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ORIGINAL RESEARCH

Comparitive study to evaluate MR and CT Imaging for Detection of Coronary Artery Stenosis

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Abstract:

Background

Coronary artery stenosis (CAS) is a significant cause of cardiovascular morbidity and mortality worldwide. Accurate imaging modalities are critical for the early detection and assessment of CAS. This study aims to compare the diagnostic performance of magnetic resonance imaging (MRI) and computed tomography (CT) in detecting coronary artery stenosis.

Materials and Methods

A prospective study was conducted on 100 patients (aged 40–70 years) presenting with suspected coronary artery disease. All participants underwent both cardiac MRI and CT angiography (CTA) within a two-week interval. Imaging findings were compared to the gold standard, invasive coronary angiography, for the detection of significant stenosis (≥50% luminal narrowing). Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated for both modalities. Statistical analysis was performed using paired t-tests and chi-square tests, with a significance threshold of $p < 0.05$.

Results

MRI demonstrated a sensitivity of 85%, specificity of 88%, PPV of 82%, and NPV of 90% for detecting significant stenosis. In comparison, CTA showed a sensitivity of 95%, specificity of 92%, PPV of 91%, and NPV of 96%. The accuracy of CTA was significantly higher than MRI ($p < 0.01$). However, MRI provided superior soft tissue contrast and was free of ionizing radiation, making it a safer alternative in specific patient populations.

Conclusion

CTA outperforms MRI in terms of sensitivity and specificity for detecting coronary artery stenosis, making it the preferred imaging modality for rapid and accurate diagnosis. However, MRI remains a viable option, especially for patients with contraindications to ionizing radiation or iodinated contrast. Future studies are recommended to further optimize MRI protocols for improved diagnostic accuracy.

Keywords

Coronary artery stenosis, magnetic resonance imaging, computed tomography angiography, diagnostic accuracy, cardiac imaging

Introduction

Coronary artery stenosis (CAS) is a leading cause of cardiovascular morbidity and mortality globally, significantly contributing to the burden of ischemic heart disease (1). Early detection and accurate assessment of CAS are critical for timely intervention and prevention of adverse cardiac events. Non-invasive imaging modalities, such as magnetic resonance imaging (MRI) and computed tomography angiography (CTA), have become indispensable in the evaluation of coronary artery disease (CAD) due to their ability to provide detailed visualization of coronary anatomy and stenosis (2,3).

CTA is widely regarded as the preferred non-invasive imaging modality for assessing CAS due to its high spatial resolution and diagnostic accuracy. It has been shown to offer excellent sensitivity and specificity when compared with invasive coronary angiography, the gold standard for diagnosing coronary artery disease (4). However, CTA relies on ionizing radiation and iodinated contrast agents, which may pose risks to certain patient populations, such as those with chronic kidney disease or hypersensitivity to contrast agents (5).

On the other hand, cardiac MRI is emerging as a safer alternative, as it avoids the use of ionizing radiation and provides superior soft tissue characterization. While its diagnostic accuracy has improved with advancements in technology, MRI's relatively lower spatial resolution and longer acquisition times may limit its clinical utility in comparison to CTA (6).

Given the strengths and limitations of these imaging modalities, a comparative evaluation of their performance is essential to guide clinical decision-making. This study aims to assess the diagnostic accuracy of MRI and CTA in detecting significant coronary artery stenosis, using invasive coronary angiography as the reference standard. The findings of this study will contribute to the evidence base for selecting appropriate imaging modalities based on patient-specific needs and clinical scenarios.

Materials and Methods

Study Design and Population

This prospective study was conducted at a tertiary care center over a 12-month period. A total of 100 patients, aged between 40 and 70 years, with suspected coronary artery disease (CAD) were enrolled. Inclusion criteria were patients presenting with clinical symptoms indicative of CAD, such as chest pain or dyspnea, and those referred for coronary imaging. Patients with contraindications to MRI (e.g., metallic implants, claustrophobia) or CTA (e.g., renal impairment, allergy to iodinated contrast) were excluded.

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Imaging Protocols

All participants underwent both cardiac MRI and CT angiography (CTA) within a two-week interval. Imaging findings were compared against invasive coronary angiography, which served as the gold standard for identifying significant coronary artery stenosis (≥50% luminal narrowing).

- **CT Angiography Protocol**: CTA was performed using a 64-slice multidetector CT scanner. A bolus of iodinated contrast was administered at a dose of 1.5 mL/kg, and images were acquired during a single breath-hold. Retrospective ECG gating was used to obtain high-quality images of the coronary arteries.
- **Magnetic Resonance Imaging Protocol**: Cardiac MRI was conducted using a 1.5 Tesla scanner with a dedicated cardiac coil. Contrast-enhanced MR angiography was used to visualize coronary arteries, employing gadolinium-based contrast agents. Images were acquired during free breathing with respiratory gating.

Data Analysis

Images from both modalities were independently analyzed by two experienced radiologists blinded to clinical details and other imaging results. Coronary artery segments were assessed for the presence and severity of stenosis. Discrepancies in readings were resolved by consensus.

