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Research Article

The Added Values of Duplex Study and Cranial Ultrasonography in Clinically Suspected Preterm Brain Injury

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Abstract

50 premature newborns (less than 32 weeks) having clinically diagnosed preterm brain damage participated in our study. At the NICU from Minia University Hospitals, high-resolution sonography equipment was used to perform cranial ultrasonography on each patient. Transcranial sonar and transcranial Doppler examinations of the ICA, MCA, and ACA for mach number, PSV, and resistive index were performed for all patients and controls. Based on a cerebral ultrasound scan, Volpe's grading system for innermost matrix hemorrhage/intra ventricular hemorrhage (GMH/IVH) (CUS). Haemorrhage in the lateral ventricle absent ventricular dilatation and/or haemorrhage constituting less than 50% of ventricle are classified as grade II and are both limited to the subependymal GM. As opposed to grade IV hemorrhage, which is defined as ventricular hemorrhage with periventricular hemorrhagic infarction, grade III hemorrhage is described as ventricular dilatation and/or hemorrhage occupying more than 50% of the ventricle. 40% of Americans had GMH/IVH. 35.3% of those were in grade 1, 29.4% in grade 2, 23.5% in grade 3, and 11.8% in grade 4. These instances contained associated pathologies that included: 10% of patients developed cerebellar hemorrhage. 15% of patients had Doppler-detected brain edema, an early observation. Of these, 5% had only advanced to PVL-grade I periventricular echogenicity, whereas 10% had progressed to thalamic cf leukomalacia at Tdi (PVL – grade II – IV) . Age and weight were much lower in the positive cases than the negative. Preterms had a higher mean velocity & lower PI & RI according to transcranial doppler results. **Conclusion:** Due of the frail capillary vasculature and abrupt changes in CBF, newborns under 32 weeks of gestation or weighing under 1500 g are more vulnerable to bleeding in the GM. Although the minority of GM-IVH cases are clinically quiet, hospitals should establish a protocolized schedule using repeated real-time CUS to allow prompt identification of GM-IVH. Despite the possibility that duplex investigations do not accurately reflect a particular disease entity, transcranial Doppler and cranial ultrasonography aid in the early evaluation of evaluation of premature brain injury.

Keywords: Preterms, TCUS, Neural stimulation Doppler, and GMH/IVH

Introduction

The catastrophic neurological consequence known as blastocyst matrix-intraventricular hemorrhage (GM-IVH) still has a high death rate [Pieper et al., 2003]. as well as neurological disabilities [Bolisetty et men, 2014]. The ductal germinal matrix (Gp) of the neurodevelopment is the site of the hemorrhage's origin.

The periventricular area of the brain contains the germinal matrix (GM), a specialized layer of glial - neuronal precursor cells with high

metabolic activity that is heavily reliant on its voluminous vascularity and quick angioplasty (Atienza-Navarro et al., 2020). The subepen-dyma of both the ventricular myocardium is where the GM is situated. It is highly cellular, gelatinous, and extensively vascularized by veins that are not well maintained by muscle or collagen. It also gives rise to the cerebral 'build and glia (Ballabh, 2012)

The complex and multifaceted pathophysiology of GM-IVH is largely related to the fragile nature of the primitive Fm vasculature, changes in blood flow to the brain (CBF) brought on by low mean arterial pressures and decreased cerebral autoregulation in physiologically unwell preterm infants (Lin et al., 2016).

The incidence, survival, incidence morbidity of GMH have increased due to the widespread on use skull ultrasonography ever since early 1980s, growing awareness of risk factors, the use of prenatal steroids, and improved critical care (Yeo et al., 2020).

To evaluate the cerebral vasculature and spot vascular abnormalities, ultrasonography imaging in color and pulsed Diagnostic mode can be performed. With the use of this technology, it is possible to recreate images in several planes to help with the diagnosis of infant brain disorders (Kurian et al., 2017).

Patients and Methods

Between December 2021 and December 2022, a prospective research study was conducted. At the Nursery of Minia University Clinic for Women and Children, each patient got a thorough cranial ultrasound using a high-resolution diagnostic scanner.

