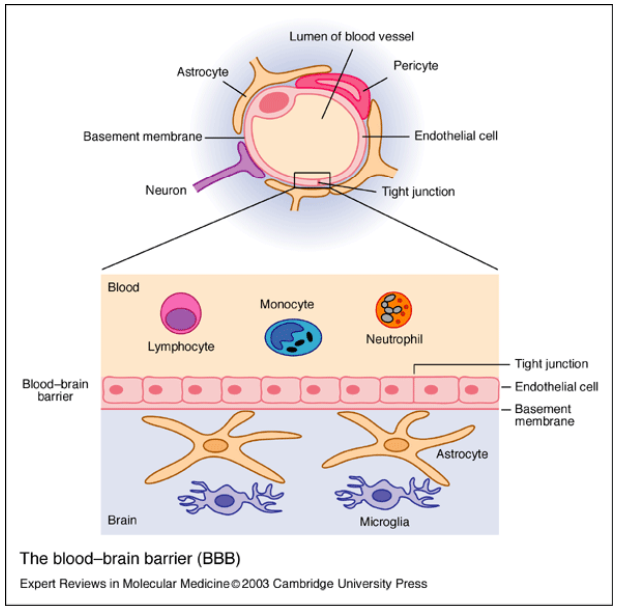
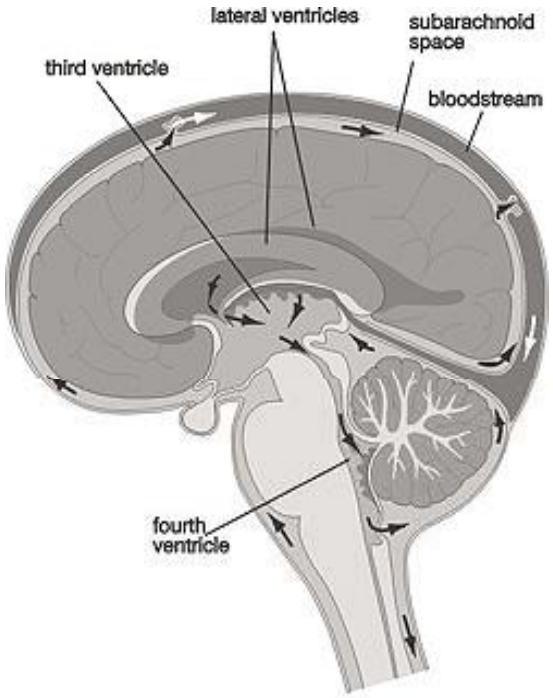
# Central Nervous System



