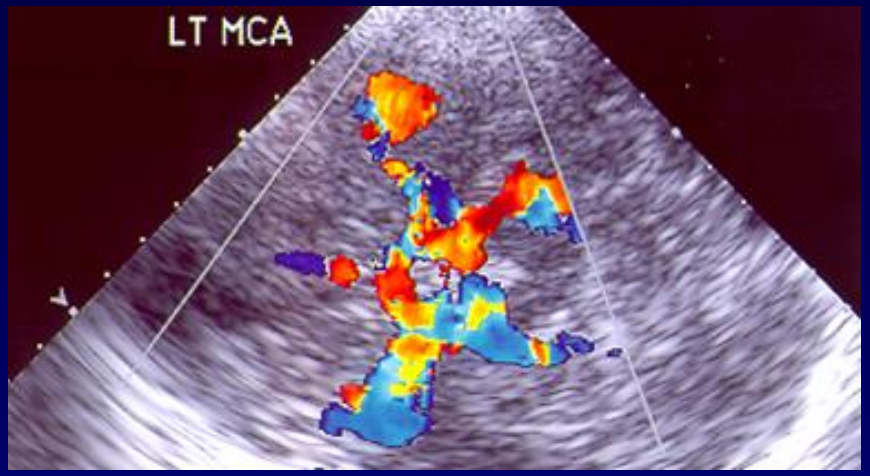

Transcranial Doppler (TCD) in the Critically Ill Child

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Raymond Sze, MD

Children's National Health System

Washington D.C.

Outline of Talk

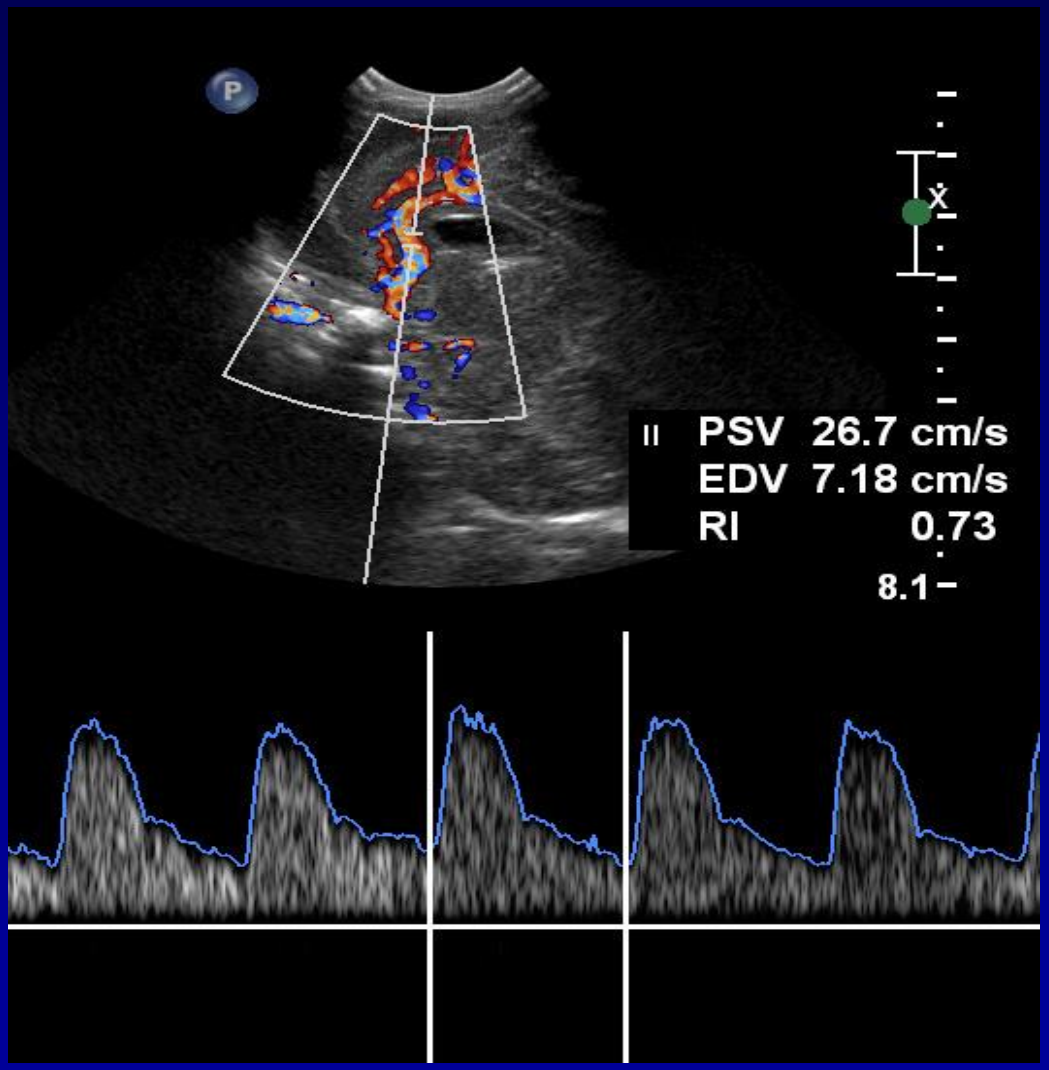
Technique

- **Neonate**
- **Child**
- **Doppler Measurements**

Indications

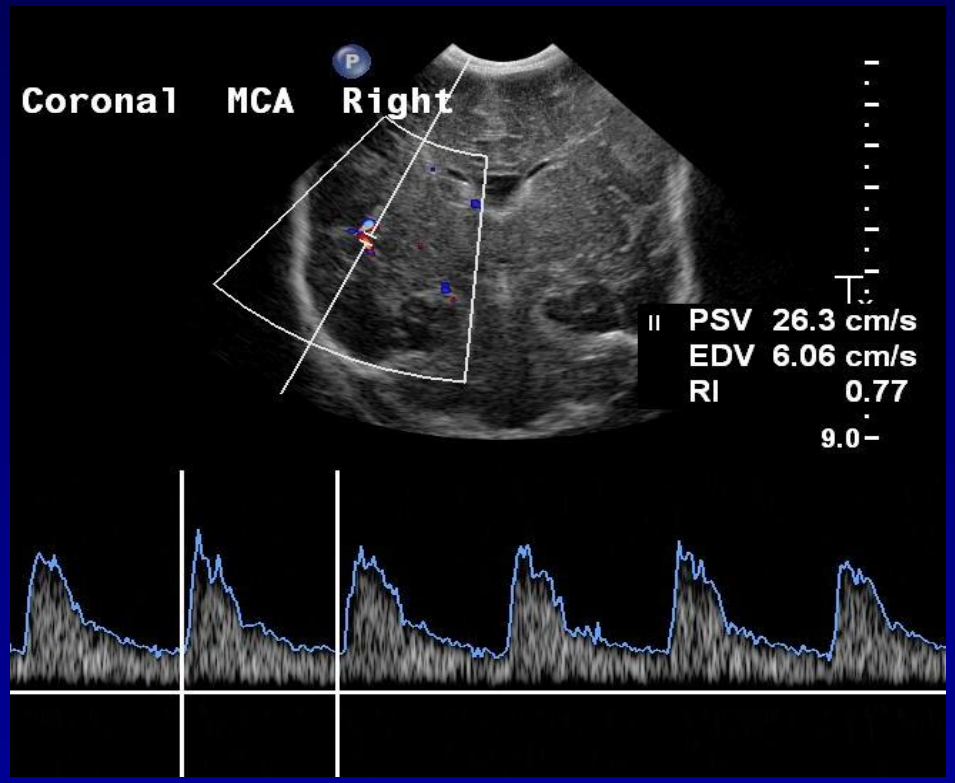
- Subarachnoid vs Subdural Collections
- Venous Thrombosis
- Vascular Malformations
- Hydrocephalus
- Asphyxia
- Brain death
- Vasospasm

