

Definition and Classification of Hydrocephalus

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The definition and classification of hydrocephalus: a personal recommendation to stimulate debate

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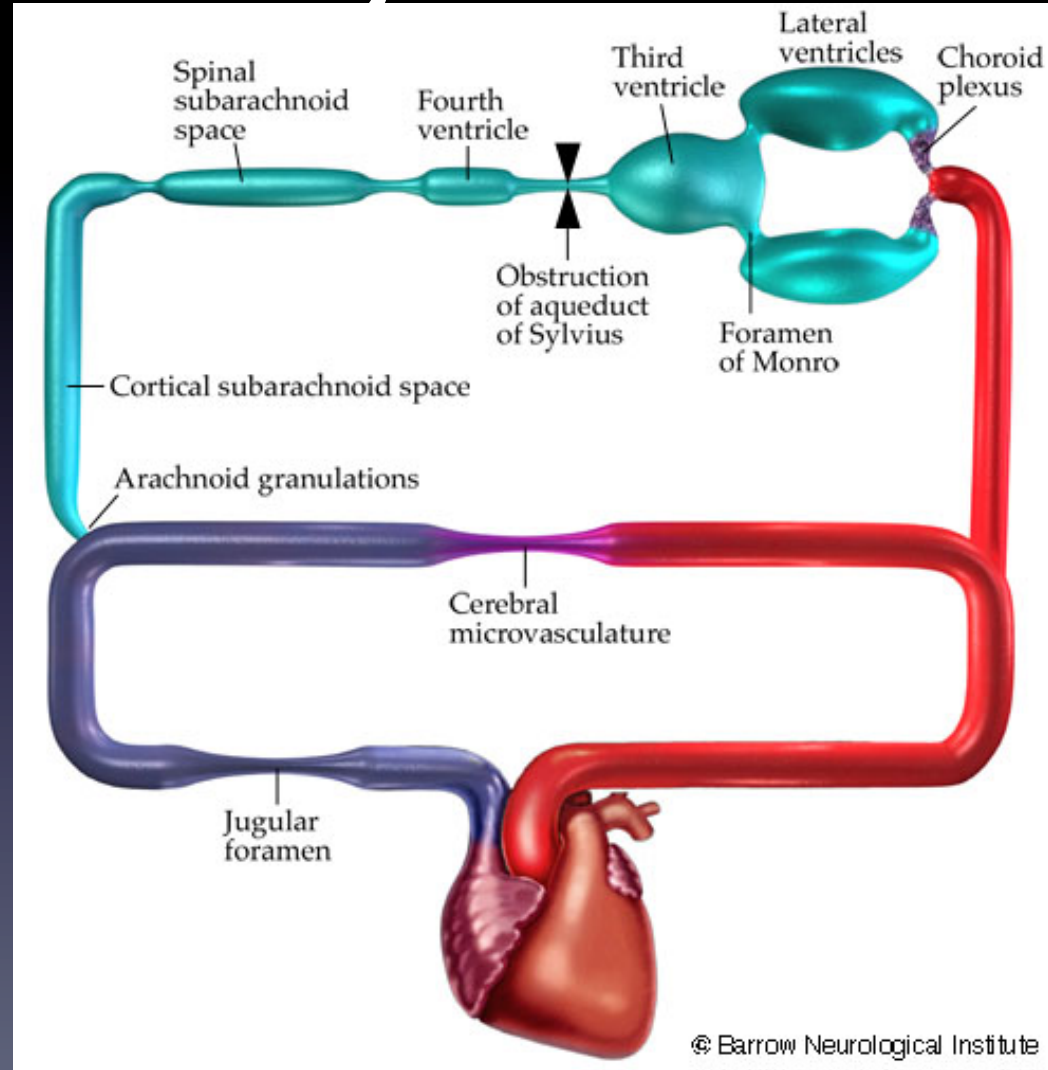
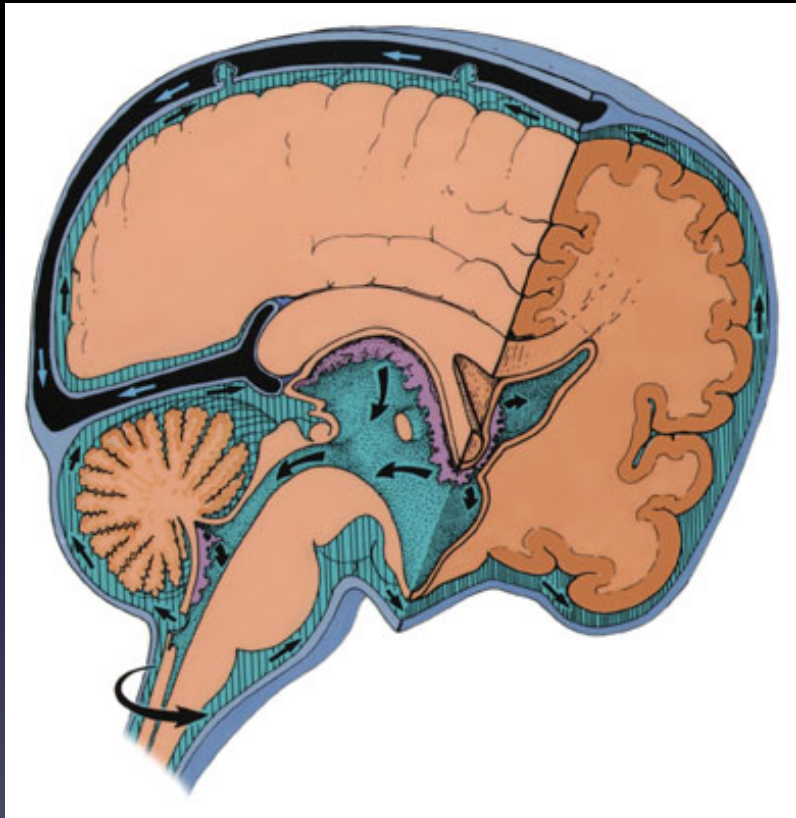
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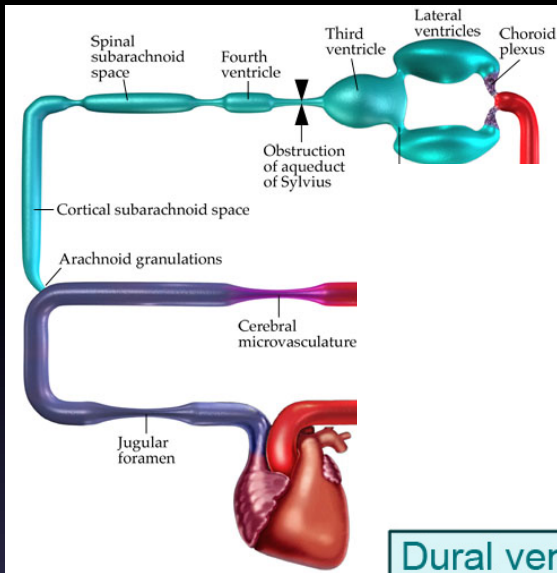
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How it Began



