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Original Research Article

Neurosonogram in high-risk neonates delivered in a rural tertiary care hospital

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ABSTRACT

Background: A neurosonogram can detect both congenital and acquired brain lesions in neonates. Abnormal neurosonogram findings in high-risk neonates range from 3% to 47%. The aim was to study the neurosonogram findings in high-risk neonates and to associate them with maternal and neonatal risk factors.
Methods: Seventy-nine high-risk neonates delivered in this rural tertiary care hospital were included. Maternal demographic data along with neonatal examination findings at birth, neurosonogram, investigations, treatment given and short-term follow-up till discharge were entered in a pre-validated proforma. In cases with abnormal neurosonogram findings, a repeat neurosonogram was done between the 8th to 28th day of life, and the findings were recorded. Statistical analysis used: The Fischer exact test was used for parameters on a categorical scale. A $p \leq 0.05$ was considered statistically significant.
Results: The overall prevalence of abnormal neurosonogram findings was 11.4% with cysts, midline shifts, intraventricular haemorrhage, germinal matrix haemorrhage and hydrocephalus being the most common intracranial abnormalities detected. Factors associated with abnormal neurosonogram in high risk neonates were premature rupture of membranes, polyhydramnios, APGAR score less than seven at five and ten minutes, positive blood culture, low platelet count, low hematocrit, hypocalcaemia, low pH and high pCO_2. These high risk neonates with abnormal neurosonogram had a longer hospital stay of more than 10 days and a mortality of 11.1%.
Conclusions: Neurosonography is an effective screening modality for early detection of intracranial abnormalities in high-risk neonates. Morbidity and mortality were more in high risk neonates with abnormal neurosonogram.

Keywords: High risk neonates, Neurosonogram, Short term follow up

INTRODUCTION

Neurosonography, is a vital non-invasive screening tool used for detecting intracranial abnormalities in high-risk neonates.[1] A neurosonogram can detect congenital and acquired brain lesions such as intraventricular haemorrhage, cystic lesions, cerebral edema, periventricular echogenicity and germinal matrix haemorrhage.

Neurosonography offers advantages over imaging modalities such as CT and MRI as it allows bedside imaging without the need for transportation.

Prematurity, low birth weight, hypercarbia, and acidosis are known risk factors for germinal matrix hemorrhage and intraventricular hemorrhage. There is a 31% incidence of birth asphyxia in India, which may cause

hypoxic-ischemic encephalopathy and focal/multifocal ischemic brain necrosis in the term neonate.[2]

Abnormal neurosonogram findings in high-risk neonates range from three to forty-seven percent.[3,4] Incidence of periventricular echogenicity ranges from 2-15% in most infants.[5,6] The highest risk of IVH is within the first 48 hours of life.[7] Neonatal sepsis is known to be associated with multiple cystic degeneration in full-term neonate.[8]

Rationale

Neurosonography can be efficiently used in the screening of high-risk neonates to diagnose both congenital and acquired brain abnormalities in the early neonatal period itself and thereby facilitate prompt intervention and management of these neonates.

Objectives

Objectives were to study the neurosonogram profile in high-risk neonates as a modality for congenital and acquired intracranial lesions and to associate the neurosonogram findings with maternal risk factors, neonatal risk factors, and various etiological causes in high-risk neonates.

METHODS

Location of study

The study was conducted at Symbiosis university hospital and research centre, Lavale, Pune.

Type of study

It was an observational prospective study.

Study population

All high-risk neonates delivered and roomed in with their mother in PNC Wards as well as those admitted in NICU in this rural tertiary care hospital during the study period.

Duration of study

Study conducted from June-November-2023 (6 months).

Sample size

Seventy-nine neonates, calculated by using the sample size formula:$n=Z^2p\ (1-p)/m^2$

Where Z (90%) is the confidence interval, p is the incidence rate and m (5%) is the margin of error.

Inclusion criteria

All high-risk neonates both preterm and term with low birth weight, meconium-stained liquor, respiratory distress, perinatal asphyxia, hypoxic-ischemic encephalopathy, neonatal seizures, neonatal sepsis, hypoglycemia, and hypocalcemia delivered in this hospital were included in the study.

Exclusion criteria

Neonates who succumbed to death within 24 hours of admission and for whom parents did not give consent were excluded from the study.

