International Journal of Radiology and Diagnostic Imaging

E-ISSN: 2664-4444
P-ISSN: 2664-4436
www.radiologypaper.com
IJRDI 2024; 7(3): 106-111
Received: 08-07-2024
Accepted: 13-08-2024

Ahmed F Youssef
Department of Radiodiagnosis, Faculty of Medicine, Benha University, Benha, Egypt

Abdullah Mohammed Al Ramzi
Department of Radiodiagnosis, Armed Forces Hospital, King Abdul Aziz Naval base, Jubail, Saudi Arabia

Abdulaziz Shyee Al Aoun
Department of Radiodiagnosis, Armed Forces Hospital, King Abdul Aziz Naval base, Jubail, Saudi Arabia

Corresponding Author:
Ahmed F Youssef
Department of Radiodiagnosis, Faculty of Medicine, Benha University, Benha, Egypt

Recent advances of MRI in diagnosis of cerebral atherosclerotic disease

Ahmed F Youssef, Abdullah Mohammed Al Ramzi and Abdulaziz Shyee Al Aoun

DOI: https://doi.org/10.33545/26644436.2024.v7.i3b.402

Abstract
Background: Intracranial atherosclerotic disease (ICAD) is a leading cause of ischemic stroke, often presenting with vessel wall abnormalities that are not detected by conventional imaging techniques. The advent of vessel wall magnetic resonance imaging (VW-MRI) has provided a novel approach to directly visualize and assess these abnormalities, offering potential improvements in diagnosis and patient management.
Objective: To evaluate the effectiveness of VW-MRI in the detection and characterization of intracranial vasculopathies, with a focus on differentiating ICAD from other conditions such as reversible cerebral vasoconstriction syndrome (RCVS), vasculitis, and Moyamoya disease.
Methods: This prospective study included 150 patients (mean age 51 ± 15.7 years, 62% female) with suspected intracranial vasculopathies, conducted from March 2022 to February 2024 at Benha University Hospital and Al-Gobeal Military Hospital. VW-MRI was used to assess vessel wall morphology, including patterns of thickening, enhancement, and outward remodeling. Imaging findings were compared across the vasculopathy groups.
Results: ICAD was identified in 66% (n=99) of patients, with 91.9% exhibiting eccentric wall thickening. In contrast, concentric thickening was predominant in vasculitis (88.5%) and RCVS (77.8%). Significant differences were noted in outward remodeling (P=0.02) and enhancement grading (P=0.008) across the groups. The high-grade enhancement was observed in 78.8% of ICAD lesions, highlighting the utility of VW-MRI in differentiating these conditions.
Conclusion: VW-MRI provides crucial insights into the vessel wall pathology of ICAD and other vasculopathies, offering superior diagnostic accuracy over traditional lumen-based imaging. Its ability to distinguish between different types of intracranial vasculopathies underscores its potential as a valuable tool in stroke prevention and management.

Keywords: Vessel wall MRI, intracranial atherosclerosis, stroke, plaque enhancement, vasculopathy

Introduction
Intracranial atherosclerotic disease (ICAD) is a significant cause of ischemic stroke and other cerebrovascular events, contributing to substantial morbidity and mortality worldwide [1]. Traditionally, the assessment of intracranial vasculopathies has relied on lumen-based imaging techniques such as magnetic resonance angiography (MRA), computed tomography angiography (CTA), and digital subtraction angiography (DSA) [2, 3]. While these modalities are effective in detecting luminal stenosis or occlusion, they often fail to provide detailed insights into the underlying pathology within the vessel wall itself. This limitation can result in missed diagnoses or suboptimal management of conditions like ICAD, where early wall changes occur without significant luminal narrowing [4].
Recent advancements in magnetic resonance imaging (MRI) have led to the development of high-resolution vessel wall imaging (VW-MRI), which offers a direct assessment of the vessel wall, enabling the detection of subtle pathological changes that precede or accompany luminal alterations [5]. VW-MRI has demonstrated its utility in evaluating a range of intracranial vasculopathies, including vasculitis, reversible cerebral vasoconstriction syndrome (RCVS), Moyamoya disease, and intracranial aneurysms. By providing detailed information on wall thickening, enhancement patterns, and plaque morphology, VW-MRI can significantly enhance the diagnostic accuracy and guide treatment decisions in patients with suspected cerebrovascular diseases [5-7].

