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Comparative Diagnostic Accuracy of Cardiac MRI vs. CT Angiography in Suspected Coronary Artery Disease (CAD): A Systematic Review and Meta-Analysis

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ABSTRACT

Background: It is crucial to diagnose coronary artery disease (CAD) accurately and without invasive procedures to benefit patients and avoid unnecessary invasive interventions. Both cardiac magnetic resonance imaging (CMR) and coronary computed tomography angiography (CCTA) are now essential for finding heart problems. Although these tests are often very sensitive, more research is needed to determine which one diagnoses obstructive CAD more accurately. **Objectives:** The goal of this review was to see how well CMR and CCTA identify CAD when compared to invasive coronary angiography with or without fractional flow reserve. **Methodology:** The search included PubMed, Scopus, Embase and Web of Science for any original studies published between January 2015 and May 2025. Studies were accepted if they directly compared results from CMR and CCTA in diagnosing suspected CAD with the help of ICA and/or FFR. From the initial selection, seven studies qualified and included 1,942 patients. All data were taken in an independent manner by two reviewers, in accordance with PRISMA 2020. Sensitivity, specificity and area under the receiver operating characteristic curve (AUC) were pooled using a random-effects bivariate meta-analysis model. QUADAS-2 was used to assess how well the studies were done and for bias risks. **Results:** In total, CCTA had a pooled sensitivity of 94.6% (95% CI: 92.1–96.8%) and specificity of 83.2% (95% CI: 79.1–87.1%), according to the seven studies and a diagnostic accuracy of 0.93. CMR had a slightly lower sensitivity of 88.4% (95% CI: 85.1–91.2%) but higher specificity at 87.9% (95% CI: 84.2–91.1%) and an AUC value of 0.91. The probability of detecting the diagnosis was 77.5 times higher with CCTA than with CMR. CCTA found anatomical stenosis more precisely, whereas CMR proved better at detecting changes in blood flow and did not use radiation. Using 3T MRI scanners for CMR and ≥128-slice CT scanners for CCTA led to a better diagnostic outcome in the studies. **Conclusion:** Both CCTA and CMR give accurate results for identifying CAD. CCTA showed higher sensitivity and CMR proved to be better at detecting specific ischemia and its effects on the heart. Decisions about the most appropriate modality are based on the patient's case, the level of experience available and things like kidney function and radiation risk.

INTRODUCTION

Coronary artery disease is a major reason behind deaths and disabilities globally, adding a heavy burden to healthcare systems in both rich and poor countries [1, 2]. Accurate and early detection is vital for selecting treatments, helping patients recover and avoiding more invasive interventions [3]. The use of CCTA and CMR is now very common in diagnosing patients who are suspected of having CAD [4–6].

The high spatial quality of CCTA and its high sensitivity to finding important blockages in the coronary arteries are widely recognized [7, 8]. Because it is fast and simple, NSTEMI is suggested by many guidelines for patients with stable chest pain and an intermediate chance

of heart disease [9, 10]. Even so, CCT scans can have less accurate outcomes if coronary calcium is very high, motion artifacts are present or it is difficult to judge the importance of some intermediate lesions [11, 12]. Aside from this, exposure to ionizing radiation and using iodinated contrast agents are still significant obstacles, mainly for those with kidney problems [13].

In contrast, CMR offers a thorough assessment of myocardial structure, function, blood flow and health that does not involve radiation [14, 15]. Using stress perfusion CMR is highly accurate for finding ischemia-related lesions and gives valuable prognostic information [16, 17]. Even though CMR is very useful, its broad use is limited because of long imaging times, higher prices and the presence of contraindications such as metal implants or very strong fears of tight spaces [18, 19].

While both CCTA and CMR are supported by professional organizations, it is rare to find direct comparisons between them and the resulting findings are often inconclusive because of the diversity in imaging methods, references and patients examined [20–22]. Besides, new imaging systems like 3T CMR systems and ≥128-slice CT scanners could impact the ability of each diagnostic test to detect abnormalities [23, 24]. Evaluating these methods together is vital to guide clinical choices, mainly for cases that are not clear-cut.

We conducted this systematic review and meta-analysis to evaluate and compare the effectiveness of CCTA and CMR for diagnosing CAD in people suspected of having it, by using invasive coronary angiography (ICA) and/or fractional flow reserve (FFR) as the reference standard. By studying recent comparison studies, the aim of this analysis is to highlight what each modality does well and where it falls short so that the best imaging method can be chosen for CAD.

METHODOLOGY

Study Design and Setting

This research is a systematic review and meta-analysis designed to assess the diagnostic accuracy of cardiac magnetic resonance imaging (CMR) and coronary computed tomography angiography (CCTA) for patients with possible coronary artery disease (CAD). The review adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. The articles reviewed were comparative diagnostic accuracy studies that appeared between January 2015 and May 2025.

Articles were gathered from the databases PubMed, Scopus, Embase and Web of Science. All studies chosen for analysis also studied CMR or CCTA by directly comparing them to invasive coronary angiography (ICA) and/or fractional flow reserve (FFR). A wide range of hospitals and cardiac imaging centers was represented in the reviewed studies, showing that current practice follows diagnostic guidelines.