After obtaining institutional ethics committee (IEC) approval, those neonates who fulfilled the inclusion criteria were included in the study after procuring informed consent from their parents, the demographic data, birth history, clinical history, gestational age, birth weight, clinical examination findings, and relevant investigations along with maternal demographic data, antenatal and obstetric history, ANC visits findings, investigations, treatment given were entered in the prevalidated proforma. A neurosonogram was performed on all neonates included in the study on the GE LOGIQ E-10 machine. The anterior fontanelle was taken as the starting point which acted as an acoustic window to facilitate viewing of anterior fossa structures, supratentorial structures, choroid plexus, corpus callosum, ventricular system, and posterior fontanelle facilitated to view the posterior fossa structures. Neurosonogram findings, treatment, and short-term follow-up till discharge from the hospital of the neonate were entered in the pre-validated proforma. If a neurosonogram was suggestive of abnormal findings, a repeat neurosonogram was advised at discharge or between the eighth to twenty-eighth day of life, and the findings of the repeat neurosonogram were also recorded. The data was entered in an excel sheet and statistical analysis was done.

Statistical analysis

Statistical analysis was performed using SPSS 29.0. The Fischer exact test was used to study the parameters on a categorical scale between two groups. A p=0.05 or less was considered statistically significant.

RESULTS

Fischer exact test was used to analyse the data.

Demographic data

Among the neonates with positive neurosonogram findings, the majority were males (88.9%). However, the other demographic factors such as gender, birth weight, gestational age and type of delivery showed no statistically significant association with abnormal neurosonogram (Table 1).

Maternal factors

Majority of the maternal factors were not associated with abnormal neurosonogram. however, premature rupture of

membranes (>18 hours) and polyhydramnios had significant associations with abnormal neurosonogram. (p=0.018) (Table 2).

Appearance, pulse, grimace, activity, respiration (APGAR) at birth

APGAR score less than seven at five (p=0.047) and ten minutes (p=0.029) had a significant association with abnormal neurosonogram, however, it was not associated with APGAR less than seven at one minute (Table 3).

Condition at birth

There was a significant association of abnormal neurosonogram findings with admission to neonatal intensive care unit (NICU) since the p value came out to be 0.032 which is statistically significant (<0.05). Poor activity (p=0.014) and poor sucking (p=0.05) during the hospital stay was associated with abnormal neurosonogram (Table 4).

Investigations

A positive blood culture had a significant association with abnormal neurosonogram (p=0.019); however, no correlation was noted with a high C reactive protein (CRP) value. Additionally, low platelet counts of <1.5 lakh/mm3 (p=0.005) and low packed cell volume (PCV) (p=0.025) had a significant association with abnormal neurosonogram findings. Hypocalcemia was associated significantly with abnormal neurosononngram (p=0.016) however hypoglycemia did not show any significant association. Arterial blood gas (ABG) analysis revealed that a low potential of hydrogen (pH) (p=0.016) and a high partial pressure of carbon dioxide (pco2) (p=0.033), had a significant association with abnormal neurosonogram findings (Table 5).

Treatment modalities

Continuous positive air pressure was needed by the majority of the neonates having an abnormal neurosonogram (p=0.05). However, no association was obtained with the other treatment modalities such as blood transfusion, mechanical ventilation, and phototherapy. A statistically significant association (p=0.025) was seen between abnormal neurosonogram and the requirement of orogastric tube feeding. An association was also seen between abnormal neurosonogram and therapy with drugs such as calcium gluconate (p=0.002), and anticonvulsants (p=0.044) to treat hypocalcemia and neonatal seizures respectively (Table 6).

Abnormal neurosonogram findings

The percentage of abnormal cranial ultrasonography findings in the present study was 11.4%. The various intracranial lesions noted were cysts, midline shift, intraventricular hemorrhage, hydrocephalus, grade- one germinal matrix hemorrhage, subdural hemorrhage, periventricular echogenicity, and cerebral edema. Cysts were the most consistent finding, followed by midline shift, intraventricular hemorrhage, hydrocephalus, and grade one germinal matrix hemorrhage and the least consistent findings were subdural hemorrhage, periventricular echogenicity, and cerebral edema (Table 7).

Discharge parameters

Fifty-five percent of the neonates having abnormal neurosonogram were discharged and thirty-three percent of neonates had to be referred for superspecialist care. One (11.1%) neonate with abnormal neurosonogram died due to septic shock, intraventricular hemorrhage, and severe anemia (Figure 1).