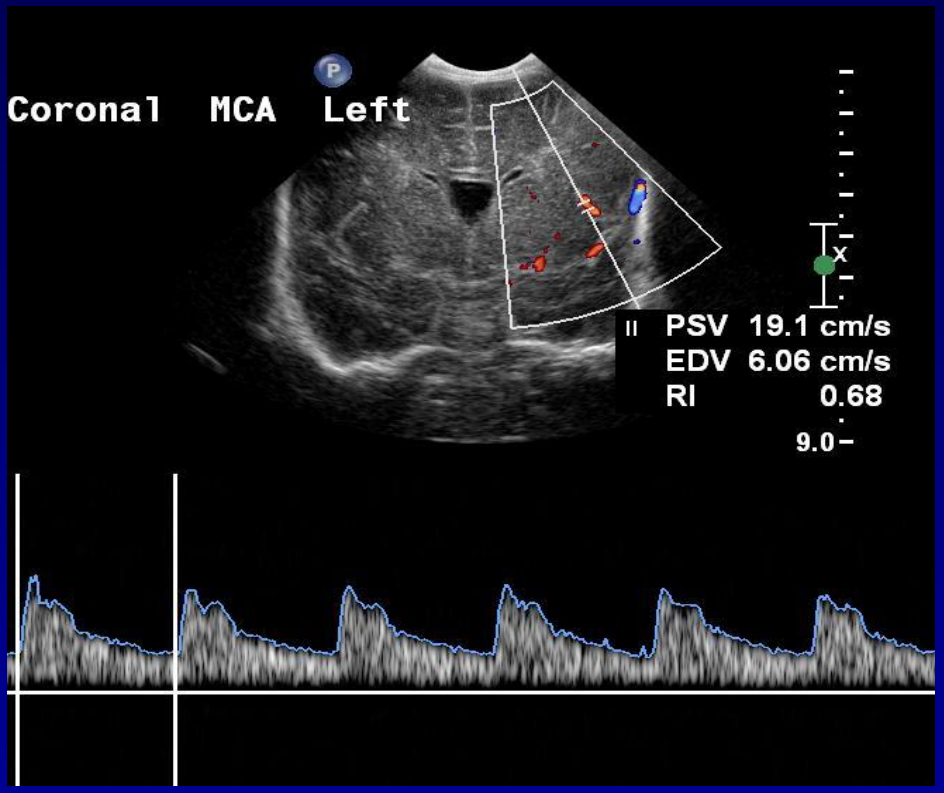
Neonate - Anterior Fontanelle Sagittal



Ant Cerebral Artery

Neonate - Anterior Fontanelle Coronal

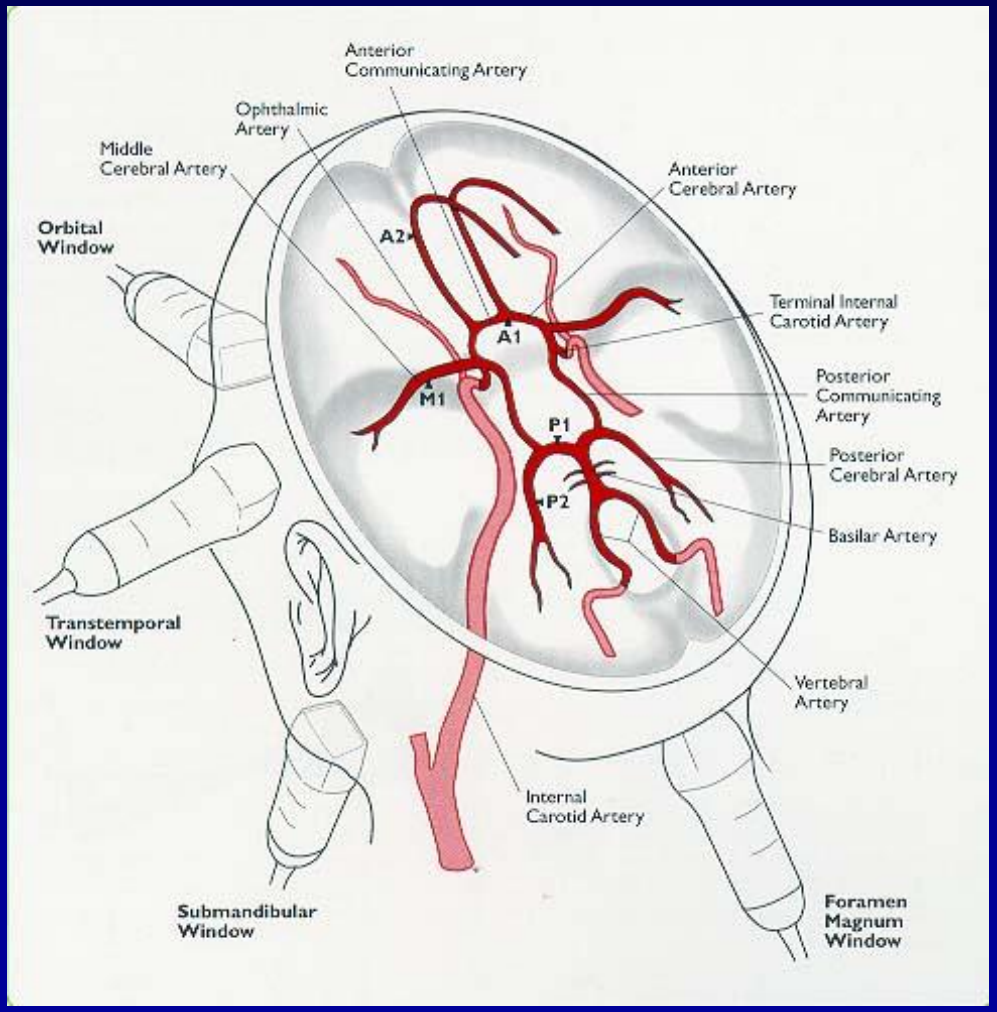




Middle Cerebral Artery

Right and Left via coronal plane

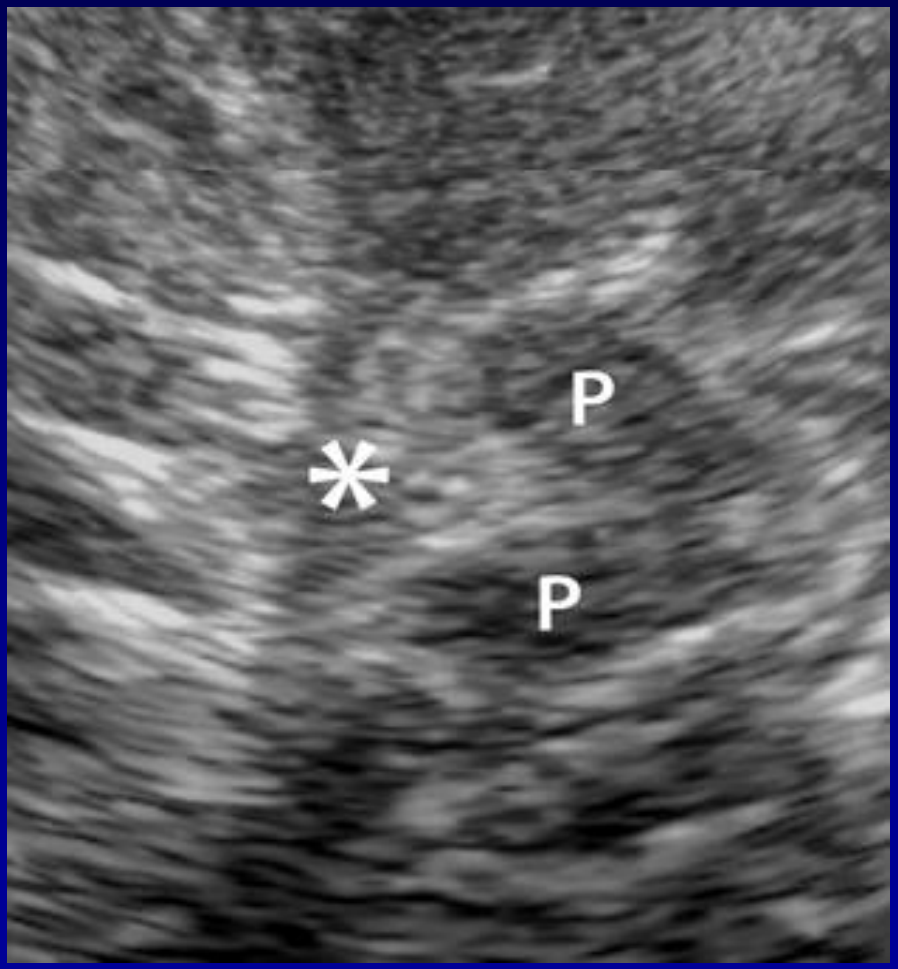
Child (closed anterior fontanelle)

