



THE ROLE OF CEREBROSPINAL FLUID DYNAMICS IN ARACHNOID GRANULATIONS AND BRAIN HERNIATION: CLINICAL SIGNIFICANCE AND IMPLICATIONS

Radio-Diagnosis

Dr Abhishek Pratapbhai Gohil

Postgraduate, Department Of Radiology, Narayana Medical College Nellore

Dr B N Rahul

Postgraduate, Department Of Radiology, Narayana Medical College Nellore.

Dr Rama Krishna Rao Baru

Professor And Hod, Department Of Radiology, Narayana Medical College Nellore.

Dr Krishna Teja Nerella

Associate Professor, Department Of Radiology, Narayana Medical College Nellore.

ABSTRACT

Background: Arachnoid granulations (AGs) are small projections into the brain's venous sinuses, crucial for cerebrospinal fluid (CSF) absorption. Brain herniation into arachnoid granulations (BHAGs) is associated with elevated intracranial pressure, particularly idiopathic intracranial hypertension (IIH). **purpose:** This study investigates the prevalence and clinical significance of AGs and BHAGs in patients with headaches, vertigo, and pulsatile tinnitus. **Methods:** A retrospective study of 200 patients undergoing MRI from January 2022 to January 2023 assessed T2-weighted imaging (T2WI). Inclusion criteria focused on patients over 18 with unexplained neurological symptoms. **Results:** AGs were present in 13.6% of patients, with BHAGs observed in 7%. Among BHAG patients, 57% showed features of IIH. Temporal BHAGs were most common, constituting 64.3% of cases. **Conclusion:** AGs are common findings, while BHAGs significantly correlate with IIH. Their presence warrants further evaluation for elevated intracranial pressure, emphasizing their importance in clinical practice.

KEYWORDS

herniation · Arachnoid granulation · Idiopathic intracranialhypertension · Pulsatile tinnitus · Magnetic resonance imaging

INTRODUCTION

Arachnoid Granulations: Arachnoid granulations (AGs) are small protrusions of the arachnoid membrane that project into the venous sinuses of the brain. They play a crucial role in the absorption of cerebrospinal fluid (CSF) from the central nervous system into the venous circulation. AGs are frequently located in the transverse and superior sagittal sinuses, typically near the entry points of veins into the dural venous sinuses.¹

Brain Herniation into Arachnoid Granulations (BHAG): Brain herniation into arachnoid granulations (BHAG) refers to the displacement of brain tissue into or around a preexisting AG. This phenomenon can occur when increased intracranial pressure due to CSF flow obstruction compresses or blocks the AGs, potentially leading to CSF accumulation in the brain. Although BHAGs are often identified as incidental findings during imaging for unrelated conditions, they may be associated with headaches, epilepsy, and conditions characterized by elevated intracranial pressure, such as idiopathic intracranial hypertension (IIH).^{2,3}

MATERIALS AND METHODS:

A retrospective analytical observational study was conducted involving 200 patients who underwent MRI of the brain for evaluation of headaches, pulsatile tinnitus (PT), and vertigo between January 2022 and January 2023 at the Department of Radiodiagnosis, Narayana Medical College, Nellore. MR imaging was performed using a 3.0 T scanner, with all patients examined using T2-weighted imaging (T2WI).

Inclusion Criteria: Patients aged over 18 years with unknown causes of headaches, vertigo, or pulsatile tinnitus.

Exclusion Criteria: Patients with known causes of headaches, such as stroke, tumours, or haemorrhages.

Results And Statistical Analysis:

Patients complaining of headache, vertigo, and PT were divided among those with MR imaging findings of arachnoid granulation and brain herniation in to Arachnoid Granulation (BHAG).

