

How to perform a lumbar puncture

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Background

The first reports of a lumbar puncture (LP) being undertaken are from the late 19th century [1]. Heinrich Irenaeus Quince (with whom the Lumbar Puncture is commonly associated with) reported to the tenth congress of Internal Medicine in April 1891 that he had performed in one case 3 lumbar punctures in a patient with suspected tuberculous meningitis who was comatose [1,2]. The procedures were done at 3 day intervals and the patient recovered. The other case was in a patient that had chronic hydrocephalus and suffered headaches. Lumbar puncture in this patient relieved the symptoms. One month after Quincke's report to the congress, Walter Essex Wynter, a Registrar at the time, published in the Lancet 4 cases of cerebrospinal fluid (CSF) aspiration in patients with meningitis suspected [3]. The Lumbar Puncture was a procedure dedicated to the relief of symptoms (at that time mainly meningitis or raised intracranial pressure) [4]. It has subsequently become a procedure that can be diagnostic or therapeutic, and the technique has become more refined with improved instruments, awareness of aseptic techniques and the increased availability and knowledge of anaesthesia.

Indications

- In cases of suspected subarachnoid haemorrhage (SAH)
- Diagnosis of meningitis (bacterial, viral, fungal, malignant, atypical)
- Treat raised intracranial pressure (idiopathic intracranial hypertension or other causes such as meningitis)
- Aid diagnosis of normal pressure hydrocephalus
- Exclusion of neurological, vasculitic, autoimmune or paraneoplastic disorders and syndromes
- Administration of therapeutic agents (for chemotherapy, analgesia/anaesthesia, antimicrobial therapy)

It important to note that in suspected SAH, a lumbar puncture 12 hours after onset of symptoms is ideal, but can be diagnostic after 2 weeks of onset [8]. This is not the case after 4 weeks.

Contraindications

- Suspected intracranial mass lesion or space occupying lesion
- Disorders of coagulation or blood diathesis
- Underlying spinal abscess
- Imaging evidence of midline shift
- Posterior fossa tumour or other suspected 4th ventricular lesion

Consent

It is good practice that consent is obtained before undertaking any invasive intervention or procedure, and this is the case for performing a lumbar puncture.

Equipment and Tools

- Up to 6 sample bottles (usually white top) depending on the tests required from the sample. These should normally be pre-labelled with a number (1-6). Some centres use up to three, others four, but this will depend on the number of tests needed.
- A serum glucose bottle is part of the equipment (a paired serum with CSF glucose is usually sent particularly in infective diagnosis).
- A serum bottle for electrophoresis paired with CSF when checking for oligoclonal bands (when diagnosing multiple sclerosis for instance).
- Drawing up needles for local anaesthetic, with 10-20ml syringe for the administration of the local anaesthetic including a needle for subcutaneous injection and deep tissue injection.
- Spinal needle (we advise 22G Whitcare or 'pencil tip' needle which is atraumatic and is the preferred choice over the cutting or Quincke needles)
- Manometer with 3 way tap
- Dressings pack with appropriate disinfectant, gauze and sterile drapes
- For cytology in suspected cancer 10cc is best, otherwise 1-2 cc per bottle. All these quantities are safe if LP is safe in the first place!
- If pressure is > 25cm I take 30 cc and don't do closing pressure (not reliable).

Positioning

There are two positions that a patient can be in for a lumbar puncture – see Figure 1. The preferred position is lying on their side (left lateral) with the patients legs flexed at the knee and pulled in towards their chest, and upper thorax curved forward in an almost foetal position.

It is important to note that the point at which the needle enters the spine needs to be at the same level as the midline of the spine, which ideally should be at the same level as the patients head to give the most accurate reading^{5, 6}. At times for comfort a pillow may be placed under the patient’s head and / or between their legs. The patient’s back should be perpendicular to the table.

The second position is the upright or sitting position. This is used when the lateral position has failed. Sit the patient on the edge of bed, with their legs resting on a stool or chair, ask them to roll their shoulders and upper back forwards and the chair is positioned to bring the thighs up towards the abdomen. The opening pressure where indicated is measured in the lateral position.

If the sitting position is adopted for whatever reason and an opening pressure is sought, the patient should be moved carefully into the lateral position once the needle is in the correct space. Once the patient is in this position, the stylet may be withdrawn. It is important not to remove the stylet before the patient is safely positioned onto the lateral side.

