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Role Of Transcranial Ultrasound and Color Doppler in Neonatal Brain Diseases

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Abstract

Background: The standard imaging technique for preterm neonates is Sequential Cranial Ultrasound (CUS). By adding anatomical images with physiologic information, Trans Cranial Doppler (TCD) is the only non-invasive examination technique that permits reliable assessment of blood flow from the basal intracerebral vessels.

Aim and objectives: To assess the efficacy of universal cranial ultrasound screening in neonates for the identification of various intracranial pathologies specific to this pediatric population.

Patients and methods: This cross-sectional investigation was conducted on eighty cases of neonates who exhibited neurological symptoms or symptoms suggestive of a neurological lesion. TCD and transcranial ultrasound were utilized in every case. The present investigation was carried out at the Department of Radiodiagnosis, Al-Azhar University Hospitals (Assiut), extended the months of February 2022 to August 2023.

Results: A statistically significant distinction was observed in the Doppler results among cases with normal anomalous CUS (P value = 0.0216). Also, in the Doppler results, the categorization of brain lesions is congenital or acquired (P = 0.0359). A higher percentage of neonates delivered by CS exhibited aberrant US findings (67.5% versus 12.5%). Conversely, a greater proportion of neonates delivered via NVD exhibited normal US findings (12.5 percent) in comparison to 7.5 percent.

Conclusion: A significant development in the investigation of the neonatal brain, transcranial ultrasound is a portable, non-invasive, cost-effective, safe method that is particularly useful for assessing intracranial disorders in newborns.

Keywords: Transcranial Ultrasound, Neonatal Brain Diseases, Trans Cranial Doppler (TCD)

1. Introduction

Predicting long-term outcomes in neonates at risk for brain disorders continues to be difficult despite significant advancements in neonatal care aimed at preventing future neurodevelopmental impairment and brain disorders. Brain disorders go on to be a major clinical concern and an important cause of perinatal mortality and morbidity.¹ Brain diseases come in different forms; they may be congenital (e.g., Dandy Walker malformation, congenital hydrocephalus, Chiari II malformation, and corpus callosum agenesis), vascular (e.g., hemorrhagic complications of prematurity, neonatal stroke, and hypoxic-ischemic brain injury), infections, e.g.(brain abscess), traumatic (e.g., brain concussion), also brain diseases may involve ventricular

system(e.g., ventricular dilatation, cystic periventricular leukomalacia, and posthemorrhagic hydrocephalus).²

Since its introduction in the late 1970s, transcranial ultrasound has evolved into an important diagnostic instrument in radiology. Uninvasive in nature, ultrasound is an optimal imaging modality for assessing neonates. The skull's fontanelles and numerous sutures are exposed, providing acoustic windows through which to observe the brain. This imaging modality is crucial for the ICU when it comes to high-risk and unstable neonates, as it enables prompt assessment without sedation and with minimal risk. Furthermore, its portability, cost-effectiveness, speed, and absence of ionizing radiation make it an ideal choice for imaging neonates.³

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Transcranial color Doppler sonography (TCD), a component of ultrasonography, is a cost-effective, repeatable, and non-invasive method utilized to evaluate vascular hemodynamics. TCD serves a critical clinical function by monitoring patients who have experienced traumatic brain injury (TBI) or ischemic stroke. ⁴

Assessing the efficacy of universal cranial ultrasound screening in neonates to identify various intracranial pathologies was the principal objective of this research study.

2. Patients and methods

This cross-sectional investigation was performed on eighty cases of neonates who exhibited neurological symptoms or symptoms suggestive of a neurological lesion. TCD and transcranial ultrasound were utilized in every case. The present investigation was conducted in the Department of Radiodiagnosis at Al-Azhar University Hospitals (Assuit) between February 2022 and August 2023. All participants were recruited from the hospital's outpatient clinics or the inpatient wards of the neonatology unit and intensive care unit.

Inclusion criteria: The age of neonates ranged from thirty weeks to forty weeks, with an average age of 37.56 weeks. Clinical manifestations of neurological lesions were observed in full-term or preterm neonates, including but not limited to the following: convulsions, pathological jaundice, persistent vomiting, enlarged head, obstructed labor, bleeding tendencies, multiple congenital anomalies, respiratory distress, and trauma.

Exclusion criteria: Stillbirth of a full-term or preterm neonate without neurological symptoms.

The research received approval by the Ethical Committee of Al-Azhar University's Faculty of Medicine (Assiut). Written consent was obtained from the guardians of the neonates.

The cases were exposed to the subsequent Clinical Assessment and imaging investigations (Transcranial ultrasound examination).

