Physiology of CSF and Pathophysiology of Hydrocephalus

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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.

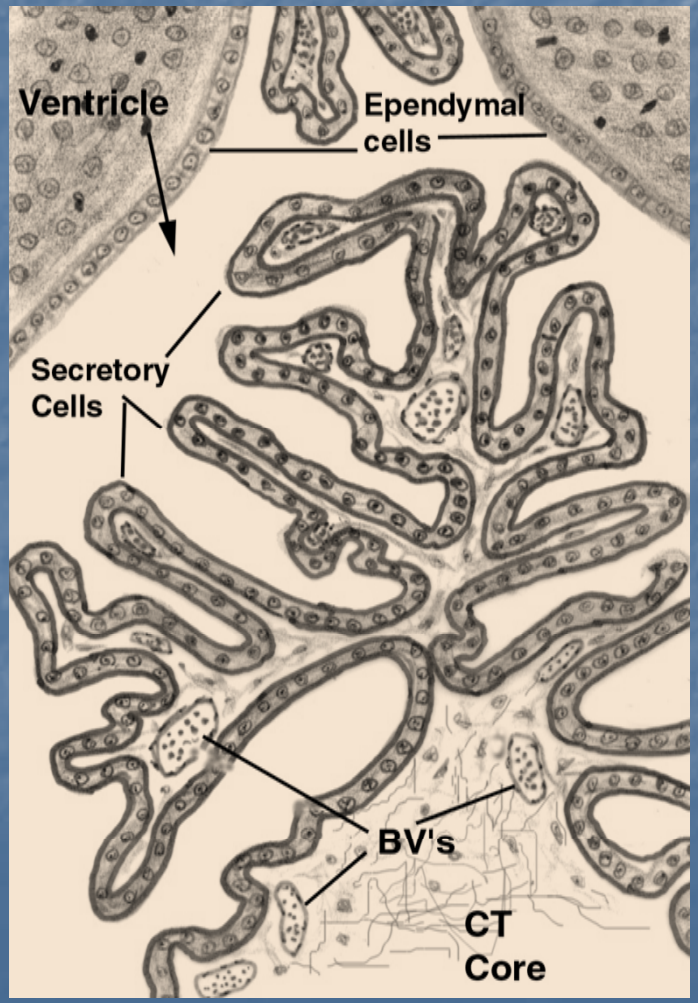
Functions of CSF

