Original Article

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Hydrocephalus - The Cross Sectional Radiological Study of Epidemiology, Classification and Causes

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Abstract

Background: Hydrocephalus is an active distension of the ventricular system of the brain resulting from inadequate passage of CSF from its point of production within the cerebral ventricles to its point of absorption into the systemic circulation. **Subjects and Methods:** This study evaluating the efficacy of Computed Tomography in the diagnosis of Hydrocephalus was done on 74 cases. All the cases were studied on a Siemens Somatom ARC Computed Tomography system which is a modified Third generation machine. Factors of 130 KV and 70 MA were a constant for all cases and factors of 110 KV and 50 MA were used for infants. Demographic profile and radiological parameters were studied and tabulated on Microsoft excel file. **Results:** Tubercular meningitis was the commonest cause of hydrocephalus, with aqueduct, stenosis and tumours as the second important causes. All patients with possible hydrocephalus should have an initial, complete noncontrast CT scan with serial sections from vertex down through the upper cervical region to i. demonstrate size of all ventricles and cisterns to help rule out low lying tumors, the Chiari I and Chiari II malformation. **Conclusion:** CT is a valuable tool with a very high diagnostic sensitivity and helps in early detection of hydrocephalus and its management.

Keywords: Hydrocephalus, Radiological, Epidemiology, Classification.

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Introduction

Hydrocephalus is an active distension of the ventricular system of the brain resulting from inadequate passage of CSF from its point of production within the cerebral ventricles to its point of absorption into the systemic circulation." The elements of this definition are simple and therefore, the number of processes included within it is limited and manageable. Hydrocephalus is an active condition. It is a process that can be demonstrated on neuroimaging studies, and the definition suggests that there is a common underlying cause for its different manifestations: a mismatch between CSF production and its absorption.[1,2]

Because the definition requires an active process, it excludes brain atrophy or ex vacuo hydrocephalus. Similarly, because this definition requires ventricular distention (ventriculomegaly), it excludes conditions in which there is a failure of CSF absorption such as pseudotumorcerebri (also called benign intracranial hypertension) and normal volume hydrocephalus, this latter being limited to patients shunted during infancy, but found to have increased intracranial pressure (ICP) without ventricular distension at the time of shunt failure. The exclusion of these two conditions will provoke especially energetic debate. It is clear that they are close relatives of hydrocephalus as they are associated with high intracranial pressure and are caused by an increase in the resistance to flow of CSF. They are excluded from the above definition because of the absence of ventricular dilatation.[3-5]

The classification of communicating or obstructive (non-communicating) was extremely useful for understanding hydrocephalus as well as for guiding the search for therapeutic options for the management of the condition. Soon, however, the classification was recognized as an inadequate portrayal of the pathophysiology underlying hydrocephalus. In a brilliant but infrequently cited study, many authors reviewed and updated Dandy's ideas.6]These researchers realized that the crude techniques available to Dandy were inadequate to understand the spectrum of diseases that led to hydrocephalus. They updated the classification to incorporate what was then understood of the pathophysiology of the condition and proposed that Dandy's classification be modified.[7,8]

With the rare exception of hydrocephalus associated with overproduction of CSF in patients with choroid plexus papillomas (CPPs), all hydrocephalus is basically obstructive. That the rare CPP causes hydrocephalus is not debated, but why it does so is the subject of some discussion. CPPs are known to lead to increases in the rate of CSF production and are known to cause hydrocephalus.[9-11]

Normal CSF absorptive mechanisms can clear the amount of spinal fluid produced in the ventricular system at

extremely high rates without producing ventriculomegaly. If CSF production and ICP increase substantially, ventricular size increases. When CSF flow is obstructed in the context of increased CSF production, there is a great tendency for ventriculomegaly or hydrocephalus to develop. CPPs, in themselves, can create the only pure form of "communicating" hydrocephalus. However, that these tumors tend to be large and to restrict CSF flow through the foramen of Monro or aqueduct of Sylvius, is more likely to account for the severity of hydrocephalus in this context.[7,12]

Obtaining a consensus on a working definition of hydrocephalus and especially on a method of classifying this complicated condition is a challenge worth pursuing. A consensus would improve the focus on basic research, the development of logical approaches to treatment decisions, the planning of prospective trials, and the development of new technologies to improve the outcomes of this most chronic of medical conditions.

