Bradford Teaching Hospitals
NHS Foundation Trust

Lumbar Puncture Skills Teaching: Pre-course Reading Manual

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Bradford Education&Training

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Introduction

Welcome to the Lumbar Puncture Skills Pre-Course Reading Manual. The aim of the Manual is to provide you with some basic information with regards to lumbar punctures (LPs). This information should help you avoid complications, appropriately consent a patient and understand the science behind the technique.

Please study the content on the following pages before attending the course. This will help prepare you for the course and the test at the end. The information does not need to be memorised and will be reiterated in a lecture on the course day.

We look forward to seeing you on the day.

Indications

Indications for carrying out a lumbar puncture can be split into those that are urgent and non-urgent.

Urgent indications include:

- Suspected Central Nervous System infection (Bacterial, Fungal, Viral or Mycobacterium)
- Suspected Sub-arachnoid Haemorrhage after a negative CT scan (Between 12 hours and 2 weeks after onset of symptoms).

Non-Urgent indications include:

- Idiopathic intracranial hypertension
- Normal pressure hydrocephalus
- CNS syphilis
- CNS vasculitis
- Multiple sclerosis (useful)
- Guillain Barre syndrome (useful)

A lumbar puncture is not strictly diagnostic in Multiple Sclerosis or Guillain Barre Syndrome, but it is commonly performed to help aide the certainty of the clinical diagnosis.

Contraindications

As with any procedure there are reasons for it not to be carried out. These contraindications can be split between absolute and relative. These contraindications are from the author's research and may change based on local policy and clinical need. Debate also exists, among clinicians, regarding which should be considered absolute, relative, or even a contraindication at all.

Absolute Contraindications:

- Patient refusal
- Cardiorespiratory compromise
- Local sepsis (i.e. cellulitis, skin or epidural abscess overlying planned insertion site)
- Raised intracranial pressure (risk of cerebral herniation)

Relative Contraindications:

- Sepsis/bacteraemia (seeding infection)
- Spinal deformity
- Spinal metalwork
- Coagulation disorder (risk of spinal haematoma)
    - INR >1.5 (some sources state >1.4)
    - PT ratio >1.5
    - Platelets $<40x10^9$L or $<75x10^9$L (varies between sources and clinicians)

If in doubt, escalate to a senior regarding clinical need and possible contraindication.

Below is a link to a helpful BMJ infographic that details how to manage bleeding risk around the lumbar puncture procedure.

https://pn.bmj.com/content/practneurol/18/6/436/F1.large.jpg

Complications and Risk

There are risks and complications to any procedure. As the clinician performing the lumbar puncture you should have a good understanding of these to appropriately consent the patient. The two categories complications can be split into include rare, serious complications and more common, less serious complications.

Rare, serious complications include:

- Cerebral Herniation
- Bleeding (spinal haematoma)
- Infection
- Nerve damage (<8/10000 spinal anaesthetics)
- Paralysis (haematoma or dural abscess, <1/100000 spinal anaesthetics)
- Epidermoid Tumours

Cerebral herniation occurs in the context of increased intracranial pressure. This is often ruled out by a CT head scan. In patients that have not undergone a CT head scan the following clinical indicators should be ruled out before a lumbar puncture is performed:

- Altered mental state
- Focal neurological signs
- Papilledema
- Seizure within previous week
- Impaired cellular immunity

If the patient is negative for the above, then the risk of raised intracranial from a mass is low.

The risk of infection (meningitis) and subsequent paralysis from a Dural abscess is low. Lumbar punctures are carried out under an aseptic technique. Chlorhexidine wash, sterile drapes and gloves are utilised to reduce the risk of inducing infection. Lumbar punctures should not be carried out through an area of obvious infection and discussion of clinical need should be had on an overtly septic patient with a proven bacteraemia. If a Dural abscess is suspected the patient will demonstrate focal neurological signs and/or cauda equine syndrome. Immediate discussion with the neurosurgical team is required for evacuation to prevent permanent nerve damage.

Bleeding risk should be established before performing a lumbar puncture to reduce the risk of spinal haematoma which can lead to permanent nerve damage or paralysis. Platelet count and medication history should be completed for all patients undergoing a lumbar puncture. If the patient has a low platelet count ($<80x10^9$/L author recommends) the clinical need should be discussed. Discussion with the haematology team may be required if the need is urgent

and the patient either had a low platelet count or take an anti-platelet/coagulant medication that need reversing quickly.