Despite its promising clinical applications, the use of VW-MRI in routine practice is still evolving, with ongoing research aimed at optimizing imaging protocols and validating its diagnostic and prognostic capabilities. Current evidence suggests that VW-MRI can distinguish between different types of vasculopathies based on wall characteristics, but further studies are needed to establish standardized criteria for interpretation and to fully integrate this technology into clinical workflows [8, 9].

This study aims to evaluate the effectiveness of VW-MRI in the detection and characterization of intracranial vasculopathies, with a particular focus on differentiating ICAD from other conditions such as RCVS, vasculitis, and Moyamoya disease.

Patients and methods

Study Design and Setting

This prospective, observational study was conducted at the Radiology Department of Benha University Hospital and Al-Gobeal Military Hospital from March 2022 to February 2024. The study aimed to evaluate the utility of VW-MRI in the detection and characterization of intracranial vasculopathies, with a specific focus on ICAD, RCVS, vasculitis, and Moyamoya disease.

Study Population

The study included 150 patients with suspected intracranial vasculopathies. The inclusion criteria were adults aged 16 to 89 years who had been diagnosed with intracranial arterial stenosis on either MRA or CTA. Patients were required to undergo contrast-enhanced VW-MRI as part of their diagnostic evaluation. Exclusion criteria included patients with known contraindications to MRI, such as metallic implants, severe claustrophobia, or contraindications to gadolinium-based contrast agents, as well as those with a history of contrast-induced sinusitis.

Imaging Techniques

All patients underwent a comprehensive imaging protocol that included brain MRI, MRA, and contrast-enhanced VW-MRI. VW-MRI was performed using a 3T MRI scanner, with a focus on achieving high spatial resolution and effective flow suppression. The imaging parameters were optimized to visualize vessel wall characteristics, including wall thickening, enhancement patterns, and the presence of plaques or other pathological changes. The imaging data were analyzed by two experienced neuroradiologists who were blinded to the clinical history of the patients.

Ethical Considerations

The study was conducted in accordance with the Declaration of Helsinki and was approved by the institutional review boards of Benha University and Al-Gobeal Military Hospital. Informed consent was obtained from all participants prior to their inclusion in the study. All patient data were anonymized to ensure confidentiality.

Data Collection and Analysis

Clinical data, including patient demographics, neurological examination findings, and laboratory results (renal function, coagulation profile, and complete blood count), were collected at the time of admission. The VW-MRI findings were categorized based on the pattern of wall thickening (eccentric or concentric), the enhancement grade, and the presence of outward remodeling. The data were compared across the different vasculopathy groups (ICAD, RCVS, vasculitis, and Moyamoya disease) using appropriate statistical methods. Categorical variables were compared using the chi-square test, while continuous variables were analyzed using the t-test or ANOVA, as applicable.

Results

Variables	All patients (n=60)
Age	
Mean ±SD	51.3±15.7
Range	(16-89)
Sex (N. %)	
Male	20 (38%)
Female	40 (62%)
Clinical Data (N. %)	**All patients**
TIA	25
SAH	10
CVA	15
IPH	10
	ICAD (n=60)
Pattern	
Eccentric	91 (91.9%)
Concentric	4 (4%)
Limited	0 (0%)
NA	4 (4%)

Section: Cases

This study included 150 patients with suspected cranial vasculopathy, their ages ranged from 16 to 89 years old, (62%) of them were females and (38%) were males, most of them were Caucasians (55.3%)

Demographic data among studied patients

Variables	All patients (n=150)
Age	
Mean ±SD	51±15.7
Range	(16-89)
Sex (N, %)	
Male	57 (38%)
Female	93 (62%)
Race (N, %)	
Caucasian	83 (55.3%)
Asian	30 (20%)
Hispanic	10 (6.7%)
Black	14 (9.3%)
Others	5 (3.3%)
Unspecified	8 (5.3%)

Clinical history among studied patients on admission

	All patients (n=150)
TIA	49 (32.9%)
SAH	14 (9.3%)
CVA	102 (68%)
IPH	23 (15.3%)

*TIA: Transient ischemic attack, SAH: Subarachnoid hemorrhage, CVA: Cerebrovascular accident, IPH: Intracranial hemorrhage.

As regards clinical history among studied patients, most of the studied patients (68%) had history of CVA, (32.9%) of patients had history of TIA, (15.3%) had history of IPH and only (9.3%) of patients had history of SAH.

