

CASE REPORTS

EVALUATING ARTERIOVENOUS MALFORMATION AND DIFFUSE GLIOMA: THE ROLE OF ARTERIAL SPIN LABELING MRI IN COMPLEX NEUROIMAGING— A CASE REPORT

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ABSTRACT

In this case report, we explore the utility of arterial spin labeling (ASL) MRI in a complex neuroimaging scenario featuring concurrent arteriovenous malformation (AVM) and a non-enhancing glioma in a 38-year old male. The report delves into the integration of ASL MRI with standard neuroimaging techniques, highlighting its role in providing detailed hemodynamic insights, particularly in characterizing the AVM and assessing the glioma's perfusion pattern. The case presents a diagnostic challenge due to the coexistence of these pathologies and discusses the implications of these findings in light of the evolving WHO brain tumor classification, which emphasizes the importance of molecular markers alongside histopathology. The report emphasizes the need for careful interpretation of advanced imaging in the absence of histopathological confirmation and advocates for a multidisciplinary approach in the management of such cases, underscoring the significance of ongoing research in harmonizing imaging techniques with molecular diagnostics.

Keywords: *arterial spin labeling, MRI, arteriovenous malformation; glioma*

INTRODUCTION

Arteriovenous malformations (AVMs) and diffuse gliomas, each with their distinct clinical and imaging challenges, significantly impact neurological health. Arteriovenous malformations, marked by their web of abnormal vessels, and diffuse gliomas, with their spectrum of presentations and prognoses, necessitate precise imaging for accurate characterization and management (1,2). The prevalence of these conditions in neurological practice underscores the importance of innovative and effective diagnostic techniques.

Traditional imaging modalities, such as computed tomography (CT) and magnetic resonance imaging (MRI), while foundational in neuroimaging, sometimes fall short in capturing the full complexity of these pathologies. Arterial spin labeling (ASL) MRI, a non-invasive method that maps cerebral blood flow without contrast agents (3,4), offers an additional perspective in this regard. Its role, particularly in complex cases involving concurrent pathologies like AVMs and gliomas, can be illustrative, providing clinicians with enhanced details on vascular and perfusion patterns.

This case report presents the application of ASL MRI in a patient diagnosed with both an AVM and a diffuse glioma. The findings from ASL MRI complemented traditional imaging methods, offering a more detailed view of the vascular dynamics of the AVM and the perfusion characteristics of the glioma. The case also touches on the evolving nature of brain tumor classification, particularly in light of the World Health Organization's (WHO) ongoing up-

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dates to its central nervous system tumors classification system (5). These updates reflect the rapidly advancing understanding of tumor biology, underscoring the importance of integrating both histological and molecular features in diagnosis. In discussing this case, we aim to shed light on the nuances and evolving understanding of neuroimaging and neuropathology. This case highlights the potential of ASL MRI to add valuable information in the assessment of complex cerebral pathologies, especially in cases where traditional imaging modalities may offer limited perspectives.

CASE PRESENTATION

Patient Information

A 38-year-old male, with no significant past medical history, presented with episodic headaches and newly emerging focal seizure activity. The headaches and seizures appeared without clear precipitating factors and gradually increased in frequency over a few weeks prior to presentation. The absence of prior neurological or systemic issues in the patient's history rendered the diagnostic process more challenging, emphasizing the need for comprehensive neuroimaging. There was no family history of neurological disorders or known environmental exposures.

Clinical Findings

Neurological examination revealed mild left-sided hemiparesis with decreased motor strength. These findings warranted further investigation given their potential association with a number of cerebral pathologies. Cognitive functions and other neurological assessments were within normal range, offering no further clues to the underlying condition.