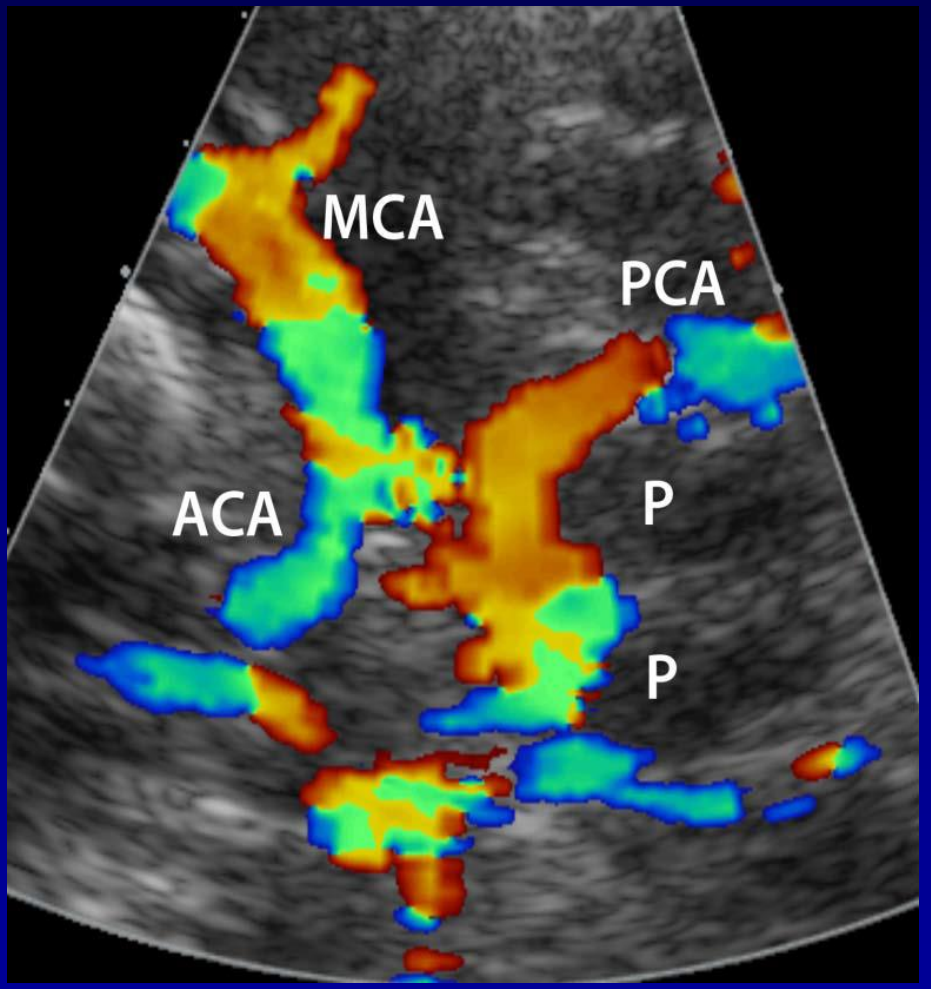


3 Cranial Windows

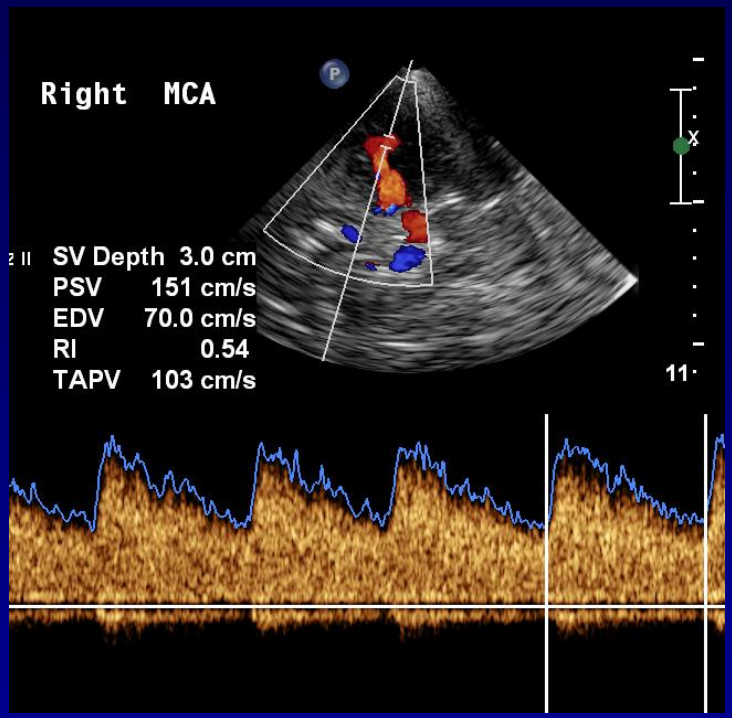
- Temporal bone
- Orbit
- Foramen Magnum

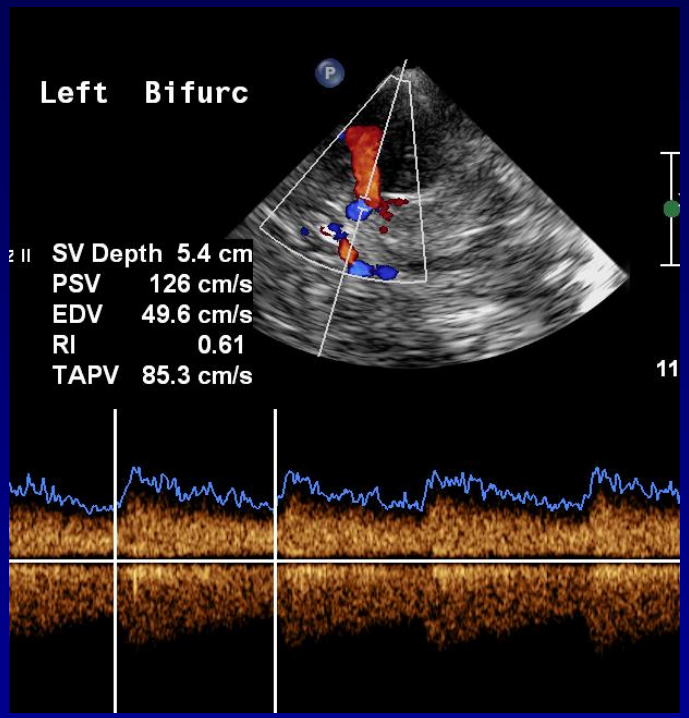
Transtemporal Window

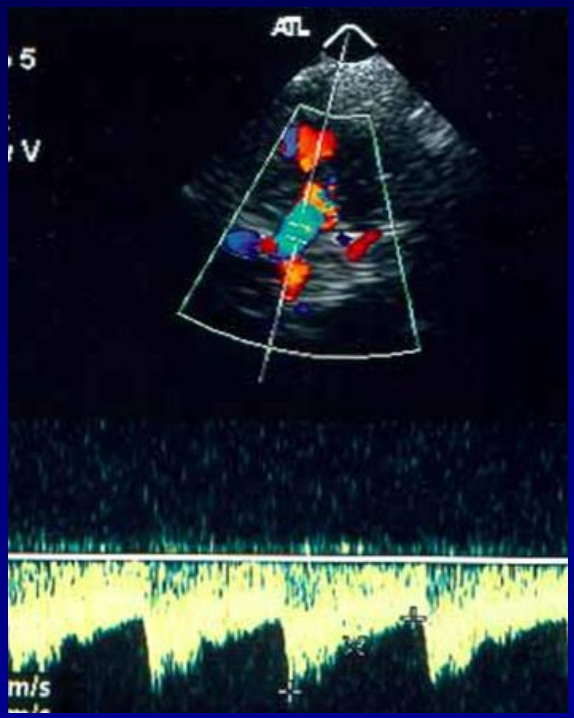




Transtemporal Window





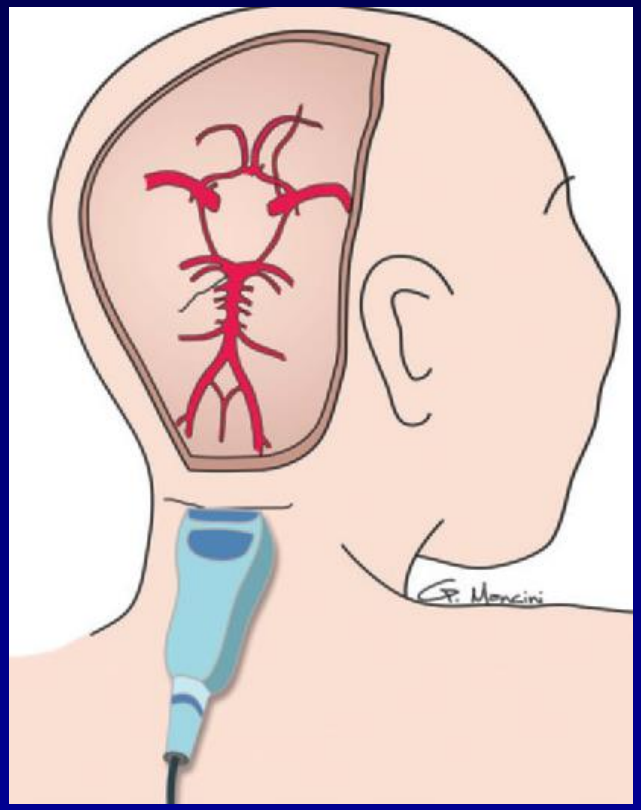


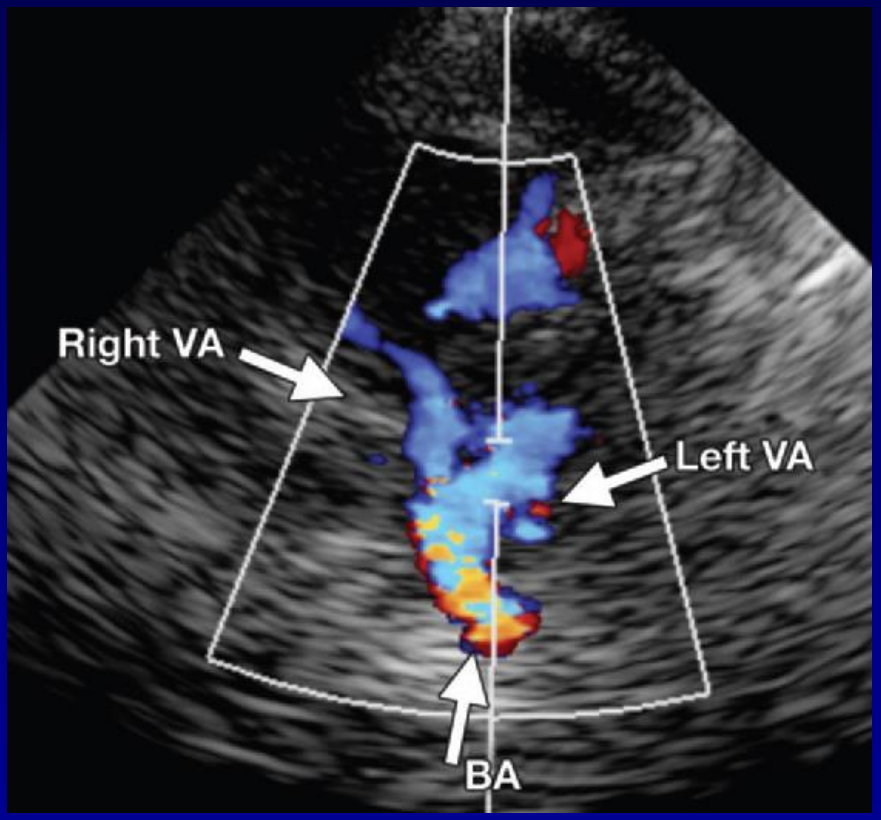
MCA
Towards transducer

MCA-A1 bifurcation
Bidirectional flow

ACA
Away from transducer

Basilar Artery





Transducer placed midline angle towards orbits

Vertebral arteries **V** shape before form basilar artery

Kirsch JD. RadioGraphics 2013

Pulsatility: Resistive Index

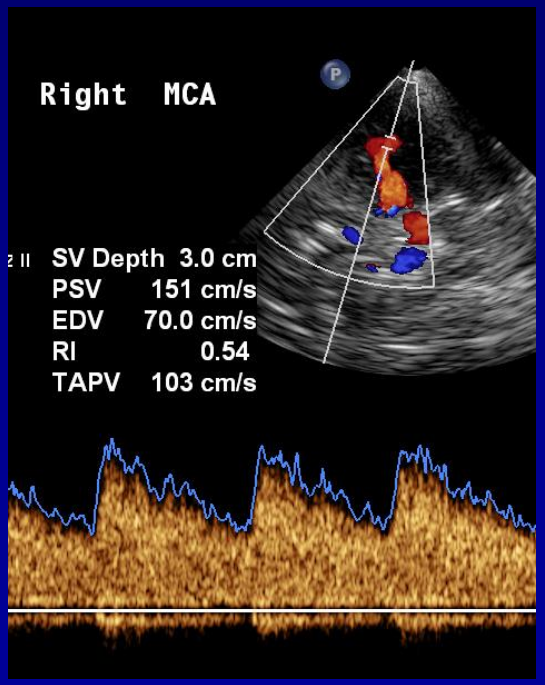
Peak Systole Velocity – End Diastole Velocity

