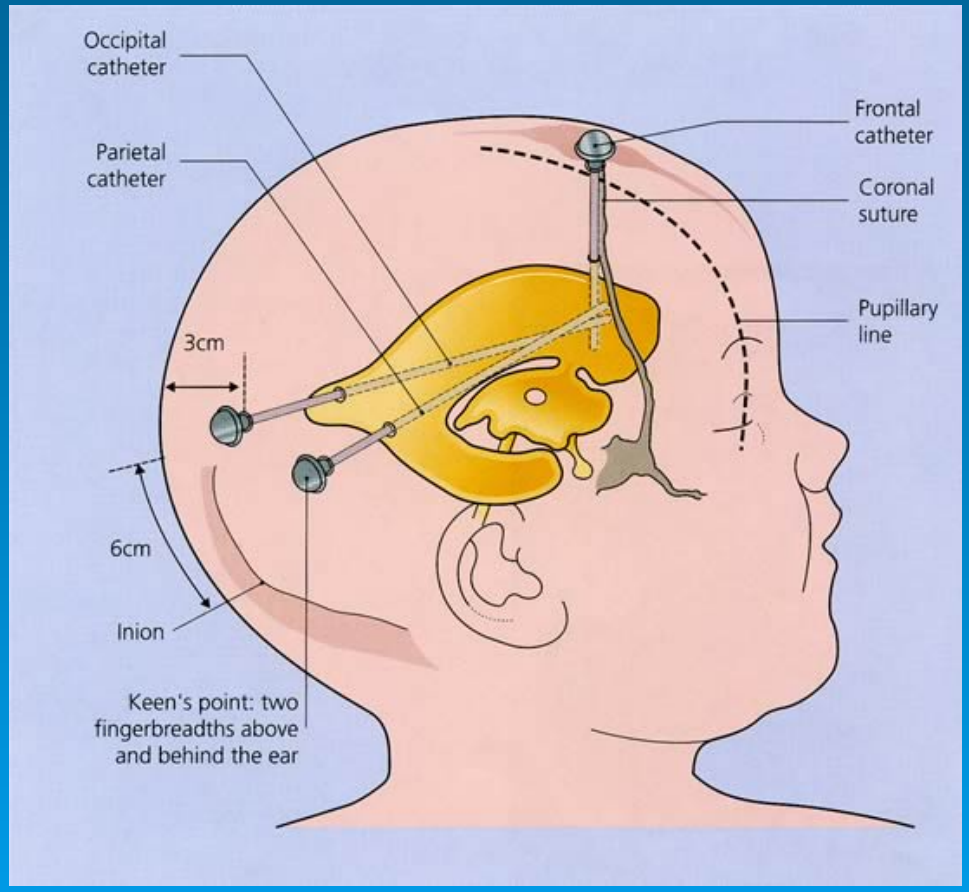
# Neonatal Hydrocephalus

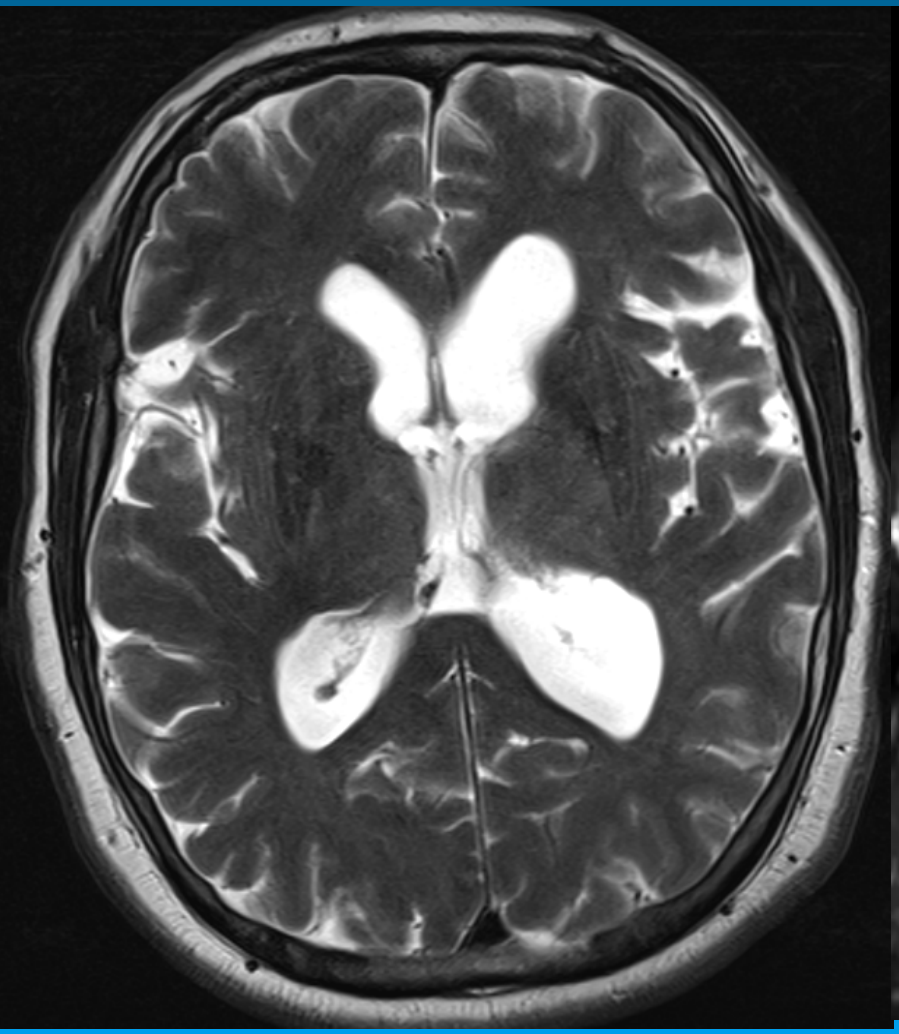


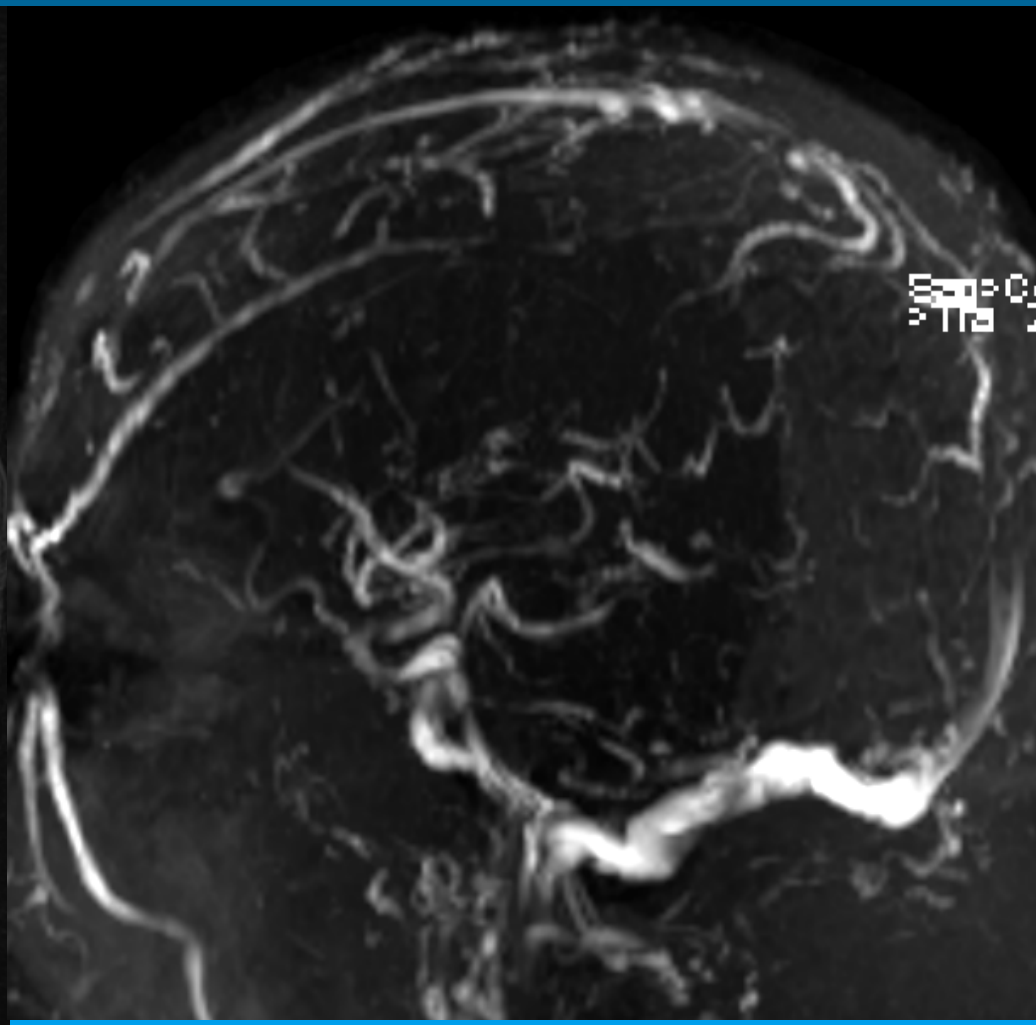

Dr Grant Bateman MBBS MD
Conjoint Associate Professor
John Hunter Hospital
Newcastle Australia

# Outline

- A reversed timeline of CSF disorders
- What does the literature say about neonatal hydrocephalus?
- What did I find?

# An NPH patient with a big head





58 yrs old male ataxia, incontinence

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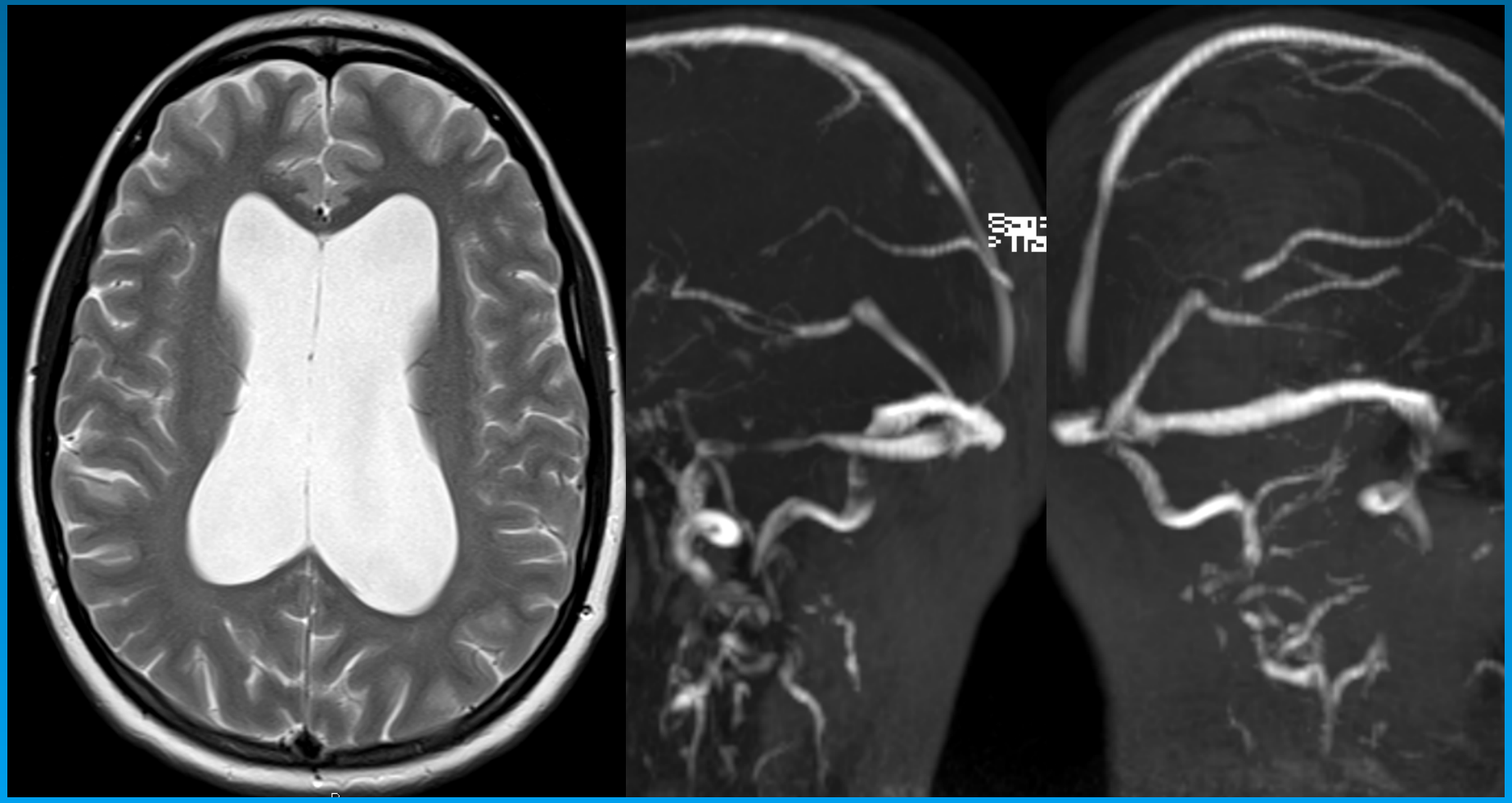
# Late Onset Ventriculomegally of Adults



A 32 yrs old pregnant female!

