



Original Research

Non-Neoplastic Etiologies of Adult-Onset Hydrocephalus

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ABSTRACT

Objective: To analyze non-neoplastic causes of adult-onset hydrocephalus and review their associations with clinical parameters.

Materials & Methods: This is a retrospective cross-sectional study conducted at the Department of Neurosurgery of a tertiary care hospital, from 1st January 2024 to 30th June 2024. We included 89 adult patients with hydrocephalus of any cause except brain tumors. To diagnose each type of hydrocephalus, we have established primary selection criteria based on patient history and imaging results.

Results: In our analysis, meningitis was the leading cause of hydrocephalus (n=28, 31.46%), followed by subarachnoid hemorrhage (n=23, 25.84%), trauma (n=21, 23.59%), and hydrocephalus with normal pressure (n=17, 19.1%). Among the four mentioned etiologies, meningitis was more common in the fourth and fifth decade of life (12/28 patients, p = 0.166), whereas the rest of the etiologies were more prevalent in the sixth to seventh decade, highlighting a significant correlation between age and these conditions. Additionally, significant p-values also suggested a correlation between gender and etiology in this cohort. However, when comparing genders, trauma was observed more frequently among male patients while subarachnoid hemorrhage and meningitis were noted more often among female patients.

Conclusion: In our study, meningitis was the most common cause of hydrocephalus. A better understanding of non-neoplastic causes and their links to demographics will improve risk assessment and management in patients.

Keywords: Adult-Onset hydrocephalus, meningitis, normal pressure hydrocephalus, cross-sectional study.

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DOI: 10.36552/pjns.v28i3.1009

Date of Submission: 02-05-2024
Date of Revision: 25-09-2024
Date of Acceptance: 28-09-2024
Date of Online Publishing: 30-9-2024
Date of Print: 30-9-2024

INTRODUCTION

The abnormal build-up of cerebrospinal fluid (CSF) caused by excessive production, poor arachnoid granulation absorption, or blockage in the normal flow of CSF is commonly referred to as hydrocephalus. Neurosurgeon Dr. Walter Dandy

divided hydrocephalus into two categories at the beginning of the 20th century: non-communicative (obstructive) or communicative (non-obstructive).¹ Both of these conditions cause hydrocephalus through various mechanisms.² This condition is quite common and affects 88 people out of every 100,000, this value fluctuates from 11 to 93 per 100,000 depending on the age group.³ There are various causes of communicative and non-communicative hydrocephalus. Tumors and congenital abnormalities are the main causes of obstructive hydrocephalus. Non-obstructive (communicating) hydrocephalus can be brought on by intracerebral bleeding, subarachnoid hemorrhage from aneurysms or trauma, hemorrhage after a stroke or car accident, and infections that create adhesions (e.g., meningitis).^{4,5} However, certain bacterial infections predominantly, belonging to the category of gram-positive organisms could lead to communicating hydrocephalus.⁶ A type of communicating hydrocephalus known as normal pressure hydrocephalus (NPH) is most frequent in the elderly but can happen to anyone at any age. It could be caused by a tumor, infection, head trauma, subarachnoid hemorrhage, or complications following surgery.⁷ On the other hand, a large number of persons experience idiopathic normal pressure hydrocephalus, or NPH, for unclear causes; however, this is more seen in patients who at the time of diagnosis are older than 80 years.⁸ Hydrocephalus is also classified as acute or chronic based on the duration of symptoms from the initial insult. In both of the cited articles, acute hydrocephalus lasted less than 3 months whereas chronic was more than 3 months.^{9,10}

There are several approaches to treating hydrocephalus. The disease can be treated directly by eliminating the cause of CSF obstruction, or indirectly by redirecting the extra fluid, depending on the underlying cause. The most popular kind of treatment is to implant a "shunt"—a device that directs extra CSF away from the brain.¹¹ Medication

or endoscopic third ventriculostomy are two alternate treatment options that are only available to a small percentage of patients.¹² At Jinnah Postgraduate Medical Center, individuals with adult-onset non-neoplastic hydrocephalus had their ages, sexes, and etiologies prospectively investigated. The results, which are based on certain diseases and demographic traits, could be useful in determining the risk of any given patient.

MATERIALS AND METHODS

Study Design and Setting

It was a retrospective cross-sectional study, carried out at the Department of Neurosurgery of a tertiary care hospital, for six months from 1st January 2024 to 30th June 2024 analyzing the data of 89 patients suffering from hydrocephalus.

