Intraventricular Hemorrhage in the Newborn

Dr. Sharon Fassino, DNP, RN, NNP-BC
No Financial Disclosures
Objectives:

• By the end of this lecture, the participant will:
  - Identify signs and symptoms of intraventricular hemorrhage in the newborn.
  - Describe the different stages of an intraventricular hemorrhage in the newborn.
  - Describe nursing care of preterm neonates for the prevention of IVH during 1st week of life.
  - Identify the treatment for neonates with intraventricular hemorrhage.
  - Describe short- and long-term outcomes in neonates with known intraventricular hemorrhage.
History

• 1951: First described in as a rupture in immature vessels germinal layer by Gruenwald
• 1953: Described as rupture of terminal vein by Grontoft
• 1978: Grading system developed for IVH by CT scan by Papile et al.
  - Grade I – IV
• 2008: Modified grading system by Volpe
  - Grade I – III
  - Grade IV/ PHI (periventricular hemorrhage infarction)
Definition

• ELBW – extremely low birth weight  
  - 27 weeks gestation or less  
  - 1000 grams or less

• LBW – low birth weight  
  - 32 weeks gestation or less  
  - 2500 grams or less

• IVH – intraventricular hemorrhage

• PVL – periventricular leukomalacia

• PVHI – periventricular hemorrhagic infarction
Who’s at Risk of IVH

• ELBW
• LBW
• Neonates with following diagnosis:
  - RDS
  - PDA
  - Head injury
  - Complications from labor and delivery
    • Vacuum assist
Who’s at Risk of IVH

• Neonates at risk
  - Infection
  - Genetic anomalies
  - Maternal complications
    • Infection
    • PIH
    • HELLP
  - Clotting issues
Definition

• Bleeding in and around the ventricles in the brain

• Intracranial hemorrhage starting in the germinal matrix and extending into the ventricles
Background

• Rate of occurrence
  - ~12,000 neonates annually
  - ~24% - 26% (<1500 gm)
  - ~45% (<1000 gm)
  - No change in rate of occurrence in last two decades

• Risk increases as gestational age decreases
  - Can occur in term or late preterm but unusual

• Morbidity: 50% - 80%

Annibale, 2018; Ballabh, 2010; Fanning & Annibel, 2019
Background

• Usually occurs within 72 hours of birth (90%)
  - Extent of hemorrhage is at worst level at 5 days of life
    - 1st 24 hrs: 50%
    - DOL 2: 25%
    - DOL 3: 15%
  - Extension of IVH usually happens 3 – 5 days after initial bleed

• Thought to be related to two factors
  - Loss of cerebral autoregulation
  - Abrupt shifts in cerebral pressure and blood flow

Annibale, 2018; Ballabh, 2010; Fanning & Annibel, 2019
Occurrence

• Primary IVH in term or late preterm infants is uncommon – occurs in 3%
  - Usually occurs with trauma or asphyxia
  - Arises in the choroid plexus

• Overall rate in preterm infants is 20%
  - <750 gm:
    • ~42% for any type of IVH
    • ~20% higher for more severe IVH
  - ¾ of neonates with more severe IVH will have cerebral palsy and/or mental retardation

Annibale, 2018; Vries & Leijser, 2019; Fanning & Annibale, 2019
Occurrence

GA dependent IVH incidence

<table>
<thead>
<tr>
<th>Week</th>
<th>≤ 22</th>
<th>23-24</th>
<th>25-26</th>
<th>27-28</th>
<th>≥ 29</th>
</tr>
</thead>
<tbody>
<tr>
<td>%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

BW dependent IVH incidence

<table>
<thead>
<tr>
<th>Gram</th>
<th>&lt; 500</th>
<th>500-749</th>
<th>750-999</th>
<th>1,000-1,249</th>
<th>1,250-1,499</th>
</tr>
</thead>
<tbody>
<tr>
<td>%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Pathophysiology

• Occurs in the subependymal germinal matrix (GM) which regresses as gestation age increases
  - 1st 20 weeks
    • Neuronal proliferation in the form of neuroblasts divide and migrate into the cerebral parenchyma
  - 20 – 32 weeks
    • Neuronal proliferation complete at 20 weeks
    • Glial cell proliferation continues up to 32 weeks
    • GM aids the division of glioblasts and differentiation of glial elements up to 32 weeks
  - Regression complete by 32 weeks
  - Area is high in mitochondria which is sensitive to ischemia
  - Entire process is sustained by a fragile network of capillaries