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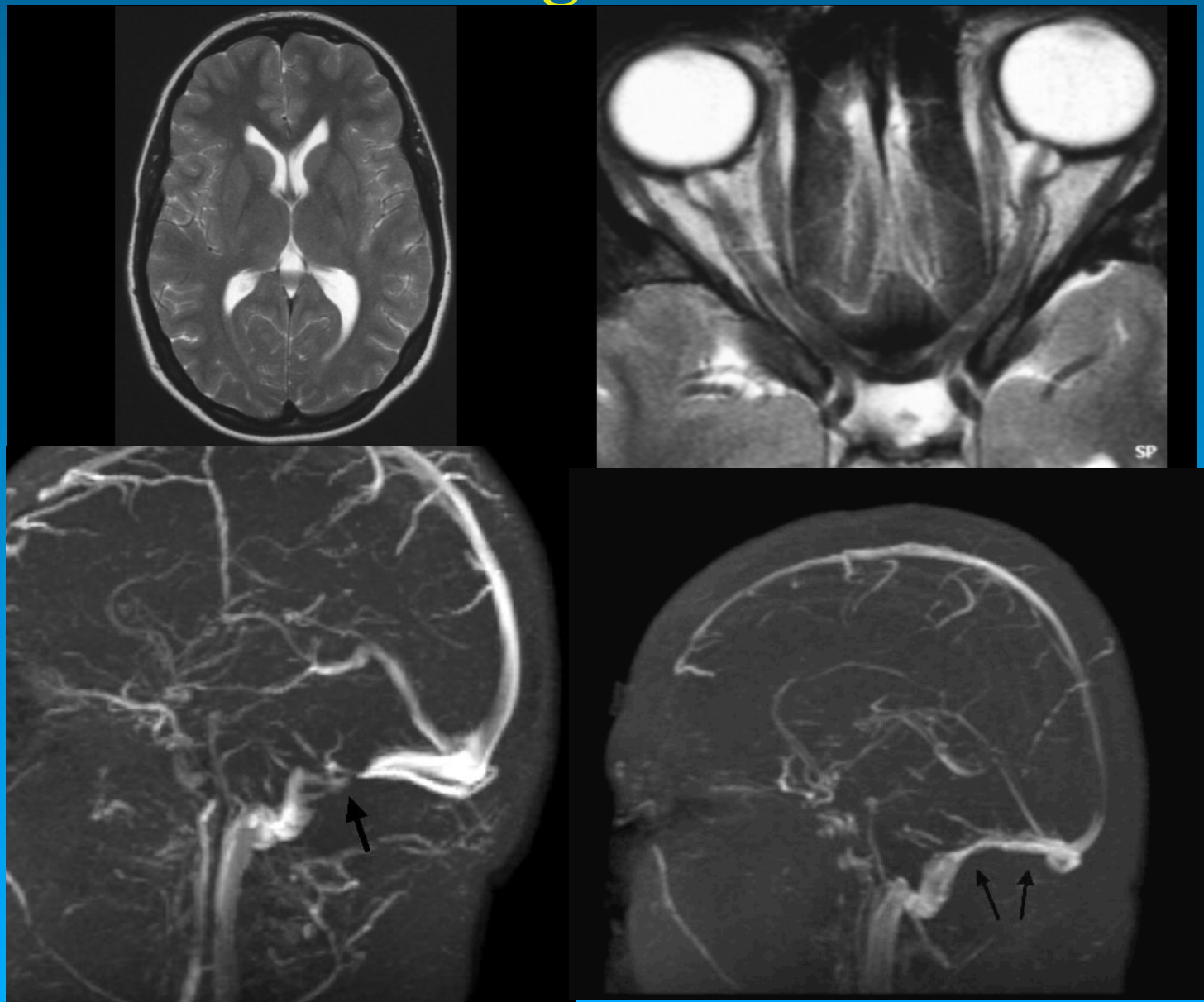
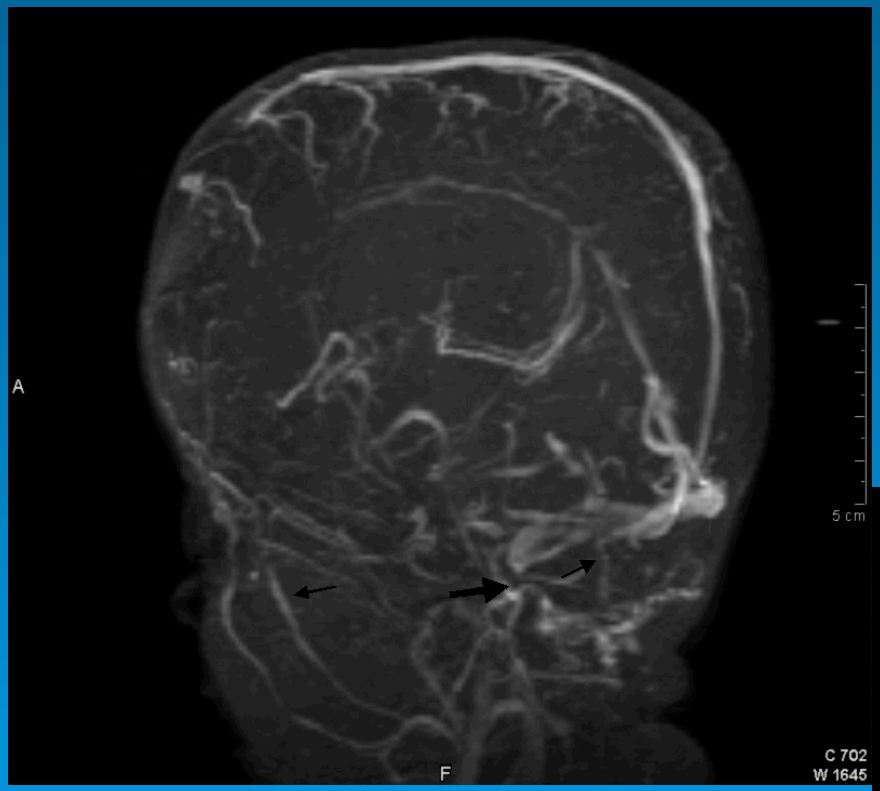
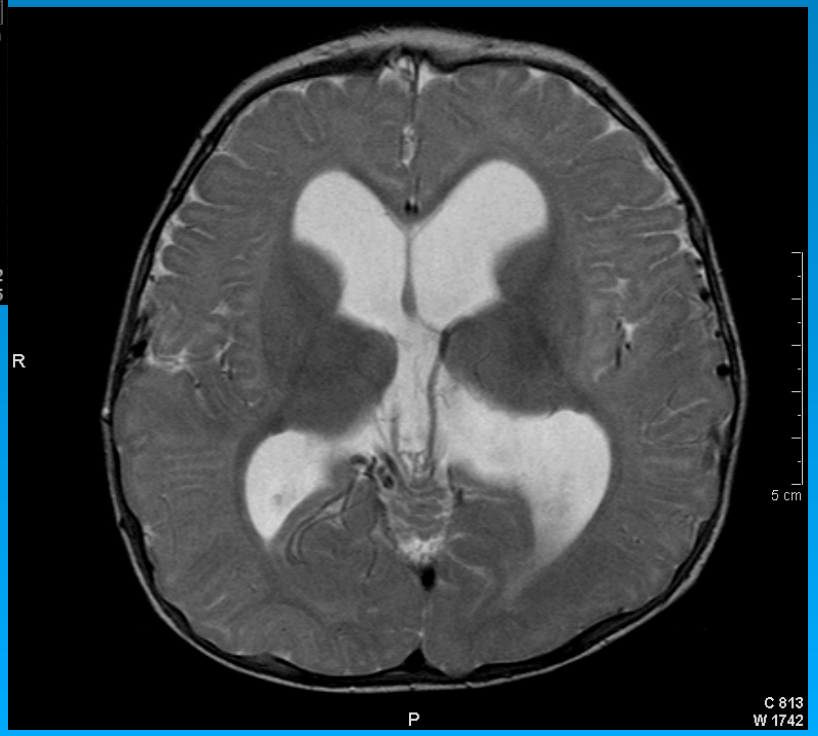
# Idiopathic Intracranial Hypertension
# Age 20



# Achondroplasia




- Children with hydrocephalus and achondroplasia or craniostenosis have venous outflow stenosis

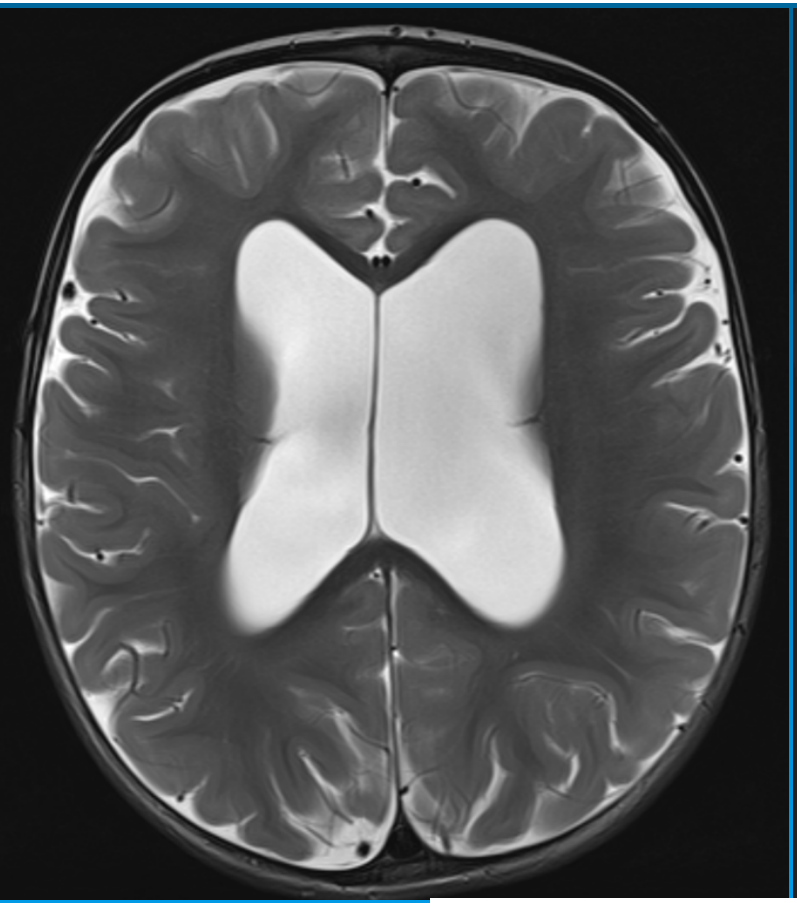


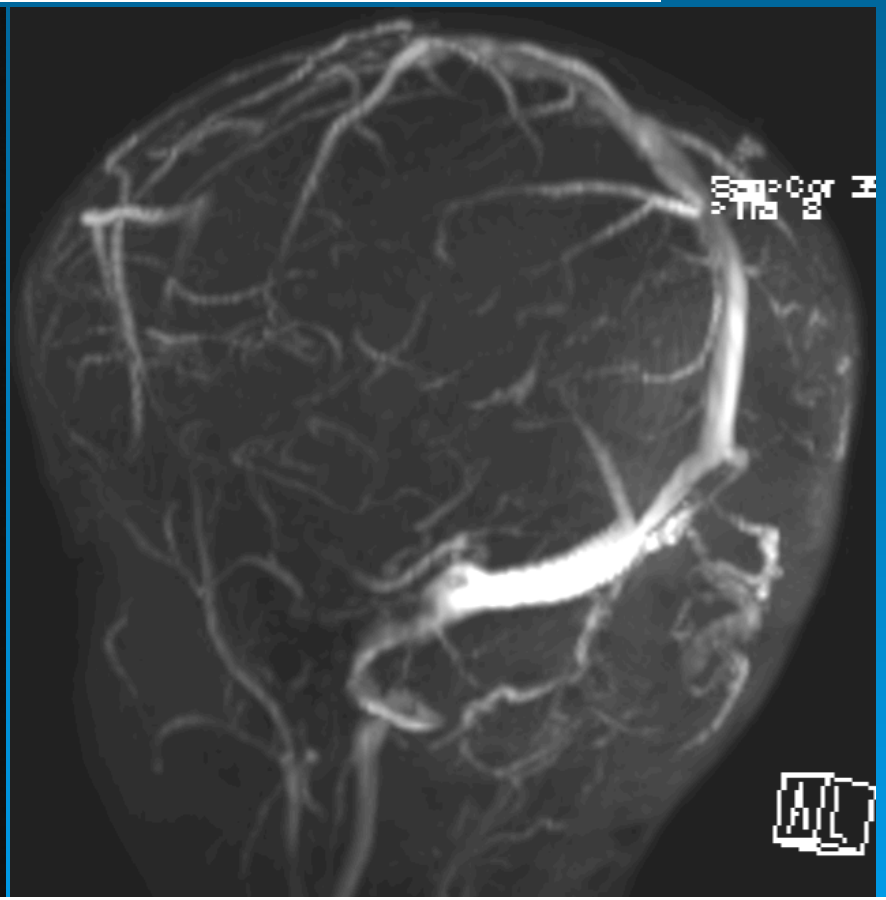

Shulman K, Ransohoff: Sagittal sinus pressure in hydrocephalus. **J Neurosurg 23:**169-173, 1965

# Sagittal Sinus Venous Pressure in Hydrocephalus*

KENNETH SHULMAN, M.D.,† AND JOSEPH RANSOHOFF, M.D.
*Department of Neurological Surgery, New York University School of Medicine, New York, New York*

JNS 1965





JNS 2007

## Idiopathic hydrocephalus in children and idiopathic intracranial hypertension in adults: two manifestations of the same pathophysiological process?

