Diagnostic Performance of Cardiac MRI for Significant Coronary Artery Disease

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Purpose

- In the past 10 years we have witnessed a great development of new techniques and equipment for magnetic resonance imaging to study cardiovascular disease. Cardiac magnetic resonance imaging (CMRI) has revitalized the study of the myocardial ischemia, providing information on the functional importance of the coronary stenosis and the status of the myocardial microcirculation, due to its multiplanar capability, high spatial resolution and tissue contrast, and has emerged as a patient-friendly modality, being a noninvasive method and without exposing to ionizing radiation. There were major recent advances, regarding both to the new equipments and also the development and refinement of techniques and protocols to study the cardiovascular system by CMRI\textsuperscript{1-5}.

- The assessment of myocardial perfusion abnormalities is used to identify patients with coronary artery disease (CAD) and evaluate the hemodynamic significance of coronary stenosis, enhancing clinical decisions.

- Preliminary studies, including a multicenter trial, have demonstrated high accuracy of the perfusion and delayed enhancement sequences at MRI for detection of CAD and also to identify areas of myocardial infarction\textsuperscript{6-11}, with potential advantages in comparison with myocardial scintigraphy\textsuperscript{12}.

- Currently, invasive coronary angiography (ICA) is still regarded as the standard reference for CAD detection with definitive demonstration of coronary stenosis, guiding the choice between medical therapy, interventional or surgical treatment. Nevertheless, ICA is an invasive method that exposes the patient to ionizing radiation and intravenous iodinated contrast media, with relatively low accuracy in estimating the physiologic importance of coronary stenosis\textsuperscript{13}.

- In this study, we have evaluated the accuracy of CMRI in the detection of CAD, with the ICA as the reference standard. The objective was to determine the diagnostic performance of a noninvasive method in the assessment of CAD, for optimal planning of medical therapy, revascularization or cardiac surgery.
Methods and Materials

Study design and patient population

- All the CMRI examinations performed between 2007 and 2009 were analyzed retrospectively, being included in the study those patients that have undergone both CMRI and ICA for CAD detection, with a maximum interval of 60 days between both examinations.
- Exclusion criteria involved those patients who had not performed the ICA or not performed it within the range of 60 days. Most patients (68.5%) performed the CMRI before the ICA, and those who underwent ICA before CMRI, we have only included patients who underwent ICA without associated procedure.
- 220 CMRI were performed in the selected period, and of these, 54 patients had also performed the ICA within the range of 60 days, which represented our sample. From the 54 patients, 39 were male (72.2%) and 15 females (27.8%), with an age range from 42 to 84 years (mean age 60.4 years ± 10.5 [standard deviation]). This population consisted of 38 patients suspected of having CAD (group A) and 16 patients with a history of prior CAD (group B).

CMRI protocol

- All patients were examined with a 1.5 Tesla MRI scanner (Magnetom Symphony; Siemens Medical Solutions, Erlangen, Germany) with 23 mT/m maximum gradient amplitude and 150T/m/s slew rate, four element phased-array cardiac coil, coupled to ECG. Steady-state free-precession (SSFP) cine images were acquired in multiple short-axis and three long-axis views.
- After cine imaging, perfusion mask without gadolinium was acquired. Dipyridamole (Persantin®, Boehringer Ingelheim, Germany) was infused at a 0.56 mg/kg dose over 4 minutes, under continuous electrocardiography and blood pressure monitoring.
- Perfusion stress sequence was then applied, triggered 5 seconds after the start of intravenous infusion of gadolinium contrast (gadoversetamida, Optimark®, Mallinckrodt, USA) at a 0.2 ml/kg dose at an injection rate of 5 ml/s, followed by a 40-ml saline flush.
- During gadolinium washout, left ventricular stress function was assessed with SSFP cine images in the short axis. Afterward, aminophylline (AM Hyfilina®, Hypofarma, Brazil) was infused at a dose of 250 mg over 2 minutes to reverse the effects of dipyridamole. SSFP sequence on radial planning was then obtained for rest segmental left ventricular function study. After that, rest perfusion images were acquired 5 seconds after a second bolus of intravenous infusion of gadolinium at a 0.2 ml/kg dose at an injection rate of 5 ml/s. Approximately 10 minutes later, delayed-enhanced
sequences were obtained in short-axis and radial design, with varying inversion times and then the most appropriate images were selected.