Subjects and Methods

This study evaluating the efficacy of Computed Tomography in the diagnosis of Hydrocephalus was done on 74 cases. The patients were referred to our department from the Paediatric, Neurosurgery and Neurology departments on the basis of their clinical presentation.

Selection of patients:

The patients who were subjected for the study include:

1. Clinically diagnosed cases of hydrocephalus.
2. Patients who were undergoing CT for other indications (Eg: Suspected tumor) and in whom hydrocephalus was detected incidentally.
3. Infants with meningomyelocele and other congenital malformations who were suspected to have hydrocephalus and which were confirmed after CT imaging.
4. Suspected cases of Tubercular Meningitis.

A detailed history along with complete clinical examination and laboratory investigations was done before the CT examination. This study was conducted in the department of RadiodiagnosisBapuji Hospital between Januray 1996 and March 1998.

The computed tomography (CT) machine:

All the cases were studied on a Siemens Somatom ARC Computed Tomography system which is a modified Third generation machine. Factors of 130 KV and 70 MA were a constant for all cases and factors of 110 KV and 50 MA were used for infants.

Preparation of patients:

Prior to performing the scan, particularly in infants and children aged one month to six years, sedation was usually required. The purpose of sedation was to avoid motion artifact and to ensure a CT scan of diagnostic quality. From six years onwards the need for sedation generally decreased. Sedatives used in our institution were Tricloryl syrup administered orally. Dosage:- for infants - 1/4 to 1/2 tsp, young children 1 tsp and older children upto 2 tsp. (Each 5 ml- 1 tsp contains Triclofos sodium BP 500 mg) adminstered 30 minutes prior to the study.

Intravenous Diazepam (Valium) was also used quite frequently. Dose: 0.2-0.4 mg/kg either IV/ rectal.

Patients were kept nil orally 4 hours prior to the procedure to avoid complications of contrast. In infants the last feed before the procedure was omitted.

Technique:

Routine axial scans were performed on all the 74 cases, taking, infraorbito-meatal line as the baseline. 5 mm slices for posterior fossa with 5 mm table increment and 10 mm slice for the supratentorial region with 10 mm table increment with a scan time of 3 seconds were employed routinely. Thin slices were done where-ever necessary. Sagittal and Coronal reconstrucions were done whenever necessary. Coronal scans were not done routinely and were obtained wherever necessary.

For contrast enhancement, a bolus injection of DiatrizoateMeglumine and Diatrizoate sodium were given in the dose of 300 nig Iodine /Kg of body weight.

i.e., Trazograf or Urografin 60% - in children

Trazograf 76% or Urograffin 76%o - in adults.

This was given just before the contrast enhancement CT was to be performed.

Following parameters were measured:

Ventricles: lateral Ventricle:

Ventricle: size of the ventricles:

Dilated/not dilated

Mass lesions: yes /no

Connected with ventricles / not connected posterior cranial fossa:

Impression: iv.

C.T. findings:

Topogram: supratentorium:

Ventricles: lateral ventricles: dilated /not dilated

Dilated /not dilated

A. Ventricle :

B. Ventricle :

Size of the ventricles: bodies of lateral ventricle: frontal horn: 3rd ventricle:

Size.

Ventricular size index:

Ratio of transverse diameter of frontal horns ratio of transverse diameter of skull at inner table

Site of obstruction: cisterns: sulci:

Periventricular oedema: present /not present cerebral parenchyma: thinned out/not thinned out. Focal mass lesions: yes/no cystic / solid mass: number: connected with ventricles/not present

Haemorrhage: present/not present calcification: present /not present.