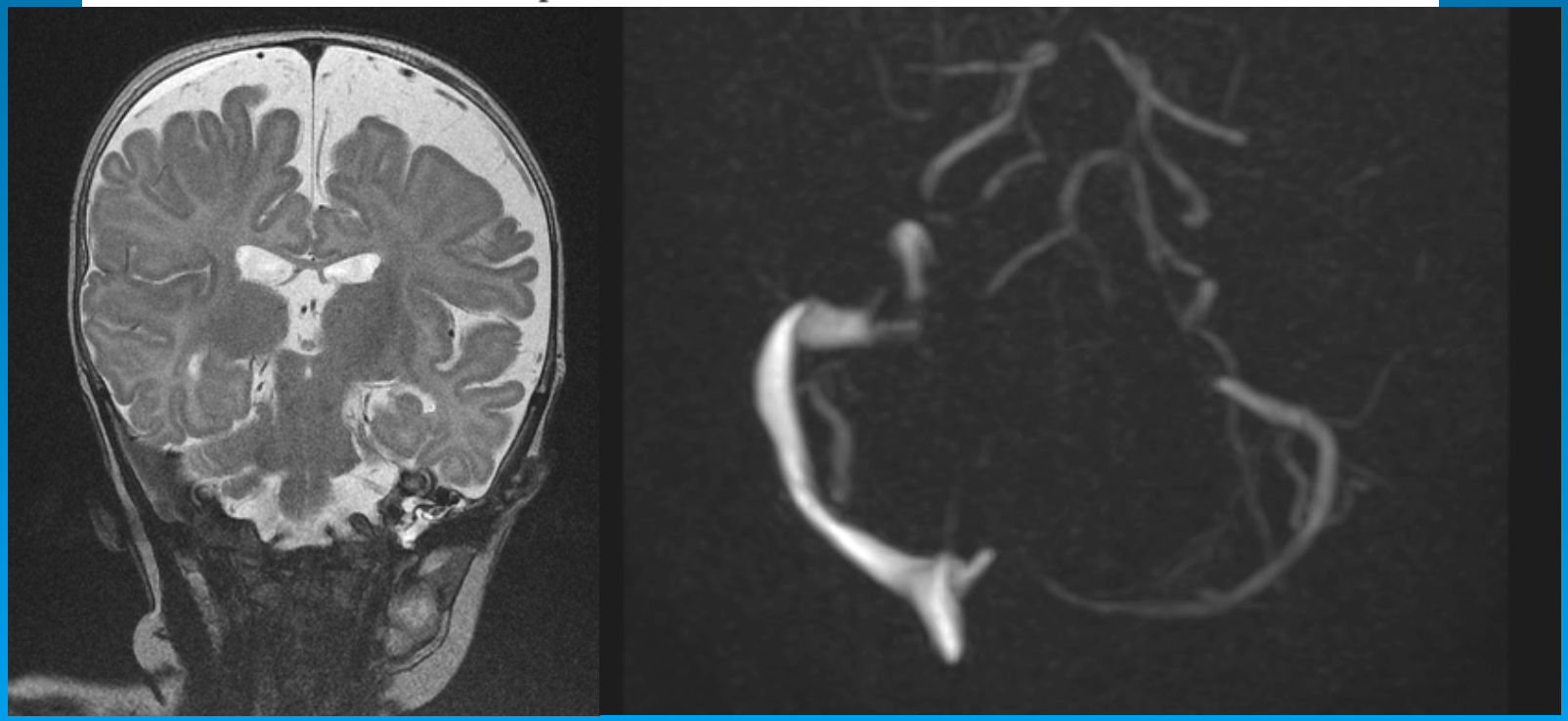
GRANT A. BATEMAN, M.B.B.S., F.R.A.N.Z.C.R.,[1,2] ROBERT L. SMITH, M.B.B.S., F.R.A.C.P.,[2,3] AND SABBIR H. SIDDIQUE, M.B.B.S., F.R.A.N.Z.C.R.[1]

Childs Nerv Syst
DOI 10.1007/s00381-011-1549-z

ORIGINAL PAPER

# External hydrocephalus in infants: six cases with MR venogram and flow quantification correlation

Grant A. Bateman · Brett D. Napier



- Case Courtesy of Dr Anders Von Heijne MD
- Dept Diagnostic Radiology, Danderyd Hospital, Karolinska Institute

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# Neonatal hydrocephalus: what do we know?

*Pediatric Research* (2004) **55**, 872–876; doi:10.1203/01.PDR.0000119370.21770.AC

## CSF Removal in Infantile Posthemorrhagic Hydrocephalus Results in Significant Improvement in Cerebral Hemodynamics

Janet S Soul[1], Eric Eichenwald[2], Gene Walter[1], Joseph J Volpe[1] and André J Du Plessis[1]

[1]Department of Neurology, Children's Hospital, Boston, Massachusetts 02115, U.S.A.

[2]Department of Newborn Medicine, Brigham and Women's Hospital and Harvard Medical School, Boston, Massachusetts 02115, U.S.A.

Correspondence: André J. du Plessis, M.D., Children's Hospital, Department of Neurology, Fegan 11, 300 Longwood Avenue, Boston, MA 02115, U.S.A.; e-mail: adre.duplessis@childrens.harvard.edu

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# Neonatal hydrocephalus: Where's the blockage?

ding editorial in this issue, pp 161–162.

J Neurosurg Pediatrics 2:163–170, 2008

## Magnetic resonance imaging for quantitative flow measurement in infants with hydrocephalus: a prospective study

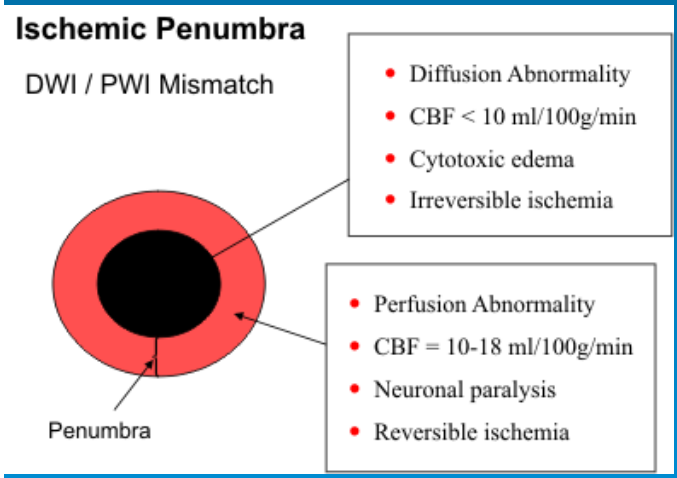
PAUL H. LELIEFELD, M.D.,[1] ROB H. J. M. GOOSKENS, M.D., PH.D.,[1] KOEN L. VINCKEN, PH.D.,[3] LINO M. P. RAMOS, M.D.,[2] JEROEN VAN DER GROND, M.D., PH.D.,[4] CEES A. F. TULLEKEN, M.D., PH.D.,[1] L. JAAP KAPPELLE, M.D., PH.D.,[1] AND PATRICK W. HANLO, M.D., PH.D.[1]

*Department of [1]Neurology and Neurosurgery, Rudolf Magnus Institute of Neuroscience, and [2]Department of Radiology, and [3]Image Sciences Institute, University Medical Center Utrecht; and [4]Department of Radiology, University Medical Center Leiden, The Netherlands*

*Object.* Raised intracranial pressure (ICP) that is associated with hydrocephalus may lead to alterations in cerebral hemodynamics and ischemic changes in the brain. In infants with hydrocephalus, defining the right moment for surgical intervention based on clinical signs alone can sometimes be a difficult task. Clinical signs of raised ICP are known to be unreliable and sometimes even misleading. Furthermore, when sutures are closed, ICP does not always correlate with the size of the ventricles or with the clinical signs or symptoms. In this study the authors investigated whether cerebral blood flow (CBF) can be measured by using quantitative MR angiography in infants with progressive hydrocephalus. In addition, the authors investigated the relationship between CBF and ICP, before and after cerebrospinal fluid (CSF) diversion.

*Methods.* Fifteen infants with progressive hydrocephalus (age range 1 day–7 months) were examined. All patients underwent anterior fontanel pressure measurement, MR angiography, and mean arterial blood pressure measurements before and after CSF diversion. Brain volume was measured to compensate for the physiological increase in CBF during brain maturation in infants.

*Results.* The mean preoperative ICP was 19.1 ± 8.4 cm $H_2O$ (± standard deviation). The mean postoperative ICP was 6.7 ± 4.0 cm $H_2O$ ($p < 0.005$). The mean preoperative CBF was 25.7 ± 11.3 ml/100 $cm^3$ brain/min. After CSF diversion, CBF increased to 50.1 ± 12.1 ml/100 $cm^3$ brain/min ($p < 0.005$). The mean arterial blood pressure did not change after surgical intervention.




The CBF increased by 100% post shunt in infantile hydrocephalus

from 25 mls/100gm/min to 50 ml/100gm/min

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# Are the arterioles constricting ?

A. Pratap[1]
M. Srinivas[1]
P. Hentok[2]
C. S. Bal[2]
V. Bhatnagar[2]

## Evaluation of Cerebral Vascular Reserve by Single Photon Emission Tomography in Children with Congenital Hydrocephalus

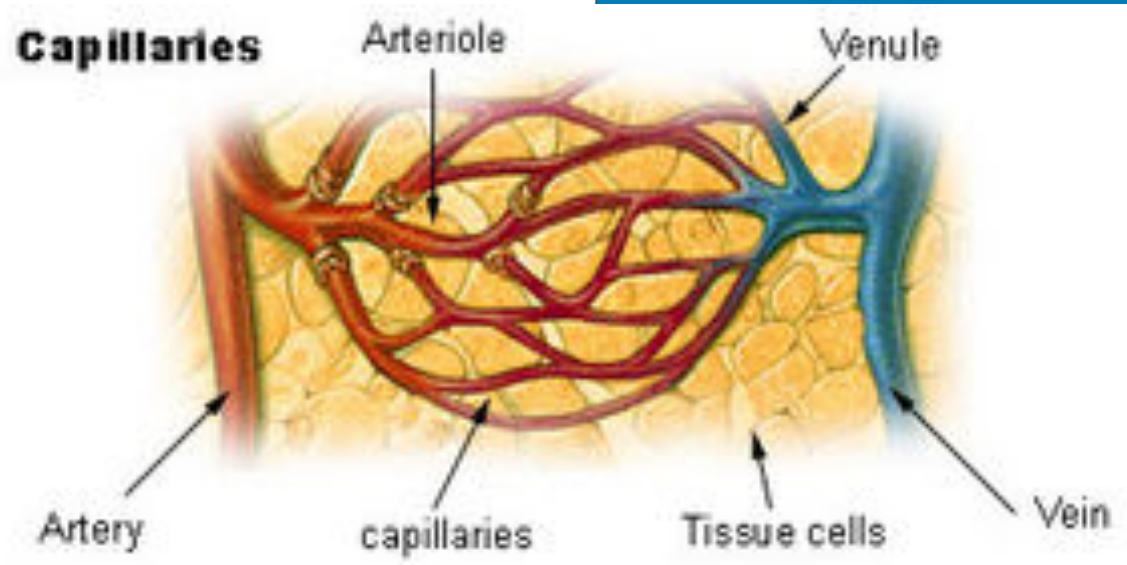
**Abstract**

**Background/Aims:** Single photon emission tomography scan (SPECT) is used to measure cerebral blood flow (CBF) and also cerebral vascular reserve (CVR) after intravenous acetazolamide (ACZ) challenge. This prospective study was designed to test the utility of CVR in congenital hydrocephalus (CHC).

**Methods:** Patients (n = 21, mean age 6.2 m) with CHC underwent a baseline ultrasonography (US), retinal fundus examination (RF), neurological score (NS), and SPECT to evaluate CVR after intravenous ACZ. Monthly US, RF, NS, CBF, and CVR were evaluated.

**Results:** Ten patients showed good CVR and also had stable NS and RF despite mild to moderate ventriculomegaly and were followed up on conservative treatment. None of these patients in a mean follow-up period of 9.8 months showed deterioration. Eleven patients, who had poor CVR initially, were also treated conservatively. Over a period of 4 months, 8 patients showed a fall in CVR to < 30% of baseline and a fall in NS despite RF and US remaining the same and hence were operated. Five of these operated cases showed an improvement in CVR and NS over a mean follow-up period of 4 months and the remaining 3 patients failed to show improvement in CVR and NS.

**Conclusions:** In CHC, CVR measured by ACZ challenge test is a sensitive parameter as alterations in CVR occur prior to changes in other conventional parameters such as ventriculomegaly and RF. Patients with normal CVR at presentation are unlikely to deteriorate and can safely be managed conservatively. Patients who show a deterioration in CVR should be considered for prompt surgery.




ces enfants, une intervention chirurgicale a permis une amélioration de la RCV et du SN pendant une période de quatre mois. Aucune amélioration de la RVC ni du SN n'était observée chez les trois autres.

