

# Neurosonography Evaluation of Brain Injuries in Preterm Neonates

Dr. Pushpak Tomar<sup>1</sup>, Dr. Saurabh Goyal<sup>2</sup>, Dr. Hariram<sup>3</sup>, Dr. Kapil Dalal<sup>4</sup>

<sup>1</sup>PG Resident 3<sup>rd</sup> year, MD Radiodiagnosis, Pacific Institute of Medical Sciences, Umarda, Udaipur  
Corresponding Author Email: [pushpaktomar26\[at\]gmail.com](mailto:pushpaktomar26[at]gmail.com)

<sup>2</sup>Associate Professor, MD Radiodiagnosis, Pacific Institute of Medical Sciences, Umarda, Udaipur

<sup>3</sup>Professor & HOD, MD Radiodiagnosis, Pacific Institute of Medical Sciences, Umarda, Udaipur

<sup>4</sup>PG Resident 3<sup>rd</sup> year, MD Radiodiagnosis, Pacific Institute of Medical Sciences, Umarda, Udaipur

**Abstract:** ***Background:** Preterm birth, defined as delivery before 37 weeks of gestation, affects over 15 million infants annually and is a leading cause of neonatal morbidity and mortality. The immature brain is vulnerable to injuries such as germinal matrix hemorrhage, intraventricular hemorrhage, and periventricular leukomalacia. Neurosonography is a non - invasive, bedside imaging technique that uses open fontanelles to visualize the brain and is ideal for critically ill neonates due to its safety, portability, and repeatability. **Methods:** This observational study was conducted from July 2023 to December 2024 at the Department of Radiology, Pacific Institute of Medical Sciences, Udaipur. A total of 72 preterm neonates underwent cranial ultrasound using high - resolution linear probes. **Results:** Abnormal neurosonographic findings were observed in 37% of neonates. Cerebral edema (60%), periventricular flare (35%), and periventricular leukomalacia (15%) were the most common. Abnormal findings were significantly associated with adverse clinical outcomes. **Conclusion:** Cranial ultrasound is effective in detecting and monitoring brain injuries, guiding prognosis and management in the NICU.*

**Keywords:** Critically ill neonates; Neurosonogram; NICU; Brain injury; Preterm infants

## 1. Introduction

Neurosonography is an essential, non - invasive imaging modality in neonatology for detecting normal and abnormal brain development. Open sutures and fontanelles in neonates serve as acoustic windows, allowing real - time bedside imaging. It is particularly valuable in high - risk neonates—those with prematurity, low birth weight, or complications during pregnancy or delivery.

Cranial ultrasound is simple, safe, repeatable, and effective in monitoring brain maturation, detecting lesions, and assessing the timing of brain injury. Advances in ultrasound technology and the use of additional acoustic windows—such as mastoid and posterior fontanelles—have enhanced diagnostic accuracy, particularly for hindbrain and subcortical abnormalities.

Neurosonography plays a key role in identifying intraventricular hemorrhage (IVH), periventricular leukomalacia (PVL), hypoxic - ischemic injuries, infections, and congenital malformations. It supports prognosis and guides treatment decisions, including continuation or withdrawal of intensive care. In neonatal intensive care units (NICUs), serial imaging is standard, especially for preterm infants, to track injury evolution and assist in neurodevelopmental outcome prediction.

Timely and repeated ultrasounds improve the detection of subtle white matter injuries and cystic PVL, a known marker for cerebral palsy. Proper imaging depends on suitable equipment, probe selection, and examiner expertise. Neurosonography remains crucial in managing neonates with hypoxic - ischemic encephalopathy (HIE), seizures,

stroke, and infections like meningitis, providing early and ongoing insight into cerebral health and development.

