Cerebrospinal fluid analysis

Cerebrospinal fluid (CSF) analysis is a set of laboratory tests that examine a sample of the fluid surrounding the brain and spinal cord. This fluid is an ultrafiltrate of plasma. It is clear and colorless. It contains glucose, electrolytes, amino acids, and other small molecules found in plasma, but has very little protein and few cells. CSF protects the central nervous system from injury, cushions it from the surrounding bone structure, provides it with nutrients, and removes waste products by returning them to the blood. CSF is withdrawn from the subarachnoid space through a needle by a procedure called a lumbar puncture or spinal tap. CSF analysis includes tests in clinical chemistry, hematology, immunology, and microbiology. Usually three or four tubes are collected. The first tube is used for chemical and/or serological analysis and the last two tubes are used for hematology and microbiology tests. This reduces the chances of a falsely elevated white cell count caused by a traumatic tap (bleeding into the subarachnoid space at the puncture site), and contamination of the bacterial culture by skin germs or flora.

The purpose of a CSF analysis is to diagnose medical disorders that affect the central nervous system. Some of these conditions are:

- meningitis and encephalitis, which may be viral, bacterial, fungal, or parasitic infections
- metastatic tumors (e.g., leukemia) and central nervous system tumors that shed cells into the CSF
- Syphilis.
- bleeding (hemorrhaging) in the brain and spinal cord
- multiple sclerosis, a degenerative nerve disease that results in the loss of the myelin coating of the nerve fibers of the brain and spinal cord
- Guillain-Barré syndrome, a demyelinating disease involving peripheral sensory and motor nerves

Routine examination of CSF includes visual observation of color and clarity and tests for glucose, protein, lactate, lactate dehydrogenase, red blood cell count, white blood cell count with differential, syphilis serology (testing for antibodies indicative of syphilis), Gram stain, and bacterial culture. Further tests may need to be performed depending upon the results of initial tests and the presumptive diagnosis. For example, an abnormally high total protein seen in a patient suspected of having a demyelinating disease such as multiple sclerosis dictates CSF protein electrophoresis and measurement of immunoglobulin levels and myelin basic protein.

GROSS EXAMINATION. Color and clarity are important diagnostic characteristics of CSF. Straw, pink, yellow, or amber pigments (xanthochromia) are abnormal and indicate the presence of bilirubin, hemoglobin, red blood cells, or increased protein. Turbidity (suspended particles) indicates an increased number of cells. Gross examination is an important aid to differentiating a subarachnoid hemorrhage from a traumatic tap. The latter is often associated with sequential clearing of CSF as it is collected; streaks of blood in an otherwise clear fluid; or a sample that clots.

GLUCOSE. CSF glucose is normally approximately two-thirds of the fasting plasma glucose. A glucose level below 40 mg/dL is significant and occurs in bacterial and fungal meningitis and in malignancy.

PROTEIN. Total protein levels in CSF are normally very low, and albumin makes up approximately two-thirds of the total. High levels are seen in many conditions including bacterial and fungal meningitis, multiple sclerosis, tumors, subarachnoid hemorrhage, and traumatic tap.
LACTATE. The CSF lactate is used mainly to help differentiate bacterial and fungal meningitis, which cause increased lactate, from viral meningitis, which does not.

LACTATE DEHYDROGENASE. This enzyme is elevated in bacterial and fungal meningitis, malignancy, and subarachnoid hemorrhage.

WHITE BLOOD CELL (WBC) COUNT. The number of white blood cells in CSF is very low, usually necessitating a manual WBC count. An increase in WBCs may occur in many conditions including infection (viral, bacterial, fungal, and parasitic), allergy, leukemia, multiple sclerosis, hemorrhage, traumatic tap, encephalitis, and Guillain-Barré syndrome. The WBC differential helps to distinguish many of these causes. For example, viral infection is usually associated with an increase in lymphocytes, while bacterial and fungal infections are associated with an increase in polymorphonuclear leukocytes (neutrophils). The differential may also reveal eosinophils associated with allergy and ventricular shunts; macrophages with ingested bacteria (indicating meningitis), RBCs (indicating hemorrhage), or lipids (indicating possible cerebral infarction); blasts (immature cells) that indicate leukemia; and malignant cells characteristic of the tissue of origin. About 50% of metastatic cancers that infiltrate the central nervous system and about 10% of central nervous system tumors will shed cells into the CSF.

RED BLOOD CELL (RBC) COUNT. While not normally found in CSF, RBCs will appear whenever bleeding has occurred. Red cells in CSF signal subarachnoid hemorrhage, stroke, or traumatic tap. Since white cells may enter the CSF in response to local infection, inflammation, or bleeding, the RBC count is used to correct the WBC count so that it reflects conditions other than hemorrhage or a traumatic tap. This is accomplished by counting RBCs and WBCs in both blood and CSF. The ratio of RBCs in CSF to blood is multiplied by the blood WBC count. This value is subtracted from the CSF WBC count to eliminate WBCs derived from hemorrhage or traumatic tap.

GRAM STAIN. The Gram stain is performed on a sediment of the CSF and is positive in at least 60% of cases of bacterial meningitis. Culture is performed for both aerobic and anaerobic bacteria. In addition, other stains (e.g. the acid-fast stain for Mycobacterium tuberculosis, fungal culture, and rapid identification tests [tests for bacterial and fungal antigens]) may be performed routinely.

SYPHILIS SEROLOGY. This involves testing for antibodies that indicate neurosyphilis. The fluorescent treponemal antibody-absorption (FTA-ABS) test is often used and is positive in persons with active and treated syphilis. The test is used in conjunction with the VDRL test for nontreponemal antibodies, which is positive in most persons with active syphilis, but negative in treated cases.

Substance Cerebrospinal Fluid Serum

Water Content (%) 99 93
Protein (mg/dL) 35 7000
Glucose (mg/dL) 60 90
Osmolarity (mOsm/L) 295 295
Sodium (mEq/L) 138 138
Potassium (mEq/L) 2.8 4.5
Calcium (mEq/L) 2.1 4.8
Magnesium (mEq/L) 0.3 1.7
Chloride (mEq/L) 119 102
pH 7.33 7.41

see Cerebrospinal fluid cytology.

Cerebrospinal fluid eosinophilia.

There appears to be no correlation between CSF sampling during first time ventriculoperitoneal shunt insertion and the later development VP shunt infection. This questions the need for routine CSF sampling at the time of insertion. This would be confirmed as a part of future randomised trials.