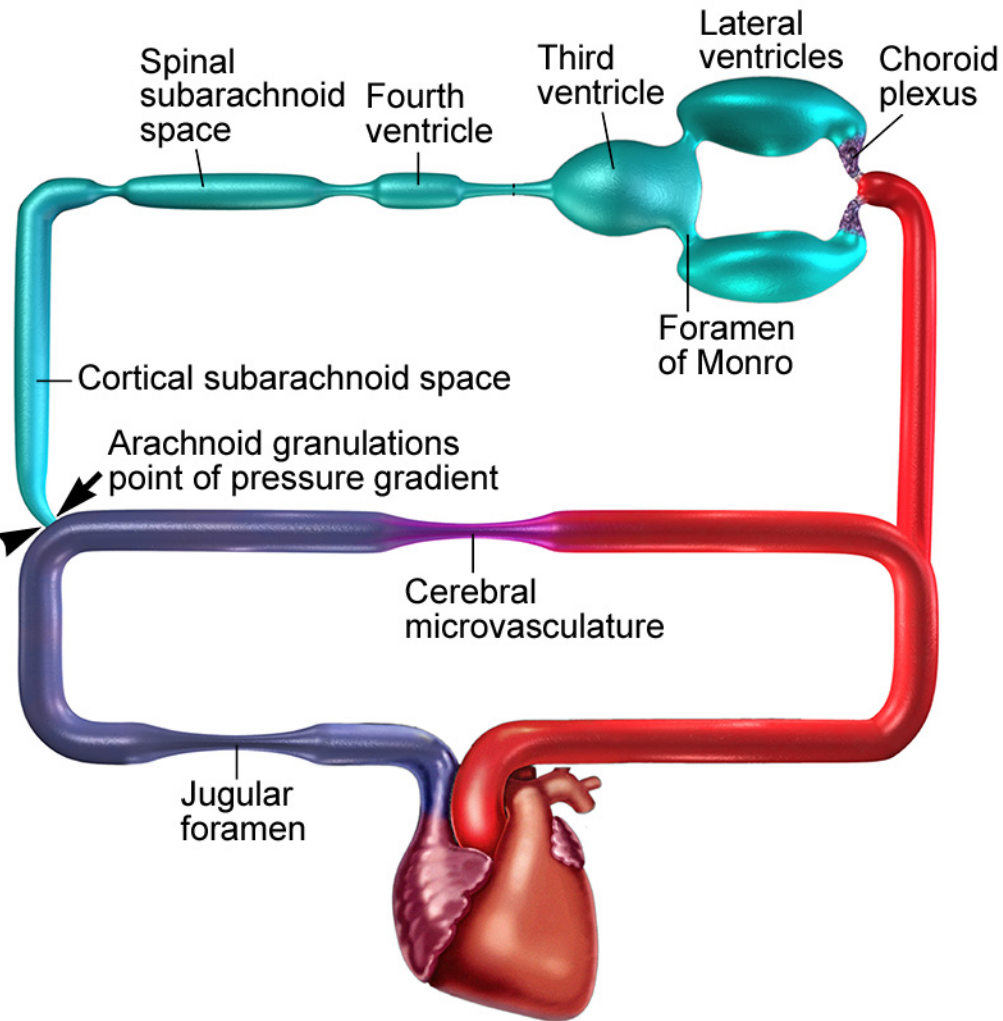
After Consensus Meetings



Dural venous sinuses
Lymphatics

Nerve root sleeves
Olfactory bulbs

Transepndymal
parenchymal capillaries



Using the Classification Scheme

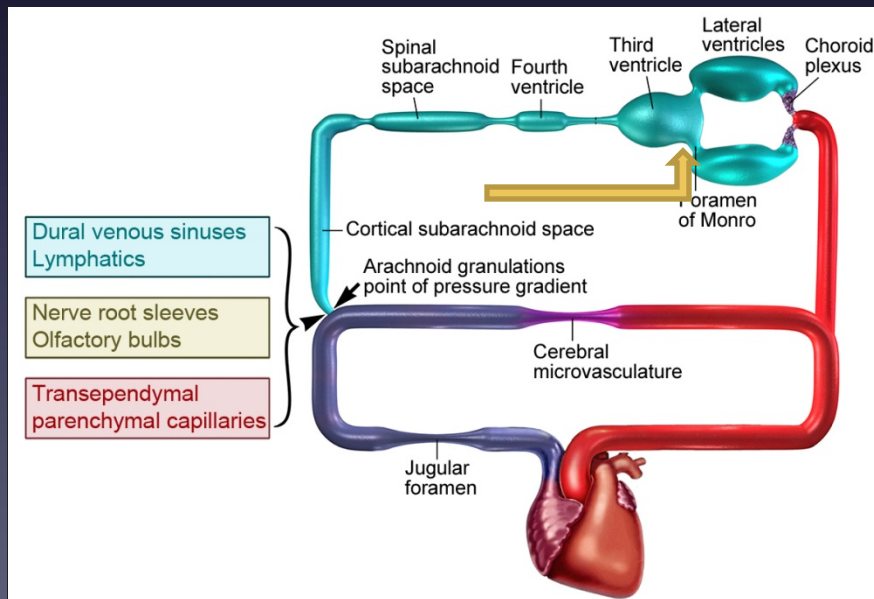
- Classification based on point of obstruction
 - Modified by differential diagnosis
 - Modified by potential treatment options
 - Modified by time
 - » Acute
 - » Chronic
 - » Compensated
 - » ? Arrested

