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ORIGINAL ARTICLE

Diagnostic accuracy of Itransfontanelle sonography as compared to computed tomography of brain in the detection of hydrocephalus.

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ABSTRACT… Objective: To determine diagnostic accuracy of trans fontanelle ultrasound for detection and diagnosis of hydrocephalus in terms of sensitivity, specificity, Positive predictive value and Negative predictive value by keeping CT brain as gold standard. **Study Design:** Cross-sectional study. **Setting:** Department of Diagnostic Radiology, MTI/Hayatabad Medical Complex, Peshawar. **Period:** August 01, 2024 to January 1, 2025. **Methods:** The study included 34 patients (aged 1 day to 6 months) with increased head circumference, using non-probability consecutive sampling. Trans fontanelle ultrasound was performed to diagnose hydrocephalus, with CT scans serving as the reference standard. Data were analyzed using SPSS software, and sensitivity, specificity, and predictive values were calculated. **Results:** The study included 33 patients (72.72% boys, 27.27% girls) with a mean age of 29.45 ± 7.31 days. Trans-frontal ultrasound was used to measure the lateral ventricle diameter and compared with CT scan findings. The ultrasound demonstrated a sensitivity of 66.70%, specificity of 88.90%, a positive predictive value of 83.30%, and a negative predictive value of 76.20%. **Conclusion:** The study highlights trans-fontanelle sonography to be a useful, non-invasive diagnostic tool for diagnosis of hydrocephalus in infants, especially when compared to the standard CT scan.

Key words: Computer Tomography Scan, Diagnosis, Diagnostic Radiology, Hydrocephalous, Trans Frontal Ultrasound.

INTRODUCTION

Hydrocephalous is a broad term that can be explained through various definitions. It comprises different clinical entities characterized by increase in cerebrospinal fluids (CSP) in brain with enlarge ventricle.[1] The pathophysiology of hydrocephalous is the abnormal regulation between formation and pulsastile drainage of CSF that could be occur due to various condition most commonly include inflammation of brain, brain tumor and traumatic brain injuries.[2] The condition is more common in children and in individuals older than 60 years. According to the literature, the prevalence of hydrocephalous is 11 out of one hundred thousand in individuals age 18 to 64 and this number increased to 174 out of one hundred thousand in individual age above 64 years.[3] Patients with hydrocephalous are usually presented with headache, disorientation, vision, gate abnormalities and sleep disturbance.[4]

During gestational period, the cerebrum and cerebellum shows a rapid development both in size and complexity: the development of brain include, neuronal formation, migration, proliferation and differentiation forming functional connectivity and patterning. Any abnormality of the in brain development due to traumatic, ischemic or genetic factor could lead to the development of brain malformation.[5] Hydrocephalous is a complex disease could be due to multiple pathophysiology. Many researchers had described and classified the hydrocephalous in different way; the recent review summarized the concept of hydrocephalous based on seven factors based on CSF dynamics including; CSF production, major and minor pathways, absorption of CSF and respiration may have different relevance and may also overlap for the individual hydrocephalic condition.[6]

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Different imaging modalities are used for diagnosis of hydrocephalous including head ultrasound, magnetic resonance image (MRI-Scan) and computer tomography (CT-Scan).[7]

A detail examination of head using trans frontal Ultrasound could be used to diagnosed brain malformation including the diagnosis of hydrocephalous. A recent advancement in ultrasonography could enable the diagnostic radiologist to identify the morphological features of brain including Sulci, gyri and fissures that can also help in identifying brain abnormalities in fetus.[8] In neonates, TF ultrasound emerge as a valuable non-invasive modality for diagnosis of hydrocephalous.[9] It has several advantages as compare to gold standard CT scan including no harm from ionizing radiations, could be done at bed side; many literature studies had highlight the significance of TF ultrasound in diagnosis of different brain abnormalities: a study conducted by G El Adioui et.[10] all concluded TF ultrasound as a simple, non-invasive, safe and reproducible tool showing a positive correlation with reference imaging modalities (Computer tomographic Imaging). Another study conducted by Rabia Ali et.[11] all in Pakistan identifying the diagnostic accuracy of ultrasound in comparison with CT Scan, concluded ultrasound as an effective screening tool for diagnosis of Hydrocephalous in neonates. In conclusion, these studies significantly highlight the importance of TF ultrasound as a reliable and non-invasive alternative tool for diagnoses of hydrocephalous in neonates and pediatric population.

Different studies in literature reported a various sensitivity and specificity for trans frontal ultrasound in diagnosis of hydrocephalous indicating the need for standardized assessment. Our Study aim to determine diagnostic accuracy of trans fontanelle ultrasound for detection and diagnosis of hydrocephalus in terms of sensitivity, specificity, Positive predictive value and Negative predictive value by keeping CT brain as gold standard. By doing this, the study could highlight the significance of TF ultrasound as the safer, noninvasive and reproducible alternative to gold standard CT especially in vulnerable patients.