Enhancement after contrast administration: yes/no cavumseputmpellucidum: persistent/not persistent subdural hematoma /collection: yes/no

Extradural hematoma/collection: yes/no

Intracerebralhaemorrhage: subarachnoid hameorrhage:

Posterior fossa: cerebellum:
Fourth ventricle: dilated/not dilated size:
Aqueduct of sylvius:

Results & Discussion

Our study included a total of 74 cases of hydrocephalus which were diagnosed by means of CT imaging in association with clinical and lab findings.

Table 1: Incidence of number of patients with Hydrocephalus according to age: (n=74)

Age	No. of Cases	Percentage
0-1 Years	28	38
1-3 Years	18	24
3-6 Years	09	12
6-12 Years	11	15
> 12 Years	08	11
Total	74	100

In our study of CT evaluation of hydrocephalus the most common age group was 0-1 years - infants, they accounted for a total of 28 cases (38%). The next common age group was between 1-3 years and they accounted for a total of 18 cases (24%).
Adolescents and adults (>12 years) constituted only a small percentage in our study accounting for a total of 8 cases (11%).

Table 2: Distribution of causes of hydrocephalus

Causes	Cases	Percentage
Tubercular Meningitis	20	27
Aqueduct Stenosis	15	20
Tumours	15	20
Congenital Communicating Hydrocephalus	13	17
Dandy Walker Malformation	7	10
Intracranial Haemorrhage	2	3
Others	2	3
Total	74	100

Table 3: Incidence of communicating and obstructive hydrocephalus

Type	Cases	Percentage
Obstructive (Non communicating)	38	51
Communicating	36	48

Table 4: Distribution of causes of Hydrocephalus in obstructive type

Causes	Cases	Percentage
1. Aqueduct stenosis or Obstruction at aqueduct	15	40
2. Obstruction at the level of IVth ventricle (Tumors)	08	21
3. Dandy Walker cyst and outlet foramina obstruction	08	21
4. Obstruction at anterior Illrd ventricle	03	08
5. Obstruction at posterior Illrd ventricle	03	08
6. Others	01	02

This study showed Tubercular meningitis as the major cause of hydrocephalus, and it accounted for (20 cases) 27% of cases. The next 2 important causes included aqueduct stenosis and tumours which constitued a total of 30 cases i.e, 15 cases each and accounted for 40%o of cases.
The other causes included Dandy Walker malformation, 7 cases (10%) and congenital communicating hydrocephalus 13 cases (17%). Intracranial haemorrhage and others together acccounted for the remaining 6%o of the cases.

