

# Neurosonogram in Critically Ill Neonates in Neonatal Intensive Care Unit

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## Abstract

**Aim:** Neonates born prematurely and sick full-term neonates are at risk of brain injury. Although advances in neonatal intensive care have greatly improved the survival and outcome of these vulnerable patients, brain injury remains of major concern. Early diagnosis is important for prognostication, optimal treatment, and predicting the neurological outcome.

**Objective:** This study was done to describe the pattern of cranial ultrasound abnormalities in preterm and term critically ill neonates in neonatal intensive care unit (NICU).

**Materials and Methods:** This prospective observational clinical study was done in Vydehi Institute of Medical Sciences Hospital and Research Centre, Bengaluru between January 2014 and July 2015. After obtaining informed consent 100 critically ill neonates admitted to our NICU were included in this study. History and clinical examination followed by appropriate investigations were done. These critically ill neonates were subjected to neurosonography on selected days as per as protocol and different patterns of morphology abnormalities were noted. Clinical correlation with neurosonogram findings was observed and if found abnormal follow-up neurosonogram were done.

**Results:** The incidence of neurosonographic abnormalities in high-risk neonates is 31% in the present study. Of these 41% of these had evidence of intracranial bleed, 25% had cerebral edema, 6% periventricular leukomalacia, 16% hyperechogenic thalami, and one had ventriculomegaly. Of the 31% of neonates with abnormal findings on neurosonogram, 22% had hypoxic-ischemic encephalopathy as per Apgar scoring, 25% had features of sepsis. One neonates with intraventricular bleed on regular follow-up of neurosonogram developed ventriculomegaly.

**Conclusion:** This study signifies the importance of neurosonogram in critically ill neonates as diagnostic tool and as screening modality in NICU. It also emphasizes its use as a screening modality for preterm and birth asphyxia neonates influencing their neurodevelopmental outcome. Neurosonogram is critical as an investigatory modality in NICU for early, safe and easy diagnostic tool for predicting the neurological damage for management in NICU and predicting outcome.

**Key words:** Birth asphyxia, Neonatal intensive care unit, Neurosonogram, Preterm

## INTRODUCTION

Cranial ultrasonography (cUS) is the preferred modality to image the neonatal brain. The advantages of cUS are numerous: It can be performed at the bedside with little disturbance to the infant, it is relatively safe, and can be

repeated whenever needed, enabling visualization of ongoing brain maturation and the evolution of lesions.<sup>1</sup>

Ultrasound is the most widely used cranial imaging modality in the neonatal intensive care unit (NICU). Ultrasound machines are portable, the images can be acquired at bedside conveniently in the NICU, which meets the definition of point-of-care testing. The cumbersome transport of the neonates to the computerized tomography (CT) or the magnetic resonance imaging (MRI) suite is avoided. In addition, ultrasound is cost-effective and considered a safer modality in the pediatric population due to the lack of harming effect of ionizing radiation, as in CT,

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as well as avoiding the need for sedation required for MRI. Ultrasound is the least costly of all modalities for cranial imaging and is readily available in all intensive care units. In the neonate, many sutures and fontanelles are still open and these can be used as acoustic windows to “look” into the brain. The modality is operator-dependent and should be performed by an experienced sonographer, neonatologist, or radiologist. In many cases, a final diagnosis and treatment guidance can be achieved with neurosonography, such as in neonatal germinal matrix hemorrhages, neonatal malformations.<sup>2,3</sup>

Any neonate, regardless of birth weight, size, or gestational age, who has a greater than average chance of morbidity or mortality, due to fetal, maternal or placental anomalies or an otherwise compromised pregnancy, especially within the first 28 days of life is categorized as critically ill neonate. Neurosonogram plays an important role in assessing neurological prognosis of these high-risk infants.<sup>2,4</sup>

Modern machines, with a variety of acoustic windows and sequential scanning giving high-quality images has increased the recognition of features suggestive of developmental, metabolic and infectious disorders.

