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Original Research Article

Study of Incidence and USG imaging patterns of GMH in Pre-Term Neonates.

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ABSTRACT:
Germinal matrix hemorrhage (GMH) are prevalent and distinctive issues among premature infants, particularly those with very low birth weight (VLBW; less than 1500 g) or gestational age (GA) below 32 weeks. GMH is linked with elevated mortality rates and adverse neurodevelopmental consequences, including posthemorrhagic hydrocephalus, cerebral palsy, epilepsy, severe cognitive impairment, and visual and hearing impairments. Since many affected neonates show no symptoms, diagnosis typically relies on real-time transfontanellar ultrasound.. The occurrence of GMH rises as gestational age (GA) and body weight decrease. Hemorrhage begins within the capillary network of the subependymal germinal matrix (GM) in the developing brain and can potentially disrupt the ependymal lining, advancing into the lateral cerebral ventricle . This review highlights the significance of cranial ultrasound (cUS) in premature infants, exploring the incidence and diverse imaging characteristics of germinal matrix hemorrhage GMH.

Keywords: Germinal matrix hemorrhage , Preterm Neonates, Grades of GMH, Transcranial USG

1. INTRODUCTION

Germinal matrix hemorrhage (GMH) are prevalent and distinctive issues among premature infants, particularly those with very low birth weight (VLBW; less than 1500 g) or gestational age (GA) below 32 weeks(1,2). It continues to be a severe neurological complication associated with significant mortality and neurodevelopmental disability(3,4). The occurrence of GMH rises as gestational age (GA) and body weight decrease. Hemorrhage begins within the capillary network of the subependymal germinal matrix (GM) in the developing brain and can potentially disrupt the ependymal lining, advancing into the lateral cerebral ventricle (5,6). While advancements in obstetrics and neonatal medicine have enhanced the survival rates of preterm infants with lower gestational age and birth weight, it appears that we have reached the limits of our capacity to guarantee survival without morbidity for very-low-birth-weight (VLBW) infants in advanced care environments.(7,8). Cranial ultrasound is the preferred imaging method for diagnosing, assessing the severity, and monitoring the progression of GMH. It can be conducted at the bedside, offering high-resolution images without the use of ionizing radiation.. This review highlights the

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significance of cranial ultrasound (cUS) in premature infants, exploring the diverse imaging characteristics of germinal matrix-intraventricular hemorrhage (GM-IVH).

ANATOMY AND PATHOGENESIS:

The germinal matrix (GM) is situated in the subependymal region of the ventricular walls. It serves as the source of cerebral neuroblasts and glia, exhibiting a high cellular density and gelatinous consistency. Additionally, it is extensively vascularized by capillaries that have minimal support from muscle or collagen fibers.(9,). The precursor cells within the germinal matrix (GM) exhibit vigorous proliferation until around 28 weeks of gestation, after which they rapidly decrease and nearly disappear by approximately 36 weeks. In premature infants, the majority of GM-IVH cases occur within the first 3 days after birth, with about 95% occurring within 7 days(10).

The development of GM-IVH is complex and involves multiple factors, primarily linked to the vulnerability of the primitive GM vasculature, fluctuations in cerebral blood flow (CBF) caused by low mean arterial pressure, and compromised cerebral autoregulation in clinically unstable preterm neonates. These factors collectively heighten the risk of vascular rupture (12,13,14).

2. METHODS:

The present study was carried out for the time period of 2 years from May 2022 to May 2024 and was approved by our Institutional Research Ethics Board.320 preterm neonates referred to department of radiodiagnosis for cranial ultrasound were included in this study and were evaluated upto day 5-7. All patients underwent cranial USG of the brain with GE Voluson S8 after taking proper informed consent for the same. All neonates were transported and monitored by a specialized NICU transport team. The neonates were monitored during the procedures using pulse oximetry and blood pressure monitoring. The clinical and demographic data for all neonates were reviewed.