- 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

Histology of choroid plexus



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

CSF pathways

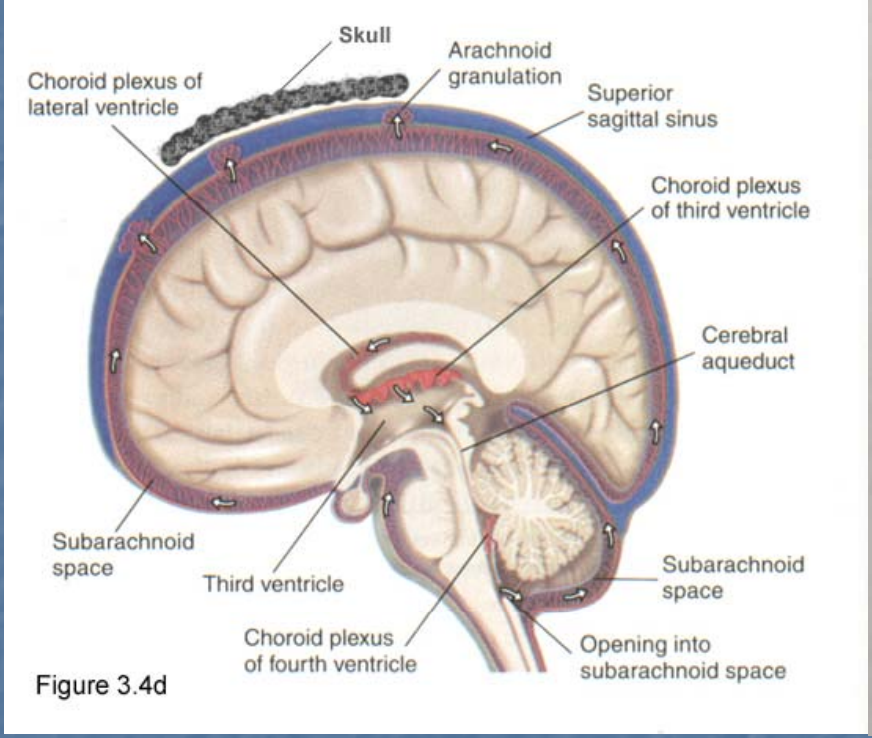
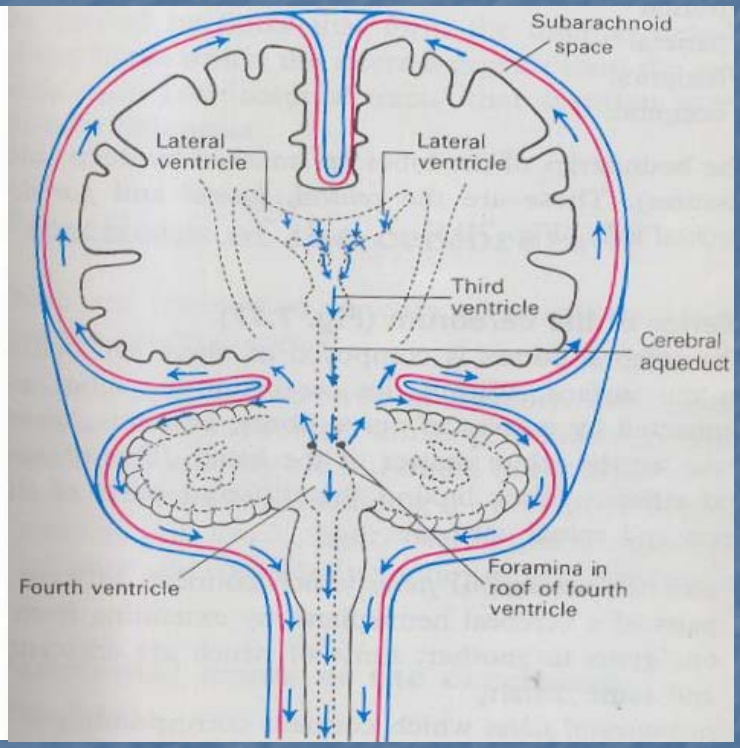


