PHYSIOLOGY OF CSF AND PATHOPHYSIOLOGY OF HYDROCEPHALUS

Introduction

- Dynamic component of CNS
- Invaluable tool to diagnosis
- Physiological reservoir of human proteome
- Reflects the physiologic state of CNS

Historical account

- Hippocrates described fluid in brain
- Galen described ventricles
- Vesalius showed the anatomy
- Megendi performed first cisternal puncture in animals
- Quinke performed first LP
- Dandy was credited first ventricular puncture
- Quekensted did first cisternal puncture in humans.

Functions of CSF

- Mechanical cushion to brain
- Source of nutrition to brain
- Excretion of metabolic waste products
- Intracerebral transport medium
- Control of chemical environment
- Autoregulation of intracranial pressure

Production of CSF

- Choroidal
- Extrachoroidal
  - Ependyma
  - ? Neighboring brain substance

Facts of interest

- Only choroidal CSF production is tightly regulated active process
- CSF secretion shows diurnal variation with peak in the morning.

Factors affecting production

- Vascular bed autoregulation
- Intracranial pressure
- Brain metabolism
- Drugs

Absorption of CSF

- Arachanoid granulations
- Along the olfactory nerves
- Extracellular spaces in brain
- Brain substance (glial cells).

Factors affecting absorption

- Intracranial pressure

Quantitative dynamics

- Daily secretion:
- Total CSF volume:
  - Ventricular
  - Cisternal
  - Spinal

Techniques of CSF analysis

- Lumber puncture
- Cisternal puncture
- Ventricular puncture

Lumber puncture

- **Diagnostic indications:**
  - Infective pathology
  - Inflammatory pathology
  - Subarachanoid hemorrhage
  - Malignancy and spread
  - Pressure recordings
  - Cisternography, myelography,

- **Therapeutic indications:**
  - CSF drainage
  - Drug delivery

Contraindications

- **Absolute**
  - Posterior fossa mass
  - Coagulopahty, blood dyscrasias
  - Known spinal AVM
- **Relative**
  - Raised ICT (guarded LP)
  - Local infection

Technique

- Positioning
- Cleaning and draping
- Puncture
- CSF

Complications

- Post LP headaches
- Hematoma
- Infection
- Neural injury
- Iatrogenic dermoids

Other methods

- Cisternal puncture
- Lateral cervical puncture
- Ventricular puncture

Ventriculostomy

- Dandy`s point
- Keen`s point
- Frazier`s point
- Kocher`s point

Analysis

Glucose	**60-90**	**≥ 0.66**
Proteins	35mg/dl	0.005
globulins	10-50 mg/L	0.001
RBC	0-1	
WBC	0-1 (L)	
Lactate	1.6	1.6

Diagnostic characteristics

Type	Sugar	Cells	Lactate
Bacterial	Very low	Neutrophils	Increased
Fungal	low	L/N	-
Viral	Normal to low	L/N	-
Aseptic	Normal	Neutrophils	Normal
Post operative	Normal	Neutrophils (≥1000)	

Hydrocephalus

- Definition
  - Imbalance between production and absorption of CSF leading to accumulation of fluid in the ventricular system leading to elevation of intracranial pressure.

Epidemiology

- Infantile HCP: 3-4 per 1000 LB
- As a single congenital disorder: 0.9-1.5 per 1000 live births
- Associated with SD: 1.3-2.9 per 1000 LB

Classification

- Communicating
  - AKA extraventricular,
- Noncommunicating
  - AKA obstructive
  - Triventricular
  - Biventricular

CLASSIFICATION OF HYDROCEPHALUS

NON COMMUNICATING HYDROCEPHALUS	COMMUNICATING HYDROCEPHALUS
I. CONGENITAL LESIONS **A. AQUEDECTAL OBSTRUCTION (STENOSIS)** 1. GLIOSIS 2. FORKING 3. TRUE NARROWING 4. SEPTUM **B. ATRESIA OF THE FORAMINA OF LUSCHKA AND MEGENDIE (DANDY-WALKER CYST)** **C. MASSES** 1. BENIGN INTRACRANIAL CYST 2. VASCULAR MALFORMATION 3. TUMOURS **II. ACQUIRED LESIONS** **A. AQUEDECTAL STENOSIS(GLIOSIS)** **B. VENTRICULAR INFLAMATIONS AND SCARS.** **C. MASSES** 1. TUMOURS 2. NON-NEOPLASTIC MASSES	**I. CONGENITAL LESIONS** **A. ARNOLD-CHIARI MALFORMATION** **B. ENCEPHALOCELE** **C. LEPTOMENINGEAL INFLAMATION** **D. LISSENCEPHALY** **E. CONGENITAL ABSENCE OF ARACHNOIDAL GRANULATIONS** **II. ACQUIRED LESIONS** **A. LEPTOMENINGEAL INFLAMATION** 1. INFECTIONS 2. HEMORRHAGE 3. PARTICULATE MATTER **B. MASSES** 1. TUMOURS 2. NON-NEOPLASTIC MASSES **C. PLATYBASIA** **III. OVERSCREATION OF CSF (CHORIOD PLEXUS PAPILLIOMA)**

