International Journal of Contemporary Pediatrics
Kavya MK et al. Int J Contemp Pediatr. 2017 May;4(3):804-809
http://www.ijpediatrics.com
pISSN 2349-3283 | eISSN 2349-3291

DOI: http://dx.doi.org/10.18203/2349-3291.ijcp20171524

Original Research Article

Cranial ultrasound in detection of neurological lesions in preterm neonates in a tertiary center in North Kerala, India

Kavya M. K.[1]*, Radhamani K. V.[2], Mahesh P.[3]

[1]Department of Radiodiagnosis, Academy of Medical Sciences, Pariyaram, Kannur, Kerala, India
[2]Department of Pediatrics, Academy of Medical Sciences, Pariyaram, Kannur, Kerala, India
[3]Department of Radiodiagnosis, Academy of Medical Sciences, Pariyaram, Kannur, Kerala, India

Received: 29 March 2017
Accepted: 03 April 2017

***Correspondence:**
Dr. Kavya M. K.,
E-mail: kavyamk@gmail.com

ABSTRACT

Background: Incomplete formation and maturation of the central nervous system makes it extremely vulnerable to injury, in the case of premature neonates. This can result in a broad range of neurodevelopmental abnormalities. Cranial ultrasound is a sensitive tool for the early detection of these. Hence the present study was undertaken to assess the prevalence of neurosonological abnormality in preterm infants. The aims of the study were to identify and enumerate the neurosonographic features, to assess the severity of brain injuries by grading the neurosonographic findings and to correlate the clinical presentations with the neurosonographic findings.
Methods: The present study was conducted in Department of Radiodiagnosis, Pariyaram Medical College. It consisted of all preterm neonates (less than 37 weeks of gestational age) referred to the Radiology department. The initial scan will be done as soon as possible (within 2 weeks of birth) followed by a repeat scan of the same infants at 36 weeks of corrected age, and at 8weeks post-partum.
Results: A total of 100 neonates with gestational age varying from 29 to 37 weeks were studied, with the birth weight varying from 1.5 to 1.9 kg. The most common abnormality found on neurosonogram was germinal-matrix haemorrhage, followed by periventricular leukomalacia.
Conclusions: Real time sonography is a sensitive non-invasive initial investigation for the detection of various brain lesions in the preterm neonates.

Keywords: Cranial ultrasound, Germinal matrix haemorrhage, Neonates, Neurodevelopment, Preterm

INTRODUCTION

Annually, an estimated 15 million babies are born preterm (before 37 completed weeks of gestation), and this number is increasing. India ranks among the top ten countries with the greatest number of preterm births. Increased survival rate of premature newborns has resulted in increased number of neurologically impaired babies as well. Preterm is defined as babies born alive before 37 weeks of pregnancy are completed. There are three sub-categories of preterm birth, based on gestational age: extremely preterm (<28 weeks) very preterm (28 to <32 weeks) and moderate to late preterm (32 to <37 weeks).[1]

Neuromaturation is a dynamic process in which the central nervous system gets formed by a continuous interaction between the programmed genetic processes encoded in the genome and the intrauterine and the extrauterine environment. Incomplete formation of the nervous system makes neonates vulnerable to CNS injury, especially if the infant was born preterm. In preterm infants, white matter around the ventricles and highly vascular germinal matrix eminence are especially vulnerable to injury.[2] Ischemia, hypoxia, and

inflammation contribute to CNS injury in the preterm infant. The most common signs of CNS injury in preterm infants are intraventricular haemorrhage (IVH), intra parenchymal hemorrhage (IPH), and white matter insult (including periventricular leukomalacia [PVL]). Takashima et al and DeReuck have described the time sequence and location of different perinatal ischemic brain lesions.[3,4] Normally, there is a watershed zone between the ventriculopetal and ventriculofugal arteries. Below 34weeks of gestation, this watershed zone is located in the periventricular area. With increasing maturity, the sulci deepen and the long straight medullary arteries change from a gentle bend to more acute bend. The watershed zone, therefore, moves from the periventricular zone to a subcortical location. Ischemic lesions of hypoxia are the result of injury in this watershed zone, either periventricular or subcortical depending upon the gestational age. It is generally agreed that those below a dividing line of 34 weeks have an immature brain, and those above have a mature brain.

