Original Articles

NEUROSONOGRAPHIC ABNORMALITIES IN NEONATES WITH HYPOXIC ISCHEMIC ENCEPHALOPATHY

N.K. Anand
A.K. Gupta
I.M.S. Lamba

ABSTRACT

Pattern of neurosonographic (NSG) abnormalities in 150 term newborn infants with hypoxic ischemic encephalopathy (HIE) was studied. Monographic abnormalities, presumably indicating cerebral edema and or ischemia, were observed in 86% (n=129) cases. Obliteration of the ventricles occurred as the sole abnormality in 30 (20%) cases. Eighty (53%) patients had diffusely increased echogenicity of the brain parenchyma (DPE) in addition to the compression of the ventricles, sulci and the interhemispheric fissure. Focal parenchymal echodense (FPE) lesions occurred in nine (6%) neonates with HIE. Ten (6.6%) patients, however, had increased periventricular echogenicity (PVE). Two patients, one with focal parenchymal lesions and the other with PVE had obliterated ventricles in addition. Regarding temporal sequence earliest NSG abnormalities were DPE or slit like ventricles that were observed on day-1 itself. Focal or periventricular echogenic lesions, however, made their first appearance on day-3 of life. Twenty one patients had normal scans. Fifty patients with abnormal scans died. None of the infants with normal scans, however, died (p<0.001). At 4 weeks of age, scans performed in 100 survivors revealed no abnormality in 51 cases. Others showed development of cerebral atrophy (n=21), multicystic encephalomalacia (n=2), porencephalic cyst (n=l), or persistence of PVE without cystic changes (n=4). The results of this study highlight the diagnostic efficacy of neurosonography in cases of HIE. We suggest that it should be incorporated in the routine evaluation of patients with hypoxic brain injury.

Key words: *Neurosonography, Hypoxic ischemic encephalopathy.*

Hypoxic ischemic encephalopathy (HIE) is well recognized as an important cause of brain damage in newborn infants(l,2). Although HIE is associated with a high mortality and morbidity(l-3), neurological sequelae do not subsequently develop in all neonates with this condition. Recently, attempts have been made to diagnose HIE and to determine the prognosis of such patients by use of CT(4,5), MRI(6), and radionuclide studies(7). In addition, some of the studies(8-ll) have highlighted the diagnostic efficacy of neurosonography in cases of HIE. However, the number of cases studied previously have been very small. To evaluate the role of neurosonography, we studied its capability to detect parenchymal lesions in the early neonatal period among neonates with HIE.

From the Department of Pediatrics, Safdarjang Hospital, New Delhi and Institute for Research in Medical Statistics (ICMR), New Delhi 110 029.

Reprint requests: Dr. N.K. Anand, Consultant and Head, Department of Pediatrics, Safdarjang Hospital, New Delhi 110 029.

Received for publication: August 11, 1992; Accepted: March 3, 1994

Material and Methods

This study was conducted in the Neonatal Intensive Care Unit (NICU) of Safdarjang Hospital between July, 1991 and October, 1991. Of the total 4,098 live births, 3,776 neonates were classified as term while 322 as preterm babies. Of the term neonates, 180 babies had Apgar scores <6 at 5 min of birth while similar figures for preterm babies were 32. Patients were included based on following criteria: gestational age 38 weeks or above as determined by Ballard's Scoring(12); an Apgar score of 6 or less at 5 minutes; and abnormal neurological findings during first 48 hours of life including altered muscle tone, altered sensorium and seizures. Preterm neonates (n=322) and neonates with congenital anomalies of the central nervous system (n=10) were excluded. Twenty term neonates who fulfilled all above criteria; however, could not be studied as they died before inclusion to the study. Sarnat and Sarnat classification was used for grading of HIE(13). Finally, one hundred and fifty term neonates ($mean_s$ gestational age=38.80±1.88 weeks) with HIE were included.