## 2. Material and Methodology

This observational clinical study was conducted at the Department of Radiology, Pacific Institute of Medical Sciences, Umarda, Udaipur, between July 2023 and December 2024, to evaluate neurological abnormalities in preterm neonates. A total of 72 preterm infants underwent cranial ultrasound using high - resolution ultrasound systems, including Samsung V8, GE Voluson S10 - BT22, GE Voluson E - 8, and Mindray DC 80, with linear probes optimized for neonatal imaging. The inclusion criteria were preterm infants with a gestational age of less than 37 weeks, those exhibiting clinical symptoms suggestive of neurological abnormalities, or those with abnormal neurological examination findings. Exclusion criteria included preterm infants with a gestational age greater than 37 weeks, cases suspected of congenital malformations, severe infections, or those with failed resuscitation. Neurosonography was selected as the primary imaging modality due to its non - invasive nature, bedside applicability, and repeatability, making it ideal for critically ill neonates. The study aimed to detect brain injuries and correlate sonographic findings with clinical outcomes, supporting early diagnosis and guiding management strategies in neonatal intensive care.

## 3. Result and Observations

A total of 72 preterm neonates were included in this study.

**1) Overall Cranial Ultrasound Findings**

- **Normal:** 42 neonates (58.33%)
- **Abnormal:** 30 neonates (41.67%)

**2) Demographic Data****a) Birth Weight Distribution**

- <1.5 kg: 24 (33.33%)
- 1.5–2 kg: 37 (51.39%)
- 2–2.5 kg: 10 (13.89%)
- 2.5 kg: 1 (1.39%)

**b) Gender Distribution**

- Male: 44 (61.11%)
- Female: 28 (38.89%)

**3) Cranial USG Findings vs. Demographic Factors****a) Gender vs USG Findings**

- No statistically significant difference ( $p = 0.252$ )

**b) Gravida (Primi vs Multi)**

- Primi: 31 (43.06%)
- Multi: 41 (56.94%)
- No significant association with USG findings ( $p = 0.159$ )

**4) Clinical Complications****a) Presence of Complications**

- Present: 23 (31.94%)
- Absent: 49 (68.06%)
- **Significant correlation** with abnormal USG ( $p = 0.0001$ )

**b) Types of Complications**

- RDS: 8 (11.11%)
- Sepsis: 3 (4.17%)
- Failure to thrive: 3 (4.17%)
- Jaundice: 2 (2.77%)
- Delayed milestones: 7 (9.72%)
- Absent complications: 49 (68.06%)
- **RDS, delayed milestones, sepsis, and failure to thrive** showed significant association with abnormal USG findings.

**5) Neonatal Outcomes**

- Died: 4 (5.56%)
- Discharged: 68 (94.44%)
- All deceased neonates had abnormal USG findings ( $p = 0.014$ )

**6) Mechanical Ventilation Requirement**

- Yes: 36 (50%)
- No: 36 (50%)
- Significant association with abnormal USG ( $p = 0.0001$ )

**7) Perinatal Risk Factors**

- Most common: Preterm with labor pain (48 cases, 66.67%)
- Others: Previous LSCS (12.5%), Transverse lie (8.33%), Twin (4.17%)

**8) Intracerebral Hemorrhage (ICH)****a) Present: 13 (18.06%)****b) Grades:**

- Grade 1: 7
- Grade 2: 2

- Grade 3: 3

- Grade 4: 1

c) All ICH cases showed abnormal USG ( $p = 0.000002$ )

**9) Periventricular Leukomalacia (PVL)****a) Present: 29 (40.28%)****b) Grades:**

- Grade 1: 17 (23.61%)
- Grade 2: 12 (16.67%)

c) Strong association with abnormal USG ( $p = 0.000001$ )

**10) Neurological Symptoms and USG Correlation**

Symptom	Present (n)	p – value	Interpretation
Seizures	9	0.0001	Significant
Lethargy	23	0.0001	Significant
Absent suckling	21	0.0001	Significant
Flaccidity	22	0.0001	Significant
Bulging anterior fontanel	5	0.07	Non - significant
Caput succedaneum	3	0.369	Non - significant
Excessive cry	7	0.09	Non - significant