- Before the examination it was explained to the patient the procedure he would undergo, emphasizing the importance of his understanding and cooperation during the examination execution.
- The procedure was performed with the patient in supine position, during expiratory apnea and without chest or abdomen movements during the image acquisitions.
- All patients underwent the complete examination without severe complications.
- This CMRI protocol had an average duration of 48.3 minutes (± 9.6 minutes).

**CMRI Analysis**

- The results of CMRI were based on the segmentation proposed by the American Heart Association\textsuperscript{14}, which divides the left ventricle myocardium into 17 segments, excluding segment 17 (apex) from the analysis, once the stress perfusion was performed only in the short axis. Segments 1, 2, 7, 8, 13 and 14 were defined as supplied by left anterior descending coronary artery (LAD). Segments 3, 4, 9, 10 and 15 were defined as supplied by right coronary artery (RCA) and segments 5, 6, 11, 12 and 16 were defined as supplied by circumflex coronary artery (Cx).
- The results were then grouped according to these 3 major coronary arterial territories, to allow a per-vessel analysis.
- Two experienced observers (RAFM and MSN, respectively with 2 and 5 years of experience in CMRI) who were blinded to the angiographic results and to clinical data qualitatively interpreted by consensus each MRI sequence independently and then by combining MRI data (perfusion and delayed enhancement and all sequences combined).
- Each coronary territory was classified as positive for significant CAD if CMRI presented criteria for ischemia in the sequential analysis of perfusion studies, cine and delayed enhancement. In patients with prior CAD that showed areas of delayed enhancement (infarction) at CMRI, were considered positive only if there were signs of recent injury and microvascular obstruction.
- Coronary territories that did not showed any criteria for ischemia in any of the CMRI tests were classified as negative.
- Perfusion deficits on stress perfusion sequences were defined as delayed persistent enhancement pattern during the first pass of contrast medium in the myocardium, observed in at least 3 consecutive temporal images and at least 2 sectional images of contiguous planes.
- Myocardial ischemia was defined as a segment with perfusion deficit and without late enhancement.
- Myocardial infarction was defined as an area with high signal in the delayed enhancement sequence\textsuperscript{12,15}. 
• Myocardial segments that showed perfusion abnormalities at stress and rest with the same characteristics, were considered negative for ischemia.
• Perfusion images considered artifacts were classified as negative, and the criteria for its identification were the presence of a low signal intensity halo before the gadolinium arrival in the cardiac muscle or subendocardial signal reduction persisting longer than the first-pass of the gadolinium through the left ventricle cavity.
• Cine images were considered abnormal if any degree of wall contractility abnormality was observed: hypokinesia, akinesia or dyskinesia.
• Cine abnormalities were considered true positive when the study showed normal wall motion at rest and impaired contractility during stress. The abnormal segments were also considered positive in cases whose cine images showed a regional contractility abnormality at rest and improved segmental contraction in neighboring segments after the hyperemia produced by the vasodilator.

Invasive coronary angiography

• The ICA was performed by standard technique via a transfemoral or radial approach.
• Biplane projections of the coronary artery system were assessed by an experienced observer for detection of arterial stenosis without knowledge of clinical history and outcome of the MRI.
• Coronary stenosis greater than or equal to 70% luminal narrowing were classified as hemodynamically relevant.
• Patients were also classified as having CAD in 1, 2 or 3 vessels.

Statistical analysis

• Sensitivity, specificity and accuracy of MRI in detecting coronary stenosis greater than or equal to 70%, which are considered hemodynamically relevant by ICA, were calculated independently for the left anterior descending, circumflex and right coronary artery.
• Myocardial segments positive for ischemia during CMRI in areas supplied by a coronary stenosis $\geq 70\%$ were classified as true positive.
• Positive segments during MRI in areas without significant stenosis ($\geq 70\%$) in the ICA, were classified as false positive.
• Segments supplied by a stenotic coronary artery ($\geq 70\%$) and without myocardial ischemia in CMRI were classified as false negative.
• Segments supplied by a coronary artery without significant stenosis (<70%) and without ischemia on CMRI were classified as true negative.
• For all continuous parameters, the means and their standard deviations (SD) were calculated.
• Sensitivity, specificity and accuracy were calculated according to the standard definitions, on a per-vessel basis, with 95% confidence interval.
• Kappa test was used to calculate the diagnostic performance of the CMRI sequences, with the ICA result as the reference standard. A p value $\leq 0.05$ was considered statistically significant.
Results

- CMRs were performed on 220 patients in the selected period, and of those, 54 patients had also undergone ICA within 60 days, which represented our sample.
- Of the 54 patients, 39 were male (72.2%) and 15 female (27.8%), with an age range from 42 to 84 years (mean age 60.4 years ± 10.5 [standard deviation]).
- This population consisted of 38 patients suspected of having CAD (group A) and 16 patients with a history of prior CAD (group B).
- The CMR protocol had an average duration of 48.3 minutes (± 9.6 minutes).

