Enhancement of Cranial US: Utility of Supplementary Acoustic Windows and Doppler

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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 ± 7% (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