It detects most of the hemorrhagic, ischemic and cystic brain lesions as well as calcifications, cerebral infections, and major structural abnormalities in critically ill neonates. It is also very helpful in the early diagnosis of the many etiologies of neonatal encephalopathy and seizures in the term infant and the subsequent monitoring of progress of hypoxic-ischemic brain injury.

Most newborn intensive care unit centers perform serial cUS evaluations early in the course of hospitalization for premature infants and often, a follow-up examination is done at a later age. These evaluations are done to document the presence of intracranial hemorrhage, to guide choice of therapies that may exacerbate the risk of further hemorrhage, and to counsel families about neurodevelopment outcomes.<sup>5,7</sup>

Neurosonogram is also very helpful in assessing severity and neurodevelopment outcome in infants with hypoxic-ischemic encephalopathy (HIE) and in seriously ill neonates with cerebral abnormalities, either congenital or acquired, it plays a role in decision making on continuation or withdrawal of intensive treatment.<sup>10</sup>

The quality of neurosonography and its diagnostic accuracy depends on the ultrasound machine and also expertise of the examiner. When performed as per protocol, it is reliable investigation for commonly occurring neonatal events. Neurosonogram can be initiated even immediately after

birth and hence suitable for screening and can be repeated as often as possible without any adverse-effects and hence helps in proper follow-up of babies with neurological problems. In this review, we discuss the applications and indications of neonatal cUS.<sup>12</sup>

We list the most frequently occurring abnormalities of the neonatal brain, as seen on cUS in preterm and sick full-term neonates. However, cUS also has several limitations: Quality of imaging depends on the skills and experience of the ultrasonographer, some areas of the brain is difficult to visualize, and several abnormalities remain beyond its scope.<sup>2</sup>

## MATERIALS AND METHODS

This study was conducted in Vydehi Institute of Medical Sciences Hospital and Research Centre, Bengaluru between January 2014 and July 2015. A total of 100 neonates admitted to our NICU who were critically ill were included in the study.

All critically ill neonates admitted to NICU were selected as per the inclusion criteria on non-randomized manner and were subjected to neurosonography on selected days. If neurosonogram revealed any abnormal findings, they were followed up for any sequelae.

All neonates admitted to NICU with prematurity, birth asphyxia, HIE, neonatal convulsions, neonatal sepsis, neonate with traumatic/instrumental delivery, respiratory distress, congenital malformation of central nervous system, and neural tube defects were included in the study.

After obtaining the informed consent from the parents/guardians neonates are included in the study. Factors that identify the neonate as “critically ill” were assessed by taking detailed maternal history looking into perinatal and antenatal records. Clinical examination and in detail neurological system was done.

All routine investigations were done for all babies and neurosonogram of the high-risk neonate fulfilling the inclusion criteria was performed. Follow-up cUS was done in the case of presence of any findings and for preterm neonates. Morphology of cUS findings was studied and recorded and clinical correlation with various findings on neurosonogram was done. Neonates were followed till recovery and discharge from NICU.

The sonograms were performed on a Philips HD 11 XE machine using a multi-frequency high-density

volume - TV/TR probe. A single radiologist to avoid inter-observer variation performed all ultrasounds.

### Statistical Analysis

Descriptive statistical analysis was carried out in this study. Results on continuous measurements are presented on mean  $\pm$  standard deviation (SD) (min-max) and results on categorical measurements presented in number (%). Significance is assessed at 5% level of significance.

Chi-square test was used to find the significance of study parameters and also categorical scale between two or more groups.

## RESULTS

Out of 100 cases included in the study, 31% of the neonates had neurosonographic abnormalities. There were 56% male and 44% female neonates enrolled of which 63% were preterm and 37% term high-risk neonates with birth weight distribution of mean  $\pm$  SD:  $1.84 \pm 0.62$ . Mode of delivery was normal vaginal for 52% neonates and 48% via LSCS for various reasons.