Within these two groups, further subdivision of patients with BHAG was performed, distinguishing between those with and without imaging findings of idiopathic intracranial hypertension (IIH). A comparison was then made to identify the significance of BHAG in increasing the odds of IIH

Study Population: This retrospective observational study analysed data from 200 patients who presented with complaints of headaches, vertigo, and pulsatile tinnitus (PT) at the Department of Radiodiagnosis, Narayana Medical College, from January 2022 to January 2023. Patients were categorized based on MRI findings into two primary groups: those with arachnoid granulations and those with brain herniation into arachnoid granulations (BHAGs).

Prevalence of Arachnoid Granulations and BHAGs:

- **Arachnoid Granulations (AGs):**
 - Total prevalence among the study cohort was 13.6% (n = 27 patients).
- **Brain Herniation into Arachnoid Granulations (BHAGs):**
 - BHAGs were identified in 7% of patients (n = 14 patients).

BHAG Subgroup Analysis:

Among the patients diagnosed with BHAGs:

- Patients exhibiting imaging features consistent with IIH: 8 out of 14 (57%).
- Patients without imaging features of IIH: 6 out of 14 (43%).

This significant correlation suggests a potential link between the presence of BHAGs and underlying IIH.

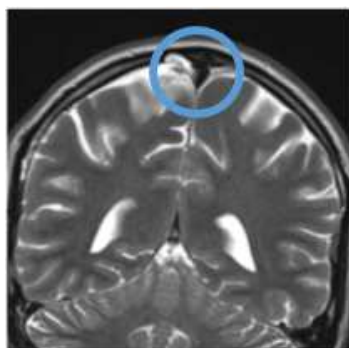
Distribution of BHAG Locations: The analysis of BHAG locations revealed:

- **Temporal/occipital BHAGs:** 9 out of 14 (64.3%).
- **Cerebellar BHAGs:** 4 out of 14 (29%).
- **Parietal BHAG:** 1 out of 14 (6.7%).

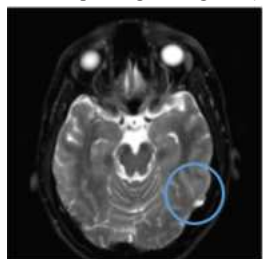
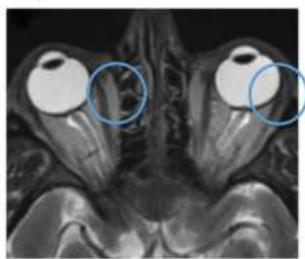
This distribution indicates that temporal and occipital lobe involvement is predominant among BHAG cases, emphasizing the need for focused imaging evaluations in this region.

Summary of Findings:

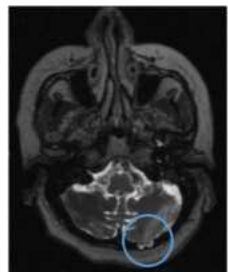
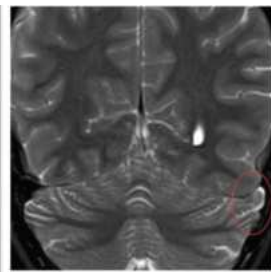
- The overall prevalence of AGs (13.6%) and BHAGs (7%) highlights their clinical significance in patients presenting with headache-related symptoms.
- The association of BHAGs with imaging features of IIH (57%) underscores the necessity for careful neuroimaging interpretation in this context.
- The predominance of temporal BHAGs among the studied population may influence clinical management strategies and the necessity for monitoring intracranial pressure in these patient

RESULTS AND CASE IMAGES:**Case 1: Arachnoid Granulation**

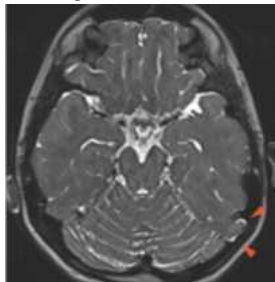
Coronal/sagittal T2 MR images show arachnoid granulation in bilateral parasagittal regions (Figure 1).