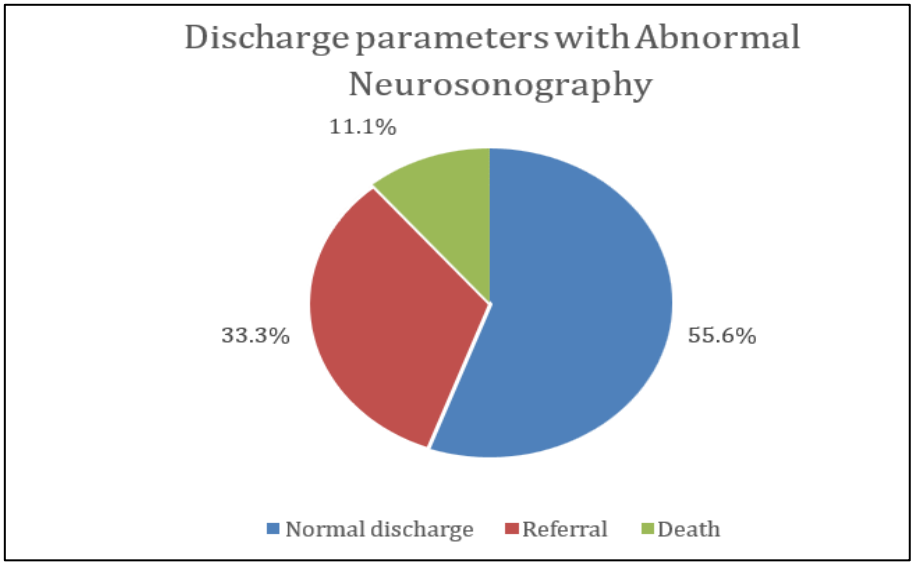

Figure 1: Discharge parameters.

Pie chart depicting percentage of neonates with a normal discharge, referral and mortality.

Table 1: Demographic data.

Birth details	Normal neurosonogram, (n=70) (%)	Abnormal neurosonogram, (n=9) (%)	P value
Male	38 (54.3)	8 (88.9)	0.072
Female	32(45.7)	1 (11.1)	
Normal birth weight	39 (55.7)	6 (66.7)	0.725
Low birth weight	31 (44.3)	3 (33.3)	
Term	54 (77.1)	6 (66.7)	0.443
Preterm	16 (22.8)	3 (33.3)	
NVD	23 (32.8)	6 (66.7)	0.068
LSCS	47 (67.2)	3 (33.3)	

NVD-Normal vaginal delivery, LSCS- Lower segment caesarean section.

Table 2: Maternal factors.

Maternal Factors	Normal neurosonogram, (n=70) (%)	Abnormal neurosonogram, (n=9) (%)	P value
Age (in years)			
<30	54 (77.1)	8 (88.9)	0.675
≥30	16 (22.9)	1 (11.1)	
Folic acid taken	67 (95.7)	8 (88.9)	0.390
Folic acid not taken	3 (4.3)	1 (11.1)	
Hypertension/PIH/ pre-eclampsia/ eclampsia	13 (18.6)	1 (11.1)	1.000
No PIH	57 (81.4)	8 (88.9)	
Normal antenatal USG	49 (70)	6 (66.7)	1.000
Abnormal antenatal USGs	21 (30)	3 (33.3)	
PROM more than 18 hours	3 (4.3)	3 (33.3)	0.018
No PROM	67 (95.7)	6 (66.7)	
Oligohydramnios	5 (7.1)	1 (11.1)	0.528
Polyhydramnios	1 (1.4)	1 (11.1)	0.018
Normal liquor amount	64 (91.5)	7 (77.8)	

PIH-Pregnancy induced hypertension, USG-Ultrasonography, PROM-Premature rupture of membranes.

Table 3: APGAR scores.

APGAR at 1, 5 and 10 min	Normal neurosonogram, (n=70) (%)	Abnormal neurosonogram, (n=9) (%)	P value
APGAR <7 at 1 min	17 (24.3)	3 (33.3)	0.685
APGAR ≥7 at 1 min	53 (75.7)	6 (66.7)	
APGAR <7 at 5 min	10 (14.3)	4 (44.4)	0.047
APGAR >/=7 at 5 min	60 (85.7)	5 (55.6)	
APGAR <7 at 10 min	4 (5.7)	3 (33.3)	0.029
APGAR ≥7 at 10 min	66 (94.3)	6 (66.7)	

Table 4: Condition at birth.

Parameters	Normal neurosonogram, (n=70) (%)	Abnormal neurosonogram, (n=9) (%)	P value
Baby in PNC ward	36 (51.4)	1 (11.1)	0.032
Baby in NICU	34 (48.6)	8 (88.9)	
Cried after birth	51 (72.9)	5 (55.6)	0.436
Not cried after birth	19 (27.1)	4 (44.4)	
Resuscitation not needed	45 (64.3)	4 (44.4)	0.289
Resuscitation needed	25 (35.7)	5 (55.6)	

Continued.

