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Cranial Ultrasonography in Preterm and Term Neonates

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Abstract:

Introduction: The newborn brain is vulnerable to injury from many causes, like preterm delivery, hypoxia, trauma etc. Cranial ultrasonography are widely used to identify preterm neonates at risk for brain injury and subsequent neurodevelopmental defects. **Aims and Objectives**: Role of cranial ultrasonography to evaluate intracranial abnormalities in preterm and term neonates. Materials and methods: This is a prospective hospital based study conducted in Sagar Hospitals, Jayanagar, Bangalore. This study included a cohort of total 52 numbers of cases in preterm and term neonates, who were admitted in NICU. **Results:** This study included a cohort of total 52 numbers of cases in preterm and term neonates. In our study, total 12 neonates 23.1% were having flaring, total 11 neonates 21.2% were having ICH, total 6 neonates 11.5% were having PVL, total 4 neonates 7.7% were having cysts, total 4 neonates 7.7% were having cerebral oedema and normal 15 neonates 28.8%. Conclusion: Cranial ultrasonography is a cheap, convenient, non-invasive technique for imaging the newborn brain. Because of its accuracy, ease of performance, and safety, the use of real-time cranial ultrasonography of neonates has gained wide acceptance as a first line imaging investigation in the neonatal intensive care unit.

Key words: Cerebral Oedema; Cranial ultrasonography; Flaring; Intracranial hemorrhage; Periventricular hyperechogenicity

Introduction

The newborn brain is vulnerable to injury from many causes, like preterm delivery, hypoxia, trauma etc, resulting in significant mortality and morbidity despite recent improvements in neonatal intensive care [1].

Cranial ultrasonography are widely used to identify preterm neonates at risk for brain injury and subsequent neurodevelopmental defects, most commonly as a consequence of severe intracranial hemorrhage (ICH) and cystic periventricular leukomalacia (PVL) [1,2]. Intracranial hemorrhage occurs in 40% of premature neonates who weigh less than 1500 gm; 90% of hemorrhages occur within the first 3 postnatal days and the remainder by 10 days. Intracranial hemorrhage is usually clinically occult, and detection requires a screening ultrasonography (USG) [2].

Periventricular leukomalacia is seen in 3% to 10% of premature neonates [1]. The sonographic criteria of PVL are increased white matter echogenicity that evolves to cyst formation [2]. Cystic PVL is invariably associated with significant long-term neurologic morbidity, early identification of the preterm infant at highest risk for the subsequent development of this lesion is critical. Early identification may facilitate future preventive strategies [1].

Spontaneous hemorrhage in and around the cerebral ventricle is a phenomenon that occurs in premature neonates and is now being increasingly observed in high risk term neonates. Its incidence is approximately 40-45% in newborns weighing less than 1500 gm or born before 35 weeks of gestational age. It is due to rupture of the fragile capillaries of the germinal matrix [3].

Aims and Objectives

Role of cranial ultrasonography to evaluate intracranial abnormalities in preterm and term neonates.

1. To ascertain the clinical course of intracranial haemorrhage and to determine the short-term outcome of the affected baby neonates who develop intracranial complications of prematurity.
2. The utility of real-time ultrasonography in the diagnosis of neonatal periventricular leukomalacia.

Materials and Methods

This is a prospective study conducted in Sagar Hospitals, Jayanagar, Bangalore for a period of 2 years. A total of 52 neonates were evaluated during the study period from December 2007 to December 2009. This study included a cohort of total 52 numbers of cases in preterm and term neonates, who were admitted in NICU.

The US machine "**Prosound SSD 3500SV**" from Aloka with a microconvex high resolution array sector transducer of 7-10 MHz was used during the present study. Standard coronal, sagittal and parasagittal imaging were carried out using anterior fontanelle for gray scale examination.

Inclusion criteria:

Babies born within gestational age (GA) varied between 28 to 42 weeks. The studies included clinically indicated scans and included the cases of lesser grades of ICH, PVL, diffuse cerebral oedema, solitary cysts, transient periventricular hyperechogenicity (PVHE), and 15 normal cases. The birth weight and gestational age were also recorded.