DIAGNOSTIC ASSESSMENT

MRI Observations

1. Arteriovenous Malformation in the Left Frontal Region:

High-resolution MRI scans demonstrated a complex arteriovenous network in the left frontal lobe, characteristic of an arteriovenous malformation. The nidus of the AVM was defined by a cluster of dysplastic vessels, with aberrant arterial feeders originating from the left middle cerebral artery. Venous drainage was notably complex, featuring a dilated venous structure draining into the left internal cerebral vein, and a secondary drainage pathway ex-

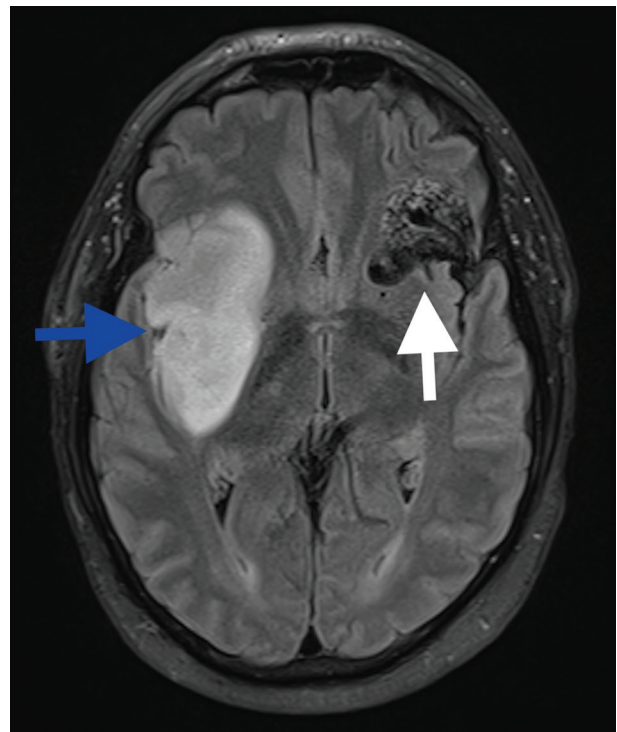


Fig. 1. FLAIR MRI depicting a complex of serpiginous flow-voids within the AVM nidus (white arrow) and a prominent hyperintense supratentorial mass (blue arrow), histopathologically confirmed as a WHO grade 2 Gemistocytic Astrocytoma. FLAIR: Fluid-Attenuated Inversion Recovery.

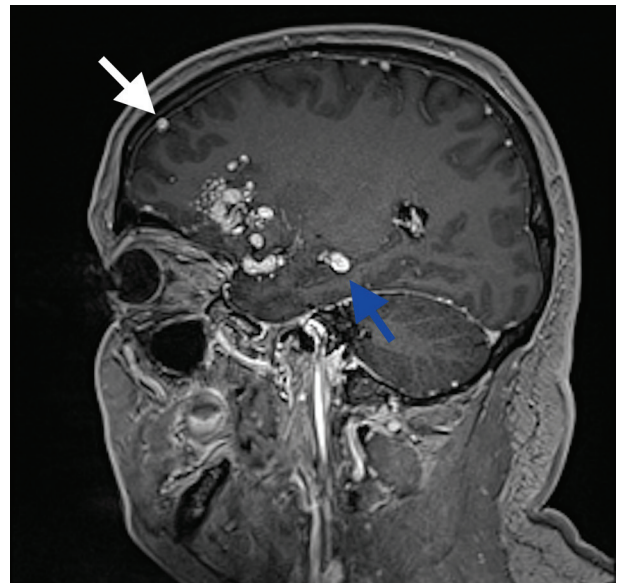


Fig. 2. T1-weighted MRI with contrast is one of the conventional techniques for highlighting AVM's draining venous pathways: one vein leading to the superior sagittal sinus (white arrow) and another draining into the left internal cerebral vein (blue arrow).

tending anteriorly towards the superior sagittal sinus (Fig. 1, 2).