Epidermoid tumours are rare and generally only become apparent years after the procedure is performed. It is thought to be caused by transplanting tissue into the spinal canal during a lumbar puncture without a stylet. Hence this complication is avoided by using a well-fitting stylet.

Common, less serious complications include:

- Post Dural puncture headache
- Failure of procedure
- Back Pain
- Abducens palsy
- Radicular pain or numbness

Post Dural/procedural puncture headache will be dealt with in the 'Post-procedural Headache' section.

The patient should always be warned the procedure may fail, necessitating either the aide of a different medical physician, anaesthetic help if urgent or radiological help if less urgent.

Localised back pain occurs in 33% of lumbar punctures and settle with simple analgesia within 2 weeks.

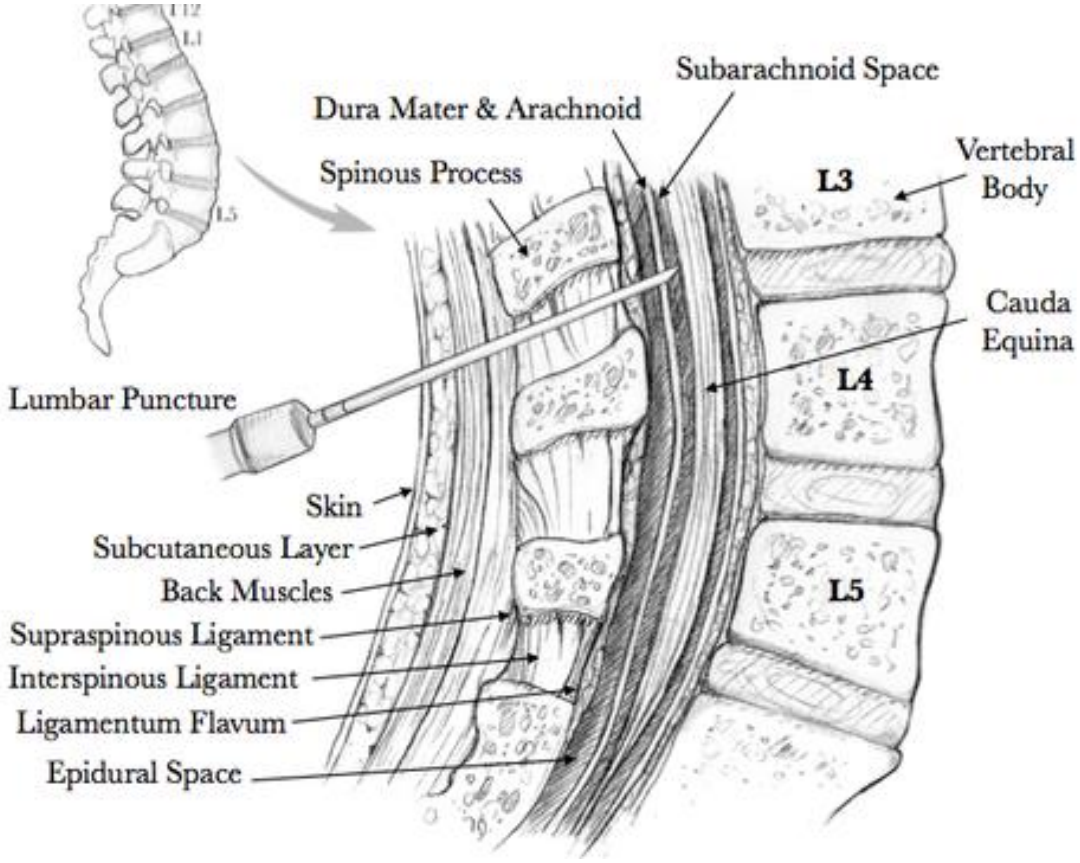
Abducens palsy is believed to occur due to intracranial hypotension and is generally accompanied by other clinical features of post Dural puncture headache.

Approximately 13% of patients experience transient electrical type pain in one leg during the procedure (irritation of cauda equina nerves). Sustained pain is rare.

Anatomy of the Lumbar Spine

The lumbar spine consists of 5 lumbar vertebrae and protects the end of the spinal cord, at the conus medullaris, and the cauda equina. The subarachnoid and dura matter extend beyond the conus medullaris, encasing the cauda equina in cerebrospinal fluid, the dural sac.

