CHAPTER e46 Technique of Lumbar Puncture

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In experienced hands, lumbar puncture (LP) is usually a safe procedure. Major complications are extremely uncommon but can include cerebral herniation, injury to the spinal cord or nerve roots, hemorrhage, or infection. Minor complications occur with greater frequency and can include backache, post-LP headache, and radicular pain or numbness.

IMAGING AND LABORATORY STUDIES PRIOR TO LP

Patients with an altered level of consciousness, a focal neurologic deficit, new-onset seizure, papilledema, or an immunocompromised state are at increased risk for potentially fatal cerebellar or tentorial herniation following LP. Neuroimaging should be obtained in these patients prior to LP to exclude a focal mass lesion or diffuse swelling. Imaging studies should include the spine in patients with symptoms suggesting spinal cord compression, such as back pain, leg weakness, urinary retention, or incontinence. In patients with suspected meningitis who require neuroimaging prior to diagnostic LP, administration of antibiotics, preferably following blood culture, should precede the neuroimaging study.

Patients receiving therapeutic anticoagulation or those with coagulation defects including thrombocytopenia are at increased risk of post-LP spinal subdural or epidural hematomas, either of which can produce permanent nerve injury and/or paralysis. If a bleeding disorder is suspected, the platelet count, international normalized ratio (INR), and partial thromboplastin time should be checked prior to lumbar puncture. There are no data available to assess the safety of LP in patients with low platelet counts; a count of <20,000/μL is considered to be a contraindication to LP. Bleeding complications rarely occur in patients with platelet counts ≥50,000/μL and an INR ≤1.5. Patients receiving low-molecular-weight heparin are at increased risk of post-LP spinal or epidural hematoma, and doses should be held for 24 h before the procedure.

LP should not be performed through infected skin as organisms can be introduced into the subarachnoid space (SAS).

ANALGESIA

Anxiety and pain can be minimized prior to beginning the procedure. Anxiety can be allayed by the use of lorazepam, 1–2 mg given PO 30 min prior to the procedure or IV 5 min prior to the procedure. Topical anesthesia can be achieved by the application of a lidocaine-based cream. Lidocaine 4% is effective when applied 30 min prior to the procedure; lidocaine/prilocaine requires 60–120 min. The cream should be applied in a thick layer so that it completely covers the skin; an occlusive dressing is used to keep the cream in place.

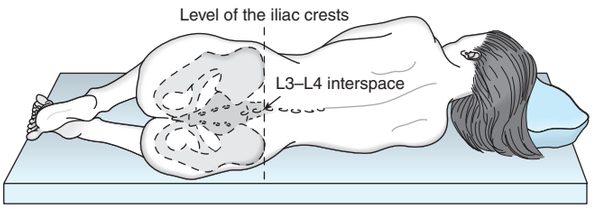

Figure e46-1 Proper positioning of a patient in the lateral decubitus position. Note that the shoulders and hips are in a vertical plane; the torso is perpendicular to the bed. *[From RP Simon et al (eds): Clinical Neurology, 7th ed. New York, McGraw-Hill, 2009.]*

POSITIONING

Proper positioning of the patient is essential. The procedure should be performed on a firm surface; if the procedure is to be performed at the bedside, the patient should be positioned at the edge of the bed and not in the middle. The patient is asked to lie on his or her side, facing away from the examiner, and to "roll up into a ball." The neck is gently ante-flexed and the thighs pulled up toward the abdomen; the shoulders and pelvis should be vertically aligned without forward or backward tilt (Fig. e46-1). The spinal cord terminates at approximately the L1 vertebral level in 94% of individuals. In the remaining 6%, the conus extends to the L2-L3 interspace. LP is therefore performed at or below the L3-L4 interspace. A useful anatomic guide is a line drawn between the posterior superior iliac crests, which corresponds closely to the level of the L3-L4 interspace. The interspace is chosen following gentle palpation to identify the spinous processes at each lumbar level.

