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Original Research Article

Cranial Computed Tomographic Findings in Children with Hydrocephalus in Sokoto North Western Nigeria

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Background: Hydrocephalus is a condition in which excess fluid accumulates in the brain resulting in dilatation of the ventricles. The prognosis of hydrocephalus depends on the cause and severity of the condition. Computed tomography (CT) is one of the imaging modalities used for diagnosis and evaluation of treatment options as well as for follow up and monitoring of the patients. ***Aim and Objectives:*** This study is aimed at documenting CT findings of hydrocephalus in children at Usmanu Danfodiyo University Teaching Hospital (UDUTH) Sokoto with specific objectives of determining the common causes of hydrocephalus and comparing the incidence of congenital and acquired hydrocephalus. ***Materials and Methods:*** This was a four-year retrospective study of 100 consecutive children with clinical and/or Computarized Tomographic (CT) diagnosis of hydrocephalus who had CT scan at the Radiology Department of UDUTH Sokoto, North Western Nigeria. Data and the images were retrieved from the departmental archives and patient's case folders. These data regarding the demographics of patients, clinical history and examination, cranial CT findings and radiological measurements were entered into the proforma. Data was analyzed using SPSS statistical software package version 20. ***Results***: The age range of patients was from 5 days to 14 years with male/female ratio of 1.6:1. Congenital hydrocephalus accounted for 54% while acquired hydrocephalus occured in 46%. Non communicating hydrocephalus was the predominant form of hydrocephalus accounting for 59% while communicating hydrocephalus occured in 41% of patients. Aqueductal stenosis (32%) was the commonest cause of hydrocephalus followed by post meningitic hydrocephalus (22%) and intracranial tumours (16%) respectively. ***Conclusion:*** This study shows that congenital hydrocephalus is the predominant type in the study population. Aqueductal stenosis was the commonest cause of hydrocephalus.

Keywords: Cranial Computed Tomographic Hydrocephalus brain Aqueductal.

INTRODUCTION

The term hydrocephalus literally means "water in the brain" and in this condition, excess fluid accumulates in the brain resulting in dilatation of the ventricles [1]. It results from imbalance between cerebrospinal fluid (CSF) production and absorption. CSF is produced by the choroid plexus of the two lateral ventricles, the third and the fourth ventricles, though some may be formed on the surface of the brain and spinal cord [2]. The rate of formation of CSF is 0.35-0.40ml/minutes which is equivalent to about 500ml per day and this is same for both paediatric and adult population [1].

The overall incidence of hydrocephalus is unknown. The reported incidence of primary congenital hydrocephalus is 0.9-1.5 per 1000 births. Those occurring with spina bifida and myelomeningocele vary from 1.3 to 2.9 per 1000 births [1]. In the United States, the incidence of congenital hydrocephalus is 3 per 1000 births, while that of acquired hydrocephalus is not known exactly due to variety of disorders that may cause it [3]. Although no reliable estimate is available in the African literature, the incidence is likely to be higher because of untreated/poorly treated neonatal meningitis and nutritional deficiencies [4]. Generally, the incidence of hydrocephalus is the same for males and females [3].

The cause of hydrocephalus is either congenital or acquired. Children with hydrocephalus present with macrocephaly associated with tense/bulging fontanelle, 'setting-sun' sign, vomiting, reduced activity, lower limb spasticity and hypertonia [5]. Hydrocephalus in children, if untreated, causes developmental disorders, mental deficiencies and shortened life expectancy in addition to blindness and other neurological deficits as a result of cerebral injury due to compression of brain tissues [2].

Various imaging methods play roles in the diagnosis of hydrocephalus with each having its limitations. Plain radiography of the skull shows features of raised intra cranial pressure which is nonspecific for hydrocephalus. Ultrasonography is unsuitable in older children with fused fontanelles. Magnetic resonance imaging (MRI) has excellent soft tissue resolution but has a long time of acquisation of images which make sedation necessary in children. Computed tomography (CT) on the other hand is rapid, compatible with life support devices and often requires no sedation in children [5]. Computed tomography plays a central role in diagnosing hydrocephalus and also in the evaluation of treatment options, follow up and monitoring of patients [6].

There is also paucity of research work on CT findings in children with hydrocephalus in the study area. Therefore, this study will serve as baseline for comparison with other regions and future studies.

