: none"> • Recommended Platelet ≥ 50,⁸ INR $\leq 1.4$⁹ • <i>Per guidelines: Routine coagulation testing is not indicated in unselected patients with a negative bleeding history, negative history of renal or liver disease.</i>⁹ However, for the majority of our complex medical patients, based on our expert opinion, it would be prudent to ensure platelet and INR are within the recommended parameters if no recent blood work is available • Low dose aspirin not typically considered a contraindication⁹ • Non-steroidal anti-inflammatory drugs not considered a contraindication¹⁰ • Other antiplatelets should be discontinued prior to LP (e.g. clopidogrel, ticagrelor, prasugrel x 7 days; dipyridamole x 24 hrs; tirofiban, eptifibatide x 4-8 hrs, abciximab x 48 hrs)⁹

	<ul style="list-style-type: none"> • For those on direct oral anticoagulants, consult the latest Thrombosis Canada perioperative management guidelines for management under high-bleed-risk procedure¹¹ • Suggest no LP for 24 hrs from last dose of subcutaneous (SC) therapeutic low molecular weight heparin (LMWH); 12 hrs from last dose of SC prophylactic LMWH;⁹ both can be restarted 4 hours post-procedure • For those on unfractionated intravenous (IV) heparin, suggest hold heparin 4-6 hours; American Society of Regional Anesthesia and Pain Medicine suggests verifying normal PTT prior to LP.¹⁰ Can resume IV heparin 1 hour post-LP^{9,10} • For those on anticoagulants and high risk for thromboembolism (VTE), e.g. VTE within previous 3 months, mechanical heart valves other than bileaflet aortic valve, atrial fibrillation with CHA₂DS₂-VASc score of 3 or higher, consider bridging⁹
Relative contraindications	<ul style="list-style-type: none"> • Cardiopulmonary compromise (may not tolerate positioning)¹ • Consider technical difficulty/feasibility of procedure in patients with prior lumbar spine surgery/instrumentation (note that presence of spinal hardware is NOT a contraindication to LP but note that typical bony and ligamentous landmarks may have been disrupted)
Obtain patient consent	<ul style="list-style-type: none"> • Ensure patient has capacity to consent If not, obtain consent from substitute decision maker (SDM) • Go over indications, complications (common and rare but serious ones), options for the patient if he/she does not wish to undergo procedure • Note: consider inviting patient to watch video (listed on page 2) “What to Expect for Your Lumbar Puncture Appointment” for details on the procedure • Obtain written consent prior to procedure
Common complications	<ul style="list-style-type: none"> • Post-LP headache, within 24-48 hours after the procedure. Incidence up to 36.5%,¹ as high as 60% in some studies.⁴ May last between 3-15 days¹² <ul style="list-style-type: none"> • Highest risk in younger patients, female, low body mass index (BMI), history of headaches¹³ • Risk decreased by use of atraumatic needles¹³ such as “Whitacre” or “Sprotte” needles vs traumatic needles such as “Quincke” (Figure 1) • Smaller gauge needle (25G instead of 22G) may also decrease risk^{3,13} • No evidence that bedrest decreases risks of post-LP headache, and in fact may increase its risk¹⁴ • Epidural blood patch (performed typically by colleagues in anesthesia) should be considered for patients with a clinical diagnosis of post dural puncture headache (e.g. postural headache that improves when supine, occurring within 72 hours after the LP, especially in the setting of a traumatic LP and/or use of a large gauge cutting needle) if the headache is debilitating, prolonged, and/or has failed an initial trial of conservative treatment such as oral analgesics and bedrest • Pain, local or referred

