Research Article

Cranial Usg Findings of Asphyxiated Preterm Neonates and Their Apgar Scores – A Correlation

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Abstract

Background: Neonatal asphyxia is a major cause of morbidity and mortality among preterm infants, often leading to hypoxic-ischemic brain injury. The Apgar score serves as a rapid tool to assess neonatal well-being, while cranial ultrasonography (USG) provides a non-invasive method to detect early brain abnormalities. This study aimed to evaluate cranial USG findings in asphyxiated preterm neonates and correlate them with Apgar scores. Methods: A cross-sectional study was conducted at Dr. D. Y. Patil Hospital and Research Centre, Kolhapur, from October 2019 to October 2021, involving 30 preterm neonates (<37 weeks) with a 5-minute Apgar score <6. Cranial USG was performed within the first 14 days of life using a GE Logiq F8 machine. Findings such as intracranial hemorrhage (ICH), ventricular dilatation, periventricular leukomalacia (PVL), and cerebral edema were analyzed according to the severity of asphyxia. Results: Among the 30 neonates, 56.7% were females and 53.3% were delivered by cesarean section. Moderate asphyxia was seen in 50%, mild in 40%, and severe in 10% of neonates. Abnormal cranial findings were noted in 80% of cases. ICH was the most frequent abnormality, observed in 50%, 53%, and 67% of mild, moderate, and severe asphyxia, respectively. Subependymal hemorrhage predominated in mild and moderate cases, while all severe cases showed high-grade germinal matrix hemorrhage. Conclusion: Cranial USG is a valuable bedside tool for early detection of brain injury in asphyxiated preterm neonates. The incidence and severity of ICH correlated with lower Apgar scores, highlighting its prognostic importance.

Keywords: Neonatal asphyxia, Preterm neonates, Cranial ultrasonography, Apgar score, Intracranial hemorrhage

1. Introduction

Neonatal asphyxia continues to be one of the major causes of neonatal morbidity and mortality worldwide, particularly among preterm infants. The transition from intrauterine to extrauterine life is a critical physiological process, and failure in this adaptation may result in hypoxic-ischemic injury to vital organs, especially the brain.[1] The Apgar score, introduced by Virginia Apgar in 1953, remains a rapid and reliable method to assess the newborn's clinical condition immediately after birth.[2] It evaluates five components—heart rate, respiratory effort, muscle tone, reflex irritability, and color—each scored from 0 to 2, with a total score ranging from 0 to 10.[3] Low Apgar scores at 1 and 5 minutes have been associated with an increased risk of neonatal mortality, hypoxic-ischemic encephalopathy, and long-term neurodevelopmental impairment.[4, 5]

Neuroimaging plays an essential role in identifying and assessing brain injury in neonates. Cranial ultrasonography (USG), due to its bedside availability, non-invasive nature, and absence of radiation exposure, has become the preferred modality for neuroimaging in preterm and critically ill neonates.[6] It enables visualization of key structures such as the ventricles, germinal matrix, and periventricular white matter, and is valuable for detecting intraventricular hemorrhage (IVH), periventricular leukomalacia (PVL), cerebral edema, and parenchymal hemorrhage. The timing and severity of perinatal asphyxia directly influence the type and extent of these lesions.[7, 8]

Previous studies have demonstrated a significant association between the severity of asphyxia and abnormal cranial USG findings, with IVH and PVL being the most frequent abnormalities observed in preterm neonates.[7-9] However, limited data exist correlating cranial USG findings specifically with Apgar scores in asphyxiated preterm infants. Most

prior research has either focused on term neonates or did not stratify preterm infants based on asphyxia severity and Apgar scoring.[10]

Therefore, the present study aims to evaluate the cranial ultrasonographic findings in asphyxiated preterm neonates and to correlate these findings with their Apgar scores at birth. Establishing such a correlation may help clinicians predict early neurological injury, guide timely intervention, and improve prognostic counseling in neonatal intensive care settings

Material and Methods

The present cross-sectional study was conducted at Dr. D. Y. Patil Hospital and Research Centre, Kolhapur, from October 2019 to October 2021 after obtaining approval from the Institutional Ethics Committee. Thirty preterm neonates (<37 weeks of gestation) with suspected asphyxia were enrolled based on the inclusion criteria: heart rate <100/min, apnea or unresponsiveness to stimulation, need for assisted ventilation immediately after birth, and a 5-minute Apgar score <6. Informed parental consent was obtained before inclusion. Neonates with major cardiovascular disorders, low Apgar due to anesthetic effects, lethal congenital anomalies, or those requiring emergency surgery were excluded.

