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Comparison of Cranial Ultrasound and Computed Tomographic Scan Finding in Infants with Post Meningitis Complications

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ABSTRACT

Objective: To compare the findings of cranial ultrasound and computed tomographic (CT) scans in infants with post-meningitis complications.

Methodology: A prospective analysis of 124 consecutive term infants was conducted in the department of radiology at the Pakistan Institute of Medical Sciences, Islamabad from August 2021 to April 2022. Transfontanelle ultrasonography was performed with a two-dimensional Sonoace 1500 ultrasound scanner (Medison Inc, South Korea 1995) equipped with a 6.5 megahertz (MHz) curvilinear small head probe. Sagittal and coronal sections were scanned using standard techniques. We included all 124 confirm cases of meningitis came to our hospital in the period through consecutive non probability sampling, which fulfilled the required sample size to test the objective in our population.

Results: The average age of the infants was 4 months, with 71 (57.3%) males and 53 (42.7%) were females. Ultrasonography results were confirmed by CT scans in all patients. The diagnostic accuracy of ultrasonography was found to be 32.14%. Seizures disorders were the most common complication observed in the study population.

Conclusion: Using transfontanelle ultrasound, it is possible to diagnose lesions inside the infant's brain. Transfontanelle ultrasound scans are most often requested for hydrocephalus detection and for abnormal findings. Infants with post-meningitic complications commonly suffer seizures. In post meningitic complications, ultrasound can still be used as an early non-invasive diagnostic modality despite its low diagnostic accuracy. Improved collaboration between radiologists and pediatricians can lead to better outcomes and reduced mortality and morbidity in neonates and infants.

Keywords: CT scan, Post meningitis, Ultrasonography, Cranial Ultrasound.

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Introduction

Acute bacterial meningitis is a deadly disease, especially among newborns aged between 1 and 12 months. There is a high fatality rate associated with this disease, i.e., up to 30%.[1] This infection also varies in incidence among children of different ages. In infants younger than 2 months, this bacterial infection occurs most frequently.[2] Compared to countries with high incomes or developed nations, low- or middle-income countries are more likely to suffer from the disease.[3] Compared to Australia where the rate of bacterial meningitis was calculated to be 0.5 per 100,000, the rate of bacterial meningitis in South Sudan in 2016 was 270 per 100,000 in individuals of all ages.[4]

Pathogens invade the body and cause infection. There are two mechanisms by which the pathogen affects the central nervous system (CNS). The first mechanism involves invasion through the hematogenous route (bacteremia), while the second involves invasion through direct extension caused by sinusitis or mastoiditis and multiplying in the subarachnoid space. In the subarachnoid space, the natural immune response causes bacterial lysis.[5]

Cranial CT is used in simple cases of meningitis to exclude the risks of acute brain edema, hydrocephalus, and diseases of the base of the skull.[6] In contrast, complicated cases of meningitis are characterized by enlarged heads, heightened intracranial pressure, papilledema, and focal deficits. Imaging, particularly CT imaging, is required for such patients.[7]

An ultrasound scan of the infant brain through the fontanel, which functions as an acoustic window, has become a simple, accurate, cost-effective and non-invasive means of comparing normality and abnormality with great detail in infant brain anatomy.[8] As an alternative to plain skull radiography, conventional tomography or computed tomography (CT) scans, ultrasound is free of radiation hazards to the baby. In developing countries, even in remote areas, it is widely available because of its low power consumption and low cost.

So, this study aimed to compare cranial ultrasound and computed tomography findings in infants with post meningitis complications.

Methodology

The study was conducted in accordance with the Helsinki Declaration. This study was approved by the Ethical Review Board of Shaheed Zulfiqar Ali Bhutto Medical University – approval F 1.1/2015/ERB/SZABMU/928. Informed consent was obtained from parents of infants. This prospective cross sectional study was planned at Children Hospital (PIMS), Islamabad, on the patients came in between August 2021 to April 2022. The sample size of the study was calculated with the help of WHO sample size calculator, keeping the proportion of post-meningitis complication (hydrocephalus) 0.07, absolute precision 5% and level of significance 5%. Keeping the above reference characteristics, the minimum sample size for this study was 101. We included all 124 confirm cases of meningitis came to our hospital in the period through consecutive non probability sampling, which fulfilled the required sample size to test the objective in our population. We conducted trans fontanelle ultrasonography (TF-US) and cranial CT scans for detection of any post-meningitis complication after 3 weeks. Patients came with clinical signs and symptoms of CNS abnormalities were scan on emergency basis and treated if required.

CT scan results were considered gold standard. One of the authors performed all the TF-US without knowing the CT scan results. A 7.5 Mega Hz mechanical sectorial transducer was used in the ultrasound equipment. This study excluded patients with health conditions other than meningitis or who declined to participate. A questionnaire was used to collect data, and SPSS 22.0 was used to analyze it.

The study analyzed various factors such as age, gender, treatment completion time, post-meningitis complications, and early and late complications from cranial ultrasound and computed tomography scans. CT scans were used as the gold standard for calculating sensitivity, specificity, positive predictive value, negative predictive value, and accuracy of cranial ultrasound in detecting post-meningitis complications. Statistical significance was determined with a p-value ≤ 0.05 which was considered significant to interpret the results.

