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ASL in the Aging Mind: Tracing Perfusion Patterns in Emerging Dementia

Dr. Malgireddy Vinitha[1], Dr. Uma Maheshwara Reddy[2], Dr. Rama Krishna Rao Baru[3], Dr. Pentyala Suneetha[4]

[1]Postgraduate, Department of Radio-Diagnosis, Narayana Medical College, Nellore

[2]Professor, Department of Radio-Diagnosis, Narayana Medical College, Nellore

[3]Professor & HOD, Department of Radio-Diagnosis, Narayana Medical College, Nellore

[4]Professor, Department of Radio-Diagnosis, Narayana Medical College, Nellore

Abstract: ***Arterial Spin Labeling (ASL) is a novel, non-invasive MRI-based perfusion imaging technique utilizing magnetically labelled arterial blood as an endogenous tracer to quantify cerebral blood flow (CBF). Dementia, a clinical syndrome defined by progressive decline in one or more cognitive domains, is a growing global health challenge, presents with characteristic regional perfusion deficits corresponding to specific neurodegenerative pathologies. ASL enables early detection of such patterns, aiding in the diagnosis and differentiation of dementia subtypes, including Alzheimer's disease (AD), Frontotemporal Dementia (FTD), and Dementia with Lewy Bodies (DLB). This paper outlines the clinical application of ASL in detecting early perfusion changes in patients with cognitive decline and discusses imaging correlations in typical dementia cases.***

Abbreviations: ASL-Arterial spin labelling, MRI-Magnetic Resonance Imaging, CBF-Cerebral blood flow, AD-Alzheimer's disease, FTD-Fronto-temporal dementia, DLB-Dementia with lewy bodies

Keywords: ASL, dementia, MRI, perfusion patterns, cognitive decline, Alzheimer's disease, Fronto-temporal dementia, Lewy body dementia.

1. Introduction

Dementia is a progressive neurological disorder characterized by impairment in memory, reasoning, language, and other cognitive functions. The global burden of dementia is expected to rise exponentially, with estimates indicating over 150 million cases by 2050 (1). The identification of early biomarkers is therefore crucial in mitigating the personal and societal impact of the disease.

Conventional MRI primarily reveals structural changes such as atrophy and white matter hyperintensities. However, these are often late manifestations. Arterial Spin Labeling (ASL) perfusion imaging has emerged as a powerful technique to detect functional alterations in the brain by measuring CBF non-invasively without contrast agents (2, 3). ASL is particularly useful in distinguishing dementia subtypes based on their unique perfusion signatures, potentially even before significant atrophy occurs (4).

2. Objectives

To evaluate the diagnostic utility of ASL MRI in identifying regional cerebral perfusion abnormalities in patients presenting with clinical features of cognitive decline and to examine characteristic hypoperfusion patterns across different dementia subtypes.

3. Materials and Methods

Study Design: A prospective case-based observational study.
Instrumentation: Imaging was conducted using a **SIEMENS 3T MAGNETOM Spectra** MRI scanner employing **pseudo-continuous ASL (pCASL)** sequences.
Population: Patients aged 60–75 years presenting with clinical features of cognitive impairment or behavioral changes, referred for neuroimaging.
Procedure: Each subject underwent standard MRI brain screening followed by ASL perfusion imaging. Radiological evaluation was correlated with clinical features to determine the most likely subtype of dementia.

4. Illustrative Cases

Case 1: Alzheimer's Disease
71-year-old male, presented with symptoms of memory loss, behavioral changes, reduced motor activity

Imaging findings revealed bilateral temporal lobe atrophy with periventricular hyperintensities on FLAIR. ASL showed hypoperfusion in bilateral parietal, temporal, and left frontal lobes.

Interpretation: These findings are typical of Alzheimer's Disease (AD), where posterior cortical hypoperfusion and medial temporal atrophy are characteristic (3, 5).

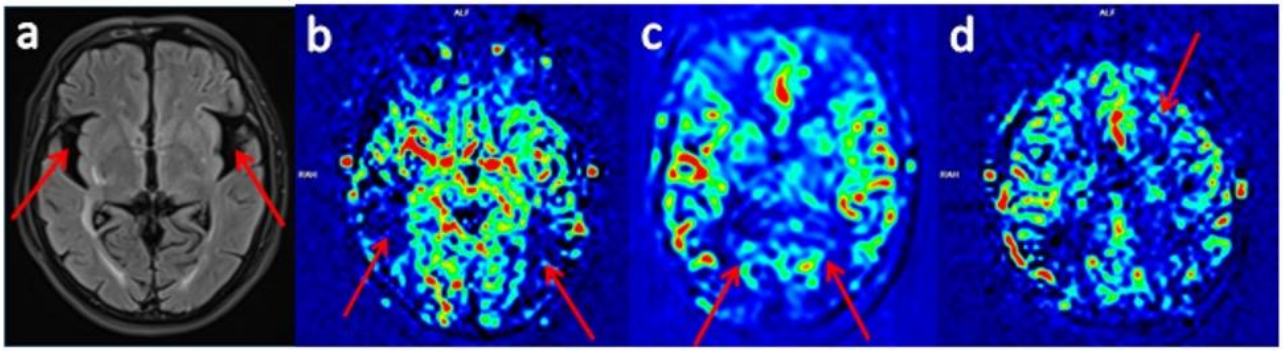

Figure 1: (a) Axial FLAIR MR image showing bilateral temporal lobe atrophy (arrows), periventricular hyperintensities, (b, c, d) MRI brain fused ASL perfusion depicting hypoperfusion in bilateral temporal, parietal & left frontal lobes.