2. Neoplastic Lesion in the Right Insula, Frontal, and Temporal Lobes:

The lesion exhibited a heterogeneous signal intensity on T2-weighted and FLAIR sequences, with a predominantly hyperintense signal and regions of hypointensity on T1-weighted images, without significant post-contrast enhancement. These imaging characteristics were suggestive of a diffuse glial neoplasm, potentially indicative of an infiltrative astrocytic tumor. Notably, there was evidence of moderate mass effect, as indicated by the local distortion of adjacent cerebral structures. A slight midline shift was also observed, reflecting the lesion's impact on surrounding brain parenchyma. (Fig. 1)

Arterial Spin Labeling MRI Findings

1. AVM Characterization:

Arterial spin labeling MRI provided functional insight into the hemodynamic status of the AVM (6). There was marked hyperperfusion within the nidus, extending to the abnormal venous channels. This hyperperfusion was indicative of a high-flow vascular shunt, characteristic of AVMs. The ASL data, when integrated with the structural MRI findings, offered

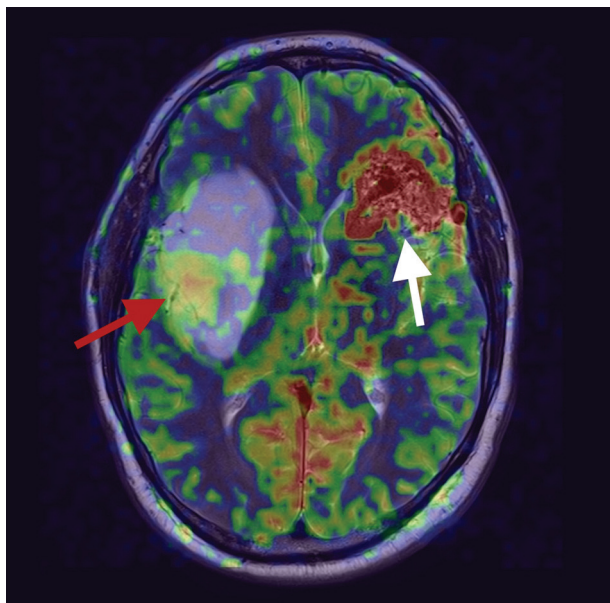


Fig. 3. Fused T2-weighted and ASL MRI images, providing both structural and functional insights. Notable signal enhancement in the AVM nidus (white arrow) and an area of increased perfusion within the glioma (red arrow).

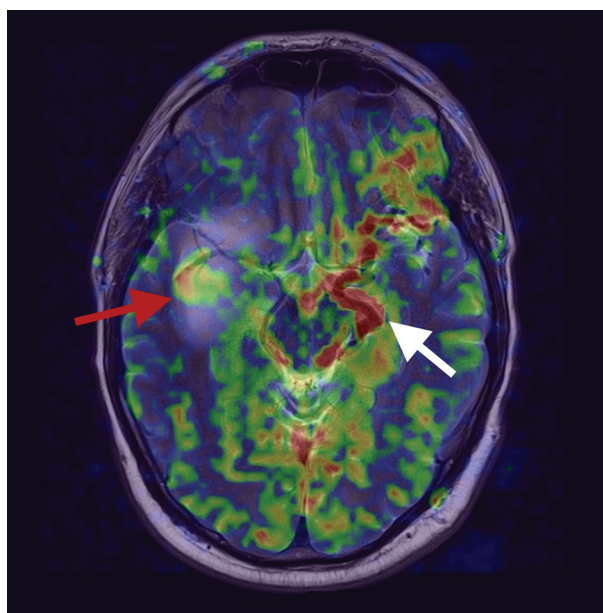


Fig. 4. ASL MRI demonstrating the utility in identifying draining veins of vascular malformations, with pronounced signal enhancement along the vein to the left internal cerebral vein (white arrow). Increased perfusion within a segment of the tumor (red arrow).

a comprehensive view of the AVM's vascular dynamics (Fig. 3, 4).

2. Neoplasm Perfusion Patterns:

Within the region of the suspected glioma, ASL MRI revealed a focal area of increased cerebral blood flow (Fig. 3, 4). This finding suggested elevated metabolic and vascular activity within the tumor, a feature often associated with higher-grade gliomas (6). However, given the heterogeneity inherent in diffuse gliomas, this observation was approached with caution, recognizing the need for histopathological correlation.