A good understanding of the anatomical layers between the skin and the dural sac is imperative when performing a lumbar puncture. The procedure is blind, counting on the clinician's identification of the correct insertion point by landmark technique and haptic feedback from the needle as it progresses through the layers. The haptic feedback is best appreciated by performing multiple lumbar punctures so the clinician can 'feel' when they are in the correct position or not.



A description of the 'feeling' of passing the needle through the layers, in relation to the diagram above, is as follows. The skin is initially tough to get through, once through and in the subcutaneous tissues of fat and muscle, the needle progresses easily with little resistance. The ligaments provide more resistance and are tougher than the skin to progress through. A 'rock hard' feeling here is typically bone. At the end of the ligamentous area the

resistance increases slightly (due to ligamentun flavum and dura matter) before a sudden loss of resistance as the needle progresses into the Dural sac and cerebrospinal fluid is obtained. As a rule of thumb, the Dural sac is reached at around 4-6cm, but every patient is different.

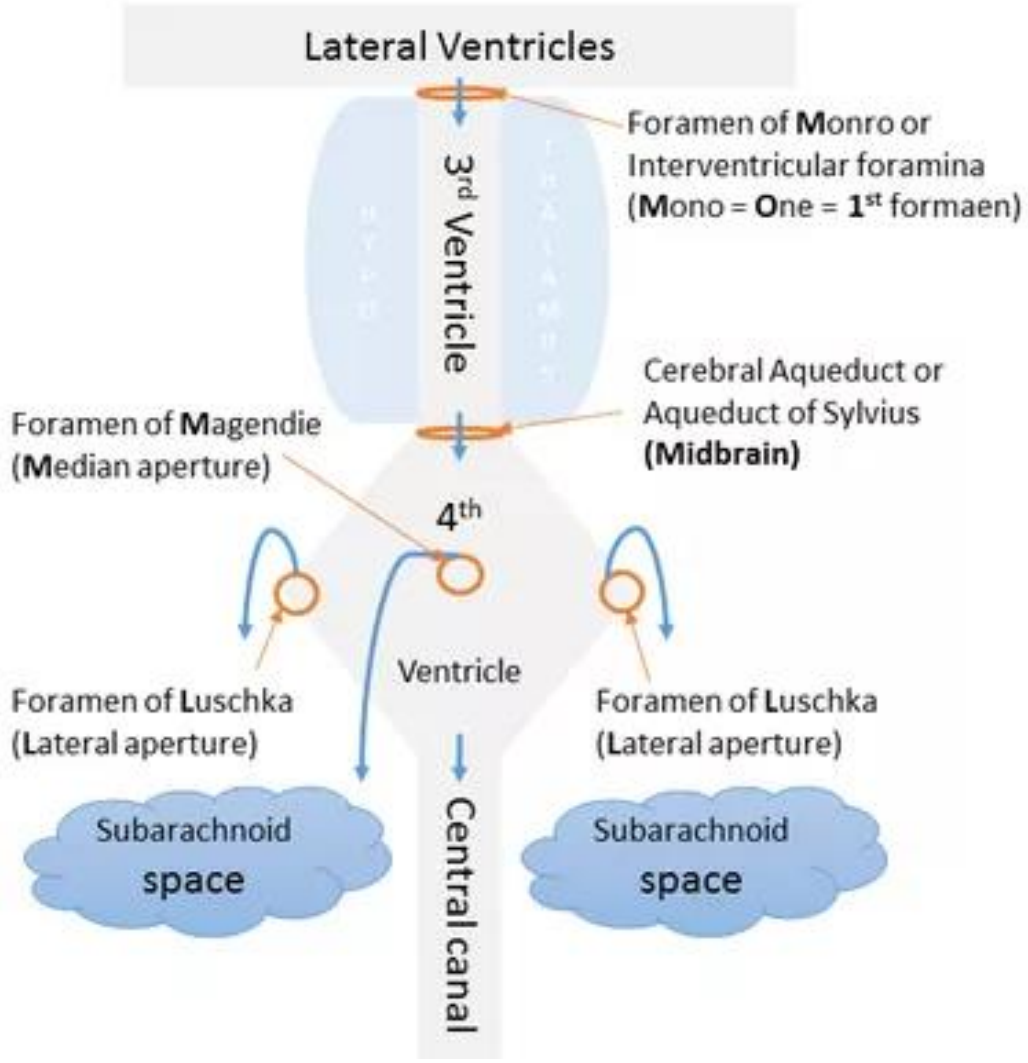
Cerebrospinal Fluid Physiology

Cerebrospinal fluid physiology can be broken down it four key areas: role, production and flow, composition, and absorption.