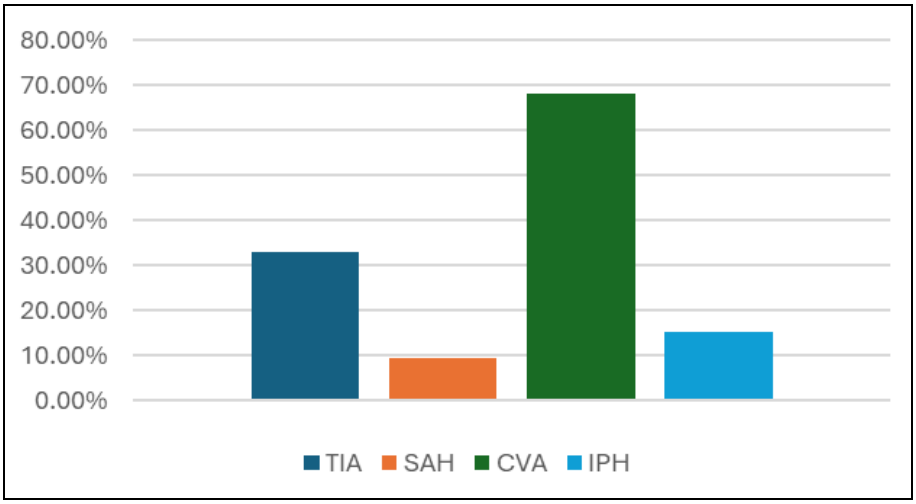


Fig 1: Clinical data among studied patients.

Comparison of LUMINAL+IVWI findings between vasculopathy groups

	ICAD (n=99)	RCVS (n=9)	Vasculitis (n=26)	Moyamoya (n=15)	P-value
Pattern					
Eccentric	91 (91.9%)	1 (11.1%)	1 (3.8%)	4 (26.7%)	<0.001
Concentric	4 (4%)	7 (77.8%)	23 (88.5%)	8 (53.3%)	
Limited	0 (0%)	1 (11.1%)	0 (0%)	1 (6.7%)	
NA	4 (4%)	0 (0%)	2 (7.7%)	2 (13.3%)	
Outer border					
Smooth	85 (85.9%)	8 (88.9%)	21 (80.8%)	12 (80%)	0.09
Limited	0 (0%)	1 (11.1%)	0 (0%)	1 (6.7%)	
Irregular	10 (10.1%)	0 (0%)	3 (11.5%)	0 (0%)	
NA	4 (4%)	0 (0%)	2 (7.7%)	2 (13.3%)	
Outward remodeling					
Yes	13 (13.1%)	1 (11.1%)	0 (0%)	0 (0%)	0.02
No	86 (86.9%)	7 (77.8%)	26 (100%)	14 (93.3%)	
Limited	0 (0%)	1 (11.1%)	0 (0%)	1 (6.7%)	
Enhancement grade					
I	78 (78.8%)	5 (55.6%)	14 (53.8%)	11 (73.3%)	0.008
I	21 (21.2%)	3 (33.3%)	12 (46.2%)	3 (20%)	
Limited	0 (0%)	1 (11.1%)	0 (0%)	1 (6.7%)	

There was significant difference between different types of vasculopathy as regards IVWI findings, as most of vasculopathy groups had concentric pattern except ICAD group where most of patients (91.9%) had eccentric pattern ($P < 0.001$).

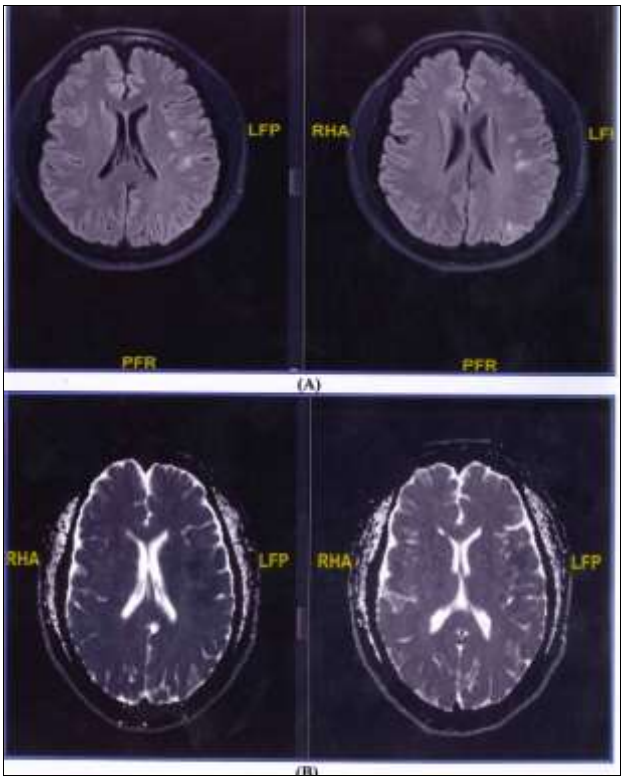
The majority of patients among different vasculopathy groups had smooth outer borders, with no statistically significant differences between studied groups (P=0.09).