Foramen of Monro

Pathologic Process

Possible treatments

- Shunt
- Septum
- Pellucidotomy
- Opening of the foramen of Monro



Foramen of Monro Animal Model

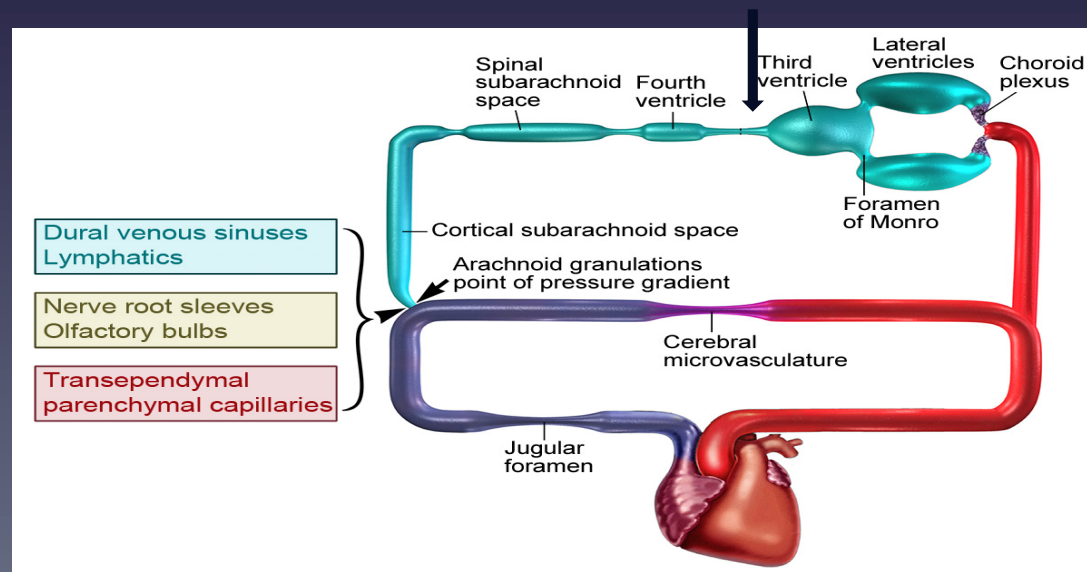
- Dandy et. al. 1919
- Occluded the foramen of Monro in kaolin hydrocephalus
- Dandy, W. E. "EXPERIMENTAL HYDROCEPHALUS." Ann.Surg. 70.2 (1919): 129-42.

Rekate

- Functional occlusion of Foramen of Monro with ipsilateral ventricular drainage
- Rekate, H. L., et al. "Resistance of the foramen of Monro." Pediatr.Neurosci. 14.2 (1988): 85-89.

Aqueductal Stenosis

- Congenital Acquired
- X-linked
- Tumor
- Chronic Shunting
- LIAS (Chronic Compensated)
- Ventricular Shunting
- ETV
- Aqueductoplasty



Aqueductal Stenosis Animal Models

- AS produced by injection
- Secondary closure of aqueduct from primary hydrocephalus in HTx Rat
- Aikawa, H. and K. Suzuki. "Aqueduct stenosis induced by a single injection of antivitamin." Brain Res. 354.2 (1985): 284-87

Data following ETV in LOVA patients

Rekate, H. L. "Longstanding overt ventriculomegaly in adults: pitfalls in treatment with endoscopic third ventriculostomy." Neurosurg.Focus. 22.4 (2007): E6.