	<ul style="list-style-type: none"> • Backache – from injury to spinal ligaments, periosteum, or annulus fibrosis¹⁵ (35-40%)^{4,16} • Bleeding • Bruising of overlying skin • Dysesthesia during procedure (13%)¹⁵
	 <p>Figure 1. Picture of a conventional traumatic needle tip (Quincke) on left. An example of the recommended atraumatic needle tip on the right (Whitacre). Notice the pencil-point appearance of the atraumatic needle on the right, compared to the sharp cutting needle profile on the left.</p>
Rare	<ul style="list-style-type: none"> • Herniation (rare) • Nosocomial infection (1 in 50, 000)¹⁷ • Iatrogenic CSF Leakage (up to 50% reported, although incidence of clinically relevant CSF leak is lower)¹⁸ • Permanent sensory or motor loss¹⁹ • Epidural hematoma <ul style="list-style-type: none"> • Associated with difficult or traumatic needle insertion,²⁰ coagulopathy,^{20,21} and older age • Spinal cord injury (if performed at an improper level or in the presence of tethered cord/spinal cord abnormality) • Subarachnoid epidermal cyst (if skin plug is introduced into the subarachnoid space)¹ • Unsuccessful procedure – Ensure patient aware there is a risk of being unsuccessful at the bedside, necessitating another attempt or radiologically-guided LP. Common reasons for being unsuccessful including patient discomfort and unexpected anatomical challenges • Rare but has been described: isolated cranial nerve VI (abducens) nerve palsy²² – possibly due to long intracranial course and/or angulation points

Equipment Gathering Note: Items in purple are already in the standardized kit (see Figure 2)

Ultrasound machine (optional) for landmarking or estimating depth ²³	<ul style="list-style-type: none"> • Curvilinear and linear transducer • Ultrasound gel • Towel to wipe gel off • Disinfectant wipes to disinfect the machine
For preparing field	<ul style="list-style-type: none"> • Blue soaker pad • 3 sterile dry swab/sponge sticks (without chlorhexidine) • Chlorhexidine solution • Lumbar puncture tray (Figure 2)

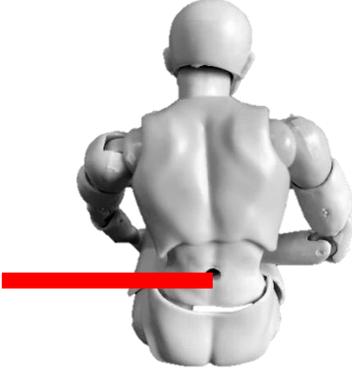
For anesthesia	<ul style="list-style-type: none"> • 1-2% lidocaine, with NO EPINEPHRINE (epinephrine <i>may</i> potentiate anesthetic-induced neuraxial injury; poses theoretical risk of spinal cord ischemia²⁴) • 3 cc syringe* • 25G needle*; 22G* for deeper tissues
For procedure	<ul style="list-style-type: none"> • Sterile gloves, mask, eye protection (sterile gown optional) • Sterile fenestrated paper drape, one non-fenestrated sterile drape • Sterile gauze, (consider obtaining additional sterile gauze) • Spinal needle (a traumatic needle with stylet, Quincke, 22G, is included in the standard LP kit) – consider obtaining an atraumatic needle (see below) • 3.5 inch atraumatic needle (Whitacre, 22G, Figure 1) is recommended to reduce the risk of post LP headaches²⁵ **Note: Smaller gauge such as 25G would be preferred if no opening pressure (OP) measurements are needed as smaller needles that are >25G are not considered suitable for measuring OP,³ and will also take significantly longer to obtain measurements.²⁶ Larger needles (< 22G) are not recommended due to the increased risk of post-LP complications and the risk of contamination with blood³ • Manometer and stopcock
	<p>A comment re: masks being mandatory Due to iatrogenic meningitis commonly being caused by streptococcal species, consistent with oropharyngeal flora, Center for Disease Control and Prevention (CDC) recommends that face masks be worn during LP procedures²⁷</p>
For diagnostic collection	Suggest using the 4 collection tubes that are already included in the tray, labelled from 1-4
For post-procedure	Bandage

Items in purple are already in tray (see Figure 2).*



Figure 2: Lumbar Puncture Tray

Procedure Steps (after consent obtained)