GRADING OF GMH:

The grading systems established by Papile et al. (18) and Volpe are widely acknowledged as the most accepted, although various other grading systems also exist (19). Papile et al. (18) devised a four-grade classification of GM-IVH using computed tomography scans, focusing on the location and severity of hemorrhage (15,16). Grade I is characterized by hemorrhage restricted to the germinal matrix, grade II involves the extension of hemorrhage into the lateral ventricles without ventricular dilatation, grade III is identified when ventricular hemorrhage occurs along with ventricular dilatation, and grade IV is defined by the presence of parenchymal hemorrhage (15).

Volpe's grading system, based on cranial ultrasound scan (CUS), follows a similar framework. Grade I denotes hemorrhage confined to the subependymal germinal matrix, while grade II encompasses hemorrhage within the lateral ventricle without ventricular dilation or hemorrhage occupying less than 50% of the ventricle. Grade III hemorrhage is characterized by ventricular dilation or hemorrhage occupying more than 50% of the ventricle, while grade IV involves ventricular hemorrhage extending into the surrounding parenchyma (17).

Grade	Cranial USG Findings (Volpe 2008)

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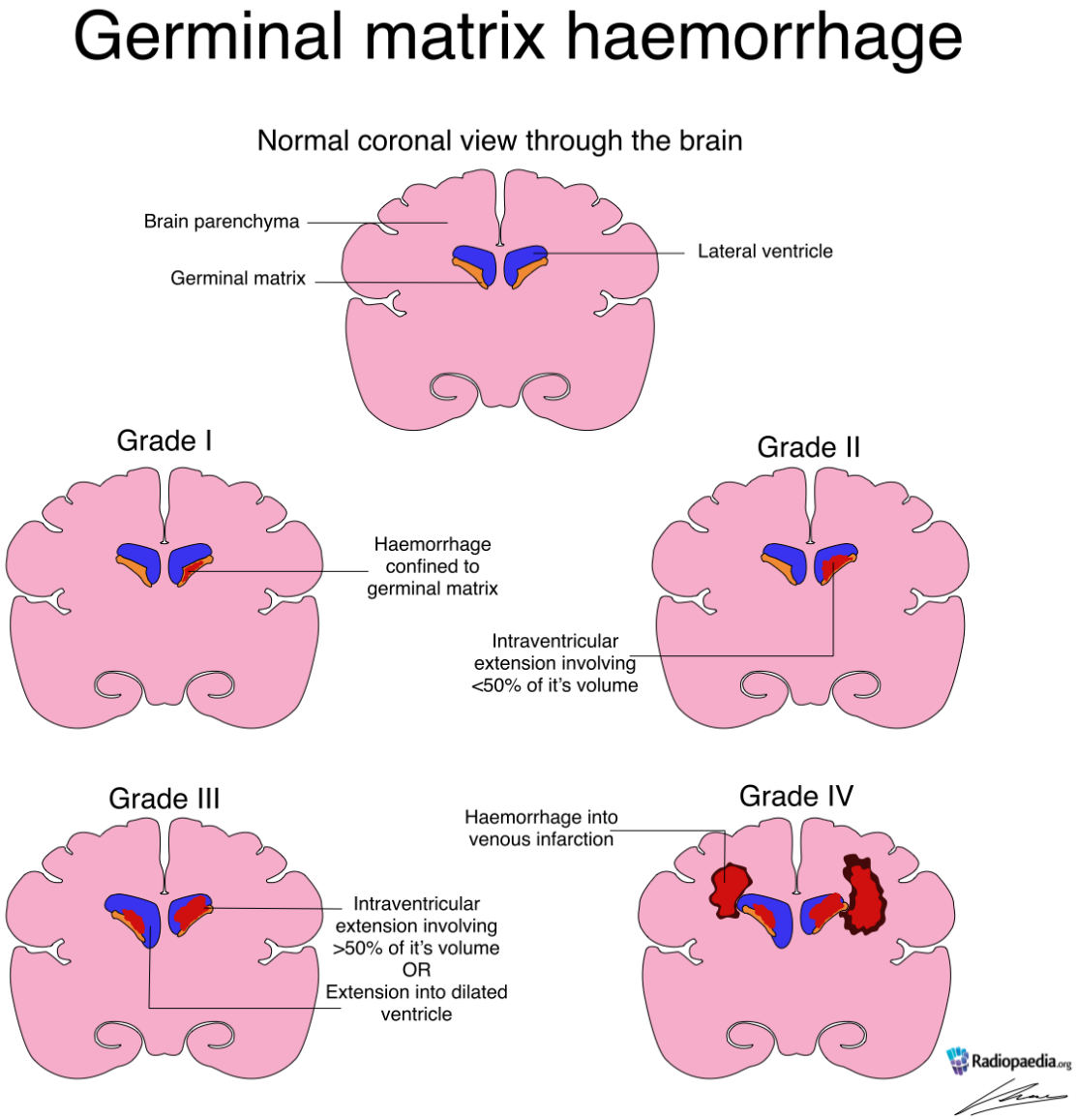
I	GMH with no or minimal IVH (<10% on parasagittal view)
II	IVH (10–50% on parasagittal view)
III	IVH (>50% on parasagittal view; usually distends lateral ventricle)
IV	Periventricular echodensity (called PVHI)



