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Review Article

Cognitive Profiles in Pediatric Hydrocephalus: A Theoretical Review with Focus on African Cohorts

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Abstract

Pediatric hydrocephalus represents a major neurological and public health concern in African countries due to its high prevalence, limited access to healthcare, and significant impact on neurodevelopment. This mini review explores the cognitive and neuropsychological outcomes associated with hydrocephalus in African pediatric populations. Drawing on recent empirical studies, the review highlights three core aspects: the heterogeneity of neuropsychological profiles, the moderating role of hydrocephalus etiology (congenital vs. acquired), and the influence of sociodemographic and clinical factors on cognitive outcomes. Results suggest substantial variability in cognitive trajectories, with gross motor function and executive abilities frequently impaired. Moreover, early intervention, brain structure integrity, and type of treatment appear to be key prognostic factors. This review underscores the need for context-sensitive clinical protocols and further research on neurodevelopment in low-resource settings.

Keywords: Pediatric hydrocephalus, cognitive development, neuropsychological profile, Africa

Introduction

Pediatric hydrocephalus is described as an excess of cerebrospinal fluid (CSF) in the lateral ventricles leading to abnormal dilatation of the lateral ventricles. It is usually caused by a defect in CSF circulation due to physiological problems or a malfunction of the CSF reabsorption system [1, 2]. This defect may be congenital as a consequence of other disorders and/or malformations of the neural tube such as spina bifida and myelomeningocele [3] or acquired as a result of having suffered tuberculosis or perinatal trauma [4], among others. The immediate physical implication of this disorder is the increase of pressure inside the intracranial cavity, thus compressing the brain and sometimes irreversibly injuring the pediatric patient if not treated early [5]. Its potential mortality and high incidence in low-income countries make this disorder a health and social emergency. Previous studies focused on East African countries have shown that pediatric hydrocephalus is a disease with a very high potential severity whose prognosis depends on the evolution of the disease in the first two years of life, evolving in 25% of cases in a very unfavorable way (some die and others develop irreversible brain disorders) for the life of the pediatric patient [6, 7]. Worldwide, the incidence of pediatric hydrocephalus ranges from 0.48-0.81 per 1,000 births, which translates into an incidence of 5.9 per 10,000 live births. In low-income countries in Africa, this defect is more frequent due to prenatal (lack of folic acid in the mother) and infectious causes, with an estimated 200,000 live births per year [8].

This contrast in the data according to the resources of the countries is explained, in part, by the etiology of the disorder that ultimately falls on the capacity of support and resources offered by the health system of each country. Most of the cases reported in areas such as Tanzania, for example, refer to the congenital type of hydrocephalus that is a consequence of prematurity of the newborns, poor nutrition of the mother, and lack of folic acid intake and prenatal control during pregnancy, among others [8]. This explains why countries with fewer socioeconomic resources are the most affected by this disorder. Together with these causes, infection of the brain in the perinatal environment is another of the most frequent, thus obtaining the diagnosis of post-hemorrhagic hydrocephalus of prematurity [9]. The most a priori visible symptoms in pediatric hydrocephalus are physical: increased head circumference, tense anterior fontanel, opening of the sutures, prominence of the epicranial vessels, Parinaud's sign and neck stiffness, which rapidly follow with physical symptoms characterized by an exaggerated head circumference, headaches, irritability, nausea, repeated vomiting, somnolence, motor impairment and seizures [10, 11].

Therefore, the most immediate intervention requires neurosurgery. Although several types of intervention have been proposed, currently the most widely used due to its good results is the ventriculoperitoneal shunt (VPD) in which several silicone catheters are used to drain the excess CSF [12]. Another common procedure is Endoscopic Third Ventriculostomy of the Third Ventricle (ETV) which positions the focus of intervention in the third ventricle. In some cases, it has been shown that it is possible that hydrocephalus can be controlled without surgical intervention depending on the patient's age, severity, etc [1]; control and follow-up of physical symptoms around the intervention being paramount.

Discussion

The neuropsychological effects associated with pediatric hydrocephalus should be more studied. Most of the work has been carried out in upper-middle income countries and the neuropsychological profile found so far is heterogeneous. Some studies have related the clinical characteristics of hydrocephalus (infections, etiology, screening and clinical measures) with cognitive impairment in memory [13], and also in other higher abilities such as metacognition, executive function [14, 15] and cognitive development over the years [16]. Consistent with these data, in the study by Hampton, et al. [17], specific deficits in memory and concept formation were observed in the group diagnosed with pediatric hydrocephalus, as compared to the control. In addition, significant impairment in fine motor skills associated with hydrocephalus was shown [17]. Likewise, in the study by Pike, et al. [18] it was obtained that the group with hydrocephalus presented a worse communicative discourse with altered levels in learning scales and verbal comprehension [18]; while in a later study an outstanding verbal fluency was demonstrated in comparison with the scores of the control group [14]. Finally, another study highlights the deficit of the hydrocephalus group in arithmetic functions, but not so much in linguistic functions [19].

Following a theoretical review, the following findings have been identified three relevant aspects which will be explained. First, several studies have documented an altered neuropsychological profile in pediatric patients with hydrocephalus in Africa, with considerable variability depending on the type of assessments used and the underlying etiology of the condition. For instance, Frank et al. reported poor performance in nonverbal tasks among children with congenital hydrocephalus, while Schoeman et al. described motor impairments, reduced quality of life, and lower emotional well-being. In contrast, Warf et al. found that children without treatment for hydrocephalus performed comparably to normative groups, except in gross motor function. These findings highlight a heterogeneous profile that appears to be modulated primarily by the type of hydrocephalus—congenital versus acquired—and its underlying cause, such as spina bifida or postnatal infections. The type of hydrocephalus emerges as a potential moderating factor in the observed neuropsychological outcomes, although findings across studies remain inconsistent. Bannink et al. reported no significant cognitive differences in patients with congenital hydrocephalus and spina bifida, whereas Frank, et al. found that children with acquired hydrocephalus exhibited better developmental outcomes. Schoeman, et al., in contrast, reported considerable motor deficits in patients with tuberculosis-acquired hydrocephalus.

Notably, several studies did not include hydrocephalus type as a variable in their analyses, limiting the capacity for cross-study comparison and reinforcing the need for more standardized methodological approaches. Sociodemographic and clinical factors also appear to play a role in shaping the neuropsychological profile of pediatric hydrocephalus in African populations. Most studies focused on children under 24 months, with cognitive scores generally improving with age. Gender did not emerge as a significant factor, and geographic location, although noted, was not analyzed as a variable. Clinically, high mortality rates were observed in early childhood. Certain treatment modalities, such as ventriculostomy with choroid plexus cauterization (VETV-CPC), were associated with better verbal comprehension but poorer overall developmental outcomes compared to untreated groups. Structural brain factors, such as ventricular size ratios and the presence of subdural hematomas, were significantly correlated with cognitive performance, highlighting the importance of integrating neuroimaging data into clinical assessments.

Conclusion

In conclusion, pediatric hydrocephalus in Africa presents a unique clinical and neuropsychological challenge, shaped by both biological and systemic factors. While current findings reveal considerable heterogeneity in cognitive outcomes, there is a clear need for more consistent methodologies, early diagnosis, and culturally adapted interventions. Future research should aim to integrate neuroimaging, longitudinal follow-up, and standardized cognitive assessments to better understand and address the needs of this vulnerable population.

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Conflict of Interest

No Conflict of Interest

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