Table 5: Sex distribution of hydrocephalus

Sex	Cases	Percentage
Males	42	57
Females	32	43

In this study it was observed that males (57%) significantly outnumbered the females (43%).
Hydrocephalus is a common disease complex with a diverse etiology, particularly in the paediatric population, with variable morbidity and mortality.[13,14]
It results from impaired circulation and absorption of CSF or in the rare circumstance from increased production of CSF.[10]
Since most hydrocephalus is obstructive other than a minority due to over production, it would be more accurate to classify hydrocephalus as obstructive (IVOH) and of communicating type (EVOH).[15]
The most common cause for obstructive hydrocephalus is aqueduct stenosis, followed by obstruction by tumours and congenital deformities such as Dandy walker malformation.
Non obstructive or communicating hydrocephalus most commonly follows post haemorrhagic and post infectious fibrosis at basal cisterns, incisura convexity cisterns and / or parasagittal region.[16,17]
Congenital causes such as Arnold chiari malformation II and agenesis of arachnoid granulation account for probably the second commonest cause.
The major CT criteria for determining the site of obstruction in hydrocephalus is the point of transition from dilated to non-dilated CSF, containing spaces. This approach is not without major pitfalls, however as pointed out by Morgan T et al, who found that 25-35 percent of patients with communicating hydrocephalus had little or no dilatation of fourth ventricle.[18]
In our study done on 74 cases we found that obstructive hydrocephalus (51%) slightly outnumbered communicating hydrocephalus (49%).
In our study hydrocephalus was more below the age group of 3 years (62%), with the major incidence found in infants (38%).
The common clinical presentation was a rapidly enlarging head 70%, convulsions 30%), developmental delay 28%, and fever with altered sensorium in about 20%o of cases.
Most of the patients had neurological deficits, particularly in those patients in whom hydrocephalus was secondary to tubercular meningitis or tumors. Clinical signs such as sunset sign, crackpot sign and bulging anterior fontanels was seen in about 90%) of children presenting with an enlarging head.
Our study showed tubercular meningitis as the major cause of hydrocephalus (27%), followed by aqueduct stenosis and tumors as the next 2 important causes (20% each).

The other causes included congenital communicating hydrocephalus (17%), Dandy walker malformation (10%), intracranial hemorrhage and Shunt malfunction 3 % respectively.

In a study done by Naff N et al on a series of 109 cases of hydrocephalus, tumours were the commonest cause of hydrocephalus (56 cases) - 51%, (although it is only the 4th commonest cause of hydrocephalus) followed by communicating hydrocephalus (20 cases) - 18%, aqueduct stenosis (17 cases) -16% and posterior fossa cysts (16 cases)- 15%.[19]

In computed tomography diagnosis of hydrocephalus both the qualitative as well as quantitative criteria have been used Yamada S,[13] had reported 23 cases of meningomylocele causing hydrocephalus out of a total of 57 cases.

A study done by Kulkarni AV,[10] 28 out of 29 cases of meningomyelocele showed hydrocephalus. In another study done by the same people, out of 71 cases of hydrocephalus only 5 cases were due to meningomyelocele.

Desai B7 measured CSF production in a child with choroid plexus papilloma, pre and post operatively. The pre-operative CSF formation rate was increased fourfold and fell to normal rate after surgical removal.

Bateman GA,[4] stated dilatation of subarachnoid spaces over the convexity was commonly encountered in EVOH (communicating) of childhood.

As per the study done by Vinchon M,[11] on infants with enlarging head-dilatation of subarachnoid channels overlying the cerebral hemispheres i.e., external hydrocephalus can be an early neuroradiologic finding of congenital communicating hydrocephalus.

Chen Q,[15] described the fluid collection in children with meglencephaly to be bifrontal in location, the frontal interhemispheric space was widened and the ventricles were slightly enlarged. Follow up usually shows disappearance of abnormality by 2 years of age.

Conclusion

In the present study patients who were clinically diagnosed, clinically suspected and undiagnosed cases of hydrocephalus were subjected to CT scan. CT scan revealed.

Whether the hydrocephalus was of communicating or non-communicating type.

Pathological causes of hydrocephalus

Severity of hydrocephalus.

In this study it was noted that tubercular meningitis was the commonest cause of hydrocephalus, with aqueduct, stenosis and tumours as the second important causes. The other causes included congenital communicating hydrocephalus, Dandy Walker malformation and intracranial haemorrhage.

In this study it was noted that most of the cases were of severe and moderate degrees of hydrocephalus, indicating that most of the patients presented late clinically.

To obtain maximal benefit for these patients and to avoid potential misdiagnosis, we have developed the following simple protocol for evaluation of hydrocephalus.

All patients with possible hydrocephalus should have an initial, complete noncontrast CT scan with serial sections from vertex down through the upper cervical region to i. demonstrate size of all ventricles and cisterns ii. to help rule out low lying tumors, the Chiari I and Chiari II malformation.