The role of CSF is as follows:

1. Buoyancy and cushioning. The adult brain weighs 1.4kg but when floating in CSF has an effective weight of <50g. This reduces the brains inertia on sudden head movements, which may produce damaging acceleration and deceleration forces against a rigid skull.
2. Maintenance of a constant ionic environment. Neurones are highly sensitive to changes in the external environment hence a constant ionic environment is required for normal function.
3. Buffering changes in intracranial pressure. Displacement of CSF from the skull is a limited compensatory mechanism when there is an increase in intracranial pressure.
4. Control of the respiratory system. The CSFs low protein concentration means it has limited buffering capacity for CO_2. As CO_2 is a small lipid soluble molecule it can readily cross the blood brain barrier. Central chemoreceptors detect CSF CO_2 causing changes in the respiratory centre.
5. Glymphatics system. Recently discovered glymphatic system allows CSF to run in paravascular channels, between blood vessels and astrocyte foot processes, removing waste products.

CSF is produced by the choroid plexus, located in the lateral ventricles, third and fourth ventricles. It is produced by a combination of filtration and active secretion at a rate of 20ml/hour or 500ml/day. Normal adult volume is 125-150mls with 20% in the ventricles. The anatomy of CSF flow is best seen in the diagram below.


Lateral Ventricles
Foramen of Monro or
Interventricular foramina
(Mono = One = 1st formaen)
3rd Ventricle
Cerebral Aqueduct or
Aqueduct of Sylvius
(Midbrain)
Foramen of Magendie
(Median aperture)
4th
Ventricle
Foramen of Luschka
(Lateral aperture)
Foramen of Luschka
(Lateral aperture)
Subarachnoid
space
Subarachnoid
space
Central canal

The composition of CSF compared to plasma.

Parameter	CSF	Plasma
Na^+ (mmol/L)	140	140
Cl^- (mmol/L)	120	110
Glucose (mmol/L)	4	6
Protein (g/L)	0.2-0.4	70
pH	7.32	7.4
$HCO3^-$ (mmol/l)	24	24
WCC (cells/mm3)	0-5	4000-11000

Absorption of CSF is performed by arachnoid villi located in 90% Sagittal and sigmoid Dural sinuses (90%) and the spinal column (10%). The villi function as a one-way valve with endothelium and tight junctions. Movement across is via giant vesicles usually letting particles <7.5 micrometres in diameter across. These vesicles may become obstructed by bacteria or cells in inflammatory processes or SAH.

Lumbar Puncture Technique

A brief guide to performing a lumbar puncture is below. Please remember positioning is crucial for success. If unable to obtain a CSF sample in the lateral decubitus position, sit the patient up. During the skills session you will have time to practice on mannequins and run through a scenario with staff.

Set Up

- Check appropriate investigation if required (e.g. FBC, coagulation or CT head).
- Consent patient
- Inform staff member for help
- Assemble equipment
    - LP pack
    - lidocaine 1% (3mg/kg max dose. 70kg patient aim <20mls)
    - Sterile gloves
    - Chlorhexidine/ETOH cleaner
    - Envelope (if xanthochromia)

Positioning

- POSITIONING IS THE MOST IMPORTANT STEP FOR SUCCESS.
- Shoulders in line, not twisted.
- Hips not twisted.
- Patient's back in line with the edge of the bed.
- Knees up to a comfortable position
- Sit on a chair and elevate bed.
- Feel iliac crest, come across, space below is L3/L4 space
- Mark
- Feel for inline spinal processes

Asepsis

- Disinfect skin with chlorhexidine (0.5% in 70% alcohol)
- Face mask on (debatable)
- Scrub up

- Sterile gloves
- Sterile drape with opening

Local Anaesthetic

- Infiltrate lidocaine, aspirate before injection

Procedure

- Insert introducer, mild cephalic angulation 15 degrees, toward umbilicus
- Insert needle with stylet (usually 22G Quincke) with bevel towards head.
- CSF around 4-6 cm
- Patient may feel a shooting sensation down a leg-nerve irritation, withdraw and aim more for the midline

Collection

- Attach manometer
- Collect x3 samples in universal container
- Collect x1 sample in glucose

Aftercare

- Replace stylet
- Remove all in one go
- Apply dressing
- Ask patient to lie flat for 1 hour (no evidence)

Post Procedural Headache

The post Dural puncture headache (PDPH) is one of the most commonly occurring complications after a lumbar puncture, with up to 32% of LPs complicated by a PDPH.