Figure 3.4d



Techniques of CSF analysis

- Lumbar puncture
- Cisternal puncture
- Ventricular puncture

Lumbar puncture

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

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

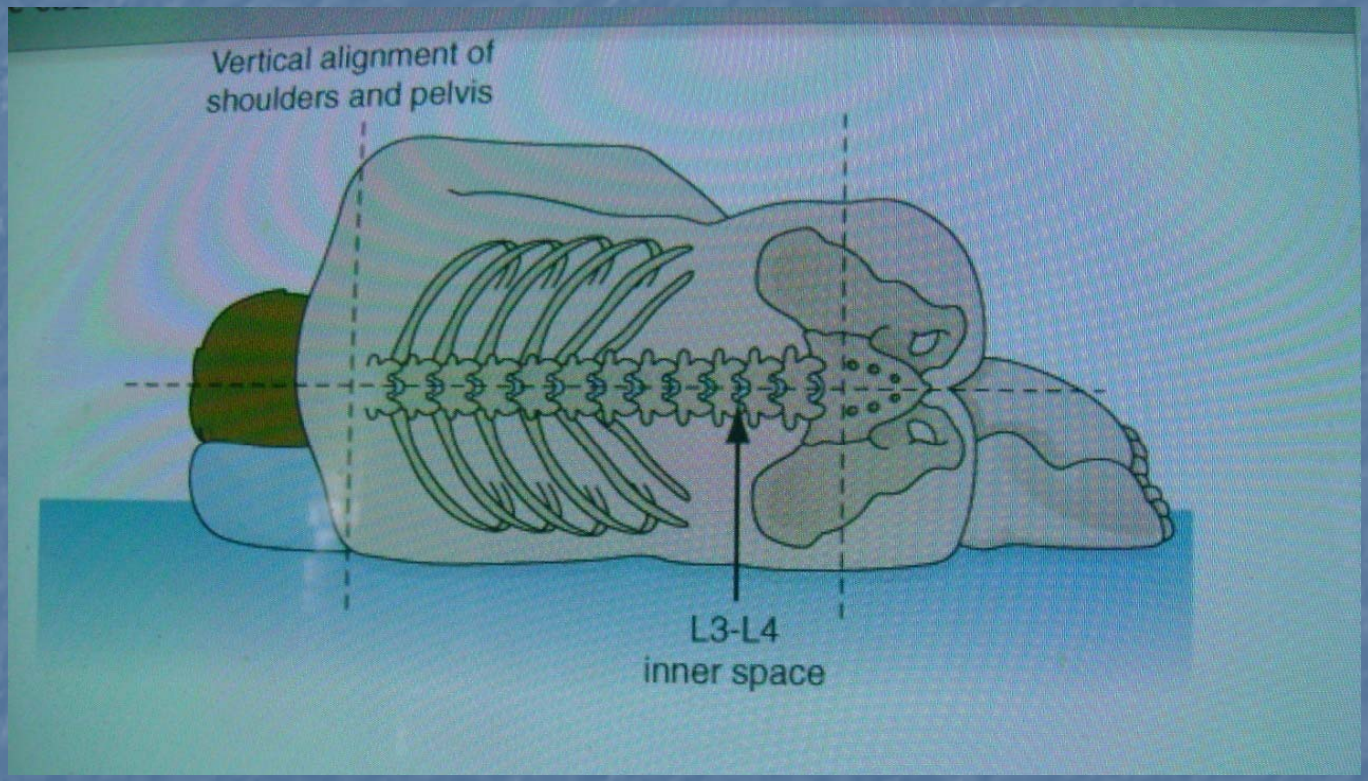
Contraindications

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

Technique

- Positioning
- Cleaning and draping
- Puncture
- CSF

figure


Vertical alignment of
shoulders and pelvis
L3-L4
inner space

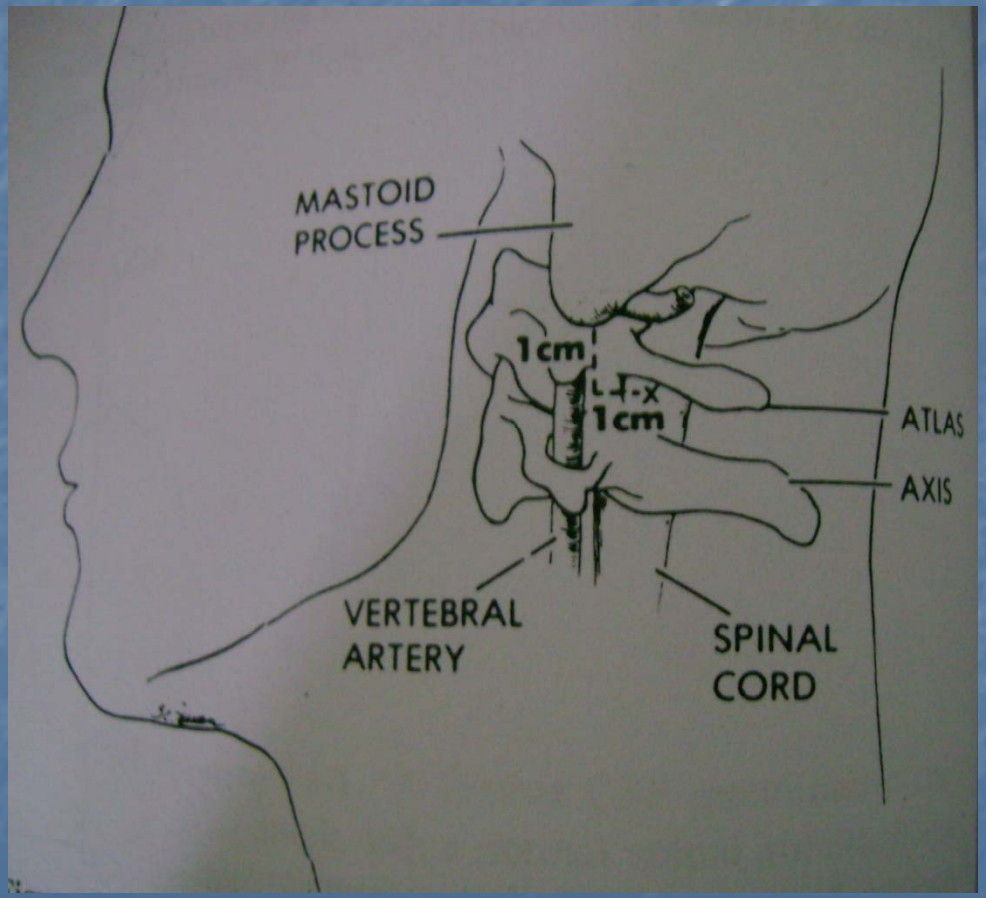
Complications

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