Peak Systole Velocity

- **Minimize affect of angulation**

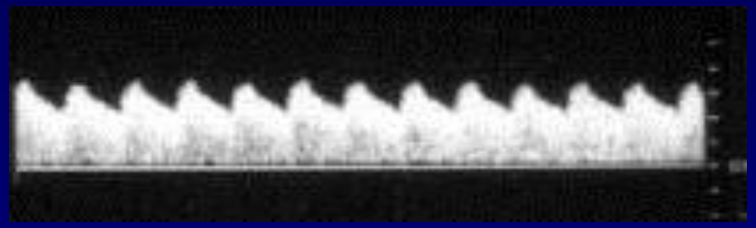
  Age dependent values

  - Preterm infant .77 ± 7%
  - Term infant 0.7 ± 7%
  - By age 2 0.5 ± 15%

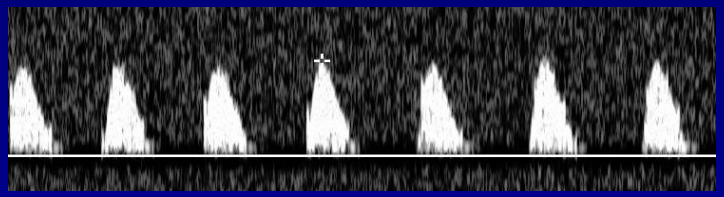


Resistive Index

- An **increase** in diastolic flow will result in a decrease in RI



- A **decrease** in diastolic flow will result in an increase in RI



- as ICP increases above mean arterial pressure, diastolic flow may become **reversed** RI > 1.0.

Blood Flow Velocity

- Velocity is better than RI to predict cerebrovascular resistance
- Velocity in PCA and vertebral and basilar arteries should be approximately 50% velocity in MCA
- Take 2 readings/vessel and use highest (best insonating angle)

Outline of Talk

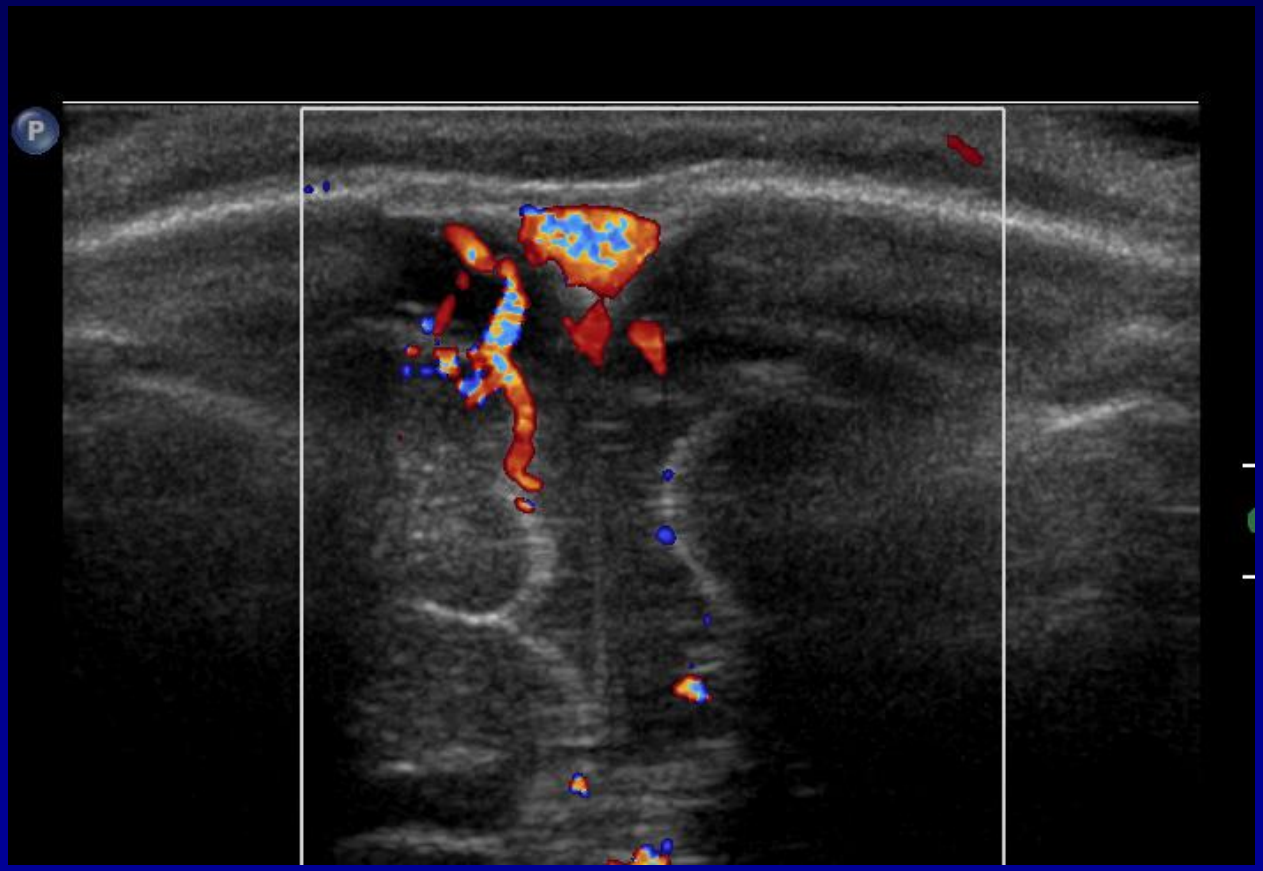
Technique

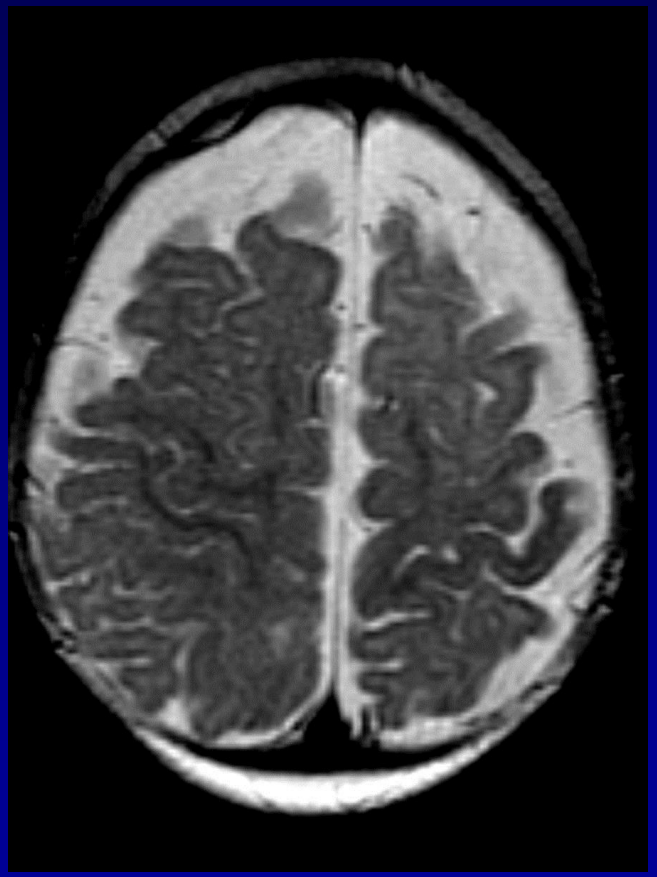
- Neonate
- Child
- Doppler Measurements

