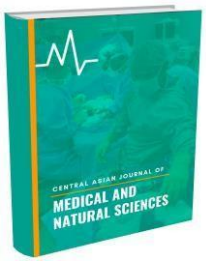

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Article

Clinical and Neurological Features of Hydrocephalus in Children: a Comparative Study

Abdullaev Botir Erkinovich[1], Kariev Gayrat Maratovich[2], Isoboev Bakhtiyorjon Anvarjonovich[3]

1,3. Department of Pediatric Neurology, Uzbekistan
2. Department of Neurosurgery and Neurology, Uzbekistan
Correspondence: b.abdullaev1991@gmail.com[1], gmkariev@gmail.com[2], dr.abdumajid83@mail.ru[3]

Abstract: Hydrocephalus is among the most common neurological disorders affecting children and remains a significant cause of developmental and functional impairment despite considerable advances in diagnostic and therapeutic approaches. The present study was conducted to evaluate the clinical and neurological characteristics of hydrocephalus in childhood through a comparative assessment involving 40 children diagnosed with hydrocephalus and 40 healthy controls. Comprehensive clinical examinations, neurological assessments, and analysis of neuroimaging findings were performed to identify the most frequent manifestations associated with the disease. The results demonstrated that developmental delay, speech impairment, cognitive dysfunction, muscle tone abnormalities, gait disturbances, visual disorders, and seizure episodes occurred significantly more often among children with hydrocephalus than among healthy participants. Furthermore, the severity of neurological deficits tended to increase in parallel with the degree of ventricular enlargement, highlighting the impact of prolonged cerebrospinal fluid circulation disturbances on the developing brain. The findings emphasize the importance of early diagnosis, continuous neurological monitoring, and multidisciplinary management aimed at preventing long-term complications and improving functional outcomes. Timely intervention and individualized rehabilitation strategies may contribute substantially to better neurological development and quality of life in affected children.

Keywords: Hydrocephalus, Children, Pediatric Neurology, Neurological Disorders, Developmental Delay, Cognitive Impairment, Cerebrospinal Fluid, Neuroimaging

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1. Introduction

Because of its importance in disrupting the normal circulation and absorption of cerebrospinal fluid, hydrocephalus is one of the most significant neurologic disorders encountered in pediatric practice, and if untreated will cause progressive enlargement of the ventricles with possible irreversible damage to the developing brain. Despite the significant improvements in the survival and long-term prognosis of hydrocephaly over the past few decades due to progress in prenatal screening, neuroimaging techniques, and neurosurgical treatment, it remains a significant clinical and social problem, especially in infants and young children whose nervous systems are still at critical stages of growth and maturation [1].

It can occur as a result of a congenital defect, genetic abnormalities, intraventricular haemorrhage, infection of the central nervous system, tumour formation, or any other pathological process which disrupts the normal dynamics of the circulation of

cerebrospinal fluid (CSF) and for this reason the clinical picture may be very different from one child to another [2].

On the neurological level, hydrocephalus is not only accompanied by structural changes in the brain but by a broad range of functional impairments which can include cognitive development, motor performance, language acquisition, visual function and overall quality of life. The initial symptoms are often mild and may not be noticed by those caring for the patient, while continued enlargement of the ventricles eventually leads to a rise in ICP and subsequent deterioration of neurological function making early diagnosis and ongoing monitoring even more important [3].

In addition, although surgical procedures such as ventriculoperitoneal shunting and endoscopic third ventriculostomy have been applied widely, in many cases CSF accumulation is effectively managed and neurological deficits still remain, indicating that hydrocephalus is not just a surgically curable disorder, but should be treated as a chronic neurological disorder and long-term management is required [4].

Despite the many challenges that hydrocephalus poses to patients, their families and healthcare systems, a thorough assessment of clinical and neurological presentation will continue to be key to achieving a more accurate diagnosis, better treatment options and understanding factors that might contribute to poor neurological outcomes. Hence, the present study was performed to assess the clinical and neurological characteristics of hydrocephalus in children by comparing the clinical and neurological profile of hydrocephalic children with the healthy ones.

2. Materials and Methods

This study was undertaken to assess the clinical and neurological features of hydrocephalus in children using an observational methods that enabled detailed neurological assessment, developmental assessment and clinical features in children with hydrocephalus and healthy children. The study was conducted in an outpatient clinic specialized in the care and treatment of children with neurological disorders, who were examined by a pediatric neurologist in accordance with a standard clinical protocol. The total number of children in the study was 80 and were split into two groups: The main group comprised children with confirmed diagnosis of hydrocephalus based on clinical and neuroimaging data, and the control group consisted of neurologically normal children of similar age and sex without a history of CNS disorders, congenital malformations or major chronic diseases [5].