Other methods

- Cisternal puncture
- Lateral cervical puncture
- Ventricular puncture

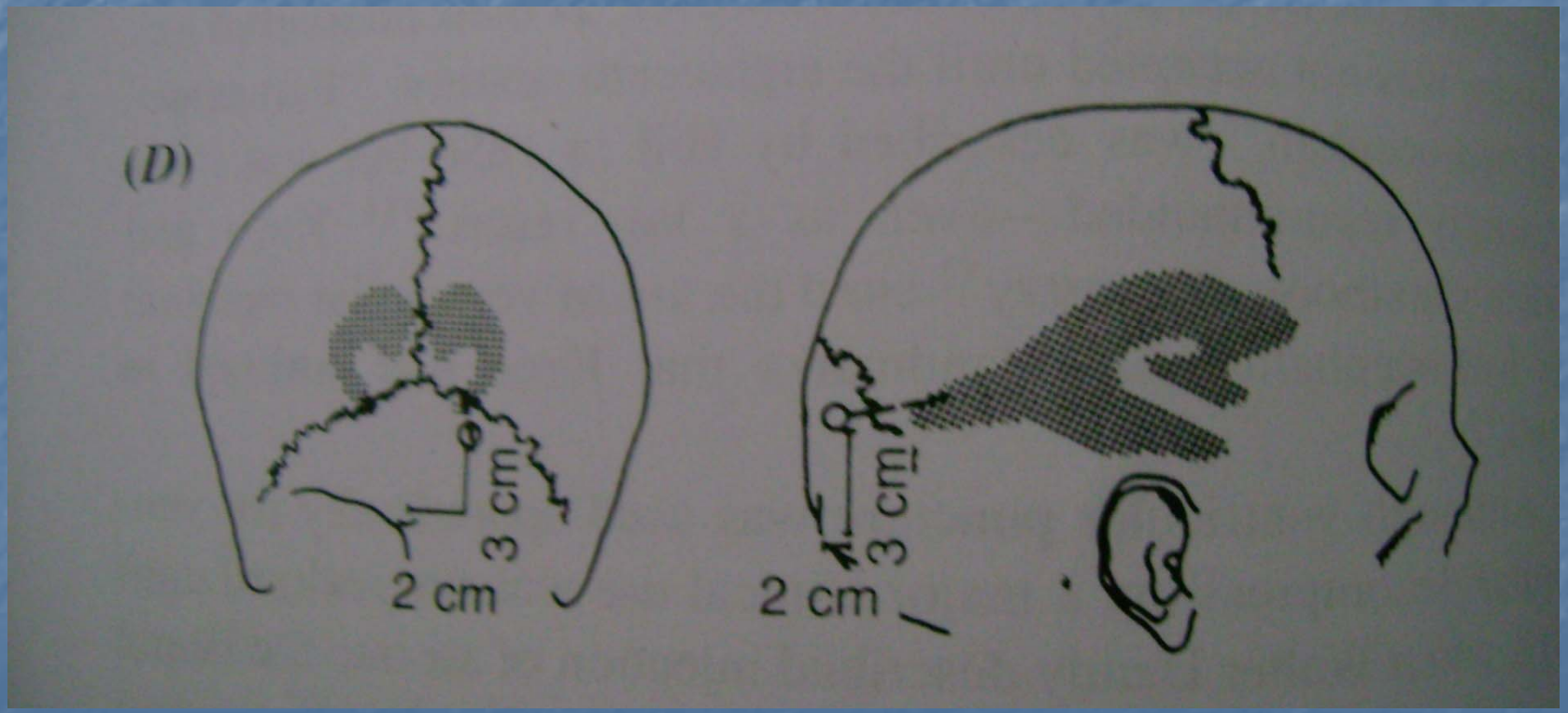
Lateral cervical puncture



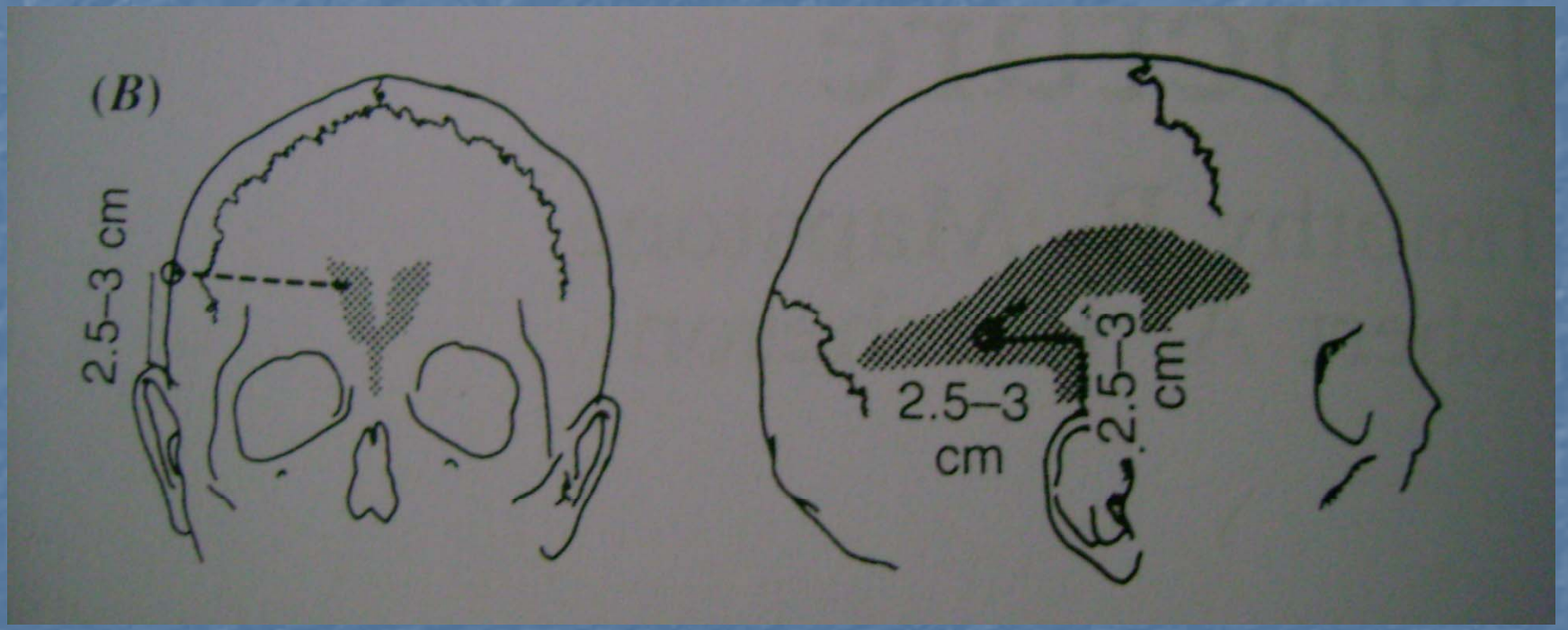
Ventriculostomy

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

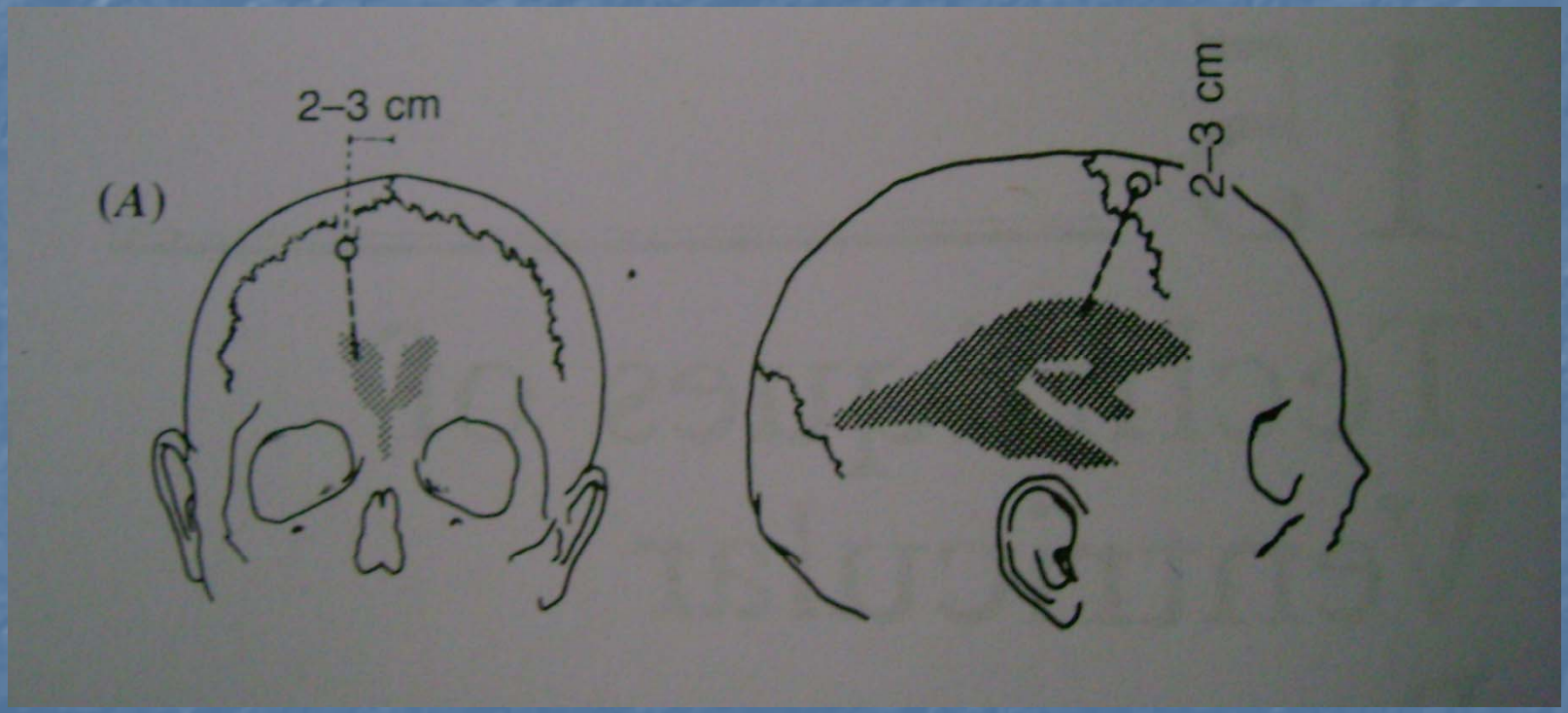
Dandy`s point



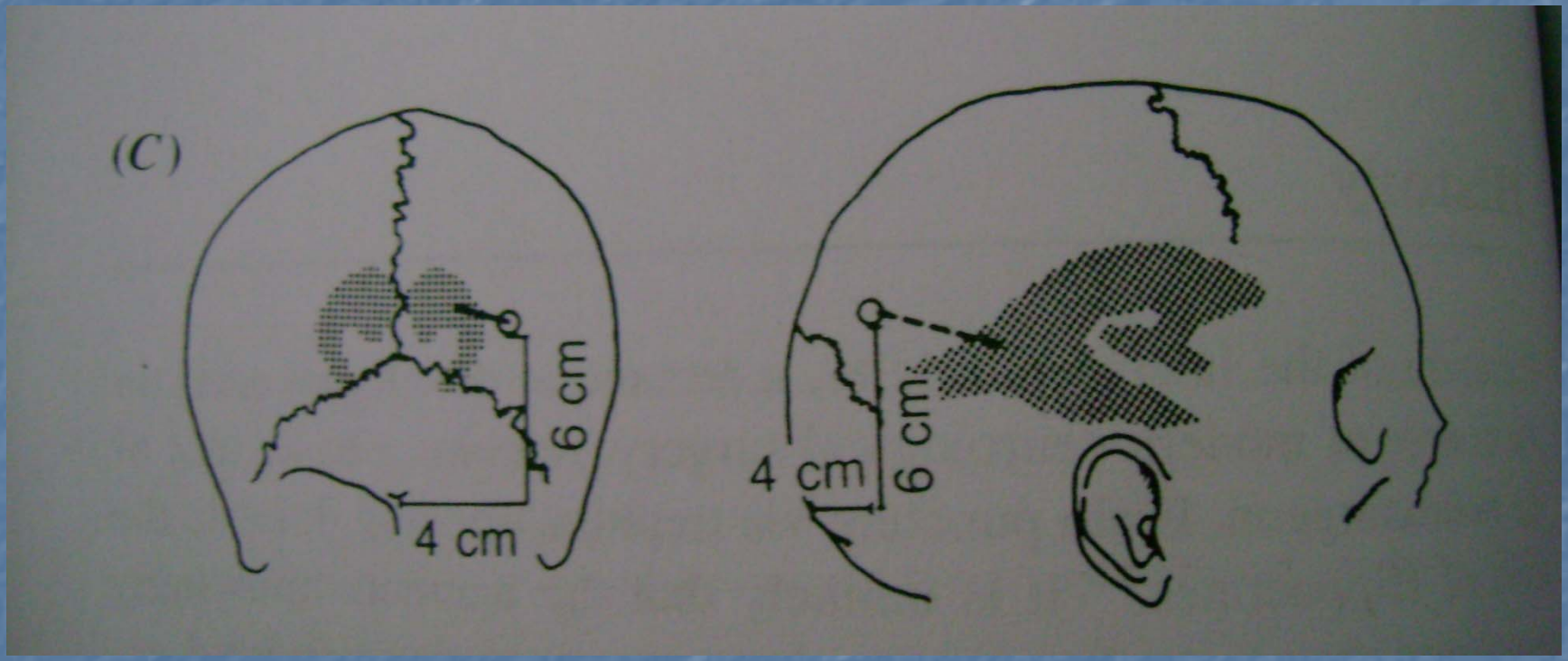
Keen`s point



Kocher`s point



Frazier`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

TABLE 365-1 Classification of Hydrocephalus

Noncommunicating Hydrocephalus	Communicating Hydrocephalus