Fourth Ventricular Outflow

- Late after acute meningitis
- Chronic meningitis
- Arachnoiditis
- Congenital anomalies especially Dandy-Walker Malformation
- Brain Tumor
- ETV
- Aqueductoplasty from above or below
- Lysis of obstructive membranes
 - Endoscopic
 - Open
- Removal of Tumor

Animal Models

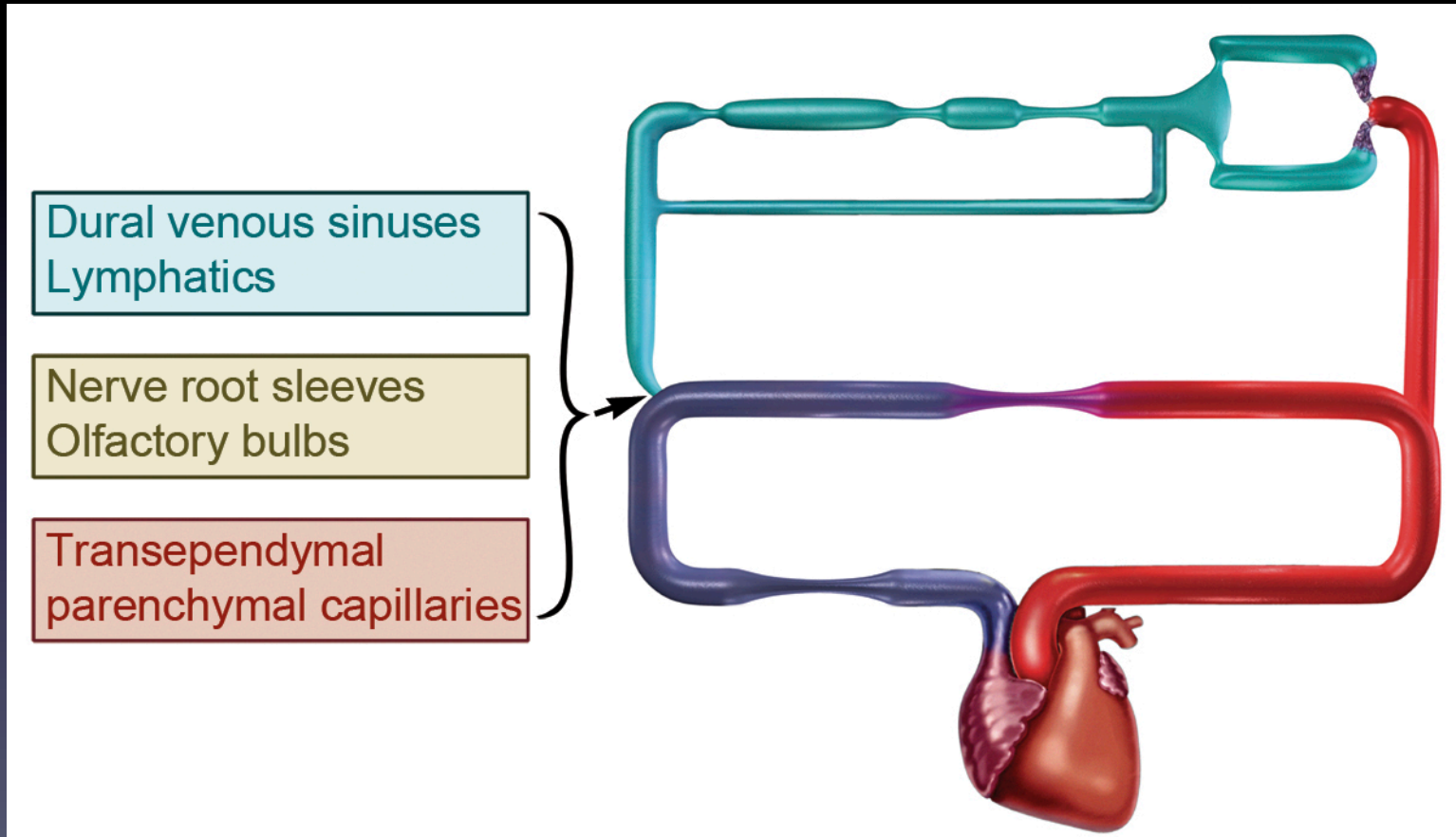
Intracisternal injection of kaolin in dogs produces hydrocephalus by occluding the outlet foramina of the fourth ventricle with intense scarring

Also a model of syringomyelia

McCormick, J. M., et al. "Time course of intraventricular pressure change in a canine model of hydrocephalus: its relationship to sagittal sinus elastance." Pediatr.Neurosurg. 18.3 (1992): 127-33.