The clinical suspicion of preterm concussion in 50 preterm babies (born at fewer than 32 weeks after conception) is used to highlight the effectiveness and precision of serial transcranial ultrasonography.

Scan in the coronal, sagittal/parasagittal, and axial planes through the frontal fontanelle and its complementing windows, such as the posterior periodontal ligament, temporal window, and mastoid fontanelle.

In order to evaluate the health of the cerebral vascular and arterial systems in every instance, an integrated scan with colors doppler was carried out. To track the flow wave patterns and obtain the Doppler values of the various arteries and veins, pulsed wave type was employed. Laterally, the sylvian fissure was seen as Y-shaped echogenic regions. Thalami, which surrounded the lateral ventricles, had echo-genicity that was comparable to or somewhat lower than that of the parenchyma around. The anterior cerebral vessels were seen in the sagittal gap during the same scan in Doppler mode.

Coronal scans through the reticular formation were performed, and at this depth, the choroid plexus could be seen in the third ventricle's roof as well as the floors of both lateral ventricles. the placement of a Doppler gate allowed for the visualization of the middle cerebral vein in the sylvian fissure.

The brain parenchyma and echogenic parameters give white matter pathways were seen on laterally sagittal images. The main branches of the Willis circles were assessed using axial scanning via the temporal bone. The transducer was positioned on the lateral side of the head, just above the condyles and in front of the ear.

The artery artery, middle cerebral artery, and anterior cerebral arteries—collectively known as the "big three" cerebral arteries—are all evaluated. The mean velocity (cm/sec), pulsatility index (PI), and resistance index (RI) for each artery were the analyzed parameters. With each Single display sweep, our imaging technique could calculate that PI & RI.
In all of the cases that were looked at, the resistive Doppler index (Li) for brain arterial system was used to anticipate how the blood flow would be regulated in the early phases of hypoxic ischemic alterations.

The echogenicity of acute bleeding is on par with or comparable to that of the choroid's plexus. The center of the clot lyses and becomes hypoechoic, but the clots' periphery remains echogenic.

The Volpe grading system is based on cerebral ultrasound imaging (CUS). Hemorrhage in the

lateral ventricle lacking ventricular dilatation and/or hemorrhage occupying just under 50% of the ventricle is classified as grade II and is referred to as grade I if it is restricted to the subependymal GM. Ventricular dilatation and/or bleeding occupying more than 50percent of total of the ventricle are indicators of grade III hemorrhage, while periventricular hemorr-hagic infarction is a sign of grade IV hemorrhage (Inder et al., 2018).

GMH-IVH consequences are diagnosed by ultrasound as forebrain hemorrhagic infarction. A triangular, "fan-shaped" echodensity in the ivh white tissue, ipsilateral to GMH-IVH, is the hallmark ultrasonographic feature of PHI. The production, circulation, and/or resorption of CSF are out of balance, which results in post-hemorrhagic ventricular dilatation (PHVD). After the initial IVH, it typically appears a few days between a few weeks later.

Results

Our study was conducted on 50 premature infants (born less than 32 weeks gestation) with clinically suspected of preterm brain injury.
The mean age of the was 30.7± 1.7 weeks. They included 34 males (68%) and 16 females (32%). Their mean weight was 1544.3 ± 295.4 gm.

Table (1) Clinical and laboratory characteristics of the studied group (N=50).

		(N=50)
Clinical signs and symptoms	Normal	31 (62 %)
	DCL	7 (14 %)
	Fits	6 (12 %)
	Respiratory distress	6 (12 %)
	Fever	6 (12 %)
	Bulging fontanelle	3 (6 %)
	Apnea	5 (10 %)
Anemia	Yes	7 (14 %)
	No	43 (86%)
Hematocrit	Low	5 (10 %)
	Normal	45 (90%)
TLC	High	1 (2 %)
	Normal	49 (98%)
Platelets	Low	8 (16 %)
	Normal	42 (84%)
Septicemia	Yes	4 (8 %)
	No	46 (92%)
CRP	High	2 (4 %)
	Normal	48 (96%)

This table shows that 62% had normal history and examination, 14% had DCL and apnea, 12% suffered from fits, respiratory distress, and fever, and 6% had bulging fontanels. 14% had anemia, 10% had decreased hematocrit, 2% had high TLC, 16% had thrombocytopenia, 8% had septicemia, and 4% had high CRP.