Ultrasound scans were obtained daily on each patient during the first week of life using **a** commercially available (Mark SIM 5000) portable real time sector scanner with 7.5 MHz internally focussed transducer. No sedation was used. All the scans were performed by one of the authors (AKG) who was unaware of the Apgar scores and the neurological status of the patients. All the scans were performed at bed side. Scans were obtained in coronal, sagittal and parasagittal planes using anterior fontanelle as the window.

The ultrasound scans were evaluated with special attention to the size of ventricles and the extent of parenchymal abnormalities. The ventricles were classified as non-visualized, slit-like, normal sized, mildly enlarged (4-7 mm), moderately enlarged (8-12 mm) and severely enlarged (>12 mm)(14). The cerebral echopattern was characterized as normal or with increased parenchymal echogenicity (focal or diffuse). A homogenous striated triangle posterior to the atrial region, less echogenic than the choroid plexus and no bigger than the size of the atrial region, was considered to be the normal post trigonal blush. Periventricular echogenicity was also looked for in the posterior coronal plane. PVE was considered increased when it was equal or more in brightness to the choroid plexus or when it extended into the brain for at least twice the diameter of the ventricles. The presence of extra-axial fluid collection or intracranial hemorrhages were also evaluated. Fifty normal newborn infants of comparable gestational ages (Mean ± SD = 38.26 ± 1:66 weeks) were also examined to study the pattern of parenchymal echotexture in normal neonates. Finally, late scans were performed at 4 weeks of postconceptional age in all the survivors to study the evolution of sonographic abnormalities.

Results

NSG findings in 150 newborn infants with HIE are shown in *Table I.* Twenty one (14%) patients had normal scans. Several patterns of abnormalities were present in the other infants. Obliteration of the ventricles occurred as the sole abnormality in thirty (20%) cases. Eighty (53%) patients had a diffusely increased echogenicity of the cerebral parenchyma in addition to the compression of the ventricles, sulci, and the interhemispheric-fissure *(Figs. 1 &* 2). Focal areas of parenchymal echodense lesions occurred in nine (6%) patients *(Fig 3).* Ten

TABLE I - *Neurosonographic Findings Versus Immediate Outcome*

Sonographic findings	No. of cases (n=150)		Died (n=50)	
	n	(%)	n	(%)
Normal	21	(14.0)	0	(0,0)
Slit like ventricles alone	30	(20.0)	2	(6.7)
Diffuse parenchymal echoes	80	(53.3)	39	(48.7)
Focal parenchymal ED lesions*	9	(6,0)	7	(0.0)
Periventricular echoes*	10	(6.7)	2	(20.0)

* One patient each had compression of ventricles in addition.

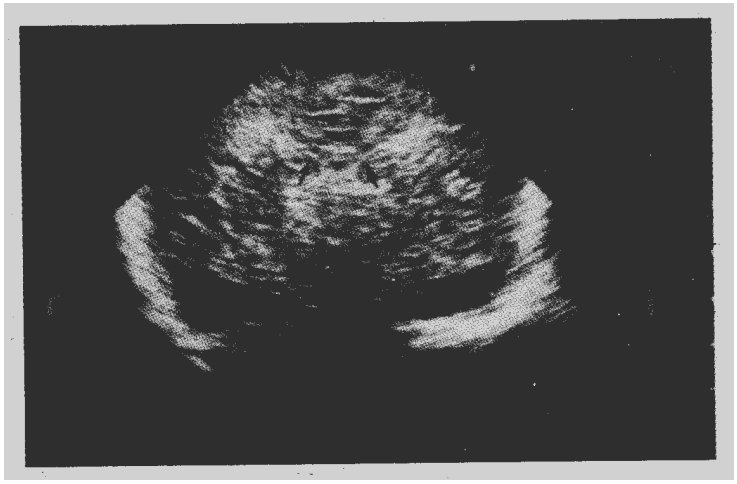

Fig. 1. 7.5 *mHZ coronal scan from a term infant with Stage III HIE (day* 3) *showing diffuse parenchymal hyperechogenicity with compression of sulci, interhemispheric fissure and lateral ventricles (black arrows). CP-choroid plexus; R-right; L-left.*

(6.6%) infants had increased PVE *(Fig. 4).* Two patients, one with FPE and the other with PVE had obliterated ventricles in addition.