Apgar scores at 5 minutes were used to classify asphyxia as mild, moderate, or severe. Cranial ultrasonography (CUS) was performed within the first 14 days of life, depending on the neonate's hemodynamic stability. All scans were carried out by a single investigator using a GE Logiq F8 machine equipped with a 3SC-RS sector probe (1.7–4.0 MHz) and an L6–12-RS linear probe (4–13 MHz) through the anterior fontanelle. Due to the absence of a portable unit, scans were done with full resuscitative support available. Common cranial USG findings were documented according to the severity of asphyxia.

Data were entered in Microsoft Excel and analyzed using descriptive statistics. Continuous variables were expressed as mean ± SD, while categorical variables were summarized as frequencies and percentages.

Results

Out of 30 preterm neonates included in the study, 17 (56.7%) were females and 13 (43.3%) were males. Table 1 summarizes the baseline characteristics. The majority of neonates (53.3%) were delivered by lower segment cesarean section (LSCS), while 46.7% were born vaginally. Most infants (66.7%) had a birth weight between 1000–1500 g, and 83.3% were above 34 weeks of gestational age.

Table 1. Baseline characteristics of neonates

Variable	Category	n (%)
Mode of delivery	Vaginal	14 (46.7)
	LSCS	16 (53.3)
Birth weight (g)	<1000	6 (20.0)
	1000–1500	20 (66.7)
	>1500	4 (13.3)
Gestational age (weeks)	<28	3 (10.0)
	28–34	2 (6.7)
	>34	25 (83.3)

According to the 5-minute Apgar score, moderate asphyxia was observed in 15 (50%) neonates, while mild and severe asphyxia were noted in 12 (40%) and 3 (10%) neonates, respectively (Figure 1).

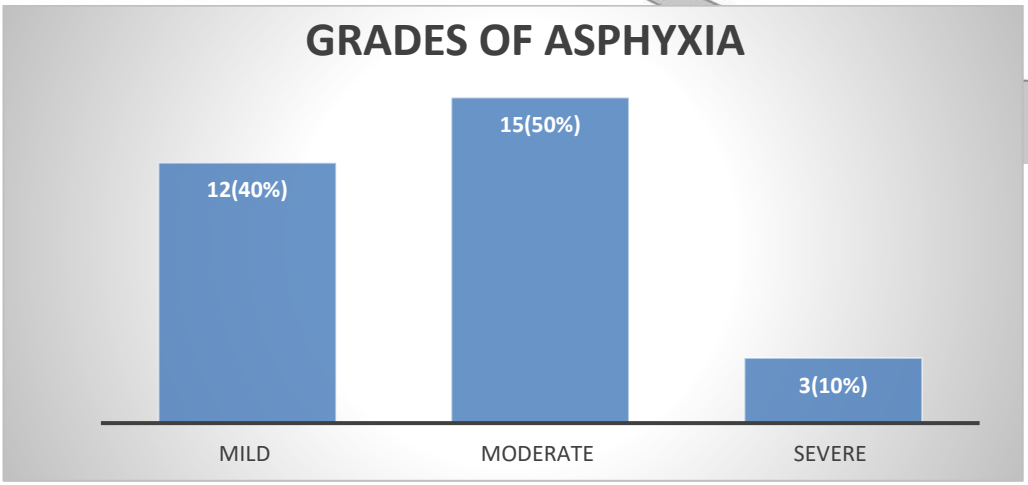


Figure 1. Grades of asphyxia

Cranial ultrasonography (CUS) findings among different grades of asphyxia are shown in Table 2. Intracranial hemorrhage (ICH) was the most frequent abnormality, detected in 50% of mildly, 53% of moderately, and 67% of severely asphyxiated neonates. Ventricular dilatation was observed in 8%, 20%, and 33% of mild, moderate, and severe groups, respectively. Periventricular leukomalacia (PVL) was seen only in one moderately asphyxiated neonate, while cerebral edema was found in a single case of mild asphyxia.