Table (2): Finding of GMH/IVH by US among the studied group (N=50).

		(N=50)
Finding	Positive Negative	17 (34 %) 33 (66 %)
Grading of GMH/IVH by US (n=17)	1 2 3 4	6 (35.3 %) 5 (29.4 %) 4 (23.5 %) 2 (11.8 %)

This table shows that 34% had IVH in the US. Among those 35.3% were grade 1, 29.4% were grade 2, 23.5% were grade 3, while 11.8% were grade 4.

Table (3): Finding of GMH/IVH by US among the studied group (N=50).

		(N=50)
CBH	Yes No	3 (6 %) 47 (94%)
Early brain edema by Doppler	No Grade 1 Grade 2 Grade 3 Grade 4	45 (90 %) 0 2 (4 %) 2 (4 %) 1 (2 %)
PVE	Yes No	4 (8 %) 46 (92%)
PVL at TEA	Yes No	1 (2 %) 49 (98%)

This table shows that 6% had CBH. 5% had brain edema by Doppler, 4. 8% had PVE, and 2% PVL at TEA.

Table (4): Difference between positive and negative cases regarding sociodemographic and baseline clinical characteristics of the studied group (n=31).

		Positive (n=19)	Negative (n=12)	P value
Age at time of 1st scan (weeks)	**Mean ± SD**	29.5 ± 2.0	31.8 ± 0.6	0.001
Sex	**Male** **Female**	13 (68.4 %) 6 (31.6 %)	8 (66.7 %) 4 (33.3 %)	0.919
Weight (gm)	**Mean ± SD**	1361.4 ± 307.6	1710.0 ± 201.2	0.002

This table shows that there is no significant difference between positive and negative cases regarding their sex. While the positive cases had a significantly lower age and weight than the negative.

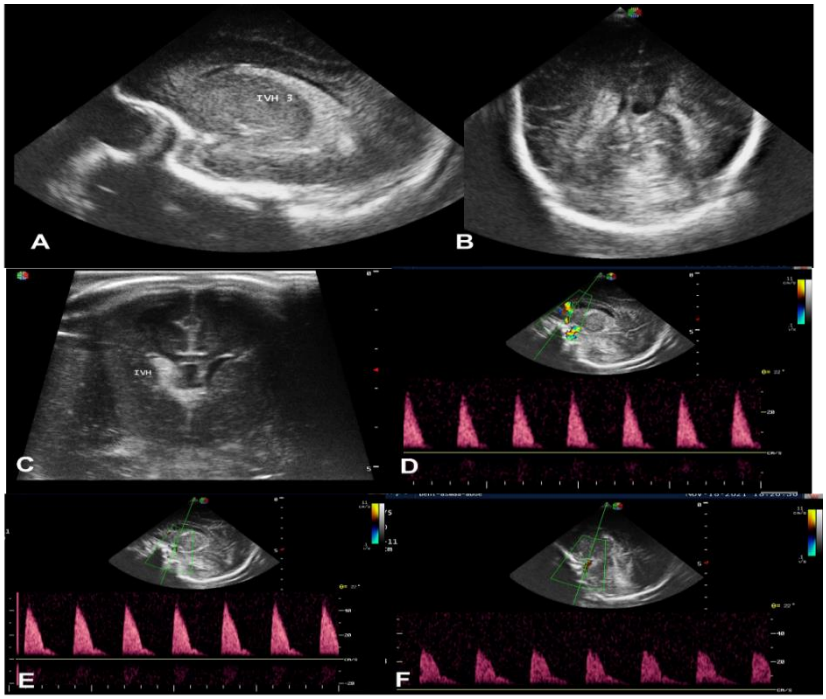

Figure (1); Doppler criteria (wave forms) include mean velocity [MV], pulsatility index [PI] and resistive index [RI]. These parameters were measured in internal carotid artery [ICA]; (A), middle cerebral artery [MCA]; (B) and anterior cerebral artery [ACA]; (C).
In our study, the higher readings of the mean velocity, PI and RI in ICA than in MCA and ACA {both in the controls and cases either preterms or full terms}

