Neonatal Head US: Useful Techniques to Improve Diagnosis

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Disclosures
• None

Conventional US
• Anterior fontanelle approach
• Coronal and sagittal projections
• Sector transducers
• Center frequency about 7.5 MHz
• Excellent depiction of ventricles, periventricular white matter, deep gray matter

Conventional US
• Adequate for diagnosis of brain injury in preterm infants
  – usually confined to periventricular areas and/or white matter
• Additional techniques add value to this approach in selected patient populations and clinical situations

Near-Term and Term Infants with Hypoxic-Ischemic Brain Injury
• High-frequency linear array transducer over anterior fontanelle
• Improved evaluation of superior sagittal sinus, cortical and subcortical regions of cerebral hemispheres

Supplementary Acoustic Windows
• Images of midbrain and posterior fossa obtained via anterior fontanelle often suboptimal in quality
• Alternate acoustic windows permit placement of US probe close to areas of interest
• Images can be acquired using high transducer frequencies with detailed depiction of structures not readily obtainable via anterior fontanelle
  – posterior and mastoid fontanelles; craniocervical junction
Supplementary Acoustic Windows

- **Posterior fontanelle:**
  - Improved visualization of occipital horns of lateral ventricles, occipital parenchyma, cerebellum
  - Particularly helpful in detection of IVH
- **Mastoid fontanelle:**
  - Optimal imaging of cerebellum, fourth ventricle, aqueduct, cisterna magna
  - Facilitates clot detection

Supplementary Acoustic Windows

- **Craniocervical junction:**
  - Permits evaluation of cisterna magna, medulla, cerebellar tonsils, vermis, cervical cord, central canal
  - Subarachnoid blood
  - Fourth ventricular clot
  - Chiari II malformation
  - Cisterna magna obliteration, cervicomedullary kink, cerebellar peg

Color and Spectral Doppler Imaging

- Determination of blood flow velocity and direction
- Assessment of vascular resistance
- Evaluation of intracranial hemodynamics

Doppler Imaging Technique

- Intracranial vessels imaged on coronal and sagittal views obtained via anterior fontanelle with 5-7.5 MHz sector transducer
  - Internal carotid, anterior and middle cerebral arteries
  - Central veins
  - Vein of Galen, straight and transverse sinuses
- Superficial arteries, veins, dural sinuses best evaluated with high-resolution linear array transducers

Doppler Imaging Technique

- Middle cerebral artery optimally assessed via axial images obtained through squamous portion of temporal bone
- A1 segment of anterior cerebral artery, posterior communicating artery, and posterior cerebral artery also well-depicted
  - More favorable interrogation angle

Assessment of Cerebral Flow

- Flow velocity and resistive index (RI) most frequently used spectral Doppler measurements
- Systolic and diastolic blood flow velocities increase while RIs decrease with increasing gestational age due to changes in cerebrovascular resistance
- In full-term infants antegrade arterial flow present throughout systole and diastole
  - RI 0.7 ± 1% (range: 0.65—0.75)
Assessment of Cerebral Flow
• Diastolic flow may be absent in premature infants <30 weeks gestational age
• Diastolic steal from PDA
• Resistance to flow in cerebral vasculature greater than in pulmonary vessels
• Shunting of blood from brain during diastole
  – RI approximately 0.77

Assessment of Cerebral Blood Flow
• Cerebral edema, hydrocephalus, hemorrhage and extra-axial fluid collections increase vascular resistance
• Diastolic blood flow reduced
• RI increased
• Transducer pressure on anterior fontanelle may transiently increase intracranial pressure with concomitant increase in RI of ACAs

Assessment of Cerebral Blood Flow
• In normal infants, firm pressure produces small increase in mean RI (about 5%)
• With increased vascular resistance, firm pressure results in larger increase in mean RI (about 17%)
• RI changes used to monitor patients with increased ICP and to determine effectiveness of various interventions
  – ventricular tapping for hydrocephalus

Neonatal Stroke
• Most are ischemic and secondary to thrombosis
• More common in term infants than preterm infants
• Color Doppler imaging (& contrast-enhanced US):
  – increased flow around infarcted tissue and in vessels supplying and draining the infarcted zone
  – increased mean blood flow velocity in parenchyma around infarcted artery
  – thrombosis of SSS and large deep veins with parenchymal infarction

Differentiation of Subarachnoid from Subdural Fluid
• Based on vascular displacement
• Superficial cortical vessels lie on cortical surface within the pia-arachnoid layer
• Subarachnoid fluid displaces cortical vessels from brain surface toward cranial vault
• Subdural space devoid of blood vessels
• Subdural fluid pushes superficial cortical veins against brain surface

Characterization of Vein of Galen Malformation
• Fistulous connection between the cerebral arteries and a primitive midline prosencephalic vein
• Hemodynamic effects can be followed and quantified after embolization
  – decrease in caliber and flow in embolized feeding vessels
  – increase in size and flow velocity in vessels not occluded during embolization
  – increased blood flow velocity in normal vessels in uninvolved areas of the brain indicating rerouting of blood after elimination of arterial steal
Conclusion

- The utility of neonatal cranial US can be significantly enhanced through the use of supplementary acoustic windows, color and spectral Doppler US
- Promising (but as yet minimally explored) role for contrast-enhanced US, especially in evaluation of hypoxic-ischemic injury and vascular malformations