Indications

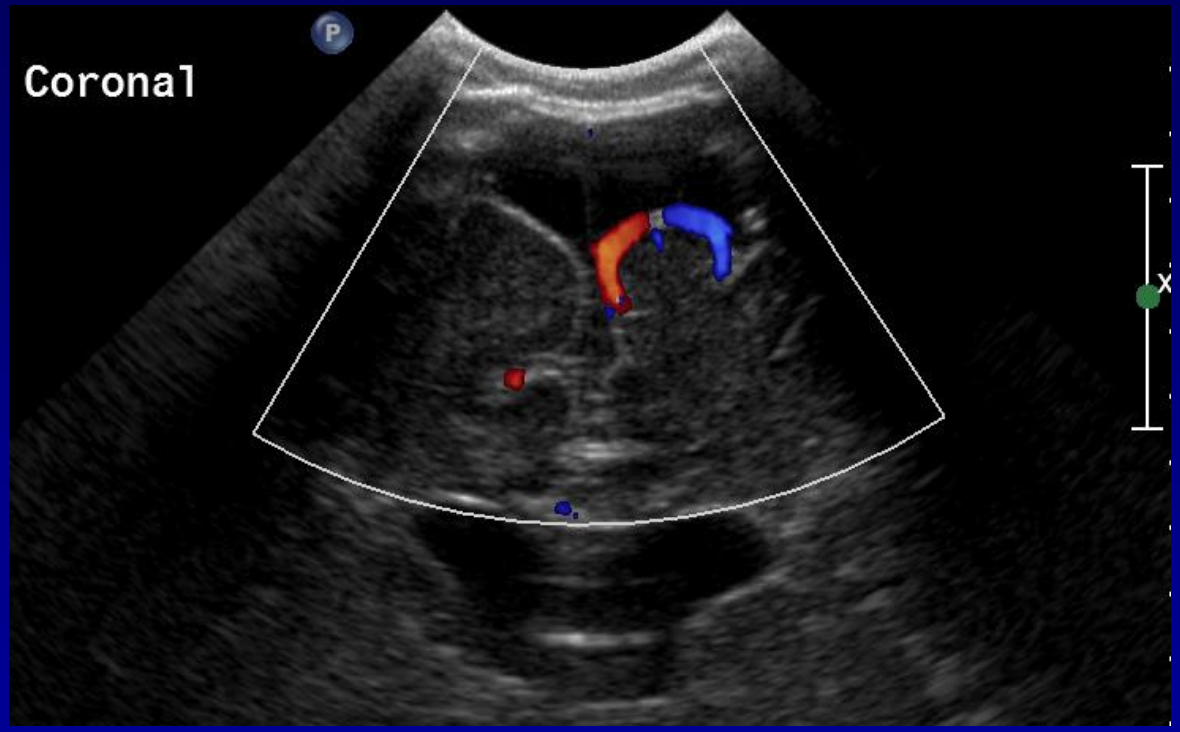
- **Subarachnoid vs Subdural Collections**
- **Venous Thrombosis**
- **Vascular Malformations**
- **Hydrocephalus**
- **Asphyxia**
- **Brain death**
- **Vasospasm**

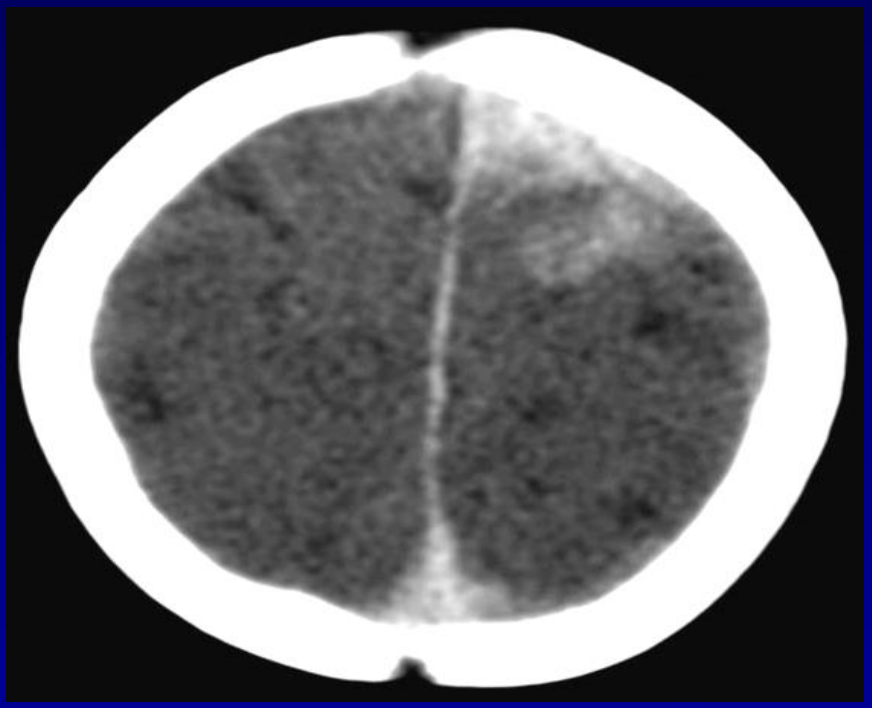
Subarachnoid Collection



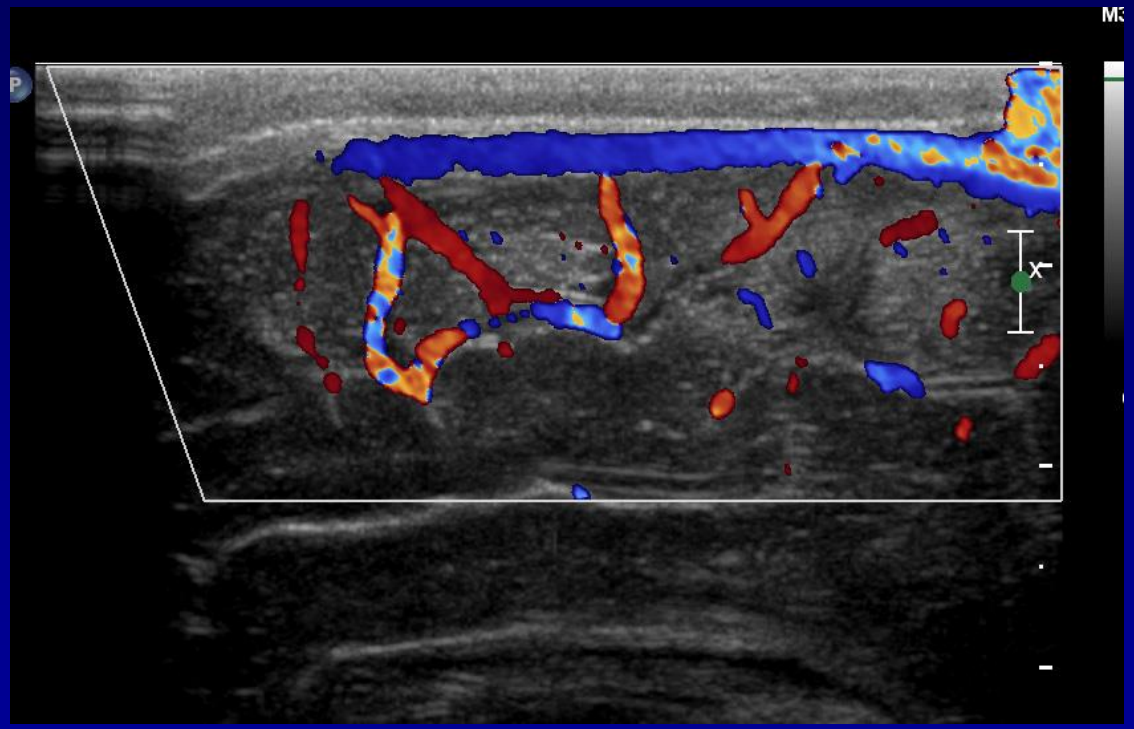


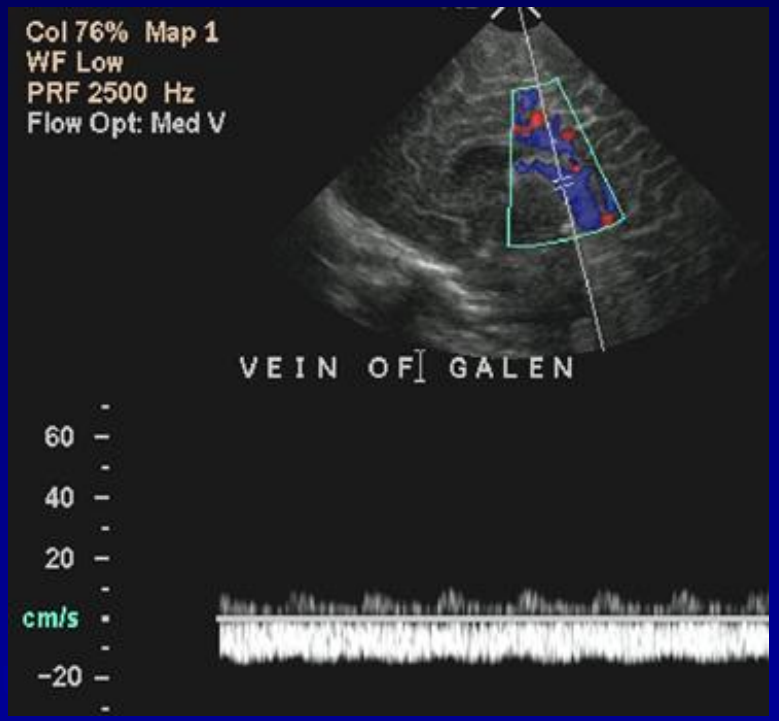
Subdural Collection (hematoma)