Injury to the CNS can occur anytime during pregnancy, labor, delivery, the transition to extra uterine life, or a subsequent illness or exposure. Despite the specific cause of injury, the common underlying physiologic processes that result in hypoxic injury remain diminished cerebral blood flow (ischemia) and reduced blood oxygenation (hypoxemia). The pattern of cerebral injury in a newborn depends mainly on the degree of maturity of the brain. Other interrelated factors are birth weight, severity and duration of the hypoxic/ischemic episodes, multiple gestation, respiratory distress, fluctuating cerebral blood flow and vitamin K deficiency.[5] Mortality has been observed to be indirectly related to the maturity.

Neuroimaging studies namely ultrasound, computerized tomography, and magnetic resonance imaging (MRI), now provide ways to visualize brain injury in infants. Recent advances in sonographic technology made ultrasound a very accurate and adequate method to detect cranial morphology and intracranial pathology in infants.[5] Current ultrasound technology allows for rapid evaluation of infants in intensive care nursery with no risk of radiation. The advantages of sonography over computed tomography (CT)/magnetic resonance imaging (MRI) include portability, lower cost, speed, no risk of ionizing radiation, and no need for sedation and the wide availability. Screening of premature infants for intracranial hemorrhage has been proven to be highly sensitive and specific. Ultrasound is essential (is the key investigation modality) to the neonatal evaluation and follow up of hydrocephalus and periventricular leukomalacia (PVL).[6]

Many studies showed that a normal ultrasound scan provides considerable confidence that an infant will have normal neurodevelopment.[7] The best predictor for outcome was a simple cranial ultrasound classification according to the presence or absence of ventriculomegaly and intraparenchymal damage of any cause. Infants with a normal neonatal cerebral scan without ventriculomegaly almost had a normal neurological outcome. In infants with cerebral lesions with ventriculomegaly, the incidence of normal neurological outcome decreased to less than 50%. Intraparenchymal damage was associated with cerebral palsy as well as other (mental and sensory) handicaps in over 85% of the cases.[8]

So, the purpose of our study was to detect neuro-sonological abnormalities which may be of paramount importance in the early identification and intervention to mitigate neuro-developmental impairments. This information may then be utilized in counselling families about the prognosis and management.

METHODS

This observational study was done in the Department of Radio diagnosis, Academy of Medical Sciences, Pariyaram, Kannur, Kerala. This study comprised of 100 preterm neonates, who were referred to Department for cranial ultrasonography from 01/01/2014 to 31/03/2014. All preterm neonates (less than 37 weeks of gestation) were included for the study. Babies with gross congenital malformation were excluded**.**

The studies were obtained by using GE VOLUSON 730 ultrasound machine, probes of 2-15 MHz frequencies (convex and linear probes) were used. The findings of two experienced radiologists were taken into consideration to reach the final impression. With baby in supine position, scanning done through the anterior fontanelle using standard coronal and sagital sweeps. Additional views such as posterior fontanelle and mastoid view were used when required.

A structured questionnaire was used for recording all the information after taking written consent from the mother/ caretaker. The initial scan was done as soon as possible (within 2 weeks of birth) followed by a repeat scan at 36 weeks of corrected age and at 8weeks post-partum. The following obstetric and neonatal characteristics were collected: mode of delivery (vaginal delivery, vacuum extraction, elective or emergency caesarean section), gender, gestational age, birth weight, significant maternal history, history of antenatal steroid intake, significant natal or post-natal history including respiratory distress, seizures, jaundice, hypoglycemia, hypotension, sepsis etc.

The ultrasound report included the description of ventricular system, midline structures, parenchymal echogenicity, focal lesions. Ventricular dilatation was estimated according to the measurement of anterior horn width and of the thalamo-occipital distance.[9,10] The parenchymal echogenicity in the periventricular areas was defined as periventricular hyperechogenicity (PHE) when isoechogenic/hyperechogenic to the choroid plexus.