An alternative to the lateral recumbent position is the seated position. The patient sits at the side of the bed, with feet supported on a chair. The patient is instructed to curl forward, trying to touch the nose to the umbilicus. It is important that the patient not simply lean forward onto a bedside tabletop, as this is not an optimal position for opening up the spinous processes. LP is sometimes more easily performed in obese patients if they are sitting. A disadvantage of the seated position is that measurement of opening pressure may not be accurate. In situations in which LP is difficult using palpable spinal landmarks, bedside ultrasound to guide needle placement may be employed.

TECHNIQUE

Once the desired target for needle insertion has been identified, the examiner should put on sterile gloves. After cleansing the skin with povidone-iodine or similar disinfectant, the area is draped with a sterile cloth; the needle insertion site is blotted dry using a sterile gauze pad. Proper local disinfection reduces the risk of introducing skin bacteria into the SAS or other sites. Local anesthetic, typically 1% lidocaine, 3–5 mL total, is injected into the subcutaneous tissue; in nonemergency situations a topical anesthetic cream can be applied (see above). When time permits, pain associated with the injection of lidocaine can be minimized by slow, serial injections, each one progressively deeper than the last, over a period of ~5 min. Approximately 0.5–1 mL of lidocaine is injected at a time; the needle is not usually withdrawn between injections. A pause of ~15 s between injections helps to minimize the pain of the subsequent injection. The goal is to inject each mini-bolus of anesthetic into an area of skin that has become numb

from the preceding injection. Approximately 5–10 mini-boluses are injected, using a total of ~5 mL of lidocaine.

If possible, the LP should be delayed for 10–15 min following the completion of the injection of anesthetic; this significantly decreases and can even eliminate pain from the procedure. Even a delay of 5 min will help to reduce pain.

The LP needle (typically 20- to 22-gauge) is inserted in the midline, midway between two spinous processes, and slowly advanced. The bevel of the needle should be maintained in a horizontal position, parallel to the direction of the dural fibers and with the flat portion of the bevel pointed upward; this minimizes injury to the fibers as the dura is penetrated. When lumbar puncture is performed in patients who are sitting, the bevel should be maintained in the vertical position. In most adults, the needle is advanced 4–5 cm (1–2 in.) before the SAS is reached; the examiner usually recognizes entry as a sudden release of resistance, a "pop." If no fluid appears despite apparently correct needle placement, then the needle may be rotated 90°–180°. If there is still no fluid, the stylet is reinserted and the needle is advanced slightly. Some examiners halt needle advancement periodically to remove the stylet and check for flow of cerebrospinal fluid (CSF). If the needle cannot be advanced because it hits bone, if the patient experiences sharp radiating pain down one leg, or if no fluid appears ("dry tap"), the needle is partially withdrawn and reinserted at a different angle. If on the second attempt the needle still hits bone (indicating lack of success in introducing it between the spinous processes), then the needle should be completely withdrawn and the patient should be repositioned. The second attempt is sometimes more successful if the patient straightens the spine completely prior to repositioning. The needle can then be reinserted at the same level or at an adjacent one.

Once the SAS is reached, a manometer is attached to the needle and the opening pressure measured. The examiner should look for normal oscillations in CSF pressure associated with pulse and respirations. The upper limit of normal opening pressure with the patient supine is 180 mmH_2O in adults but may be as high as 200–250 mmH_2O in obese adults.

CSF is allowed to drip into collection tubes; it should not be withdrawn with a syringe. Depending on the clinical indication, fluid is then obtained for studies including: (1) cell count with differential; (2) protein and glucose concentrations; (3) culture (bacterial, fungal, mycobacterial, viral); (4) smears (e.g., Gram's and acid-fast stained smears); (5) antigen tests (e.g., latex agglutination); (6) polymerase chain reaction (PCR) amplification of DNA or RNA of microorganisms (e.g., herpes simplex virus, enteroviruses); (7) antibody levels against microorganisms; (8) immunoelectrophoresis for determination of γ-globulin level and oligoclonal banding; and (9) cytology. Although 15 mL of CSF is sufficient to obtain all of the listed studies, the yield of fungal and mycobacterial cultures and cytology increases when larger volumes are sampled. In general 20–30 mL may be safely removed from adults.