**4. Discussion**

In this study of 72 neonates, 41.67% exhibited abnormal cranial ultrasound (USG) findings, highlighting a substantial burden of neurological abnormalities. Male neonates (61.11%) slightly outnumbered females, and multigravida mothers (56.94%) were more common. However, neither gender nor gravidity showed a significant association with cranial USG results. A highly significant correlation ( $p < 0.0001$ ) was noted between overall neonatal complications and abnormal USG findings. Among specific complications, all cases of intracerebral hemorrhage (ICH, 18.06%) and periventricular leukomalacia (PVL, 40.28%) showed abnormal USG results with  $p$  - values  $< 0.00002$  and  $< 0.000001$  respectively, underscoring the diagnostic utility of cranial USG in these conditions.

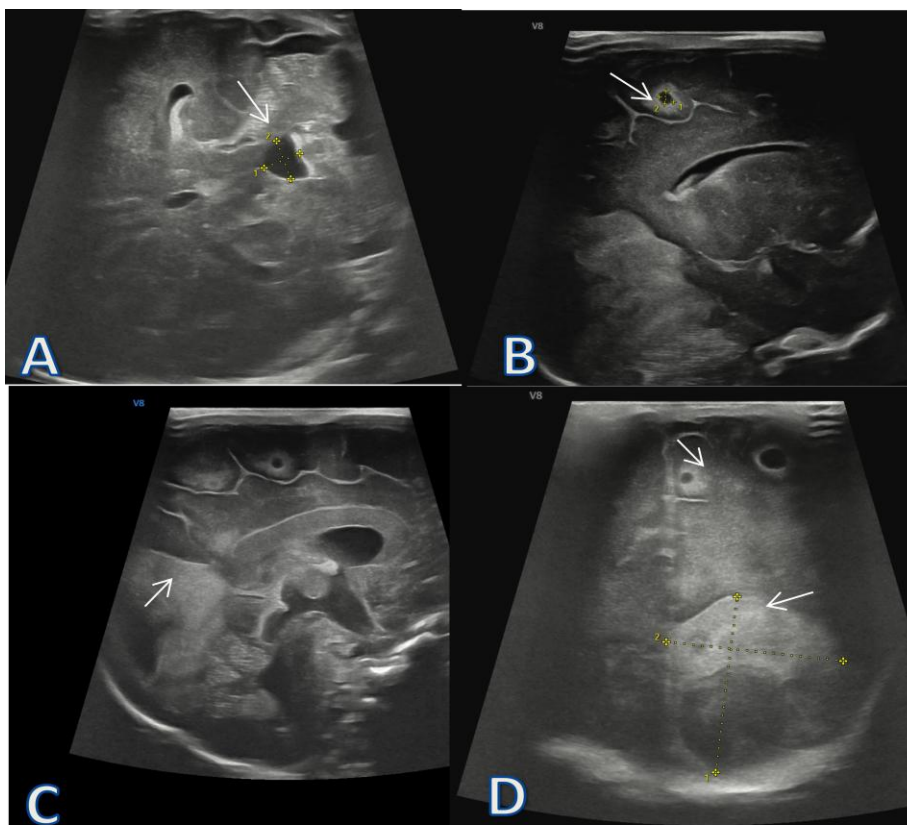
Neurological signs also correlated significantly with abnormal USG. All neonates presenting with seizures (12.5%), absent suckling (29.17%), and flaccidity (30.56%) had abnormal imaging findings ( $p < 0.0001$  for each). Lethargy (31.94%) similarly showed a strong association. Although RDS and delayed milestones were more common in the abnormal USG group, specific  $p$  - values were not detailed. Birth weight, with most neonates weighing 1.5–2 kg (51.39%), was not statistically analyzed in relation to USG outcomes, though it remains a relevant clinical factor. The most prevalent perinatal risk factor was “preterm with labor pain” (66.67%), but associations with USG findings were not statistically examined.