I. Congenital lesions	I. Congenital lesions
A. Aqueductal obstruction (stenosis)	A. Arnold-Chiari malformation
1. Gliosis	B. Encephalocele
2. Forking	C. Leptomeningeal inflammations
3. True narrowing	D. Lissencephaly
4. Septum	E. Congenital absence of arachnoidal granulations
B. Atresia of the foramina of Luschka and Magendie (Dandy-Walker cyst)	II. Acquired lesions
C. Masses	A. Leptomeningeal inflammations
1. Benign intracranial cysts	1. Infections
2. Vascular malformation	2. Hemorrhage
3. Tumors	3. Particulate matter
II. Acquired lesions	B. Masses
A. Aqueductal stenosis (gliosis)	1. Tumors
B. Ventricular inflammations and scars	2. Non-neoplastic masses
C. Masses	C. Platybasia
1. Tumors	III. Oversecretion of CSF (choroid plexus papilloma)
2. Non-neoplastic masses	

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 temporal horns
  - Anterior and posterior recess of third ventricle
  - Fourth ventricle
  - Third ventricular ballooning

Hydrocephalic edema

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

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 atrophy 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 fontanel
- Dilated and tortuous scalp veins
- Unilateral or bilateral abducens palsies
- Cracked pot or Macewen`s sign
- Hypopituitarism and growth retardation
- Transillumination of skull

Adult acute HCP

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

Adult chronic HCP

- Bifrontal generalized headache, vomiting
- Papilledema and secondary optic atrophy
- Congnitive deficits
- Unilateral or bilateral abducens palsy
- 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 Papilledema"

Pathophysiology

- Intermittent 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 dissipated
  - 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