Results

Out of total 124 participants, mean age of participants was found to be 4 months, out of which 71 (57.3%) were males and 53 (42.7%) were females. Mean time duration in completion of treatment of meningitis after which complications appear was 7 days. Post-meningitis complications were confirmed through CT in 84 (67.7%). One sample t test was used to find out the minimum proportion of infants in our population who have chance to develop any post-meningitis complication. The result showed that post meningitis complications may be observed in at least 60% cases with p value 0.035.

Out of those 84 patients, post meningitic macrocephalic, hypersomnia, vomiting, seizures, vertical gaze restriction, eating problem, apneic spells and developmental delay were observed respectively as shown in table I.

Table I: Clinical Characteristics of Infants.

Variables	n (%)
Macrocephaly	20 (23.8%)
Hypersomnia	46 (54.8%)
Vomiting	20 (23.8%)
Seizures	66 (78.6%)
Vertical Gaze Restriction	20 (23.8%)
Eating problems	36 (42.9%)
Apneic Spells	7 (8.3%)
Developmental delays	27 (32.1%)

The results of computer tomography showed that 30 (35.7%) patients had hydrocephalus, 11 (13.1%) patients had brain atrophy, 2 (2.4%) patients had strokes, 35 (41.7%) patients had ventriculomegaly, and 6 (7.1%) patients had brain abscesses. Out of total 84 participants results of ultrasound showed that hydrocephalus, brain

atrophy, stroke, ventriculomegaly and brain abscesses were found in 21 (25%), 11(13.1%), 2(2.4%), 44 (52.4%) and 6(7.1%) patients respectively.

Sensitivity, specificity, positive predictive value, negative predictive value and diagnostic accuracy of cranial ultrasound keeping CT scan as gold standard was 42.9%, 7.5%, 49.3%, 5.9% and 31.5%, respectively. (Table II)

One sample t test was used to predict the maximum accuracy of cranial ultrasonography for detection of post-meningitis complications in infants. The result showed that there were maximum 39% chance that the cranial ultrasound gives you the accurate result as the computed tomography scan for detection of post meningitis complications with p value 0.037.

Table II: Frequency of diagnostic percentage of ultrasound and CT scan.

Cranial Ultrasound	Computed Tomography	
	Complication found	No Complication
Complication found	36	37
No Complication	48	3
Sensitivity	42.86%	
Specificity	7.5%	
Positive Predictive Value	49.32%	
Negative Predictive Value	5.88%	
Diagnostic Accuracy	31.45%	

Discussion

Seizure disorders were the most common complication observed in our study. Delayed check-ups or hospital visits have been associated with an increased risk of subdural effusions, hydrocephalus, hearing impairment, and seizure disorders, as noted by Softic et al.[2]

The seizures are reversible if they occur in the early stages of the disease. However, it is difficult to cure after 72 hours due to axonal damage and distortion of glutamate inhibitory pathways. In addition, it increases the chances of experiencing a cardiovascular event.[10] In his systematic review, Zunt et al. found that meningitis can cause symptomatic seizures, hydrocephalus, hearing loss, and mental retardation.[4] As reported by Zainel, children with meningitis aged less than 12 months are more likely to develop hydrocephalus, subdural effusions, seizure disorders, and hearing loss, and our study shows that meningitis causes hydrocephalus, strokes, and other symptoms (mean age was 4 months).[5]

(a)ultrasound image showing dilated bilateral frontal horns of lateral ventricles (b) and (c) CT images of the same patient showing hydrocephalus

It was reported by Saha et al. that 41% of patients in short- and long-term groups had deficiencies in mental development and psychomotor delay.[15] The Brazilian study showed that 5.88% of children developed learning disabilities, while 7.35% of children had developmental delays.[9] Hydrocephalus is another common problem. It has been reported in some research studies that neonatal Gram-negative meningitis patients are more likely to suffer from this particular problem.[11] After the passage of a few weeks, hydrocephalus appears as a complication of meningitis[9], which is supported by our study's results indicating that the most common complication of meningitis is hydrocephalus. CSF can be obstructive and communicating i.e. not adequately reabsorbed back into the blood stream in hydrocephalus. A temporary or permanent ventricular shunt placement may be required depending on the size of the hydrocephalus and the resultant neurologic impairment. It was reported that 50% percent of those who survived this disease had neurological complications.[12] Several factors affect the outcome of these complications, such as the patient's age or the organism that caused the infection.[13]

Transfontanelle ultrasonography findings may assist in intervening and treating conditions that predispose to these complications in developing countries although the low diagnostic accuracy as per our study. Meningitis plays a critical role in the pathogenesis of hydrocephalus, even though it is congenital.[14] Transfontanelle ultrasound shows brain anatomy as its primary objective.

Radiologists' performance will improve with improved awareness of the ability of cranial ultrasonography to diagnose or exclude brain lesions. Through improved collaboration between radiologists and paediatricians, early diagnosis of treatable intracranial lesions can be improved, resulting in fewer neonatal and infant deaths and morbidities.

Conclusion

Transfontanelle ultrasound is a valuable tool for diagnosing intracranial lesions in infants, particularly for detecting hydrocephalus and identifying abnormal findings. Despite its relatively low diagnostic accuracy in post-meningitis complications, ultrasound remains an important non-invasive diagnostic modality, especially in the early stages, for infants experiencing seizures and other complications. Further research and improvements in ultrasound technology may enhance its diagnostic capabilities in this context.

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