Findings were classified as: (1) normal; (2) mild abnormalities: asymmetric lateral ventricles, mild

dilatation of the occipital horns (thalamo-occipital distance <95 percentiles), cysts of the choroid plexus, frontal, temporal and caudothalamic pseudocysts, lenticulostriate vasculopathy; (3) PHE; (4) severe abnormalities: GHM-IVH, defined according to the Papile's criteria, cPVL, venous/arterial stroke and malformations.[11]

RESULTS

Out of 100 preterm neonates 58% were male, majority of babies were born to primigravida women (59%). 45% of babies in our study were born through vaginal route, 11% via outlet forceps, 21% by assisted breech technique and LSCS was done in 23%. Significant maternal history was found in 16 infants, with maternal diabetes being the most common one. However, no neurological abnormality was found. 4 infants were born to mothers who suffered from PIH. Among them 1 developed PVL while 3 others were normal. Study group comprise of babies born between the gestational age of 29 to 37 wks of which 60% were less than 34weeks. Birth weight was ranging from 1.4 to 2.7 kg of which most babies were between 1.5-2.5 kg (45%). Most of the infants (72%) were asymptomatic. The commonest clinical manifestation in symptomatic preterm babies was seizures followed by hypoglycemia. Initial neurosonogram performed within 14 days of birth showed abnormal findings in 18 babies. One baby showed abnormal study (PVL0 in follow-up examination (total 19%). Among them 14 had intra-ventricular / sub-ependymal haemorrhage in the initial study, 3 had PVL and 1 had cerebellar haemorrhage.

The findings from the data analysis are documented below:

Table 1: Characteristics of the study population.

Variables	Description of variables	Number of subjects and %
Sex	Male	58
	Female	42
Age	34 week 1 day to 36 weeks 6 days	40
	30 week 1 day to 34 weeks	32
	Less than 30 weeks	28
Weight in kg	>2.5kg	30
	1.5 to 2.5 kg	45
	<1.5 kg	25
Gravida wise distribution	Primigravida	59
	Multigravida	41
Significant maternal history	Diabetes Mellitus	5
	Hypertension	4
	Antepartum Hemorrhage	3
	Infection	4
Mode of delivery	Vaginal	45
	Outlet forceps	11
	Assisted Breech	21
	LSCS	23
Antenatal steroid administration	Received	45
	Not received	55
Distribution of cases according to significant natal and post natalhostory	Routine screening	72
	Respiratory distress	4
	Seizures	10
	Jaundice	2
	Hypoglycaemia	5
	Hypocalcemia	1
	Hypotension	3
	Sepsis	3

DISCUSSION

Neurosonography is now being routinely performed in premature infants in many centers. This has produced a wealth of information about the central nervous system, abnormalities like GMH, PVL and ventriculomegaly, including the timing and evolution of these lesions and their eventual correlation with neurological outcome. Our study comprised of 100 preterm neonates who were sent for routine cranial ultrasound. The study group had male predominance (58%), majority of babies were born to primi women (59%). Among the 58 male babies, 29

babies (50%) had abnormal neurological findings. Among the 42 female babies 23 (54%) had abnormal neurological findings. Male gender was reported as an independent risk factor for intra-ventricular hemorrhage by the studies conducted by Tioseco et al and it was found to be related to poor neurological outcome.[12] However, studies conducted by Locatelli et al suggests otherwise which correlates with the present study.[13]

Table 2: Distribution of abnormal neurosonological findings.

Findings	Number	Percentage
Normal	81	81 %
Gmh/ivh	14	14 %
Pvl	4	4 %
Cerebellar hemorrhage	1	1 %
Total	100	100 %

Table 3: Changes in incidence of ultrasound findings in the first and follow up studies.

Lesions	Initial USG results	Follow up scan results at 6th and 36th weeks of corrected age			
		New lesion	Death	Complete resolution	Persistance/sequelae
Normal	82	1	0	1	0
GMH grade I	10	6	0	10	0
GMH grade2	2	0	0	2	0
GMH grade3	1	0	1	0	1
GMH grade4	1	0	1	0	1
Cerebellar Hemorrhage	1	0	0	1	0
PVL	3	1	0	1	3

GMH- germinal matrix haemorrhage; PVL- Periventricular leukomalacia

45% of babies in our study were born through vaginal route, 11% of the infants were born via outlet forceps, 21% by assisted breech technique and LSCS was done in 23%.