Table 2. CUS findings among different grades of asphyxia

CUS Findings	Grades of asphyxia		
	Mild n (%)	Moderate n (%)	Severe n (%)
Intracranial hemorrhage	6 (50)	8 (53)	2 (67)
Ventricular dilatation	1 (8)	3 (20)	1 (33)
Periventricular leukomalacia	0	1 (7)	0
ICH with PVL	0	1 (7)	0
Cerebral edema	1 (8)	0	0
No abnormality	4 (34)	2 (13)	0

Detailed analysis of ICH patterns (Table 3) revealed that subependymal hemorrhage was the predominant form in mild (81%) and moderate (62%) asphyxia. In moderate cases, intraventricular hemorrhage (IVH) and germinal matrix hemorrhage (GMH) were observed in 25% and 13% of neonates, respectively. All neonates with severe asphyxia demonstrated high-grade (Grade III/IV) GMH. Table 3. CUS findings in asphyxiated neonates

Table 4. ICH in Asphyxiated neonates

ICH	Mild asphyxia (%)	Moderate asphyxia (%)	Severe asphyxia (%)
Subependymal bleed	81	62	0
GMH-grade 3 or 4	0	13	100
IVH	19	25	0

Discussion

The present study was undertaken to identify common cranial ultrasonographic findings in different grades of asphyxiated preterm neonates, to assist in early diagnosis, counseling, and timely intervention. The major finding of this study was that intracranial hemorrhage (ICH) was the most frequent abnormality, observed in 50%, 53%, and 67% of neonates with mild, moderate, and severe asphyxia, respectively. Among the identified cases, subependymal hemorrhage was the most common type of bleed across all grades of asphyxia. These findings emphasize the value of

cranial ultrasound (CUS) as an essential imaging modality in the evaluation of preterm neonates with perinatal asphyxia. In this study, the majority of neonates were female (56.67%). However, previous studies by Aliyu et al. [11] and Motepalli et al. [12] have reported a higher prevalence of asphyxia in male neonates. The variation in gender distribution in the present study may be attributed to the relatively small sample size and population differences. Several studies have also shown that male neonates tend to have poorer perinatal outcomes due to delayed lung maturity and a greater susceptibility to hypoxic injury, though this was not observed in the present cohort.[11, 12]

It has been reported that neonates delivered by caesarean section (CS) have a two- to nineteen-fold higher risk of developing asphyxia compared to those delivered vaginally.[13, 14] In the present study, more than half of the neonates (53.33%) were delivered by caesarean section, a finding consistent with that of Wosenu et al. [15] The higher occurrence of asphyxia in CS deliveries may be due to underlying maternal complications necessitating surgical intervention or the added physiological stress of anesthesia. Conversely, during spontaneous vaginal delivery, the mechanical compression of the neonate's chest facilitates clearance of airway secretions and better lung expansion, thereby reducing the risk of asphyxia.[15]

Low birth weight and prematurity are recognized as key determinants of perinatal asphyxia. According to earlier reports, neonates with low birth weight have a seven- to eight-fold higher risk of asphyxia compared to normal birth weight neonates.[16, 17] In the current study, all subjects were preterm with low birth weight, which is in agreement with the findings of Aliyu et al. [11] and Bundi et al. [18] This association can be explained by the physiological immaturity of preterm neonates, who often have insufficient surfactant production leading to respiratory distress, impaired cardiopulmonary transition, and consequently, perinatal asphyxia.[15]

The Apgar score at five minutes remains one of the most practical tools for assessing the severity of asphyxia. In the present study, moderate asphyxia was observed in half of the neonates (50%), while mild and severe asphyxia were found in 40% and 10% respectively. Similar findings were reported by Bundi et al. [18], who found mild, moderate, and severe asphyxia in 33.3%, 28.9%, and 20% of neonates respectively. The variation in the severity of asphyxia across studies may be partly due to differences in timing and interpretation of the first- and fifth-minute Apgar scores, as well as variation in resuscitation practices.[19, 20]

Cranial ultrasonography is a valuable and non-invasive tool for detecting hypoxic-ischemic brain injury in neonates. Its findings correlate well with postmortem examinations, making it a reliable imaging modality in the neonatal intensive care setting.[21, 22] In this study, 80% of asphyxiated neonates showed abnormal cranial USG findings. The most common abnormality was ICH, followed by ventricular dilatation, which was noted in 8%, 20%, and 33% of neonates with mild, moderate, and severe asphyxia, respectively. Cerebral edema was found in one mildly asphyxiated neonate, while periventricular leukomalacia (PVL) and combined ICH with PVL were observed in two moderately asphyxiated neonates.

