Intraventricular Hemorrhage and Periventricular Leukomalacia

Diagnosis and Management in the Preterm Infant

Prepared by An Massaro

OBJECTIVES

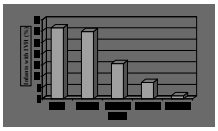
To understand the:

- Pathogenesis and epidemiology of GM-IVH
- Clinical features
- Diagnosis and Grading – CNMC Protocol
- Complications
- Prevention/Treatment
- Outcome
- Relation to PVL
- CNMC Protocol for Term Equivalent MRI

Epidemiology

- *Incidence* **in preterm infants (<1500g) declining in recent decades from 40-50% to** *15-20%*

•Inversely related to gestational age (i.e. up to 30% in <1000g versus 2% 1500-2500g)
From Sheth RD: *J Child Neurol* 1998

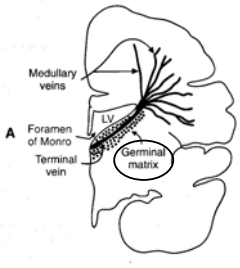


•Majority occur within first 5 days of life (up to 50% on D1)
From Volpe: *Neurology of the Newborn* 2001

Postnatal day	Percent of infants with GM-IVH
1	50
2	25
3	15
>= 4	10

Neuropathology

- **Distinct entity- to be differentiated from other types of intracranial hemorrhage term infants**
- **originates in the** *subependymal germinal matrix*
  - **richly vascularized (capillary network AND venous drainage)**
  - **site of active cellular proliferation (neuronal and glial precursors)**
  - **ventrolateral to the lateral ventricles**



Risk Factors and Pathogenesis

- Anatomical
- Changes in Cerebral Blood Flow
- Hematologic

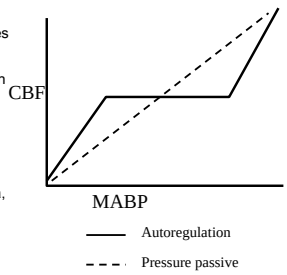
Anatomical Factors

- Poor endothelial integrity of capillary network- collagen sheath/ basement membrane develops closer to term
- Arterial supply to GM = vascular endzone vulnerable to ischemic injury
- High metabolic demand (cellular proliferation)
  - ⇒ further susceptibility to ischemia

Impaired Regulation of CBF in Preterm Infants

IVH as consequence of:

- Decreased or fluctuating CBF
  - Respiratory disturbances (changes in CVP during suctioning/ mechanical ventilation)
  - Hypoxia-ischemia with reperfusion injury
- Increased CBF
  - Hypertension (pain, cares/ suctioning, volume boluses)
  - Increased intrathoracic pressure (PTX)
  - Response to hypercarbia, anemia, hypoglycemia
  - ?NaHCO3- related to hyperosmolarity, rapid infusion and/or hypercarbia



Autoregulation

Pressure passive

Hematologic Factors

- Thrombocytopenia
  - 40% infants <1500g have plt <100K
  - Incidence of IVH 80% in thrombocytopenic pts vs 50% in non-thrombocytopenic infants <1000g
  - Recommend plt>100K in preterm infants at risk for IVH
- Coagulation disturbances

Clinical Features

Three basic clinical syndromes accompany IVH

1. **Catastrophic deterioration**
   - **Evolves in minutes to hours**
   - **Hemodynamic instability, acidosis, falling Hct**
   - **Coma, posturing, seizures, fixed pupils**
2. **Saltatory deterioration**
   - **Evolves hours to days**
   - **More subtle – decreased movement/ hypotonia**
3. **Clinically Silent Syndrome**
   - **Up to 50% of patients – need to screen!**

IVH- Grading

- Grade I – subependymal
- Grade II – SEH + IVH <50%
- Grade III – IVH >50% + ventriculomegaly
- Grade IV – Parenchymal (Periventricular Hemorrhagic Infarction)