METHODS

It was a cross-sectional study conducted at the Department of Diagnostic Radiology MTI/ Hyatabad Medical Complex Peshawar. The study was 6 months in duration (August 01, 2024 to January 1, 2025) and ethical approval was obtained from the College of Physicians and Surgeons Pakistan (Reference Number# CPSP/ REU/RAD-2021-021-3510) and MTI/ Hayatabad Medical Complex Peshawar (685/HEC/ B&PSC/2022). The study includes 34 patients and was collected using a Non-probability consecutive sampling technique. Both written and verbal informed consent were taken from the guardians of patients and data was collected using a hard copy of the questionnaire. A different variable was used for data collection including age, head circumference, neck circumference gender, presence/absence of hydrocephalus.

For the purpose of the study, all those patients on transfontanelle ultrasound having mean transverse diameter of lateral ventricle at the level of atria > 10mm were labelled as hydrocephalous and on CT brain width of lateral ventricle at the level of atria of > 10mm.

Patients was labelled to have increased head circumference when their head size is: > 35 cm at birth, > 37 cm at 1 month, > 39 cm at 2 months, > 41 cm at 4 months, > 43 cm at 6 months.

After attaining the informed consent of the patients, all patients aged 1 day to 6 months, of both genders, with increased head circumference (as per operational definition) were included in the study. Patients who have normal head circumference and those having condition preventing possibility of performing transfontanelle ultrasound like local infection were excluded from the study. Strictly Exclusion criteria were followed in order to control cofounder and bias in the study.

In all these patient's CPSP Final year trainee of Diagnostic radiology performed a transfontanelle ultrasound to make the diagnosis of hydrocephalus (as per operational definition). All these patients were also then undergo CT

brain and were assessed by same radiologist who performed transfontanelle ultrasound to make diagnosis of hydrocephalus and cross cheeked by consultant radiologist All the data were documented in performa. Patient anonymity and confidentiality were maintained with utmost priority. No personal identifiers such as "patient registration number" or "Patient name or contact details" were included in documentation.

Data were analyzed using SPSS software latest version 26.0. The numeric variable (age) was documented as mean ± standard deviation. The categorical variables (gender, presence/ absence of hydrocephalus) were represented as frequency and percentages. Data were stratified by age, gender, and head circumference to deal with effect modifiers. 2×2 table were drawn in SPSS, in order to determine sensitivity, specificity, negative predictive value, and positive predictive value.

RESULTS

The study includes 33 patients, including n=24 (72.72%) baby boy and n= 09 (27.27%) baby girls with mean age of 29.45 ± 7.31 days. The mean transverse diameter of all patients was measured using trans-frontal Ultrasound and compared with a standard CT Scan. Out of 33 patients, 10 patients had a mean transverse diameter of lateral ventricle at the level of atria of > 10mm on TF ultrasound and having hydrocephalous confirmed through CT scan (True Positive = 10) while n = 16 having a transverse diameter of lateral ventricle at the level of atria of less than 10mm and didn't diagnose with Hydrocephalous using CT scan (True Negative = 16). Moreover, n= 02 patients having mean transverse diameter of lateral ventricle at the level of atria of < 10mm on trans fontanelle ultrasound but have hydrocephalus (based on CT) (False Positive = 02) and n= 02 presents having mean transverse diameter of lateral ventricle at the level of atria of > 10mm on trans fontanelle ultrasound but no hydrocephalus (based on CT). sensitively and specificity measured using above mention formula in the material and methods section. The ultrasound demonstrates a positive predictive value of 83.30 %, showing this percentage of patients who test positive actually had a disease and a negative predictive value of 76.20, indicating that these patients who test negative for a disease; didn't have hydrocephalous based on standard diagnostic tool (CT scan). Overall, trans-frontal sonography had a sensitivity of 66.70% and a specificity of 88.90%. graphical representation of results is shown in the following figure and table.

2 x 2 Table for sensitivity, specificity, PPV and NPV

	Hydrocephalus present	Hydrocephalus absent
Transfontanelle ultrasound showing mean transverse diameter of lateral ventricle at the level of atria of > 10mm.	10	02
Transfontanelle ultrasound showing mean transverse diameter of lateral ventricle at the level of atria of < 10mm.	02	16