Annibale, 2018
Pathophysiology

• Grade I, II, and III IVH felt to occur within the arteries
  - Initiates around the Heubner artery and within the lateral striate arteries
    • Subependymal region by lateral ventricles
    • Related to fragility of vascular network in germinal matrix
  - Distribution of the anterior and middle cerebral arteries
  - Related to an increase in arterial pressure, cerebral blood flow, and volume

Annibale, 2018; Fanning & Annibale, 2019
Pathophysiology

• Grade IV changed to Post Hemorrhage Ventricular Dilatation (PHVD) as it is now felt to occur due to a venous infarction around the terminal vein and its feeder veins
  - Due to an increase in venous pressures
  - Impaired blood flow in the medullary veins which flow into the terminal veins
  - Terminal vein drains into internal cerebral vein which flows into the Vein of Galen

Annibale, 2018; Fanning & Annibale, 2019
Intraventricular Hemorrhage

• Severity is defined across a gradient
  - Grade 1: germinal matrix
  - Grade 2: blood in ventricles (<50% of ventricle)
  - Grade 3: blood in ventricles with dilatation (>50% of ventricle)
  - Periventricular hemorrhagic infarction (previously known as Grade 4): blood in gray/white matter

Vries & Leijser, 2019
Intraventricular Hemorrhage

- Grade I/II: mild
- Grade III/IV: severe
- Incidence is 15 – 20%
- Diagnosis of IVH
  - 15% will develop hydrocephalus
  - 10% will require VP shunt

Vries & Leijser, 2019
Maternal Treatment

• Maternal transport to facility with Level III/VI NICU for ELBW
• Treatment for chorioamnionitis
• Administer antenatal corticosteroids
• Tocolytic administration
Types of Brain Hemorrhages

[Diagram showing different types of brain hemorrhages including epidural hematoma, subdural hematoma, and intracerebral hematoma.]
Intraventricular Hemorrhage

Cross section through brain

- Blood fills ventricles
- Injury to brain causes bleeding and swelling
- Ventricular spaces contain CSF

© Catherine Delphia 2016
Germinal Matrix
(Primary site of IVH/PVH)
Grade 1 Intraventricular Hemorrhage (Blood in GM only)
Grade I
Grade I IVH
Grade 2 IVH
(Blood in LV without ventriculomegaly)
Grade II
Grade II IVH
Grade 3 IVH
(Blood in LV with ventriculomegaly)

Ventriculomegaly
GM SEH
Occipital Horn
Monro
3rd

Blood on Arachnoid Villi
OBLITERATIVE ARACHNOIDITIS

Luschka
Magendie

3rd

Germinal Matrix
Choroid Plexus
Blood

Slowly Evolving Hydrocephalus
Grade III
Grade III IVH
Grade 4 IVH
(Periventricular Hemorrhagic Infarction)

PVHI

Arachnoid Villi

CSF

Monro

3rd

GM

SEH

Lateral Ventricle

Occipital Horn

Luschka

Magenie

4th

Germinal Matrix

Choroid Plexus

Blood
PVHI

Annibale, 2018
Grade IV IVH or PHVD
Locations of PHVD/ Grade IV IVH

- Posterior Frontal: $n = 42 (72\%)$
- Parietal: $n = 49 (84\%)$
- Anterior Frontal: $n = 25 (43\%)$
- Occipital: $n = 9 (16\%)$
- Temporal: $n = 4 (7\%)$

Thalamus
Left IVH Clot (Left Ventricle)

Communication connection and 3rd ventricle floor

Right IVH Clot (Right Ventricle)

Infusion site

1 cm
Intracerebral hemorrhage into lateral ventricle
GM-IVH

Hematoma

Mechanical compression on periventricular tissue

Alteration in CSF dynamics

Blood clots Outflow site fibrosis

Blockage of CSF drainage

Post-hemorrhagic ventricular dilatation

TLR-4 activation NF-kB-inflammatory response in choroid plexus

Hypersecretion of CSF

AQP1 blockage
Interventions
Maternal Interventions

• Transfer to facility with Level III/IV NICU for neonatal care if delivered
• Maternal medications
  - Antenatal corticosteroids
  - Magnesium sulfate
• Delayed cord clamping
  - Increase neonatal Hct on admission