Exclusion criteria:

Neonates which were incompletely examined (once or twice) due to early discharge and died during the study period.

Gray scale examination:

Sonographic examinations are performed through the anterior fontanelle in both the coronal and sagittal planes. The anterior fontanelle remains open until approximately 2 years of age, but suitable for scanning only until about 12 to 14 months.

Magnified views are essential to study near-field pathology. Whenever possible, the transducer should be held firmly between the thumb and index finger, and lateral aspect of hand should rest on the infant's head for stability.

Coronal images are obtained by placing the scan head transversely across the anterior fontanelle. The plane of the ultrasound beam is then made sweep in an anterior to posterior direction, completely through the brain. Care must be taken to maintain symmetrical imaging of each half the brain and skull.

Sagittal images are obtained by placing the transducer longitudinally across the anterior fontanelle and angling it to each side.

Results

This study included a cohort of total 52 numbers of cases in preterm and term neonates, who were admitted in neonatal intensive care (Table 1).

The study cohort consisted of neonates of varying gestational age groups, however, mean gestational age of the neonate 35.50±3.08 week (Table 2).

Out of the 52 neonates studied, 33 were preterm and 19 were term (Table 3 and 4). The birth weights of neonates were varying with mean birth weight of 2251.73±395.39 gm (Table 5).

Flaring

In our study, total 12 neonates 23.1% (Table 1) were having flaring, all the neonates were preterm 36.4% (Table 3) and weighing between 2001 to 2500 gm 54.6% (Table 7).

This flaring was present between 3 to 5 days scan (Table 9) which subsequently became normal between 10 to 14 days and 26 to 30 days scans (Table 10 and 11).

Intracranial hemorrhage

In our study, total 11 neonates 21.2% (Table 1) were having ICH, 10 neonates were preterm 30.3% (Table 3) and 1 neonate was term 5.3% (Table 4). Neonates weighing less than 2000 gm had 6 ICH type I 42.9% and 1 ICH type II 7.1% (Table 6). Neonates weighing between 2001 to 2500 gm had 4 ICH type I 18.2% (Table 7).

Cranial USG done between 3 to 5 days scan revealed 10 ICH type I 19.2% and 1 ICH type II 1.9% (Table 9). On subsequent Cranial USG done between 10 to 14 days scan revealed 6 ICH type I 11.5% as reducing and 3 ICH type I 5.8%, 1 ICH type II 1.9% as same (Table 10). Cranial USG done between 26 to 30 days scan revealed 2 ICH type I 3.9%, 1 ICH type II 1.9% as reducing and 1 ICH type I 1.9% as same (Table 11).

Periventricular leukomalacia

In our study, total 6 neonates 11.5% (Table 1) were having PVL; all the neonates were preterm 18.2% (Table 3) and weighing less than 2000 gm 42.9% (Table 6). Cranial USG done between 3 to 5 days scan revealed 18 Flaring 34.6% (Table 9). On subsequent Cranial USG done between 10 to 14 days scan revealed 6 Flaring 11.5% persistent (Table 10). Cranial USG done between 26 to 30 days scan revealed 6 PVL 11.5% (Table 11).

Cysts

In our study, total 4 neonates 7.7% (Table 1) were having cysts, 1 neonate was preterm 3.0% (Table 3) and 3 neonates were term 15.8% (Table 4). Neonates weighing between 2001 to 2500 gm had 2 cysts 9.1% (Table 7). Neonates weighing 2501 gm and above had 2 cysts 12.5% (Table 8).

Cranial USG done between 3 to 5 days scan revealed 4 cysts 7.7% (Table 9). On subsequent, Cranial USG done between 10 to 14 days, and 26 to 30 days showed persistence these cysts 7.7% (Table 10) and 7.7% (Table 11) respectively.

Cerebral oedema

In our study, total 4 neonates 7.7% (Table 1) were having cerebral oedema; all the neonates were preterm 12.1% (Table 3). One neonate weighing less than 2000 gm 7.1% (Table 6) and remaining three neonates were weighing between 2001 to 2500 gm 13.6% (Table 7).