Invasive coronary angiography

- Of a total of 54 patients, 37 (68.5%) showed significant CAD (≥ 70%) in the ICA. Of the 162 coronary territories assessed, 71 (43.8%) had hemodynamically significant stenosis, consisting of 28 in the LAD, 21 in the LCx and 22 in the RCA.
- Of the thirty seven patients with significant CAD, 15 (40.6%) showed single-vessel disease, 10 (27%) patients had two-vessel disease and 12 (32.4%) patients had three-vessel disease.

Myocardial perfusion

- Myocardial perfusion (figure 1) was assessed in 864 left ventricular segments, grouped according to the respective coronary territory.
- Hypoperfusion (perfusion defect) was detected in 35 patients, in a total of 69 territories (27 in LAD, 19 in LCx and 23 in RCA). In 19 patients, no perfusion defects were found.

Myocardial viability

- The left ventricular segments were also evaluated for myocardial viability.
- Delayed enhancement, representing myocardial infarction (figure 2) was found in 22 patients, totaling 37 territories (14 in the LAD, 11 in the LCx and 12 in the RCA).
- In 32 patients, no delayed enhancement was found.

Diagnostic performance of CMRI
In comparison with the ICA, based on a per vessel analysis of the 3 coronary artery territories, the sensitivity of the CMR (figure 3) was 91.5% (considering the combination of the sequences: stress and rest perfusion, cine and delayed enhancement) for stenosis greater than or equal to 70%, with a specificity of 83.5%, resulting in a diagnostic accuracy of 87%.

Table 1 summarizes the diagnostic performance of the CMR sequences alone and combined for the detection of CAD.

Regarding the individual analysis of each of the CMR sequences, perfusion (figure 4) showed the highest accuracy (83%), with sensitivity of 78.9% and specificity of 85.7%, with a statistically significant difference in relation to cine and delayed enhancement sequences (p=0.0294 and p=0.0086 respectively).

The combined analysis of perfusion and delayed enhancement sequences increased the accuracy to 86%, with sensitivity of 90.1% and 84.6% specificity. However, no significant difference (p=0.4350) was found between the diagnostic performance of CMR using the combined total or the perfusion + delayed enhancement results.

Table 2 shows the diagnostic performance of CMRI sequences alone and combined for each coronary territory. There was no statistically significant difference in CMRI performance in relation to each of the territories.

From the analysis of patients defined as suspected CAD (group A) and prior CAD (group B), we observed a greater accuracy in group A (table 3), both in the evaluation of perfusion and delayed enhancement results, and also with all sequences combined, but without statistically significant differences (p=0.3452 and p=0.2871 respectively). Patients with known prior CAD had a higher sensitivity, but a lower specificity to detect significant CAD as defined by ICA.

In the separate evaluation of patients with one, two, and three-vessel disease, the accuracy of CMR was respectively 84%, 77% and 92% (table 4). The highest accuracy was achieved in patients with three-vessel disease, with a statistically significant difference when compared to patients with two-vessel disease (p = 0.0453), but no statistically significant difference in relation to single-vessel disease patients (p=0.1631). The diagnostic accuracy was higher in patients with single vessel disease than in two-vessel disease patients, but also without a statistically significant difference (p=0.1985).

**DISCUSSION**

Cardiovascular disease is the leading cause of mortality and morbidity in the world, with estimates that by 2020 approximately 35 to 40 million deaths will occur from cardiovascular disease in the world[16]. CMR has shown great progress and has been gaining increasing importance in the study of myocardial perfusion. We investigated the diagnostic performance of CMR in patients with known or suspected CAD.
• In our study, the CMR sequence with the highest sensitivity for detection of significant CAD was the perfusion stress/rest sequence, what is in agreement with previous studies by Klem et al.[10], Cury et al.[15], and Gebker et al[18]. Adding delayed enhancement analysis to the CMR protocol, increased the examination specificity (93.5%) despite its low sensitivity (43.7%). These results are consistent with previous studies[9, 10, 15, 19]. The combined analysis of all CMR sequences achieved the best accuracy, without a statistically significant difference from the combined analysis of perfusion and delayed enhancement sequences, a result similar to that found in previous studies.