This study is carried out to document pattern of intracranial findings on CT in children with hydrocephalus in the study area. The common causes of hydrocephalus in children in the study population will also be determined. This may enhance the treatment option and improve the prognosis of children with the disease.

MATERIALS AND METHODS

This is a four year (January 2009 – December 2013) cross sectional retrospective study of 100 consecutive paediatric patients with a clinical and/or CT diagnosis of Hydrocephalus. Cranial CT was performed at the Radiology Department UDUTH Sokoto, North Western Nigeria. All children < 14 years that had cranial CT in the Radiology Department, UDUTH between January, 2009 and December, 2013 with clinical and/or CT diagnosis of hydrocephalus were included in the study. Ethical approval to conduct the study was obtained from the Ethical Committee of UDUTH Sokoto.

All patients had brain CT scan using the spiral dual slice computed tomographic scanner of Phillip Neusoft, manufactured 2003. Contigous axial 5mm slices were obtained pre and post intravenous contrast medium from vertex to the base of the skull. Images were reformatted in coronal and sagittal sections and stored in the memory of the CT scanner before being copied on LG recordable CDs.

In this study the patients' biodata were retrieved from the Departmental archives mainly departmental record books, patient's cards and reports. The hospital number on the patient's cards was used to retrieve their case folders from the Medical Records department of the hospital. Information obtained include name, age, sex, tribe, address, presenting complain, onset of symptoms, clinical diagnosis and indication for cranial CT. Gaps in patients records from the Radiology cards were made up from the case folders. The patients CT images were retrieved from the memory of the CT scanner and the back-up recordable CDs in the CT suite of the Department. Cranial CT scans and ventricular measurements were obtained using the normal departmental protocol.

The data obtained was analyzed using statistical package for social sciences (SPSS) version 20. Analysis of descriptive statistics using mean and standard deviation (SD) for quantitative data (age, CMT and Evans ratio) and frequencies for qualitative data (gender, tribe, address, causes, types and forms of hydrocephalus) was done. This was followed by inferential statistics using Chi square test to determine associations between categorical variables and independent t test was done for continuous variables.

The result was presented in form of tables and charts. All statistical tests were carried out using a two-tail test, with level of significance set at 0.05.

RESULTS

A total of 100 patients who had brain CT scan over a 4-year period (January 2009 – December 2013) were studied. Sixty-two (62) of the patients were male and 38 were female with male/female ratio of 1.6:1. The mean age was 3.3 ± 3.7 years with a range of 5 days to 14 years. The patients were divided into five groups according to their ages in years. The highest number of patients (64) was recorded in the age group 0-3 years. There was a gradual decrease in the number of patients with increasing age.

The tribe of the patients was mainly Hausa (85%) with Yoruba and Igbo accounting for 4% each. Two percent of the patients were from neighboring Niger republic.

Suspected hydrocephalus (43%) was the most common clinical indication for requesting CT scans in the patients studied followed by meningitis (22%), space occupying lesion (16%), and lumbar myelomeningocele (6%) as shown in table 1.

Table-1: Clinical indications for CT in patients

Clinical indications	Frequency %
Encephalocele	5
Head injury	5
Hydrocephalus	42
Intracranial metastasis	1
Lumbar myelomeningocele	6
Meningitis	22
Sacral meningocele	2
Space occupying lesion	16
Total	**100**

The majority of the cases of hydrocephalus were the congenital type consisting of 54 patients with an incidence of 54% while the acquired hydrocephalus was found in 46% (table 2). There was no statistically significant difference in gender of patients among the types or causes of hydrocephalus (table 3).