Pathogenesis

- Obstruction of CSF pathways leading to decreased absorption
- Increased production
- Increased venous pressure

Increased production

- Choroid plexus papilloma

Decreased absorption

- Due to anatomical block in the pathways
- Block at arachanoid granulations level

Increased venous pressure

- Evidence with this theory
  - VOGM
  - Experimental studies in animals
- Evidence against this theory
  - Ligation of various sinuses doesn't cause HCP
  - Experimental studies

Pathology of hydrocephalus

- Atrophy of white matter
- Spongy edema of brain
- Fibrosis of choroid plexuses
- Stretching and denuding of ependyma
- Fenestration of septum pellucidum
- Thinning of interhemispheric commisures

Acute HCP

- Cerebral, IV or cerebellar hematoma
- Paraventricular tumors
- Gunshots
- Subarachanoid hemorrhage
- Acute head injuries
- Shunt malfunction.

Progression

- **Ventricular dilatation**
  - Occipital and frontal horns f/b temporals
  - Anterior and posterior recess of TV
  - Fourth ventricle
  - Third ventricular balloning

Hydrocephalic edema

- Available space in the cavity consumed
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- Stretching and denuding of ependyma
- Edema of white matter
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Mechanism

- Stasis of brain interstitial fluid
- Reflux of CSF into the periventricular area
- Increase in cerebral capillary permeability

Progression

- Dorsal angles of lateral ventricle
  - 3-6 hrs
- Centrum semiovale
  - 19-24 hrs
- Diffuse
  - afterwards

Chronic HCP

- Compensatory mechanisms in chronic HCP
  - Expansion of skull
  - Contraction of cerebral vascular volume
  - White matter atropy and ventricular enlargement
  - Decreased rate of CSF formation.
  - Diversion of CSF flow to alternative pathways

Changes in cerebral circulation

- Increased venous pressure
- Delayed emptying of cerebral veins
- Narrowing of cerebral arteries
- Prolongation of circulation time
- Reduced cerebral blood flow
- Lowering of CMRO2
- Reduced glucose metabolism

Clinical features

- Age
- Expansibility of skull bones
- Type of HCP
- Duration of HCP

Pediatric hydrocephalus

- Enlargement of head
- Thin and glistening scalp
- Tense, bulging fontanalles
- Dilated and tortuous scalp veins
- unilateral or bilateral abducent palsies
- Cracked pot or macewen`s sign
- Hypopituitarism and growth retardation
- Transillumination of skull

Adult acute HCP

- Headache, nausea, vomitting
- Alteration of sensorium
- Visual obscurations
- Perinaud`s syndrome
- Progression to herniation syndromes

Adult chronic HCP

- Bifrontal generalized headache, vomitting
- Papilloedema and secondary optic atrophy
- Congnitive deficits
- Unilateral or bilateral abducent palsies
- Upward gaze palsy
- Spastic quadriparesis, dysmetria,
- Bitemporal hemianopia
- Endocrine disturbances

Normal pressure hydrocephalus

- “Hydrocephalus with normal CSF opening pressure on lumber puncture and absence of papilloedema”

Pathophysiology

- Intermittant rise of CSF pressure causing ventricular dilatation.
- Intraventricular pressure head is decreased

Basis of clinical symptoms

- Gait problems
- Urinary incontinence
- Memory problems

Arrested hydrocephalus

- Definitions
  - CSF pressure has normalized
  - Pressure gradient between ventricles and parenchyma has been dessipated
  - Ventricular size remains stable or decrease
  - New neurological deficits do not appear
  - Advancing psychomotor development with age.

Pediatric NPH

- Enlarged head usually in or above ninth percentile
- History of delayed psychomotor development
- Mild to moderate mental retardation
- Glib verbal abilities
- Mild spastic paraparesis

Hydrocephalus ex vacuo

- Cerebral atrophy and dilatation of sulci
- Intracranial pressure is normal
- Absence of periventricular edema
- Absence of retrograde filling Isotope cisternography

- Thank you