There was significant difference between different types of vasculopathy as regards outward remodeling and enhancement grading (P=0.02).

Case presentation

Case 1: Atherosclerosis

A 50-year-old female presented with a left ischemic stroke and word-finding difficulties. FLAIR images (A) showed multiple foci of hyperintense signals in the left posterior and lateral fronto-parietal lobes, while DWI (B) revealed restricted diffusion in the same areas of the frontal lobe, indicating acute infarction. Angiography (AP & OBLIQUE views) demonstrated mild narrowing of the proximal left M1 segment with a cutoff at the origin of the superior left M2 branch. MRA TOF with 3D reformatting (D, E) revealed multiple segments of narrowing and irregularities of the left M1 MCA, P2 of the right PCA, with occlusion of the inferior division of the M2 MCA distal to the bifurcation. T2 black blood VWI (F, G) showed irregular narrowing and wall thickening of the M1 segment of the left MCA, along with internal hyperintensity in the lumen of M2, suggesting thrombosis. T1 post-contrast black blood VWI (H, I) demonstrated eccentric enhancement of the left M1 MCA, indicating an atherosclerotic nature of the vessel involvement. MRA TOF (J) also showed focal narrowing of the P2 segment of the right PCA, and T2 & post-contrast T1 black blood VWI (K) confirmed eccentric vessel wall thickening and enhancement of the P2 segment of the right PCA, consistent with atherosclerosis.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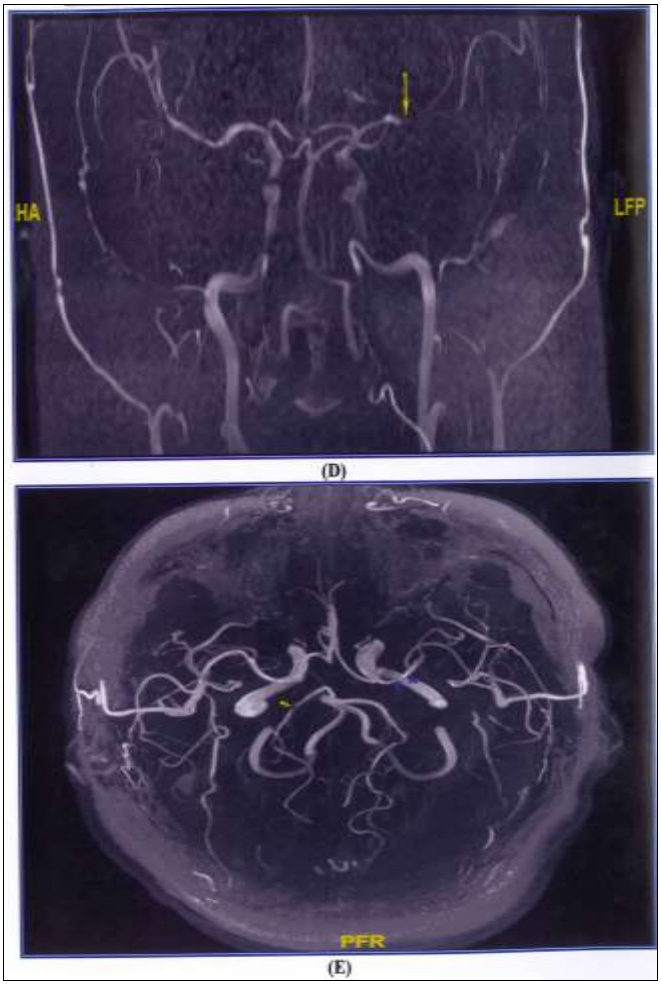
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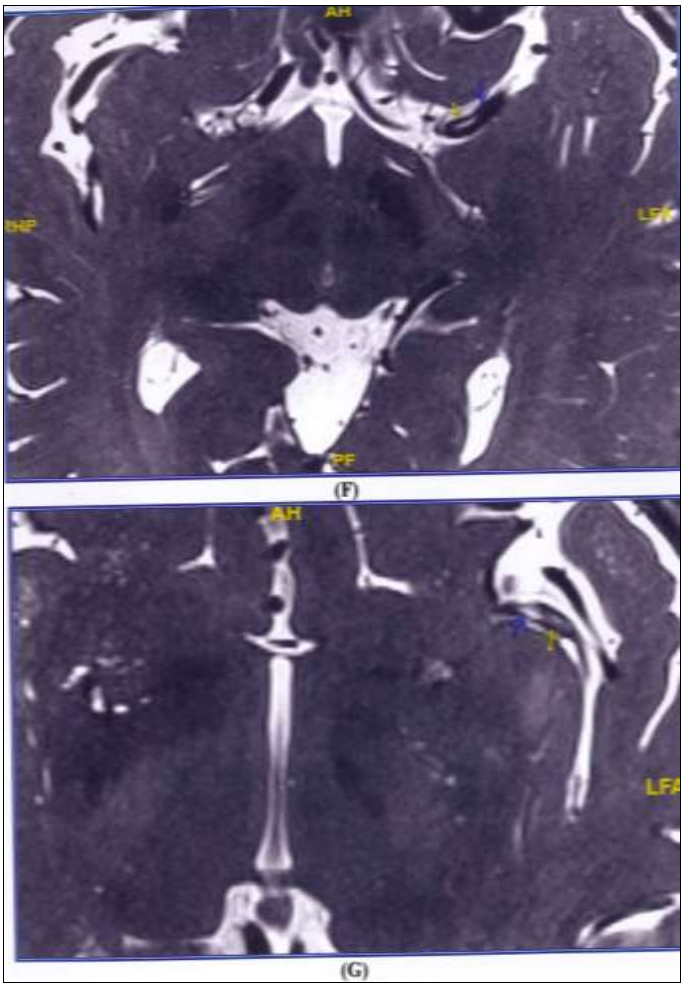
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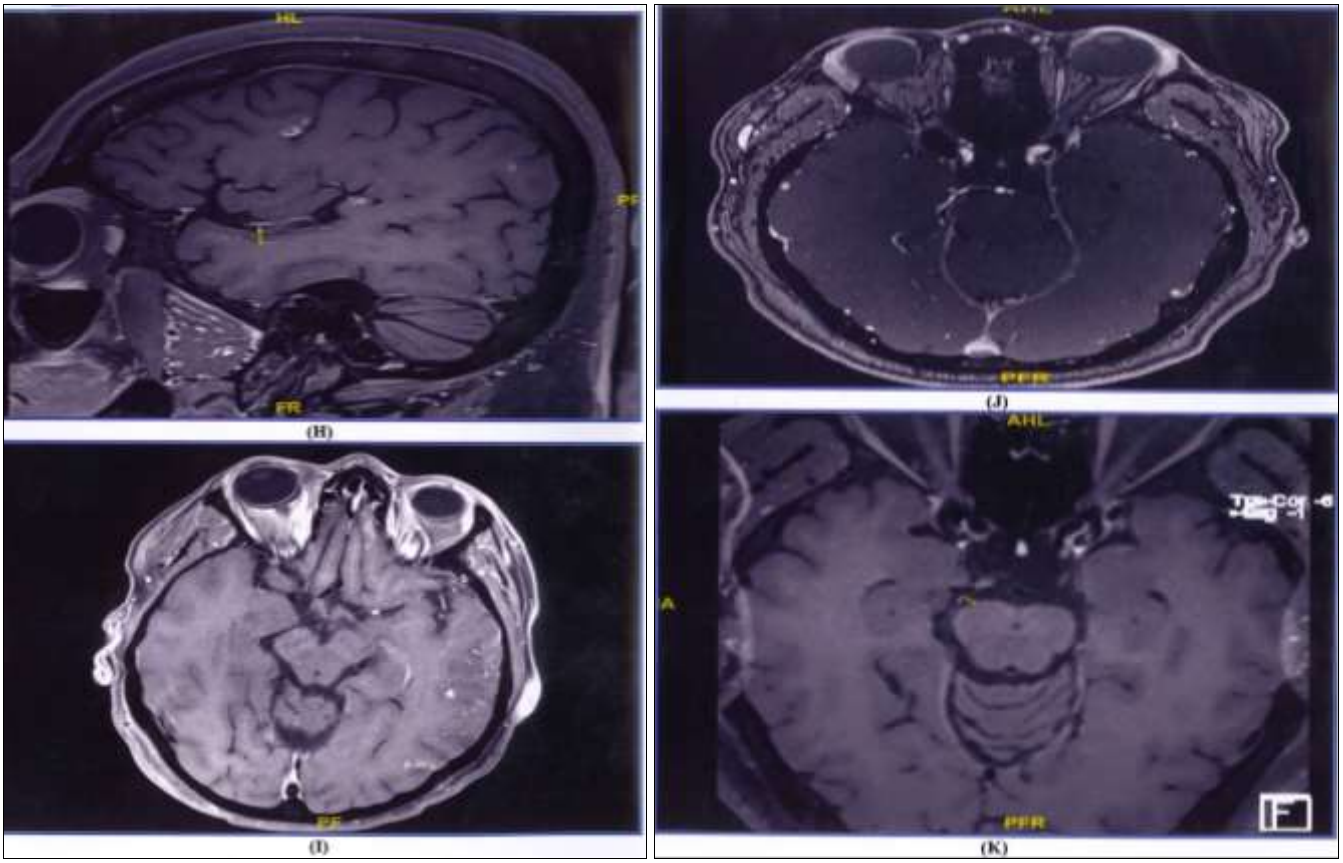

