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Role of MR Angiography in the Evaluation of Peripheral Arterial Disease

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Abstract

Background: Peripheral Arterial Disease (PAD) is a common vascular condition often underdiagnosed due to its varied clinical presentation. Magnetic Resonance Angiography (MRA) has emerged as a non-invasive, high-resolution imaging modality for evaluating arterial pathologies. This study aims to assess the role of MRA in the diagnosis and management planning of PAD. **Methods:** A prospective observational study was conducted on 50 patients clinically suspected to have PAD. All patients underwent MRA of the lower limb arterial system. Demographic data, risk factors, clinical presentation, MRA findings, and post-imaging management plans were recorded and analyzed. **Results:** The majority of patients were aged 51–60 years, with a male predominance (68%). Common risk factors included smoking (62%), diabetes (58%), and hypertension (54%). Intermittent claudication (78%) was the most frequent symptom. MRA detected femoro-popliteal involvement in 72% of patients, followed by tibial-peroneal (54%) and aorto-iliac segments (44%). Multilevel disease was present in 62%. Lesions included stenosis >50% in 48% and complete occlusion in 30%. MRA demonstrated a sensitivity of 96%, specificity of 92%, and overall diagnostic accuracy of 95%. Based on MRA findings, 46% of patients underwent endovascular procedures, 16% surgical bypass, while 10% required amputation. **Conclusion:** MR Angiography is a highly accurate, non-invasive imaging modality for evaluating PAD. It not only identifies the extent and severity of vascular lesions with precision but also plays a crucial role in guiding therapeutic decision-making.

Keywords: Peripheral arterial disease, MR angiography, vascular imaging, non-invasive diagnosis, endovascular intervention, atherosclerosis, limb ischemia.

Introduction

Peripheral arterial disease (PAD) is a common manifestation of systemic atherosclerosis characterized by the narrowing or occlusion of arteries, predominantly affecting the lower extremities. It significantly contributes to morbidity, especially in elderly and diabetic populations, with symptoms ranging from intermittent claudication to critical limb ischemia [1,2]. Early and accurate diagnosis of PAD is crucial for timely intervention and to prevent limb loss and other cardiovascular complications.

Conventional angiography, once considered the gold standard, is invasive, involves ionizing radiation, and requires iodinated contrast agents, which limit its use in patients with renal insufficiency or contrast allergies [3]. In this context, magnetic resonance angiography (MRA) has emerged as a promising non-invasive modality for the evaluation of PAD. It offers high-resolution vascular imaging without radiation exposure and can be performed with or without gadolinium-based contrast agents [4]. Contrast-enhanced MRA (CE-MRA) has demonstrated high sensitivity and specificity in detecting hemodynamically significant arterial stenoses and occlusions in the peripheral circulation [5]. Moreover, advancements such as time-resolved MRA and non-contrast techniques like time-of-flight (TOF) and phase-contrast imaging have further expanded its utility, particularly in patients contraindicated for contrast use [6,7]. MRA also provides a comprehensive anatomical roadmap, aiding in therapeutic planning for endovascular or surgical interventions.

Thus, this study aims to evaluate the role of MR angiography in the assessment of peripheral arterial disease and to determine its diagnostic accuracy, advantages, and limitations compared to conventional methods.

Materials and Methods

This was a hospital-based, prospective observational study conducted in the Department of Radiodiagnosis at Chalmeda Anand Rao Institute of Medical sciences, Karimnagar, a tertiary care teaching hospital over a period of 18 months. Ethical clearance was obtained from the Institutional Ethics Committee prior to the initiation of the study.

Study Population

Patients clinically suspected of peripheral arterial disease (PAD) based on symptoms such as intermittent claudication, rest pain, non-healing ulcers, or diminished peripheral pulses were included. The study population comprised both inpatients and outpatients referred for imaging evaluation of PAD.

Inclusion Criteria

- Patients aged ≥18 years with clinical suspicion of lower limb PAD.
- Patients willing to provide informed written consent.
- Patients with an ankle-brachial index (ABI) ≤0.9.

Exclusion Criteria

- Patients with contraindications to MRI (e.g., pacemakers, cochlear implants, ferromagnetic implants).
- Known allergy to gadolinium-based contrast agents.
- Renal insufficiency (eGFR <30 mL/min/1.73 m^2).
- Claustrophobic patients or those unable to lie still during the examination.

Sample Size

A total of 50 patients meeting the inclusion criteria were consecutively enrolled during the study period.

MR Angiography Protocol

All patients underwent contrast-enhanced MR angiography (CE-MRA) using a 1.5 Tesla MRI scanner equipped with a peripheral vascular coil. The imaging protocol included:

- **Pre-contrast sequences:** Axial T1-weighted and T2-weighted images of the lower extremities.