Some findings like bulging anterior fontanel ( $p = 0.07$ ), caput succedaneum ( $p = 0.369$ ), and excessive crying ( $p = 0.09$ ) showed no significant correlation with cranial USG, possibly due to low incidence or transient nature. Regarding clinical outcomes, all neonates who died (5.56%) had abnormal cranial USG findings ( $p = 0.014$ ), suggesting prognostic relevance. Mechanical ventilator usage showed a striking correlation: all neonates requiring ventilation (50%) had predominantly abnormal USG, while those not requiring support had normal scans ( $p < 0.0001$ ). This confirms

abnormal cranial USG as a strong predictor for intensive care requirements.

**Patient 1:** A 28 - week, 1, 050 g infant was intubated briefly in the delivery room and received surfactant, then transitioned to CPAP at 12 h of life. At 36 h, the baby

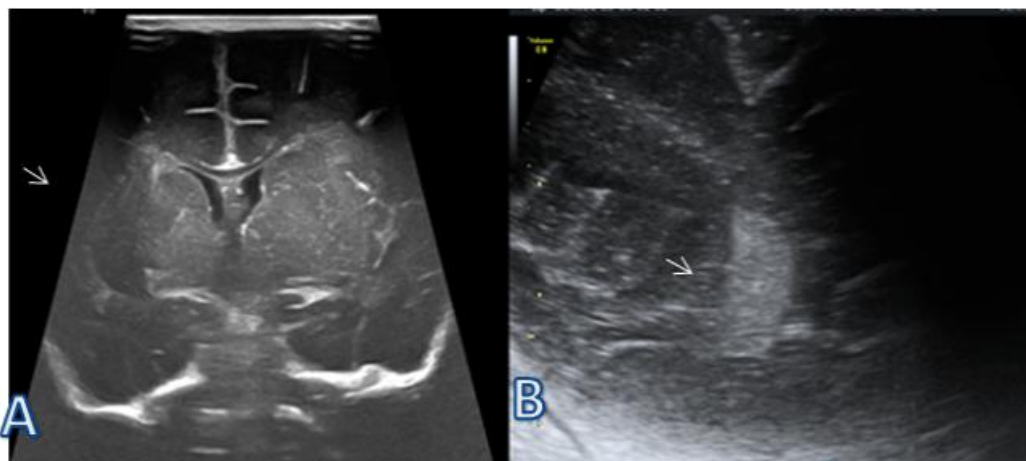
developed pallor, apnea, and bradycardia with CPAP at 6 cm H<sub>2</sub>O and FiO<sub>2</sub> 0.32. Given the rapid deterioration in an extremely preterm infant, an urgent cranial ultrasound was ordered to evaluate for germinal - matrix/intraventricular hemorrhage (GMH-IVH), which is common in this gestational age group and often manifests similarly.