Case 2: Frontotemporal Dementia (FTD)
65-year-old female, came with complaints of apathy, social disinhibition, language dysfunction
Imaging findings showed mild frontal and temporal atrophy with corresponding decreased perfusion in these regions on ASL.

Interpretation: Consistent with FTD, which demonstrates anterior lobar hypoperfusion due to regional hypometabolism (2).

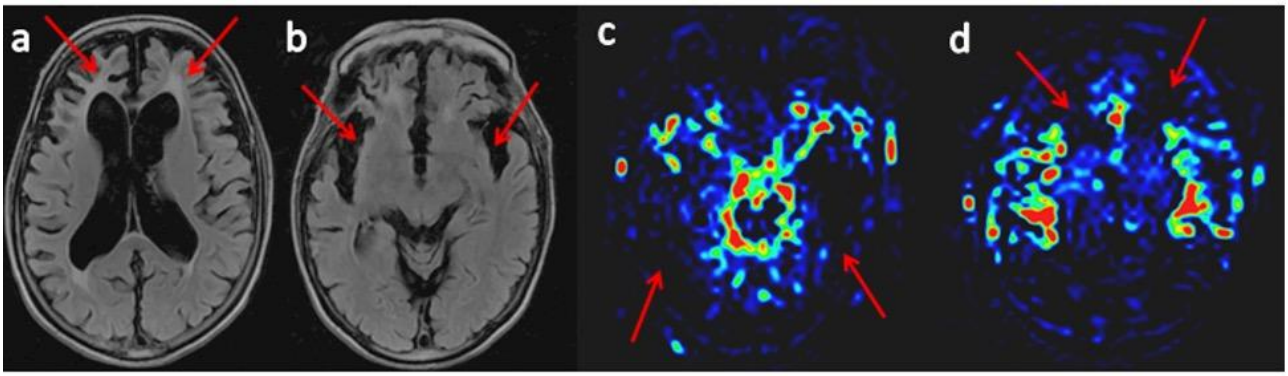

Figure 2 (a, b): MRI: Axial FLAIR images showing mild atrophy in the frontal & temporal lobes (arrows) with corresponding (c, d) ASL images depicting gross decrease in perfusion in bilateral frontal and temporal lobes.

Case 3: Dementia with Lewy Bodies (DLB)
68-year-old male patient presented with symptoms of cognitive decline and memory disturbances
Imaging Findings revealed ASL showed bilateral occipital hypoperfusion and cerebellar involvement with preserved posterior cingulate perfusion, known as the "Cingulate Island Sign."

Interpretation: A distinguishing feature of DLB which helps differentiate it from AD (4).

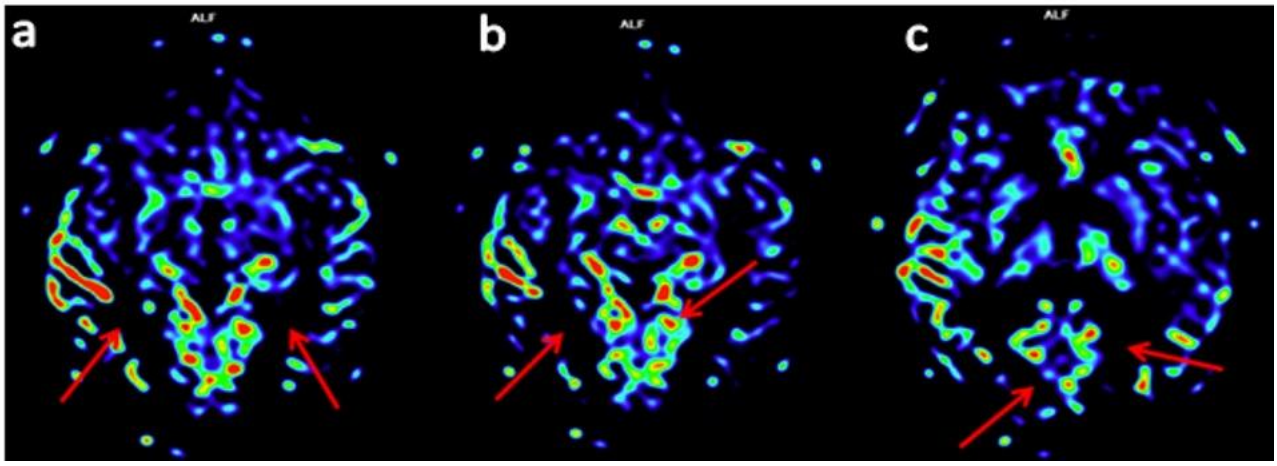

Figure 3 (a, b, c): MRI brain fused ASL images depicting bilateral occipital regional hypoperfusion with preserved perfusion of posterior cingulate cortex (arrows) giving "CINGULATE ISLAND SIGN".