Significant maternal history was found in 16 infants, with maternal diabetes being the most common one. However, no neurological abnormality was found in babies born to diabetic mothers in our study. 4 infants were born to mothers who suffered from PIH. Among them 1 developed PVL while 3 others were normal.

Study group comprised of babies born between the gestational age of 29 to 37 wks of which majority were less than 34 weeks of gestation comprising of 60% of the study population. So, very preterm and moderate to late preterm were included in the group. Birth weight was ranging from 1.4 to 2.7 kg of which most babies were between 1.5-2.5 kg (45%).

Initial sonogram was performed within 14 days of birth followed by two repeat scan at 36 weeks of corrected age and 8weeks post-partum. Initial study showed abnormal neurosonogram findings in 18 babies and rest of the 42 babies showed normal neurosonogram study. The most common abnormality found on neurosonogram was germinal-matrix haemorrhage. This result correlated with study done on preterm babies by Paneth N et al.[14] Germinal matrix haemorrhage was graded into I, II, III and IV. Grading was done according to Papile's classification. Grade I GMH was found in 10% babies, grade II was found in 2%, grade III in 2% and grade IV in 1% babies. This study is compared to previous studies as shown (Table 4).[15-17]

Table 4: Grading of germinal matrix haemorrhage.

Grade of GMH	Ramenghi la (%)	NilgunKosal (%)	Kadri (%)	Present study (%)
I	57.9	50	52.4	70
II	19.3	17	30.9	14
III	24.5	11	11.9	8
IV	4.8	22	4.76	8

Our study showed periventricular leukomalacia in 4 % babies on whom neurosonogram was done. This finding was in common with study done by Rezaie P et al.[18] One baby had cerebellar haemorrhage in initial scan which underwent complete resolution in the follow up scans. On follow-up death had occurred in 2 of them having GMH grade IV and grade III (one each). Studies done by Skullerud and Westre had also found mortality rate of 9.5% with grade I and II and mortality rate of 49% with grade III and IV GMH. Among the 10 cases of grade I GMH, all had resolved at the end of 8 weeks. All of the grade II hemorrhages resolved in subsequent studies.

Both babies with grade III and IV GMH expired during follow-up. The 3 of the 4 cases of PVL persisted in the subsequent studies and developed cystic changes.

In our study 60 babies were less than 34 weeks and 40 babies were more than 34 weeks' gestational age. Out of 60 babies born less than 34 weeks, 16 showed abnormal neurosonogram findings i.e. 26.66%. In study done by Perry RN et al. which showed 37%. Out of 40 babies >34 wks gestational age 3 babies showed abnormalities (i.e. 7.5%) which co-relates with the study done by Amato M, Howald H Von Muralt.[19]

Abnormal neurosonogram findings in babies who have not received steroids were about 63.6%. It co-relates with studies done by Singh Uma et al (76%).The protective mechanism of it may be due to an increase in neonatal blood pressure which prevents blood pressure fluctuations or may result from enhanced maturation of the cardiopulmonary system and germinal matrix of the premature infant. In our study only full dose of corticosteroid therapy was considered positive for antenatal steroid therapy.

All cases of germinal matrix hemorrhage were discovered in the initial study. In a study done by Tsiantos A et al. found that 60% of the hemorrhages took place between 15 to 48 hours of age with mean age of 38 hours.[20] In another study done by Carol M Rumack MD et al found that 64% of the hemorrhage took place within 24 hours.[21] A study done by Leven MI et al states that most hemorrhages occurred during first two days of life. Whereas Tzipora Dolfin et al study shows 25% haemorrhage were diagnosed on first scan within first 6 hours.

CONCLUSION

Ultrasound is an optimal imaging and cost effective modality for the screening of neurological abnormality in premature infants. Early identification of these abnormalities will help in therapeutic intervention and subsequent long term follow up.