IVH- Grading

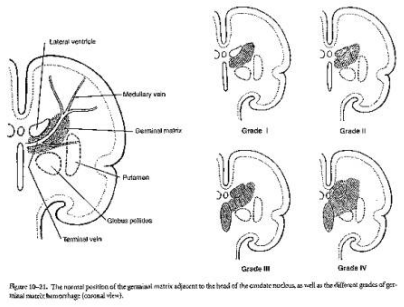
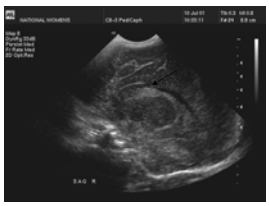
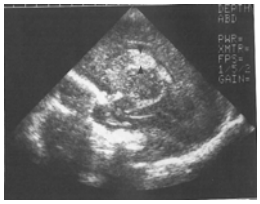


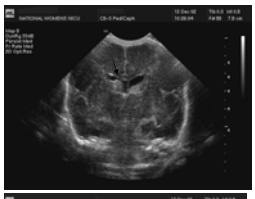
Figure 10–21. The normal position of the germinal matrix adjacent to the head of the caudate nucleus, as well as the different grades of germinal matrix hemorrhage (coronal view).

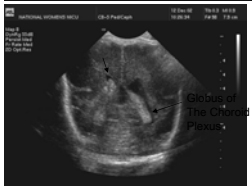
Grade I

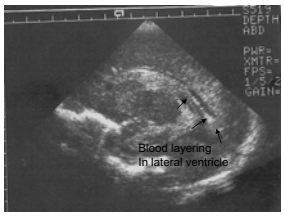




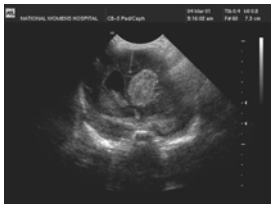
Grade II

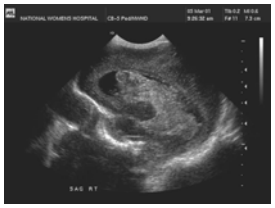




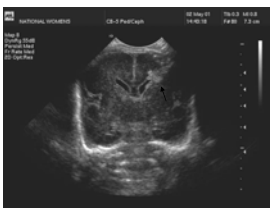


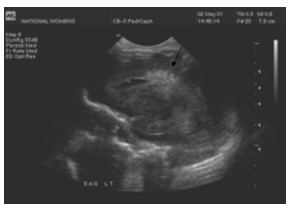
Grade III





Grade IV





"Gr IV" = Periventricular Hemorrhagic Infarction (PHI)

Germinal Matrix IVH

↓

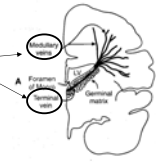
Periventricular Venous Congestion

↓

Periventricular Ischemia

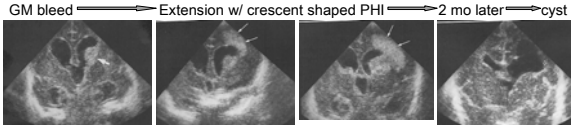
↓

Periventricular Hemorrhagic Infarction



NOT just parenchymal extension of bleeding:

GM bleed ⟹ Extension w/ crescent shaped PHI ⟹ 2 mo later ⟹ cyst



CNMC US Protocol

- All infants <1750g at birth (by DOL #5)
- If - Repeat at 1-2 weeks of life
- If + then follow weekly until stable on 2 scans
- Then repeat at 6 wks for PVL*

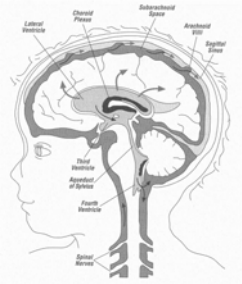
* PVL/ role for MRI to be discussed later