Fig 2: A case of 50-year-old female presented with a left ischemic stroke and word-finding difficulties

Discussion

Early diagnosis intracranial atherosclerotic disease is important be case of delayed therapy can lead to worse outcome [10-12].

Intracranial vessel MRI has shown a promise in its ability to differentiate and characterization of vasculopathy [12-14].

The main age of ICAD is 54 years old, 40 patients are males and 20 are females. These results are in agreement with Daniel Mandelate (2011).

The most common clinical history of the patients with intra-cranial vasculopathies was stroke presentation at least one was subarachnoid hemorrhagic.

Rula a Hogg - Ali et al (2002) reported that the subarachnoid 206 hemorrhagic is at least presentation among patinates with intracranial vasculopathy.

In our study nearly half the ICAD plaques were located proximally followed by distal locations. In accordance with Arja G. Vander Kolk *et al* 2008.

According to the patterns of vessel wall imaging, about 92% of ICAD were eccentric in location Kim 2013, have described nearly the same pattern.

The enhancing of our study of moderate enhancement agreed with Mothew D Alexander, et al (2016).

Our study results reflect 2010 the effectiveness of VM-MR for differentiation of different patterns of intracranial of ICAD.

Accurate and timely sclerotic of intracranial atherosclerotic diseases is important due to significant risk of morbidity with delayed or incorrect diagnosis. MRI, MRA CT or digital subtraction angiography provide limited inflammations as they only identify the lumen. New advance VW-MRI technique can allow direct characterization of vessel wall. This technique improves the patient outcomes. The study was caried out in radiology department in Benha University Hospital and Al-Gobeal Military Hospital, from March 2022 to February 2024.

This study has several limitations that should be acknowledged. Firstly, the relatively small sample size, particularly within the subgroups of different vasculopathies, may limit the generalizability of the findings. Additionally, the study was conducted at two centers with specific imaging protocols, which may not be directly applicable to other settings with different MRI equipment or techniques. The use of contrast-enhanced VW-MRI, while essential for detailed vessel wall assessment, introduces potential variability due to differences in contrast agent administration and patient-related factors, such as renal function. Furthermore, the cross-sectional design of the study precludes assessment of the longitudinal progression of intracranial vasculopathies or the impact of therapeutic interventions. Finally, while the study focused on the technical and diagnostic aspects of VW-MRI, it did not explore the cost-effectiveness or accessibility of this advanced imaging modality in routine clinical practice, which could be important for broader implementation.