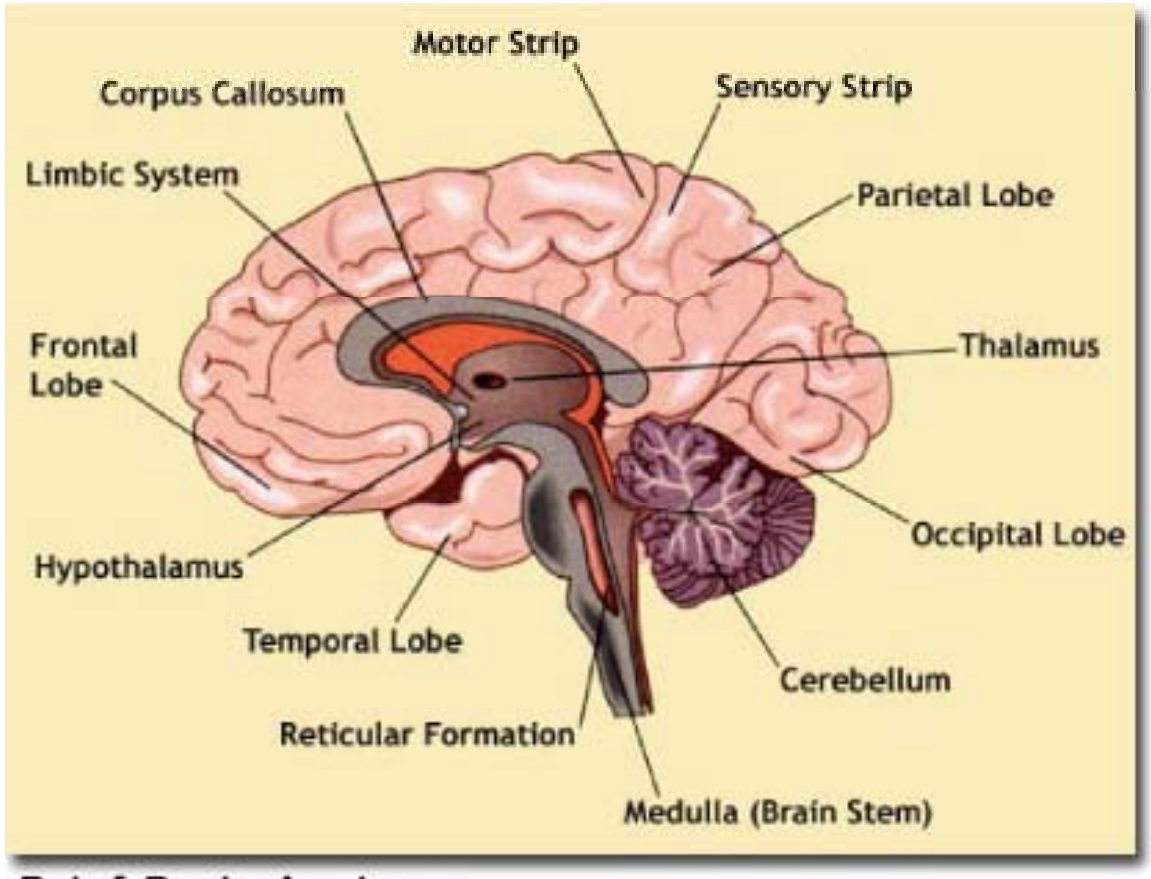

The blood–brain barrier (BBB)



The blood-brain barrier (BBB) is a membranic structure that acts primarily to protect the brain from chemicals in the blood, while still allowing essential metabolic function. It is composed of endothelial cells, which are packed very tightly in brain capillaries. This higher density restricts passage of substances from the bloodstream much more than endothelial cells in capillaries elsewhere in the body. Astrocyte cell projections called astrocytic feet surround the endothelial cells of the BBB, providing biochemical support to those cells




Cerebrospinal Fluid Flow




Brief Brain Anatomy

# Planar Brain Imaging

Indications:

- Brain Death
- Primary and metastatic tumors
- Intracranial inflammatory
- Cerebrovascular disease: hemorrhage and occlusion
- Hemotoma (post trauma)

Radiopharmaceuticals:

(NORMALLY DO NOT CROSS BLOOD BRAIN BARRIER):

- Tc99m: least desirable due to uptake in choroid plexus. Require potassium perchlorate.
- Tc99m DTPA or Tc99m GH: best to use. Clear far away from the brain, and offer optimal imaging characteristics.

Imaging:

- Flow: 1sec/frame for 1-2 minutes
- Immediate Blood Pool: 180 sec/frame immediately after the flow study
- Delays: 300 sec/frame depending on the indications may be done 15 min. – 2 hrs. after blood pool.

# Planar Brain Imaging

Patient Positioning:

- Vertex view is the ideal position for flow and statics. Lead shield over shoulders is required to block background radiation from the shoulders and below. If vertex view is not possible then:
- Anterior/Posterior positioning is acceptable .
- Laterals and Obliques may be helpful when imaging blood pool and delayed views.

Image Findings:

- Normal: Symmetrical distribution of the isotope in the right and left carotid arteries and visualization of the anterior cerebral artery. Visualization of the superior sagittal sinuses indicates that isotope is entering venous circulation. Sagittal, transverse and sigmoid sinuses will be visualized on the delayed images.
- Abnormal: any disruption of BBB is an abnormal finding.
  - Brain Death: no activity visualized above carotid arteries on flow, bp, or delayed images.
  - Inflammation: increased activity on flow and statics around the suspected area. (less focal than hematoma).
  - Hematoma: increased focal uptake around the suspected area. (more focal than inflammation).
  - CVA: occlusion of blood vessels demonstrated by narrowing of the affected blood vessels on flow study.
  - Flip-flop: one hemisphere is receiving more isotope in the beginning of the flow study. Pattern reverses by the end of the flow study.
  - Luxury perfusion: affected area is attempting to restore flow by dilating vessels responsible for CVA seen as increased flow to the affected area.

# SPECT BRAIN IMAGING

Indications:

- Cerebrovascular disease:  acute stroke, transient ischemic attacks.
- Dementia: Alzheimer's disease, multi-infarct dimentia.
- Schizophrenia.
- Seizires: location  of epileptic foci.
- Head trauma.

Radiopharmaceuticals (ALL CROSS BBB):

I123 iodofetamine not available in U.S.

Tc99m HMPAO (Ceretec) 30mCi

Tc99m Neurolite (ECD) 30mCi

All of the above isotopes are lipid soluble allowing them to cross BBB. Once across BBB the solubility changes and the agents remain in the brain tissue.