Risk factors include:

- Female (x2-x3 increase risk)
- Pregnancy
- Prior headaches (limited evidence)
- Age 18-50 years
- Low opening pressure
- BMI (inconclusive)

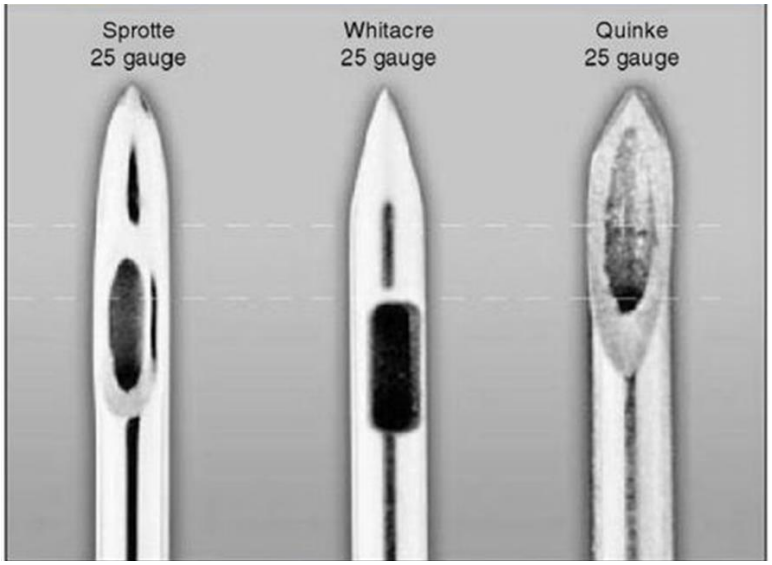
Symptoms generally start withing 24 hours, with 90% occurring within 72 hours. Symptoms consist of a dull headache classically worse on standing or sitting upright. Associated symptoms include: nausea, neck stiffness, low back pain, vertigo, vision changes, dizziness, auditory disturbances. It can be classified as mild (patients who tolerate upright position and perform ADL or are able to care for their baby) or debilitating (patient unable to sit or stand, perform ADL or baby care and refractory to conservative management). Often a blood patch is required for the treatment of debilitating PDPH.

Numerous theories exist for the pathophysiology of PDPH. Central to all is the leak of CSF fluid through a hole in the dura matter and hence intracranial hypotension. The theories generally fit into one of two categories, either relating to vasodilation or traction on brain structures. There is significant overlap between some.

- Leak of CSF fluid causing decrease CSF cushion especially for sensitive meningeal vascular coverings. Gravitational traction on these structures causes pain.
- Decrease CSF volume may activate adenosine receptors causing vasodilation and stretching of pain sensitive cranial structures
- CSF hypotension results in compensatory meningeal vasodilation with headache caused by acute venous distension
- Intracranial hypotension related to CSF leak may cause sagging of intracranial structures and stretch sensory intracranial nerves (supported by MRI in small study)
- Altered craniospinal elasticity results in increased caudal compliance relative to intracranial compliance and acute intracranial vasodilation in the upright position

Prophylaxis of PDPH is focused on the use of appropriate equipment.

- Needle tip
    - Pencil point tip parts the dura fibre.
    - 4.2% (pencil) vs 11% (cutting) for PDPH
- Needle size
    - 40% risk 20-22G
    - 12% risk 24-27G
    - Practically 22G usually smallest for manometer.
- Bevel orientation
    - x2 as likely if needle inserted with bevel perpendicular to dura fibres (run longitudinally)
- Stylet replacement
    - Theory that pulling needle alone pulls sub arachnoid strand and leaves dura hole open.



Research into treatment of PDPH is currently ongoing. Historical treatments which have no evidence or benefit include:

- Decrease volume of CSF removed (not helpful).
- Bed rest.
- Increase hydration.
- Patient position during LP.
- ACTH analogues and sumatriptan

Treatments which currently do work and there is good evidence for include:

- Simple analgesia (paracetamol/NSAIDs)
- Epidural blood patch

- Surgical repair

Treatments which either have questionable benefits, are novel or are still being researched include:

- Gabapentin, hydrocortisone, or neostigmine
- Epidural saline (variable results-increases pressure on thecal sac, not routinely done as marginal benefit)
- Caffeine (reduce intracranial vasodilation-poor quality data)
- Trans nasal sphenopalatine block with topical intranasal local anaesthetic (new, none invasive)
- Greater occipital nerve block

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