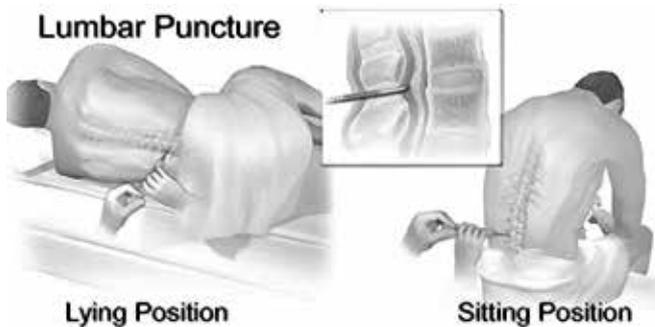


Figure 1. Positioning the patient for Lumbar Puncture – illustration by Chirwa CA &Chirwa M reproduced with permission.

Anatomy

Locating the correct entry point is performed by identifying the surface anatomy of the L3/L4 interspinal space (which is a few mm above the spinous process of L4). This is done generally by palpating the iliac crests.

An imaginary line between the highest points of the iliac crests usually bisects the L3/L4 space. However this will vary according to a number of variables, such as obesity.

As such is can be used as a guide in conjunction with palpating for the spinous process of the lumbar vertebrae and their interspaces.

The interspace of L3/L4 or L4/L5 are used as entry points – see Figure 2.

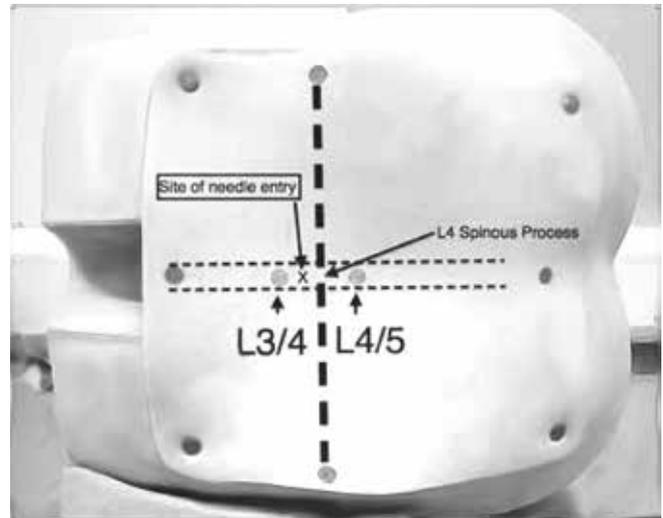


Figure 2. Surface anatomy with markings on a training mannequin for lumbar puncture -Doherty CM. & Forbes RB. Diagnostic Lumbar Puncture. Ulster Medical Journal 2014; 83(2): 93-102 – reproduced with permission.

Technique

Once the correct entry point is identified, clean the skin with antiseptic and proceed with local anaesthetic initially subcutaneously, and then deeper into the layers ensuring a wider distribution of anaesthetic.

After giving the anaesthetic enough time to work, the spinal needle (see Figure 3) may be introduced into the space. Advance the needle slowly towards the umbilicus.

When using a cutting needle it is important to ensure that the bevel of the needle faces parallel to the direction of the cord and spinal fibres. Therefore if in the sitting position, the bevel faces to the side, in the lying position it shall face upwards [6].

This reduces the likelihood of post procedure complications such as headache. The atraumatic needle (‘pencil tip’) reduces the likelihood of this problem.

The dural space is approximately 4-5cm (see Figure 4) from the surface if the skin [5,6]. When the needle is advanced some practitioners will feel a give or a ‘pop’ sensation when the needle enters into the space although this is not always the case.

At times with the needle passing through the different layers, there may be similar sensations felt but the needle

is not yet in the correct space. As such, some practitioners advance the needle and withdraw the stylet at intervals until the space is entered and CSF is drawn.

If no fluid is obtained, replace the stylet replacing and advance the needle again by a few more centimetres or adjust the angle of the needle. Some patients may require longer needles which are available.



Figure 3. Examples of Spinal needles (Quincke's) demonstrating the needle with stylet in situ before being withdrawn. Black is 22G and Yellow is 20G.



Figure 4. Depicting the distance to the Ligamentum Flavum through which the needle enters and passes through, at which point CSF will be aspirated- Doherty CM. & Forbes RB. Diagnostic Lumbar Puncture. Ulster Medical Journal 2014; 83(2): 93-102 – reproduced with permission.



Figure 5. Manometer with three way tap (stopcock) used for the measurement of opening and closing pressures

The manometer (see Figure 5) is attached to measure the opening pressure (if indicated) one CSF is drawn. This must be measured in the lying position. A pressure of 10-20cm H₂O is normal.

If measuring opening pressures for diagnostic purposes or for therapeutic purposes, a closing pressure is useful, but if the opening pressure greater the 25cm H₂O, the closing pressure may not reliable.

Normally 1-5mls of CSF is generally enough per bottle. In general terms up to 20mls in total of CSF can be drawn safely. With idiopathic intracranial hypertension for instance, greater volumes of up to 30-40mls may be needed to aid symptomatic relief.