Fanning & Annibale, 2019; Vries & Leijser, 2019
Maternal Interventions

• Unproven and/or ineffective perinatal treatment
  - Medications
    • Vitamin K
    • Phenobarbital
  - C/Section deliveries

Vries & Leijser, 2019
Postnatal Interventions – Medications

• Indomethacin
  - Some short term benefits
  - No reduction in long term outcomes or neurological developmental outcomes
  - May reduce the severity of IVH but not overall risk of development
  - May improve cognitive and verbal outcomes

• Ibuprofen
  - May reduce risk of Grade III or Periventricular hemorrhage

• Vitamin E
  - Strong antioxidant
  - Does reduce risk of IVH
  - Increases risk of sepsis

Annibale, 2018; Vries & Leijser, 2019
Postnatal Interventions – Events

- Asynchronous breathing pattern
  - Spontaneous vs. mechanical ventilation
- Noxious procedures by care givers
- ETT suctioning
- Pneumothorax
- Rapid volume expansion (NaHCO$_3$)
- Rapid colloid infusion (exchange transfusion)
- Seizures
- Changes in ABG (pH, PaCO$_2$, PaO$_2$)
  - Hypocarbia
  - Hypercarbia
  - Hypoxemia
  - Acidosis

Annibel, 2018
Nursing Care
General Screening

• HUS on DOL 7 – 10 for all neonates born at <30 weeks gestation and/or < 1500 gm
• Follow up HUS at 36 – 40 weeks PMA or prior to discharge home

• Also consider infants with history of high acuity, abnormal clinical signs and other risk factors for IVH

Fanning & Annibale, 2019
Signs and Symptoms

- Apnea
- Bradycardia
- Pale or blue coloring (cyanosis)
- Weak suck
- High-pitched cry
- Lethargy, stupor, or coma
- Decreased reflexes
- Decreased muscle tone
- Abnormal eye movement
Signs and Symptoms

• Increasing FOC
• Anemia
• Hypotension
• Hyperglycemia
• Bulging fontanelle with or without split sutures
• Seizures
MINDFUL

• Maintain head midline position
• Incline of bed $\geq 30$ degrees
• Neutral head position only
• Do not place prone or suction frequently
• Family can perform Kangaroo care with head midline
• Use gentle techniques avoiding sudden movements
• Log roll when repositioning
Nursing Care: Delivery

• Delayed cord clamping at birth if no resuscitation needed immediately
• Aim for hemodynamic stability at birth as soon as possible
  - Avoid hypoxia, hypercarbia, hyperoxia, and hypocarbia at resuscitation
• Avoid hypotension and hypertension

Vries & Leijser, 2019
Nursing Care: Admission to NICU

• Midline positioning
• Avoid acute changes in blood pressure
• Metabolic management
  - IV fluids
  - Avoid hypoglycemia, hyperglycemia, and hyperosmotic solutions
  - Correct acidosis and/or alkalosis carefully

Vries & Leijser, 2019
Nursing Care – General

• 1st week of life
  - MINDFUL
    - Minimal stimulation with midline positioning

• Weekly FOC to monitor head growth

• If IVH on HUS will need to follow up depending on severity of IVH
  - If Grade I or II: follow up HUS close to term
  - If Grade III or IV: follow up HUS in 1 week and as needed with FOC growth
Nursing Care with known IVH

• Daily FOC
• Weekly HUS or more often if continuing increase in FOC noted
• Serial LP taps to decrease CSF and dilatation
  - May need reservoir if non-communicating
• If ICP noted, surgical intervention with temporary ventricular peritoneal (VP) shunt and permanent shunt if needed
• No interventions will prevent the development of PHVD

Vries & Leijser, 2019
Short and Long Term Outcomes
Morbidity

• Main neurodevelopmental disorders associated with prematurity
  - Cerebral Palsy in 3 – 4/1000 live births
  - Intellectual disabilities (MR) in 4 – 5% of LBW babies
  - Visual impairment in 5% of LBW babies
  - Hearing impairment in 2 – 3% of LBW babies

• The lower the gestation, the more likely the neonate will develop one or more disabilities