DIAGNOSIS, TREATMENT AND FOLLOW-UP

Symptom management was initiated with standard anticonvulsant therapy. Cerebrospinal fluid analyses were not performed, as initial imaging provided sufficient diagnostic information. The neurosurgical team, informed by the comprehensive imaging findings, planned a targeted approach for biopsy of the neoplasm. The ASL MRI findings, while not radically altering the treatment trajectory, provided additional context for the biopsy, guiding the selection of the region with the highest perfusion for

tissue sampling. This strategy aimed to increase the likelihood of obtaining a representative sample, particularly given the potential for histological heterogeneity within the tumor. Furthermore, the perfusion insights from ASL MRI provided a baseline for monitoring the tumor's progression over time.

Histopathological examination of the biopsied tissue revealed a diagnosis of gemistocytic astrocytoma, WHO grade 2, a classification based on criteria existing prior to the 2021 WHO updates. The discovery of an area of high perfusion, typically associated with more aggressive neoplastic phenotypes, presented an intriguing contrast to the histological findings. This discrepancy raised considerations about the dynamic and possibly evolving nature of the tumor.

The patient was subsequently referred to a multidisciplinary team, comprising specialists in neuro-oncology, radiation oncology, and medical oncology, for comprehensive management. This collaborative approach facilitated the initiation of a targeted treatment regimen, which included chemotherapy and precision-focused radiation therapy directed at the tumor region.

Over the subsequent three years, follow-up imaging showed progressive enlargement of both the neoplasm and the areas of high perfusion identified on ASL MRI. This radiological progression, in the absence of further histopathological data, suggests a potential transformation to a higher-grade glioma, highlighting the complexity and evolving nature of glioma classification and management.

DISCUSSION

This case report highlights the nuanced role of ASL MRI in the context of neuro-oncology and vascular neurosurgery. The ASL MRI findings, while not pivotal in altering the treatment course, provided additional hemodynamic information, complementing the conventional MRI findings of the AVM and diffuse glioma. Additionally, the ability of ASL MRI to detect perfusion changes over time underscores its potential value in long-term monitoring of glioma progression and transformation.

This case is particularly instructive for understanding the radiological-histopathological correlation in diffuse gliomas (7). The initial diagnosis of the glioma as a WHO grade 2 gemistocytic astrocy-

toma, despite radiological signs typically indicative of higher-grade tumors, such as increased perfusion, presents a challenging dichotomy. This discrepancy highlights the intricacies of glioma classification, particularly in light of the recent WHO updates that emphasize molecular features alongside histopathology. The historical context of gemistocytic astrocytomas as aggressive tumors, often equated with WHO grade 3 tumors, contrasts with their reclassification in the post-2021 WHO guidelines. Now, these tumors are assessed with a focus on molecular markers, especially isocitrate dehydrogenase (IDH) mutation status, critical for determining the tumor's classification and prognosis (5). This evolution in classification, underlining the importance of molecular diagnostics in neuro-oncology, reflects the dynamically changing landscape of brain tumor diagnosis and treatment strategies.

The presented case contributes to the understanding of the complex interplay between imaging findings, histopathological features, and clinical decision-making in the management of cerebral pathologies. The insights gleaned from ASL MRI in this case, especially in the context of an evolving tumor classification system, highlight the potential of integrating advanced imaging modalities with molecular diagnostics. This integration could significantly enhance the precision of diagnosis and treatment strategies in neuro-oncology. The importance of a multidisciplinary approach in navigating these complexities cannot be overstated, as it ensures a comprehensive and nuanced understanding of each case. The findings underscore the need for ongoing research, particularly in the harmonization of imaging techniques with the rapidly advancing field of molecular pathology, to better understand and treat complex cerebral disorders.

CONCLUSION

This case illustrates the value of ASL MRI in enhancing the understanding of complex neurovascular and neuro-oncological conditions. It highlights the need for cautious interpretation of imaging findings in light of evolving histopathological classifications and advocates for the integration of advanced imaging with molecular diagnostics in neuro-oncology. This report reinforces the importance of a multidisciplinary approach in the management of such

cases and underscores the ongoing need for research at the intersection of imaging technology and molecular pathology. Future studies should focus on validating the clinical utility of ASL MRI in dual-pathology scenarios and exploring its potential to guide personalized treatment strategies in neuro-oncology.

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