A bloody tap due to penetration of a meningeal vessel (a "traumatic tap") may result in confusion with subarachnoid hemorrhage (SAH). In these situations a specimen of CSF should be centrifuged immediately after it is obtained; clear supernatant following CSF centrifugation supports the diagnosis of a bloody tap, whereas xanthochromic supernatant suggests SAH. In general, bloody CSF due to the penetration of a meningeal vessel clears gradually in successive tubes, whereas blood due to SAH does not. In addition to SAH, xanthochromic CSF may also be present in patients with liver disease and when the CSF protein concentration is markedly elevated [>1.5–2 g/L (150–200 mg/dL)].

Prior to removing the LP needle, the stylet is reinserted to avoid the possibility of entrapment of a nerve root in the dura as the needle is being withdrawn; entrapment could result in a dural CSF leak, causing headache. Some practitioners question the safety of this maneuver, with its potential risk of causing a needle-stick injury to the examiner. Injury is unlikely, however, given the flexibility of the small-diameter stylet, which tends to bend, rather than penetrate, on contact. Following LP, the patient is customarily positioned in a comfortable, recumbent position for 1 h before rising, although this may be unnecessary as it does not appear to affect the development of headache (see below).

POST-LP HEADACHE

The principal complication of LP is headache, occurring in 10–30% of patients. Younger age and female gender are associated with an increased risk of post-LP headache. Headache usually begins within 48 h but may be delayed for up to 12 days. Head pain is dramatically positional; it begins when the patient sits or stands upright; there is relief upon reclining or with abdominal compression. The longer the patient is upright, the longer the latency before head pain subsides. The pain is usually a dull ache but may be throbbing; its location is occipitofrontal. Nausea and stiff neck often accompany headache, and occasionally, patients report blurred vision, photophobia, tinnitus, and vertigo. In more than three-quarters of patients, symptoms completely resolve within a week, but in a minority they can persist for weeks or even months.

Post-LP headache is caused by a drop in CSF pressure related to persistent leakage of CSF at the site where the needle entered the subarachnoid space. Loss of CSF volume decreases the brain's supportive cushion, so that when a patient is upright there is probably dilation and tension placed on the brain's anchoring structures, the pain-sensitive dural sinuses, resulting in pain. Although intracranial hypotension is the usual explanation for severe LP headache, the syndrome can occur in patients with normal CSF pressure.

Because post-LP headache usually resolves without specific treatment, care is largely supportive with oral analgesics [acetaminophen, nonsteroidal anti-inflammatory drugs, opioids (Chap. 11)] and antiemetics. Patients may obtain relief by lying in a comfortable (especially a recumbent or head-down Trendelenburg) position. For some patients, beverages with caffeine can provide temporary pain relief.

For patients with persistent pain, treatment with IV caffeine (500 mg in 500 mL saline administered over 2 h) may be effective; atrial fibrillation is a rare side effect. Alternatively, an epidural blood patch accomplished by injection of 15 mL of autologous whole blood is usually effective. This procedure is most often performed by a pain specialist or anesthesiologist. The blood patch has an immediate effect, making it unlikely that sealing off a dural hole with blood clot is its sole mechanism of action. The acute benefit may be due to compression of the CSF space by the clot, increasing CSF pressure. Some clinicians reserve epidural blood patch for patients who do not respond to caffeine, while others prefer to use blood patch as initial management for unremitting post-LP symptoms.

Strategies to decrease the incidence of post-LP headache are listed in Table e46-1. Use of a smaller caliber needle is associated with a lower risk: In one study, the risk of headache following use of a 24- to 27-gauge standard (Quincke) needle was 5–12%, compared to 20–40% when a 20- or 22-gauge needle was used. The smallest gauge needles usually require the use of an introducer needle and are associated with a slower CSF flow rate. Use of an "atraumatic" (Sprotte, "pencil point," or "noncutting") needle also reduces the incidence of moderate to severe headache compared with standard LP (Quincke, or "traumatic") needles (Fig. e46-2). However, because atraumatic needles are more difficult to use, more attempts may be required to perform the LP, particularly in overweight patients. It may also be necessary to use an introducer with the atraumatic needle, which does not have the customary