Fanning & Annibale, 2019; Vries & Leijser, 2019
Morbidity

• Results from the destruction of the cerebral parenchyma and the development of post hemorrhagic hydrocephalus

• Two disorders resulting from IVH
  - Periventricular Leukomalacia (PVL)
    • Injury to periventricular white matter
    • Similar to PHVD
  - Global hypoxic-ischemic injury

Fanning & Annibale, 2019; Vries & Leijser, 2019
Outcomes from IVH

• Resolution
• Hydrocephalus
  - Non-obstructive
  - Obstructive
  - Posthemorrhagic
• Irreversible brain damage
  - Developmental impairment
  - CP
  - Periventricular hemorrhagic infarction (PHI)
• Seizures
• Shock
• Death

Annibale, 2018; Vries & Leijser, 2019
Complications

• Post hemorrhagic ventricular dilatation (PHVD)
  - Usually occurs when Grade III/IV exists
  - Increase in mortality and neurodevelopmental impairment (NDI)
  - Occurs 1-3 weeks after severe IVH occurs

Outcomes
• 40% stops with no need for intervention
• 10% rapid progression
• 50% slow progression
  • 20% stabilize with serial LPs or reservoir placement
  • 30% require permanent shut placement
Complications

- Post hemorrhagic ventricular dilatation (PHVD)
  - Effects thought to be caused by injury to the white matter
    - One study shows decrease in deep gray matter and cerebellum
  - Management
    - Serial taps or reservoir placement to help with ICP
    - VP shunt when protein < 1.5 g/L and weight > 2 kg
      - Need to make sure no further bleeding occurs as clot can prevent shunt from functioning properly.
    - Early intervention helps neurodevelopmental outcomes
Complications

• White matter injury
  - Most common injury is diffuse gliotic damage
  - Cystic Periventricular Leukomalacia (c-PVL)
    • Defined as periventricular focal necrosis of the white matter with cystic formation
  • 40% noted on HUS within 28 days
    • 50% resolution after 36 weeks PMA
  • 60% observed at 36 weeks PMA
    • Associated with development of CP, intellectual impairment, and cerebral visual disturbances
    • No difference in development of neurodevelopmental issues if cysts remained or disappeared

Vries & Leijser, 2019
Complications

• White matter injury
  - Periventricular hemorrhagic infarction
    • An extension of germinal matrix hemorrhage
    • Affects ~10% - 15% of neonates with IVH
    • Considered as hemorrhagic necrosis in the periventricular white matter
    • Usually unilateral/asymmetrical
    • Happens when pressure exerts on the periventricular terminal drain causing venous congestion with ischemia and extension of hemorrhage
Outcomes

• Mortality increases with severity of IVH
  - Grade I: 4%
  - Grade II: 10%
  - Grade III: 18%
  - PHVD IV: 40%
  - PVHI and/or PVL: 80%

Vries & Leijser, 2019
Outcomes

• Grade III IVH
  - 30% - 40% develop cognitive and/or motor disorders
• PVHI
  - 90% develop severe neurologic sequela with cognitive and motor disorders
• Two thirds of survivors developed PHVD
• Increase in white matter injury increases with the severity of the IVH
• Cost: >$3.6 billion for lifetime of care

Annibale, 2018; Vries & Leijser, 2019
Long Term Outcomes

• Outcomes worsen with severity of IVH, decrease in gestational age, and PHVD requiring shunt placement

• Development of CP by 5 years of age
  - Grade I: 8%
  - Grade II: 11%
  - Grade III: 19%
  - Grade IV (PHVD): 50%

• All infant’s with any IVH have an increased risk for developing CP and neurodevelopmental impairment (NDI)

Vries & Leijser, 2019
Long Term Outcomes

• Infants requiring permanent shunt placement showed lower scores on Bayley Mental Developmental Indexes
  - Without shunt
    • Grade III: 74
    • Grade IV: 71.5
  - With shunt
    • Grade III: 66
    • Grade IV: 60

Vries & Leijser, 2019
Long Term Outcomes

• Infants requiring permanent shunt placement showed lower scores on Bayley Psychomotor Developmental Indexes
  - Without shunt
    • Grade III: 77
    • Grade IV: 73
  - With shunt
    • Grade III: 64
    • Grade IV: 55
Questions?
References

- All images obtained from search on google.com/images


References