- **Contrast agent:** Gadolinium-based contrast agent (0.1 mmol/kg) administered via power injector at 2 mL/sec, followed by a 20 mL saline flush.
- **Dynamic imaging:** Time-resolved imaging using time-resolved imaging with stochastic trajectories (TWIST) or time-resolved angiography with interleaved stochastic trajectories (TRICKS), depending on scanner capability.
- **Post-contrast 3D MRA:** Acquired in three stations (pelvis, thigh, and leg) using moving-table technique and maximum intensity projection (MIP) reconstructions.

Image Analysis

MRA images were independently analyzed by two experienced radiologists blinded to each other's interpretations and to clinical findings. Arterial segments were evaluated for:

- Presence and extent of stenosis or occlusion.
- Collateral vessel formation.
- Anatomical variants or abnormalities.

Stenosis was graded as:

- **Normal:** 0% narrowing
- **Mild:** <50% narrowing
- **Moderate:** 50–69% narrowing
- **Severe:** 70–99% narrowing
- **Occlusion:** 100% obstruction

Comparison Modality

Where available, digital subtraction angiography (DSA) findings were used as the reference standard for comparison. Diagnostic accuracy of MRA in detecting

significant stenosis (≥50%) was assessed in terms of sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV).

Statistical Analysis

Data were entered into Microsoft Excel and analyzed using SPSS software version 20.0. Categorical variables were expressed as percentages, and continuous variables as mean ± standard deviation (SD). Inter-observer agreement was assessed using the kappa statistic. A p-value <0.05 was considered statistically significant.

Observation and Results

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Table 1 : Demographic distribution among study population

Parameters	Number of Patients	Percentage (%)
Age Group (Years)		
<40	4	8%
41–50	9	18%
51–60	16	32%
61–70	13	26%
>70	8	16%
Gender		
Male	34	68%
Female	16	32%
Risk Factors		
Smoking/Tobacco Use	31	62%
Diabetes Mellitus	29	58%
Hypertension	27	54%
Dyslipidemia	21	42%
Coronary Artery Disease	13	26%
Obesity (BMI > 30)	11	22%

The study included a total of 50 patients with suspected peripheral arterial disease. The age distribution showed that the majority of patients (32%) belonged to

the 51–60 years age group, followed by 26% in the 61–70 years group. A smaller proportion of patients were below 40 years (8%) and above 70 years (16%). This indicates that PAD predominantly affects middle-aged and elderly individuals. Regarding gender distribution, males were more commonly affected, comprising 68% of the study population, whereas females accounted for 32%, suggesting a male preponderance in the occurrence of PAD. Analysis of risk factors revealed that smoking or tobacco use was the most prevalent risk factor (62%), followed by diabetes mellitus (58%) and hypertension (54%). Dyslipidemia was present in 42% of cases, coronary artery disease in 26%, and obesity (BMI >30) in 22%. These findings reinforce the multifactorial etiology of PAD and highlight the importance of addressing modifiable cardiovascular risk factors.

Table 2 : Clinical distribution among study population

Clinical Presentation	Number of Patients	Percentage (%)
Intermittent Claudication	39	78%
Rest Pain	17	34%
Ulceration/Gangrene	9	18%
Cold limb	25	50%

The clinical presentation of the patients was varied, with intermittent claudication being the most common symptom, reported in 78% of the participants. Cold limbs were present in 50% of patients, followed by rest pain in 34% and ulceration or gangrene in 18%. These findings reflect the typical symptomatology associated with peripheral arterial insufficiency, ranging from exertional pain to critical limb ischemia. The data underscore the need for prompt diagnosis and staging of disease severity to guide appropriate intervention.

Table 3 : MR Angiography Findings distribution among study population

Parameters	Number of Patients	Percentage (%)
Arterial Segment		
Aorto-iliac	22	44%
Femoro-popliteal	36	72%
Tibial/peroneal arteries	27	54%
Multilevel involvement	31	62%
Type of Lesion		
Stenosis <50%	11	22%
Stenosis >50%	24	48%
Complete Occlusion	15	30%

MR angiographic evaluation revealed that the femoro-popliteal segment was the most commonly involved arterial territory, seen in 72% of patients, followed by tibial and peroneal artery involvement in 54%. Aorto-iliac involvement was observed in 44% of cases. Multilevel arterial disease, affecting more than one segment, was present in 62% of patients, indicating the diffuse nature of atherosclerotic involvement in many cases. In terms of lesion characteristics, significant stenosis (>50%) was observed in 48% of patients, complete arterial occlusion in 30%, and less severe stenosis (<50%) in 22%. These findings highlight the utility of MR angiography in accurately delineating both the site and severity of vascular lesions, which is critical for planning therapeutic interventions.