Out of 63 neonates with preterm gestation, 36% had abnormal cUS and out of 37 term critically ill neonates with, 21% had abnormal cUS.

Of 63% of neonates admitted with prematurity, 57% was <32 weeks gestation and 36% had abnormal cUS. Out of 63% preterm neonates, 47% had respiratory distress, 15% had neonatal sepsis, 12% had hypoglycemia, 11% had HIE, 46% clinically had respiratory distress, 7% had neonatal seizures in NICU stay, 3% had hypocalcemia seizures and 1% had documented birth trauma at birth. There were no neonates with congenital malformations or neural tube defect.

Of the preterm neonates having abnormal findings on cUS, 43% had intracranial bleed, 17% had cerebral edema, 4% had thalamic hyperechogenicity, 8% had periventricular leukomalacia (PVL) and 8% with other findings (Table 1).

Correlation of cUS abnormalities and HIE showed that of the 13 of neonates with HIE at birth based on APGAR score, 53% had abnormal cUS abnormalities. Of 13 neonates with HIE, 38% had cerebral edema and 23% had thalamic hyperechogenicities and 30% had intracranial bleeds (Table 2).

There was statistically significant correlation between findings on cUS and day of life of neonate when cUS was done. Around 16% abnormal findings on cUS were picked

up before 24 h, around 32% picked up during 24-72 h of life and around 25% after 72 h of life (Figure 1).

In the correlation of perinatal risk factors with abnormal cUS findings, there was statistically significant correlation only with PIH ( $P = 0.05$ ). Correlation of APH, PROM, multiple births and birth trauma was statistically not significant.

There was statistically significant correlation between abnormal cry ( $P = 0.052$ ), abnormal tone ( $P = 0.021$ ), abnormal activity ( $P = 0.018$ ), and presence of cyanosis ( $P = 0.035$ ) on clinical examination and presence of abnormalities on cUS.

One preterm neonate on regular follow-up cUS developed findings suggestive of hydrocephalous correlating with clinical outcome. There was no statistically significant correlation between various findings on cUS and clinical outcome of the neonate. 94% of neonates enrolled had good recovery at the time of NICU discharge, 4% died and 2% were discharged from NICU for various reasons before clinical recovery.

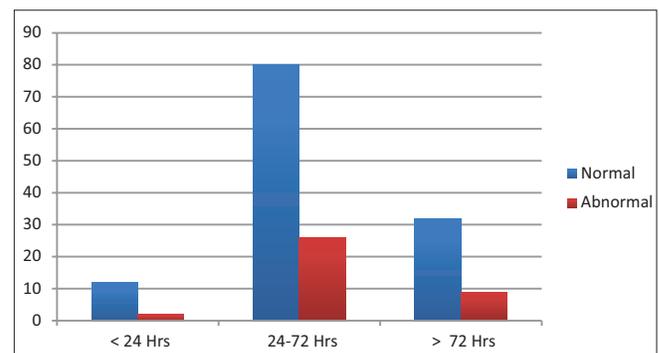


Figure 1: Distribution of high-risk neonates based on timing of cranial ultrasound

Table 1: Correlation of gestational age with various cUS findings

Neurosonogram	Number of neonates n=100 (%)	Gestation age (weeks)		
		<32 n=36 (%)	33-36 n=27 (%)	>37 n=37 (%)
Normal	69 (69)	23 (63)	17 (62)	29 (78)
Abnormal	31 (31)	13 (36)	10 (37)	8 (21)
Intracranial bleed	13 (13)	6 (46)	4	3 (8)
Cerebral edema	8 (8)	2 (15)	2	6 (16)
PVL	2 (2)	0	2	0
Thalamic hyperechogenicity	5 (5)	0	1	3 (8)
CNS malformation	2 (2)	0	1	1 (2)
Miscellaneous	1 (1)	1 (7)	0	0

