



Cerebrospinal fluid (CSF)



OUTLINES:

- CSF definition, functions and methods
- of sampling
- Indications and contraindications of CSF

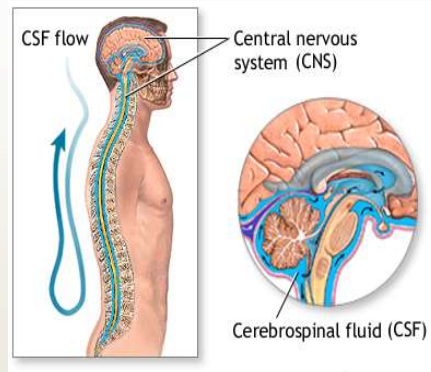
Sampling.

- Examination of CSF.
- Abnormalities in CSF examination.



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- ❑ Physical support & protection (shock absorber)
- ❑ Provides controlled chemical environment (nutrient supply and waste removal)
- ❑ Intra and extra cerebral transport (Neuroendocrine function)



- ❑ The liquid surrounding the brain and spinal cord.
- ❑ It flows in the subarachnoid space (Between arachnoid and pia matter)

FUNCTION

CIRCULATION

DEFINITION

Formation

ABSORPTION
EXCRETION

Cerebrospinal fluid (CSF)

- Formed at the choroid plexuses by the cells lining the ventricles.
- Rate of formation: 500 ml/day
- Mechanism of formation:
 - 1) Selective ultrafiltration of plasma
 - 2) Active secretion by epithelial membranes.

occurs at the arachnoid villi
 → protrude through the dura to the venous sinuses of the brain.
 → bloodstream

Excretion volume = production volume
 => constant CSF volume

- CNS infection
- Demyelinating diseases
- CNS Malignancy
- Hemorrhage in CNS

INDICATIONS OF CSF
lab investigations

CSF Specimen Collection

- Bleeding diathesis (tendency)
- Increased intracranial pressure
- Infection at site of needle insertion

CONTRAINDICATIONS
OF LP (lumbar puncture)

Obtained by lumbar puncture

(At the interspace L3-4, or lower)¹

Using aseptic techniques

⇒ Then, separated into 3 aliquots:

- ✓ For chemistry & serology
- ✓ For microbiology
- ✓ For cell count.

Immediate analysis is required to avoid exposure to microbes

Because it is a precious sample, preserving any remaining sample is highly suggested.

1: Because spinal cord ends at L2

EXAMINATION OF CSF



Physical examination

Biochemical analysis

1- Physical examination of CSF

- Normal CSF is:
 - 1) Colorless
 - 2) Clear
 - 3) Free of clots
 - 4) Free of blood
- If CSF is turbid => perform microscopic examination.
Usually due to leucocytes or may be due to micro-organisms

Blood & Hemoglobin pigments in CSF

Due to:

TRAUMATIC TAP

Subarachnoid hemorrhage (SAH)

- ◆ Bright red color
- ◆ RBCS decrease in number as the fluid is sampled.

It indicates hemorrhage if we exclude:

- 1) Prior traumatic tap
- 2) Hyperbilirubinemia
(bilirubin > 20 mg/dL)

Xanthochromia
Hemoglobin pigment breakdown
= RBCs lysis and metabolism
previously occurred (2 hours earlier)

Biochemical analysis of CSF

Tests of interest:

- Glucose¹
- Protein¹: total and Specific e.g. Albumin, Immunoglobulin, others e.g. myelin basic protein
- Lactate
- Glutamine :(replaced by measuring plasma [ammonia])

ABNORMAL CSF GLUCOSE

↑ CSF [glucose]

- Not clinically informative
- Provides only confirmation of hyperglycemia

↓ CSF [glucose]
(hypoglycorrhachia):

- Disorder in carrier-mediated transport
e.g. TB meningitis, sarcoidosis
- Active metabolism of glucose by cells
or organisms e.g:
acute purulent, amebic, & fungal meningitis
- Increased metabolism by the CNS
e.g. by CNS neoplasm