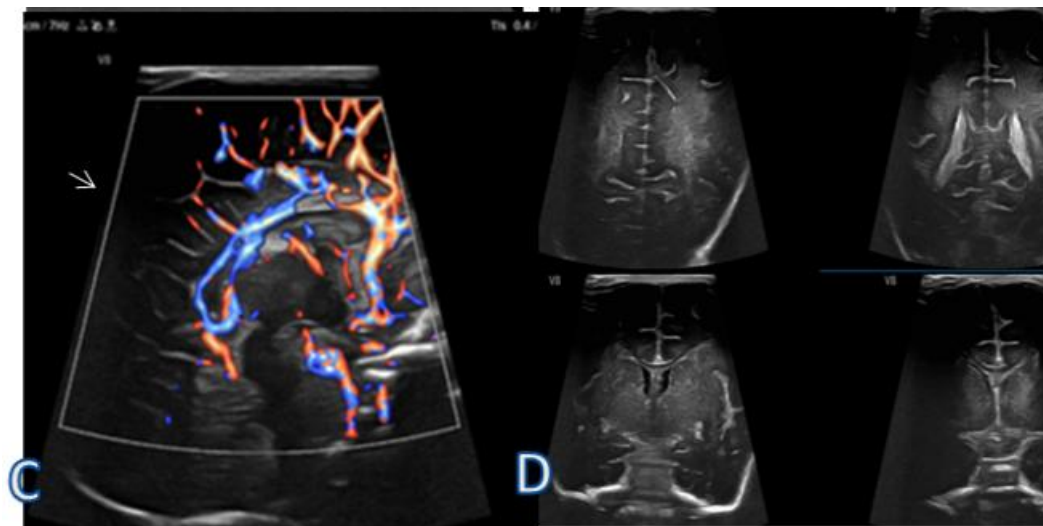
**Patient 1:** The provided cranial ultrasound images illustrate key neurosonographic abnormalities in neonates. Image A shows a solitary hyperechoic focus in the caudothalamic groove, indicating Grade I germinal matrix hemorrhage (GMH), typically mild with low risk for complications. Image B reveals small periventricular cysts and mild echogenicity, consistent with Grade II periventricular leukomalacia (PVL), which carries a variable prognosis. Image C demonstrates multiple extensive cysts in the parietal-occipital white matter, characteristic of Grade III PVL and associated with a high risk of motor and cognitive impairments. Image D displays a large echogenic intraventricular clot occupying over 50% of the ventricular

volume with ventriculomegaly (~3.5 cm), diagnostic of Grade III GMH-IVH, a severe form often requiring neurosurgical intervention due to its risk of post - hemorrhagic hydrocephalus and neurodevelopmental delay.

**Patient 2:** A 30 - week, 1, 200 g preterm stabilized on CPAP from birth requiring FiO<sub>2</sub> escalation from 0.25 to 0.38. Post - surfactant Apgar scores were 5 and 8. Between 24–48 h, the infant developed anemia, hypotension, and gasping, raising concern for evolving grade II–III IVH causing hemodynamic instability. Cranial ultrasound was promptly performed to assess hemorrhagic progression.

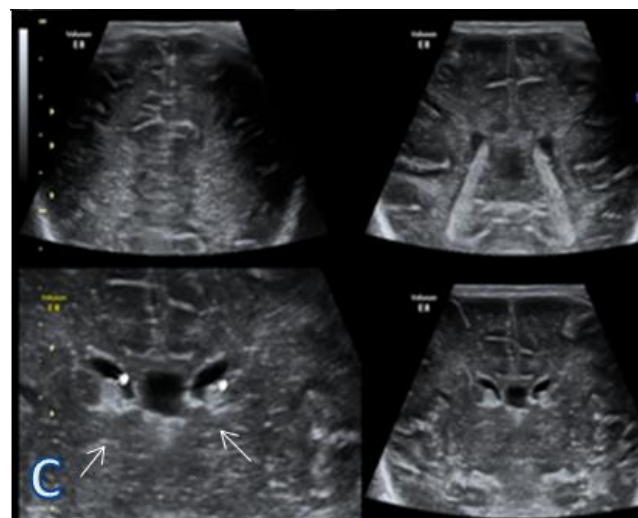
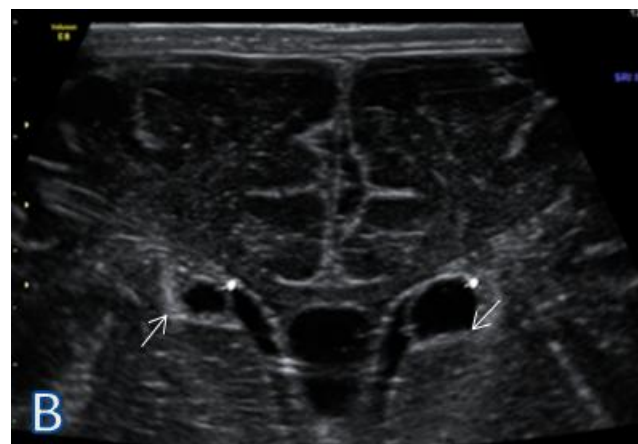
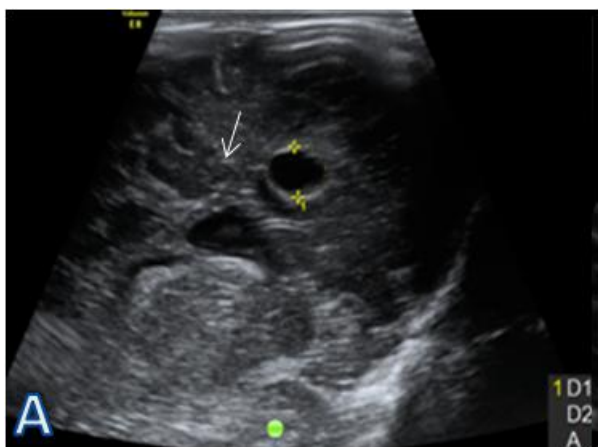