References

1. Rekate HL. A consensus on the classification of hydrocephalus: its utility in the assessment of abnormalities of cerebrospinal fluid dynamics. Childs Nerv Syst. 2011;27(10):1535-1541.
2. Raybaud C. MR assessment of pediatric hydrocephalus: a road map. Childs Nerv Syst. 2016; 32(1):19-41.
3. Bradley WG. CSF flow in the brain in the context of normal pressure hydrocephalus. AJNR Am J Neuroradiol. 2015;36(5):831-838.
4. Bateman GA, Smith RL, Siddique SH. Idiopathic hydrocephalus in children and idiopathic intracranial hypertension in adults: two manifestations of the same pathophysiological process? J Neurosurg. 2007;107(6 Suppl):439-444.
5. Wagshul ME, Eide PK, Madsen JR. The pulsating brain: A review of experimental and clinical studies of intracranial pulsatility. Fluids Barriers CNS. 2011;8(1):5.
6. Kahle KT, Kulkarni AV, Limbrick DD, et al. Hydrocephalus in children. Lancet. 2016;387 (10020):788-799.
7. Desai B, Hsu Y, Schneller B, et al. Hydrocephalus: the role of cerebral aquaporin-4 channels and computational modeling considerations of cerebrospinal fluid. Neurosurg Focus. 2016;41(3):E8.
8. Iliff JJ, Wang M, Liao Y, et al. A paravascular pathway facilitates CSF flow through the brain parenchyma and the clearance of interstitial solutes, including amyloid ß. SciTransl Med. 2012; 4(147):147ra111.
9. Dandy WE, Blackfan KD. Internal hydrocephalus: an experimental, clinical and pathological study. Am J Dis Child. 1914;8(6):406-482.
10. Kulkarni AV, Drake JM, Kestle JR, et al. Endoscopic third ventriculostomyvs cerebrospinal fluid shunt in the treatment of hydrocephalus in children: a propensity score-adjusted analysis. Neurosurgery. 2010;67(3):588-593.
11. Vinchon M, Baroncini M, Delestret I. Adult outcome of pediatric hydrocephalus. Childs Nerv Syst. 2012;28(6):847-854.
12. Rekate HL, Blitz AM. Hydrocephalus in children. HandbClin Neurol. 2016;136:1261-1273.
13. Yamada S, Miyazaki M, Kanazawa H, et al. Visualization of cerebrospinal fluid movement with spin labeling at MR imaging: preliminary results in normal and pathophysiologic conditions. Radiology. 2008;249(2):644-652.
14. Dinçer A, Kohan S, Ozek MM. Is all "communicating" hydrocephalus really communicating? Prospective study on the value of 3D-constructive interference in steady state sequence at 3T. AJNR Am J Neuroradiol. 2009;30(10):1898-1906.
15. Chen Q, Feng Z, Tan Q, et al. Post-hemorrhagic hydrocephalus: Recent advances and new therapeutic insights. J Neurol Sci. 2017;375:220-230.
16. Yu H, Zhan R, Wen L, et al. The relationship between risk factors and prognostic factors in patients with shunt-dependent hydrocephalus after aneurysmal subarachnoid hemorrhage. J Craniofac Surg. 2014;25(3):902-906.
17. Germanwala AV, Huang J, Tamargo RJ. Hydrocephalus after aneurysmal subarachnoid hemorrhage. NeurosurgClin N Am. 2010;21(2):263-270.
18. Morgan T, Awad I, Keyl P, et al. Preliminary report of the clot lysis evaluating accelerated resolution of intraventricular hemorrhage (CLEAR-IVH) clinical trial. ActaNeurochir Suppl. 2008;105:217-220.
19. Naff N, Williams MA, Keyl PM, et al. Low-dose recombinant tissue-type plasminogen activator enhances clot resolution in brain hemorrhage: the intraventricular hemorrhage thrombolysis trial. Stroke. 2011;42(11):3009-3016

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