Conclusions

Vessel wall imaging has provided information beyond the epiphenomena of luminal narrowing in the evaluation of intracranial arteriopathies. As described in this review article, VW-MRI is a noninvasive imaging method that has proved to be useful in the detection of inflammatory changes of the intracranial arteries and veins that are frequent in certain arteriopathies. This information is undoubtedly useful for clinicians and stroke neurologists in the workup of patients with acute stroke. Further work is necessary for many areas; these include the use of VW-MRI

as a biomarker for immunosuppressive therapy response, prediction of aneurysmal rupture based on aneurysmal wall enhancement, the clinical use of VW-MRI in the pre-stenotic phase of atheromatous disease, increased resolution, and faster sequences are also needed for our acutely ill patients. Radiologist should be knowledgeable of the normal patterns and pitfalls of vessel wall enhancement and the main morphological characteristics of vessel wall lesions.

Conflict of Interest
Not available

Financial Support
Not available

References

1. Yaghi S, Prabhakaran S, Khatri P, Liebeskind DS. Intracranial Atherosclerotic Disease. Stroke. 2019;50:1286-1293.
2. Ghouri MA, Gupta N, Bhat AP, Thimmappa ND, Saboo SS, Khandelwal A, *et al*. CT and MR imaging of the upper extremity vasculature: pearls, pitfalls, and challenges. Cardiovasc Diagn Ther. 2019;9:S152-s73.
3. Edjlali M, Qiao Y, Boulouis G, Menjot N, Saba L, Wasserman BA, *et al*. Vessel wall MR imaging for the detection of intracranial inflammatory vasculopathies. Cardiovasc Diagn Ther. 2020;10:1108-1119.
4. Ismail A, Ravipati S, Gonzalez-Hernandez D, Mahmood H, Imran A, Munoz EJ, *et al*. Carotid Artery Stenosis: A Look Into the Diagnostic and Management Strategies, and Related Complications. Cureus. 2023;15:e38794.
5. Mazzacane F, Mazzoleni V, Scola E, Mancini S, Lombardo I, Busto G, *et al*. Vessel Wall Magnetic Resonance Imaging in Cerebrovascular Diseases. Diagnostics (Basel), 2022, 12.
6. Edjlali M, Qiao Y, Boulouis G, Menjot N, Saba L, Wasserman BA, *et al*. Vessel wall MR imaging for the detection of intracranial inflammatory vasculopathies. Cardiovascular Diagnosis and Therapy. 2020;10:1108-1119.
7. Hedjoudje A, Darcourt J, Bonneville F, Edjlali M. The Use of Intracranial Vessel Wall Imaging in Clinical Practice. Radiol Clin North Am. 2023;61:521-533.
8. Mandell DM, Mossa-Basha M, Qiao Y, Hess CP, Hui F, Matouk C, *et al*. Intracranial Vessel Wall MRI: Principles and Expert Consensus Recommendations of the American Society of Neuroradiology. AJNR Am J Neuroradiol. 2017;38:218-229.
9. D'Aniello S, Rustici A, Gramegna LL, Godi C, Piccolo L, Gentile M, *et al*. The Contribution of Vessel Wall Magnetic Resonance Imaging to the Diagnosis of Primary and Secondary Central Nervous System Vasculitis. Diagnostics. 2024;14:927.
10. Wang Y, Meng R, Liu G, Cao C, Chen F, Jin K, *et al*. Intracranial atherosclerotic disease. Neurobiol Dis. 2019;124:118-132.
11. Prabhakaran S, Romano JG. Current diagnosis and management of symptomatic intracranial atherosclerotic disease. Curr Opin Neurol. 2012;25:18-26.
12. Mossa-Basha M, Shibata DK, Hallam DK, de Havenon A, Hippe DS, Becker KJ, *et al*. Added Value of Vessel Wall Magnetic Resonance Imaging for Differentiation of Nonocclusive Intracranial Vasculopathies. Stroke. 2017;48:3026-3033.
13. Mossa-Basha M, Zhu C, Wu L. Vessel Wall MR Imaging in the Pediatric Head and Neck. Magn. Reson. Imaging Clin. N Am. 2021;29:595-604.
14. Song JW, Wasserman BA. Vessel wall MR imaging of intracranial atherosclerosis. Cardiovascular Diagnosis and Therapy. 2020;10:982-993.

How to Cite This Article
Youssef AF, Al Ramzi AM, Al Aoun AS. Recent advances of MRI in diagnosis of cerebral atherosclerotic disease. International Journal of Radiology and Diagnostic Imaging 2024; 7(3): 106-111.