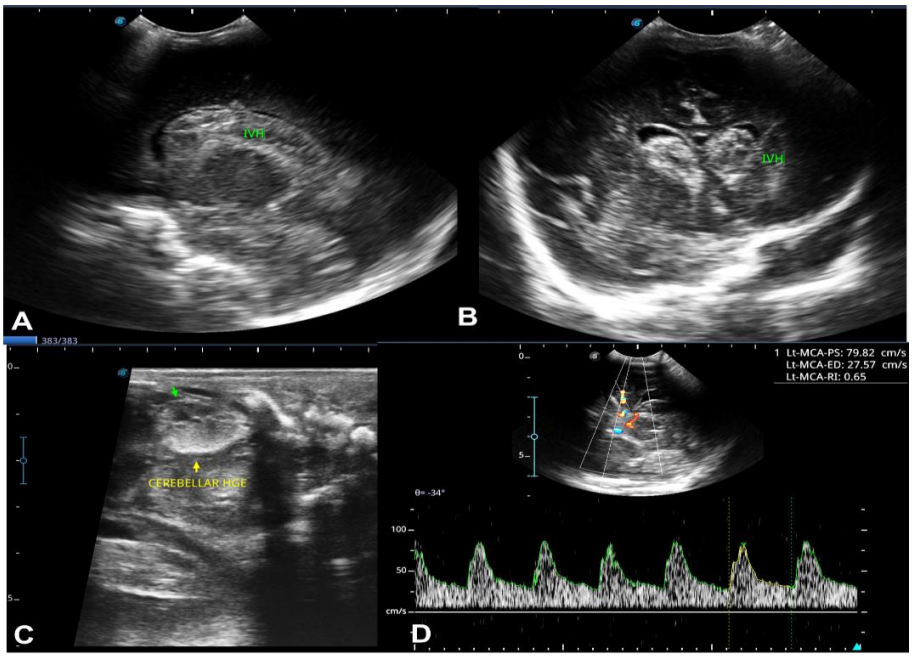

Figure (2) (A) Sagittal images shows increased echogenicity in the cortex of the brain, gyri not identified, ventricles compressed by edema (arrows), thalamus (th) and caudate nucleus (cau) seen. (B) Doppler spectral display an ischemic child, ant cerebral artery wave form, elevated diastolic flow and decrease systolic flow, resistivity index 0.4 1. Initial ultrasound study and pulsed wave Doppler tracing from anterior cerebral artery appear unremarkable.