Inclusion Criteria

Adult patients (age 18 and above) of any gender. It was diagnosed as a case of hydrocephalus based on the CT and/or MRI findings. Additional parameter of clinical presentation and/or lumbar puncture was used to diagnose NPH.

Exclusion Criteria

Patients less than 18 years of age. Patients having hydrocephalus due to brain tumors. Patients previously treated surgically for hydrocephalus and/or any brain tumor.

Data Collection

Data was collected from the Department of Neurosurgery after the approval of the institutional review board. History and imaging studies were reviewed, and data on each patient including age, gender, and etiology of hydrocephalus, were collected.

Statistical Analysis

The analysis was performed using SPSS 23.0; the

use of descriptive statistics such as mean, standard deviation, percentages, and dichotomous data were used to summarize the responses from the participants. The Chi-square test was applied to determine the relation of the observed effect with the null hypothesis.

RESULTS

Age & Gender Distributions of Adult-Onset Hydrocephalus

The mean age was 48 ± 2 years (ranging from 18 to 75 years). 48 (53.9%) among 89 patients were males while 41 (46.06%) were female.

Etiologies of Hydrocephalus

In our analysis of these 89 individuals, meningitis (31.46%), subarachnoid hemorrhage (25.84%), trauma (23.59%), and NPH (19.1%) were the most frequent causes of hydrocephalus.

Impact of Demographic Parameters on the Etiology of Hydrocephalus

Age: In the fourth and fifth decades of life, hydrocephalus was more prevalent overall. Among

the four aforementioned etiologies, there was no significant correlation with patient age, as indicated by the non-significant p-value, although meningitis was more common in the fourth and fifth decade of life, followed by a decline in the elderly age group and trauma was more common in the third decade of life, followed by a steep decline and no cases were reported in patients aged 70. However, NPH was more common in the sixth decade of life with minimal cases between 3rd and 4th decade, and sub-arachnoid hemorrhage gradually increased from the third decade onwards to a maximal rise which was evident in the sixth decade, followed by a decline. These findings suggest a correlation between age and these etiologies (Table 1).

Gender: Although meningitis was more common in females an increment was also observed in the male population. Likewise, NPH was more common in males, however; in the third and fourth decade, it was equally observed in both genders among the etiologies of hydrocephalus in our sample. As for trauma, it was observed as the cause of hydrocephalus in higher percentages of male patients, and subarachnoid hemorrhage was seen in higher percentages of female patients (Table 2).

Table 1: Association between age distribution and etiology.

Pathology	Age			Total	p-value
	Young (18-35)	Middle (36-50)	Old (More Than 50)		
Meningitis	15 (53.6%)	9 (32.1%)	4 (14.3%)	28 (100%)	0.001 (significant value)
SAH	3 (13%)	12 (52%)	8 (34.8%)	23 (100%)	
Trauma	14 (66%)	5 (23%)	2 (9%)	21 (100%)	
NPH	2 (11%)	11 (64%)	4 (23%)	17 (100%)	
Total	34 (38.2%)	37 (41.6%)	18 (20.2%)	89 (100%)	

Table 2: Association between Gender and etiology.

Gender	Pathology				Total	P-value
	Meningitis	SAH	Trauma	NPH		
Male	13 (46.4%)	14 (60.9%)	12 (57.1%)	10 (58.8%)	49 (55.1%)	0.138 (insignificant value)
Female	15 (53.6%)	9 (39.1%)	9 (42.9%)	7 (41.2%)	40 (44.9%)	
Total	28 (100%)	23 (100%)	21 (100%)	17 (100%)	89 (100%)	

DISCUSSION

In neurosurgical practice, hydrocephalus stands out as one of the most prevalent conditions necessitating early or urgent intervention to alleviate elevated intracranial pressure. Among adults, the most frequent causes of hydrocephalus include subarachnoid hemorrhage (SAH) and normal pressure hydrocephalus (NPH). SAH often leads to obstructive hydrocephalus due to blood clots disrupting cerebrospinal fluid (CSF) flow, while NPH is characterized by a gradual accumulation of CSF, leading to ventriculomegaly without a corresponding increase in intracranial pressure. Prompt diagnosis and management are crucial to preventing long-term neurological deficits and improving patient outcomes as the cited articles show that timely management avoids the dire consequences associated with this condition.^{13,14} However, our findings suggest that the most common causes of non-neoplastic hydrocephalus are subarachnoid hemorrhage and meningitis.

