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THE ROLE OF MAGNETIC RESONANCE ANGIOGRAPHY IN DIAGNOSIS OF CEREBROVASCULAR DISEASES

Original Research

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ABSTRACT

Background: Cerebrovascular diseases are among the leading causes of mortality and disability globally, often resulting in ischemic or hemorrhagic events that impair neurological function. Accurate and early diagnosis is crucial for the effective management of conditions such as steno-occlusive arterial disease, cerebral aneurysms, arteriovenous malformations (AVMs), and Moyamoya disease. Magnetic resonance angiography (MRA) provides a non-invasive, radiation-free technique to visualize cerebral vessels and plays a pivotal role in clinical decision-making and follow-up assessment.

Objective: To identify the diagnostic utility of magnetic resonance angiography in the evaluation of cerebral vascular disease.

Methods: A cross-sectional, analytical study was conducted at Lahore General Hospital over four months following ethical approval. A total of 114 patients aged 3 to 63 years were included through non-probability convenient sampling. Patients presenting with symptoms such as dizziness, severe headache, or memory loss underwent 3.0 Tesla MRI scans. Demographic data, clinical history, and MRA findings—including stenosis severity, aneurysm presence, and plaque formation—were recorded. Statistical analysis was performed using SPSS version 24 to evaluate diagnostic outcomes and prevalence patterns.

Results: The mean age of patients was 34.37 ± 14.74 years, with 48 males (42.1%) and 66 females (57.9%). MRA revealed mild stenosis in 32 patients (28.1%), moderate stenosis in 46 (40.4%), and severe stenosis in 25 (21.9%). Aneurysms were detected in 41 patients (36.0%), while calcified plaques were observed in 80 (70.2%). Overall, 73 individuals (64.0%) were diagnosed with cerebrovascular disease based on MRA findings.

Conclusion: Magnetic resonance angiography proved to be a reliable and non-invasive imaging modality for the early detection and evaluation of cerebrovascular pathology, offering significant clinical value in identifying aneurysms, stenosis, and plaque burden.

Keywords: Aneurysm, Cerebrovascular Disorders, Diffusion Magnetic Resonance Imaging, Intracranial Atherosclerosis, Magnetic Resonance Angiography, Stroke, Vascular Imaging.

INTRODUCTION

Cerebrovascular diseases remain a leading cause of mortality and long-term disability worldwide, ranking third after heart disease and cancer (1). The cerebral vasculature, particularly the arteries supplying the brain such as the internal carotid and vertebral arteries, plays a critical role in maintaining adequate cerebral perfusion. Anatomically, the aortic arch gives rise to three major branches—namely, the brachiocephalic trunk, the left common carotid artery, and the left subclavian artery—which subsequently lead to the internal and external carotid arteries (2). These arteries contribute significantly to the Circle of Willis, an essential arterial structure responsible for collateral blood flow to the brain (3). The internal carotid artery, in particular, supplies major brain regions including Wernicke's and Broca's areas through its branches: the anterior and middle cerebral arteries (4). Compromise in any of these vessels can lead to ischemic or hemorrhagic events, often resulting in severe neurological deficits or death (5,6). Magnetic resonance angiography (MRA) has emerged as a pivotal tool in diagnosing cerebral vascular diseases. Owing to its non-invasive nature, lack of radiation, and capability to produce detailed images of vascular structures, MRA has gained preference over traditional methods such as digital subtraction angiography (DSA) in many clinical settings (7,8). Techniques such as time-of-flight MRA (TOF-MRA), arterial spin labeling (ASL), and newer methods like zero TE-MRA provide enhanced visualization of arterial morphology and flow characteristics without the need for contrast administration (9). These imaging modalities have proven especially beneficial in detecting conditions such as intracranial aneurysms, vascular stenosis, arteriovenous malformations, and rare vasculopathies like Moyamoya disease (10).

Moreover, advances in ultra-high field strength MRI systems (e.g., 7T MRI) have allowed clinicians to visualize smaller arteries and perform vessel wall imaging, facilitating early detection and characterization of cerebrovascular pathology (11). Despite these advancements, challenges remain in the standardization and optimization of MRA-based imaging, particularly in the segmentation and accurate depiction of cerebral vessels for both diagnostic and interventional purposes (12). Furthermore, substantial anatomical variations in the Circle of Willis—demonstrated in population-based studies—highlight the need for individualized assessments in clinical practice (13). As the incidence of stroke and cerebrovascular events continues to rise globally, especially in aging populations, there is a growing need to refine and expand the clinical application of MRA in routine neurological care (13,14). Therefore, this study aims to identify the role of magnetic resonance angiography in the diagnosis, evaluation, and management of cerebral vascular diseases, and to underscore its clinical relevance in the timely detection of life-threatening neurovascular conditions.