Gather equipment (see above)
Print up lab requisition forms (if performing diagnostic taps) and patient labels, where relevant
Wash hands
Patient positioning (2 options; choose option 1 if accurate OP is needed)
<p>1) Place patient in lateral decubitus position with back arched, with hips, and knees flexed (Figure 3), close to the edge of the bed on the side where the procedure will be performed. A pillow can be placed between the patient’s knees to increase comfort. To minimize lower body rotation or over-rotating hips, ensure that knees/lower legs are symmetrically stacked on top of each other. Ensure also that shoulders are also not over-rotated.</p> <p>The lateral decubitus position is preferred if an accurate OP is needed.¹</p>  <p>Figure 3. Lateral decubitus positioning with back arched, with hips, and knees flexed, with edge of bed outlined by orange line and pillow in blue. Red line indicates intercrystal line.</p>
<p>2) Have patient in a sitting position (Figure 4)</p>  <p>Figure 4. Patient in a sitting position. Red line indicates intercrystal line. Consider placing a stool for the feet so that the patient is better able to round the lower back. Consider having patient ‘hug’ a pillow while seated or place arms on a padded, low table in front of them.</p>
Place blue soaker pad beneath patient
Palpate Landmarks and Mark the Appropriate Site
Identify the intercrystal line: A line connecting the superior aspect of the iliac crests on the posterior aspect of the patient (see red lines in Figures 3 and 4)
This line commonly identifies L4 spinous process or L4-5 intervertebral space at the midline ¹
Significant variability exists in the corresponding level of the intercrystal line ²⁸
28% of the time, this line indicates L3 or higher, which may be too high ²⁹

Acceptable sites: L3-L4, L4-L5, L5-S1
Conus may terminate as low as superior third of L3, ³⁰ thus target below L3
Ultrasound is recommended by the Society of Hospital Medicine ²³ and can be used to identify spinal landmarks, assist in selecting an appropriate needle insertion site, and estimate depth to ligamentum flavum (see Lumbar Puncture Landmark Identification by Ultrasound video listed above)
Mark Target Site for Needle Entry
If ultrasound was used, wipe off nonsterile gel
Mark site with surgical pen or sustained pressure with the end of a needle cap
Wash hands
Open tray with sterile technique
Don Personal Protective Equipment
Wash hands again, put on mask, face shield/eye protection, sterile gown (optional), and sterile gloves
Prepare field
Have assistant pour chlorhexidine into tray well (if no allergy to chlorhexidine); and anesthetic agent into a separate well
Dip swab sticks in kit into chlorhexidine and clean x 3 in concentric circles, allowing it to dry in between, with application and dry time per manufacturer's recommendations. ³¹ For example, 2% chlorhexidine gluconate and 70% isopropyl alcohol solution in a bottle: a minimum 30 sec application time may be required ³²
If using individually packaged chlorhexidine swabs, clean skin first BEFORE putting on sterile gloves/gown as many of these swabs are not supplied with a sterile applicator ³²
If allergy to chlorhexidine, use 70% alcohol, or iodine ³¹
Remove adhesive tape on the fenestrated drape and place this drape over the desired area (be careful not to contaminate your gloves during draping)
Place the non-fenestrated drape beneath (again, be careful not to contaminate your gloves)
Anesthesia
Withdraw anesthetic with syringe
Using 25 G needle, raise lidocaine bleb under skin, aspirate as you go in (to ensure you are not in a blood stream), inject as you come out
Use a 22G for deeper tissues (same technique, aspirate as you go in, inject as you come out)
Note
Maximum recommended dose of lidocaine without epinephrine is 4.5 mg/kg or 300mg ³³
Maximum recommended dose of lidocaine with epinephrine is 7 mg/kg or 500mg ³³
In practical terms, 1% lidocaine contains 10 mg lidocaine per mL; thus 300 mg = 30 mL
Most patients should need MUCH less than the maximum recommended dose of lidocaine for skin anesthesia
Prepare Equipment Tray
While anesthetics are taking effect, prepare equipment tray
Unscrew/loosen the tops of the collection tubes and line them up in order from #1-#4 on the tray (Figure 5)



