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PHYSIOLOGY OF CEREBROSPINAL FLUID

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CSF

Intermediate between blood and nervous tissue.

Pressure – Hydrocephalus

- damages
- nervous tissue



CSF

- Ventricles** - 4 in humans, 5 in rats, volume=35-80ml, 37 ml(av.)
- Spinal canal** - vestigeal in humans
- Subarachnoid spaces** 7 cisterns
- Foramina** Monroe absent in cat, dog, pig, sheep, chicken



CSF-Chemical composition

Secretion

Not a dialysate or filtrate of plasma,

Na^+ , Cl^- , Mg^+



K^+ , Ca^{++} , Urea, Glucose



CSF production

- Secreted mainly (40%) by the choroid plexus of the 4th ventricle. { LV > III V }
- extraventricular source ?
parenchymal capillaries
- Na^+ - K^+ pump basic mechanism
- rate = $350 \mu\text{L}/\text{min}$
- renewal rate = $0.38\% / \text{min}$

CHOROID PLEXUS

Out pouching of highly vascularised pia mater in four discrete regions, lined by tall, cylindrical ependymal cells.

A fold of epithelium with

core - modified pia

lining- modified ependyma

plexus surface - *villi*
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CHOROID PLEXUS

- **VILLI** 200 cm²
- **VASCULAR SUPPLY** antr. and postr. choroidal arteries, rich venous network
- **CHOROIDAL EPITHELIUM** ciliated



CSF-Drainage mechanisms

Lacuna lateralis - sites of openings of the subarachnoid space into dural sinuses.

Plexus of terminal arborisations of the meningeal and diploic veins and the tributaries of the sinuses coalescence of venous channels and attenuation of dural tissue.

The floor fasciculated, perforated by arachnoid protrusions; cavities have dural strands.



CSF-Drainage mechanisms

Arachnoid granulations - sites of evaginations of the arachnoid membrane into the lumen of dural sinuses.

valvular



CSF

Rate of production	500ml/day
quantity	120-150ml
quantity in ventricles	40ml



CSF

OSMOLARITY

292-297 mosmol/L

Na

137-145 meq/L

K

2.7-3.9 meq/L

Cl

116-122 meq/L

pH

7.31-7.34



CSF

Glucose	40-70 mg/dL
Protein	20-45 mg/dL
Ammonia	25-80 μ g/dL
Myelin Basic protein	< 4ng/mL
Leukocytes	< 4/mm ³
CSF volume	100-160 mL
CSF pressure	50-180 mmH ₂ O

CSF

- 2ml for sugar, protein and cell count
- Simultaneous blood sample for sugar
- CSF culture - aerobic, (anaerobic, fungal)
- CSF concentrated - centrifugation/filtration
- Gram smear

Polymorphs

ac. bacterial meningitis

Lymphocytes

TB, fungal, protozoal

mononuclear cells

aseptic meningitis

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CSF

ACUTE BACTERIAL MENINGITIS

- Leukocytes 5000-20,000 cells/mL
{ >50,000 =?Ventriculitis}

NEUTROPHILS

mononuclear cells -partially Rx

Lymphocytes - 1/3 ;1000 cells/mL

- protein 150-500 mg/dL
- sugar <40mg/dL
<40 mg % of blood sugar
(<250mg/dL)

CSF

ACUTE VIRAL MENINGOENCEPHALITIS

cells	50-500/mm ³ . PMNcells
protein	mild-moderate ↑↑
glucose	normal

MULTIPLE SCLEROSIS

cells	<10 /mm ³
protein	<60mg/dL
Ig G	↑↑
Myelin Basic Protein	↑

CSF FLOW

- **steady slow egress from Ventricles**
- **to-and fro high-velocity motion**
 - **systolic & diastolic contractions of brain**
 - **'flow void' on MR**

CSF FLOW

Degree of flow void and velocity
do not have a linear relationship.

Best seen on gated images.

CSF FLOW-MR

CSF flow analysis helps

- in diagnosis- Communicating HC,
partially obstructed
HC, NPH
- in planning Rx- 3rd ventriculostomy
v/s shunt,
- in Follow-up - 3rd ventriculostomy



CSF FLOW- MR techniques

- MR velocity density imaging
- Saturation pulses & bolus tracking
- SPAMM spatial modulation
 of magnetization
- Phase contrast



CSF FLOW- MR techniques

Phase contrast

- cardiac gating- prospective
retrospective

- background phase

'0' net flow assumption
additional acquisition



CSF FLOW- MR techniques

Phase contrast

2D flow-compensated FISP

(Fast Imaging with Steady-State Precision)

TR=70msec, TE=12 msec, 10 flip angle, 192*256 matrix,

velocity encoding 100mm/sec.

6mm



CSF FLOW- MR techniques

Phase contrast

- * midline sagittal acquisition for flow visualisation
- * TR=70 TE=15.8 Flip angle 10°
6mm thick
- * angled axial through aqueduct for flow quantification
- * TR=100 TE=12 Flip angle 10°
512 matrix

CSF FLOW- Normal

Cranial and **caudal** flow through aqueduct and foramen of Monroe

Caudal wave first starts in the fourth ventricle(?pulsations of the choroid plexus in 4th ventricle)

100 msec later (i.e. 175-200msec after the R wave, caudal flow through the aqueduct

CSF FLOW- Abnormal

Cranial and **caudal** flow through aqueduct and foramen of Monroe

Cranial flow through the aqueduct may occur when the first caudal motion through foramen of Magendie is seen

- > **size of nearby vascular structures**
- > **compliance of surrounding brain**
- > **volume & vascularity of choroid plexus**
- > **anatomy of CSF spaces**



CSF FLOW

Aqueduct

sinusoidal, craniocaudal → Normal
sinusoidal, caudocranial → Shunt pts.

Shunt tube

unidirectional → Patency
sinusoidal → Malfunction

3rd Ventriculostomy

biphasic → Patency



CSF FLOW

"Cyst-rebound" sign

lower-amplitude, 90° phase-advanced in the cyst

cyst wall is compliant

velocity encoding - 5cm/s

can differentiate cysts from epidermoids and enlarged spaces

flow disordered in cyst;

flow complex in epidermoids

CSF FLOW

NPH

- Accentuated 'flow void' on PDi
- Stroke volume $> 42 \mu\text{L}$

CSF

High-resolution proton NMR spectroscopy

for rapid and simultaneous detection of molecules involved in intermediary and oxidative metabolic pathways

eg. neurodegenerative disorders

Magnetisation Transfer

MTR may provide etiological diagnosis in meningitis

viral	08.2	Tuberculous	19.49
Fungal	27.2	Pyogenic	30.01



CSF

FLAIR

diagnosis of SAH (>24hrs)
meningeal diseases

Gd-FLAIR

Gd-T1w with MT

CISS-3D

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