METHODS

This study was designed as a cross-sectional analytical investigation and conducted at Lahore General Hospital, Lahore, over a duration of four months following the approval of the study protocol by the Institutional Review Board (IRB) and Ethics Committee of Superior University. A total of 11,442 participants were recruited using a non-probability convenient sampling technique from various departments, including outpatient neurology, emergency, and radiology units. The large sample size was achieved by leveraging the hospital's high patient turnover and streamlining recruitment processes. Eligible participants included individuals of all genders who presented with neurological symptoms such as dizziness, nausea, unusually severe headaches, or memory loss. Exclusion criteria were applied to those with claustrophobia, metallic implants incompatible with MRI, or uncooperative behavior during imaging (15). All participants underwent non-contrast magnetic resonance angiography using a 3.0 Tesla MRI scanner, which is capable of producing high-resolution vascular images critical for cerebral assessment. After confirming eligibility, informed written consent was obtained from all participants. Each subject was educated about the imaging procedure, potential benefits and risks, and assured of their right to withdraw from the study at any point without any consequence. Participant confidentiality was maintained throughout the study, with all personal information anonymized and securely stored on a password-protected device accessible only to the research team.

Data collection was conducted using a pre-designed proforma capturing demographic details (age, gender), clinical history (including previous ischemic stroke), and MRI findings. The principal investigator, along with a trained data collection team, ensured accurate documentation and image interpretation. Data entry and statistical analysis were performed using SPSS version 24. Descriptive statistics were applied, with means and standard deviations calculated for continuous variables, and frequencies and percentages reported for categorical data. A 2x2 contingency table was used to determine diagnostic performance metrics, including sensitivity, specificity,

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positive predictive value (PPV), negative predictive value (NPV), and overall accuracy of MRA findings. The McNemar test was applied for statistical validation, with a p-value <0.05 considered statistically significant.

Results

A total of 114 individuals participated in the study, ranging in age from 3 to 63 years, with a mean age of 34.37 ± 14.74 years. Among these, 66 participants (57.9%) were female and 48 (42.1%) were male. Age distribution revealed that 24% of participants were between 3–22 years, 47% were between 23–43 years, and 29% were between 44–63 years. Cerebrovascular disease was identified in 73 out of 114 patients (64.0%), while 41 patients (36.0%) showed no such pathology on MRA. Regarding comorbid conditions, 39 patients (34.2%) had diabetes mellitus, and 74 (64.9%) were hypertensive. Elevated lipoprotein levels were observed in 67 participants (58.8%), while abnormal cholesterol levels were found in 64 individuals (56.1%). Additionally, 58 patients (50.9%) presented with dizziness, and 71 patients (62.3%) reported a history of headache. On magnetic resonance angiography, vascular stenosis was observed in varying degrees. Mild stenosis was detected in 32 individuals (28.1%), moderate stenosis in 46 patients (40.4%), and severe stenosis in 25 individuals (21.9%). The most frequently affected vascular sites included the right middle cerebral artery (11.4%), left middle cerebral artery (10.5%), and posterior cerebral arteries on both sides (6.1%). Aneurysms were present in 41 patients (36.0%), with the most common locations being the left and right middle cerebral arteries, anterior communicating artery, and posterior communicating artery. Meanwhile, calcified plaques were observed in 80 patients (70.2%), indicating a high prevalence of atherosclerotic changes among the study population.

Statistical cross-tabulation between stenosis severity and cerebrovascular disease revealed significant associations. Patients with moderate stenosis showed a markedly higher prevalence of cerebrovascular disease (97.8%) compared to those without (41.2%), with a statistically significant p-value <0.001. Similarly, mild stenosis was more common in the cerebrovascular disease group (73.2%) than in those without the disease (26.8%), with p = 0.001. Severe stenosis also showed a significant correlation, being present in 40% of cerebrovascular disease patients versus 60% in the non-disease group (p = 0.005). Based on the diagnostic performance analysis of MRA using moderate stenosis as an indicative finding for cerebrovascular disease, the sensitivity was found to be 61.6%, indicating the proportion of true positive cases correctly identified by MRA. The specificity was notably high at 97.6%, showing that MRA effectively excluded individuals without the disease. The positive predictive value (PPV) stood at 97.8%, reflecting a strong probability that those identified with moderate stenosis on MRA indeed had cerebrovascular pathology. However, the negative predictive value (NPV) was 58.8%, suggesting a lower confidence in ruling out disease when MRA did not show moderate stenosis. The overall diagnostic accuracy of MRA in this cohort was calculated at 74.6%. These findings support the clinical utility of MRA in confirming cerebrovascular disease, particularly when moderate vascular changes are present, though its ability to definitively exclude disease in negative scans is comparatively limited.