• In our analysis, the diagnostic accuracy of CMR was higher in patients with triple (91.7%) and single-vessel disease (84.4%) than in two-vessel disease (76.7%) patients, agreeing with the findings of Cury et al[15]. A possible explanation for this difference may be the difficulty in correctly classifying the coronary territory of myocardial segments and anatomical variations in two-vessel disease patients.

• In the study by Klem et al[10] and in our study, no significant differences were found among the accuracy of CMR in the three coronary territories, indicating that the diagnostic performance of CMR is independent of the vascular territory that presents significant CAD. There was also no significant difference in the accuracy between group A (suspected CAD) and group B (prior CAD), again indicating that CMR may have a similar diagnostic performance regardless of the presence or absence of prior known CAD and coronary artery bypass grafting.

• The main limitation of this study is the referral bias as patients that underwent ICA likely had a positive CMR study. However, we tried to limit the referral bias by also adding patients that had CMR after ICA. Another limitation in the CMR analysis are presence of artifacts, mainly in perfusion images, which may show a variation of the signal intensity at different times during examination, with focal areas alternating low and iso-signal intensity in consecutive temporal images, leaving doubts about the real existence of the perfusion deficit. Special attention should be given to the evaluation of patients with three-vessel disease, when the myocardial hypoperfusion may present with diffuse homogeneous low signal, making it harder to define the expected normal signal intensity. In addition to the caution that must be taken in relation to image artifacts, another point of attention and a possible source of errors in comparison with ICA, is the anatomical variation presented by the coronary circulation, which leads to difficulty in standardizing the myocardial segments and their respective territories. At this point, coronary CT angiography offers advantages by allowing better spatial resolution and direct visualization of the coronary arteries as compared to CMR. It is also necessary to reaffirm that the ICA, as the gold standard, does not necessarily reflect the true representation of the coronary disease status, since it does not allow proper evaluation of the lesion hemodynamics.
Despite these difficulties, CMR with stress perfusion and delayed enhancement sequences for detection of CAD with significant coronary obstruction has shown good accuracy in single centers and multicentric trials[6, 10, 15, 18, 20, 21]. It has been shown to be a very safe noninvasive examination with shorter duration, no ionizing radiation or iodinated contrast, thus avoiding nephrotoxicity. However, its clinical use remains low, perhaps partly due to the lack of knowledge about the clinical applications and diagnostic performance of this method, or the convenience of maintaining the investigation routine already established in daily clinical practice[1]. The introduction of newer methods often brings initial suspicion and insecurity due to the uncertainty of their results. The few published data on prognosis and low usage in routine clinical practice contributes to the lack of implementation of this method[22-26].
Fig. 0: 57-year-old man. Stress perfusion MRI during dipyridamole hyperemia demonstrating perfusion defect at the LAD coronary artery distribution (black area), with reversibility during rest perfusion, representing inducible ischemia. Negative delayed enhancement without myocardial infarction. Coronary angiogram demonstrates focal high-grade lesion in the proximal LAD.

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**Fig. 0:** 62-year-old woman. Coronary angiogram demonstrates a 90% stenosis in the distal right coronary artery by selective catheterization. Transmural myocardial infarction demonstrated by delayed hyperenhancement in the mid inferior segment of the left ventricle. Stress perfusion showed a segmental perfusion defect, larger than the area of infarction, compatible with peri-infarction ischemia.

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**Fig. 0:** 59-year-old man. Patient with prior myocardial infarction and severe in-stent stenosis in LAD - Stress perfusion during dipyridamole hyperemia demonstrating myocardial perfusion defect within the LAD territory, coincident with the area of infarction identified during delayed enhancement. The infarcted area is less than 50% of the segment, suggesting preserved viability. Coronary angiogram confirmed severe proximal LAD lesion.

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**Fig. 0:** 52-year-old man. Patient with prior CAD and CMR demonstrating lateral wall perfusion defect during stress perfusion in the left circumflex coronary artery (Cx) distribution. Coronary angiogram shows Cx lesion proximal to the first marginal.