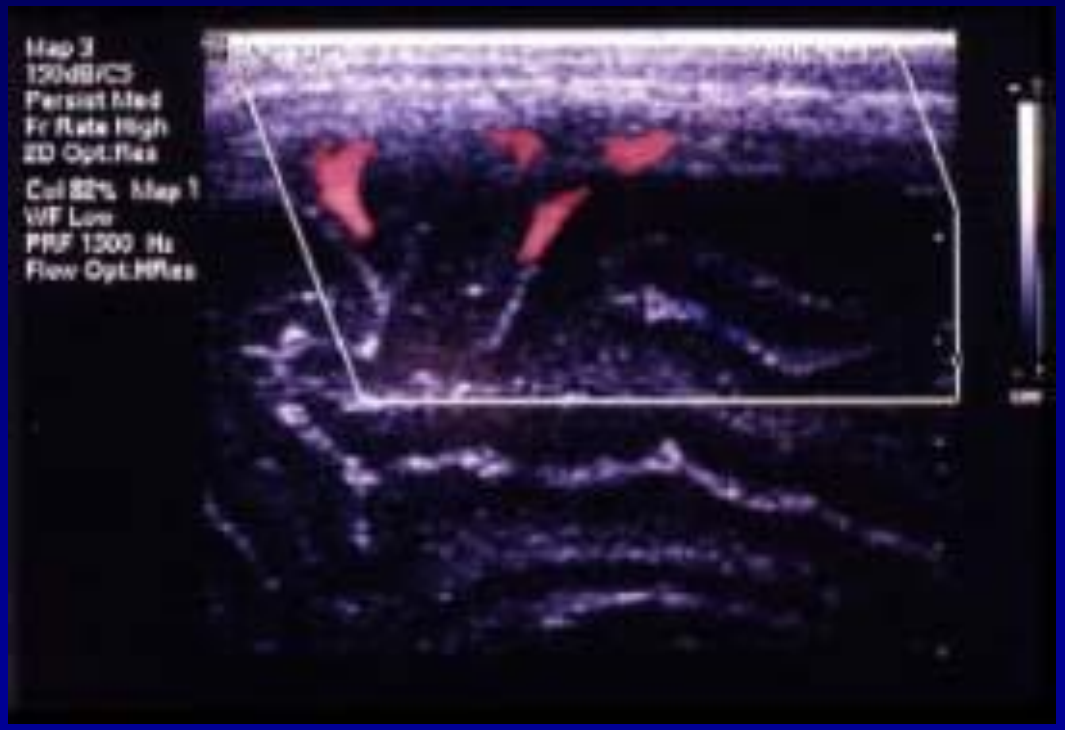


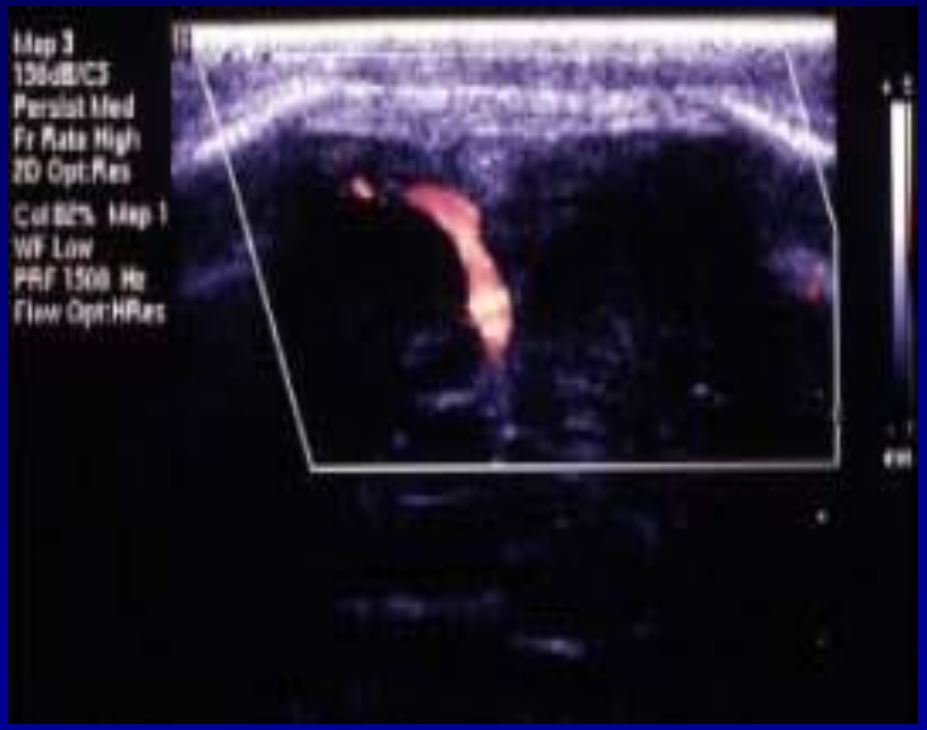
Normal venous sinuses





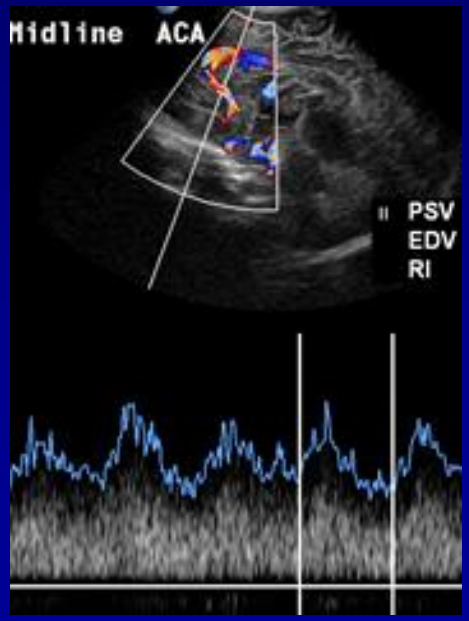
Superior Sagittal Sinus Thrombosis

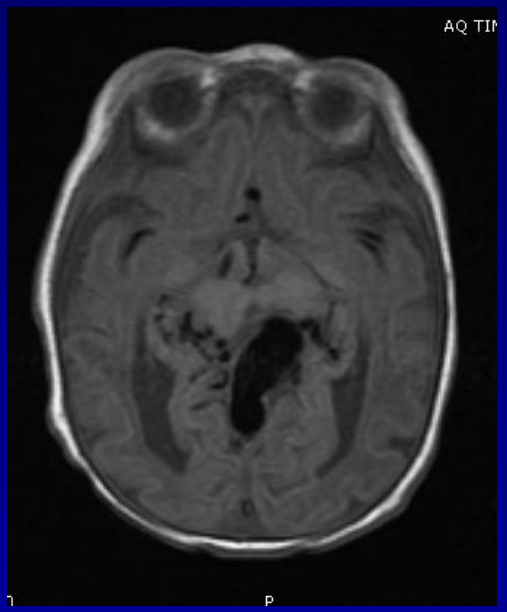




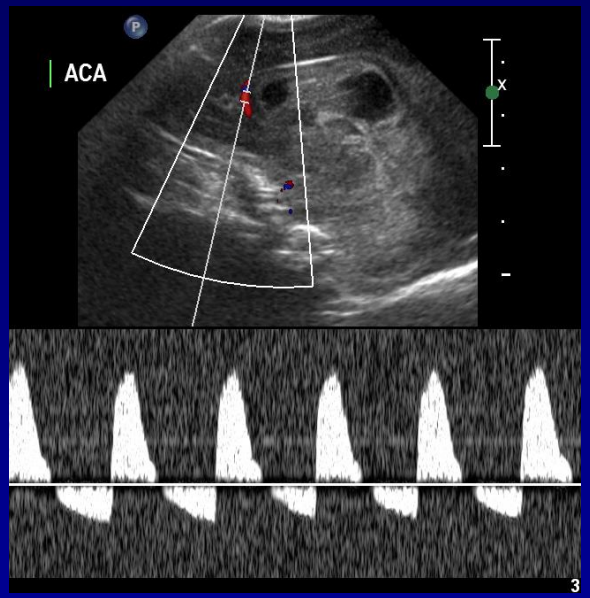
Vein of Galen Aneurysm

Feeding vessels, nidus and draining veins

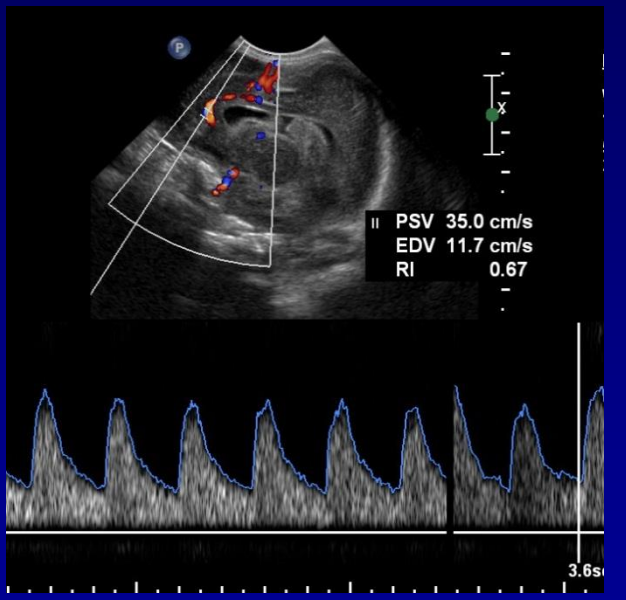




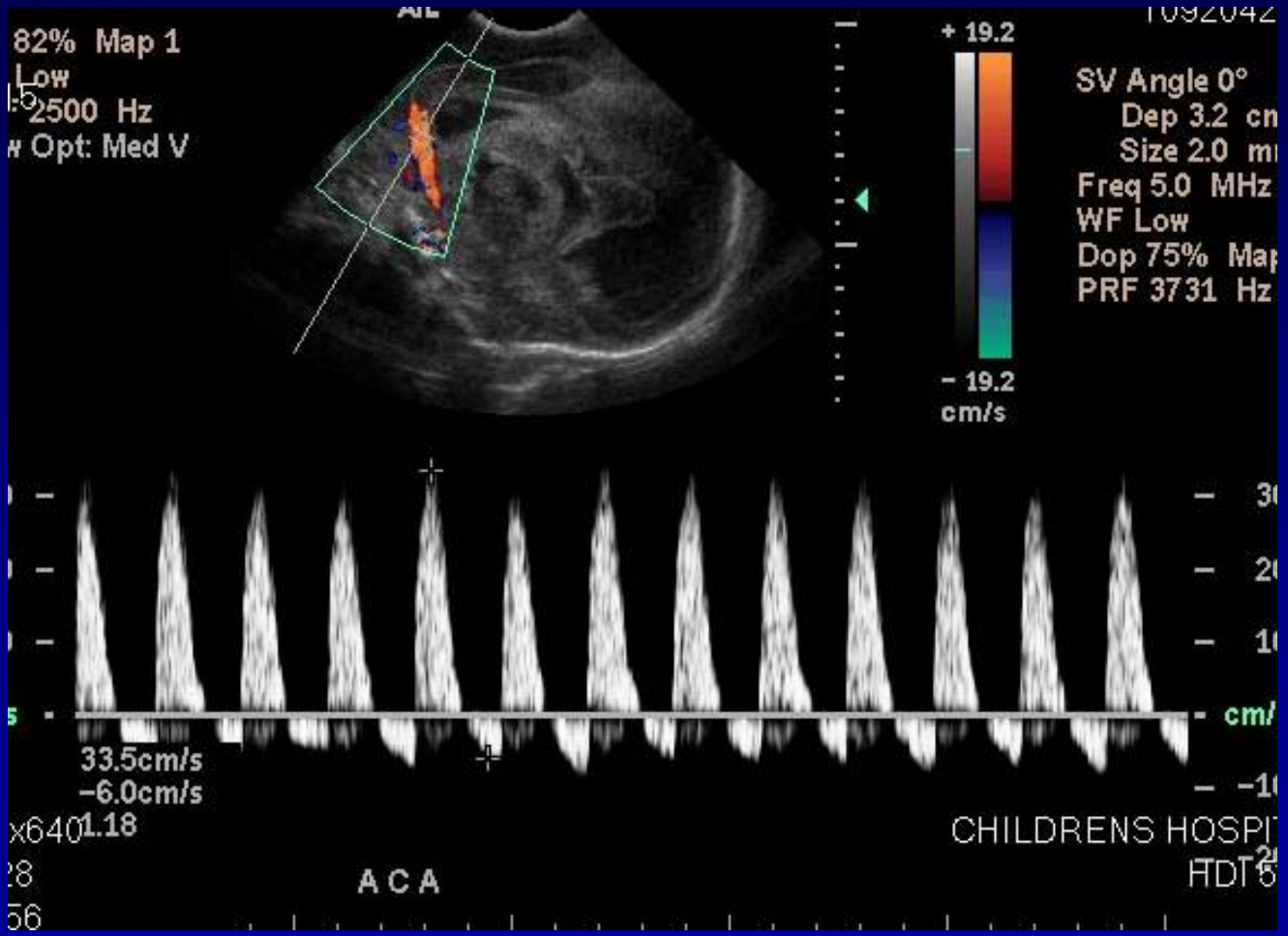
Hydrocephalus



- ↑ RI is sign of ↑ ICP
  - >0.8 in neonate