Hydrocephalus is frequently a consequence of meningitis, which can lead to reduced cerebrospinal fluid (CSF) absorption within the meninges. This form of hydrocephalus is especially common in developing nations, where infectious diseases such as tuberculosis (TB) are prevalent. Tuberculous meningitis, in particular, is a significant cause, as the inflammatory response to the infection can obstruct CSF pathways and impair absorption, leading to hydrocephalus,¹⁵ however; because tuberculosis meningitis is a more common cause of hydrocephalus in children, we were unable to report its data. Timely diagnosis and treatment are critical in these settings to mitigate the long-term neurological impact of the condition which is discussed in these cited articles.^{14,16} Hydrocephalus secondary to meningitis, usually occurs in the fourth and fifth decades of life, it is more common in women, however, this trend is not statistically significant. A recent study conducted in Pakistan found that 61 out of 93 cases of TBM (65.59%) had

hydrocephalus. This result is in line with other research.¹³ Only 33.3% of the 45 individuals in Indian research with hydrocephalus were found to have it. On the other hand, a Chinese study found that hydrocephalus developed in 29% of TBM cases.¹⁶ There are several reasons for these variations in prevalence, however, it was observed that hydrocephalus was more common in men.

In our study, subarachnoid hemorrhage (SAH) was found to be significantly more common in females, with a notable correlation between SAH incidence and both age and gender. The data revealed that the prevalence of SAH increases particularly in the sixth decade of life, highlighting a critical period where women are at higher risk for this condition. These findings underscore the importance of considering gender and age when assessing the risk factors and developing preventive strategies for SAH. The most often found cause of SAH was aneurysms.¹⁷ This is corroborated by another study, which discovered that aneurysms are most commonly seen in people between the ages of 30 and 70, with peak incidence for both sexes occurring in the fifth and sixth decades of life. In addition, 31% of patients with aneurysmal SAH¹⁸ had acute hydrocephalus, and females had a higher prevalence of intracranial aneurysms (69% vs. 31%).¹⁹

The third decade of life had the highest rate of hydrocephalus following a head injury.²⁰ The younger age distribution of patients with head injuries may be explained by the fact that younger people typically travel more and are more likely to be involved in car accidents. Males are more likely than females to experience it, for comparable reasons. This effect was observed in two different studies which demonstrated the prevalence of post-traumatic hydrocephalus in different settings.^{21,22}

Another significant contributor to adult hydrocephalus is normal pressure hydrocephalus, which is thought to be an age-related condition with an unclear etiology.²³ The seventh decade of life was the peak incidence of NPH in our series,

and it differed considerably from other age groups. Men were primarily affected which is highlighted in a study that discussed the implications of normal pressure hydrocephalus.²⁴

CONCLUSION

The clinical spectrum of hydrocephalus in adults extends beyond NPH and acquired hydrocephalus. Clinicians must recognize variations in etiology, pathology, and risks to tailor care accordingly. Demographic variations in adult-onset hydrocephalus are still underexplored in current literature. This requires further research to deepen the understanding of causes and risk factors in Pakistan to develop more effective treatment options.

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Additional Information

Disclosures: Authors report no conflict of interest.

Ethical Review Board Approval: The research was a retrospective study.

Human Subjects: Consent was obtained by all patients/participants in this study.

Conflicts of Interest:

In compliance with the ICMJE uniform disclosure form, all authors declare the following:

Financial Relationships: All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work.

Other Relationships: All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

Data Availability Statement: Required data is presented in the paper.

Funding: N/A.

AUTHORS CONTRIBUTIONS

Sr.#	Author's Full Name	Intellectual Contribution to Paper in Terms of:
1.	Raheel Gohar	1. Study design and methodology.
2.	Tehniat Khaliq & Farrukh Javeed	2. Paper writing.
3.	Farrukh jawed & Tehniat Khaliq	3. Data collection and calculations.
4.	Tehniat Khaliq & Iram Bokhari	4. Analysis of data and interpretation of results.
5.	Ghulam Brohi & Tehniat	5. Literature review and referencing.
6.	Talha Shafiq & Yousra	6. Editing and quality insurer.