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Case Report

Neurocognitive Heterogeneity in Learning Disabilities: A Case with a Focal Left Anterolateral Thalamic Abnormality

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Abstract

This article presents a case of clinico-radiological correlation of a 16 year old male student with persistent dyslexia and dysgraphia, language and visuo-spatial weaknesses, with preserved executive functioning and superior general intellectual ability, and a small left anterolateral thalamic T2/FLAIR hyperintensity. The discussion examines the possibility of hyperintensity in left-antero lateral thalamus on T2WI and FLAIR sequence as an anatomically plausible contributor to the cognitive profile.

Keywords: *Learning Disabilities (LDs); Neurocognitive Heterogeneity; Focal Left Anterolateral Thalamic Abnormality*

Introduction

Learning disabilities (LDs) may be understood as a group of neurodevelopmental deficits that negatively affect the acquisition, organization, retention, comprehension, or application of age appropriate knowledge [1]. As explained by the IQ-Achievement Discrepancy model [2] an individual may demonstrate adequate or even superior general intellectual functioning while experiencing considerable disproportionate difficulty with specific academic processes such as reading, spelling, written expression, language processing, or visuo-spatial organization. Such individuals may therefore be perceived as inattentive, unmotivated, unserious or inconsistent because their measurable academic performance does not correspond with their underlying cognitive potential.

The presenting case was of interest to the authors as it gives a possible anatomical relationship between the left anterolateral thalamus and cognitive network functions involved in attention, language, learning, memory, and executive regulation. The thalamus was traditionally viewed as a passive relay station of information from sensory organs or subcortical structures to the cortex. However, the thalamus is being increasingly recognised as an integrative node within corticothalamic networks [3]. The anterior thalamic region is a vital node within hippocampal-diencephalic-cingulate circuits that support spatial learning and memory, while left thalamic involvement has been associated with language and cognitive disturbances [4]. Despite the evidence in existing literature, the MRI finding cannot

by itself establish that the thalamic abnormality caused the patient's learning disability. The case therefore provides an opportunity to discuss a possible clinicoradiological correlation along with the contribution of a high IQ and executive functioning with LD.

Case Presentation and Discussion

The patient is a right-handed adolescent previously diagnosed with dyslexia and dysgraphia on four different occasions. He was born by caesarean section at the beginning of the eighth month of gestation due to premature onset of labour. According to history reported by the parents, the pregnancy was complicated near delivery, and the patient had low oxygen levels at birth. He subsequently required incubation for 2 - 3 days and nursery care for another 22 - 23 days. All developmental milestones were reportedly delayed by approximately four to five months. No major head injury was reported and there was no significant family history of neurological or psychiatric disorders.

Developmentally, the patient demonstrated persistent speech and language vulnerabilities. Despite sustained speech therapy intervention, articulation difficulties continued, and during assessment some phonological substitutions were observed. Academic difficulties were apparent from the early years of schooling, and he was first assessed for learning difficulties in Grade 2. These difficulties were characterized by poor academic performance, difficulty learning rhymes, limited classroom participation, difficulties expressing himself in complete sentences, and problems with age-appropriate self-care.

Later, problems in spelling and written expression were observed by the parents and teachers, including omission of words while writing and inconsistent spelling of the same word across different instances, example 'this' and 'dis'. The patient received special education for several years and was provided with a scribe and one additional hour during Grade 10 Central Board of Secondary Education (CBSE) examinations as per accommodations provided in the Indian Gazette [5]. With these provisions, he achieved 85.4%, suggesting that improved writing speed and written articulation could substantially improve the expression of his academic knowledge. He is currently in Grade 11 in the Commerce stream. He reports that theoretical information and factual learning are more difficult than analytical tasks. He is able to understand and retain concepts such as scattering of blue light in the sky.

The patient also reports difficulty remaining seated and studying for prolonged periods. He describes one-to-one interactions on the same topics that don't require analytical understanding as monotonous and reports becoming bored easily. While these complaints could superficially resemble an attentional disorder, formal assessment did not demonstrate impaired attention or executive functioning. During testing, attention could be aroused and sustained, instructions did not require repetition, and comprehension of conversation was intact. Therefore, the case should not be interpreted as evidence of inattention, lack of motivation or ADHD solely on the basis of subjective boredom or difficulty sustaining prolonged study.

Neuropsychological profile

The neuropsychological assessment demonstrated a striking discrepancy. General intellectual functioning was superior, with an IQ of 110, while reading, handwriting, spelling, and punctuation were below grade level. Spatial orientation was poor, and difficulties were observed on visuo-spatial inversion and maze tasks. The learning-disability assessment showed intact figure-ground perception, figure constancy, general cognitive abilities, auditory perception, and mathematical computational skills. Mild impairment was observed in hand-eye coordination and position-in-space abilities, while moderate impairment was identified in spatial relations, receptive language, and expressive language.