These findings are in partial agreement with those reported by Moniruzzaman et al. [23], who observed ventricular dilatation as the most common abnormality, followed by intraventricular hemorrhage (IVH), ICH, and cerebral edema. Giri et al. [24] also reported ICH as the predominant finding in 24% of asphyxiated neonates, along with cerebral edema and ventricular dilatation. Other studies by Khan et al. [25], Cowan et al. [26], have described variable frequencies of ICH, cerebral edema, ventricular dilatation, and PVL depending on the gestational age, timing of scan, and severity of asphyxia. Such variation across studies may also be attributed to differences in equipment sensitivity, imaging protocols, and study population characteristics.

The present study, with uniform imaging criteria and a standardized protocol, highlights the diagnostic value of cranial ultrasonography (USG) in detecting early brain abnormalities among preterm neonates with asphyxia, identifying intracranial hemorrhage (ICH) as the most common finding. However, the lack of randomization, blinding, and a control group may introduce bias. Additionally, small subependymal hemorrhages and late-developing PVL could have been missed, while subtle hemodynamic or metabolic changes remain undetectable on USG. Despite these limitations, USG remains a safe, portable, and cost-effective imaging tool. The study suggests a clear correlation between the severity of asphyxia and the degree of ICH, emphasizing the need for larger controlled studies to confirm these results and refine early intervention strategies.

Conclusion

Cranial ultrasonography is a valuable, non-invasive tool for detecting early brain abnormalities in asphyxiated preterm neonates. In this study, intracranial hemorrhage (ICH) emerged as the most common cranial finding, with its incidence and severity increasing proportionally with the grade of asphyxia. These results highlight the importance of routine cranial USG in the early evaluation of preterm neonates with low Apgar scores, as timely detection can aid in parental counseling and guide early therapeutic interventions. Further studies with larger sample sizes and control groups are recommended to validate these findings and strengthen the role of USG as a prognostic tool in neonatal asphyxia.

