How to perform a lumbar puncture

Lumbar puncture is a practical clinical procedure involving access to (and often collection of) CSF. It may be performed for diagnostic or therapeutic purposes. Indications and contraindications to lumbar puncture are listed in *Table 1*.

Anatomy

At birth the spinal cord ends at around the L3 vertebral level. During childhood and adolescence the vertebrae grow more quickly than the spinal cord and so in adults the spinal cord is approximately 45 cm long and ends at around the level of the L1/L2 intervertebral disc. There is, however, considerable variation and in some patients it may be as low as L3. For these reasons it is imperative to perform a lumbar puncture below the L3 vertebral level. Most clinicians would advocate lumbar puncture in at the L4/L5 or L5/S1 interspace.

Successful lumbar puncture can be performed in either the sitting or flexed lateral (traditionally the left) position. In both positions it is important for the spine to be as flexed as possible to widen the spaces between the lumbar vertebrae.

Equipment

The following equipment is needed (*Figure 1*):

- A trained assistant to help (ideally)
- Sterile gloves
- Surgical drape
- Cleaning solution (preferably chlorhexidine 2% in alcohol)
- 1% or 2% lidocaine 5–10 ml
- Green needle
- Blue needle
- Filter needle (if available)
- Sterile syringes (2 ml, 5 ml and 10 ml)
- Sterile specimen bottles
- Spinal needle (25G (orange) or 22G (black)).

Smaller needles and pencil point (e.g. Whitacre) needles have been shown to reduce the incidence of post-dural puncture headache in adults.

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Table 1. Indications and contraindications to lumbar puncture

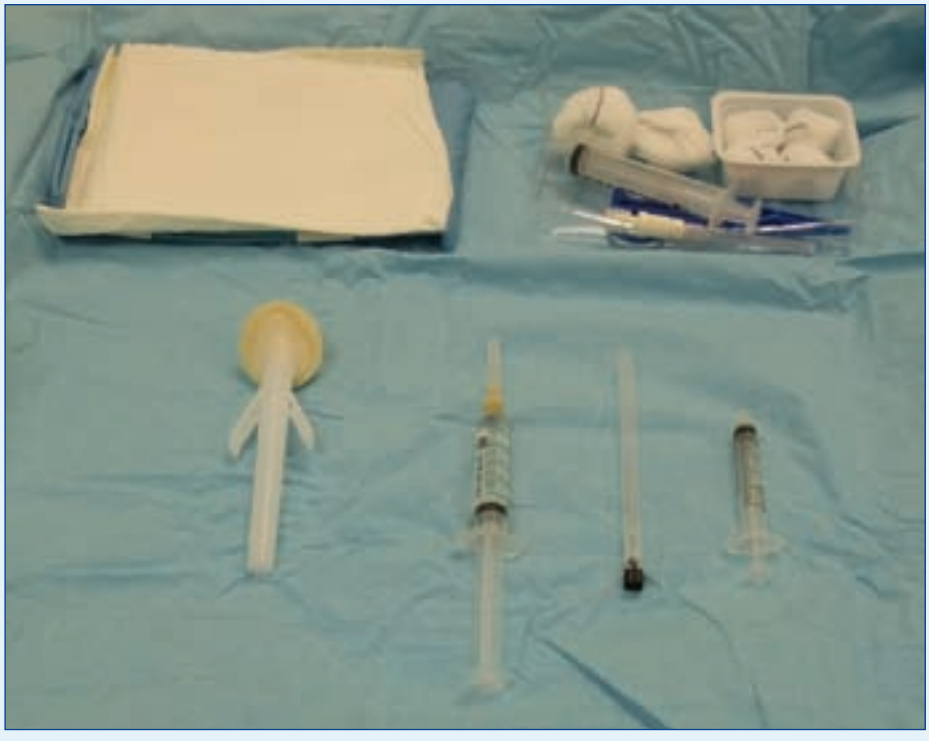
Indications	Diagnostic	Meningitis
		Encephalitis
		Subarachnoid haemorrhage
	Therapeutic	Spinal anaesthesia
		Chemotherapy
		Intrathecal antibiotics
Contraindications	Absolute	Raised intracranial pressure
		Localized soft tissue infection
		Patient refusal
		Platelet count $<50x10^9$/litre
	Relative	Severe sepsis
		Cardiovascular instability
		Coagulopathy

Preparation of the patient

Informed verbal consent should be obtained either from the patient or the parents of a child if he/she is either too young or not deemed competent to give consent. This consent should include a discussion of the benefits and complications of the procedure. Complications of lumbar puncture are shown in *Table 2*.