**Patient 2:** The ultrasound images illustrate early - stage and mild cranial abnormalities in neonates. Image A shows a solitary hyperechoic focus in the caudothalamic groove, diagnostic of Grade I germinal matrix hemorrhage (GMH–IVH), which is confined and typically resolves with routine follow - up. Image B demonstrates increased periventricular echogenicity without cyst formation, indicating Grade I periventricular leukomalacia (PVL), while Image D shows small focal periventricular cysts, consistent with Grade II PVL—both suggest early white matter injury with moderate neurodevelopmental risk. Image C reveals normal pericallosal artery perfusion on Doppler, with normal resistive index, reflecting stable cerebral blood flow and intracranial pressure.

**Patient 3:** A 27 - week preterm neonate weighing 1, 000 g was managed on CPAP (FiO<sub>2</sub> 0.30) after minimal resuscitation. Routine neurosonography at 72 h of age.



**Patient 3:** The ultrasound images depict benign germinal matrix pseudocysts, commonly seen in preterm neonates. Image A shows a solitary anechoic cyst (~0.9 cm) in the caudothalamic groove, while Image B displays bilateral small subependymal cysts adjacent to the lateral ventricles. Image C confirms multiple well - defined, non - communicating pseudocysts in the caudothalamic regions, without signs of periventricular leukomalacia (PVL) or hemorrhage. These findings represent developmental or post - hemorrhagic remnants, distinct from true germinal matrix hemorrhage due to their anechoic, stable appearance. Clinically, these pseudocysts are incidental with favorable

prognosis, requiring only routine follow - up unless clinical concerns arise.

## 5. Summary

In the present study, 37% of critically ill neonates exhibited neurosonogram abnormalities. Among them, 52% were male and 48% female, with no significant gender - based correlation to abnormal findings. Preterm neonates comprised 51% and term neonates 49%, with no statistical significance in relation to neurosonogram results. Abnormalities were observed in 12/20 neonates <1500g, 9/20 between 1.5–2.0 kg, 9/29 between 2.0–2.5 kg, and 7/29 >2.5 kg. Deliveries were nearly equally split between normal (51%) and assisted labour (49%). The primary causes of illness were perinatal asphyxia (32%), seizures (23%), prematurity (36%), sepsis (4%), and birth trauma (4%). Of those with abnormalities, 13% had cerebral edema, 10% periventricular flare, 7% PVL, and 2% each had germinal matrix hemorrhage, intraventricular hemorrhage, or hydrocephalus; 1% showed a space - occupying lesion. Neurosonogram abnormalities in neonates with sepsis, trauma, seizures, and prematurity were not statistically significant. However, abnormal findings strongly correlated with poor clinical outcomes, particularly mortality.