**Fig 2****Fig 3****Case 2: BHAG in Left Temporal Lobe**

Axial T2 MR image demonstrates a small BHAG of the left temporal lobe (Figure 2). Additional axial T2 MR images show flattening of the posterior globes and protrusion of the optic nerve heads, suggestive of elevated intracranial pressure (Figure 3).

Case 3: BHAG in Left Cerebellum**Fig 4****Fig 5**

Axial and sagittal T2 MR images reveal a small left cerebellar BHAG into the left transverse sinus (Figures 4 and 5).

Case 4: BHAG in Left Temporal Lobe**Fig 6**

Axial T2 MR image shows another small BHAG of the left temporal lobe (Figure 6).

DISCUSSION

This study elucidates the prevalence and clinical significance of

arachnoid granulations (AGs) and brain herniation into arachnoid granulations (BHAGs) in patients presenting with headaches, vertigo, and pulsatile tinnitus. The findings indicate that AGs are commonly observed in neuroimaging, with a prevalence of 13.6% in our patient cohort. BHAGs, while less frequent at 7%, present important clinical implications, particularly regarding their association with idiopathic intracranial hypertension (IIH).

Clinical Relevance of Arachnoid Granulations: Arachnoid granulations play a critical role in the regulation of cerebrospinal fluid dynamics. Their presence is crucial for the absorption of CSF into the venous system, and variations in their morphology or number may reflect underlying pathological processes. The detection of AGs should prompt clinicians to consider their potential relationship with elevated intracranial pressure, especially in symptomatic patients.²

Association with BHAGs: The study highlights that a significant proportion of patients with BHAGs (57%) exhibited imaging features consistent with IIH. This suggests that BHAGs may serve as an important radiological marker for increased intracranial pressure. The pathophysiological mechanism likely involves the obstruction of normal CSF flow, leading to brain herniation into the granulations. This may occur in conditions characterized by elevated intracranial pressure, including idiopathic intracranial hypertension, where the balance between CSF production and absorption is disrupted.^{2,3}

Implications for Clinical Practice: Given the strong association between BHAGs and IIH, neuroimaging findings of BHAG should not be dismissed as mere incidental findings. Clinicians should maintain a high index of suspicion for elevated intracranial pressure in patients presenting with neurological symptoms. The identification of BHAGs in MRI can serve as a prompt for further evaluation, including lumbar puncture for direct measurement of intracranial pressure and assessment of CSF dynamics. Additionally, further investigations into the clinical significance of BHAGs could improve our understanding of their implications in headache syndromes and other neurological disorders.^{3,4}

Limitations: While this study provides valuable insights, it is not without limitations. The retrospective nature of the study may introduce selection bias, and the sample size may not be representative of the broader population. Additionally, the lumbar puncture results were equivocal, highlighting the need for more precise methodologies in future studies to assess intracranial pressure and its correlation with BHAGs.

CONCLUSION

In conclusion, this study demonstrates that arachnoid granulations are relatively common findings in patients undergoing neuroimaging for headaches, vertigo, and pulsatile tinnitus. A smaller subset of these patients exhibits brain herniation into arachnoid granulations (BHAG), which is significantly associated with idiopathic intracranial hypertension (IIH). The presence of BHAGs should be regarded as a significant neuroimaging finding that warrants expedited clinical evaluation for potential underlying conditions.

The temporal lobe emerges as the most frequent site for BHAG occurrences, emphasizing the need for targeted imaging assessments in this region. Given the implications of increased intracranial pressure, clinicians should be vigilant in considering BHAGs as potential indicators of serious neurological conditions. Future research should focus on larger cohorts and the development of standardized protocols for assessing CSF dynamics in relation to arachnoid granulations and BHAGs, ultimately enhancing our understanding of their clinical significance.

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Conflict of Interest: The authors declare no conflict of interest regarding this case report.

Ethical Clearance: This case report was conducted in accordance with ethical guidelines and received approval from the institutional review board.

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