Some clinicians advocate sedation with opioids or benzodiazepines for lumbar puncture. However, in most adults adequate explanation and reassurance with enough local anaesthesia should be sufficient for the procedure. This has the advantage that if a nerve root is hit, the patient will be able to immediately communicate this to the operator. In children,

Figure 1. Equipment required for lumbar puncture.



distraction techniques and presence of a parent for reassurance may help. In addition topical local anaesthetic cream (e.g. Ametop or Emla) may be applied to the lumbar area before starting the procedure. Explain to the patient that the local anaesthetic injection may sting but then afterwards he/she should feel pressure only but no pain in the back. Ask the patient to tell you immediately if he/she feels any pain or abnormal sensations after the local anaesthetic has been infiltrated.

Patient positioning

This is the most important part of the procedure and can often make the difference between a successful and unsuccessful lumbar puncture so it is worth spending a few minutes getting it right. After positioning the patient make sure you can palpate the intervertebral spaces before sterilizing and draping the area. Ideally place the patient in a hospital gown to reduce infection risk and so that clothing cannot be contaminated by disinfectant.

In the sitting position this is easiest with the patient sitting on the side of a bed with his/her feet raised up on a chair, flexing his/her hips. The patient may be then asked to cuddle a pillow while placing the chin to the chest and relaxing his/her shoulders (*Figures 2* and *3*). Sometimes it helps to ask the patient to imagine he/she is an 'angry cat' to widen the intervertebral spaces correctly.

In the lateral position the patient is asked to curl up bringing his/her knees and chin towards the chest, keeping the back as relaxed as possible (*Figures 4* and *5*).

In order to locate the correct intervertebral space the iliac crests should be palpated. An imaginary line drawn horizontally between the two iliac crests (Tuffier's line) usually bisects the body of the L4 vertebrae. Palpating the spine below this level should reveal the L4/5 interspace (*Figure 3*), however, studies have shown this to not always be accurate. You should always choose an interspace below this level to be safe. In both positions make sure the shoulders are dropped and level and that you are palpating the spinous processes in the midline. Increasing age, obesity, osteoarthritis, previous spinal surgery, kyphoscoliosis and ankylosing spondylitis may make identification of landmarks and subsequent lumbar puncture difficult.

Table 2. Complications of lumbar puncture

Incidence	Complication
Common	Failed tap or repeated tap required
	Post-dural puncture headache (5–15%)
Rare	Transient paraesthesia
Very rare	Permanent neurological damage
	Spinal haematoma
	Spinal abscess
	Cerebral herniation

Figure 2. Sitting position (lateral view) – note neck flexion and 'angry cat' posture.

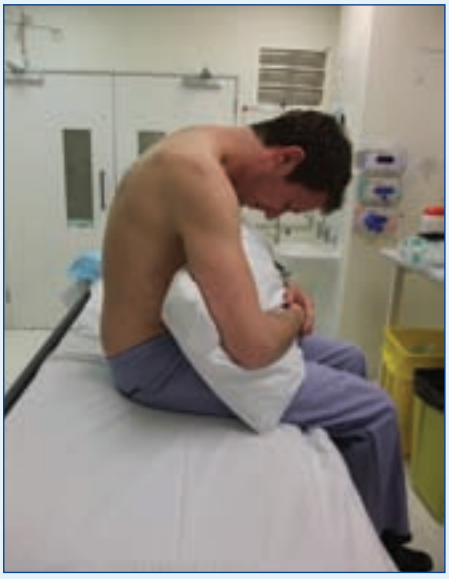
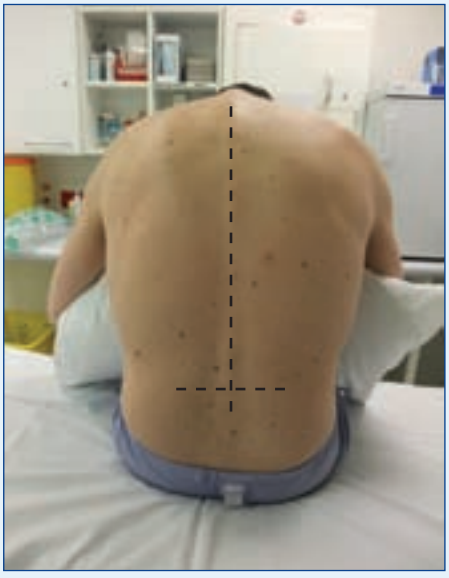


