Anatomy and Physiology of Hydrocephalus

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Hydrocephalus Association 12th National Conference; 6/27/2012
Typical MRI of Hydrocephalus

- This is communicating and not obstructive hydrocephalus
- The periventricular white matter is thinner than usual
- The cause is aqueductal stenosis
- This is slit-ventricle syndrome
Nothing “Magic”

It’s Mostly Just Vocabulary
Cerebral Ventricular System

Ventricles of Brain

- Anterior (frontal) horn
- Central part
- Inferior (temporal) horn
- Posterior (occipital) horn
- Cerebral aqueduct (of Sylvius)
- 4th ventricle
- L. lateral aperture (foramen of Luschka)
- L. lateral recess
- Median aperture (foramen of Magendie)

L. interventricular foramen (of Monro)

3rd ventricle
Optic recess
Interthalamic adhesion
Infundibular recess
Pineal recess
Suprapineal recess

Anatomical Orientation

*Head & Neck
“Horizontal”
“Axial”

Sagittal plane
Coronal plane
Transverse plane

Left Side
Left Side
Sagittal
Coronal
Left Side
Axial

Source: Neurosurg Focus © 2003 American Association of Neurological Surgeons

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Cerebrospinal Fluid (CSF) Production

CSF Formation:
- Choroid plexus (80%)
- Brain Tissue “Parenchyma” (20%)
- Normal rate
  12-15 ml/hr; 290-360 ml/day
- CSF spaces = 140 ml
Location of Choroid Plexus in Human Brain
Choroid Plexus Often Blocks the Ventricular Portion of the Shunt
CSF Flow & Absorption Pathways

**Directional (bulk) Flow**

Cranial & Spinal Pathways

Bulk Absorption

1. Arachnoid granulations/villi
   a. Cranial – superior sagittal sinus to internal jugular vein
   b. Spinal

2. Lymphatics – CNI & spinal roots

3. Tissue capillaries

**Pulsatile Flow**

Fishman RA: Cerebrospinal Fluid in Diseases of the Nervous System, 2nd ed, WB Saunders, 1992, Fig. 2-1.

CSF Absorption through Arachnoid Granulations into the Venous System
CSF Absorption through Arachnoid Granulations into the Venous System

Galea aponeurotica
Pericranium
Skin
Arachnoid granulation
Calvaria
Superior sagittal sinus
Emissary v.
Tributary of superficial temporal v.
Diploic v.
Epidural space (potential)
Dura mater
Subdural space
Arachnoid
Subarachnoid space
Pia mater
Cerebral a.
Superior cerebral v.
Falx cerebri
Cerebral hemisphere

Netter FH: The Ciba Collection of Medical Illustrations Vol 1 – Nerv. Syst. 1986
CSF Flow – Bulk vs. Pulsatile

**Flow Speed**

*Cerebral Aqueduct*
- Bulb flow ~ 0.3 cc/min
- Pulsatile flow ~ 2 cc/min

**Pulsatile Flow**
- Slower in cerebral aqueduct & over cortical surface
- Faster in basal cisterns

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Blood Supply to Choroid Plexus

- Ant. communicating a.
- Recurrent a. (of Heubner)
- Anterior cerebral artery
- Middle cerebral artery
- Post. communicating a.
- Ant. choroidal a.
- Optic tract
- Post. cerebral a.
- Cerebral peduncle
- Lateral geniculate body
- Post. medial choroidal a.
- Post. lateral choroidal a.
- Choroid plexus of lateral ventricle
- Medial geniculate body
- Pulvinar
- Lateral ventricle

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Functions of CSF

- **Diagnostic** – infection, hemorrhage, tumors, brain damage

- **Bouyancy** – protection from compressive & shearing forces

- **Physiological Balance** *(Homeostasis)*
  - “Clearing” substances from brain
  - Delivery of vitamins and other small molecules
  - Ion balance

- **Inter-brain Communication** *(Neurotransmission/Neuromodulation)*

- **Delivery of trophic factors** – cell production & maturation
Critical Balance between CSF Formation & Absorption

*CSF Formation*

- Choroid plexus (70%) & Parenchyma (30%)
- Normal rate = 12-15 ml/hr; 290-360 ml/day

*CSF Absorption Rate*

- Cranial & Spinal CSF volume = 140 ml
- Absorption must be ~ 2.5x formation per day or the VENTRICLES ENLARGE!

Causes of Hydrocephalus

- Intraventricular Hemorrhage
- Meningitis & Encephalitis
- Congenital Malformations
- Subarachnoid Hemorrhage
- Tumors & Cysts
- Normal Pressure Hydrocephalus
Types of Hydrocephalus

1. Intraventricular (obstructive)
   - Intraventricular hemorrhage 3
   - Aqueductal stenosis 1
   - Chiari malformations 5
   - Infectious Ventriculitis
   - Tumors 6

2. Extraventricular (communicating)
   - Infectious Meningitis 2
   - Subarachnoid Hemorrhage 4
     ▪ spontaneous
     ▪ traumatic
   - Venous hypertension 7
Vulnerable Brain Structures in Hydrocephalus

- Periventricular ("bordering ventricles") structures
- White matter – myelinated ("insulated") neuron processes connecting different parts of the brain
Vulnerable Brain Structures in Hydrocephalus

**Corpus Callosum**: connects R & L sensory and motor regions

- Visual problems
- Learning deficits based on visual cues

**Periventricular White Matter (PVWM)**: connects cerebral cortex to deep brain structures, cerebellum and spinal cord

- Muscle control/coordination/seizures
- Learning deficits
Ventricular Shunting for Hydrocephalus

Pre-shunt

Post-shunt

McComb and Zlokovic 1994
Third Ventriculostomy

LV

3rd Vent

SAS

LV: Lateral ventricle
3rd Vent: Third ventricle
SAS: Subarachnoid space
Don’t Miss the
Shunt Demonstration

This is easy! Why do I need a Neurosurgeon to do this?

You’ll be AMAZED
The End – *It’s Not Magic!*

Thank You & *Keep Learning!*