As regards temporal sequence of sonographic abnormalities *(Table Il),* the earliest. to observe was compressed ventricles alone or in association with diffusely increased parenchymal echogenicity. Focal and periventricular areas of increased echogenicity were first noted on day 3 of life.

Pattern and severity of NSG findings was directly related to the severity of the hypoxic injury. While in Stage II HIE, 39 (65%) cases had abnormal scans with predominant abnormality being compressed

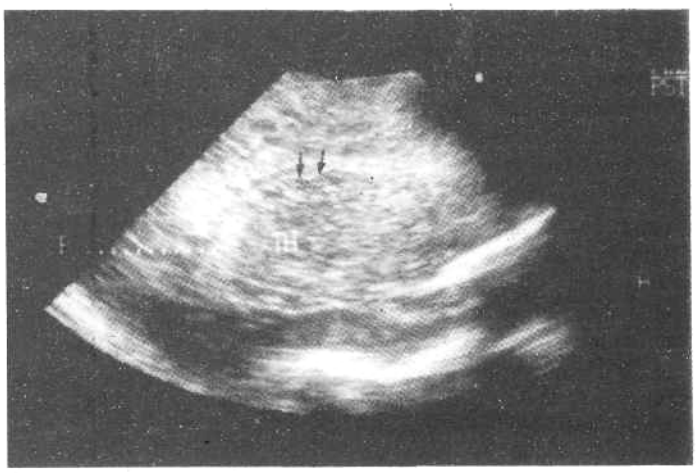

Fig. 2. 7.5 mHZ. parasagittal scan from the same patient showing slit like lateral ventricle (black arrow) and diffuse parenchymal hyperechogenicity. A—anterior; P--posterior.

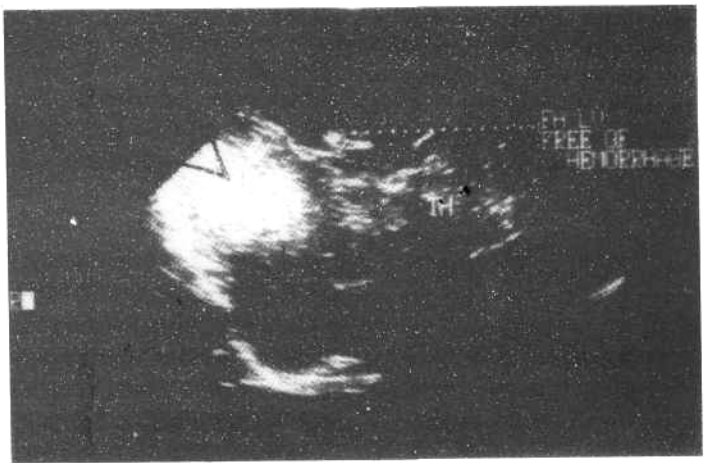

Fig. 3. 7.5 mHZ. coronal scan from a term neonate with Stage II HIE (day 4) showing an echodense focal parenchymal lesion (black arrow) in the distribution of right middle cerebral artery. R—right; L—left.

ventricles alone, all patients in Stage III HIE had cranial sonographic abnormalities with largely parenchymal/periventricular lesions *(Table III)*.

In contrast to the cases, none of the fifty control infants had increased parenchymal or periventricular echogenicity. Ventricles, however, were slit-like in 40% of the control newborn infants also,

On follow-up, 50 (44.6%) patients with abnormal scans died within one week of birth (range 1-7 days). None of the patients