Reference

1. Lawn JE, Cousens S, Zupan J. 4 million neonatal deaths: when? Where? Why?. The lancet. 2005 Mar 5;365(9462):891-900.
2. Apgar V. A proposal for a new method of evaluation of the newborn infant. Anesthesia & Analgesia. 1953 Jul 1;32(4):260-7.
3. American College of Obstetricians and Gynecologists (ACOG). Committee Opinion No. 644: The Apgar Score. Obstetrics & Gynecology 126(4):p e52-e55, October 2015.
4. Casey BM, McIntire DD, Leveno KJ. The continuing value of the Apgar score for the assessment of newborn infants. New England Journal of Medicine. 2001 Feb 15;344(7):467-71.
5. Moster D, Lie RT, Markestad T. Joint association of Apgar scores and early neonatal symptoms with minor disabilities at school age. Archives of Disease in Childhood-Fetal and Neonatal Edition. 2002 Jan 1;86(1):F16-21.
6. Ganesan D, Saravanan S. Cranial ultrasound findings in asphyxiated term neonates and their correlation clinically with hypoxic ischemic encephalopathy staging. Int J Contemp Pediatr. 2023;10:286-9.
7. Leijser LM, de Vries LS. Preterm brain injury: Germinal matrix–intraventricular hemorrhage and post-hemorrhagic ventricular dilatation. Handbook of clinical neurology. 2019 Jan 1;162:173-99.
8. Sherwani AS, Parry AH, Bhat MH, Gojwari TA, Charoo BA, Choh NA. Assessment of role of cranial ultrasound (CUS) in the evaluation of high-risk preterm and term neonates. Egyptian Pediatric Association Gazette. 2023 Feb 13;71(1):7.
9. Enhesari A, Biglari N, Shafieei M, Nejad MS, Parizi ZD, Vaghefi RE. Evaluating the correlation between brain ultra sonographic, brain MRI, and electroencephalography findings and the severity of asphyxia and neurodevelopment in infants with hypoxic-ischemic injury. Iranian Journal of Child Neurology. 2022 Jul 16;16(3):109.
10. Hand IL, Shellhaas RA, Milla SS, Committee on Fetus and Newborn, Section on Neurology, Section on Radiology, Cummings JJ, Adams-Chapman IS, Aucott SW, Goldsmith JP, Kaufman DA, Martin CR, Puopolo KM. Routine neuroimaging of the preterm brain. Pediatrics. 2020 Nov 1;146(5):e2020029082.
11. Aliyu I, Lawal TO, Onankpa B. Hypoxic-ischemic encephalopathy and the Apgar scoring system: The experience in a resource-limited setting. Journal of Clinical Sciences. 2018 Jan 1;15(1):18-21.
12. Motepalli A, Patel MR, Rao V. Birth asyphxia: Looking at trends of risk factors leading to birth asphyxia in a peripheral hospital. Journal of Dr. YSR University of Health Sciences. 2018 Oct 1;7(4):245-8.
13. Kiyani AN, Khushdil A, Ehsan A. Perinatal factors leading to birth asphyxia among term newborns in a tertiary care hospital. Iranian journal of pediatrics 2014, 24(5):637.
14. Utomo MT: Risk factors for birth asphyxia. Folia Medica Indonesiana 2011, 47(4):211–214.
15. Wosenu L, Worku AG, Teshome DF, Gelagay AA. Determinants of birth asphyxia among live birth newborns in University of Gondar referral hospital, northwest Ethiopia: A case-control study. PloS one. 2018 Sep 7;13(9):e0203763.
16. Shrestha M, Shrestha L, Shrestha PS. Profile of asphyxiated babies at Tribhuvan University Teaching Hospital. J Nepal Pediatr Soc 2009;29:3-5.
17. Thornberg E, Thiringer K, Odeback A, Milsom I. Birth asphyxia: Incidence, clinical course and outcome in a Swedish population. Acta Paediatr 1995;84:927-32.
18. Bundi LB, Mwango G, Oliver VO, Mulama B. Clinical neonatal hypoxic ischemic injury: Cranial ultrasound spectrum of findings in neonates admitted to a Newborn Unit in Nairobi, Kenya. West African Journal of Radiology. 2020 Jul 1;27(2):108-13.
19. Ekure EN, Ezeaka VC, Iroha E, Egri-Okwaji M. Prospective audit of perinatal mortality among inborn babies in a tertiary health center in Lagos, Nigeria. Niger J Clin Pract 2011;14:88-94.
20. Mukhtar-Yola M, Iliyasu Z. A review of neonatal morbidity and mortality in Aminu Kano teaching hospital, Northern Nigeria. Trop Doct 2007;37:130-2.
21. Gupta SN, Amer MK, Uday SK. Intracranial hemorrhage in term newborns: anagement and outcomes. Pediatric Neurology. 2009; 40(1): 1-12.

22. Eken P, Jansen GH, Groenendaal F, Rademaker KJ, de Vries LS. Intracranial lesions in the fullterm infant with hypoxic ischaemic encephalopathy: ultrasound and autopsy correlation. Neuropediatrics. 1994; 25(6): 301-07.
23. Moniruzzaman M, Ali MA, Akter T, Rashid MA, Kamruzzaman M, Latif T, Khan RH, Das MK, Sarker UK, Mazumder M. Comparison of Ultrasonogram of Brain Findings of Asphyxiated and Non-Asphyxiated Baby Admitted in Neonatal Ward in a Tertiary Level Hospital. Mymensingh medical journal: MMJ. 2019 Jul 1;28(3):497-502.
24. Giri S, Jana TK, Tapadar A. Ultrasonographic Evaluation of the Neonatal Brain in Cases of Birth Asphyxia. International Journal of Anatomy, Radiology and Surgery. 2016 Jan:5(1):58-63.
25. Khan IA, Wahab S, Khan RA, Ullah E, Ali M. Neonatal intracranial ischemia and hemorrhage: role of cranial sonography and CT scanning. J Korean Neurosurg Soc. 2010; 47(2): 89-94.
26. Cowan FM, Pennock JM, Hanrahan JD, Manji KP, Edwards AD. Early detection of cerebral infarction and hypoxic ischemic encephalopathy in neonates using diffusion-weighted magnetic resonance imaging. Neuropediatrics. 1994; 25(4):172-75.