Figure 3. Sitting position (posterior view) showing the approximate location of the L4/5 interspace using Tuffier's line – note relaxed shoulders.



Procedure

Prepare your trolley with sterile equipment. Ideally you should wear a gown, mask and sterile gloves. If no assistant is available snap the top off the lidocaine vial and place it somewhere where you can draw it up when you are wearing gloves without desterilizing yourself.

Expose the patient and disinfect the area. Ensure that your drape covers the iliac crests on at least one side so that you can palpate the level again if necessary while remaining sterile. Draw up to 10 ml of lidocaine using the green or drawing-up needle: 2% lidocaine contains 20 mg/ml of lidocaine so there is 200 mg in 10 ml. The toxic dose of lidocaine is 3 mg/kg without adrenaline or 7 mg/kg with adrenaline and you should bear this in mind when performing this procedure in children or small adults.

Replace the green needle with the orange needle and infiltrate a wheal around 1–2 cm^2 just under the skin. Warn the patient that this will sting. Massage the area gently with your finger and leave for up to a minute. Replace the orange needle with the green needle and infiltrate more deeply in the midline – you will feel resistance to injection when you hit the ligamentum flavum which usually extends deeper than the green needle

Figure 4. Lateral position (posterior view) – note relaxed shoulders.

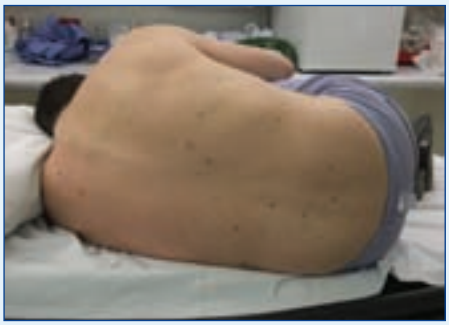
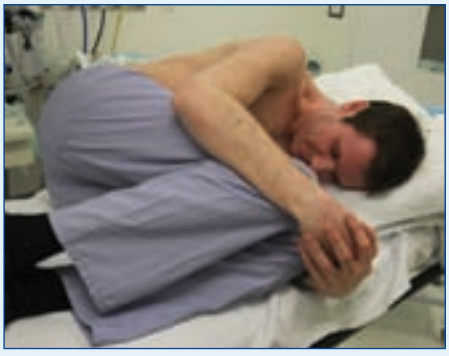


Figure 5. Lateral position (anterior view) – note knees and chin to chest.



up to the hilt but beware in the elderly, very thin or children where it is possible to perform a dural tap at this point. Leave for a further minute.

Take the spinal needle and remove the sheath. With one hand place a finger either side of the spinal column to tense the skin. With the other hand insert the introducer needle below the spinous process at L4, aiming towards the umbilicus (*Figures 6* and *7*). If you hit bone, withdraw and redirect the needle in the sagittal plane. Pass the spinal needle with stylet slowly through the introducer needle, also aiming toward the umbilicus. You will feel resistance as the needle passes through the ligamentum flavum followed by a sudden 'give' as the needle passes through the dura. The patient may feel an 'electric shock' at this point so he/she should be warned not to jump if possible. Resting your upper hand (holding the spinal needle) on your lower hand (holding the skin) will prevent uncontrolled 'plunging' through the dura.