In most reports of the use of kaolin in animal models the pathophysiology of the hydrocephalus is either not defined or is stated to be "communicating."

What Is Accomplished by Performing an ETV?



Cortical Subarachnoid Space

Clinical Relevance

- Subarachnoid hemorrhage
 - Meningitis
 - Please note, blockage of the CSAS can be either at skull base or at point of terminal CSF absorption!!!!
- Siomin, V., et al. "Endoscopic third ventriculostomy in patients with cerebrospinal fluid infection and/or hemorrhage." J.Neurosurg. 97.3 (2002): 519-24

Treatments available

- Shunt
- Lumbo-peritoneal shunt
- If previously normal ventricle size has been demonstrated and the ventricles expand the patient is a candidate for ETV
- .

Animal Model

- "Extraventricular obstructive hydrocephalus" McAllister
- Transbasal injection of kaolin to seal the cortical subarachnoid space. Mild to moderate hydrocephalus results late in the course and communication with the spinal subarachnoid space is documented
- Li, J., et al. "Communicating hydrocephalus in adult rats with kaolin obstruction of the basal cisterns or the cortical subarachnoid space." Exp.Neurol. 211.2 (2008): 351-61.
- Wagshul, M. E., et al. "Ventricular dilation and elevated aqueductal pulsations in a new experimental model of communicating hydrocephalus." Exp.Neurol. 218.1 (2009): 33-40.

Venous Obstruction

Clinical Relevance

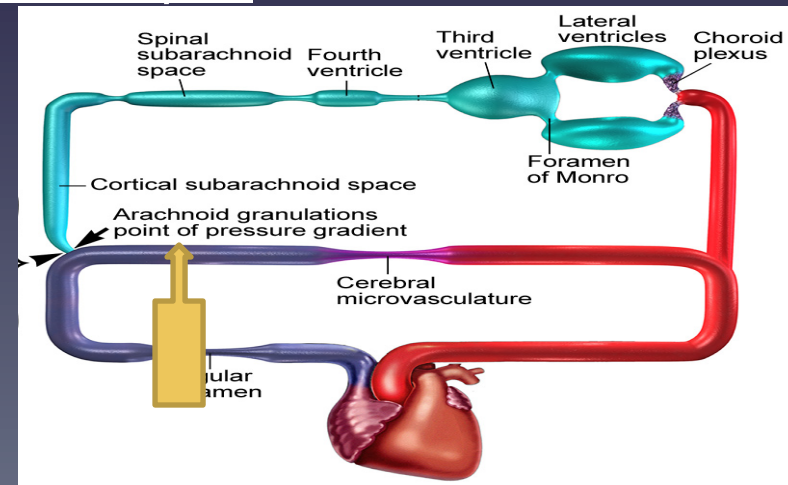
- Only causes hydrocephalus in infancy
- Benign intracranial hypertension in adults
- Aqueduct shown to secondarily close
- Severe slit ventricle syndrome or Normal Volume Hydrocephalus
- 20-25% of early shunts

Treatment available

- Ventricular shunts with very high resistance valves
- Lumboperitoneal shunts
- Cisterna magna shunts
- Venous bypass or venous stenting

Animal Model

- Sagittal Sinus occlusion in Rabbits
 - Pseudotumor when skull in tact
 - Hydrocephalus if accompanied by craniectomy." Olivero, W. C. and N. Asner. "Occlusion of the sagittal sinus in craniectomized rabbits." Childs Nerv.Syst.



No Point of Obstruction

- Essentially this has only been shown to occur clinically in the context of choroid plexus papilloma
 - Rekate, H. L., et al. "Etiology of ventriculomegaly in choroid plexus papilloma." [Pediatr.Neurosci.](#) 12.4-5 (1985): 196-201.
 - Animal Models
 - Amplification of pulsations
 - Di, Rocco C., et al. "Experimental hydrocephalus following mechanical increment of intraventricular pulse pressure." [Experientia.](#) 33.11 (1977): 1470-72.
- Bulk flow infusion of artificial CSF over long periods