Taken together, the profile is consistent with persistent specific learning difficulties, particularly involving reading and written expression, with associated language and visuospatial weaknesses despite otherwise preserved cognitive and executive functioning.

Strong reasoning abilities can sometimes mask specific academic weaknesses because the individual may compensate by relying on conceptual understanding, verbal reasoning, inference, or problem-solving. This may superficially invite comparison with popular

accounts of Albert Einstein, who faced learning difficulties in traditional schooling settings and lower academic achievements despite a high IQ. Accounts of Einstein's school years also describe him as becoming bored and disengaged in conventional classroom settings, particularly when instruction was repetitive or did not stimulate his intellectual curiosity [6]. An individual can possess strong reasoning capacity while having specific weaknesses in language-mediated learning, reading fluency, written expression, or attentional regulation.

MRI findings, anatomical correlation and behavioural explanation

The additional MRI finding in this case is a tiny hyperintensity within the left anterolateral thalamus on T2-weighted and FLAIR sequences. This radiological finding may not be considered a pathological explanation directly. T2/FLAIR hyperintensity refers to bright spots seen on MRI scans, indicating increased water content in brain tissue [7]. It is nonspecific and may be seen in a variety of pathological and sometimes incidental processes. The significance of a focal thalamic signal abnormality depends on its precise nuclear location, morphology, size, associated diffusion characteristics, enhancement, other lesions, clinical history, and evolution on serial imaging [8]. The anatomical position of this radiological finding is interesting in the context of this patient's neuropsychological profile.

The thalamus, a major part of the diencephalon, situated between the cerebral cortex and the brainstem, was traditionally described as a relay for sensory information, but contemporary neuroscience literature recognizes it as a major regulator and integrator of distributed cortical networks. Different thalamic nuclei participate in networks involving attention, arousal, language, memory, spatial learning, executive functions, emotion, and learning.

The anterior thalamic nuclei has been widely studied in context of its connectivity with the hippocampus and other sites within the 'extended hippocampal system' including the retrosplenial cortex and mammillary bodies [9]. It further participates in reciprocal connections with the mammillary bodies, cingulate cortex, and frontal cortical systems [4]. These pathways place the anterior thalamus within circuits concerned not only with memory and spatial learning but also with attention and contextual processing [10].

This is relevant to the presenting case as the patient does not demonstrate a global cognitive deficits. Instead, his difficulties are limited to reading, language processing, written expression, spelling, spatial relations, and aspects of visuo-spatial organization are disproportionately affected. A small disruption within a strategic network node may therefore produce an uneven cognitive profile.

Another notable observation is that the dominant left hemisphere for right handed individuals is strongly involved in language processing [11]. Functional neuroimaging studies have demonstrated thalamic activation during tasks of naming, reading, lexical decision, sentence generation, and working-memory, with a tendency toward greater left-sided or midline involvement [12].

Anatomically, therefore, a left anterolateral thalamic abnormality could be conceptualized as potentially influencing the efficiency of thalamocortical communication network, particularly within circuits involving frontal, cingulate, temporal, and limbic regions [4].

From anatomy to behaviour and symptomology

Reading ability requires consideration of several interacting processes- phonological processing, visual scanning, attention to sequential information, language comprehension, working memory, and integration of linguistic information. Reported symptoms in this case such as losing track of position of words while reading, becoming stuck on unfamiliar words, and experiencing reduced comprehension may therefore reflect an interaction between language-processing vulnerability and inefficient attentional allocation rather than a purely visuo-spatial problem.

The thalamus is well positioned to influence such distributed processing because thalamocortical systems can regulate the selection and amplification of task-relevant cortical information. This provides a plausible conceptual bridge between the radiological finding and a phenotype involving language and learning. This is however not conclusive of a causation relationship.

The same distinction applies to the patient's report of boredom and difficulty sustaining prolonged study. Although the anterior thalamus has recognized roles in attention, the patient's attention and executive functions on formal psychodiagnostics were intact. Thus, subjective boredom should not be equated with pathological inattention. It may instead reflect the increased cognitive effort required for tasks that are relatively inefficient for him, particularly prolonged reading, writing, and rote theoretical learning. Alternatively, it may represent an independent behavioural characteristic.

Conclusion

This case demonstrates an important neuropsychological paradox: persistent and clinically significant learning difficulties can coexist with superior general intellectual functioning and intact formal attention and executive abilities. The anatomical location of the radiological finding is potentially relevant because the thalamus is a central node within distributed networks supporting attention, learning, memory, language, and executive regulation. The case depicts a network-based interpretation rather than a lesion-symptom one-to-one model.

Further, the case emphasizes that intelligence should not be equated with uniform cognitive efficiency. A person may possess strong conceptual and analytical abilities while experiencing substantial difficulty with the specific neural processes required for reading, language-mediated learning, spelling, and written expression.

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