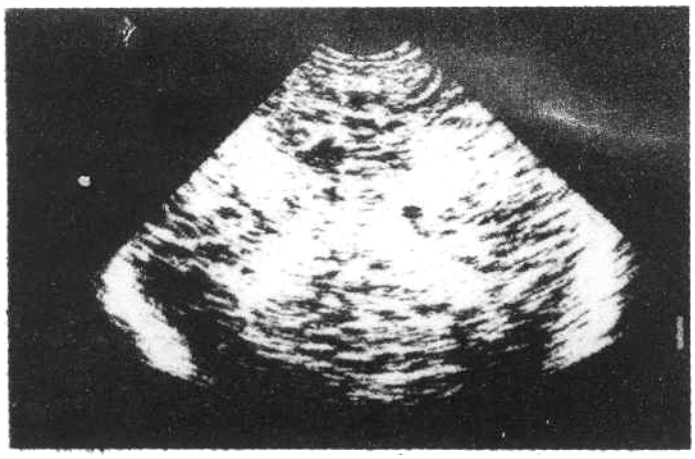

Fig. 4. 7.5 *MHz posterior coronal view from a patient with Stage III HIE showing increased periventricular echogenicity (arrows).*

TABLE *II-Temporal Sequence of Neurosonographic Abnormalities*

Day of life	No. of babies	No. dead	Frequency of lesions			
			Slit like vent	DPE	FPE	PVE
1	150	12	30	80	-	-
2	138	18	30	68	-	-
3	120	7	28	52	3	3
4	113	4	28	45	7	9
5	109	7	28	41	9	10
6	102	1	28	41	3	9
7	101	1	28	41	3	8
8	100	0	28	41	2	8

DPE=Diffuse parenchymal echoes; FPE=Focal parenchymal echoes;
PVE=Periventricular increased echoes.

with Donna! scans, however, died during the same interval or during the subsequent follow-up (χ^2=10.5; p<O.OOI).

At 4 weeks of age sonograms were repeated in 100 survivors. No abnormality was detected in 51 cases while others

TABLE III- *Pattern of Neurosonographic Findings Versus Stage of HIE*

Neurosonographic findings	Stage of hypoxic ischemic encephalopathy			
	IT (n=60)		ill (n=90)	
	n	(%)	n	(%)
Normal scan	21	(35.0)	0	(0.0)
Slit like ventricles alone	30	(50.0)	0	(0.0)
Diffuse parenchymal ecIiogenicity	7	(11.7)	73	(81.0)
Focal parenchymal echogenicity	1	(1.7)	8	(8.8)
Peri ventricular echogenicity	1	(1.7)	9	(10.0)

TABLE IV- *Evolution Sonographic Findings (n=l00)*

Early abnormalities (<7 days of age)	Late abnormalities (4 weeks of age)
Slit like ventricles (n=28)	No abnormalities (11=28)
Diffuse parenchymal echogenicity (n=4l)	Cerebral atrophy (n=21)
	Multicystic encephalomalacia (n=2)
	No abnormality (n=18)
Focal parenchymal echogenicity (n=2)	Porencephalic cyst (n=l)
	No abnormality (n=l)
Periventricular echogenicity (n=4)	Persistent PVE (n=4)
	No abnormality (n=4)

demonstrated a definite evolution into late lesions *(Table IV):* These included cerebral atrophy (n=21), MCE (n=2), persistently increased PVE (n=4), or porencephalic cyst (n=l).

Discussion

Parenchymal lesions of HIE by sonography have been successfully demonstrated by various workers(8-10). The type of reported early neurosonographic abnormalities include findings suggestive of cerebral edema, hemorrhagic parenchymal infarction, and periventricular increased echogenicity. The results of the present study confirm the ability of neurosonography to identify wide variety of parenchymal abnormalities, which were detected in 86% of our patients. Neurosonographic abnormalities consisted of diffuse or focal parenchymal or periventricular increased echogenicity and presumably indicated cerebral edema, cortical or periventricular ischemia. As regards timing of events, earliest sonographic abnormalities to be observed were diffuse parenchymal echoes or slit like ventricles. Focal and periventricular echodense lesions made their first appearance on day 3 of life. Interestingly, pattern and severity of sonographic findings was directly related to the severity of the hypoxic injury. In relatively less severe degree of HIE, a third of the scans were regarded as normal. In striking contrast none of the patients with severe HIE (Stage III) had normal scans. While focal parenchymal or periventricular lesions characterized severe HIE, diffuse parenchymal echoes or slit like ventricles were the predominent neurosonographic abnormalities in Stage II HIE. Fifty patients with abnormal scans died within the first week of life in contrast to none with normal scans ($p<0.001$).