Cranial USG done between 3 to 5 days scan revealed 4 cerebral oedema 7.7% (Table 9). On subsequent, Cranial USG done between 10 to 14 days showed reduction in cerebral oedema 7.7% (Table 10). Cranial USG done between 26 to 30 days showed complete resolution of cerebral oedema and became normal.

Table 1: Grand total distribution of number of cases in Preterm and Term neonates

Cranial USG findings	Number of cases	%
Normal	15	28.8
Flaring / PVHE	12	23.1
ICH	11	21.2
PVL	6	11.5
Cyst	4	7.7
Cerebral oedema	4	7.7
Grand Total	52	100.0

Table 2: Gestational age distribution of neonates studied

Gestational age (weeks)	Number of cases	%
28-34	19	36.5
35-36	14	27.0
37-39	13	25.0
40-42	6	11.5
Total	52	100.0

Mean±SD: 35.50±3.08

Table 3: Distribution of number of cases in Preterm neonates

Cranial USG findings in Preterm	Number of cases	%
Flaring / PVHE	12	36.4
ICH	10	30.3
PVL	6	18.2
Cerebral oedema	4	12.1
Cyst	1	3.0
Total	33	100.0

Table 4: Distribution of number of cases in Term neonates

Cranial USG findings in Term	Number of cases	%
Normal	15	78.9
Cyst	3	15.8
ICH	1	5.3
Total	19	100.0

Table 5: Birth weight of neonates studied

Birth weight (grams)	Number of cases	%
<2000	14	26.9
2001-2500	22	42.3
2501 & above	16	30.8
Total	52	100.0

Mean ± SD: 2251.73±395.39

Table 6: Cranial USG findings in neonates less than 2000 gram

Cranial USG findings	Number of cases	%
PVL	6	42.9
ICH type I	6	42.9
ICH type II	1	7.1
Cerebral oedema	1	7.1
Total	14	100.0

Table 7: Cranial USG findings in neonates between 2001-2500 gram

Cranial USG findings	Number of cases	%
Flaring/PVHE	12	54.6
ICH type I	4	18.2
Cerebral oedema	3	13.6
Cyst	2	9.1
Normal	1	4.5
Total	22	100.0

Table 8: Cranial USG findings in neonates, 2501 gram and above

Cranial USG findings	Number of cases	%
Normal	14	87.5
Cyst	2	12.5
Total	16	100.0

Table 9: Cranial USG findings done between 3 to 5 days

Cranial USG findings	Number of cases	%
Normal	15	28.9
Flaring/PVHE	18	34.6
ICH type I	10	19.2
ICH type II	1	1.9
Cyst	4	7.7
Cerebral oedema	4	7.7
Total	52	100.0

Table 10: Cranial USG findings done between 10 to 14 days

Cranial USG findings	Number of cases (n=52)	%
Normal	28	53.9
Reducing	10	19.2
ICH type I	6	11.5
Cerebral Oedema	4	7.7
Same	14	26.9
ICH type I	3	5.8
ICH type II	1	1.9
PVHE/flaring	6	11.5
Cyst	4	7.7

Table 11: Cranial USG findings done between 26 to 30 days

Cranial USG findings	Number of cases (n=52)	%
Normal	38	73.1
PVL	6	11.5
Reducing	3	5.8
ICH type I	2	3.9
ICH type II	1	1.9
Same	5	9.6
ICH type I	1	1.9
Cyst	4	7.7

Figure 1: Flaring

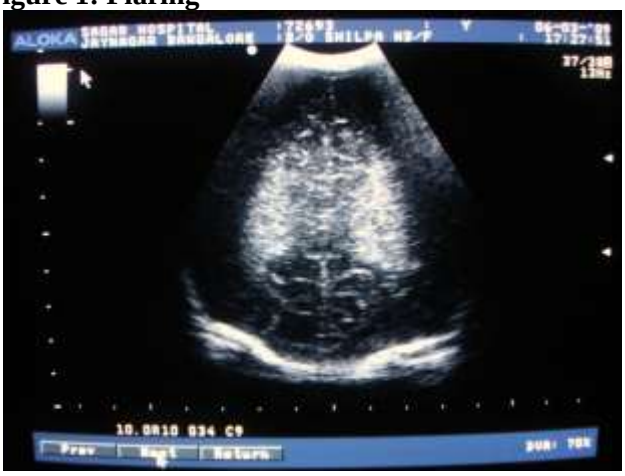


Figure 2: Periventricular leukomalacia and intracranial hemorrhage.