Prevention

- Prenatal
  - Antenatal steroids: 2-3x risk reduction for IVH
  - Transfer mother to perinatal center with NICU if possible (increased IVH in preemies transported ex-utero)
- Postnatal
  - Optimize management – ventilatory (control pCO2, ?avoid HFOV), hemodynamic (avoid BP swings), correct coagulopathy (plt >100K)
  - Medications – Use of prophylactic phenobarbital, indomethacin, vitamin E studied, but findings inconsistent and not routinely recommended

Complications: Post Hemorrhagic Hydrocephalus

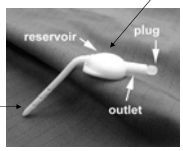
- Mechanism
  - Obliterative arachnoiditis in posterior fossa obstructs outflow of CSF from the fourth ventricle. (communicating hydrocephalus).
  - Obstruction of the aqueduct by blood clot or debris (Non Communicating)
- Diagnosis
  - Clinical: increasing HC, sx of increased ICP (A&Bs, hypertension, seizure)
  - By US: serial comparisons, Levene's index (goal < 4mm over 97%ile), RI's



Management

- If stable/ resolving – neurodevelopmental follow-up!!!
- If progressive ventricular dilation +/- clinical s/sx – consult neurosurgery. May require serial LP and/or VAD/ EVD/ VPS

Sits in subgaleal space



Into ventricle

VAD access:
- *Sterile* procedure
- Remove 10-15 ml/kg/d or as needed

Management

Timing of VPS placement controversial, but 2 important factors:

- Debris/ clot must be resorbed (indicated by US and CSF protein count) – otherwise risk for shunt obstruction/ infection/ failure
- Size of baby- must be able to tolerate enough tubing coiled in peritoneal space to grow with baby- to avoid need for revision later in life

Outcome

Severity of Hemorrhage	Mortality rate (%)	Progressive Ventricular dilatation (% of survivors)	Incidence of definite neurological sequelae (%) *
Grade I	5	5	5
Grade II	10	20	15
Grade III	20	55	35
Grade IV	50	80	90

* Motor deficits (typically spastic hemiparesis of LE), Cognitive, Visual and Auditory

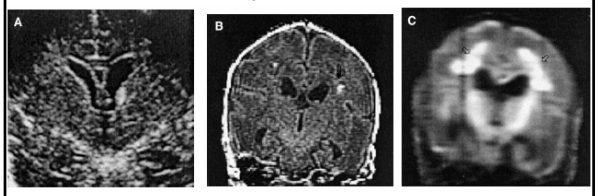
From Volpe 2001

Periventricular Leukomalacia

- White matter damage (focal necrosis), usually symmetrical in periventricular region
- Risk factors similar to IVH (cerebral autoregulation, vascular integrity, vascular endzone ⇨ ischemia), but different pathological entity
- Vulnerability of periventricular oligodendrocytes to:
  - Ischemia/ reperfusion
  - Hypocarbia
  - Sepsis (chorio), inflammation, cytokines
  - Reactive oxygen species
- Usually results in spastic diplegia but also cognitive/ behavioral, visual defects

Periventricular Leukomalacia

Findings often not evident on HUS until 4-6wks- time to develop necrosis/ neuronal loss⇨cysts evident on US



Early Ultrasound: Often (–) or only Subtle Ventricular Assymetry

T1 weighted MR DWI

MRI can detect injury earlier, and non-cystic white matter injury (WMI) not seen on US

MRI in Premature Infants at Term Equivalent

- MRI has higher sensitivity when compared to HUS, especially for WMI
- MRI at term equivalent predicts NDO for preterm infants better than US
  (Woodward et al NEJM, Mirmiran et al Pediatrics 2004, Dyet et al Pediatrics 2006)
- CNMC protocol: goal for all infants born GA <30 wks to have MRI at 36+ weeks for prognostic purposes prior to discharge
  - Denote corrected age on request
  - Attempt non-sedated exam with infant immobilizer