Withdraw the stylet – clear fluid in the hub confirms correct placement. If there has been a give but no fluid, you can try rotating the needle by 90° in case the opening is obstructed by a nerve root. Other common problems encountered during lumbar puncture and suggested solutions are shown in *Table 3*.

Maintain the position of the needle and collect CSF – either by letting the CSF slowly drip from the needle into the specimen bottles or by very gently aspirating with your sterile 2 ml syringe.

Figure 6. Insertion of the spinal needle.

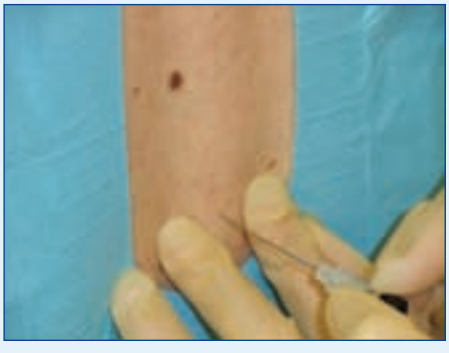
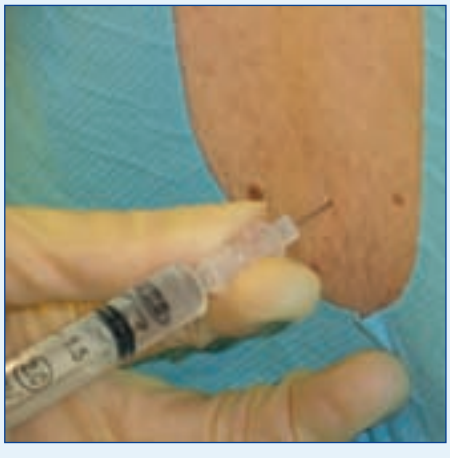


Figure 7. Withdrawal of cerebrospinal fluid.



Post-procedure care

Remove the needle, apply firm pressure with sterile gauze for at least 30 seconds and then apply a small sterile dressing to the site. For an uncomplicated lumbar puncture there is no need to lie the patient supine as studies have shown no benefit in preventing headache.

Three samples should be taken – bottles 1 and 3 for cell count to distinguish between a bloody tap and CSF blood and bottle 2 for biochemistry and xanthochromia. Viral cultures and polymerase chain reaction (PCR) or antigen testing may also be performed from untreated samples. To avoid delay in processing ring the lab before you collect the samples and ask them:

1. To confirm which bottles to place the specimens in depending on what you are trying to find
2. How much fluid is required in each
3. To bleep you with the results. BJHM

Conflict of interest: none.

Table 3. Commonly encountered problems during lumbar puncture

Problem	Solution
Patient complains of discomfort on spinal needle insertion	Infiltrate more local anaesthetic
	Ensure you are in the midline – reposition the patient and check your landmarks
You hit bone	Withdraw the needle
	Reposition the patient and check the landmarks
	Ensure the needle is in the midline and that you are at 90° to the skin in all planes
	If still hitting bone consider using a different interspace (L5/S1 or L3/L4)
Frank blood in the needle hub	You have hit the posterior venous plexus. Withdraw the needle, flush it with saline and repeat in a slightly different plane or another interspace
Bloody tap (streaky blood-stained fluid becoming clear)	Discard initial CSF and collect fresh sample when CSF runs clear
'Dry tap'	Usually a result of malposition and incorrect needle alignment. Reposition and repeat
Shooting pain referred to lower limbs	Usually caused by a nerve root being hit. Withdraw the needle completely and begin again. The patient should be followed up for any longer term nerve damage

KEY POINTS

- Explain and consent the patient for the procedure.
- Position is everything and may make the difference between a successful lumbar puncture or not: the puncture should take place at L4/5 or L5/S1 ideally.
- Prepare your equipment beforehand.
- Give adequate local anaesthetic.
- Aim towards the umbilicus in the midline at 90° to the skin in all planes.
- Once a 'give' is felt, withdraw the stylet and collect CSF.
- Remove the needle and apply pressure followed by a sterile dressing.