Figure 5. Prepare collection tubes by loosening the tops and lined up in the tray in order, so that they are readily accessible for CSF collection

Connect the 2 parts of the manometer together (if measuring opening pressure) and connect the stopcock to the manometer

Turn stopcock to the off position (away from the side of needle connection, Figure 6)

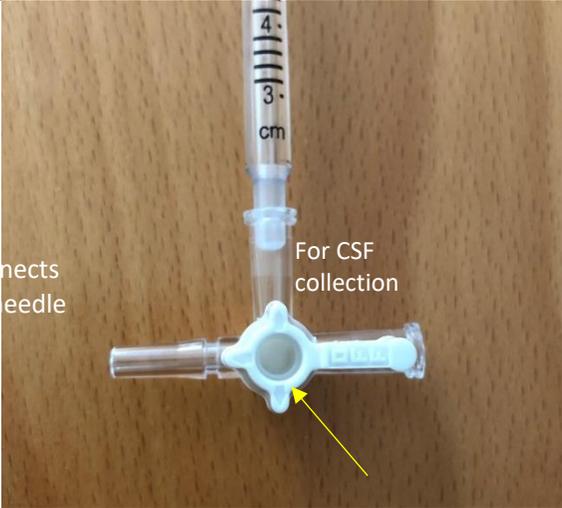


Figure 6. Stopcock should be turned “off” as shown by yellow arrow above for opening pressure measurements

When placing manometer placed back in the tray, ensure it is fully within the sterile field

Needle Insertion

Ensure stylet in place (to avoid introducing a skin plug into the subarachnoid space)

Bevel up if patient in lateral decubitus position, to minimize cutting the dural fibres

If patient in a sitting position, orient the bevel laterally (to the patient’s right or left)

Note: bevel position does not apply to the recommended atraumatic needles. However, for these needles, it may be more difficult to get through the skin. Using an 18G introducer needle superficially (only a few mm) at the insertion site may help facilitate the passage of the LP needle

Re-palpate and confirm landmarks (be careful not to touch any nonsterile areas)

Insert needle, angling 15 degrees cephalad, towards the patient’s umbilicus¹ (Figure 7)



Figure 7. Insert the needle with the stylet in place, aiming cephalad, towards the patient’s umbilicus

Order of structures that the needle will pass through (Figure 8):

Skin, subcutaneous tissue, supraspinous ligament, interspinous ligament (*), ligamentum flavum (arrow head), epidural space (venous plexus, dura and arachnoid), subarachnoid space located between the nerve roots of the cauda equina