Table-2: Type and form of hydrocephalus among study patients

Type of hydrocephalus	Frequency (N)	%	Test statistics
Congenital	54	54	One sample binomial test
Acquired	46	46	P = 0.194*
Total	**100**	**100**	
Form of hydrocephalus			
Communicating	41	41	One sample binomial test
Non communicating	59	59	P = 0.089*
Total	**100**	**100**	

*P > 0.05- Not statistically significant

Table-3: Association between gender and the type and cause of hydrocephalus in study patients

Variables	Sex of patients		Test statistics
	Male	Female	
Type of hydrocephalus			
Congenital	32	22	$X^2 = 0.948^a$
Acquired	30	16	df = 1 p =0.330 *
Total	**62**	**38**	
Cause of hydrocephalus			
Anold Chiari Malformation	2	0	
Aqueductal Stenosis	18	14	
Cranial Tumours	9	7	Fisher's test = 5.143
Dandy Walker Malformation	3	1	p = 0.786 *
Foramen of Monro Stenosis	2	1	
Intraventricular Haemorrhage	2	1	
Myelomeningocele/encephalocele associated	6	7	
Post Meningitic	16	6	
Post Traumatic	4	1	
Total	**62**	**38**	

*P > 0.05 - Not statistically significant

Non communicating hydrocephalus was the predominant form occurring in 59 patients but the difference was not statistically significant (P = 0.089) as shown in table 2. Aqueductal stenosis was found in 32 of 54 patients (59.3%) with congenital type of hydrocephalus, followed by myelomeningocele in 13 patients and Dandy-walker malformation in 4 patients. Arnold chiari malformation was the least with 2 patients (table 4). Meningitis was the commonest cause of acquired hydrocephalus occurring in 22 of 46 patients (47.8%), while intracranial tumours and trauma accounted for 16 patients and 5 patients respectively (fig 1). Intraventricular haemorrhage was the least with 3 patients.

Table-4: Causes of congenital hydrocephalus among study subjects

Causes of congenital hydrocephalus	Frequency N (%)	Test statistics
Aqueductal stenosis	32 (59.3%)	
Arnold Chiari malformation	2 (3.7%)	
Dandy-Walker malformation	4 (7.4%)	
Foramen of Monro stenosis	3 (5.5%)	One sample x^2 test
Myelomeningocele associated	13 (24.1%)	P < 0.01 *
Total	**54 (100%)**	

*P < 0.05 – Statistically Significant

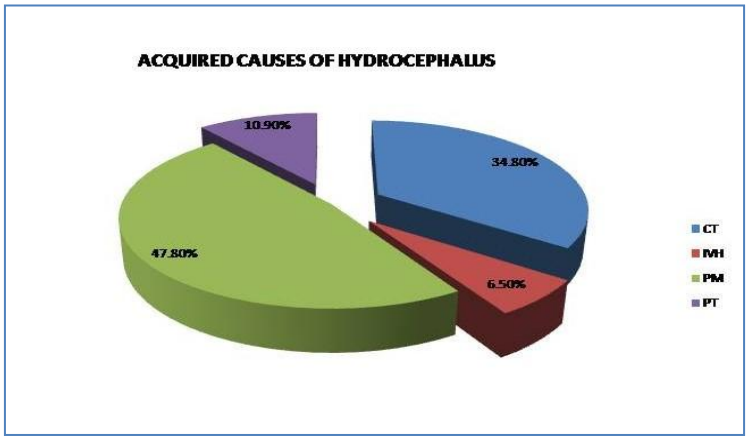

Fig-1: Pie chart showing distribution of causes of acquired hydrocephalus. CT = cranial tumours, IVH= intraventricular haemorrhage, PM = post meningitic, PT = post traumatic

Among all the causes of hydrocephalus, aqueductal stenosis (32%) was found to be the commonest (fig. 2), followed by meningitis (fig. 3) and cranial tumour (fig. 4) respectively. Arnold Chiari malformation (2%) was found to be the least cause of hydrocephalus. This difference was statistically significant, p < 0.05. However, there was no statistically significant gender difference among the causes of hydrocephalus (table 3).

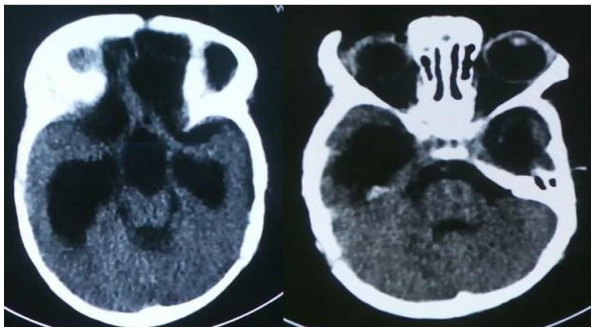

Fig-2: Axial CT brain at different levels in a 5 months old female child with non-communicating hydrocephalus due to aqueductal stenosis showing dilated lateral and third ventricles. The fourth ventricle is normal in size and not dilated.