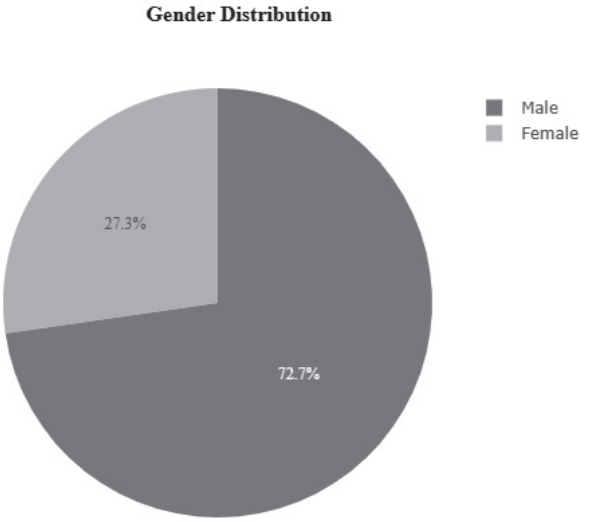

Figure-1. Gender distribution

DISCUSSION

Hydrocephalous if untreated could be presented with some serious complication including seizure, visual impairment, brain damage and particularly in infant it could lead to physical deformities, developmental delay and motor neuronal damage. Delayed diagnosis could result in all these possible complications.[12] We have different

diagnostic options including lumber puncture, Trans frontal sonography and Computer tomographic scans (CT-scan) each one has its own advantages and disadvantages. CT scan is a gold standard but has several disadvantages including cost, may require infant sedation and they are associated with high ionizing radiation that could potentially effect infant bran tissues. Lumber puncture are invasive procedure and associated with risk of infection and bleeding.[13]

In our study, majority of patients presented to us were male with male to female ratio approximately 3:1. Different studies in previous literature support our study findings including study conducted by Verma et.all.[14] reported that, 85% patients among the patients presented with hydrocephalous were male while 15% were female. Another study conducted by Abdel-Aziz KI et.all.[15] concluded the prevalence of more male patient with hydrocephalous that female. Hydrocephalous is more common in male the possible reason for this is still not clear in literature but could be due to genetic, hormonal influences and difference in brain development of brain in male and female.[16] The future research to tackle this problem should focus on improvement in diagnostic tools, personalized medication, genetic research.

Moreover, in our study we compare the diagnostic accuracy of ultrasound in diagnosis of hydrocephalous and compare it with standard i.e. CT scan. In our study trans frontal ultrasound emerge as a good alternative of CT scan for diagnosis of Hydrocephalous in term of cost, protection from ionized radiation. The available literature also supports our study finding. The study conducted by K Obilo et. all[17] find out TF ultrasound as a use full diagnostic tool for diagnosis of hydrocephalous in children; K Obilo find out significant association of increase in ventricle size using TF Ultrasound and clinical sign and symptoms of hydrocephalous in children's. Moreover, Mboka Jacob et. all[18] also concluded the importance of trans frontal ultrasound as an important diagnostic tool for diagnosis and making management plan for hydrocephalous patients. Additionally, the study conducted by Songsaeng D et.all compare the diagnostic accuracy of TF ultrasound with standard CT scan and find that that TF Ultrasound is 77.14% sensitive, 99.05% specific in diagnosis of Hydrocephalous with positive predictive value of 97.59% and negative predictive value of 82%.[19] The results show a bit similarity with our study findings mentioned in results section. But some literature study results are different from our findings: for example, a study conducted by El Adioui G et.all compare the diagnostic accuracy of TF ultrasound with standard CT scan and find that that TF Ultrasound is 100% sensitive and 94.10% specific in diagnosis of Hydrocephalous.[20] The possible reason for difference from the literature study is that our study was conducted by trainee of Diagnostic Radiology; we might have less familiarity with diagnostic tolls as compare to the consultants. Additionally, differences in study design, patient populations, and equipment quality could have influenced the results.

Our study provides a valuable and detailed explanation to the diagnostic accuracy of trans-fontanelle sonography in detecting hydrocephalus, showing strong specificity (88.90%) and a reasonable positive predictive value (83.30%). It also includes a diverse sample of 33 patients with clear comparisons to CT scans. The weekness of our study is, it's one center study with not diverse sample size to generalized the study findings also the study focus on only transverse diameter of lateral ventricle. The future researches should focus on large sample size, multi-center study and include other diagnostic tools including the advance sonography practice for diagnoses of hydrocephalous.

CONCLUSION

In conclusion, the study highlights trans-fontanelle sonography to be a useful, non-invasive diagnostic tool for diagnosis of hydrocephalus in infants, especially when compared to the standard CT scan. While it shows a high specificity of 88.90%, meaning it accurately identifies patients who do not have hydrocephalus, its sensitivity of 66.70% indicates that it may miss some cases, particularly those with mild or early hydrocephalus. This makes ultrasound as a first line screening tool and a good option for ruling out the hydrocephalous

but not necessarily for confirming it in all cases.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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AUTHORSHIP AND CONTRIBUTION DECLARATION	
1	**Kalimullah:** Data collection, synopsis writing.
2	**Musa Khan:** Study topic.
3	**Abid Ali:** Data collection, manuscript writing.
4	**Mahibullah Khan:** Review manuscript.
5	**Muhammad Tariq:** Review manuscript, cross check.
6	**Dawood Khan:** Data collection.