All patients were examined using LOGIQ S8, which is equipped with a convex probe and linear probe. ⁵

Developments in neonatal care, specifically "brain-oriented care," and the use of therapeutic hypothermia to treat hypoxic-ischemic encephalopathy have enabled the development of neuroprotection for infants at risk of brain injury. The NICU requires a multidisciplinary team for "brain-oriented care" in order to implement these treatments optimally & provide tailored care. Pediatric neurologists, neonatologists, and "brain-oriented" specialized nurses should comprise this group.

Technique of examination: The case was found in a supine position, his head tilted to one side or

the other. Utilizing a convex probe, the principal acoustic aperture was the anterior fontanel; the scanning procedures involved five standard sagittal planes and six standard coronal planes. ⁶

Temporal Window: This technique is predominantly employed to perform transcranial Doppler examination of the middle cerebral artery and, in certain patients, to obtain a clearer image of the temporal lobe. Posterolateral (mastoid) fontanel: Posterolateral fontanelles are utilized for getting pictures of the posterior fossa. Posterolateral fontanelles were utilized to place the convex transducer. To obtain the appropriate angled axial images, the transducer was subsequently rotated slightly utilizing real-time imaging. ⁷

Posterior Fontanel: After palpating the posterior fontanel, the convex transducer was positioned in its midline. The utilization of posterior fontanel scanning was particularly beneficial when evaluating the posterior fossa in neonates diagnosed with suspected Chiari malformation meninges-myelocyte. ⁸

Transcranial Doppler Examination: Transcranial color-coded Doppler is utilized exclusively on patients undergoing examination to detect vascular lesions. Utilizing a convex probe to image flow in the circle of Willis during coronal and sagittal scans through the anterior fontanel. The temporal evaluation of the MCA's echogenic fissure in the axial plane can be accomplished with a linear probe and temporal approach. **Statistical analysis:** The data were analyzed and tabulated utilizing version 20 of the Statistical Package for the Social Sciences (SPSS) software. The percentage frequency distribution and descriptive statistics (mean & SD) were estimated. As required, chi-square, t-test, and correlation analyses were conducted. P values below 0.05 were considered to be statistically significant. The findings were displayed in a table format utilizing Microsoft Excel 2016.

3. Results

Table 1. Clinical characteristics of 80 studied neonate with suspected neurological lesions

CHARACTERISTIC	NUMBER	PERCENT
BIRTH WEIGHT:		
NORMAL	68	85%
LBW	12	15%
VITAMIN K GIVEN AFTER BIRTH:		
NOT GIVEN	42	52.5%
GIVEN	38	47.5%
RESUSCITATED AT BIRTH:		
NOT RESUSCITATED	50	62.5%
MASK	28	35%
NEONATAL PUFF	2	2.5%
INTUBATION:		
NO	72	90%
YES	8	10%
INITIAL DIAGNOSIS AT BIRTH:		
ASPHYXIATED	14	17.5%
NOT ASPHYXIATED	66	82.5%
RESPIRATORY DISTRESS OR CONGENITAL PNEUMONIA:	66	82.5%

NO	14	17.5%
YES		
TREATED WITH CPAP:		
NO	74	92.5%
YES	6	7.5%
NEEDED OF MECHANICAL VENTILATION:		
NO	72	90%
YES	8	10%
RECEIVING BLOOD TRANSFUSION AFTER BIRTH		
NO	78	97.5%
YES	2	2.5%

The most of neonates under the study were males 58 (73.3%), most of that patient weren't distressed 66 (82.5%) and 50 (62.5%) weren't resuscitated. Despite that 14 patient (17.5%) were diagnosed by asphyxia at birth, only 8 (10%) needed mechanical ventilation and 6 (7.5%) were treated with CPAP (Table 1).

Table 2. Relation between Mode of delivery and ultrasound findings

MODE OF DELIVERY	NORMAL CUS	ABNORMAL CUS	TOTAL
NVD	10 (12.5%)	6 (7.5%)	16 (20%)
CS	10 (12.5%)	54 (67.5%)	64 (80%)
TOTAL	20 (25%)	60 (75%)	80 100%

A higher percentage of neonates delivered by CS exhibited abnormal US findings (67.5 percent versus 12.5 percent). A higher percentage of neonates delivered via NVD exhibited normal US findings (12.5 percent) in comparison to the 7.5 percent. (Table 2).

Table 3. The distribution of cranial ultrasonography findings within the abnormal group that was analyzed corresponding to the level of maturity of the neonates

US FINDINGS	PRETERM NEONATES	FULL TERM NEONATES
IVH GRADE I	6 (7.5%)	0(0.0) %
IVH GRADE III	2 (2.5%)	0 (0.0) %
SUBDURAL HEMORRHAGE	0 (0.0) %	2 (2.5%)
INTRACEREBRAL HEMATOMA	0 (0.0) %	2 (2.5%)
PVL	2 (2.5%)	0 (0.0) %
HIE	0 (0.0) %	20 (25%)
HYDROCEPHALUS	0 (0.0) %	16 (20%)
CONGENITAL LESIONS	0 (0.0) %	10 (12.5%)

IVH=intraventricular Hge. PVL=peri-ventricular leukomalacia.