This may also be needed if the opening pressures are very high (>25cmH₂O). However, large volume LP's can lead to complications. It is therefore advisable to discuss this with a neurologist and seek advice on other therapeutic options for patients with high opening pressures.

On the whole fluid is sent in the appropriate sample bottles for:

- Cell Count and differential
- Biochemistry which includes protein and glucose (for which a paired serum glucose is also sent)
- Microscopy, Culture and Gram Stain (MC+S)

Samples may also be sent for xanthochromia (for SAH), viral PCR, oligoclonal bands, fungal, vasculitic and autoimmune screen, malignancy and prion disease to name but a few. When testing for malignancy, up to 3 LP's may be required. Refer to local lab guidelines for results interpretation.

After obtaining CSF, always replace the stylet before withdrawing the needle.

Things to watch for post procedure [6,9]

- Headache (Post Lumbar Puncture Headache). This is the most common complication, especially in young adults. Can be managed with simple analgesics or non-steroidal anti-inflammatories. Patients are advised to lay flat for 30-60mins post procedure. They may require an additional 2 weeks depending on symptoms after this of strict bed rest. At times anaesthetic management using an epidural blood patch may be required for severe intractable cases.
- Infection can occur as cellulitis, abscesses or discitis, vertebral osteomyelitis, bacterial meningitis.
- Back Pain may occur at the entry site or elsewhere in the back as a consequence of the trauma of the procedure though mild.
- Bleeding may occur at all levels of the dura. This will be significantly worse in those with coagulopathies or anticoagulated (SAH, subdural or epidural haematoma).
- Nerve irritation or damage might occur if the spinal needle impinges on a nerve or nerve root. Also as the needle is withdrawn, it is important that the stylet is replaced before had to prevent the likelihood of a nerve being withdrawn. This also reduces the likelihood of post LP headache as mentioned before.
- Blood in the CSF can occur with initial aspiration of CSF and usually gives falsely raised red cell counts in the first bottle sent to the lab. Subsequent bottles show a reduction in the red cell count.
- Cerebral herniation is rare but a serious complication and vigilance for any symptoms or signs is advised. It is imperative that a pre LP CT scan of the brain is undertaken in patients with reduced consciousness, papilloedema or other neurological features of raised intracranial pressure. In bacterial meningitis, cerebral herniation may occur post LP. Other intracerebral infections such as TB or malaria may also. As such CT is useful in a diagnostic capacity for the cause of altered neurology as well as helping determine the risk of raised intracranial pressure and cerebral herniation in LP. It must be noted that a normal CT will not completely eliminate the risk of herniation and neurological features mentioned must be monitored nevertheless. Treatment of cerebral herniation or raised intracranial pressure is generally

to infuse mannitol. Local guidelines for this should be sought.

- Epidermoid tumour this is rare and may occur after a few years, caused by epidermoid tissue being transplanted into the spinal canal during procedure.

References

1. Quincke HI. Ueber hydrocephalus. Verhandlung des Congress Innere Medizin (X) 1891; 321-39
2. Quincke HI. Die lumbalpunktion des Hydrocephalus. Berlin Klin Wochenschr 1891; 28: 929-33
3. Pearce JM. Walter Essex, Quincke, and lumbar puncture. *Journal of Neurology Neurosurgery Psychiatry* 1994 February; 57(2): 179
4. Frederiks JAM. & Koehler PJ. The First Lumbar Puncture. *Journal of the History of the Neurosciences: Basic and Clinical Perspectives* 1997; Volume 6 Issue 2: 147-53
5. Doherty CM. & Forbes RB. Diagnostic Lumbar Puncture. *Ulster Medical Journal* 2014; 83(2): 93-102
6. Johnson KS. & Sexton DJ. Lumbar Puncture: Technique, indications, contraindications, complications in adults. http://www.uptodate.com/contents/lumbar-puncture-technique-indications-contraindications-and-complications-in-adults?source=search_result&search=lumbar+puncture+technique&selectedTitle=1-150
7. Fiorito-Torres F. Rayhill M. & Perloff M. Idiopathic Intracerebral Hypertension (IIH)/Pseudotumor: Removing Less CSF Is Best. *Neurology* April 8 2014; 82 (10): Supplement I9-1.006
8. Diagnosis and management of headache in adults. A national clinical guideline. SIGN Scottish Intercollegiate Guidelines Network. 107 November 2008
9. Ali Moghtaderi, Roya Alavi-Naini and Saleh Sanatinia (2012). Lumbar Puncture: Techniques, Complications and CSF Analyses, Emergency Medicine - An International Perspective, Dr. Michael Blaiwas (Ed.), ISBN: 978-953-51-0333-2, In Tech, Available from: <http://www.intechopen.com/books/emergency-medicine-an-international-perspective/lumbar-puncture-techniques-complications-and-csf-analyses>

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