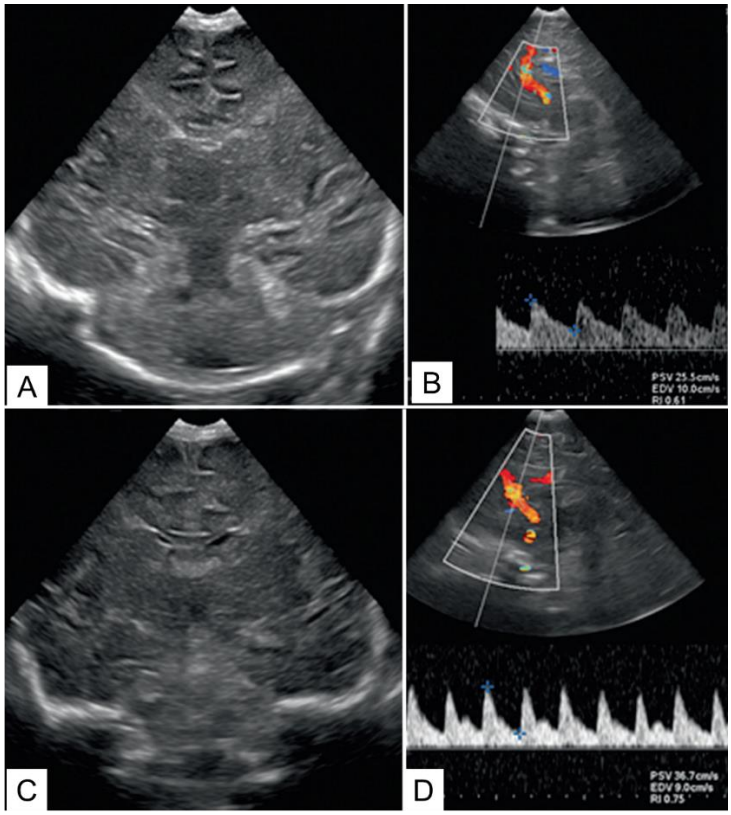

Figure (3): Neonate with perinatal hypoxic ischemic injury (A) and (B) Initial ultrasound study shows diffuse brain edema with increased echogenicity of the cerebral white matter, accentuated corticomedullary differentiation, and slit like ventricles. Anterior cerebral artery Doppler shows a resistive index (RI) value of 0.61. (C) and (D) Follow-up imaging after treatment, shows normalization of the B-mode imaging findings and a normal RI value of 0.75.

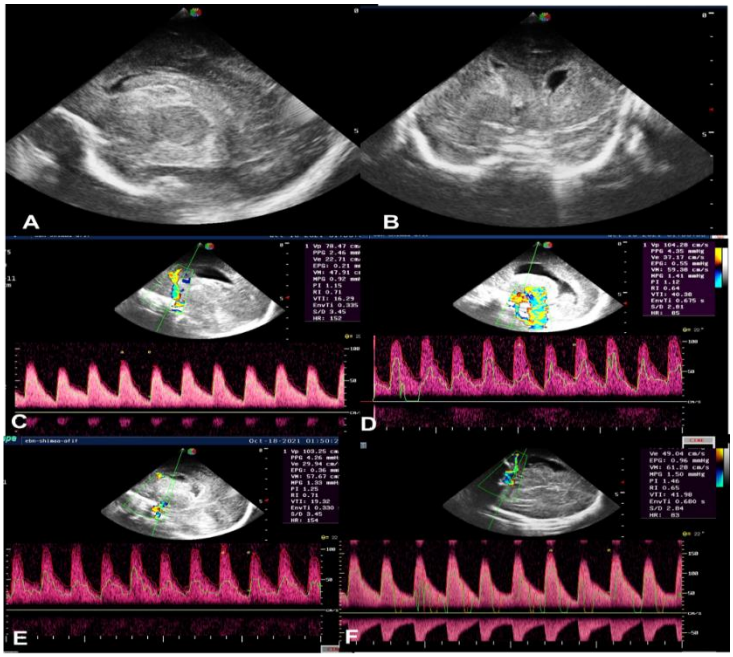

Figure (4): Grade I subependymal hemorrhage. (A) and (B) sagittal sonogram show a focus of increased echogenicity in the left subependymal area (arrows), just above the caudate nucleus. (C); the coronal image.