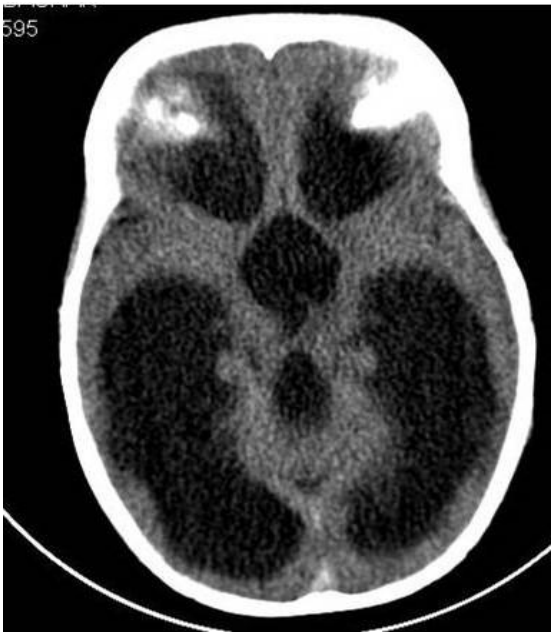

Fig-3: Axial unenhanced CT brain at the level of the third ventricle in a 1year old male child with post meningitic communicating hydrocephalus showing dilated third ventricle, dilated right posterior horn of the lateral ventricle and dilated fourth ventricle.

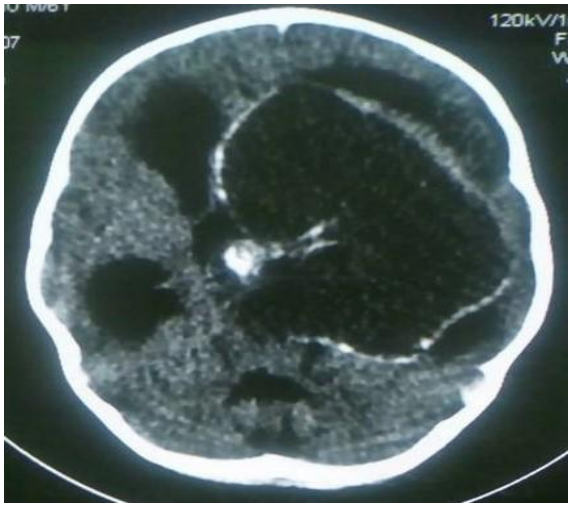

Fig-4: Contrast enhanced axial CT brain in a 6-year-old male child showing a huge supratentorial brain tumour with enhancing wall and a calcified pineal gland. Note secondary dilatation of the lateral and third ventricles.

The mean cerebral mantle thickness (CMT) was 17.5mm ± 10.3 on the right side and 16.6mm ± 9.4 on the left. There was statistically significant relationship between the cerebral mantle thickness and the forms of hydrocephalus. Non communicating hydrocephalus was found to be associated with less CMT implying more cerebral mantle thinning than communicating hydrocephalus ($p = 0.017$ and $p = 0.005$ on the right and left sides respectively).

The mean Evan's ratio was 0.49 ± 0.13. The mean Evan's ratio was found to be higher in the age range 0-3 years. There was gradual decrease in Evan's ratio with age group of patients with the lowest value recorded in 12-14 age group. A statistically significant relationship was observed between Evan's ratio and the type ($p = 0.015$) and form ($p = 0.017$) of hydrocephalus. Evan's ratio was found to be higher in congenital and non-communicating hydrocephalus.

Other incidental CT findings in this study are cerebral infarct seen as non-enhancing hypodense area in the brain parenchyma (7%), midline shift (7%), skull defect due to trauma and encephalocele (5%), cerebral abscess (3%), multiple hyperdense foci in the cerebrospinal fluid (1%) and gyral enhancement (1%).

DISCUSSION

Childhood hydrocephalus can present both in early and late childhood. In this study the age range of the patients was from 5 days to 14 years. There was gradual decrease in the number of patients with increasing age. This finding is consistent with that of Saidu et al. [7] in an earlier study of pattern of hydrocephalus among the under-five in Sokoto. Idowu et al. [8] in a study titled etiology and CT scan profile of non-tumorous hydrocephalus in children aged 4 days to 6 years in Lagos also reported gradual decrease in number of patients with increasing age. This gradual decrease is presumably as a result of surgical intervention which is preferably performed while the patients are younger.