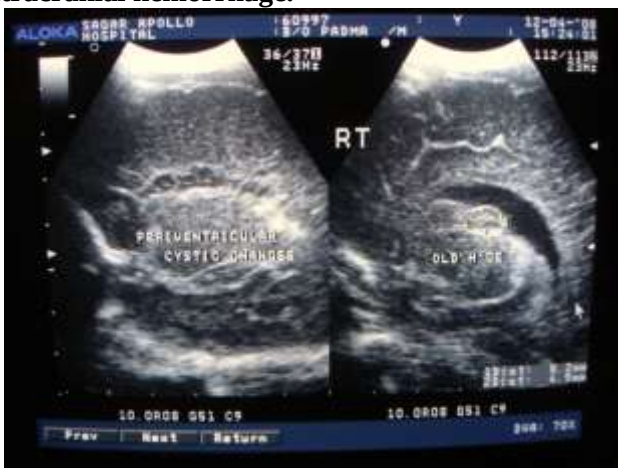
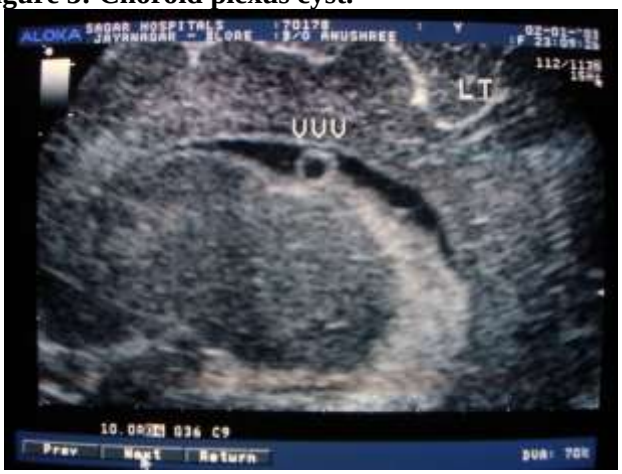


Figure 3: Choroid plexus cyst.



Discussion

Flaring

Cranial ultrasonography in neonates almost always reveals a hyperechogenicity just posterior and superior to the ventricular trigones on parasagittal views. The peritrigonal echogenic blush, appearing on parasagittal sonograms as a grouping of fine, linear densities almost like brush strokes is virtually always present on cranial sonograms of premature babies.

Few study discussion are summarised below

	Total number of Cases Studied	Number of Cases Showing Flaring	Gestational Age (wk)	Birth Weight (gm)
Present Study	52 Preterm and Term Neonates	12	<37	2001 to 2500
Edward G. Grant et al [4]	180 Preterm Neonates	All most all babies	<33	<1750
Michael A. DiPietro et al [5]	203 Neonates	154	<32	-

The best explanation for the fine, hyperechoic peritrigonal blush is a consequence of the orientation of normal fiber tracts and their accompanying vasculature in the brain. The regular, almost parallel fibers would provide multiple interfaces to a perpendicular sonographic beam, especially within the gelatinous, less echogenic, watery neonatal brain. Because almost all cranial sonograms are obtained through the window provided by the anterior fontanelle, fibers in the area

superior and posterior to the trigone would be perpendicular to the interrogating sonographic beam.

Intracranial Hemorrhage

Intracranial hemorrhage originates in the germinal matrix, a structure located beneath the ependymal lining of the ventricles and largest in the groove between the head of the caudate nucleus and the thalamus. It is a highly vascular structure with little supporting tissue. It is a source of neuroblasts which migrate peripherally during development of the fetal brain. The germinal matrix is largest at 24-32 weeks gestation and then involutes so that it is much smaller in full term infants than premature.