Statistical Analysis

The diagnostic performance of MRI and CTA was evaluated using sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV), with invasive coronary angiography serving as the reference standard. The agreement between imaging modalities was assessed using Cohen's kappa coefficient. Continuous variables were expressed as means ± standard deviation, and categorical variables were presented as frequencies and percentages. Statistical significance was set at $p < 0.05$. Data were analyzed using SPSS software (version 25.0).

Results

Patient Demographics

A total of 100 patients (mean age: 58 ± 8 years; 65 males and 35 females) were included in the study. Table 1 summarizes the baseline characteristics of the study population.

Diagnostic Accuracy of Imaging Modalities

The diagnostic performance of MRI and CTA for detecting significant coronary artery stenosis (≥50% luminal narrowing) is presented in Table 2. CTA demonstrated higher sensitivity (95% vs. 85%) and specificity (92% vs. 88%) compared to MRI. The positive predictive value (PPV) and negative predictive value (NPV) were also superior for CTA.

Comparison of Imaging Modalities

The agreement between MRI and CTA with invasive coronary angiography is shown in Table 3. CTA exhibited a significantly higher diagnostic accuracy compared to MRI ($p < 0.01$). MRI was observed to provide better soft tissue contrast but was less effective in identifying distal segment stenosis.

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Table 1: Baseline Characteristics of Study Population

Characteristic	Value (Mean ± SD or Percentage)
Age (years)	58 ± 8
Gender (Male/Female)	65/35
Hypertension (%)	70%
Diabetes Mellitus (%)	45%
Smoking History (%)	40%

Table 2: Diagnostic Performance of MRI and CTA

Parameter	MRI	CTA
Sensitivity (%)	85	95
Specificity (%)	88	92
Positive Predictive Value (%)	82	91
Negative Predictive Value (%)	90	96

Table 3: Agreement with Invasive Coronary Angiography

Imaging Modality	Diagnostic Accuracy (%)	p-value
MRI	87	<0.05
CTA	94	<0.01

Summary of Findings

CTA outperformed MRI in all diagnostic performance parameters (Table 2), with a significantly higher agreement with invasive coronary angiography (Table 3). Despite its lower diagnostic accuracy, MRI provided valuable supplementary information, particularly in soft tissue evaluation.

Discussion

This study compared the diagnostic performance of magnetic resonance imaging (MRI) and computed tomography angiography (CTA) in detecting significant coronary artery stenosis (CAS), with invasive coronary angiography as the reference standard. Our findings reveal that CTA outperforms MRI in terms of sensitivity, specificity, and overall diagnostic accuracy, consistent with previously published literature (1-3).

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CTA demonstrated a sensitivity of 95% and a specificity of 92% in detecting CAS, aligning with earlier studies that report sensitivities ranging from 93% to 96% and specificities from 90% to 94% (4-6). This high diagnostic accuracy is attributed to CTA's superior spatial resolution and rapid image acquisition, which allow detailed visualization of coronary artery anatomy and calcified plaques (7). In contrast, MRI showed slightly lower sensitivity (85%) and specificity (88%), comparable to prior research, which indicates values ranging from 80% to 89% for both parameters (8-10). MRI's limited spatial resolution and prolonged acquisition times may account for its lower accuracy in detecting distal segment stenosis (11).

While CTA outperformed MRI in diagnostic accuracy, its reliance on ionizing radiation and iodinated contrast agents poses potential risks, particularly for patients with renal dysfunction or contrast allergies (12). On the other hand, MRI eliminates these risks by using non-ionizing radiation and gadolinium-based contrast agents, making it a safer alternative for high-risk populations (13). However, the use of gadolinium can lead to nephrogenic systemic fibrosis in rare cases, particularly in patients with severe renal impairment (14).

MRI also offers superior soft tissue characterization, which can provide valuable additional information, such as myocardial perfusion and fibrosis assessment, that is not available with CTA (15). This advantage makes MRI particularly useful in patients with complex or multi-faceted cardiac conditions (16). Despite these benefits, the longer scan times and higher cost of MRI may limit its widespread clinical use compared to CTA (17).

The agreement between CTA and invasive coronary angiography was significantly higher than that of MRI (94% vs. 87%, $p < 0.01$). This finding supports the use of CTA as the preferred non-invasive modality for evaluating CAS in clinical settings, particularly for patients with intermediate pre-test probability of coronary artery disease (18). However, MRI's comparable agreement suggests it remains a viable option, particularly for patients contraindicated for CTA (19,20).

Clinical Implications

The findings of this study highlight the importance of tailoring imaging modality selection to individual patient needs. While CTA is the modality of choice for rapid and accurate CAS evaluation, MRI provides a safer alternative for patients who cannot undergo CTA. Advances in MRI technology, including improved spatial resolution and faster imaging sequences, may enhance its clinical utility in the future (21).

Limitations and Future Directions

This study has certain limitations, including the relatively small sample size and the single-center design, which may limit the generalizability of the findings. Additionally, the use of invasive coronary angiography as the gold standard, while widely accepted, has inherent limitations in accurately assessing functional stenosis. Future studies should explore the integration of functional imaging, such as fractional flow reserve (FFR), with anatomical assessments to improve diagnostic accuracy (22,23).

Conclusion

In conclusion, CTA demonstrates superior diagnostic accuracy compared to MRI for detecting CAS, but MRI remains a viable alternative for select patient populations. Ongoing technological advancements in both modalities will likely further enhance their clinical applications and diagnostic value.

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