GLUCOSE IN CSF

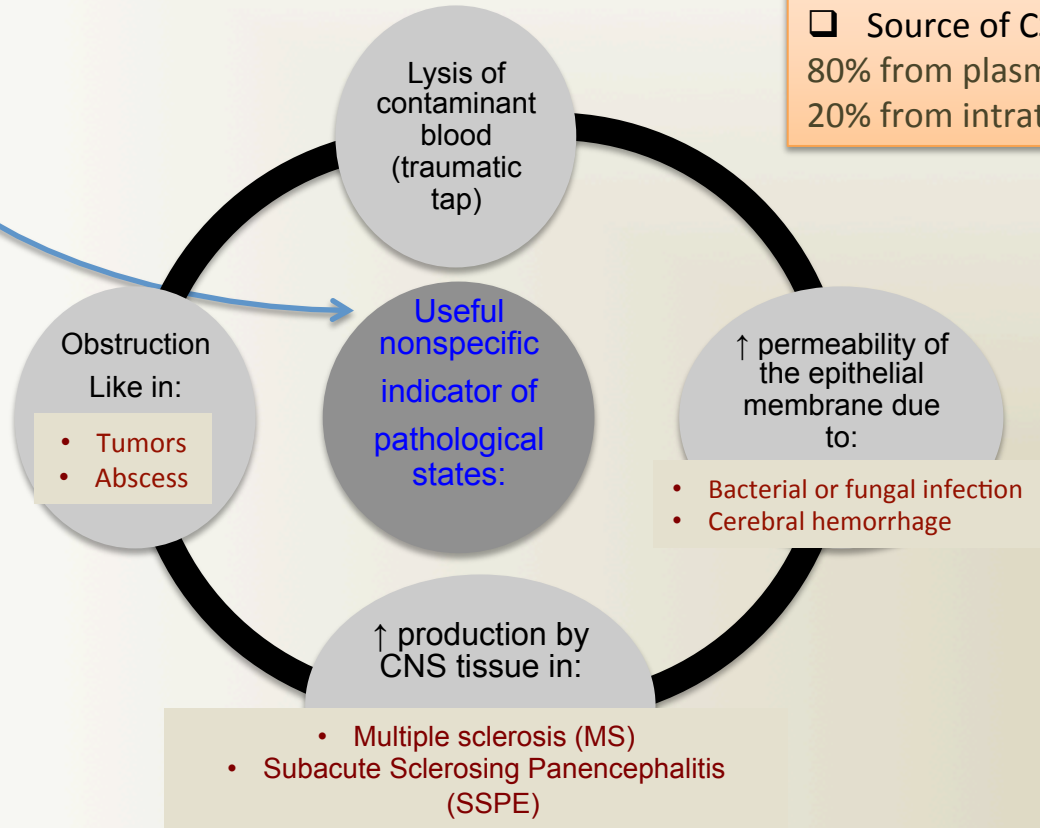
- ❑ Enters CSF via facilitative transporter (**GLUT**).
- ❑ CSF [glucose] is ~ 2/3 that of PLASMA
Which equals 50 - 80 mg/dl²
- ❖ In hypoglycemia:
=> CSF glucose may be very low
- ❖ In hyperglycemia:
=> CSF glucose is raised.
- ❑ Analysis should be done Immediately or preserve the specimen with antiglycolytic
e.g. fluoride ion.

1. The most reliable diagnostically and accessible analytically
2. A plasma sample must be obtained 2-4 hours before CSF sample

N.B. In viral meningitis, CSF [glucose] is usually normal

ABNORMAL CSF [TOTAL PROTEINS]

- ❑ ↑ CSF [total protein]:
- ❑ Must be compared to the serum [protein]



PROTEIN IN CSF

- ❑ Proteins, mostly **albumin** are found in the CSF (0.15-0.45 g/L)

- ❑ Source of CSF proteins:
 - 80% from plasma by ultrafiltration (Albumin mainly)
 - 20% from intrathecal synthesis (Immunoglobulin mainly)

CSF Immunoglobulin

- ❑ **CSF IgG can arise from:**
 - ✓ plasma cells within CSF
 - ✓ the blood through BBB
- ❑ **↑ CSF [IgG] without concomitant ↑ in CSF [Alb] suggests local production of IgG like in:**
 - ✓ multiple sclerosis (MS)
 - ✓ subacute sclerosing panencephalitis (SPEE)

$$\frac{\text{CSF IgG/Serum IgG}}{\text{CSF serum Albumin index}} = \text{CSF IgG index: Normally: } < 0.7 \quad *$$

CSF ALBUMIN

- ❑ **Albumin is produced solely in the liver**
- ❑ **Its presence in CSF must occur through BBB**

$$\frac{\text{CSF Albumin (mg/dL)}}{\text{Serum Albumin (g/dL)}} = \text{CSF serum albumin index: If } < 9 = \text{intact BBB} \quad *$$

What to do if ↑ CSF [protein] was detected?