**Conclusions:** Chez les enfants atteints d'hydrocéphalie congénitale, le mesure de la RVC par TEMP après injection d'ACZ est un moyen sensible d'évaluation car les altérations de la RVC précè-

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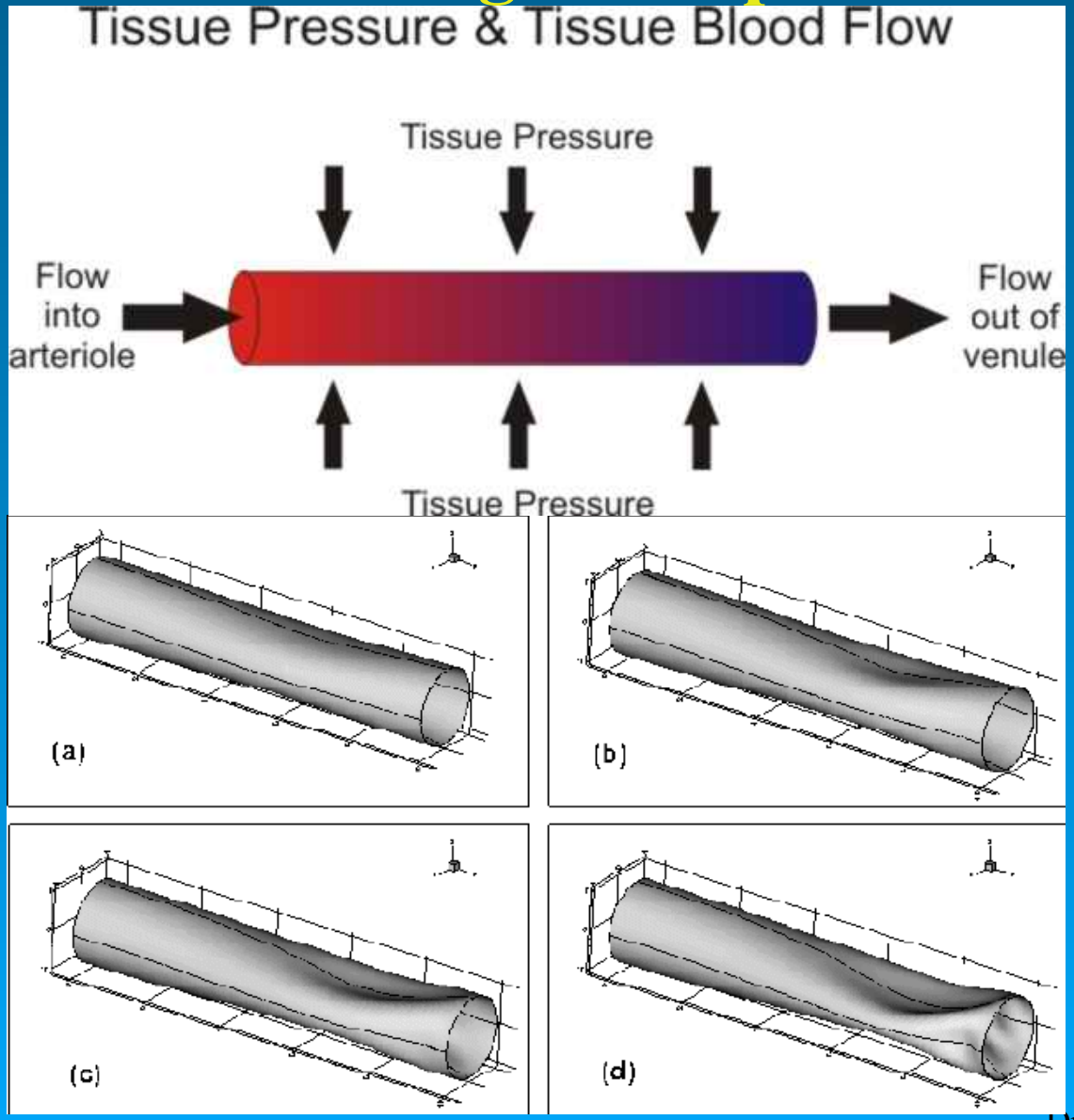
# Flow through collapsible tubes

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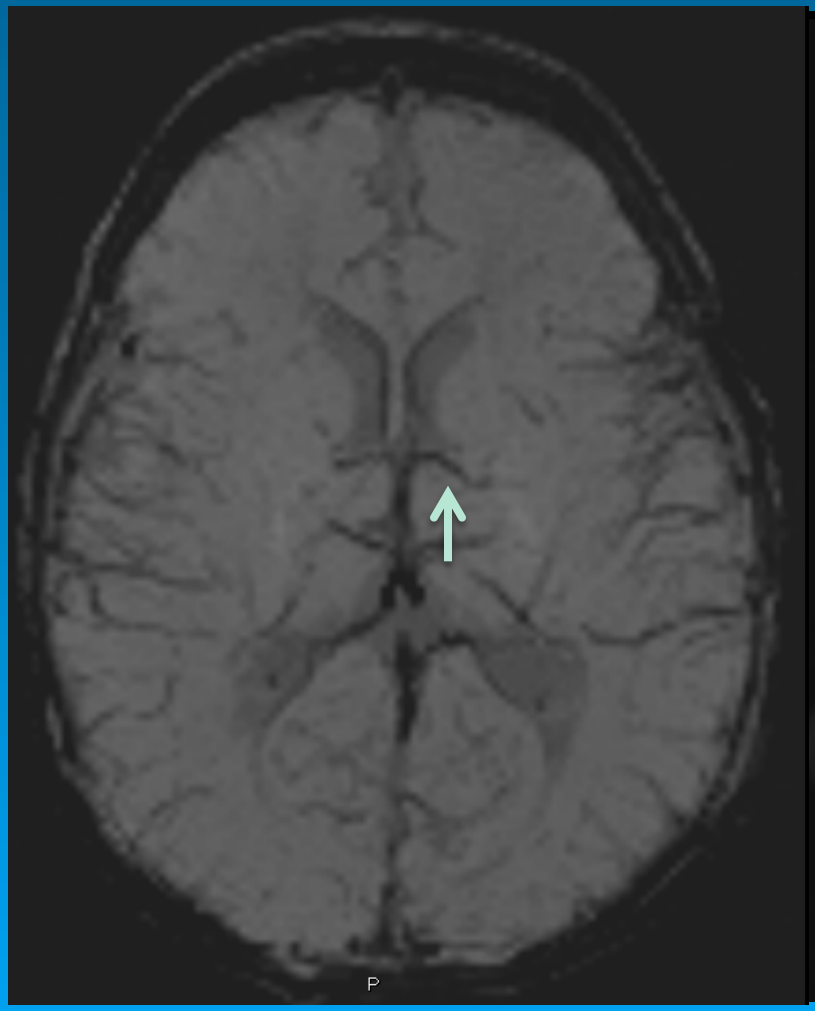
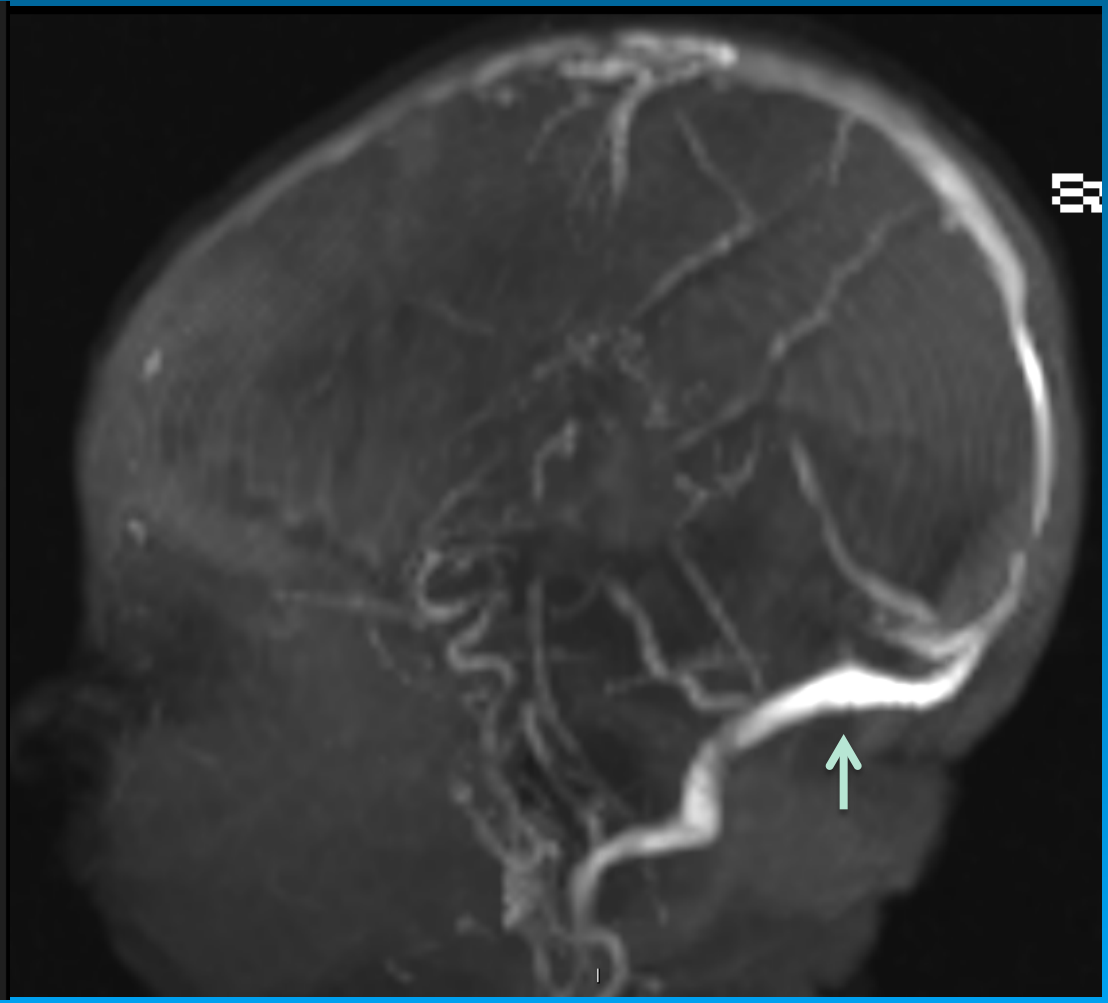
# The Study:

- Retrospective review of all neonates who had an MRV and susceptibility weighting on the 3 T scanner at a Teaching hospital
- Two groups: 10 neonates with no evidence of raised intracranial pressure and 3 with hydrocephalus.

# Normal neonate





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# Results

| | *Birth weight gms* | *Age days* | *Ventricle size %* | *Vein size mm* | *Sinus size mm* |
|---|---|---|---|---|---|
| **Normal n=10** | **2900** | **14± 10** | **31±3** | **0.7±0.2** | **6±1.4** |
| **Hydrocephalus n=3** | **2300** | **12± 10** | **54±7** | **2.0 ±0.7** | **2.7±0.4** |
| **P value** | **.08** | **0.7** | **0.001** | **0.0001** | **0.001** |

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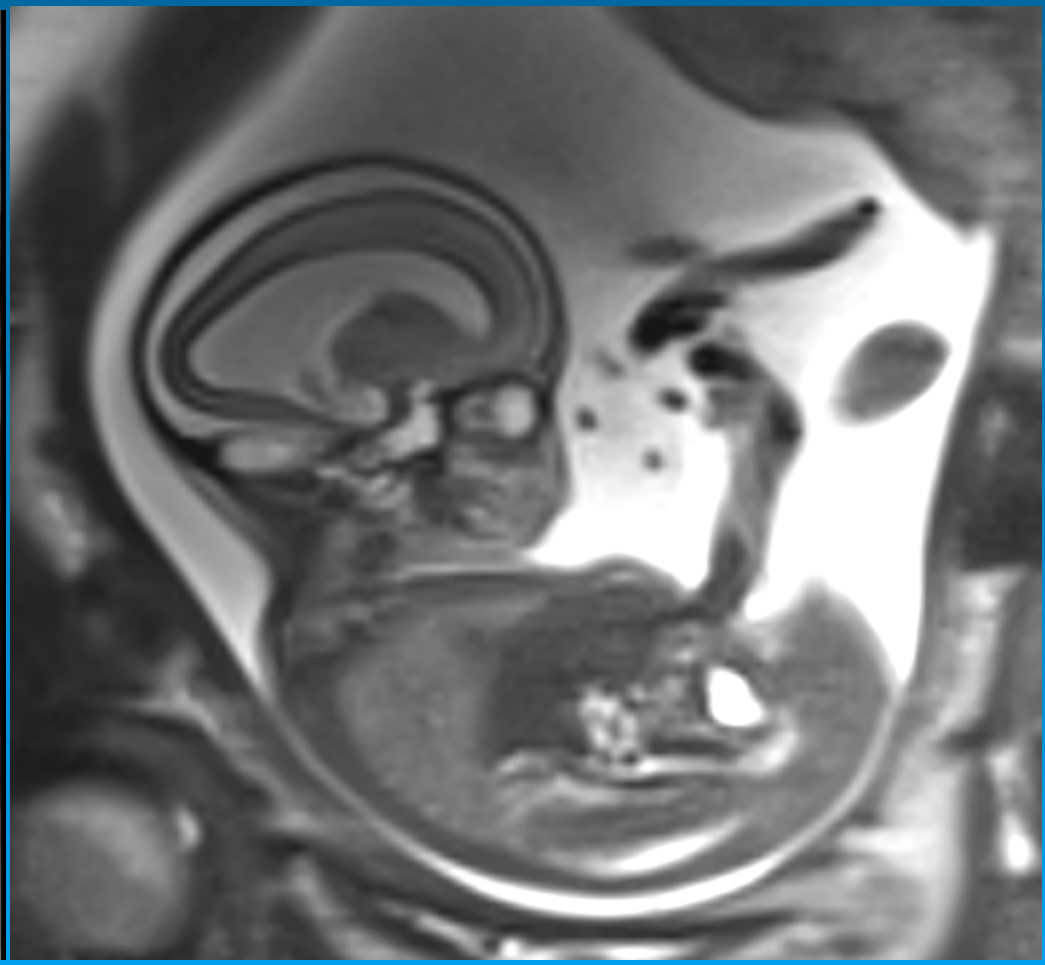
# Case 1