  - >0.65 in children
- Post tap, RI will decrease
- Persistently elevated RI may imply need to shunt



Beware! Head connected to Body

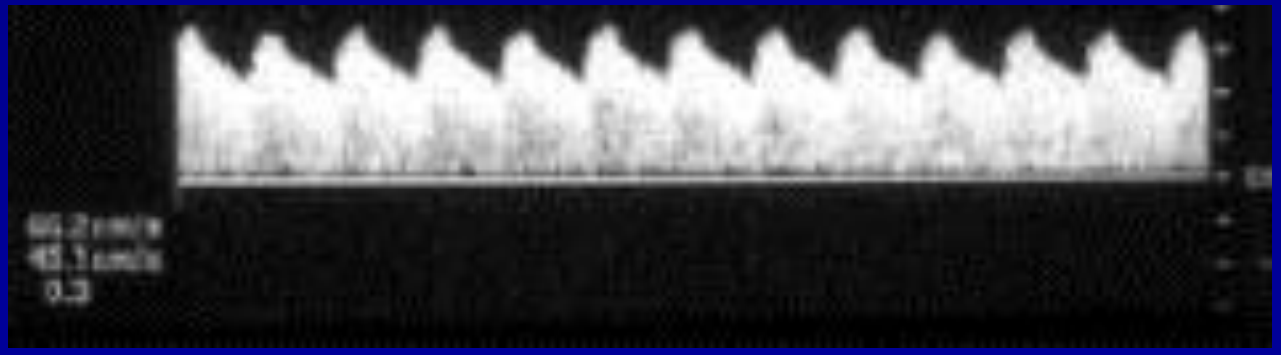


Patent Ductus Arteriosus

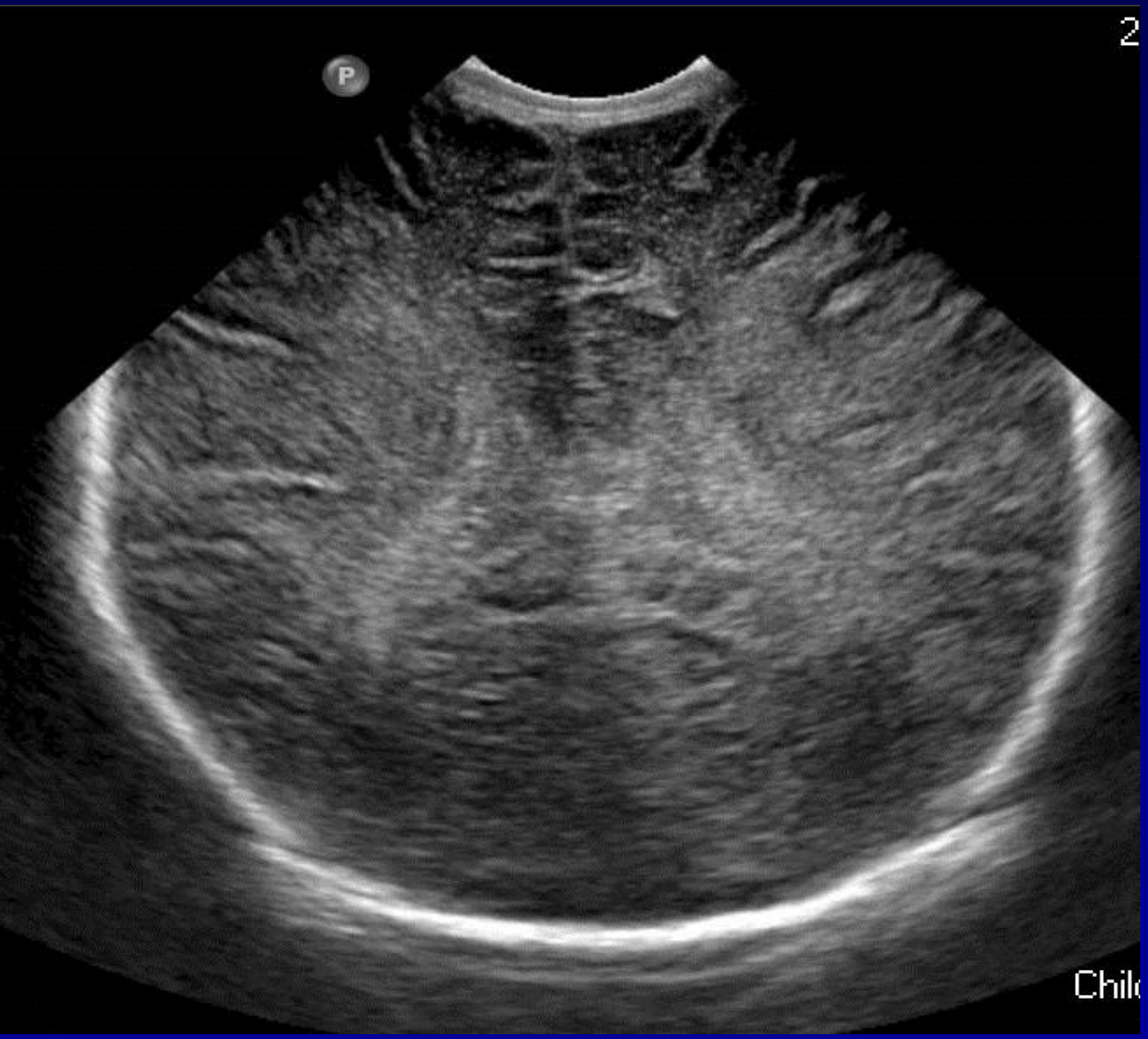
Asphyxia

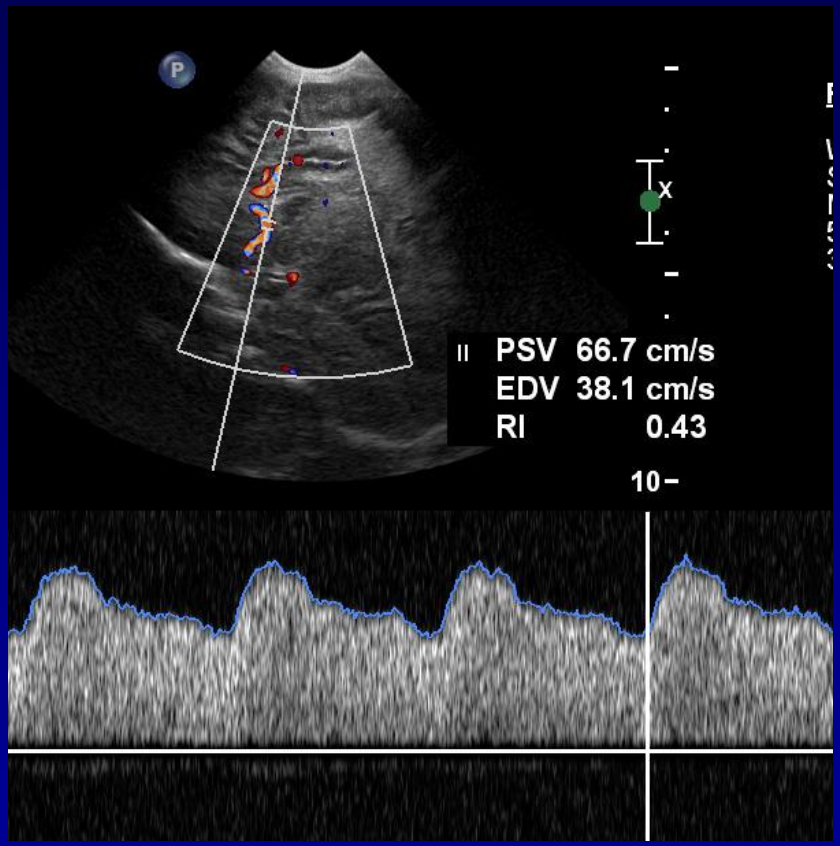
- **Impaired cerebral autoregulation** produces an increase in diastolic blood flow.
- Term infants following asphyxia:
  - **Low RI (< .6) w/in the 48^{o} of asphyxia correlated with poor neurologic outcome**.