=> Perform electrophoretic separation (CSF electrophoresis)

If multiple banding (*oligoclonal bands*) of the γ -globulin is detected

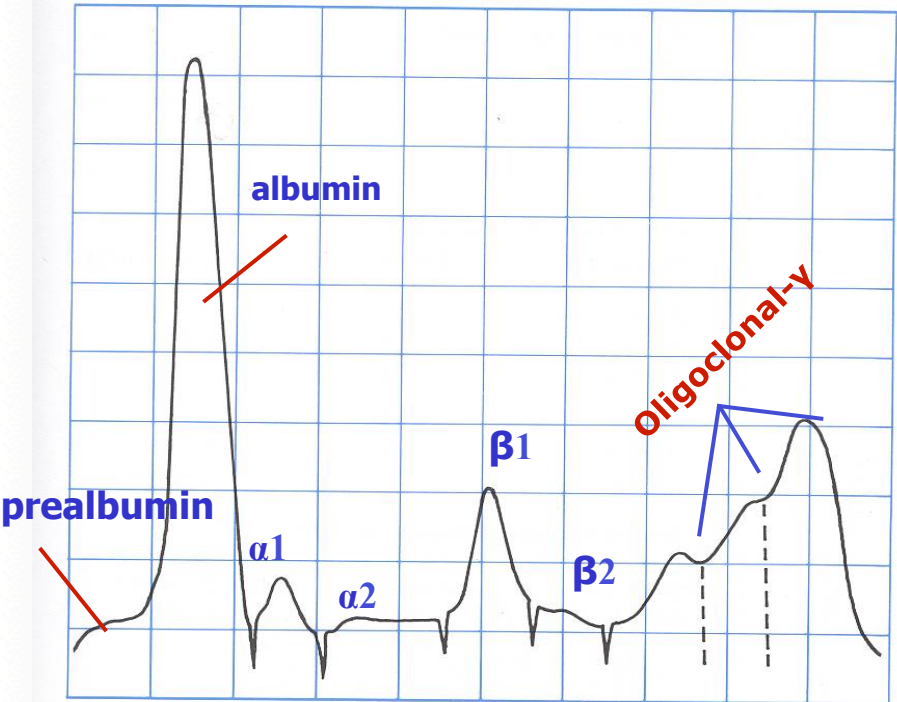
the following differential diagnosis is suspected:

- ❑ MS
- ❑ SSPE
- ❑ Inflammatory diseases

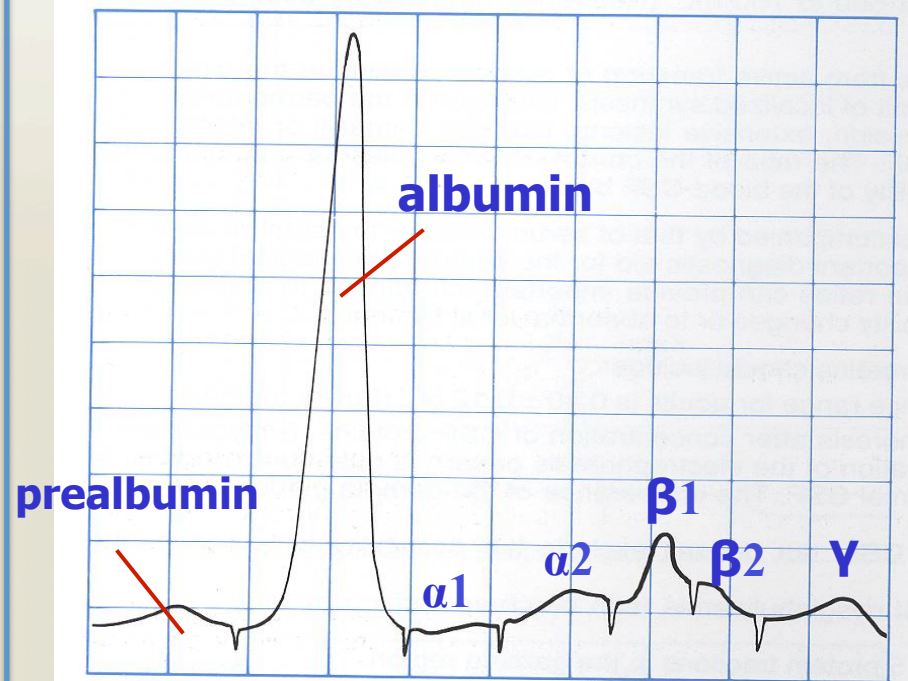
* Just for demonstration

CSF ELECTROPHORESIS

Oligoclonal Banding



NORMAL PATTERN



Other Chemical Components of CSF

- CSF [Calcium], [Potassium] & [Phosphates] are lower than their levels in the blood.
 - CSF [Chloride] & [Magnesium] are higher than their levels in the blood
- ↓
- Abnormal CSF [Chloride]
 - marked ↓↓ in acute bacterial meningitis
 - slight ↓ in viral meningitis & brain tumors

Normal composition of CSF¹

Appearance	Clear ,Colorless
Lymphocytes	<5/mm ³
Polymorphs	Nil
pH	7.4
Total Volume	100 - 150 ml
Daily Secretion	450 - 500 ml
Specific Gravity	1.006 - 1.007
Protein	0.15 – 0.45 g/L
Glucose	50 - 80 mg/dL (2.8-4.2 mmol/L) (>50% plasma level)
Chloride	115 - 130 mmol /L
Calcium	1.0 - 1.40 mmol/L
Phosphorus	0.4 - 0.7 mmol/L
Magnesium	1.2 - 1.5 mmol/L
Potassium	2.6 - 3.0 mmol/L

1: No need to memorize them. References rates will be given in the exam

Abnormal findings of CSF in some pathological conditions

Parameter	Condition		
	Bacterial Meningitis (pyogenic)	Tuberculous Meningitis	Viral Meningitis
Appearance	Often turbid	Often fibrin web	Usually clear
Predominant cell	Polymorphs	Mononuclear	Mononuclear
Cell count/mm ³	90-1000+	10-1000	50-1000
Bacteria	In smear & culture	Often none in smear	None seen or cultured
Protein (0.15-0.45 g/L)	>1.5 (↑ ↑)	1-5 (↑ ↑)	<1 (Normal)
Glucose (2.8-4.2 mmol/L)	<1/2 plasma (↓ ↓)	<1/2 plasma (↓ ↓)	>1/2 plasma (Normal or slightly ↓)
Chlorides (115 - 130 mmol/l)	↓ ↓	↓ ↓	Normal or ↓

Otorrhea: leakage of CSF from the ear

Rhinorrhea: leakage of CSF into the nose

Q: How to identify it as CSF?

=>Measure β-transferrin (a protein unique to the CSF)

1) CSF sampling is contraindicated in which ONE of the following ?

A- CSF infections

B- Vertigo

C- Increased intracranial pressure

D- Immunocompromised patients

2) While sampling CSF from a patient, the nurse noticed that a bright red color of blood has appeared and it was decreasing in color as he continue sampling. This hemorrhage is most-likely due to:

A- Traumatic tap.

B- Subarachnoid hemorrhage.

C- Infection at site of needle insertion.

D- The sample is normal.

3) Increased CSF (GLUCOSE) is a confirmation of :

A- Diabetes mellitus

B- Not clinically informative

C- Presence of micro organisms in CSF

D- Hypoglycemia

4) CSF (GLUCOSE) in a patient with viral meningitis is expected to be :

A- Very high

B- Very low

C- Normal

D- Depend on the cause.

5) Abnormal CSF total protein can be an indicator of which of the following pathological states

A- Tumors

B- MS

C- Bacterial or fungal infection

D- Hemorrhage

E- All of them

6) A CSF sample was taken from a 55-years old female for her annual check up, the biochemistry lab noted the presence of oligoclonal band of of γ -globulin In electrophoresis, this CAN indicate which ONE of the following:

A- SSPE

B- Hemorrhage

C- Tumors

D- Autoimmune diseases

7) Which ONE of the following components is present in higher levels in CSF than in the blood

A- Ca

B- Zn

C- Phosphate

D- Cl

8) The following schedule illustrate the result of some parameters of CSF sample.

Parameter	Result	Reference rate
Appearance	Fibrin web	clear
Predominant cell	Mononuclear	--
Protein	4 g/dl	0.15-0.45 g/L
Bacteria	None appear in smear	None

Based on the results shown above, the most-likely diagnosis is:

A- Bacterial meningitis

B- Viral meningitis

C- Tuberculous meningitis

D- SSPE

If you have any questions or comments, don't hesitate to contact us



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Thank You!

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