INTRODUCTION

Cerebrospinal fluid (CSF) occupies the subarachnoid space and the ventricular system in the brain. It is produced from arterial blood by the choroid plexuses of the lateral and fourth ventricles and ependymal cells. The total volume of CSF in the adult is 140 mL (Table 1). Cerebrospinal fluid is produced at a rate of 0.2–0.7 mL per minute or 600–700 mL per day. Cerebrospinal fluid is absorbed across the arachnoid villi into the venous circulation. The rate of absorption correlates with the CSF pressure.

LUMBAR PUNCTURE

Indications

Lumbar puncture (LP) is useful in suspected cases of meningitis, encephalitis, neurosyphilis, subarachnoid hemorrhage, multiple sclerosis, Guillain-Barre syndrome, meningeal carcinomatosis, unexplained seizures, fever of unknown origin, dementia and acute confusional states. Cerebrospinal fluid examination is performed as follow-up in various meningitides and as a preface to instituting anticoagulant therapy. Therapeutically, the technique is used in the treatment of certain diseases and diagnostically for the introduction of contrast.

Contraindications

Absolute

Infection in the skin overlying the access site.

Relative

Papilledema: Papilledema caused by pseudotumor cerebri and intracranial mass lesion. Mass lesions can result in the production of or exacerbation of tentorial or cerebellar pressure cones leading to death due to brainstem compression. Deterioration can be immediate or occur within 12 hours. So, prior fundus examination or computed tomography is must.

Bleeding diathesis: A platelet count of 50,000 or lower greatly increases the possibility of a spinal epidural hematoma occurring after the procedure. Platelet count, prothrombin and partial thromboplastin times should be evaluated in susceptible patients.

Severe pulmonary disease or respiratory difficulty in the patient: The optimum position significantly decreases pulmonary function. Appropriate respiratory support measures should be undertaken before the procedure.

Prerequisites

Technique is simple and three essential points must be observed:
1. The patient must be precisely horizontal
2. The back of the patient must be exactly perpendicular to the bed or table
3. The needle must be inserted in the exact midline parallel to the horizontal plane.

The patient is positioned on a hard surface on his or her side with the craniospinal axis parallel to the floor. Any elevation of the head above the level of the spinal needle may falsely elevate the CSF pressure. An assistant is helpful in maintaining the neck and thighs acutely flexed and at the same time keeping the back in the vertical plane.

Sterile technique is mandatory. After the area has been prepared, local anesthesia should be used. The occurrence of pain should immediately alert that the spinal needle is not properly positioned. The optimal entry site is the midline of L3–4 interspace. The two lower spaces are also usable.

A 20 or 22 gauge needle is recommended. The bevel of the needle is pointed upward. As soon as the needle penetrates the skin, the hub is aimed at the umbilicus.

Slowly advance the needle till a “give” is felt at approximately 3–5 cm depth. This sensation is created by penetration of the ligamentum flavum. The stylet is withdrawn. If no CSF is obtained, rotate the needle through 90°. If this is unsuccessful, withdraw the needle to the subcutaneous plane and realign it.

As soon as CSF appears in the hub, the three-way stopcock is inserted and the CSF manometer is attached rapidly in order to avoid significant fluid loss that can falsely lower the CSF pressure.

Note the opening pressure, if it is above normal; rule out causes for falsely elevated pressure like abdominal compression either due
Neurology

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Complications

- Brain herniation is the most serious complication.
- Headache is the most common complication. The onset occurs in 15 minutes to 4 days after the procedure, usually lasting 4–8 days. The headache is usually frontal or retro-orbital, pounding, occurs during sitting or standing and disappears with recumbency. The use of small-gauge needles has decreased the occurrence of headache.
- Diplopia due to unilateral or bilateral sixth nerve palsy occurs. The lowered CSF pressure causes the sixth nerve to stretch as it courses over the petrous bone. The diplopia is usually transient although on rare occasions it may be permanent. A patch is useful for a few days.
- Subarachnoid hemorrhage or a “traumatic” tap is common. The needle penetrates some of the small equina vessels causing hemorrhage.
- A spinal epidural hematoma or spinal subdural hematoma may occur due to nicking of spinal radicular arteries.