Technique and Timing of cranial ultrasound:

Preterm babies frequently experience instability in the initial days after birth, coinciding with the typical onset of GMH. CUS facilitates the swift identification of GMH and enables ongoing evaluation of its progression(18). Images capturing various angles on coronal and sagittal planes were obtained by adjusting the microconvex (5–8 MHz) and high-frequency (10–12 MHz) linear transducers through different fontanelles, including the anterior, posterior, sphenoid, and mastoid. Among these, the anterior fontanelle, situated at the intersection of the coronal and sagittal sutures and the largest fontanelle, provides the best

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sonic window for visualizing supratentorial structures. Conversely, the mastoid fontanelle is ideal for assessing the posterior fossa, particularly the cerebellum. The American Academy of Pediatrics (AAP) recommends that cUS screening should cover both the anterior fontanelle and the mastoid fontanelle. High-frequency linear transducers offer detailed visualization of the brain, providing superior resolution that aids in the evaluation of GM-IVH and brain parenchymal lesions.(19)

The AAP suggests cranial ultrasound (cUS) for both screening and ongoing assessment of GMH and periventricular leukomalacia (PVL) in premature infants (those born <30 weeks gestation or >30 weeks gestation with significant risk factors) and very low birth weight (VLBW) infants. Their recommendation includes an initial screening cUS within the first 7 days after birth. Additionally, they advise repeat screening cUS at 4–6 weeks of age to detect PVL, and another assessment at term equivalent age (TEA) or before discharge to determine the lasting impact of any brain injury, which may correlate with adverse neurodevelopmental outcomes in premature infants(19).

Incidence:

The worldwide occurrence of GMH among preterm infants varies widely, with reported incidences ranging from 14.7% to 44.7%(20-23). This variability is influenced by factors such as gestational age groups, neonatal intensive care units, and geographic regions, leading to significant differences across countries and healthcare settings(20-23,24). Hefti et al.investigated GM-IVH in 345 preterm neonates through autopsies conducted between 1914 and 2015 at Boston Children's Hospital in the United States of America(25). The incidence of GM-IVH was 4.7% before the 1960s but surged to 50% between 1975 and 1980 after the introduction of innovative positive pressure mechanical ventilation in neonatal intensive care units (NICUs). Subsequently, it decreased significantly to 12.5% by 2005, likely due to advancements in ventilator technology and the implementation of surfactant and corticosteroid therapies. Regarding the timing of onset, nearly 40.6% of low-birth-weight (<2.5 kg) preterm neonates experience GM-IVH within the first 3 days of life, with 50% affected by day 5, and 71.5% impacted by day 7(26).

USG findings of GMH:

Grade I GMH- It confined to the subependymal germinal matrix, generally appears as a hyperechoic globular lesion situated in the caudothalamic groove. Over time, the hematoma undergoes heterogeneity and develops cystic changes. IVH using cUS is still challenging(27,28).

Grade II GMH- It refers to intraventricular hemorrhage (IVH) without ventricular dilatation. If the echogenic lesions are located anterior to the caudothalamic groove or at the dependent portion of the occipital horns, this indicates IVH(28). The echogenic wall of the ventricle, owing to proliferating subependymal glial cells approximately 1 week after GMIVH, is an indirect sign suggestive of GM-IVH, which might help identify mild GM-IVH (grades I and II)(29).