Case 4: Mixed Dementia / Global Hypoperfusion

65-year-old male patient presented with diffuse cognitive impairment

Imaging findings showed global hypoperfusion across bilateral frontal, parietal, and temporal lobes.

Interpretation: Suggestive of mixed dementia or hypoperfusion due to systemic factors such as cardiac failure (1, 3).

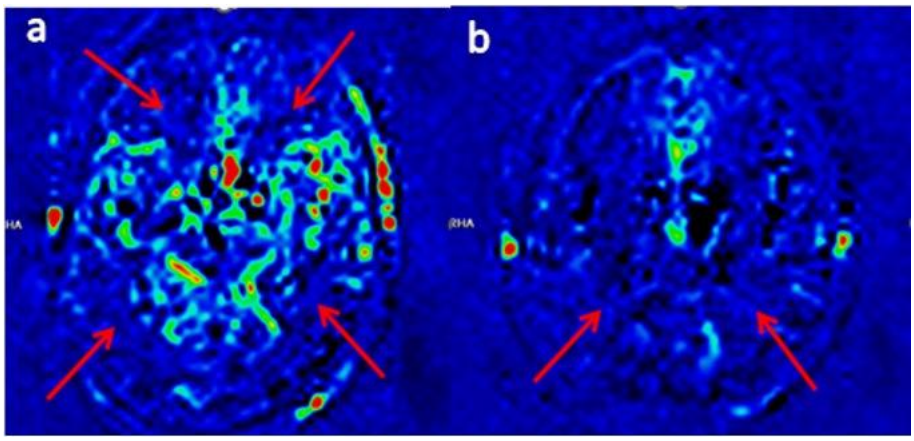

Figure 4 (a, b): MRI brain fused ASL images showing global hypoperfusion involving the bilateral cerebral parenchyma (arrows).

5. Discussion

ASL MRI allows for non-invasive, quantitative assessment of cerebral perfusion, making it a promising imaging biomarker in early-stage neurodegeneration. Several studies affirm the correlation between hypoperfusion and neuronal loss, particularly in preclinical stages of AD and FTD (3, 5).

- **Alzheimer's Disease:** Typically presents with parieto-temporal and posterior cingulate hypoperfusion, often before hippocampal atrophy becomes evident (3).
- **Frontotemporal Dementia:** Demonstrates frontal and temporal lobe hypoperfusion, particularly in behavioral and primary progressive aphasia variants (2).
- **Dementia with Lewy Bodies:** Occipital hypoperfusion and preservation of the posterior cingulate cortex are hallmarks (4).
- **Global Hypoperfusion:** May result from mixed dementia or vascular insufficiency and is seen as diffuse low perfusion on ASL (1).

ASL is advantageous compared to other modalities like PET due to its non-invasiveness, lack of ionizing radiation, and cost-effectiveness (3). These features make ASL a valuable tool for early diagnosis, differential classification, and tracking disease progression.

6. Conclusion

Arterial Spin Labeling MRI offers a unique, non-invasive method for identifying perfusion abnormalities in dementia. It provides functional insights into cerebral blood flow, aiding in the differentiation of dementia subtypes such as AD, FTD, and DLB. ASL enhances diagnostic precision, detects early cerebral dysfunction, and complements structural imaging modalities. Its implementation in routine neuroimaging protocols for dementia evaluation is strongly recommended.

References

[1] World Health Organization. Dementia Fact Sheet. Geneva: WHO; 2022.
[2] Haller S, Zaharchuk G, Thomas DL, et al. Arterial Spin Labeling Perfusion of the Brain: Emerging Clinical Applications. *Radiology*.2016; 281 (2): 337-356.
[3] Detre JA, Rao H, Wang DJ, et al. Applications of Arterial Spin Labeled MRI in the Brain. *J Magn Reson Imaging*.2012; 35 (5): 1026-1037.
[4] Wolk DA, Detre JA. Arterial Spin Labeling MRI: An Emerging Biomarker for Alzheimer's Disease and Other Neurodegenerative Conditions. *Curr Opin Neurol*.2012; 25 (4): 421-428.
[5] Jack CR Jr, Lowe VJ, Senjem ML, et al.11C PiB and Structural MRI Provide Complementary Information in Imaging of Alzheimer's Disease. *Brain*.2008; 131 (Pt 3): 665–680.
[6] Iutaka T, de Freitas MB, Omar SS, et al. Arterial Spin Labeling: Techniques, Clinical Applications, and Interpretation. *Radiographics*.2023; 43 (1): e220088.