18 week antenatal ultrasound



In-utero MRI

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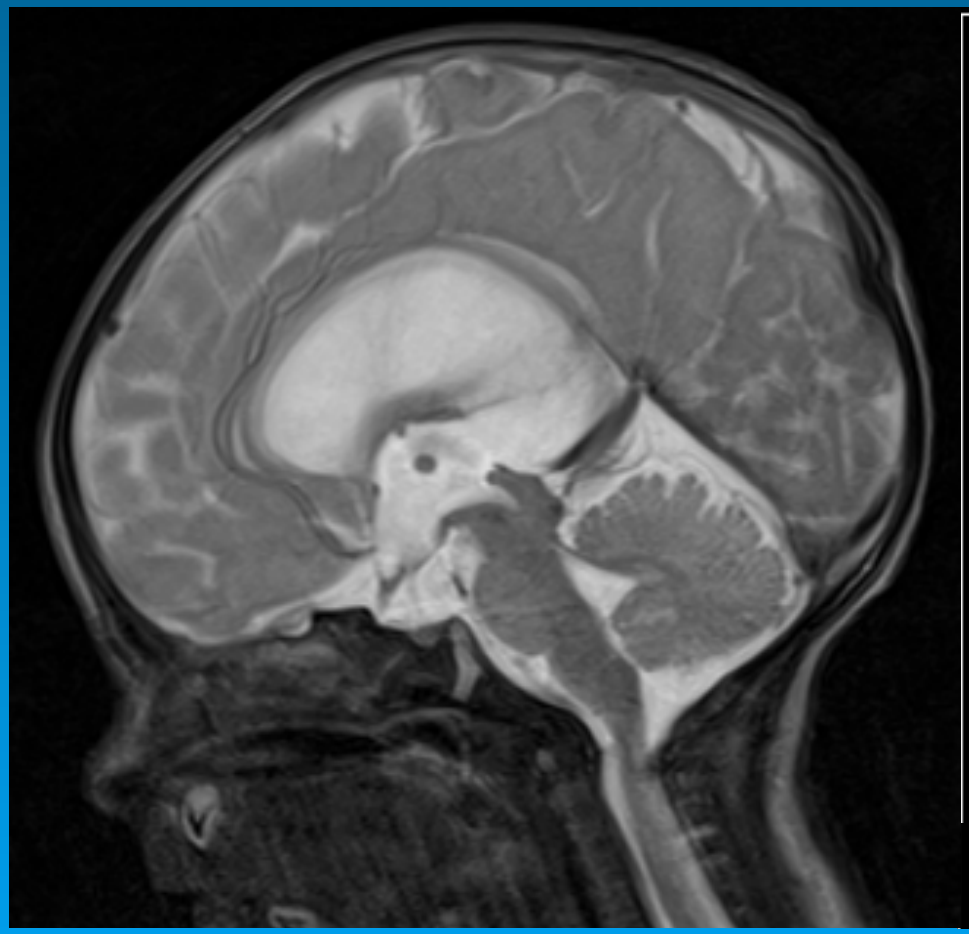
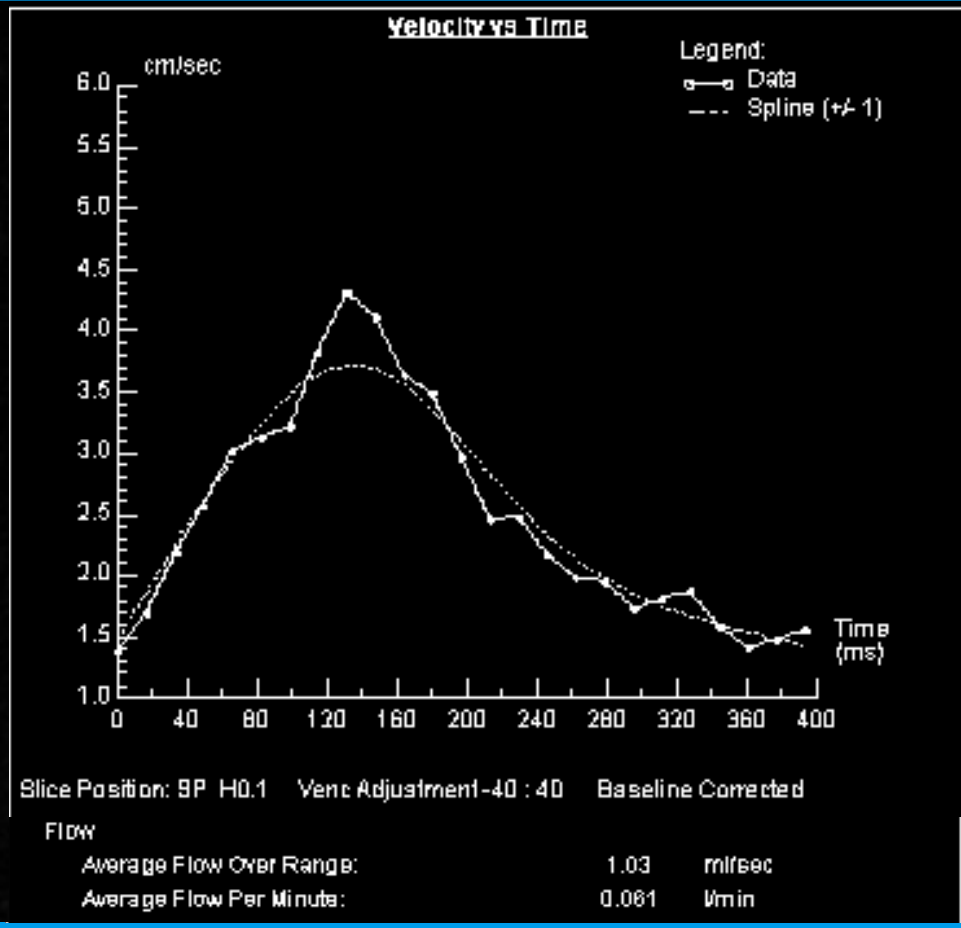
# Case 1






Immediate 3 days post birth

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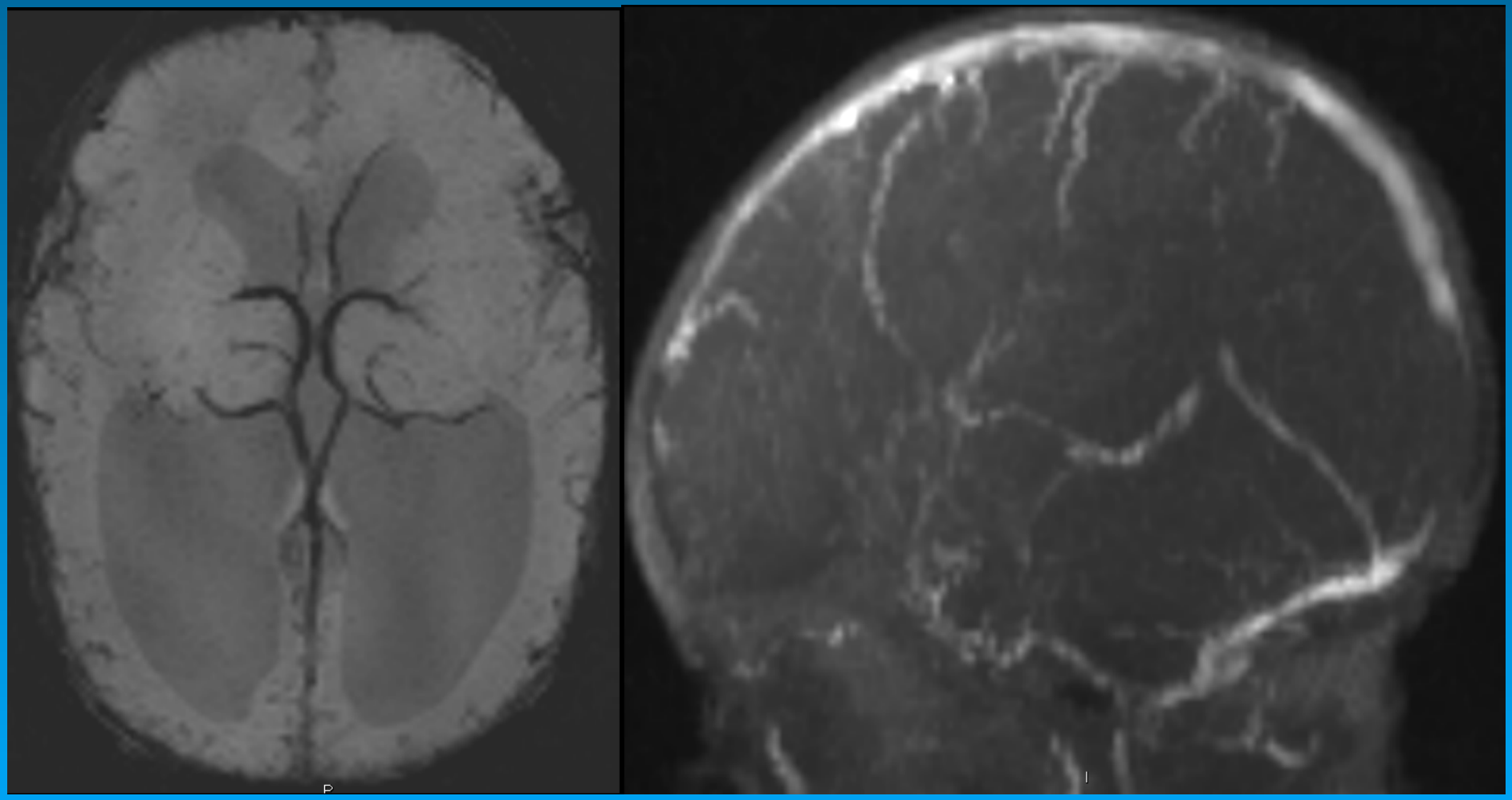
# Case 1



Immediate post birth

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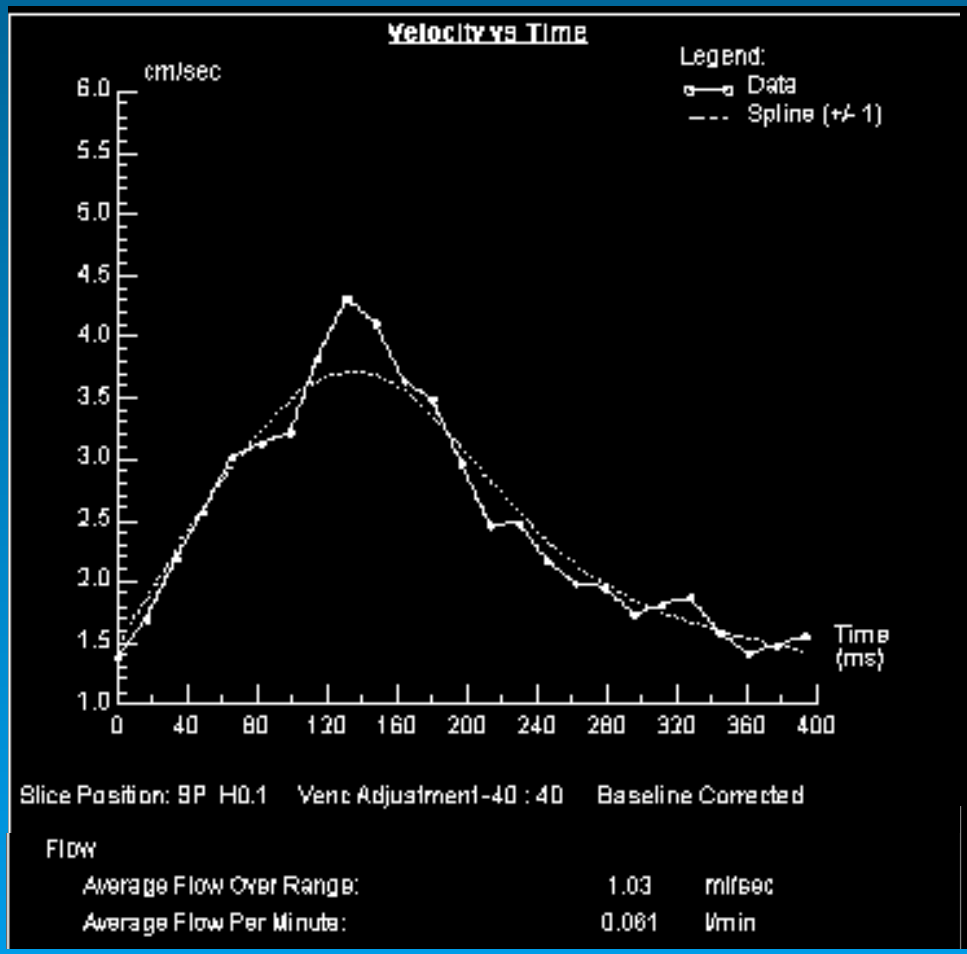
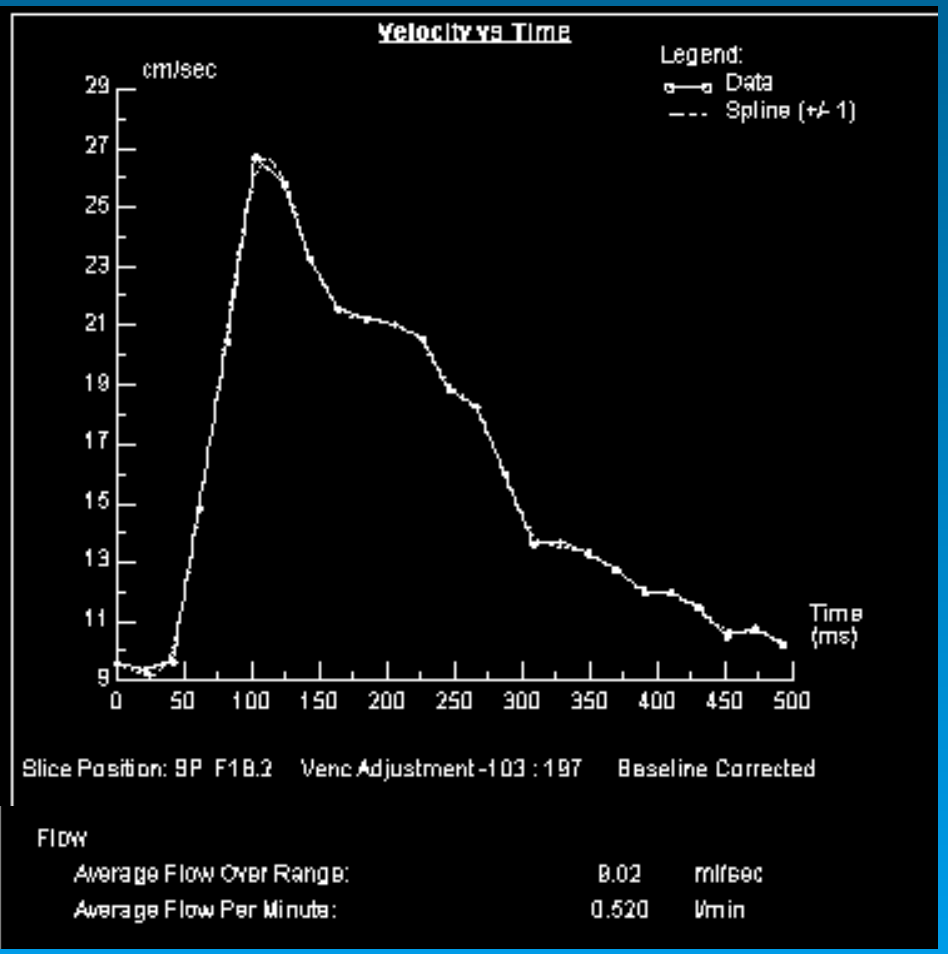
# Case 1