Injection technique:

- IV access ready (no direct sticks)
- Dim lights, eyes open, room quiet.
- Inject isotope wait 10 minutes
- Remove IV, let the patient go.
- Image 1-2 hours post injection.

# SPECT BRAIN IMAGING

Imaging Procedure:

- Prone positioning, head immobilized with straps and cushions. No pillow under patient's head.
- Triple head or double head cameras with highest resolution collimators.
- SPECT positioning should be as close to the patient as possible.
- Brain SPECT study is a long procedure, use your judgment when setting up the scan.

- Suggested SPECT setup:
  - 128x128.16 matrix
  - 128 views 30 sec/frame

Processing:

- Proper orientation must be achieved
- Coronal, sagittal, and transverse slices are generated..

Image Interpretation:

- Normal: symmetric distribution of isotope in both hemispheres. Gray matter concentrates much more isotope than the white matter.
- Abnormal:
  - Infarct: large defect directly related to the location of the CVA
  - Alzheimer's: decreased perfusion in the parietal and temporal lobe of both hemispheres
  - Multi-infarct dementia: random cold spots in both hemispheres
  - Schizophrenia: decreased uptake in the frontal lobe, with increased activity in the basal ganglia and temporal lobes
  - Epilepsy:
    - Injection during seizure: foci will concentrate isotope (intra-ictal)
    - Injection immediately after seizure: hypoperfusion of the foci (inter- ictal)

# DIAMOX STUDIES

- SPECIAL STUDIES:
- Acetazolamide (Diamox) may be used to increase the sensitivity of brain perfusion imaging for cerebrovascular ischemia (TIA's). Easy to remember hint: "DIAMOX IS TO BRAIN AS ADENOSINE TO THE HEART"
- 1. Contraindications for Diamox Study:
- a) allergy to sulfonamide.
- b) Current active transient ischemic attacks.
- 2. Side effects - occur in about 50% of patients & last for about 15 minutes:
  - a) numbness around mouth or fingers.
  - b) lightheadedness or blurred vision.
  - C) flushed feeling around face and neck.
- 3. Inject 1 gm of acetazolamide intravenously over 10-15 minutes.
- 4. Wait 15-20 minutes and then inject the radiopharmaceutical.
- 5. Wait 20 minutes and acquire images in the usual manner.
- 6. A baseline brain perfusion study without acetazolamide is performed one or more days later.
- Quantification: Activity in the tomograms may be quantitated on a regional basis.

# CISTERNOGRAPHY

CSF is produced in lateral ventricles of choroid plexus. From lateral ventricles CSF flows into third ventricle, then into fourth ventricle, and finally into subarachnoid space. CSF flows around the spinal cord and the brain in the subarachnoid space and is reabsorbed into venous circulation in the sagittal sinuses. CSF is produced and reabsorbed at the same rate to maintain constant pressure.

Indications:

- Evaluation of atrophy vs. normal pressure hydrocephalus
- CSF leaks
- Ventricular shunt patency

Patient Prep and Injection (Cysternography):

- In111 DTPA, 1.0 mCi in injected intrathecally into subarachnoid space between 3$^{rd}$ and 4$^{th}$ vertebrae. The tracer will follow the flow of the CSF. Injection is usually performed by a radiologist or a neurologist.
- After the injection, the patient remains supine for several hours to prevent leakage from the injection site.

Imaging:

- 4 hour images: ANT/POST of injection site. Tracer should be visualized in the subarachnoid space. If only a hot spot is seen and/or uptake in the kidneys, then the dose may have been infiltrated.
- 24 and 48 hours: ANT/POST of head, chest and abdomen. Lateral s of the head may be useful.

Image findings:

NPH: activity in the ventricles and cisterns is seen on 24 hours but is resolved by 48 hours.

Atrophy: activity does not resolve from the ventricles or cisterns by 48 hours.

# CISTERNOGRAPHY

CSF Leak studies:

- In patients with suspected trauma and/or reported possible clear discharge from nose (otorrhea) and/or ears (otorrhea), cotton swabs are inserted into ears and nose immediately after injection of In111 DTPA.
- Swabs are replaced and counted every time the patient returns for imaging.
- The background needs to be counted as well.

Shunt imaging:

In many cases, ventricular shunting of the CSF into the circulatory system or abdominal cavity is used to treat cases of NPH. Injection of the In111 DTPA or Tc99m directly into the shunt reservoir will clearly demonstrate shunt patency. Persistent tracer uptake in the shunt indicate partial or complete obstruction of the shunt.