## 6. Conclusion

This study of 72 neonates highlights the vital role of cranial ultrasound (USG) in neonatal assessment and prognosis. A significant proportion of neonates exhibited abnormal cranial USG findings, underscoring its diagnostic value. Abnormal USG was strongly associated with critical neurological conditions such as intracerebral hemorrhage, periventricular leukomalacia, seizures, lethargy, absent suckling, and flaccidity. Notably, in conditions like ICH, PVL, seizures, and absent suckling, all affected neonates had abnormal USG results. Cranial ultrasound also demonstrated strong prognostic value, with all neonates who died showing abnormal findings. Additionally, abnormal USG was a powerful predictor of mechanical ventilation requirement, indicating its role in anticipating severe respiratory compromise. Conversely, no significant associations were found between abnormal USG and demographic factors such as gender, maternal gravidity, or certain clinical signs like bulging anterior fontanel, caput succedaneum, and excessive cry. These findings may reflect the transient nature of these signs or limited sample size. Overall, cranial ultrasound proves to be an essential, non - invasive tool in neonatal care for early detection of neurological abnormalities and guiding critical management decisions.

## References

- [1] **Volpe JJ.** *Neurology of the Newborn*. 5th ed. Philadelphia: WB Saunders; 2001: 218–280.  
→ Authoritative text on neonatal brain disorders including USG correlates.
- [2] **Leijser LM, de Vries LS, Cowan FM.** Using cerebral ultrasound effectively in the newborn infant. *Early Hum Dev*. 2006; 82 (12): 827–835.  
→ Comprehensive guidance on applying cranial USG in neonates.
- [3] **Gerda van Wezel - Meijler.** *Neonatal Cranial Ultrasonography*. 1st ed. Berlin: Springer; 2007: 3–4, 53–59.  
→ Essential for understanding sonographic technique and interpretation.
- [4] **Nagaraj N, Berwal PK, Srinivas A, et al.** A study of neurosonogram abnormalities, clinical correlation with neurosonogram findings, and immediate outcome of high - risk neonates in NICU. *J Pediatr Neurosci*. 2016; 11 (3): 200–205. doi: 10.4103/1817 - 1745.193367  
→ Indian study directly relevant to your research, highlighting outcomes of abnormal neurosonograms.
- [5] **Soni BD, Gupta M, Soni M, Gupta D, Dabi R, et al.** Sonography in high - risk neonates. *Indian Pediatrics*. 1995; 32: 452–459.  
→ Early Indian data on cranial USG utility in NICU neonates.
- [6] **Arti Maria, Arun Gupta, Rajiv Aggarwal V, Sreenivas VK, Deorari AK.** Incidence of periventricular leukomalacia among very low birth weight neonates (<1500 g). *Indian Pediatrics*. 2006; 43: 210–216.  
→ Indian cohort study on PVL incidence using cranial USG.
- [7] **Volpe JJ et al.** Haemorrhagic leukomalacia: diagnosis by real - time ultrasound and correlation with autopsy findings. *Pediatrics*. 1982; 69: 282–284.  
→ Landmark study linking USG findings with pathology.
- [8] **Whitaker A et al.** Neonatal cranial ultrasound abnormalities: association with developmental delay at age one in low birth weight infants. *J Dev Behav Pediatr*. 1990; 11 (5): 253–260.  
→ Links imaging findings with neurodevelopmental outcomes.
- [9] **Paneth N, Pinto - Martin J, Gardiner J, et al.** Incidence and timing of germinal matrix/intraventricular hemorrhage in low birthweight infants. *Am J Epidemiol*. 1993; 137: 1167–1176.  
→ Critical for understanding the timing and incidence of GMH/IVH.
- [10] **Singh U, Singh N, Shikha S.** A prospective analysis of etiology and outcome of preterm labour. *J Obstet Gynaecol India*. 2007; 57 (1): 48–52.  
→ Indian study supporting associations between prematurity and adverse neonatal outcomes.