HIE=hypoxic ischemic encephalopathy.

In preterm neonates, each case of IVH grade I (six patient) (7.5 percent), IVH grade III (two patient) (2.5 percent), & PVL (two patient) (2.5 percent) was identified. Full-term neonates contained every patient of HIE twenty patient) (twenty five percent), hydrocephalus sixteen patient) (twenty percent), intracerebral hematoma

(two patient) (2.5 percent), subdural hemorrhage (two patient) (2.5 percent), & congenital lesions (ten patient) (12.5 percent). (Table 3).

Table 4. Frequency of transcranial doppler diagnosis between 80 studied neonates with suspected neurological signs

RI	NUMBER	PERCENT
NORMAL	52	65%
DECREASED RI	12	15%
INCREASED RI	16	20%
TOTAL	80	100.0%

RI=resistive index.

fifty-two (sixty-five percent) of the eighty cases had normal RI, while twelve (fifteen percent) had reduced RI and sixteen (twenty percent) showed higher RI. (Table 4).

Table 5. Relation among doppler findings in normal CUS cases & abnormal CUS cases

	NORMAL CUS PATIENTS	ABNORMAL CUS PATIENTS	TOTAL	P VALUE
NORMAL DOPPLER	20 (25%)	32 (40%)	52 (65%)	0.0216
ABNORMAL DOPPLER	0 (0.0%)	28 (35%)	28 (35%)	
TOTAL	20 (25%)	60 (75%)	80 100%	

There was a statistically significant difference among doppler findings in normal CUS cases & abnormal CUS cases (P value= 0.0216) (Table 5).

Table 6. Relation among doppler findings & types of brain lesions

	CONGENITAL	ACQUIRED	TOTAL	P VALUE
NORMAL DOPPLER	10 (12.5%)	22 (27.5%)	32 (40%)	0.0359
ABNORMAL DOPPLER	0 (0.0%)	28 (35%)	28 (35%)	
TOTAL	10 (12.5%)	50 (62.5%)	60 (75%)	

There was a statistically significant variance among doppler findings & types of brain lesions (Congenital and acquired) (P value= 0.0359) (Table 6).

Case Presentation

Case (1)

History

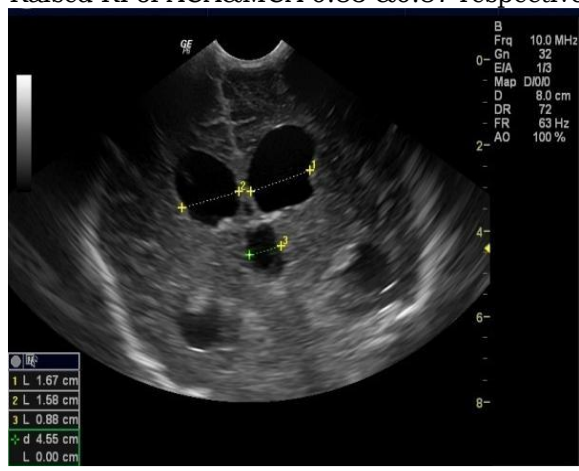
Male full-term neonate, thirty-eight weeks, delivered by cesarean section, without any history of maternal illness or birth insult, exhibited respiratory distress & no neurological symptoms when assessed by cesarean section four days postpartum via cesarean section.

CUS and doppler findings

Hyperechoic nodule seen in the region of caudothalamic groove on the right side compressing the ipsilateral frontal horn of the lateral ventricle and elevating its floor, with no intraventricular extension of the hemorrhage, normal resistive index of MCA on applying color doppler. Representing right acute GMH grade II.



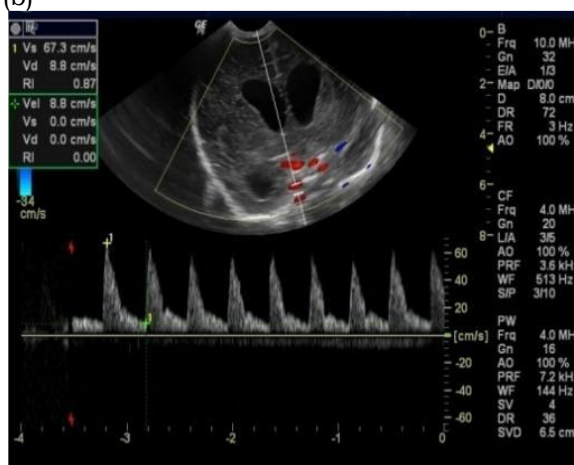
Figure 1: Right acute GMH grade II. Case (2)
 History
 Male infant aged 15 days, full term, 39 weeks, delivered by caesarian section with yellowish discoloration of skin and mucous membrane, hyporeflexia & history of head trauma.
 CUS Findings
 Dilated both lateral ventricles 1.5 cm (normal up to 1.2 cm).
 Dilated third ventricle 0.8 cm (normal up to 0.3cm).
 Raised RI of ACA&MCA 0.83 &0.87 respectively.