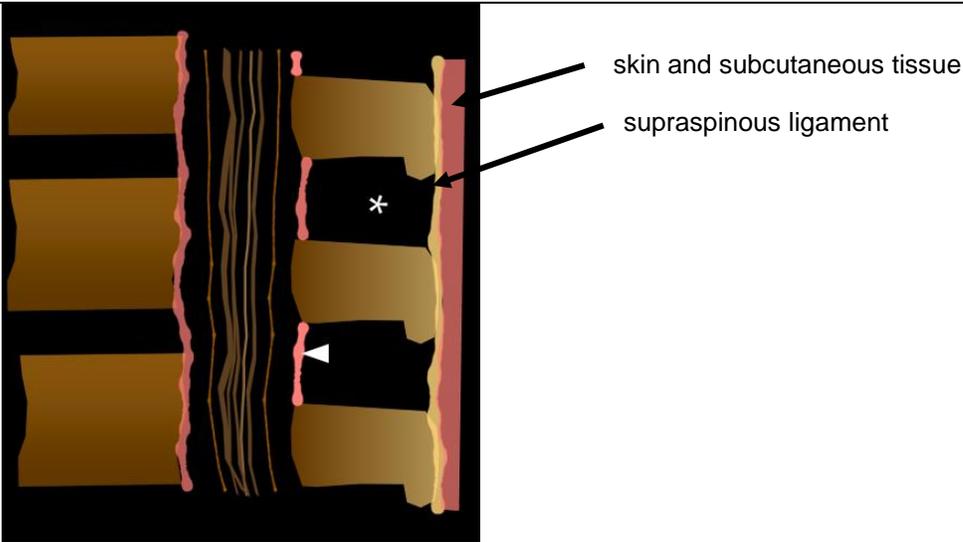


Figure 8. Relevant structures. Asterisk indicates interspinous ligament. White arrowhead indicates ligamentum flavum

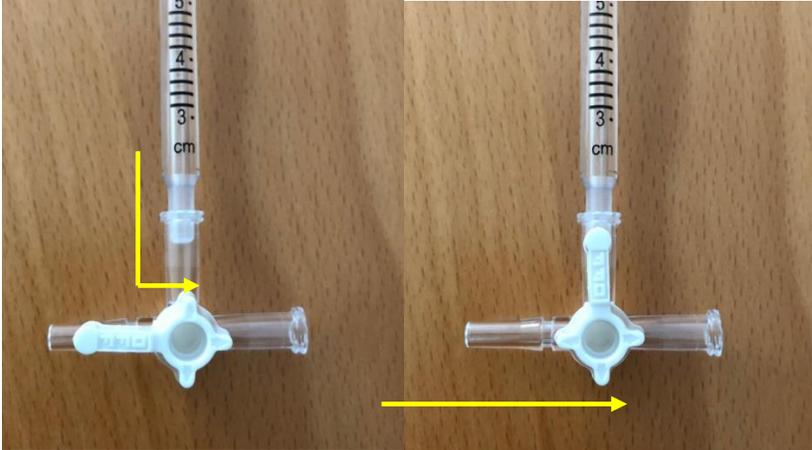
A sensation of sudden yielding (i.e. from higher to lower resistance) is expected to be felt at the level of the ligamentum flavum. A “popping” sensation commonly described but is *not always* present.

When the yielding sensation is felt, remove stylet completely to assess for CSF flow (be patient as flow may be slow, especially if a smaller gauge needle is used)

If no popping sensation is felt after 3-4 cm, remove stylet and start checking for flow as expected depth is commonly ~4-7 cm,³⁴ but significant variability exists

If no flow is observed, replace stylet back in and advance the needle at 2 mm intervals, checking for flow with the stylet removed

- If encounters bone, withdraw the needle to the level of the subcutaneous tissue and redirect
- If bone is encountered within a short distance (~1-2 cm), you are likely midline. Remove the needle and attempt cranially or caudally compared to prior needle entry point
 - If bone is encountered at a deeper distance (~3-5 cm), you are likely not at midline. Patient may be able to describe to you if the pressure sensation was felt to their right or left; this information can assist you in your needle redirection

