Accuracy of cranial ultrasound in the diagnosis of hydrocephalus in children under 6 months of age keeping CT scan as a gold standard

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Abstract

Introduction: CT and MRI modalities are considered a gold standard for the diagnosis of hydrocephalus. The more readily available and cheap options like sonography are being sought out for the diagnosis of this entity. Objectives: To determine the accuracy of cranial ultrasonography in the diagnosis of hydrocephalus keeping CT scan as a gold standard.

Study design: Cross-sectional study

Place and duration of study: Department of Pediatrics, Combined Military Hospital, Rawalpindi, from 01-01-2017 to 30-06-2017

Materials and Methods: A total of 121 children with a clinical diagnosis of hydrocephalus were selected and subjected to ultrasound of the head. Subsequently, a CT scan of the head was done and both modalities were compared. The diagnostic accuracy of the ultrasound was determined to keep CT findings as to the gold standard.

Results: The mean age was 51.36 ± 34.01 days. The male gender was dominant as 81 (66.9%) patients were males. Ultrasonography of the head detected 93 (76.9%) patients with hydrocephalus while CT scan detected 90 (74.4%). Sensitivity, specificity, PPV, NPV and accuracy of USG to diagnosed hydrocephalus were 88.9%, 58.1%, 86.0%, 64.3% and 80.99% respectively

Conclusion: Ultrasonography of head is a valuable screening tool for the diagnosis of hydrocephalus.

Keywords: Hydrocephalus, Tomography, X-Ray Computed, Ultrasonography.
**Introduction**

Hydrocephalus can be defined broadly as a disturbance of cerebrospinal fluid (CSF) at the level of formation, flow, or absorption. This leads to an increase in the volume occupied by CSF in the central nervous system (CNS). Hydrocephalus is one of the most common pathologies in newborns, which affects 4.65 per 10,000 live births. Surgery is the mainstay of treatment options to avoid further developmental disabilities. More than 150 causes have been attributed to this condition. The most common acquired cause is the brain hemorrhage associated with premature birth. The males are affected more when the condition is congenital. The excessive fluid in the skull may lead to brain compression and mental retardation.

The hydrocephalus is diagnosed clinically and adjuncts of radiological investigations can give insight regarding confirmation of diagnosis and its etiology. Ultrasonography (USG) is considered a basic screening tool for macrocephalic children. Moreover, sensitivity and specificity are more than 75%. The prognosis of the disease can be monitored by serial imaging without any danger of radiation hazards. Ultrasonography of the head is recommended as a basic tool to evaluate the cases of macrocephaly in countries like Pakistan where the availability is advanced neuroimaging techniques is scarce. Among the advanced neuroimaging, a CT scan is a cost-effective tool for the evaluation of hydrocephalus. CT scan coupled with myelography is an effective alternative of magnetic resonance imaging (MRI) where the facilities are limited. Etiological and pathological features of hydrocephalus are better studied with CT scanning and it is more than 90% sensitive and specific for this disease.

USG for the evaluation of suspected hydrocephalus is a safe, cheap, portable, readily available and radiation-free option. The aim of my study is to evaluate the diagnostic accuracy of USG for hydrocephalus in children keeping CT scans as a gold standard. The results can help us to use USG as a good alternative for CT scan as limited availability of this entity in our country. The data would help the clinicians to gain insight regarding better diagnostic modality for hydrocephalus which is cost-effective.

**Materials and Methods**

In this cross-sectional study, after ethical committee approval, 121 neonates with clinical features of hydrocephalus (increasing head size, dysmorphic features, myelomeningocele, etc.) were selected from the Department of Pediatrics, Combined Military Hospital, Rawalpindi. The sample size was calculated from a previous study taking the anticipated proportion of hydrocephalus as 76%. The precision level was kept at 7% and the level of confidence at 95%. The duration of the study was 01-01-2017 to 30-06-2017 and non-probability consecutive sampling was used. The age limit was kept under 06 months and both male and female genders were included. Informed written consent was taken from all guardians. All patients underwent cranial USG by consultant radiologist using real-time apparatus of Esoate Biomedical, AU3 USG machine with a 5-7MHz probe. Cranial USG examination of anterior, middle and posterior cranial fossa structures and CSF circulating in the ventricular chain was made in recommended standard views using open fontanelles was done. The patients were labeled as having hydrocephalus when the mean transverse diameter of the lateral ventricle at the level of atria was more than 10 mm on cranial USG. All patients underwent subsequent CT scanning and reporting radiologist was kept blind about USG results. The same diagnostic criteria were used in CT scan images i.e. the width of more than 10 mm at the level of atria.

Data was analyzed using SPSS version 20 for Microsoft Windows, IBM. Quantitative variables like age, size of the ventricle were expressed as mean and standard deviation. Qualitative variables like gender, hydrocephalus were expressed as frequency and proportions. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and accuracy were calculated for USG keeping CT findings as the gold standard. P-value of ≤ 0.05 was considered significant.