The recruitment of participants was done sequentially during the study period, and informed consent was obtained from the parents/legal guardians before the children were included in the study. In order to reduce potential confounding factors and to make a better comparison between the groups, children with severe systemic diseases, acute infectious diseases, chromosomal syndromes, and neurological diseases other than hydrocephalus were excluded. Medical records and parental interviews were used to gather demographic data, medical history, prenatal and perinatal characteristics, and previous treatment data to provide a complete clinical profile for each participant [6].

All children had a detailed neurologic examination including a focus on muscle tone abnormalities, motor development, cranial nerve function, coordination, reflex activity, gait disturbances, seizure history, and cognitive performance. Head circumference was taken and evaluated as per age appropriate paediatric norms. When available, imaging data such as computed tomography and magnetic resonance imaging were studied as well, to confirm the presence of ventricular enlargement and delineate the nature and degree of hydrocephalus. Developmental status was determined according to age-appropriate clinical evaluation methods related to speech development, psychomotor skills, social adaptation and learning abilities [7].

Data collected were transferred to an electronic database and then analyzed using statistical software. The quantitative variables were expressed as mean values with SDs, while the categorical variables were presented as frequencies and percentages. Appropriate statistical tests like Student's t-test and chi square test were used to do the comparative analysis between the study and the control groups. A means of determining statistical significance was set at $P<0.05$, which was deemed adequate to suggest meaningful differences between the groups analyzed and help interpret neurological outcomes associated with pediatric hydrocephalus [8].

3. Results

A comparison of the data obtained revealed significant differences between the children diagnosed with hydrocephalus and children in the healthy control group. Demographic distribution of participants did not show statistically significant differences in terms of age and sex which enabled the evaluation of the observed neurological and clinical characteristics without the influence of the major demographic differences. When a neurological status, developmental parameters, and clinical features were studied in detail, however, there were significant differences. A significant increase in neurological abnormalities was observed in children with hydrocephalus, illustrating the effects of abnormal CSF dynamics on the developing CNS [9].

The most striking finding was the higher rate that developmental delay was observed in the patients with hydrocephalus. Speech acquisition and acquisition of psychomotor maturation and cognitive performance appropriate to age were noted in a significant number of affected children, but not in many in the control group. In addition, hypertonia and hypotonia were also seen much more frequently in the children with hydrocephalus than in their healthy counterparts, indicating abnormal functioning of neural pathways involved in motor regulation and coordination. Gait disturbances, as well as loss of balance control were also shown in several patients, with more severe ventricular enlargement revealed by neuroimaging examinations in these patients [10].

Similarly, neurological symptoms due to raised ICP were seen more often in the study group. The most common symptoms described among children with hydrocephalus were recurrent headaches, irritability, vomiting episodes and visual disturbances as well as seizure activity, whereas these symptoms were rarely seen in healthy children. Moreover, in a significant proportion of younger children with hydrocephalus, head circumference was larger than age-appropriate levels, indicating continued growth of the ventricles and a disruption of cranial growth. A correlation between radiological severity and neurological dysfunction was more apparent, with children who had greater extent of ventricular dilatation having greater extent of neurological and developmental abnormalities [11].

Table 1. The clinical and neurological features of the participants included. The clinical and neurological features of those included in the study.

Clinical Indicator	Hydrocephalus Group (n=40)	Control Group (n=40)	p-value
Developmental delay	27 (67.5%)	3 (7.5%)	<0.001
Speech delay	24 (60.0%)	2 (5.0%)	<0.001
Abnormal muscle tone	22 (55.0%)	4 (10.0%)	<0.001
Seizure episodes	11 (27.5%)	1 (2.5%)	0.002
Visual disturbances	15 (37.5%)	2 (5.0%)	<0.001
Gait abnormalities	18 (45.0%)	3 (7.5%)	<0.001

Head circumference above age norm	20 (50.0%)	1 (2.5%)	<0.001
Cognitive impairment	19 (47.5%)	2 (5.0%)	<0.001

Table 1 clearly shows that neurological and developmental abnormalities were significantly more common among the hydrocephalic children than healthy children. The most common findings were developmental delay, speech delay, muscle tone abnormalities, abnormal gaits, and cognitive dysfunction. Based on these observations, it has been concluded that hydrocephalus has a complex impact on neurological development and that it is important to reach a diagnosis early, maintain monitoring of the neurological status, and intervene in time to avoid chronic functional impairment and growth disorder in children [12].