(a)



(b)



(c)

Figure 2: (a, b& c) CUS B- mode & color flow doppler showing post hemorrhagic hydrocephalus with raised RI of ACA & MCA.

4. Discussion

The ultrasound identified twenty (twenty-five percent) patients with normal brains and sixty (seventy-five percent) with abnormal CUS findings, according to this study. Ten (16.6 percent) of the anomalous CUS findings were congenital abnormalities, while fifty (83.3 percent) were acquired lesions. The aberrant group was thus partitioned into the following two subgroups: Cases of congenital lesions comprise subgroup (A): 2.5 percent Dandy Walker lesion, 2.5 percent Chiari malformation, 2.5 percent germinal matrix cyst, 2.5 percent arachnoid cyst, and 2.5 percent cavum septum pellucidum. Subgroup (B) comprises acquired lesion cases: twenty patients (25%), two patients (2.5 percent) had hydrocephalus, six patients (7.5 percent) had hypoxic-ischemic encephalopathy (HIE), two patients (2.5%) had IVH grade I, two patients (2.5 percent) had subdural hemorrhage, two patients (2.5 percent) had intracerebral hemorrhage, two patients (2.5 percent) had PVL, and sixteen patients (27.5 percent) had hydrocephalus.

Ziaul et al. ⁹ examined 103 preterm neonates, of

which fifty-six (54.3 percent) had normal CUS findings, and forty-seven (45.63 percent) had aberrant CUS findings in their study. Twenty-two (21.4 percent) of the anomalous CUS findings were indicative of cerebral edema, seventeen (16.5 percent) of IVH, and eight (7.8 percent) of ventricular dilatation.

Hypoxic and intracranial hemorrhagic lesions in neonates can be classified as either preterm or full-term. Similar to the findings of Yasmin et al.¹⁰ the most prevalent lesions in premature infants were germinal matrix hemorrhage (GMH), intraventricular hemorrhage (IVH), and periventricular leukomalacia (PVL).

The number of male cases in the present study was greater than that of female patients, with fifty-eight male cases and twenty-two female cases comprising 72.5 percent and 27.5 percent, respectively, of the total number of cases. There was a notable correlation between abnormal trans placement cesarean section (TCUS) mode of delivery, as neonates delivered via CS exhibited a greater proportion (54/64, 84.3 percent) of abnormal ultrasound findings in comparison to those delivered via NVD, which had a higher proportion (10/16, 62.5 percent) of normal US findings.

The results of this study agree with those of Teune et al.¹¹ who reported that there is an elevated risk of neonatal morbidity & mortality among infants delivered by primary cesarean section at thirty-two to thirty-six weeks gestation compared to vaginal delivery. The precise mechanism through which CS elevates the risk of neonatal mortality remains unclear; however, the morbidities investigated indicate that the mechanism may be associated with the cesarean section's effect on respiratory adaptation, at least with regard to the morbidities.

According to the research conducted by Mohammed et al.¹² Doppler flow measurements have the potential to differentiate vascular structures from non-vascular lesions. Additionally, cranial color duplex (CCD) imaging can be utilized to analyze cerebral hemodynamics by evaluating the major intracranial arteries and large veins.

Transcranial color-coded Doppler was utilized specifically in the present study to evaluate vascular lesions in every case analyzed to determine the RI of ACA or MCA. Abnormal RI was detected in acquired lesions, including hydrocephalic patients and those with HIE; my research concluded that HIE was more frequently correlated with higher or lower RI. According to my research, hydrocephalus is more frequently associated with elevated RI.

The results of this study agree with those of Taema et al.¹³ who reported that the degree of cerebral hemodynamic disturbance significantly

affected the blood flow velocities in HIE groups, causing an associated rise or reduction in RI.

4. Conclusion

Transcranial ultrasound, which is portable, safe, non-invasive, inexpensive, & highly effective, has significantly advanced the research of the neonatal brain. It is particularly useful for evaluating intracranial illnesses in newborns and should be incorporated into an integrated approach to central nervous system imaging in infants.

Disclosure

The authors have no financial interest to declare in relation to the content of this article.

Authorship

All authors have a substantial contribution to the article

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Conflicts of interest

There are no conflicts of interest.

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