There was slight (statistically significant, $P = 0.021$) male preponderance in this study with a male: female ratio of 1.6:1. This finding is consistent with that of Al Naddawi et al [9]. However Sergio et al. [10] found no gender preponderance with a male: female ratio of 1:1. This difference may be accounted for by the higher age range of patients in the present study. Congenital type of hydrocephalus (54%) was found to be more common than acquired hydrocephalus in this study. Sa'idu et al. [7], Nzeh et al. [11], and Idowu et al. [8] in Sokoto, Ilorin and Lagos, Nigeria respectively also reported predominance of congenital hydrocephalus in their studies. In contrast to our finding however, Komlonvi et al. [12] and Warf [13] reported more acquired (67.27% and 63%) than congenital hydrocephalus.

Aqueductal stenosis (59.3%) and myelomeningocele associated hydrocephalus (24.1%) constitute the majority of congenital hydrocephalus in this study. This agrees with the findings of Idowu et al. [8]

Adeloye [14], shows that congenital hydrocephalus was accounted for by aqueductal stenosis in only 23.8%. The different imaging modalities used in the studies may be responsible for this variation.

Myelomeningocele associated hydrocephalus was observed in 24.1% of cases. Mahmud et al. [15] in a previous study in Sokoto reported 21% association of hydrocephalus with spina bifida. Idowu et al. [8] reported 30.7% of myelomeningocele associated hydrocephalus. A higher rate of myelomeningocele associated hydrocephalus (43%) was reported by Gathura [16] in Kenya.

Meningitis (47.8%) was the most frequent cause of acquired hydrocephalus in this study. This finding is consistent with the study by Eze et al. [17] in Benin City in Southern Nigeria. Lingling [18] and Warf [13] also reported similar findings. However, at variance with the study findings, Pomschar et al. [19] in Germany recorded intracranial tumours as the majority of the causes of acquired hydrocephalus.

Among all the causes of hydrocephalus in this study, aqueductal stenosis (32%) was found to be the commonest followed by the post meningitic variety (22%) and those associated with cranial tumours (16%). Idowu et al. [8] reported that hydrocephalus associated with myelomeningocele (30.7%) was the commonest followed by aqueductal stenosis (22.6%) and post meningitic hydrocephalus (17.5%).This may be due to

regional variation and increased nutritional awareness in women of reproductive age. Komlonvi [12] in Togo reported post meningitic hydrocephalus (41.82%) to be the commonest followed by aqueductal stenosis (21.82%). Post hemorrhagic aqueductal stenosis, intracranial tumours and Dandy-Walker malformation were found to be common causes in that order in a study of hydrocephalus in children; causes and imaging patterns by Pomschar et al. [19] in Germany. In this study non communicating hydrocephalus was the most frequent form of hydrocephalus and this agrees with the findings of Pomschar et al. [19]

The predominance of non-communicating hydrocephalus in this study is presumably due to high frequency of obstructive conditions such as aqueductal stenosis and cranial tumours.

The mean cortical mantle thickness in this study was 17.5mm and 16.6mm on the right and left cerebral hemisphere respectively. Idowu et al. [8] reported a lower mean cortical mantle thickness (10.8mm). This higher value of mean cerebral mantle thickness in this study may be due to inclusion of tumorous hydrocephalus and higher age range of patients studied. A statistically significant association was found between the form of hydrocephalus and cerebral mantle thickness ($p = 0.017$ and $p = 0.005$ on the right and left sides respectively).The degree of cerebral mantle thinning was more in non communicating hydrocephalus than communicating hydrocephalus consistent with Venathramana et al. [20]. The mean Evan's ratio in this study (0.49) is at variance with findings of Idowu et al. [15] in which they reported mean Evan's ratio of 0.56.

CONCLUSION

This study shows that congenital hydrocephalus is the predominant type in the study area. Aqueductal stenosis was the commonest cause of hydrocephalus followed by meningitis and cranial tumours. Non communicating hydrocephalus is associated with more cerebral mantle thinning.

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