Archer et al Siebert et al



Asphyxia



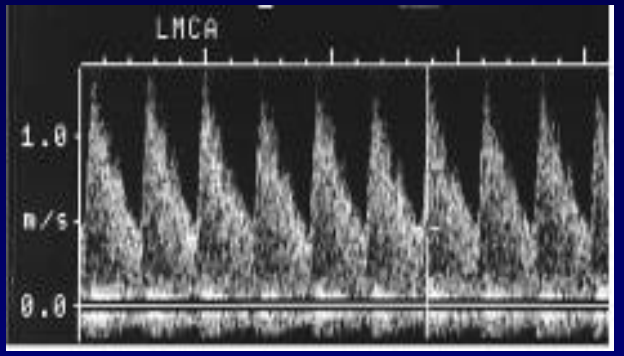


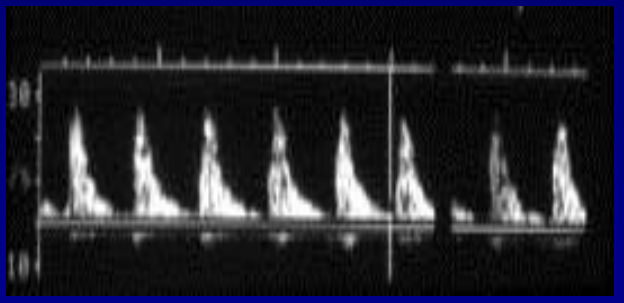
Low RI .5

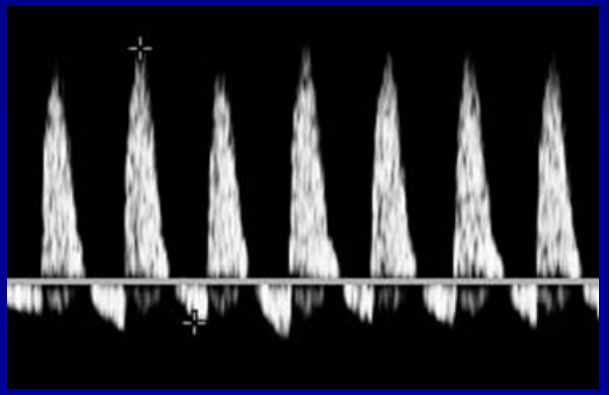
Decrease then reversed diastolic flow

If cerebral edema develops, RI will increase

- Vessels vasoconstrict
- As ICP increases above mean AA pressure, diastolic flow reverses (RI>1)







Hyperventilation

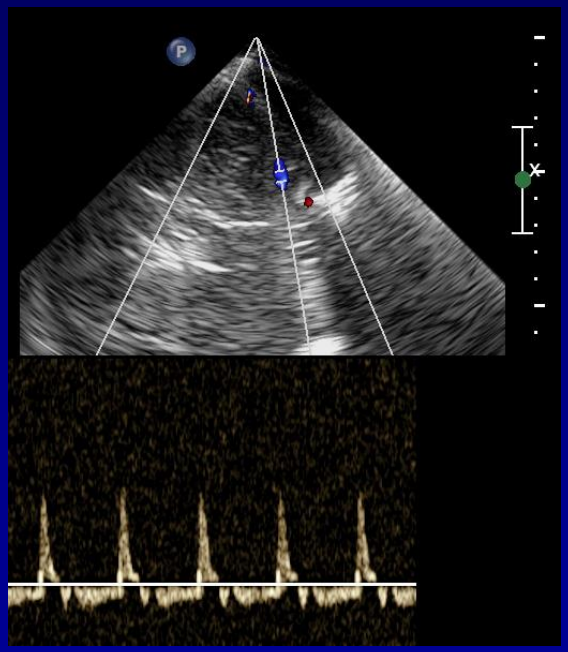
Decreasing CO_2 - cerebral vessels vasoconstrict - **RI should increase**

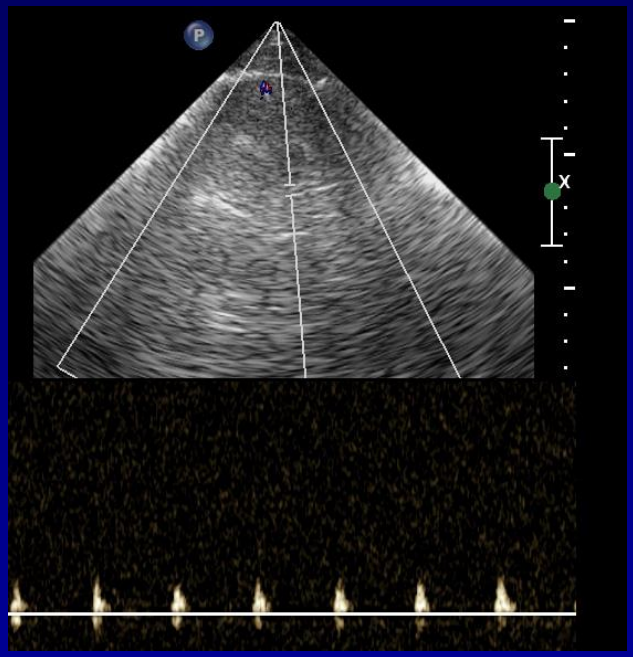
- Children w/ reduced or absent $PaCo_2$ vasoreactivity w/in $24^o$of injury = ***vegetative or died***

Beyda DH,. Wade ed. 1987

Progression to Brain Death

- **Arrest of CBF** at microcirculation level.
- Large vessels distend/constrict, thrombose/collapse.
- **Cerebral circulation arrest**
  - Decrease in systolic velocity.
  - Small spikes





Brain Death

- **TCD exam** should never be used in isolation to supplant clinical neurologic findings in children and neonates
- Provides data indicating severity of cerebrovascular arrest.
- Repeat study to confirm CBF arrest sufficient to cause irreversible damage

  to supratentorial structures

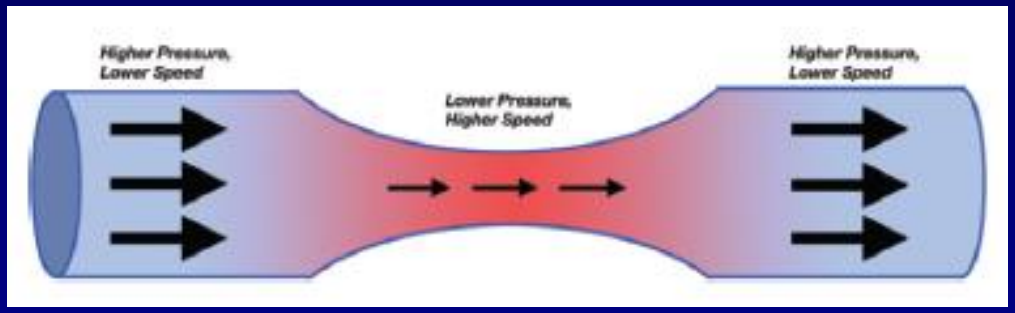
Vasospasm

- Develops in first 2 days after SAH
- Peaks 2 weeks later
- Declines gradually during the subsequent 3 weeks

Vasospasm

- As cross sectional area of vessel decrease, blood velocity increases (Bernoulli principle)
- **Mild**:100-140 cm/sec
- **Moderate:** 140-200cm/sec
- **Severe: >200cm/sec**

  – risk for ischemia



Kirsch JD. RadioGraphics 2013

- **Rapid increase:**

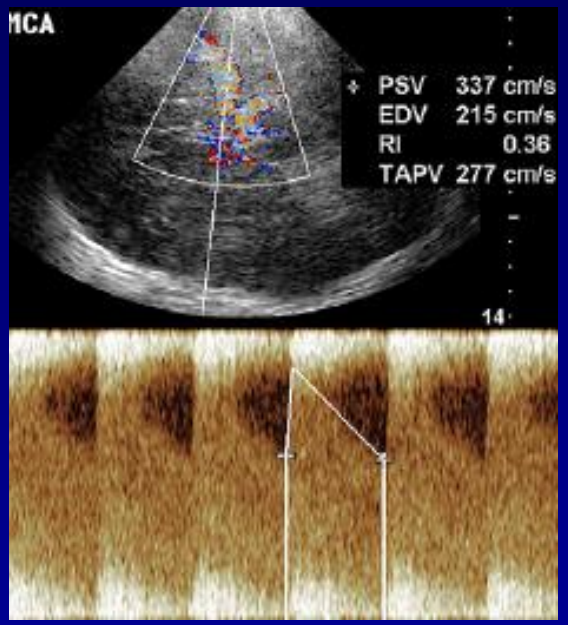
  >25 cm/sec/day first few days carries poor prognosis

Vasospasm

- Proximal MCA most accurate
- Severe
  - **PSV > 200 cm/sec**
  - **rapid increase (>50 cm/s/day)**

Errors:

- increased ICP
- low volume flow
- peripheral vasospasm



Conclusions

- US provides unique CNS applications useful in the critically ill neonate and child in the acute setting - ED/NICU/PICU
- Important to learn proper technique
- Have appropriate equipment
- Understand how results vary dependent on age, clinical status