Table 4 : MR Angiography Diagnostic Accuracy

Parameter	Value (%)
Sensitivity	96%
Specificity	92%
Positive Predictive Value	94%
Negative Predictive Value	93%
Overall Accuracy	95%

MR angiography demonstrated excellent diagnostic accuracy in detecting peripheral arterial lesions. The sensitivity and specificity were 96% and 92% respectively, indicating a high level of reliability in identifying true positive and true negative cases. The positive predictive value was 94%, while the negative predictive value was 93%. Overall diagnostic accuracy was 95%, confirming MR angiography as a robust non-invasive imaging modality for the evaluation of peripheral arterial disease.

Table 4 : Post-MRA Management Planning

Parameter	Number of Patients	Percentage (%)
Medical Management Alone	14	28
Endovascular intervention planned	23	46
Surgical bypass	8	16
Amputation Advised	5	10

Following MR angiographic evaluation, therapeutic decisions were guided based on the extent and severity of disease. Endovascular intervention was planned in 46% of the patients, indicating a shift toward minimally invasive treatment approaches. Medical management alone was deemed sufficient in 28% of patients, reflecting less severe disease or comorbid conditions precluding invasive procedures. Surgical bypass was advised in 16% of cases, typically for extensive or complex occlusive disease. Amputation was recommended in 10% of patients, highlighting the presence of advanced ischemic changes or gangrene where limb salvage was no longer feasible. These data underline the significant role of MRA in influencing and optimizing clinical management strategies.

Discussion

Peripheral Arterial Disease (PAD) is a significant health burden, especially in India, with prevalence estimates ranging from 7.6% to 26.7% depending on various demographic and clinical factors. Our study aimed to evaluate the role of Magnetic Resonance Angiography (MRA) in the assessment of PAD in 50 patients and to compare findings with existing literature published before 2015.

In our cohort, the majority of patients were in the age group of 51–60 years (32%) and males constituted 68%, indicating a male predominance and increased age-related risk. Similar trends were reported by Premalatha et al. in the Chennai Urban Population Study, where PAD prevalence increased with age and male sex was a significant predictor [8]. This demographic pattern is corroborated by the Rotterdam Study, which reported that PAD was more prevalent among older men [9].

Risk factor profiling revealed smoking or tobacco use in 62%, diabetes in 58%, and hypertension in 54% of patients. These are consistent with the Cardiological Society of India-Kerala study that identified diabetes, hypertension, and smoking as dominant contributors to atherosclerotic vascular disease in the Indian context [8]. Internationally, the Framingham Heart Study also identified smoking and diabetes as major risk factors for PAD development [10].

Intermittent claudication was the most common presenting symptom in our patients (78%), followed by cold limbs (50%), rest pain (34%), and ulceration or gangrene (18%). While these values are higher than those reported in population-based studies like the Edinburgh Artery Study, which found intermittent claudication in only 4.5% of the general population [11], our hospital-based sample consisted of clinically symptomatic individuals, explaining the higher prevalence.

MR angiographic findings revealed the femoro-popliteal segment was most frequently involved (72%), followed by tibial/peroneal arteries (54%) and aorto-iliac involvement (44%). Multilevel disease was noted in 62%. These findings are consistent with the results reported by Koelemay et al., who emphasized the accuracy of MRA in detecting significant stenoses across these segments [12]. A meta-analysis by Collins et al. also validated the high diagnostic yield of MRA in delineating lower limb arterial disease [13].

Regarding diagnostic accuracy, MRA in our study had a sensitivity of 96% and specificity of 92%, with an overall accuracy of 95%. These results mirror the findings from Visser and Hunink, who reported sensitivity and specificity values of 97.5% and 96.2%, respectively, for gadolinium-enhanced MRA [14]. Baumgartner et al. further established the role of MRA in peripheral vascular imaging and its impact on clinical decision-making [15].

Management strategies following MRA findings included endovascular interventions in 46% of patients, surgical bypass in 16%, and amputation in 10%. This distribution is similar to that described in earlier studies where therapeutic choices were guided by the extent of arterial involvement as detected by MRA [15].

Conclusion

Magnetic Resonance Angiography (MRA) proved to be a highly effective, non-invasive imaging modality in the evaluation of peripheral arterial disease (PAD). The study demonstrated that PAD predominantly affects middle-aged and elderly males, with smoking, diabetes mellitus, and hypertension being the most common associated risk factors. Clinically, intermittent claudication was the leading presentation, followed by rest pain and critical limb ischemia.

MRA was successful in accurately identifying the anatomical location, extent, and severity of arterial lesions, with the femoro-popliteal segment being the most frequently involved. The modality exhibited excellent diagnostic performance, with high sensitivity, specificity, and overall accuracy. Additionally, MRA findings played a pivotal role in guiding therapeutic decisions, including medical management, endovascular interventions, surgical bypass, and amputation where necessary.

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Conflict of Interest : None

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