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Table 1: Diagnostic performance of different sequences of MRI alone and combined

<table>
<thead>
<tr>
<th>MRI/sequence</th>
<th>Sensitivity %</th>
<th>95% CI</th>
<th>Specificity %</th>
<th>95% CI</th>
<th>Accuracy %</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perfusion</td>
<td>78.9 (56/71)</td>
<td>69.4–88.4</td>
<td>85.7 (78/91)</td>
<td>78.5–92.9</td>
<td>83 (134/162)</td>
<td>75.9–88.5</td>
</tr>
<tr>
<td>Cine</td>
<td>47.9 (34/71)</td>
<td>36.3–59.5</td>
<td>94.5 (90/91)</td>
<td>89.8–99.2</td>
<td>74 (130/162)</td>
<td>67.3–90.8</td>
</tr>
<tr>
<td>Delayed enhancement</td>
<td>43.7 (31/71)</td>
<td>32.1–55.2</td>
<td>93.4 (95/91)</td>
<td>88.3–98.5</td>
<td>72 (116/162)</td>
<td>64.7–78.5</td>
</tr>
<tr>
<td>Perfusion and Delayed enhancement</td>
<td>88.7 (83/71)</td>
<td>81.4–96.1</td>
<td>94.0 (77/91)</td>
<td>77.2–92.0</td>
<td>86 (140/162)</td>
<td>81.1–91.7</td>
</tr>
<tr>
<td>All combined</td>
<td>91.5 (65/71)</td>
<td>85.1–99.0</td>
<td>93.5 (75/91)</td>
<td>75.9–91.1</td>
<td>87 (141/162)</td>
<td>81.9–92.2</td>
</tr>
</tbody>
</table>

Note: The data in parentheses are the numbers used to calculate the percentages. CI = confidence interval.

Fig. 0: Table 1: Diagnostic performance of different sequences of MRI alone and combined

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Table 2: Diagnostic performance of different sequences of MRI alone and combined in each coronary territory

<table>
<thead>
<tr>
<th>Territories</th>
<th>Sensitivity %</th>
<th>95% CI</th>
<th>Specificity %</th>
<th>95% CI</th>
<th>Accuracy %</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PERFUSION</strong></td>
<td></td>
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</tr>
<tr>
<td>Anterior descending</td>
<td>73.8 (22/28)</td>
<td>63.4–93.8</td>
<td>80.2 (21/26)</td>
<td>65.6–95.9</td>
<td>80 (43/54)</td>
<td>68.9–90.4</td>
</tr>
<tr>
<td>Circumflex</td>
<td>76.2 (16/21)</td>
<td>58.0–94.4</td>
<td>90.9 (30/33)</td>
<td>81.1–1.00</td>
<td>85 (40/54)</td>
<td>75.7–94.7</td>
</tr>
<tr>
<td>Right coronary</td>
<td>81.8 (19/22)</td>
<td>65.7–97.9</td>
<td>94.4 (27/28)</td>
<td>71.8–97.0</td>
<td>83 (45/54)</td>
<td>73.4–93.3</td>
</tr>
<tr>
<td><strong>PERFUSION AND DELAYED ENHANCEMENT</strong></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Anterior descending</td>
<td>92.9 (25/28)</td>
<td>83.3–1.00</td>
<td>80.8 (21/26)</td>
<td>65.6–95.9</td>
<td>87 (47/54)</td>
<td>78.1–96.0</td>
</tr>
<tr>
<td>Circumflex</td>
<td>81.0 (17/21)</td>
<td>64.2–97.7</td>
<td>90.9 (30/33)</td>
<td>81.1–1.00</td>
<td>87 (47/54)</td>
<td>78.1–96.0</td>
</tr>
<tr>
<td>Right coronary</td>
<td>90.0 (20/22)</td>
<td>78.9–1.00</td>
<td>81.3 (25/28)</td>
<td>67.7–94.8</td>
<td>85 (49/54)</td>
<td>75.7–94.7</td>
</tr>
<tr>
<td><strong>ALL COMBINED</strong></td>
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<tr>
<td>Anterior descending</td>
<td>92.9 (25/28)</td>
<td>83.3–1.00</td>
<td>80.8 (21/26)</td>
<td>65.6–95.9</td>
<td>87 (47/54)</td>
<td>78.1–96.0</td>
</tr>
<tr>
<td>Circumflex</td>
<td>90.5 (19/21)</td>
<td>77.9–1.00</td>
<td>90.9 (30/33)</td>
<td>81.1–1.00</td>
<td>91 (49/54)</td>
<td>83.0–98.5</td>
</tr>
<tr>
<td>Right coronary</td>
<td>90.9 (20/22)</td>
<td>78.9–1.00</td>
<td>78.1 (25/28)</td>
<td>63.8–92.4</td>
<td>83 (45/54)</td>
<td>73.4–93.3</td>
</tr>
</tbody>
</table>

Note: The data in parentheses are the numbers used to calculate the percentages. CI = confidence interval.