The overall findings obtained indicate that there is a significant increase in neurological dysfunction burden in childhood associated with hydrocephalus, both motor and cognitive. The comparative analysis shows that children with hydrocephalus have significantly higher developmental complications rates, highlighting the need for multidisciplinary management that can help maintain neurological function and best possible quality of life in childhood and adolescence.

4. Discussion

The findings obtained in the present study demonstrate that hydrocephalus remains not only a structural disorder of cerebrospinal fluid circulation but also a complex neurological condition capable of influencing multiple aspects of a child's physical, cognitive, and psychosocial development. The significantly higher frequency of developmental delay, speech impairment, muscle tone abnormalities, gait disturbances, and cognitive dysfunction observed among children with hydrocephalus supports the growing understanding that ventricular enlargement affects neural networks responsible for higher neurological functions and motor control. Although advances in neurosurgical techniques have improved survival and reduced mortality associated with hydrocephalus, many children continue to experience varying degrees of neurological impairment even after receiving appropriate treatment, which highlights the long-term nature of this condition and the necessity of ongoing neurological surveillance [13].

An important observation emerging from this study is the close association between clinical manifestations and the severity of neurological involvement. Children who demonstrated more pronounced neurological deficits frequently exhibited a combination of motor and cognitive disturbances rather than isolated symptoms, suggesting that hydrocephalus may interfere with several interconnected developmental pathways simultaneously. This observation corresponds with contemporary neurodevelopmental concepts proposing that chronic ventricular dilatation can alter white matter integrity, disrupt neuronal connectivity, and impair normal maturation of brain structures that play essential roles in learning, behavior, and motor coordination [14].

The relatively high prevalence of speech delay and cognitive difficulties identified in the study population deserves particular attention because these impairments can significantly influence educational achievement, social adaptation, and future quality of life. Even in cases where life-threatening complications are successfully prevented through surgical intervention, subtle neurological deficits may persist and become more apparent as children grow older and face increasing academic and social demands. Consequently, successful management of hydrocephalus should extend beyond surgical correction and include developmental assessment, neuropsychological support, speech therapy, and rehabilitation measures tailored to the individual needs of each child [15].

Furthermore, the increased occurrence of seizure activity, visual disturbances, and abnormalities of muscle tone observed among affected children reinforces the importance of multidisciplinary collaboration involving pediatric neurologists, neurosurgeons, ophthalmologists, rehabilitation specialists, and psychologists. Such cooperation enables earlier identification of complications and facilitates comprehensive care aimed at maximizing neurological outcomes. Taken together, the present findings strengthen existing evidence indicating that hydrocephalus exerts a substantial influence on childhood neurological development and emphasize the need for early diagnosis, continuous follow-up, and individualized therapeutic strategies designed to minimize long-term disability and improve overall functional prognosis [16].

5. Conclusion

The results of the present study demonstrate that hydrocephalus continues to be a significant neurological condition in childhood, affecting not only the structural integrity of the brain but also numerous aspects of neurological and developmental functioning. The comparative analysis revealed that children with hydrocephalus experience developmental delays, speech difficulties, cognitive impairment, abnormalities of muscle tone, gait disturbances, visual problems, and seizure episodes considerably more frequently than their healthy peers. These findings indicate that the consequences of hydrocephalus extend far beyond ventricular enlargement and involve a broad spectrum of neurological processes that are essential for normal growth and development.The study also showed that neurological manifestations often occur simultaneously, suggesting that hydrocephalus influences multiple functional systems within the developing brain. Such impairments may negatively affect educational performance, social interaction, emotional well-being, and overall quality of life if they are not recognized and managed at an early stage. Therefore, timely diagnosis remains one of the most important factors in reducing the long-term burden of the disease and improving functional outcomes.In addition, the findings emphasize that successful treatment should not be limited solely to neurosurgical intervention. Continuous neurological assessment, developmental monitoring, rehabilitation programs, speech and cognitive support, as well as regular follow-up by multidisciplinary healthcare teams are essential components of comprehensive patient care. These measures can contribute to the early identification of complications and allow healthcare professionals to implement appropriate corrective strategies before significant disability develops.Overall, hydrocephalus represents a chronic neurological disorder that requires long-term medical attention and individualized management. Strengthening early screening programs, improving access to specialized neurological services, and ensuring continuous monitoring of affected children may play a crucial role in enhancing developmental outcomes and helping children achieve their maximum physical, cognitive, and social potential.

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