Grade III GMH- In grade III hemorrhage, cranial ultrasound (cUS) reveals ventricular dilatation resulting from intraventricular hemorrhage (IVH). However, it's important to note that progressive ventricular dilatation following grade II GM-IVH should not automatically be classified as grade III(30).

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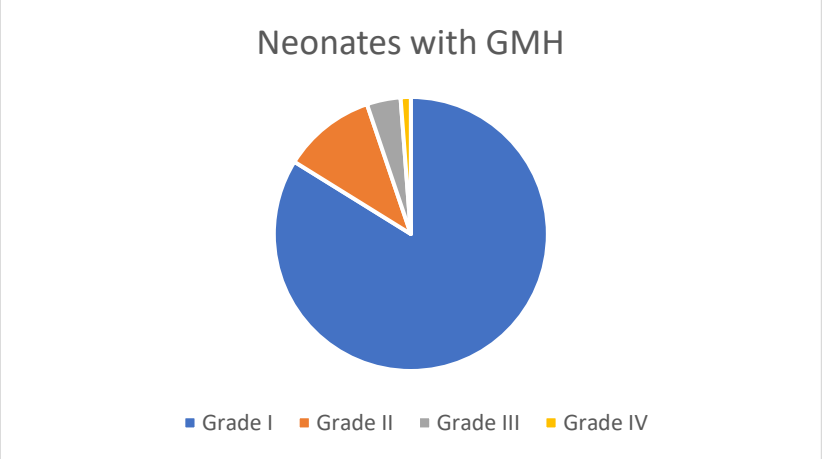
Grade IV GMH- We now recognize that parenchymal hemorrhage in grade IV GM-IVH of the Papile system is better characterized as periventricular hemorrhagic infarction (PVHI) rather than a direct extension of the hemorrhage into the brain parenchyma(31,32). Periventricular hemorrhagic infarction typically manifests as a unilateral, triangular, or "fan-shaped" echodensity adjacent to the lateral ventricle, often associated with ipsilateral GM-IVH. This condition may progress to form a porencephalic cyst, which frequently communicates with the neighboring lateral ventricle.

3. RESULTS:

In the present study, out of the total 320 pre-term neonates 103 preterm neonates were positive for GMH. The incidence for positive cases in our study is ~31.8%. Out of the positive cases, 84 preterm neonates were classified as grade I GMH, 11 as grade II GMH, 4 as grade III GMH, and 4 as grade IV GMH. Based on laterality, GMH is categorized into unilateral and bilateral. In this study, 15 preterm neonates presented with right-sided GMH, 12 with left-sided GMH, and 76 with bilateral GMH.

Preview Figures:

Laterality	**Number of newborns (Total case-103)**	
Unilateral	Right - 15(14.56%)	Left - 12(11.65 %)
Bilateral	76(73.78%)	



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Grades	Neonates with hemorrhage	Percentage of GMH
I	84	81.55
II	11	10.67
III	4	3.88
IV	4	3.88

4. CONCLUSION:

Cranial ultrasound (US) stands out as the premier imaging tool for premature infants, not only facilitating the diagnosis and monitoring of GM-IVH but also playing a crucial role in the early detection and management and follow up. In our study we concluded transcranial USG is cheaper, easily available ,non invasive, non ionising in nature and doesn't requires sedation.

In our preterm neonates, the incidence of GMH/IVH is 31.8 %, and it shows an inverse relationship with both gestational age and birth weight. The onset of GMH/IVH is closely linked to the occurrence of hypoxia and the requirement for mechanical ventilation. The majority of GMH/IVH cases are grades I and II, which are typically asymptomatic. The first 7 days of life are critical, as most bleeding occurs during this period.

Abbreviations

CUS: Cranial ultrasound scan
GM: Germinal matrix
GM-IVH: Germinal matrix-intraventricular hemorrhage
LBW: Low birth weight

AUTHORS' DECLARATION

Conflicts of interest

No potential conflict of interest relevant to this article was reported.

Informed consent

This type of study does not require informed consent.

Data sharing

None

Preprint

None

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