Examination

- Must be done within 30 minutes, since red cell lysis can affect the results.
- A gram stain, AFB stain for tuberculosis and India ink examination for cryptococci should be done promptly on the CSF.
- The gram stain has the virtue of providing an instant almost exact etiologic diagnosis in bacterial meningitis, thus permitting much needed specific therapy in 60–80% of cases of bacterial meningitis. The yield of the gram stain can be improved by cytospin slide centrifuge.
- The India ink examination is positive in only 50% of cases of cryptococcal meningitis [up to 80% in acquired immune deficiency syndrome (AIDS) patients]. Only budding yeast cells seen on India ink examination shall be considered cryptococci.

- Sensitivity of AFB stain varies, ranging from 9% to as high as 91%.
- The latter yield was reported with the “stacking” method.

Clinical Significance

Analysis of the CSF provides invaluable insight into pathologic derangements of the nervous system.

Pressure

The range of pressure is 50–200 mm CSF. Pressure over 180 is considered to be abnormal. The causes of intracranial hyper-tension are pseudo tumor cerebri, intracranial neoplasms, meningitis, subarachnoid hemorrhage and elevated central venous pressure.

Color

Xanthochromia commonly indicates spontaneous sub-arachnoid hemorrhage.

Cells

An infection of the nervous system produces three basic CSF types are:

1. **Type A fluid**: This is characterized by 500–20,000 WBC, 90% of which are neutrophils, low CSF sugar and protein elevated to 100–500 mg/dL.
   - **Bacterial meningitis** is the most common cause of this type. Partially treated bacterial meningitis6 on rare occasions (5%) will have type C fluid characteristics due to incomplete treatment with empirical antibiotics.
   - **Primary amebic meningoencephalitis** is a rare condition caused by free-living amebas. The classic epidemiology, absence of organisms on gram stain and eventually on culture, and a hemorrhagic component to the fluid should promptly suggest the diagnosis, which can be confirmed by wet mounts of the CSF revealing motile trophozoites.
   - **Ruptured brain abscess** is diagnosed by a gram stain showing multiple types of organisms, an extremely high protein level and isolation of multiple organisms including anaerobes.
   - **Nonsteroidal anti-inflammatory agent (NSAIA) meningitis** is a rare entity. It is seen predominantly in patients with collagen vascular diseases. Cerebrospinal fluid shows pleocytosis (as high as 2,000 WBC/mm³ with marked predominance of PMLs, variable protein elevation (as high as 50 mg/dL) and minimal or no drop in glucose. Most patients need empiric antibiotic coverage for acute bacterial meningitis until the diagnosis is established in retrospect.

2. **Type B fluid**: This is characterized by 25–500 WBC that are mononuclear cells (but may be PMLs early in the course of disease), a low or occasionally normal CSF sugar, and a protein of 50–500 mg/dL. This fluid is characteristic of tuberculosis and other granulomatous meningitides.
   - Fungal meningitis can be produced by a variety of fungi; the most common are **cryptococci**, **histoplasma**, **coccidioides and candida**. Usually seen in immuno-suppressed.
   - **Sarcoidosis** often has meningeal involvement. The characteristic picture is a mild to moderate pleocytosis that is almost mononuclear, in the range of 10–300 WBC/mm³, mild to moderate protein elevation (between 50 mg/dL and 200 mg/dL) and hypoglycorrachia (seen in 18% of patients).

3. **Type C fluid**: This is characterized by 5–1,000 WBC/mm³, a mononuclear pleocytosis (may be PMLs early), normal glucose (rarely quite low) and protein less than 100 mg/dL.
**Parameningeal infections** are an important group of diseases. Analysis of the fluid does not make the diagnosis, but begets the specific diagnostic procedure (i.e., sinus/spine/skull films, CAT of the head, etc.).