Parameters	Normal neurosonogram, (n=70) (%)	Abnormal neurosonogram, (n=9) (%)	P value
Clear liquor	41 (58.6)	6 (66.7)	0.732
Meconium-stained liquor	29 (41.4)	3 (33.3)	
Alert	59 (84.3)	4 (44.4)	0.014
Poor activity	11 (15.7)	5 (55.6)	
Normal sucking	54 (77.1)	4 (44.4)	0.05
Poor sucking	16 (22.9)	5 (55.6)	
Normal cry	50 (71.4)	5 (55.6)	0.443
Abnormal cry	20 (28.6)	4 (44.4)	
Normal tone	49 (70)	4 (44.4)	0.146
Hypotonia	21(30)	5 (55.6)	

Table 5: Investigations.

Parameters	Normal neurosonogram, (n=70) (%)	Abnormal neurosonogram, (n=9) (%)	P value
Normal blood culture	63 (90)	5 (55.6)	0.019
Positive blood culture	7 (10)	4 (44.4)	
Platelet >1.5 lakh/mm^3	66 (94.3)	5 (55.6)	0.005
Platelet < 1.5 lakh/mm^3	4 (5.7)	4 (44.4)	
CRP >10 mg/dl	22 (31.4)	4 (44.4)	0.467
CRP <10 mg/dl	48 (68.6)	5 (55.6)	
PCV >65%	51 (73)	3 (33.3)	0.025
PCV <65%	19 (27)	6 (66.7)	
Plasma glucose >45 mg/dl	58 (82.9)	7 (77.8)	0.657
Plasma glucose <45 mg/dl	12 (17.1)	2 (22.2)	
Total serum calcium >8 mg/dl	53 (75.7)	3 (33.3)	0.016
Total serum calcium <8 mg/dl	17 (24.3)	6 (66.7)	
pH >7.35	53 (75.7)	3 (33.3)	0.016
pH < 7.35	17 (24.3)	6 (66.7)	
pCO_2 >45 mmHg	14 (20)	5 (55.6)	0.033
pCO_2 <45 mmHg	56 (80)	4 (44.4)	

CRP- C reactive protein, PCV- Packed cell volume, pH- potential of hydrogen, pCO2- partial pressure of carbon dioxide.

Table 6: Treatment modality.

Treatment modality	Normal neurosonogram, (n=70) (%)	Abnormal neurosonogram, (n=9) (%)	P value
Blood transfusion	4 (5.7)	1 (11.1)	0.463
No blood transfusion	66 (94.3)	8 (88.9)	
CPAP	16 (22.9)	5 (55.6)	0.05
No CPAP	54 (77.1)	4 (44.4)	
Mechanical ventilator	4 (5.7)	2 (22.2)	0.136
No mechanical ventilator	66 (94.3)	7 (77.8)	
Phototherapy	37 (52.9)	4 (44.4)	0.731
No phototherapy	33 (47.1)	5 (55.6)	
Orogastric tube feeding required	19 (27.1)	6 (66.7)	0.025
Orogastric tube feeding not required	51 (72.9)	3 (33.3)	
Antibiotics needed	21 (30)	3 (33.3)	1
Antibiotics not needed	49 (70)	6 (66.7)	
Needed calcium gluconate	10 (14.3)	6 (66.7)	0.002
Calcium gluconate not needed	60 (85.7)	3(33.3)	
Anticonvulsants needed	5 (7.1)	3 (33.3)	0.044
Anticonvulsants not needed	65 (92.9)	6 (66.7)	

Table 7: Distribution according to abnormal neurosonogram findings, (n=9).

Abnormal neurosonogram findings	N	Percentage (%)
Cysts	5	23.80
Midline shift	3	14.30
Intraventricular hemorrhage	3	14.30
Hydrocephalus	3	14.30
Grade 1-germinal matrix hemorrhage	3	14.30
Subdural hemorrhage	2	9.50
Periventricular echogenicity	1	4.75
Cerebral edema	1	4.75

Table 8: Repeat neurosonography findings in cases with first neurosonogram abnormal, (n=9).