CNS: Central nervous system, PVL: Periventricular leukomalacia, cUS: Cranial ultrasonography

**Table 2: Correlation of cUS abnormalities in high risk neonates**

Neurosonogram	No of neonate n=100 (%)	Inclusion criteria			
		Preterm n=63 (%)	Sepsis n=22 (%)	Seizure n=13 (%)	HIE n=13 (%)
Normal	69 (69)	40 (63)	12 (54)	7 (53)	6 (46)
Abnormal	31 (31)	23 (23)	8 (36)	6 (46)	7 (53)
Intracranial bleed	13 (13)	10 (15)	2 (9)	4 (30)	4 (30)
Cerebral edema	8 (8)	4 (6)	4 (18)	3 (23)	5 (38)
PVL	2 (2)	2 (3)	1 (4)	0	0
Thalamic hyperechogenicity	5 (5)	1 (1)	2 (9)	0	3 (23)
Miscellaneous	1 (1)	2 (3)	0	0	0

HIE: Hypoxic-ischemic encephalopathy, PVL: Periventricular leukomalacia, cUS: Cranial ultrasonography

## DISCUSSION

The use of neurosonogram in NICU's is rapidly increasing owing to availability and early detection and management.

Neurosonogram is an easy and an affordable non-invasive procedure and treatment is initiated at a very early stage. It can be repeated as necessary, and thereby enables visualization of ongoing brain maturation and the evolution of brain lesions. It can also be used to assess the timing of brain damage.

De Vries and Cowan *et al.* have suggested that neurosonogram and MRI are complementary modalities, with ultrasound as an especially useful tool in the early days, when the infant is unstable for transport and ultrasound findings may be sufficient for major clinical decisions. Current study aims at proving the same.<sup>6</sup>

Each study found 100% correlation between neurosonography findings and neuropathologic data. Ultrasound is also particularly useful in detecting some important congenital malformations such as cystic lesions (hydrocephalus, porencephalic cysts, Dandy-Walker cysts complex, and arachnoid cysts), corpus callosal agenesis and aneurysm of the vein of Galen (color Doppler).

Four studies reported results of a total of 87 autopsies performed on PT infants, neurosonogram was 76% to 100% accurate in detecting Grade 1 lesions of >5 mm and Grade 3 and Grade 4 hemorrhages. Detection of Grade 2 hemorrhages was much less accurate. Correlation of US findings of cystic PVL with neuropathologic data was evaluated in three studies.<sup>10-12</sup>

Dubowitz *et al.*, study showed an incidence 20% of ultrasound abnormalities in apparently well neonates and reported ischemic lesions, such as periventricular and thalamic densities were the most common finding (8%), followed by intracranial hemorrhagic lesions (6%) on cUS. In this study, on cUS, 31% of neonates had abnormal findings. 13% of these had evidence of intracranial bleed, 5% hyperechogenic thalami, 8% had cerebral edema.

Hence, high efficacy of neurosonogram in detecting presence of brain damage and its evolution on regular follow-up guides clinical decisions and prognosis.

## CONCLUSION

This study shows diagnostic importance of neurosonogram in critically ill neonates in NICU.

It also signifies its use as a screening tool in preterm in diagnosis and also for predicting the neurological outcome in critically ill neonates.

Neurosonogram is used as routine in NICUs was found to be an excellent and noninvasive tool for brain imaging during the neonatal period. It enables screening of the brain and serial imaging in high-risk neonates. The study concludes that neurosonogram is critical as an investigatory modality in NICU and effectively documents morphology of brain damage, enabling early intervention and treatment, and may improve clinical outcome.

Finally, it shows the importance of neurosonogram as a routine daily use in NICU for diagnosis and prognostication and, also the need of the neonatologist working in the NICU to expertize the art of neurosonography for safe, early and effective care.

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