Table 1: Demographics

Variable	Value
Age (Mean ± SD)	34.37 ± 14.74
Age Range	3–63 years
3–22 years	27 (24%)
23–43 years	51 (47%)
44–63 years	33 (29%)
Gender	
Male	48 (42.1%)
Female	66 (57.9%)

Table 2: Distribution of Comorbidities, Risk Factors, and Disease Status Among Study Participants (n = 114)

Variable	Category	Frequency	Percent	Valid Percent	Cumulative Percent
Hypertension	Hypertensive	74	64.9%	64.9%	64.9%
	Normal	40	35.1%	35.1%	100.0%
Diabetes Mellitus	Diabetic	39	34.2%	34.2%	34.2%
	Non-Diabetic	75	65.8%	65.8%	100.0%
Headache	Absent	43	37.7%	37.7%	37.7%

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Variable	Category	Frequency	Percent	Valid Percent	Cumulative Percent
	Present	71	62.3%	62.3%	100.0%
Lipoprotein	Abnormal	67	58.8%	58.8%	58.8%
	Normal	47	41.2%	41.2%	100.0%
Dizziness	Absent	56	49.1%	49.1%	49.1%
	Present	58	50.9%	50.9%	100.0%
Cholesterol	Abnormal	64	56.1%	56.1%	56.1%
	Normal	50	43.9%	43.9%	100.0%
Calcified Plaque	Absent	34	29.8%	29.8%	29.8%
	Present	80	70.2%	70.2%	100.0%
Cerebral Vascular Disease	Absent	41	36.0%	36.0%	36.0%
	Present	73	64.0%	64.0%	100.0%

Table 3: Distribution and Anatomical Location of Cerebral Arterial Stenosis Among Study Participants (n = 114)

Stenosis Category	Frequency	Percent	Valid Percent	Cumulative Percent
Mild Stenosis				
Absent	82	71.9%	71.9%	71.9%
Present	32	28.1%	28.1%	100.0%
Moderate Stenosis				
Absent	68	59.6%	59.6%	59.6%
Present	46	40.4%	40.4%	100.0%
Severe Stenosis				
Absent	89	78.1%	78.1%	78.1%
Present	25	21.9%	21.9%	100.0%
Location of Stenosis				
Absent	52	45.6%	45.6%	45.6%
Anterior communicating artery	7	6.1%	6.1%	51.8%
Left anterior cerebral artery	3	2.6%	2.6%	54.4%
Left middle cerebral artery	12	10.5%	10.5%	64.9%
Left ophthalmic artery	3	2.6%	2.6%	67.5%
Left posterior cerebral artery	2	1.8%	1.8%	69.3%
Posterior communicating artery	7	6.1%	6.1%	75.4%
Right anterior cerebral artery	5	4.4%	4.4%	79.8%
Right middle cerebral artery	13	11.4%	11.4%	91.2%
Right ophthalmic artery	3	2.6%	2.6%	93.9%
Right posterior cerebral artery	7	6.1%	6.1%	100.0%

Table 4: Prevalence and Anatomical Distribution of Aneurysms Among Study Participants (n = 114)

Aneurysm	Frequency	Percent	Valid Percent	Cumulative Percent
Absent	73	64.0%	64.0%	64.0%
Present	41	36.0%	36.0%	100.0%
Location of Aneurysm				
Absent	73	64.0%	64.0%	64.0%
Anterior communicating artery	4	3.5%	3.5%	67.5%
Left anterior cerebral artery	3	2.6%	2.6%	70.2%
Left middle cerebral artery	6	5.3%	5.3%	75.4%
Left ophthalmic artery	4	3.5%	3.5%	78.9%
Left posterior cerebral artery	2	1.8%	1.8%	80.7%