First neurosonogram findings	Repeat neurosonogram findings
Bilateral caudate nucleus cysts	No significant finding
Choroid plexus cysts	Capsuloganglionic hemorrhage extending intothe left lateral ventricle, choroid plexus arachnoid cyst, hydrocephalus, midline shift
Germinal matrix hemorrhage, periventricular frontal horn cyst	No significant finding
Multiple bilateral cysts in thecerebrum	Periventricular echogenicity, midline shift
Focal subdural hemorrhage	No significant finding
Diffuse subdural hemorrhage, compressed right ventricle with midline shift	Cerebral edema, hydrocephalus
Germinal matrix hemorrhage	No significant finding
Mild germinal matrix hemorrhage	Slight prominence of the lateral ventricle
Choroid plexus cyst	Mild hydrocephalus

DISCUSSION

Several studies such as those by Rao et al and Jha et al revealed that males were more affected than females which is in concordance with the present study.[1,9] Neonates with abnormal neurosonogram having low birth weight were around 57% to 70% in other studies whereas in the present study 33.3% neonates with abnormal neurosonogram were LBW, probably because of more full-term neonates were there in present study as compared to the other two studies. Preterm neonates with abnormal findings in neurosonogram were 33.3% in present study as compared to 47.6% in the study by Rao et al.[1]

The association of abnormal neurosonogram and poor activity was 55.6% in the present study which correlated with the study by Rao et al where 47.6% of neonates with cranial abnormalities had poor activity.[1]

Association between abnormal cry and abnormal neurosonogram was 31.5% in Jha et al and 44.4% in the present study which was similar.[9] The association of abnormal tone with positive findings in neurosonogram was 33.3% in the study by Rao et al and 55.6% in the present study probably because the present study consisted of a higher percentage of neonates who suffered from birth asphyxia as compared to their study.[1]

The percentage of low platelets was 44.4% in the present study which is in concordance with the study by Rao et al where the percentage was 33.3%.[1]

The 44.4% of neonates with abnormal neurosonogram had positive blood culture findings whereas the same was 52.3% in the study by Rao et al which indicates a concordance and 10.5% in the study by Jha et al the disparity being due to a higher presence of premature rupture of membranes (PROM) in the present study leading to more chances of sepsis and thereby much more positive blood culture.[1,9]

The 33.3% of neonates with abnormal cranial ultrasonography required anti-convulsant therapy whereas in a study by Jha et al 15.7% required anti-convulsants, it could be due to higher percentage of culture positive sepsis in the present study leading to seizures.[9] The 42.8% neonates with abnormal neurosonogram required anti-convulsants in a study by Rao et al[1] which is comparable to our findings.

In the present study, 55.6% of neonates with abnormal neurosonogram were discharged normally which is similar to the study by Rao et al where the percentage was 57.1%.[1] Mortality was much higher in the study by Jha et al as compared to the present study since their study consisted of a higher percentage of preterm and low birth weight neonates.[9] Also, mortality was slightly higher in the study by Rao et al than in the present study due to a

higher incidence of sepsis in their study as compared to the present study.[9] The incidence of abnormal neurosonogram findings in the present study was 11.4%. In the study by Rao et al the percentage was 20% which is slightly higher than the present study probably because their study consisted of more preterm neonates, a higher percentage of sepsis, and a longer duration of study as compared to the present study.[1]

In a study by Rao et al periventricular echogenicity was 9.52% and cerebral edema 4.76%, and in the present study, it was 4.76% each.[1] Thus, the percentage of cerebral edema is in concordance whereas periventricular echogenicity is slightly lower in the present study probably because their study consisted of more preterm than term neonates whereas in our study it was vice versa and the preterm brain is more susceptible to hypoxic damage due to reduced blood supply to the periventricular white matter thus leading to periventricular echogenicity. In the present study, abnormal neurosonogram findings were seen in 11.4% cases. The various intracranial findings in the neurosonogram were cysts (most common) i.e. arachnoid cyst, choroid plexus cyst, cortical cyst followed by midline shift, intraventricular hemorrhage, hydrocephalus, grade I germinal matrix hemorrhage, subdural hemorrhage, periventricular echogenicity, and cerebral edema. Two neonates were found to have subdural hemorrhage which is consistent to a study by Allu.[10] In a study by Prithviraj et al majority of the neurosonogram findings were picked up between 24 to 72 hours of life which is consistent with the present study.[11]

Among the neonates who were found to have abnormal findings in the first neurosonogram, 56% neonates had abnormal findings in the repeat neurosonogram as well.

Limitations

Limitations of the study were its small sample size and the absence of a prolonged duration longitudinal follow-up and neurosonography.

A long-term longitudinal follow-up study of high-risk neonates with abnormal neurosonogram findings can be conducted to assess their development and long-term outcomes.

CONCLUSION

The percentage of abnormal cranial ultrasonography findings in the present study was 11.4%. Abnormal neurosonography was found to be associated with admission to the NICU, PROM, male gender, birth asphyxia, sepsis, hypocalcemia and acidosis. These high risk neonates with abnormal neurosonogram had a longer hospital stay of more than 10 days and a mortality of 11.1%. From the present study, it can be concluded that neurosonogram is an effective modality for studying cranial abnormalities in such high risk neonates, thus facilitating timely intervention.

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