Birth

Follow-up 6 months old

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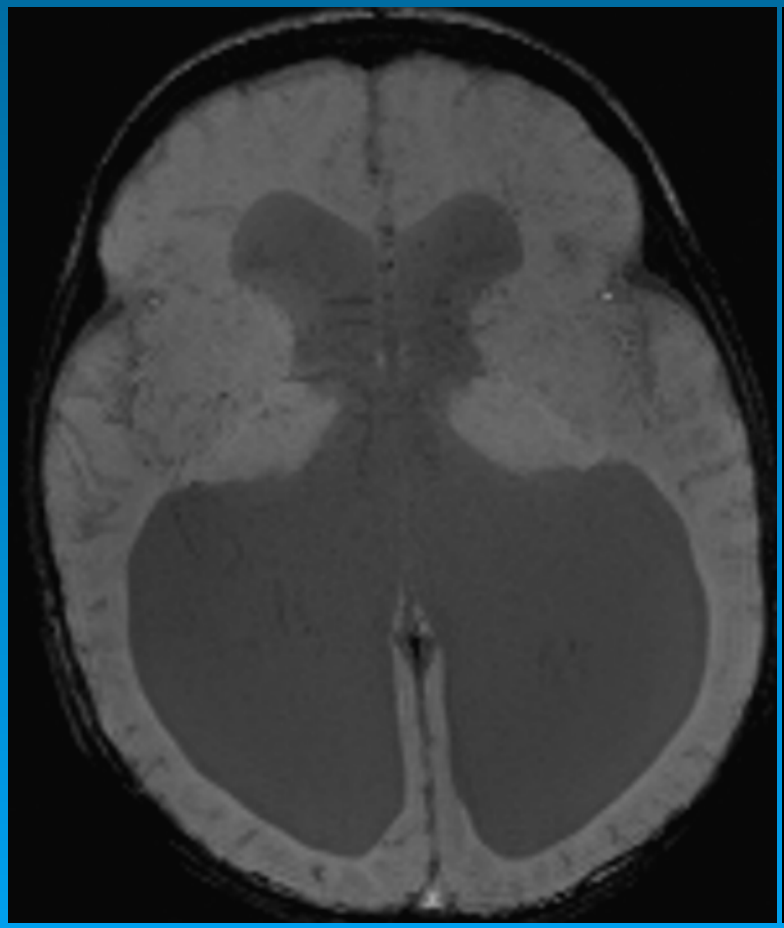
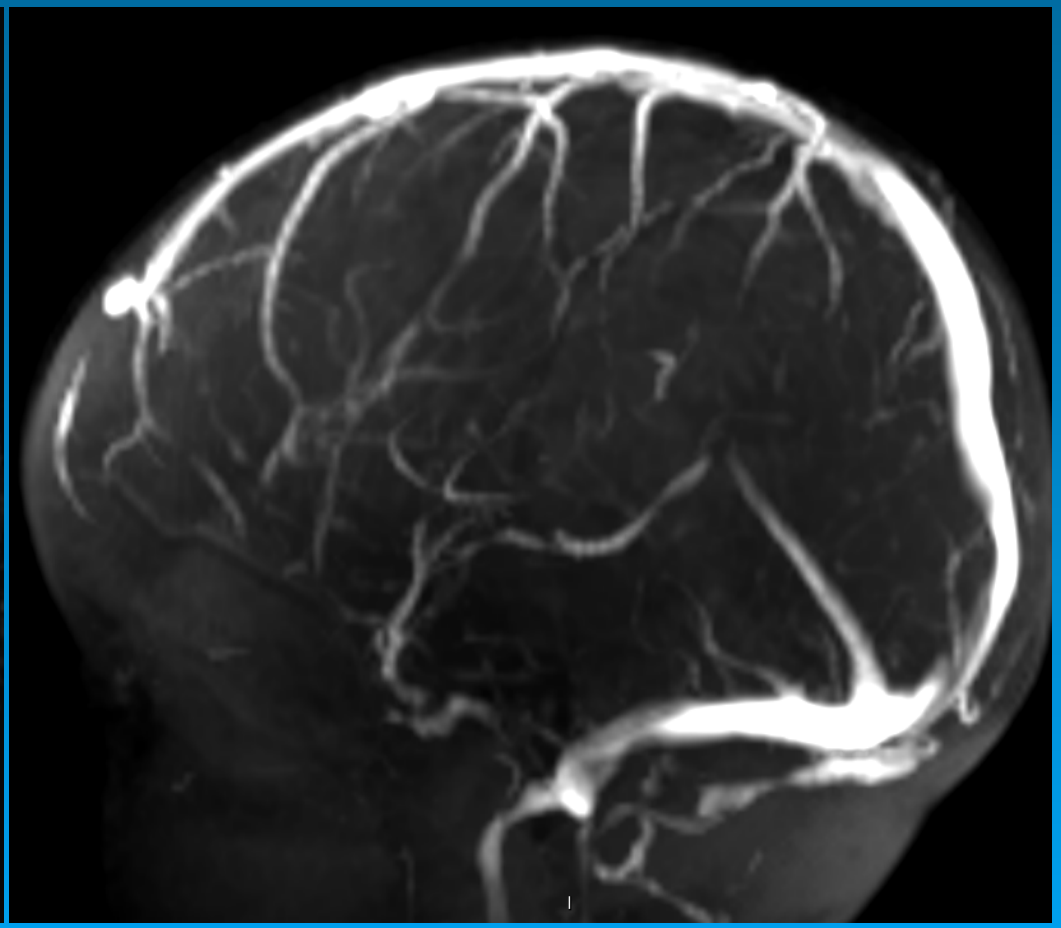
# Case 1





Follow-up 6 months

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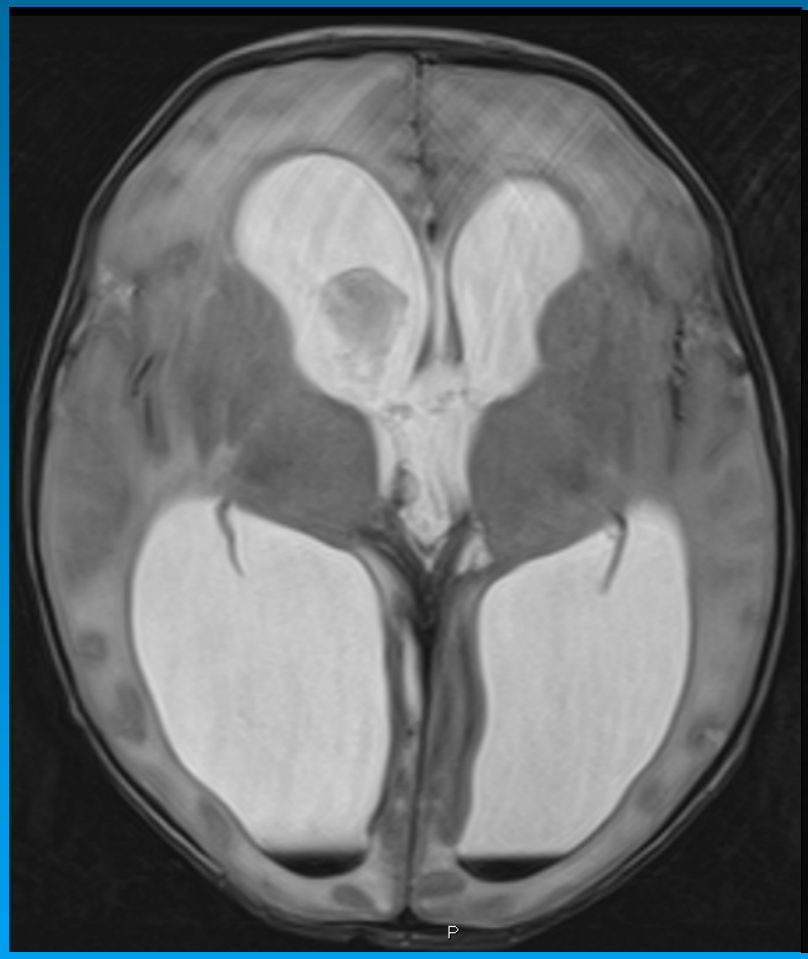
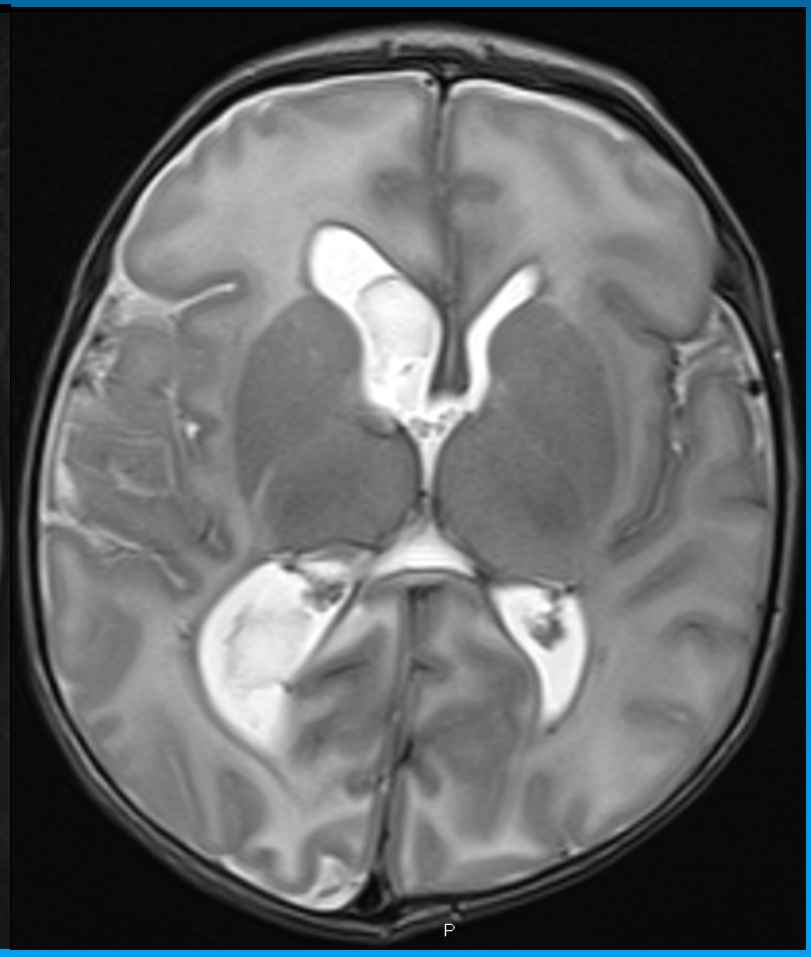
# Case 2