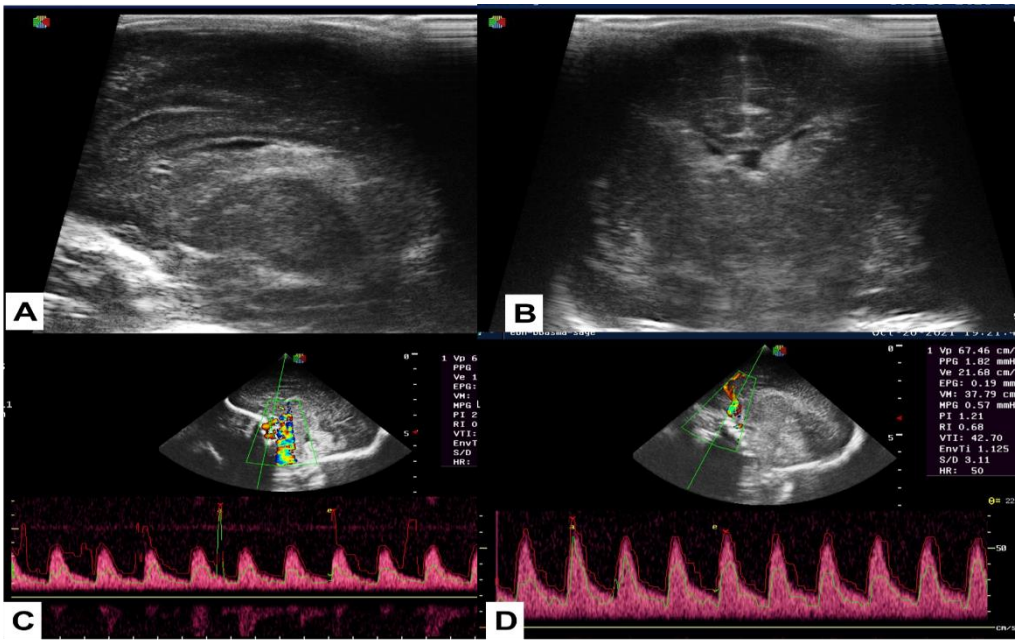

Figure (5): grade III hemorrhage(A) mid- sagittal sonar (B) coronal images of preterms child coming with dilated blood-filled lateral ventricle and third ventricle forming so called ventricular cast. (C) & (D) CT appearance 3 days after showing the resolving hemorrhage.

Discussion

In our study, 62two - thirds of the newborns who were checked had normal histories and exams, while 12% had fits. Perlman and Rollins and Ahmed et al., (2017) are also included in this presentation (2000). According to Perlman and Rollins' analysis, the majority of GM-IVH cases are symptom - free and may only be found with standard brain imaging. Clinically recognizable seizures are observed more frequently in infants with grade IV GM-IVH, according to a research by Ahmed et al.,

The main branches of the circular of Willis and the structures on the right and left do not consistently differ in their instantaneous blood flow velocities.

Preterm neonates have an anterior cerebral artery RI of 0.78 (range, 0.5-1.0), but full-term newborns have a RI of 0.71 (range, 0.6-0.8). (Horgan et al., 1989).

In cases of extensive LBW, HIE, meningitis, and CNS congenital malformations, transcranial transducer is a useful brain imaging technique. It is affordable, accessible, safe, and does not require the transport of the infant. It can be used to find IVH, PVE, ventricular enlargement, and cerebral edema.

Transcranial Doppler results showed that preterms with HIE had higher mean velocities and lower PI & RI than controls.

The duplex Doppler technique can be utilized in a number of different ways to improve the imaging's diagnostic sensitivity and specificity. Flow of color Doppler imaging can be utilized to demonstrate the subependymal & terminal veins' initial displacement, progressive encasement, and occlusion due to germinal matrix bleeding (Taylor, 1995).

This study concluded that transcranial Doppler used in conjunction with cranial ultra-sonography is helpful in classifying and evaluating preterm brain damage. This is in keeping with recent Canadian guidelines that, depending on the preterm infant's clinical

condition, propose routine CUS for all infants born at or before 32 weeks between rounds 4 and 7 of life or sooner. 2020 (Guillot et al.,).

The main advantages in our analysis for the additional benefit of Doppler over Grayscale US stated for presence of associated brain fluid retention in the cases of GMH, and this in turn helped the clinicians add antiedematous therapies in furthermore to hemorrhage medical therapy that boosts the overall clinical outcome. In addition, the use of Sonogram revealed the early changes in brain edema (as early as the first week post-natal) that accompanied the erythropoiesis and cystic chang These benefits are remarkably comparable to those found in the research. (Raets M et al., 2015)

The main technical challenges for vessel tracing were encountered in this inquiry duplex evaluation. The simultaneous sampling of the venous and arterial waveforms due to the near proximity of the arteries circles of Willis and the intravenous circle of Trolard might impact the accuracy of the calculation of several hemodynamic markers, including the RI values. Furthermore, slow-flowing, deeply seated, and superficial vessels that are hidden by the calvarial skeleton or outside the sonic window might go unnoticed.

The severity, timing, and persistence of the insult, as well as other complicated interrelated parameters, influence the cerebral effects linked to HIE or asphyxia;
The basilar artery and the vertebral arteries exhibit a significantly curved path, which might make interpretation challenging. The basilar artery frequently does not lie during an axial plane; as a result, when traced cranially, the vessel can be seen as punctiform and may cause confusion with some other vessels because of the manque of continuity. If the vessel under examination cannot be seen clearly from a distance of least approximately 1 cm, incorrect findings may result.

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