Few study discussion are summarised below

	Total number of cases studied	**Number of cases showing ICH**	**Gestational Age (wk)**		**Birth Weight (gm)**	
			Preterm (<37)	**Term (≥37)**	**<2000**	**2001 to 2500**
Present Study	52 Preterm and Term Neonates	11	10	1	7	4
Susan C. Carson et al [6]	35 Preterm Neonates	20	20	-	-	-
Jerome Burstein et al [7]	100 Preterm Neonates	44	44	-	44	-
Eric E. Sauerbrei et al [8]	100 Preterm Neonates	26	26	-	26	

Periventricular Leukomalacia

PVL is the second most frequent lesion of the infant brain, following hemorrhage into the germinal matrix or ventricle. PVL is now considered the principal form of brain injury among preterm infants. PVL among very low birth weight infants is the major reason for their increased risk of developing a variety of neurologic sequelae; including motor dysfunction; delayed cognitive development; visual impairment; and epilepsy.

Few study discussion are summarised below

	Total number of Cases Studied	**Number of Cases Showing PVL**	**Gestational Age (wk)**	**Birth Weight (gm)**
Present Study	52 Preterm and Term Neonates	6	<37	<2000
Richard A. Bowerman et al [9]	Routinely scanned all Preterm and Selected Term Neonates	8	28-36	1100-2600
Sumio Fukuda et al [10]	67 Preterm Neonates	8	25-34	608-1956
Peter P. Chow et al [11]	Preterm and Term Neonates indicated with abnormal neurologic examination or persistent seizure activity	6	28-38	1025-3500

Cysts

In similar study by Michael R. Clair et al [12] serial neurosonography was performed in 210 consecutive high risk, preterm neonates. The term high risk was applied to newborn infants assessed by a neonatologist to be less than 35 weeks estimated gestational age (EGA) or weighing less than 2000 g. 11 (5.8%) demonstrated small cystic formations in the subependymal lining of the lateral ventricles. 82% being 28-32 weeks EGA at birth. Birth weights were 940-1750 g. 44% of the cysts were seen on the initial neurosonogram, which was obtained within the first 3 days after birth. These subependymal cysts were unilateral and were detected at the exact site of a previous subependymal hemorrhage.

Cerebral Oedema

Diffuse hypoxic-ischemic brain injury in the neonate results in neonatal hypoxic-ischemic encephalopathy (HIE). Perinatal asphyxia is the most important cause of HIE, resulting in hypoxemia and hypercapnia. Hypotension and the resulting decreased cerebral blood flow lead to a cascade of deleterious events, including acidosis, release of inflammatory mediators and excitatory neurotransmitters, free radical formation, calcium accumulation, and lipid peroxidation. These biochemical substances result in loss of vascular autoregulation in the setting of cerebral hypoperfusion with subsequent development of diffuse cerebral oedema [13].

Conclusion

Cranial Ultrasonography has been used clinically to diagnose diseases and to evaluate the results of therapy. Conclusions drawn from Neonatal Cranial Ultrasonography are as follows:

❖ Ultrasound scanning is a technique that capitalizes on the bone free anterior fontanelle to provide a kind of window into the neonatal brain.

❖ Real time ultrasound is a cheap, convenient, non-invasive technique for imaging the newborn brain. Because of its accuracy, ease of performance, and safety, the use of real-time cranial ultrasonography of neonates has gained wide acceptance as a first line imaging investigation in the neonatal intensive care unit.

❖ Cranial Ultrasonography is the easiest and the most ideal investigation for diagnosing intracranial pathologies in preterm and term neonates, sensitive for the detection of intracranial hemorrhage, periventricular leukomalacia, and hydrocephalus.

Optimal use of cranial sonography will change as diagnostic equipment, treatment regimens, and the knowledge of neuropathologic processes progress. The current emphasis on standardization of examinations and interpretation will improve the accuracy of sonography for making diagnoses.

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