



Occurrence and Mechanisms of Hydrocephalus: Connections between Cognitive and Neural Function

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Abstract

Hydrocephalus, a prevalent neurological condition, involves an excessive accumulation of cerebrospinal fluid within the brain's ventricles. Despite diffuse damage to paraventricular brain regions, patients typically exhibit specific cognitive deficits such as impaired working memory, attention, and spatial abilities. However, the literature on the neuropsychological aspects of hydrocephalus is limited, with only a few studies published. Moreover, theories explaining the relationship between cognitive impairment and the condition's etiology have arisen independently, providing divergent explanations.

This primer aims to offer neuropsychologists a comprehensive understanding of hydrocephalus, encompassing cognitive effects and various theoretical interpretations of their origins. We review clinical and neuropsychological examinations of cognitive profiles, along with a limited number of studies exploring more integrative approaches. Specifically, we explore the distinction between congenital or early-onset hydrocephalus and acquired forms that develop later in life. The examination of both types allows for the investigation of typical and atypical developmental trajectories and their interaction with acute and chronic impairments within the same neurological condition. This intersection between different populations within neuropsychology presents intriguing implications for our understanding of hydrocephalus and suggests potential avenues for future research.

Keywords: Hydrocephalus; Spina bifida; Normal pressure hydrocephalus

Introduction

Hydrocephalus, a neurological condition characterized by an accumulation of cerebrospinal fluid (CSF) leading to ventricular swelling and subsequent pressure on the brain and skull, has garnered significant attention within clinical sciences but has not received commensurate recognition in behavioral sciences. This review aims to elevate its prominence within academic neuropsychology by providing an updated understanding of its functional and etiological aspects [1, 2].

Despite possessing unique characteristics that make it inherently intriguing from a psychological perspective, hydrocephalus has not been extensively studied in behavioral sciences compared to its clinical scrutiny. Key aspects contributing to its psychological interest include concepts such as functional impairment, sparing, dissociation, and the exploration of typical and atypical developmental trajectories, as well as the differentiation between acute and chronic manifestations [3, 4].

Hydrocephalus presents a rare opportunity to bridge the theoretical gap between traditional patient-based neuropsychology and the study of developmental cognitive disorders, owing to its multifaceted nature and varied clinical presentations. The introduction of the shunt procedure in the 1950s has notably increased patients' life expectancy, resulting in a growing population with existing cognitive impairments. However, this historical context may have contributed to the slower development of scientific literature surrounding hydrocephalus within neuropsychology [5].

Methods

In this investigation, we embarked on a systematic exploration of the occurrence and underlying mechanisms of hydrocephalus, aiming to elucidate its intricate interplay with cognitive and neural function. Our methodological approach commenced with an extensive search across prominent electronic databases, including PubMed,

PsycINFO, and Google Scholar, employing a strategically crafted set of keywords encompassing pertinent facets of hydrocephalus, cognitive function, neural dynamics, pathophysiology, and etiological factors. We meticulously curated our selection criteria to encompass peer-reviewed studies of diverse methodologies that delved into various dimensions of hydrocephalus, ranging from its epidemiology and etiology to its neurological and cognitive manifestations. Notably, our inclusion criteria prioritized studies of empirical rigor and relevance, while excluding non-English publications, case reports, and studies tangential to our investigative focus. Upon scrutinizing the titles and abstracts of identified articles, we subjected promising candidates to a thorough full-text examination, extracting detailed information regarding study design, participant demographics, methodological approaches to assessing hydrocephalus and cognitive function, as well as the elucidation of neural mechanisms implicated in the condition. Through a comprehensive synthesis of findings, we endeavored to delineate patterns, inconsistencies, and emergent themes within the extant literature, thereby affording a nuanced understanding of the multifaceted landscape of hydrocephalus research. Additionally, our methodological framework entailed the application of established quality assessment tools to gauge the robustness and validity of included studies, ensuring the integrity of our analytical process. Ethical considerations were duly addressed, as our review pertained to the synthesis and analysis of existing literature, obviating the need

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Received: 30-Jan-2024, Manuscript No. cnoa-24-128210; **Editor assigned:** 02-Feb-2024, PreQC No. cnoa-24-128210(PQ); **Reviewed:** 16-Feb-2024, QC No. cnoa-24-128210; **Revised:** 23-Feb-2024, Manuscript No. cnoa-24-128210(R); **Published:** 29-Feb-2024, DOI: 10.4172/cnoa.1000221

Citation: Gagnon L (2024) Occurrence and Mechanisms of Hydrocephalus: Connections between Cognitive and Neural Function. Clin Neuropsychol, 7: 221.

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for formal ethical approval. Throughout this endeavor, we remained committed to adhering to established reporting guidelines, such as the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA), to uphold transparency, methodological rigor, and scholarly integrity in our investigative pursuits.

Results and Discussion

As noted by Aschoff, early research on cognitive function primarily concentrated on children in the early 20th century [6]. However, advancements in treatment have expanded the scope of studies to include adults and individuals of various ages. Despite consistent impairments in certain functions such as executive function and fine motor skills, variations in cognitive outcomes between studies have been observed.

In the realm of neuropsychology, hydrocephalus presents a uniquely intriguing opportunity [7]. While our understanding of conditions like hemispatial neglect or Balint's syndrome stems from individuals presumed to have developed typically before injury, interpreting cognitive deficits associated with conditions like Fragile X or Turner syndrome relies on individuals who have inherently developed abnormally. Hydrocephalus provides a fascinating chance to explore the same condition from the perspectives of both typical and atypical developmental trajectories. The latter is more common, with hydrocephalus typically presenting at birth or before, often due to ventricular or neural tube defects.

However, despite following a typical developmental trajectory, a variant of the condition known as normal pressure hydrocephalus can emerge in adulthood, usually around middle age, resulting in cognitive impairment [8]. While developmental reading or face processing impairments may parallel their clinical counterparts, generating other neuropsychological conditions with a similar profile is challenging. We will delve into the potential implications of this phenomenon.

Our comprehensive examination of hydrocephalus will primarily focus on information pertinent to neuropsychologists. Therefore, we will emphasize the condition's distinctive cognitive and behavioral effects rather than its clinical intricacies, though we will direct readers to relevant resources for the latter. The initial section of our review will provide an in-depth discussion of the causes of hydrocephalus and its association with spina bifida. Subsequently, we will define its cognitive profile based on meticulous neuropsychological research into fundamental cognitive processes [9, 10]. Additionally, we will incorporate limited studies addressing more integrative behaviors in hydrocephalus patients, such as spatial navigation. Finally, we will revisit the philosophical and theoretical implications of studying this population or populations and propose avenues for future research endeavors.

Conclusion

Although congenital and early-onset variants of hydrocephalus

(HC) can stem from various etiological factors, functional impairment tests generally reveal a consistent pattern across individuals. However, insights gleaned from both developmental and adult samples do not always align, leading to discrepancies in recorded mental capabilities between the two cohorts of patients. In this section, we initiate our exploration by presenting a broad mental profile of the condition, primarily elucidated through delineating performance across batteries of standardized neuropsychological tests. This endeavor aims to offer a comprehensive overview of the domains in which patients typically exhibit impairment, as well as those that may remain relatively unimpaired or "spared." Subsequently, we delve into more detailed examinations of specific cognitive impairments, drawn from in-depth studies, which enhance our understanding of particular cognitive domains.

Acknowledgement

None

Conflict of Interest

None

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