**Fig. 0:** Table 2: Diagnostic performance of different sequences of MRI alone and combined in each coronary territory

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Table 3: Diagnostic performance of MRI in suspected CAD and CAD groups prior

<table>
<thead>
<tr>
<th>CMRI sequences</th>
<th>Sensitivity %</th>
<th>95% CI</th>
<th>Specificity %</th>
<th>95% CI</th>
<th>Accuracy %</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group A (suspected CAD)</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Perfusion and Delayed</td>
<td>87.2 (41/47)</td>
<td>77.7 - 96.6</td>
<td>88.1 (59/67)</td>
<td>80.3 - 95.8</td>
<td>88 (100/114)</td>
<td>81.7 - 93.7</td>
</tr>
<tr>
<td>enhancement</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All combined</td>
<td>89.4 (42/47)</td>
<td>80.5 - 98.2</td>
<td>88.1 (59/67)</td>
<td>80.3 - 95.8</td>
<td>89 (101/114)</td>
<td>82.7 - 94.4</td>
</tr>
<tr>
<td>Group B (prior CAD)</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Perfusion and Delayed</td>
<td>95.8 (23/24)</td>
<td>87.9 - 100</td>
<td>75.0 (18/24)</td>
<td>57.7 - 92.3</td>
<td>85 (41/48)</td>
<td>75.4 - 95.4</td>
</tr>
<tr>
<td>enhancement</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>All combined</td>
<td>100 (24/24)</td>
<td>100 - 100</td>
<td>70.8 (17/24)</td>
<td>52.8 - 89.0</td>
<td>85 (41/48)</td>
<td>75.4 - 95.4</td>
</tr>
</tbody>
</table>

Note: The data in parentheses are the numbers used to calculate the percentages. CI = confidence interval.
Table 4: Diagnostic performance of the combined analysis of CMRI sequences in patients with one, two and three-vessel disease

<table>
<thead>
<tr>
<th>Group</th>
<th>Sensitivity %</th>
<th>95% CI</th>
<th>Specificity %</th>
<th>95% CI</th>
<th>Accuracy %</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>One-vessel disease</td>
<td>100 (15/15)</td>
<td>100 – 100</td>
<td>76.7 (23/30)</td>
<td>61.5 – 91.8</td>
<td>84.4 (38/46)</td>
<td>73.9 – 95.0</td>
</tr>
<tr>
<td>Two-vessel disease</td>
<td>85.0 (17/20)</td>
<td>69.4 – 100</td>
<td>80.0 (8/10)</td>
<td>79.6 – 90.4</td>
<td>76.7 (23/30)</td>
<td>61.5 – 91.8</td>
</tr>
<tr>
<td>Three-vessel disease</td>
<td>91.7 (33/36)</td>
<td>82.6 – 100</td>
<td>---</td>
<td>---</td>
<td>91.7 (33/36)</td>
<td>82.6 – 100</td>
</tr>
</tbody>
</table>

Note: The data in parentheses are the numbers used to calculate the percentages. CI = confidence interval.

**Fig. 0:** Table 4: Diagnostic performance of the combined analysis of CMRI sequences in patients with one, two and three-vessel disease

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Conclusion

In conclusion, the results obtained in our study indicate that CMRI is a reliable method that has great diagnostic accuracy in patients with significant coronary stenosis; it is suitable for clinical investigation of patients with suspected CAD, and helpful for risk stratification and defining treatment strategies.
References


4. Rochitte CE, Pinto IM, Fernandes JL, et al. [Cardiovascular magnetic resonance and computed tomography imaging guidelines of the Brazilian Society of Cardiology]. Arq Bras Cardiol 2006;87(3):e60-100.


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Potential Conflict of Interest

No potential conflict of interest relevant.

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