**Listeria monocytogenes meningitis** is peculiar gram-positive rod with characteristic “tumbling motility”

**Secondary syphilis** clinically mimics aseptic meningitis, transverse myelitis, cranial nerve palsies, papilledema, and thrombosis of cerebral arteries, perceptive deafness and irritis. Cerebrospinal fluid findings are pleocytosis or elevated protein levels

- Cerebrospinal fluid picture of asymptomatic neurosyphilis consists of lymphocytic pleocytosis (<100 cells/mm$^3$), normal or slightly elevated protein (<100 mg/dL) and positive nonreactive test in over 90% of cases

- Meningovascular neurosyphilis is defined as ischemic injury to any part of the central nervous system (CNS) due to syphilitic endarteritis. It constitutes approximately 10% of cases of neurosyphilis. The CSF reveals mild (10–100 cells/mm$^3$) lymphocytic pleocytosis, protein in the range of 40–250 mg/dL and a positive VDRL

- Parenchymatous neurosyphilis or general paresis is syphilitic meningoencephalitis. The CSF shows essentially the same characteristics as described for the meningovascular type. The fluorescent treponemal antibody-absorption (FTA-Abs) test is not recommended in CSF as it is extremely sensitive. Consequently, minimal contamination of CSF with FTA-Abs positive blood gives false positive results.

**Toxoplasmosis** in immunosuppressed hosts (lymphoproliferative neoplasms, organ transplant recipients, AIDS, collagen vascular diseases and hemochromatosis) can produce severe necrotizing encephalitis. The CSF examination is of type C fluid without specific features

**Herpes simplex virus 1 (HSV-1) meningoencephalitis**, while a rare complication of HSV-1 infection, cerebrospinal fluid shows a moderate pleocytosis with polymorphonuclear (PMN) and lymphocytes. It is hemorrhagic in most of the cases

**Viral meningitis** enteroviruses account for over 50% of cases. Other agents include flaviviruses, mumps, herpes simplex, lymphocytic choriomeningitis (LCM) and the human immunodeficiency virus (HIV). The CSF shows PMN predominance that on repeat LP within 12–48 hours will demonstrate a shift toward mononuclear predominance

**Human immunodeficiency virus** can affect the CNS in several ways. Cerebrospinal fluid examination may have mild lymphocytic pleocytosis or normal or mildly elevated proteins are seen. Human immunodeficiency virus cultures are positive in the majority of patients. Human immunodeficiency virus can be isolated from CSF in 0–50% cases.

**Proteins**

Cerebrospinal fluid proteins are derived from serum proteins with the exception of trace proteins and some beta globulins. Three conditions can cause abnormalities of the CSF proteins:

- Increased entry of plasma proteins due to increased permeability of blood-brain barrier
- Local synthesis of proteins within the CNS
- Impaired resorption of CSF proteins.

Elevated CSF total protein is highly suggestive of neurological disease. Total protein over 500 mg/dL is seen in meningitis, cord tumor with spinal block and bloody CSF. Each 1,000 RBC/mm$^3$ raises the CSF protein 1.5 mg/dL. Cerebrospinal fluid that is xanthochromic and clots due to protein over 1,000 mg/dL is caused by complete spinal block, usually caused by a tumor (Froin’s syndrome). Immunoglobulin G (IgG) concentration in the CSF is normally 4.6 ± 1.9 mg/dL. Local synthesis within the CNS occurs in a variety of disorders: multiple sclerosis, neurosyphilis, subacute sclerosing panencephalitis, progressive rubella encephalitis, viral meningoencephalitis, sarcoidosis, etc. The majority of these conditions are inflammatory disorders. Immunoglobulin G can be characterized by agar gel electrophoresis and isoelectric focusing for the identification of oligoclonal banding.

**Glucose**

The normal CSF glucose is 60–80% of the plasma glucose. Values under 45 mg/dL can usually be considered abnormal. The most common cause of lowered CSF glucose (hypoglycorrhachia) is meningitis: bacterial, tuberculous, fungal, amebic, acute syphilitic, chemical and certain of the viral meningitides (mumps, herpes simplex and herpes zoster), 15% of cases of subarachnoid hemorrhage (normalizes in 4–8 days), meningeal carcinomatosis, sarcoidosis, cysticercosis, trichinosis and rheumatoid meningitis.2

**REFERENCES**