4 days Post birth

Seven days later after shunt insertion

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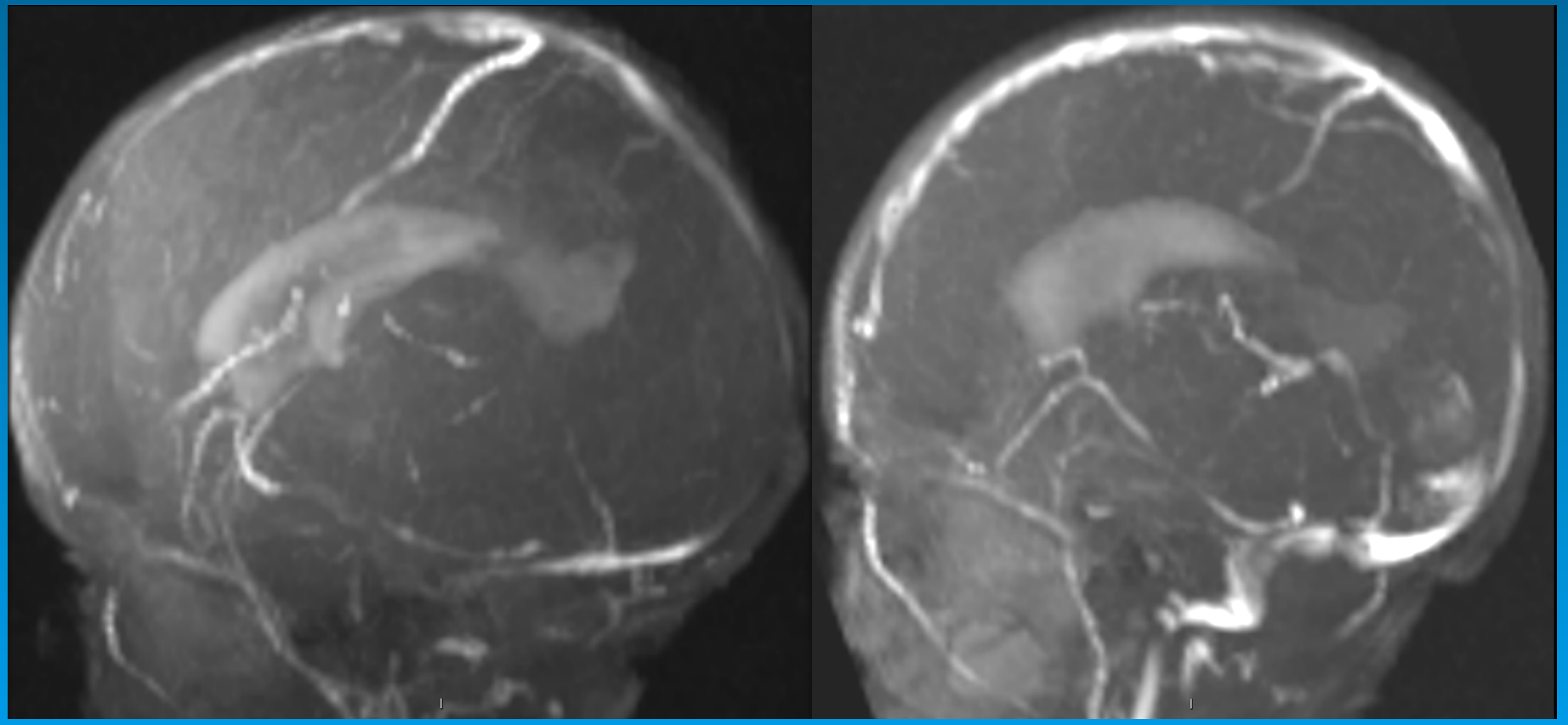
# Case 2



Birth

Seven days later post shunt

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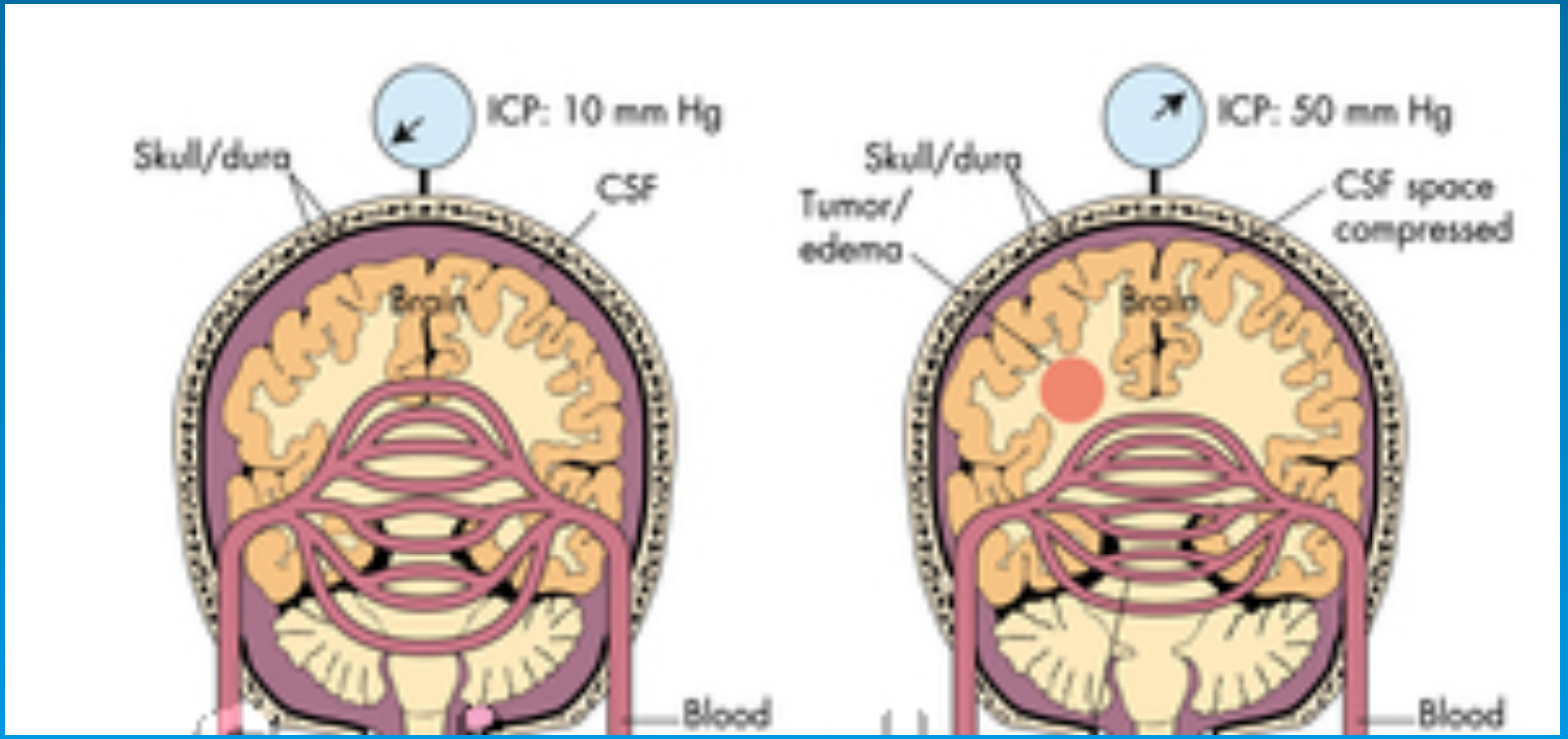
# Cerebral Perfusion Pressure




**CPP= MAP – ICP or CVP**
**(which ever is higher)**

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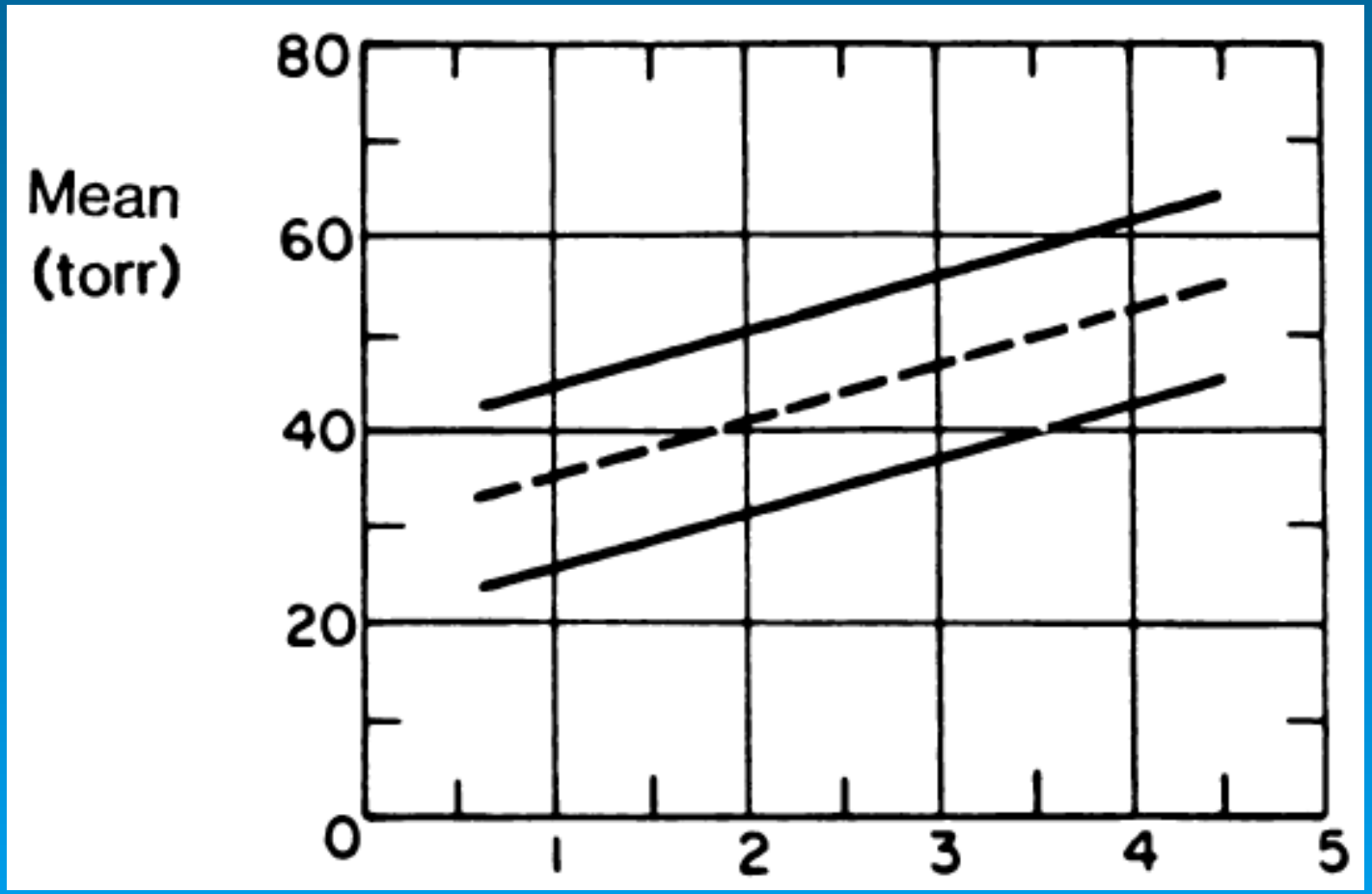
# Mean Blood pressure