TABLE e46-1 Reducing the Incidence of Post-LP Headache

Effective Strategies
Use of small-diameter needle (22-gauge or smaller)
Use of atraumatic needle (Sprotte and others)
Replacement of stylet prior to removal of needle
Insertion of needle with bevel oriented in a cephalad to caudad direction (when using standard needle)
Ineffective Strategies
Bed rest (up to 4 h) following LP
Supplemental fluids
Minimizing the volume of spinal fluid removed
Immediate mobilization following LP

cutting, beveled tip. There is a low risk of needle damage, e.g., breakage, with the Sprotte atraumatic needle. Another strategy to decrease the incidence of headache is to replace the stylet before removing the LP needle.

Patients are often advised to remain in a recumbent position for up to an hour following lumbar puncture. However, studies comparing mobilization immediately following LP with bed rest for periods up to 4 h show no significant differences in the incidence of headache, suggesting that the customary practice of remaining in a recumbent position post-LP may be unnecessary.

NORMAL VALUES

(See Table e46-2) In uninfected CSF, the normal white blood cell count is fewer than five mononuclear cells (lymphocytes and monocytes) per μL. Polymorphonuclear leukocytes (PMNs) are not found in normal unconcentrated CSF; however, rare PMNs can be found in centrifuged or concentrated CSF specimens such as those utilized for cytologic examination. Red blood cells (RBCs) are not normally present in CSF; if RBCs are present from a traumatic tap, their number decreases as additional CSF is collected. CSF glucose concentrations <2.2 mmol/L (<40 mg/dL) are abnormal.

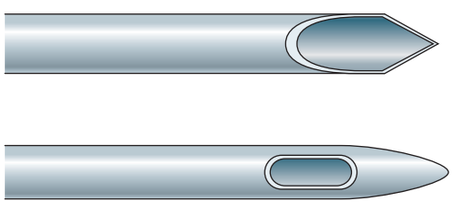

Figure e46-2 Comparison of the standard ("traumatic" or Quincke) LP needle with the "atraumatic" (Sprotte). The "atraumatic" needle has its opening on the top surface of the needle, a design intended to reduce the chance of cutting dural fibers that, by protruding through the dura, could be responsible for subsequent CSF fluid leak and post-LP headache. *(From SR Thomas et al: BMJ 321:986, 2000.)*

TABLE e46-2 Cerebrospinal Fluid[a]

Constituent	SI Units	Conventional Units
Glucose	2.22–3.89 mmol/L	40–70 mg/dL
Lactate	1–2 mmol/L	10–20 mg/dL
Total protein		
Lumbar	0.15–0.5 g/L	15–50 mg/dL
Cisternal	0.15–0.25 g/L	15–25 mg/dL
Ventricular	0.06–0.15 g/L	6–15 mg/dL
Albumin	0.066–0.442 g/L	6.6–44.2 mg/dL
IgG	0.009–0.057 g/L	0.9–5.7 mg/dL
IgG index[b]	0.29–0.59	
Oligoclonal bands (OGB)	<2 bands not present in matched serum sample	
Ammonia	15–47 μmol/L	25–80 μg/dL
CSF pressure		50–180 mmH_2O
CSF volume (adult)	~150 mL	
Red blood cells	0	0
Leukocytes		
Total	0–5 mononuclear cells per mm^3	
Differential		
Lymphocytes	60–70%	
Monocytes	30–50%	
Neutrophils	None	

[a]Because cerebrospinal fluid concentrations are equilibrium values, measurements of the same parameters in blood plasma obtained at the same time are recommended. However, there is a time lag in attainment of equilibrium, and cerebrospinal levels of plasma constituents that can fluctuate rapidly (such as plasma glucose) may not achieve stable values until after a significant lag phase.
[b]IgG index = CSF IgG (mg/dL) × serum albumin (g/dL)/Serum IgG (g/dL) × CSF albumin (mg/dL).

FURTHER READINGS

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