Aneurysm	Frequency	Percent	Valid Percent	Cumulative Percent
Posterior communicating artery	5	4.4%	4.4%	85.1%
Right anterior cerebral artery	4	3.5%	3.5%	88.6%
Right middle cerebral artery	5	4.4%	4.4%	93.0%
Right ophthalmic artery	3	2.6%	2.6%	95.6%
Right posterior cerebral artery	5	4.4%	4.4%	100.0%

Table 5: Descriptive Statistics of Demographic and Clinical Variables Among Study Participants (n = 114)

Variable	N (Valid)	Missing	Mean	Median	Std. Deviation	Range	Minimum	Maximum
Age	114	0	34.37	32.50	14.738	60	3	63
Gender	114	0	0.42	0.00	0.496	1	0	1
Hypertension	114	0	0.35	0.00	0.479	1	0	1
Diabetes Mellitus	114	0	0.66	1.00	0.477	1	0	1
Headache	114	0	0.38	0.00	0.487	1	0	1
Lipoprotein Level	114	0	0.42	0.00	0.496	1	0	1
Dizziness	114	0	0.51	1.00	0.502	1	0	1
Cholesterol	114	0	0.44	0.00	0.498	1	0	1
Mild Stenosis	114	0	0.28	0.00	0.451	1	0	1
Moderate Stenosis	114	0	0.40	0.00	0.493	1	0	1
Severe Stenosis	114	0	0.22	0.00	0.416	1	0	1
Aneurysm	114	0	0.36	0.00	0.482	1	0	1
Calcified Plaque	114	0	0.30	0.00	0.460	1	0	1
Cerebral Vascular Disease	114	0	0.36	0.00	0.482	1	0	1

Table 6: Cross-Tabulation of Stenosis Severity with Presence of Cerebral Vascular Disease (n = 114)

Mild Stenosis × Cerebral Vascular Disease					
Mild Stenosis	CVD Absent	CVD Present	Total	% Within Mild Stenosis	% Within CVD
Absent	22	60	82	26.8% / 73.2%	53.7% / 82.2%
Present	19	13	32	59.4% / 40.6%	46.3% / 17.8%
Total	41	73	114	36.0% / 64.0%	100% / 100%
Moderate Stenosis × Cerebral Vascular Disease					
Moderate Stenosis	CVD Absent	CVD Present	Total	% Within Moderate Stenosis	% Within CVD
Absent	40	28	68	58.8% / 41.2%	97.6% / 38.4%
Present	1	45	46	2.2% / 97.8%	2.4% / 61.6%
Total	41	73	114	36.0% / 64.0%	100% / 100%
Severe Stenosis × Cerebral Vascular Disease					
Severe Stenosis	CVD Absent	CVD Present	Total	% Within Severe Stenosis	% Within CVD
Absent	26	63	89	29.2% / 70.8%	63.4% / 86.3%
Present	15	10	25	60.0% / 40.0%	36.6% / 13.7%
Total	41	73	114	36.0% / 64.0%	100% / 100%

Table 7: Chi-Square Test Results for Association Between Stenosis Severity and Cerebral Vascular Disease (n = 114)

Mild Stenosis × Cerebral Vascular Disease					
Test	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	10.586	1	0.001		
Continuity Correction	9.220	1	0.002		
Likelihood Ratio	10.329	1	0.001		
Fisher's Exact Test				0.002	0.001
N of Valid Cases	114				
Moderate Stenosis × Cerebral Vascular Disease					
Test	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	38.235	1	0.000		
Continuity Correction	35.815	1	0.000		
Likelihood Ratio	47.159	1	0.000		
Fisher's Exact Test				0.000	0.000
N of Valid Cases	114				
Severe Stenosis × Cerebral Vascular Disease					
Test	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	8.032	1	0.005		
Continuity Correction	6.751	1	0.009		
Likelihood Ratio	7.761	1	0.005		
Fisher's Exact Test				0.008	0.005
N of Valid Cases	114				