At 4 weeks of age, repeat cranial ultrasound studies in 100 survivors revealed per-

sistent abnormality in 49% patients. These abnormalities included cerebral atrophy (n=21), MCE (n=2), porencephalic cyst (n=l), and persistent PVE (n=4). Previous studies on HIE have demonstrated similar results and have shown considerable predictive value of such lesions in determining long term neurological outcome(8-10).

Cranial ultrasound studies are important in patients with HIE as cystic lesions, which have been very well correlated to poor neurological outcome by various studies, cannot be picked up by CT scanning. Further, magnetic resonance imaging can not detect effects of hypoxia on the immature neonatal brain until 8 months of postnatal age(6). Hence, cranial sonography appears to have a definite edge over both CT scanning and MR imaging. Unfortunately, there are not many studies correlating neurological outcome with neurosonographic abnormalities in patients suffering from HIE(8-10). But, the available data suggests that neurosonography has a good potential in predicting neurological outcome in neonates* with HIE(8-10). A neurosonographic examination may go a long way in predicting outcome of neonates with HIE and can be incorporated in the routine evaluation of this condition.

REFERENCES

1. Volpe JJ. Perinatal hypoxic brain injury. Pediatr Clin North Amer 1976, 23: 383-397.
2. Mac Donald HM, Mulligan JC, Allen AC, Taylor PM. Neonatal asphyxia. I. Relationship of obstetric and neonatal complications to neonatal mortality in 38,405 consecutive deliveries. J Pediatr 1980, 96: 898-902.
3. Finer NN, Robertson CM, Richards RT, Pinell LE, Peters KL. Hypoxic ischemic encephalopathy in term neonates: Perinatal factors and outcome. J Pediatr 1981, 98: 112-117.
4. Fitzhardinge PM, F16"dmark O, Fitz CR, Ashby S. The prognostic value of computed tomography as an adjunct to assessment of the term infant with postasphyxial encephalopathy. J Pediatr 1981, 99: 777-781.
5. Flodmark O, Becker LE, Harwood-Nash DC, Fitzhardinge PM, Fitz CR, Chung SH. Correlation between computed tomography and autopsy in premature and full term neonates that have suffered perinatal asphyxia. Radiology 1980, 137: 93-103.
6. Byrne P, Welch R, Johnson MA, Darrah J, Piper M. Serial magnetic resonance imaging in neonatal hypoxic ischemic encephalopathy. J Pediatr 1990, 117: 694-700.
7. O'Brien MJ, Ash JM, Gilday DL. Radionuclide brain scanning in perinatal hypoxia/ischemia. Dev Med Child Neurol 1979, 21* 1*61-173.
8. Siegel MJ, Shackelford GD, Perlman JM, Fulling KH. Hypoxic ischemic encephalopathy in term infants: Diagnosis and prognosis evaluated by ultrasound. Radiology 1984, 152: 394-400.
9. Babcock DS, Ball W Jr. Post asphyxial encephalopathy in full term infants: Ultra sound diagnosis. Radiology 1983, 148: 417-423.
10. Hill A, Martin DJ, Daneman A, Fitz CR. Focal ischemic cerebral injury in the newborn: Diagnosis by ultrasound and correlation with computed tomographic scans. Pediatrics 1983, 71: 790-793.
11. Rumack CM, Johnson ML. Role of computed tomography and ultrasound in neonatal brain imaging. J Comput Tomography 1983, 7: 17-29.
12. Ballard JL, Novak KK, Driver M. A simplified scoring system for assessment of fetal maturation of newly born infant. J. Pediatr 1979, 95: 769.

13. Sarnat HB, Sarnat MS. Neonatal encephalopathy following fetal distress. Arch Neurol 1976, 33: 696-705.

14. Tudehope DI, Masel J, Mohay H, O'Callaghan M, Burns Y, Rogers Y, Williams G. Neonatal cranial ultrasonography as predictor of two year outcome of very low birth weight infants. Aust Pediatr J 1989,25:66-71.