	NEVER ASPIRATE the syringe. Negative pressure can cause herniation or subdural hemorrhage ³⁴ or result in a nerve root being pulled ³
	A maximum of 4 attempts is considered acceptable. ³ Do NOT attempt more than 4 attempts. Consider asking for assistance if unsuccessful even earlier (after 2-3 attempts)
	Once CSF appears, measure OP if indicated, or if not, proceed to collect specimens. When in doubt, measure OP
Measuring Opening Pressure (OP)	
	Note: OP is not reliable if needle size is smaller than 22G ³ and should be measured in a lateral decubitus position as the sitting position results in a falsely high CSF pressure ³
	Connect manometer to needle – you may need an assistant to stabilize the top of the manometer tube, but ensure your assistant does not contaminate your sterile field
	Many learning resources often indicate that to measure the OP, have the patient relax and extend legs. However, this movement risks dislodging the needle as well as tearing the dura. Only a small resultant increase in measurement is expected in the flexed position, ³⁵ thus, maintaining the patient in the flexed position is acceptable. Patient position during measurement should be clearly noted in the chart to facilitate serial monitoring
	Allow CSF to fill up the manometer and mentally note the OP
	Normal OP: 10-18 cm H₂O ³⁴
Collecting Samples	
	Turn stopcock to collect CSF first from the manometer (if OP measured) then from the needle, Figure 9.
	 <p>Figure 9. Left: Stopcock turned to “off” towards the needle for CSF collection from the manometer. Yellow arrow indicates expected direction of CSF flow. Right: Stopcock turned to “off” towards the manometer, for CSF collection from the patient. Yellow arrow indicates expected direction of CSF flow.</p>
	A minimum of 1 cc per tube (maximum allowed is 30 cc total – do not exceed this total) ³
	The following tests require a higher minimum volume
	Fungal culture, including cryptococcal antigen and calcofluor white stain (3 cc)
	Acanthamoeba culture (10 cc); Acid fast bacilli (AFB, 3 cc); Flow cytometry (2-10 cc)
	Oligoclonal banding (3cc); cytopathology (2 cc)
	Creutzfeld-Jacob disease (14-3-3 Protein) (3 cc) plus transportation of dangerous goods protocol and Biological and Chemical Exposure Response Plan procedure needed
Sending Samples (Alberta Precision Laboratory CSF Collection Guidelines Rev 1.04)	
	Ensure tops of collection tubes securely fastened
	Visually inspect the samples for xanthochromia (yellow or pink tinge) that indicates hemoglobin degradation products (suggesting that blood has been in the CSF for a few hours)
	Apply patient labels and send specimens with requisitions within 15 minutes of collection

	Send tube 1 for: Hematology
	Send tube 2 for: Microbiology (gram stain, aerobic and anaerobic culture); fungal culture
	Send tube 3 for: Miscellaneous tests: AFB, viral cultures, CJD
	Send tube 4 for: Hematology and Chemistry (total protein, glucose) If indicated: flow cytometry, cytopathology, oligoclonal banding, electrophoresis, LDH, lactate, pH
	** Note: if oligoclonal banding is requested, a paired serum protein electrophoresis should also be sent ** Order may depend on test priority and how much fluid was successfully obtained *** Note: red blood cell (RBC) count is commonly sent twice (once in tube 1 and again in tube 4). RBC count can decrease both in subarachnoid hemorrhage (SAH) and traumatic LP. However, if substantial RBC count is present in tube 1 but normal or negative in tube 4, SAH can be excluded. ³⁶
	Post-procedure
	MUST place stylet back in needle before removing needle (to dislodge any potential nerve fibres from being in the needle)
	Remove needle
	Place gauze and pressure over site to ensure no bleeding
	Apply bandage to site
	Dispose of sharps
	Document procedure (including any complications) in the patient chart
	No need to recommend bedrest post-procedure ¹⁴

Troubleshooting Techniques

	Sluggish flow or flow stops during drainage
	Possible obstruction by nerve root - rotate needle 90 degrees ³⁴
	Flow may be sluggish simply because of the size of a small gauge needle – patience may be required
	No fluid obtained
	Incorrect needle position – redirect, or use ultrasound guidance to better define landmarks
	Possible obstruction by nerve root – rotate needle 90 degrees ³⁴
	If procedure was traumatic, needle may be obstructed by blood – obtain new needle, or remove needle from patient and clear obstruction with sterile solution (saline or lidocaine)
	Needle not long enough - often felt to be a factor, although clinically not common: most needle lengths are 3.5 inches and based on MRI studies, 97% of the time, this is sufficient, especially if BMI < 40 kg/m ² . ³⁷ 5 inch needles are available, but this is rarely needed
	If difficulty with procedure is encountered, MUST ask for help. More experienced proceduralists may be able to try alternative approaches (e.g.: paramedian approach) that would not be appropriate for less experienced operators

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