**Results**

The data of 121 patients were analyzed. The mean age was 51.36 ± 34.01 days. The male gender was dominant as 81 (66.9%) patients were males as shown in Figure 1. Ultrasonography of the head detected 93 (76.9%) patients with hydrocephalus while CT scan detected 90 (74.4%). Sensitivity, specificity, PPV, NPV, and accuracy of USG to diagnosed hydrocephalus are...
given in Table 1. The data were stratified for age and gender groups. Both age groups had almost similar results while the specificity and diagnostic accuracy were highest for female gender (Table 2 & 3).

Table 1. USG versus CT scan for detection of hydrocephalus.

| Detection of hydrocephalus by modality | CT scan | Total |
|----------------------------------------|---------|-------|
|                                        | Positive| Negative|
| USG Positive                           | 80      | 13    | 93    |
| Negative                               | 10      | 18    | 28    |
| Total                                  | 90      | 31    | 121   |

Sensitivity = 88.9%, Specificity = 58.1%, PPV = 86.0%, NPV = 64.3%, Accuracy = 80.99%

Table 2. USG versus CT comparison after gender stratification.

| Gender | Detection of hydrocephalus by modality | CT scan | Total |
|--------|----------------------------------------|---------|-------|
|        |                                        | Positive| Negative|
| Male   | USG Positive                           | 51      | 12    | 63    |
|        | Negative                               | 07      | 11    | 18    |
|        | Total                                  | 58      | 23    | 81    |
| Female | USG Positive                           | 29      | 01    | 30    |
|        | Negative                               | 03      | 07    | 10    |
|        | Total                                  | 32      | 08    | 40    |

Male: Sensitivity = 87.9%, Specificity = 47.8%, PPV = 81.0%, NPV = 61.1%, Accuracy = 76.54%
Female: Sensitivity = 90.6%, Specificity = 87.5%, PPV = 96.7%, NPV = 70.0%, Accuracy = 90%

Table 3. USG versus CT comparison after age stratification.

| Age group | Detection of hydrocephalus by modality | CT scan | Total |
|-----------|----------------------------------------|---------|-------|
|           |                                        | Positive| Negative|
| <50 days  | USG Positive                           | 40      | 07    | 47    |
|           | Negative                               | 06      | 10    | 16    |
|           | Total                                  | 46      | 17    | 63    |
| >50 days  | USG Positive                           | 40      | 06    | 46    |
|           | Negative                               | 04      | 08    | 12    |
|           | Total                                  | 44      | 14    | 58    |

<50 days: Sensitivity = 87.0%, Specificity = 58.1%, PPV = 85.1%, NPV = 62.5%, Accuracy = 79.36%
>50 days: Sensitivity = 90.9%, Specificity = 57.1%, PPV = 87.0%, NPV = 66.7%, Accuracy = 82.76%

Figure 1. Pie chart of gender distribution

Figure 2. Coronal CT showing vertex cephalhematoma
In conclusion, ultrasonography in children under six months for the diagnosis of hydrocephalus is a good initial investigation in suspected cases. CT scanning ensures more accuracy and diagnostic information. The larger-scale study would help to evaluate cranial sonography more accurately.

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Discussion

The early diagnosis of neonatal hydrocephalus in children is the key to management to avoid neurological damages associated with it. The most common type of hydrocephalus is non-communicating and cause is intraventricular hemorrhage. The management via surgical approaches is best but the type of surgery depends upon where the accumulation of CSF occurs. Initial diagnosis of hydrocephalus is always clinical when the head circumference is increased. The use of USG, CT, and MRI is focused on the ventricular volumes and sizes. The uses of advanced radiological investigations are helpful in determining the possible cause and effects of hydrocephalus. Cranial sonography is the best initial radiological investigation due to its availability and portability. The preterm infants with the possibility of germinal matrix hemorrhages are not able to tolerate transport for CT or MRI, so USG provides good early diagnostic information. Ultrasoundography through the anterior fontanelle in infants is helpful for the evaluation of subependymal and intraventricular hemorrhage. Cranial sonography is also beneficial in the diagnosis of various neonatal pathologies other than hydrocephalus. MRI is the best diagnostic and prognostic modality but availability and cost are the major concerns over it. CT scan exposes patients to a high dose of radiations, so a low dose protocol may be a suitable alternative. All newer radiological protocols are aimed to minimize the radiation exposure.

In our study the sensitivity of USG to detect hydrocephalus was 88.9% the specificity was 58.1%. This makes sonography not an ideal investigation for hydrocephalus but it can be used as a better screening tool. All cranial pathologies can be more accurately assessed by sonography when the neonatal skull windows are wider. So, the prematurity and diagnostic accuracy of sonography are directly proportional. In my study, the accuracy of USG was 79.36% and 82.76% for the age <50 and >50 days respectively. No significant difference was noted between age groups. Specificity and diagnostic accuracy were highest for the female gender.
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