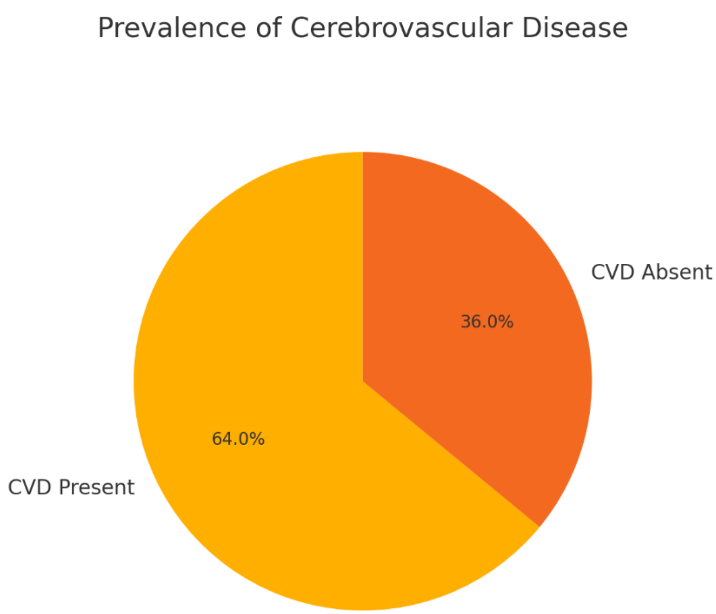

Figure 1 Prevalence of Cerebrovascular Disease

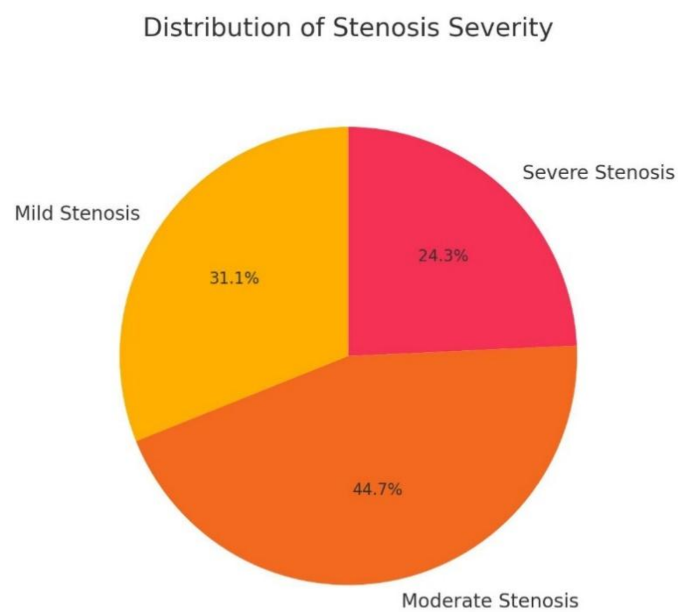

Figure 2 Distribution of Stenosis Severity

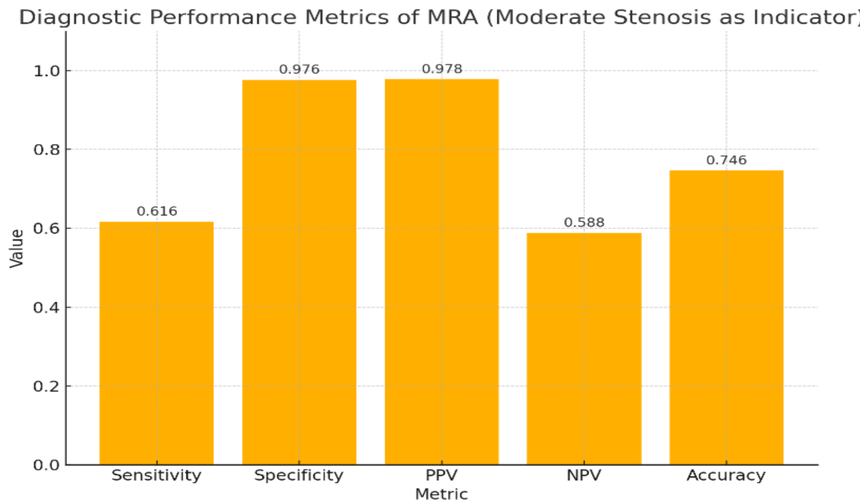

Figure 3 Diagnosis Performance Metrics of MRA (Moderate Stenosis as Indicator)