**Mean blood pressure vs birth weight in Kg**

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# The CSF Pressure

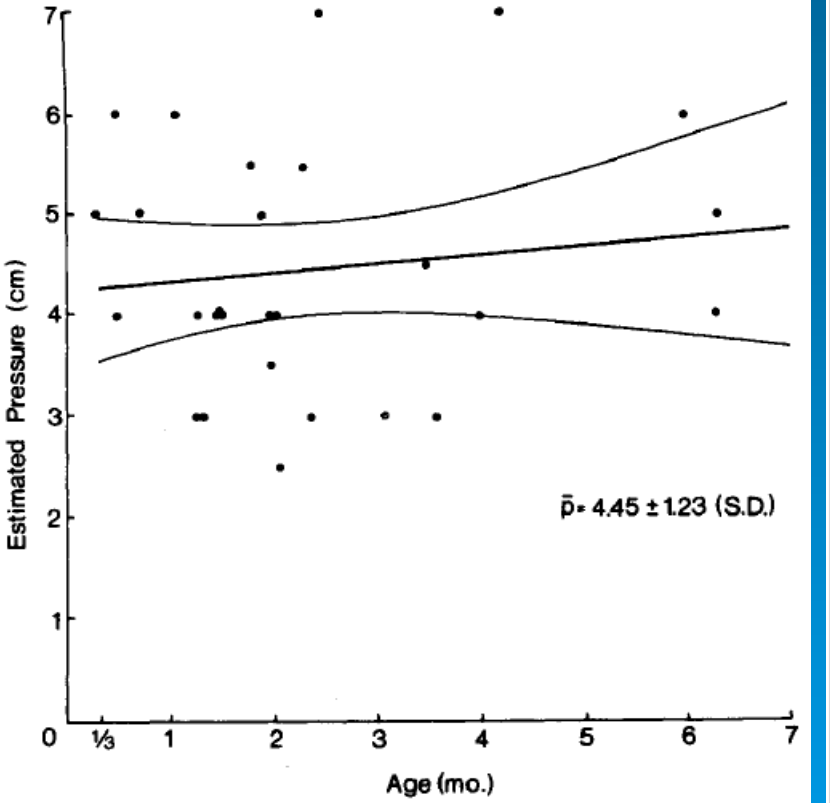
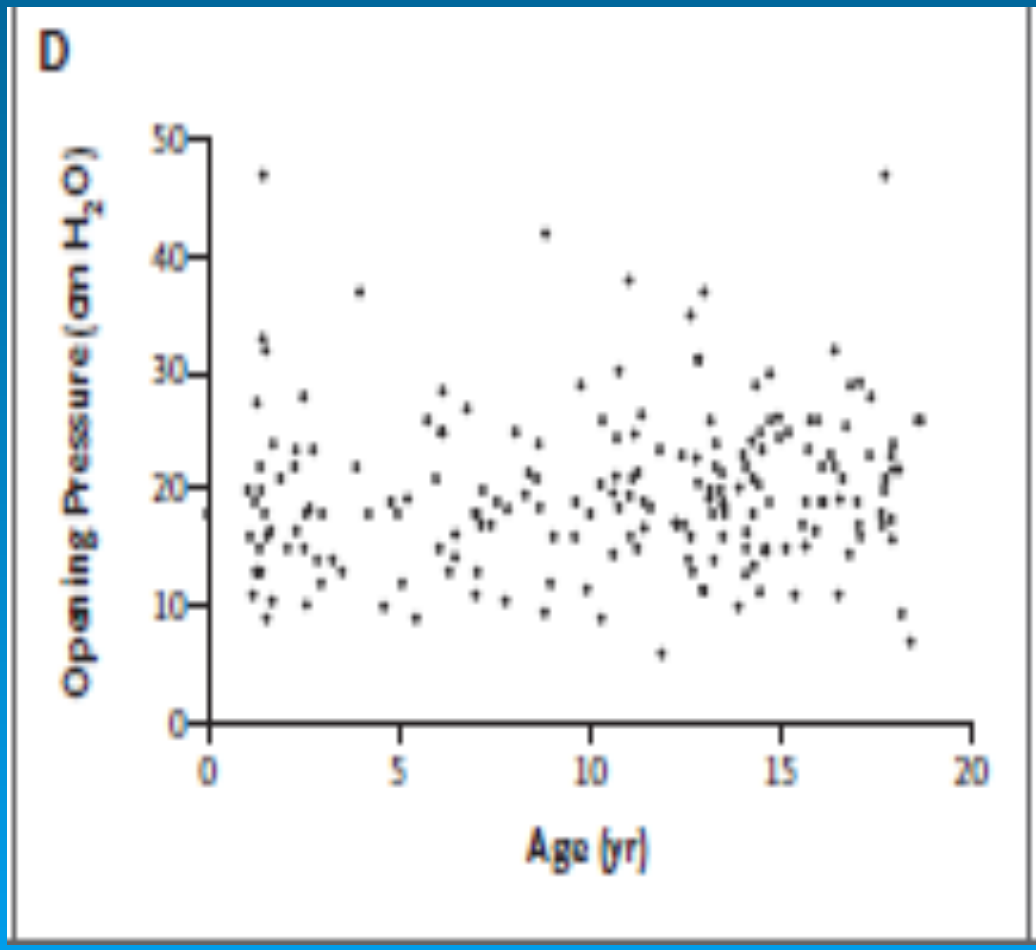



FIG. 1. Intracranial pressure versus age in months in 28 infants. The 95% confidence limits of the slope are so wide that a relationship between pressure and age is not shown.

Welch K. The intracranial pressure in infants. J Neurosurg 52:693-699, 1980




Avery RA et al. Reference Range for Cerebrospinal Fluid Opening Pressure in Children N ENGL J MED 2010; 363:891-893

1.36 cm $H_2O$= 1 mmHg

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# Sagittal Sinus Pressure

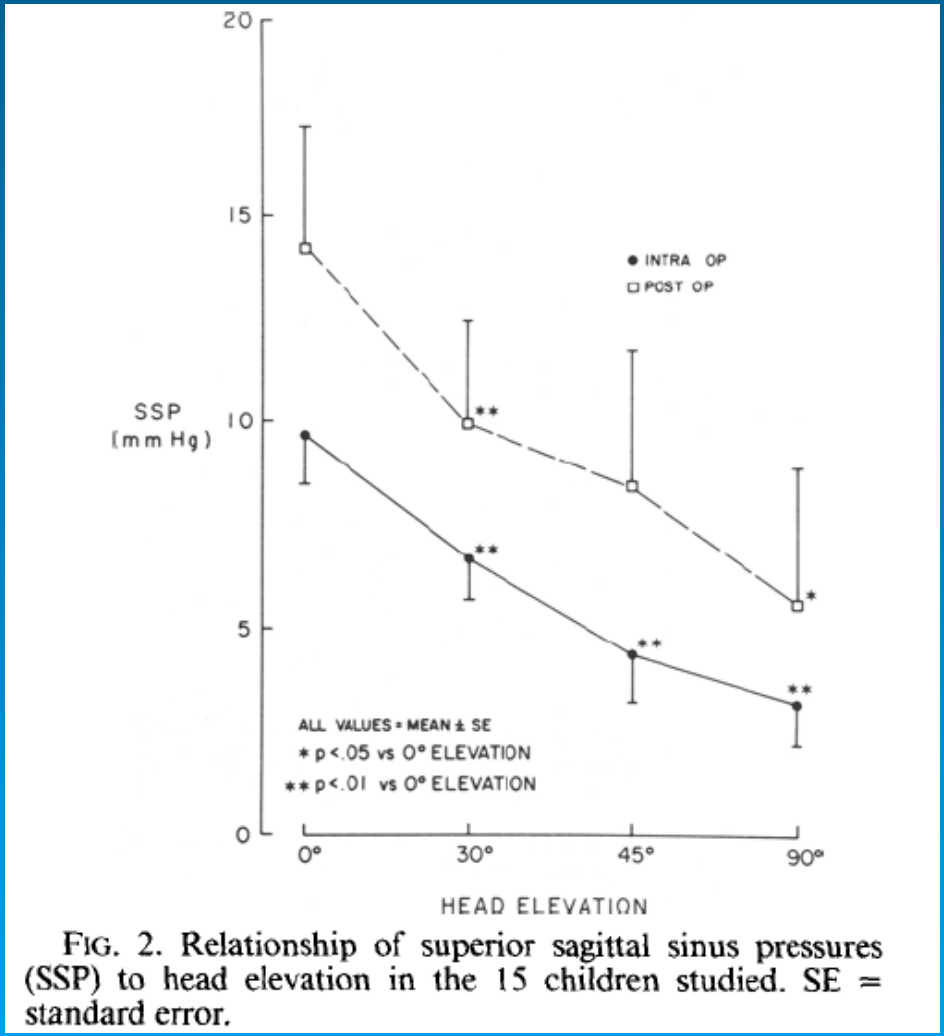
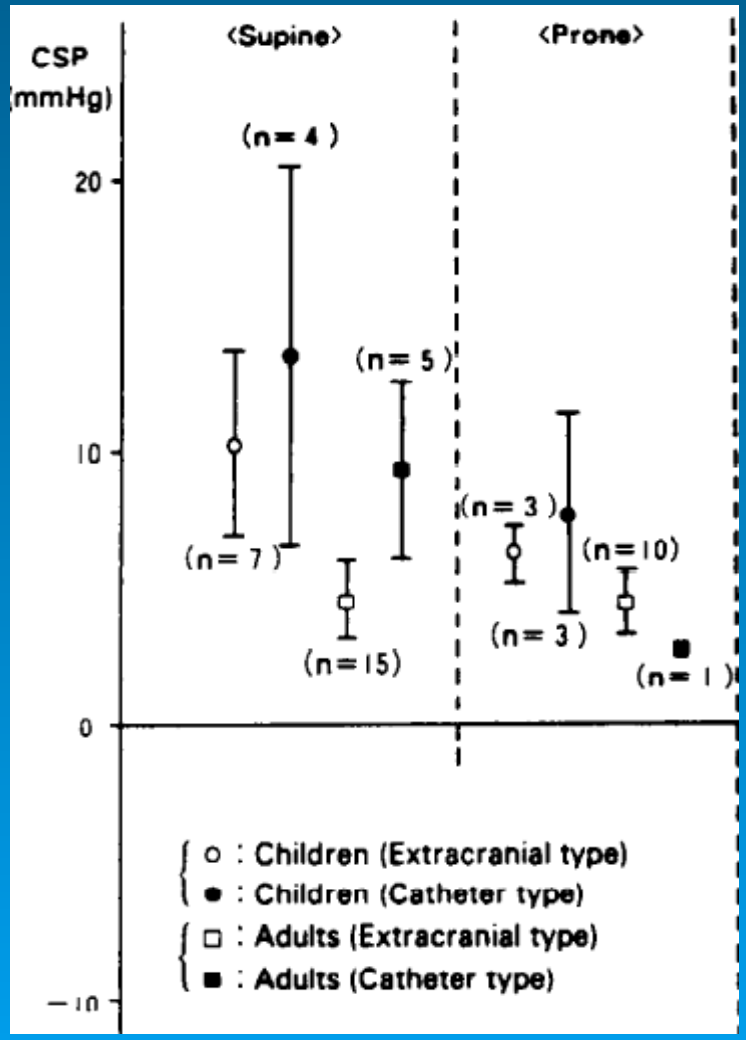



FIG. 2. Relationship of superior sagittal sinus pressures (SSP) to head elevation in the 15 children studied. SE = standard error.

Grady MS et al. Changes in superior saggital sinus pressure in children with head elevation, jugular venous compression and PEEP. J Neurosurg 65:199-202, 1986




Iwabuchi T et al. Dural sinus pressure: various aspects in human brain surgery in children and adults. Am J Physiol. 1986 Mar; 250(3 Pt 2):H389-96.

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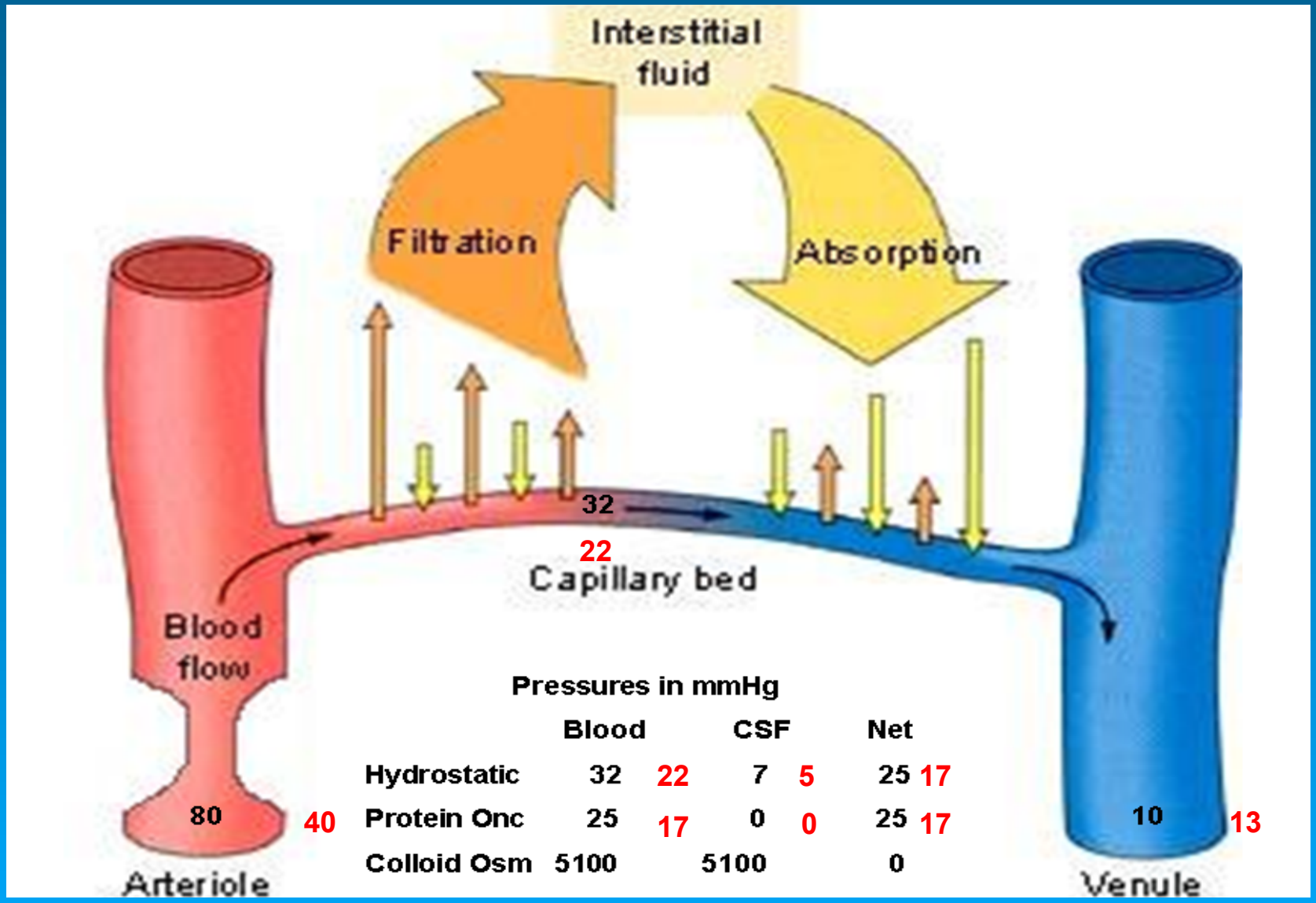
# Starling Forces at work

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# Conclusions

- Hydrocephalus in neonates reversibly reduces cerebral blood flow making some patients oligaemic/ischemic.
- The reversible stenosis is in the venous outflow at the level of the sinuses
- Even mildly elevated venous pressure in neonates significantly alters the Starling forces