ACKNOWLEDGEMENTS

Author would like to thank Dr. K. Sudhakaran, Professor of Pediatrics, ACME, Pariyaram Staff members, Departments of Radiodiagnosis and Pediatrics, ACME, Pariyaram.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

REFERENCES

1. Blencowe H, Cousens S, Oestergaard M, Chou D, Moller AB, Narwal R et al. National, regional and worldwide estimates of preterm birth. Lancet. 2012;379(9832):2162-72.
2. Behrman RE, Butler AS, Preterm Birth: Causes, Consequences, and Prevention, Institute of Medicine (US) Committee on Understanding Premature Birth and Assuring Healthy Outcomes; Washington (DC): National Academies Press (US); 2007.
3. Takashima S, Armstong DL, Becker LE, Subcortical leukomalacia. Arch Neurol. 1978;35:470-2.
4. DeReuck JL. Cerebral angioarchitecture and perinatal brain lesions in premature and full term infants. Acta Neurol Scandt. 1984;70:391-395.
5. Harwood-Nash DC, Flodmark O, Diagnostic imaging of the neonatal brain: Review and protocol. AJNR. 1982;3:103-15.
6. Rumack CM, Drose JA. Neonatal and infant brain imaging. In: Diagnostic ultrasound.4th edn. Philadelphia, Elsevier, Mosby; 2011.
7. Nongena P, Ederies A, Azzopardi DV. Confidence in the prediction of neurodevelopmental outcome by cranial ultrasound and MRI in preterm infants.Arch Dis Child Fetal Neonatal Ed. 2010;95:388-90.
8. Weisglas-Kupereus N, Baerts W, Fetter WPE. Neonatal cerebral ultrasound, neonatal neurology and perinatal conditions as predictors of neurodevelopmental outcome in very low birth weight infants. Early Human Dev. 1992; 31:131-48.
9. Liao MF, Chaou WT, Tsao LY, Nishida H, Sakanoue M. Ultrasound measurement of the ventricular size in newborn infants. Brain Dev. 1986;8(3):262-8.
10. Sondhi V, Gupta G, Gupta PK, Patnaik SK, Tshering K. Establishment of nomograms and reference ranges for intra-cranial ventricular dimensions and ventriculo-hemispheric ratio in newborns by ultrasonography. Acta Paediatr. 2008;97(6).
11. Papile LA, Burstein J, Burstein R, Koffler H. Incidence and evolution of subependymal and intraventricular hemorrhage: a study of infants with birth weights less than 1.500 g. J Pediatr. 1978;92(4):529-34.
12. Tioseco JA, Aly H, Essers J. Male sex and intraventricular hemorrhage. Pediatr Crit Care Med. 2006;7(1):40-4.
13. Locatelli A, Andreani M, Pizzardi A. Antenatal variables associated with severe adverse neurodevelopmental outcome among neonates born at less than 32 weeks. Eur J Obstet Gynecol Reprod Biol. 2010;152(2):143-7.
14. Paneth N, Rudelli R, Kazam E, Monte W. Brain damage in the preterm infant clinics in developmental medicine, UK, Mac Keith Press. 1994;131.
15. Ramenghi LA. Germinal matrix hemorrhage :Intravenricularhemorrhage in very low birth weight. Infant Stroke journal. 2011;42(7):1889-93.

16. Koksal N, Bayton B, Bayram Y, Nacorkucuk E. Risk factors for intraventricularhemorrhage in very low birth weight infants. Indian J Pediatr. 2002;69:561-4.
17. Kadri H, Mawla AA, Kazah J. The incidence, timing, and predisposing factors of germinal matrix and intraventricularhemorrhage (GMH/IVH) in preterm neonates. Child nervous system Ch NS Official J Int Soc Pediatr Neurosurg. 2006;22(9):1086-90.
18. Rezaie P and Dean A. Periventricular leukomalacia, inflammation and white matter lesions within the developing nervous system. Neuropathology: Official J Japanese Soc Neuropathol. 2006;22(3):106-32.
19. Amato M, Howald H, von Muralt G. Incidence of peri- intraventricular haemorrhage in premature neonates weighing more than 1500 g. J Perinat Med. 1987;15(1):91-4.
20. Tsiantos A, Victorin L. Intracranial haemorrhage in the prematurely born infant. J Pediatr. 1974;85:854-9.
21. Vohr B, Allan WC, Scott DT. Early-onset intraventricularhemorrhage in preterm neonates: Incidence of neurodevelopmental handicap. Semin Perinatol. 1999;23:212-7.

Cite this article as: Kavya MK, Radhamani KV, Mahesh P. Cranial ultrasound in detection of neurological lesions in preterm neonates in a tertiary center in North Kerala, India. Int J Contemp Pediatr 2017;4:804-9.