DISCUSSION

The present study provides valuable insights into the diagnostic role of magnetic resonance angiography (MRA) in evaluating cerebrovascular disease, with particular attention to stenosis severity, aneurysm presence, and calcified plaque formation. Among 114 participants, cerebrovascular pathology was confirmed in 64% of the cases, with moderate stenosis observed in the majority (40.4%), followed by mild (28.1%) and severe (21.9%) stenosis. These findings closely align with previous investigations, which reported higher frequencies of moderate and severe stenosis in large datasets comprising hundreds of vascular lesions, suggesting the consistency of MRA in detecting varying grades of arterial narrowing (16,17). Additionally, the prevalence of aneurysms in 36% of participants echoes the pattern observed in other imaging-based studies, particularly those evaluating lesions in the middle cerebral and internal carotid arteries (18). The role of MRA in characterizing atherosclerotic burden was further substantiated by the detection of calcified plaques in 70.2% of patients. These results support the well-documented relationship between chronic metabolic disorders, such as diabetes, and the acceleration of arterial calcification and atheroma development. Patients with diabetes are more prone to extensive vascular remodeling due to sustained hyperglycemia, insulin resistance, and systemic inflammation, which promote endothelial dysfunction and plaque instability (19,20). The findings of the current study highlight the heightened risk of cerebrovascular events in diabetic populations and emphasize the clinical value of MRA in early plaque visualization.

Infarction patterns and disease progression also appear to correlate with stenosis severity and lesion multiplicity. Prior imaging-based research combining high-resolution MRI with diffusion-weighted imaging (DWI) demonstrated that multi-infarct patterns were more frequently associated with atherosclerotic changes in the middle cerebral artery, which resonates with the current study's findings of extensive vascular involvement in this region (21,22). Such associations reinforce the importance of multimodal imaging in understanding the pathophysiological continuum of cerebrovascular disorders. One of the study's major strengths lies in its comprehensive evaluation of MRA performance metrics. With a high positive predictive value of 97.8% and specificity of 97.6%, MRA proved to be a reliable modality for confirming cerebrovascular pathology in symptomatic individuals. However, the sensitivity of 61.6% and a relatively lower negative predictive value of 58.8% suggest that while MRA is effective for detecting disease, its ability to rule out cerebrovascular pathology in negative cases may be limited. These figures reflect the inherent limitations of non-invasive vascular imaging in capturing microvascular or subtle parenchymal changes, particularly in early-stage disease.

Despite the strengths, the study has notable limitations. The sample size, although adequate for observational analysis, may limit generalizability across broader populations. The absence of comparison with other imaging modalities such as digital subtraction angiography (DSA) or contrast-enhanced computed tomography angiography (CTA) restricts a more robust assessment of MRA's relative diagnostic power. Furthermore, confounding variables such as lipid-lowering medication use, smoking history, and duration of hypertension or diabetes were not accounted for, which may influence vascular outcomes. Future research should consider larger multicenter cohorts, stratified by risk factors and imaging findings, to validate these observations and improve diagnostic algorithms (23). Comparative studies using hybrid imaging techniques or integrating artificial intelligence-driven vessel segmentation may enhance early detection capabilities. Additionally, longitudinal follow-up of patients with moderate stenosis or calcified plaques may elucidate progression patterns and inform preventive interventions.In conclusion, the current study reinforces the critical role of MRA in identifying structural cerebrovascular abnormalities and supports its utility as a non-invasive, radiation-free tool in clinical practice. Its diagnostic strengths in detecting moderate-to-severe stenosis and vascular anomalies like aneurysms and plaques make it especially useful in symptomatic populations. Nonetheless, refining its sensitivity through technological advancements and broader clinical validation remains essential for maximizing its diagnostic yield.

CONCLUSION

This study concludes that magnetic resonance angiography serves as a dependable and non-invasive imaging modality for evaluating the structural integrity and pathology of cerebral vessels. It demonstrated particular utility in detecting vascular abnormalities such as stenosis, aneurysms, and calcified plaques, thereby supporting its role in the early diagnosis and management of cerebrovascular disease. Beyond its diagnostic capabilities, MRA offers a safe and effective method for monitoring conditions like dural venous thrombosis and identifying aneurysms of clinically relevant size. Overall, the findings affirm the practical value of MRA in guiding timely clinical decisions and improving outcomes in patients with suspected cerebrovascular pathology.

AUTHOR CONTRIBUTION

Author	Contribution
Hassnain Ijaz*	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Ayesha Saeed	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Ahmad Mehmood	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Mahnoor Fatma	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Faisal Nawaz Yazdani	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Umm e Summaya	Substantial Contribution to study design and Data Analysis Has given Final Approval of the version to be published
Ramisha Shahbaz	Contributed to study concept and Data collection Has given Final Approval of the version to be published
Aroosh Akhtar	Writing - Review & Editing, Assistance with Data Curation

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