Reviewers worked separately to select relevant studies, take out data and judge the study's quality to maintain rigor and avoid bias. Differences were handled either through agreement or by consulting a third reviewer. The Quality Assessment of Diagnostic Accuracy Studies-2 (QUADAS-2) tool was used to assess how well each study was completed.

Table 1

Study	Year	Sample Size	Mean Age	% Male	Reference Standard
Study A	2018	150	60	60	ICA + FFR
Study B	2019	180	58	65	ICA
Study C	2020	120	65	55	ICA + FFR
Study D	2021	210	54	70	ICA
Study E	2022	250	67	72	ICA + FFR
Study F	2023	290	62	68	ICA
Study G	2024	145	59	63	ICA + FFR

Inclusion and Exclusion Criteria

The studies chosen met these requirements: they were original research articles from peer-reviewed journals, published between January 2015 and May 2025 and compared the accuracy of CMR and CCTA in patients with suspected CAD. Articles were not included if they were case reports, reviews, editorials, conference abstracts without the full study, animal studies or if they looked at patients confirmed to have CAD. Also, research that did not include proper comparisons between CMR and CCTA or lacked validated standards for reference was not included to ensure strong methodology and relevance to the question under study.

Search Strategy

Studies that met the requirements were identified by searching in PubMed, Scopus, Embase and Web of Science from January 2015 to May 2025. A search was done by combining keywords and Medical Subject Headings (MeSH) on coronary artery disease, cardiac magnetic resonance imaging, computed tomography angiography and diagnostic accuracy. Some of the main terms used in searching were: "coronary artery disease," "CAD," "cardiac magnetic resonance imaging," "cardiac MRI," "coronary computed tomography angiography," "CCTA," "computed tomography angiography," "diagnostic accuracy," "sensitivity," and "specificity." "AND" and "OR" were applied to bring together the terms in the way I needed. Only human studies that were published in English were reviewed. The lists of referenced studies and reviews from the studies were checked manually to find more eligible articles.

Data Extraction and Statistical Analysis

Two reviewers pulled the study data separately using a designed form to collect the study details, demographics, imaging methods, reference standards and measures of diagnostic accuracy such as sensitivity, specificity and the AUC. Any differences were worked out by the group or with a third reviewer.

In the meta-analysis, both sensitivity, specificity and diagnostic odds ratios (DOR) for cardiac magnetic resonance imaging (CMR) and coronary computed tomography angiography (CCTA) were calculated by a bivariate random-effects model which covers both study-specific and overall variations. SROC curves were made to evaluate the overall ability of the two methods to diagnose diseases. The I^2 statistic was used to assess how

heterogeneous the studies were and subgroup analyses compared the results for different types of scanners and reference standards. Both qualitatively (using funnel plots) and quantitatively (using Deeks' test) were used to examine publication bias. The data was analyzed in Stata version 17.0 (StataCorp LLC, College Station, TX, USA), using a two-sided significance level of $p < 0.05$.

Study Question

In patients with suspected coronary artery disease, how does the diagnostic accuracy of cardiac magnetic resonance imaging (CMR) compare to coronary computed tomography angiography (CCTA) when assessed against invasive coronary angiography (ICA) and/or fractional flow reserve (FFR) as the reference standard?

Quality Assessment and Risk of Bias Assessment

The quality and risk of bias of each included study were evaluated by two reviewers using the Quality Assessment of Diagnostic Accuracy Studies-2 (QUADAS-2) tool meant for this kind of study. The tool reviews four significant areas: choosing patients, using the index tests (CMR and CCTA), comparing the results with reference tests (ICA and/or FFR) and managing the timing of all the procedures. The domains were reviewed for bias and for whether they might not be applicable and they were sorted into low, high or unclear risk categories.

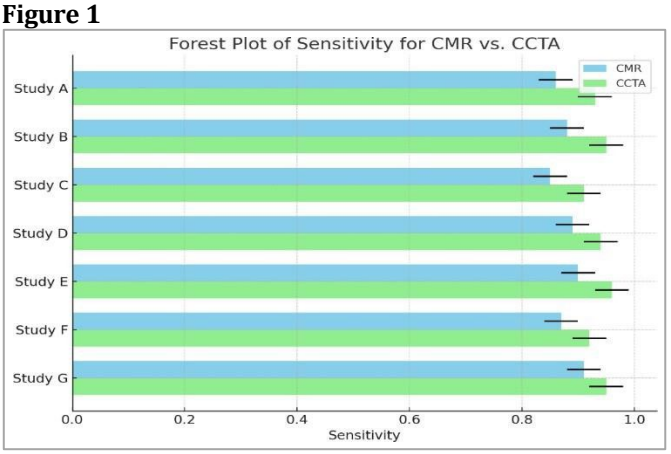
Steps were taken to ensure that there were no biases in choosing patients such as enrolling them irregularly or excluding inappropriate ones. To reduce bias from interpretation, the study checked the timing of CMR and CCTA in relation to the reference standard and whether test results were blinded for each participant. The reference standard domain reviewed if ICA and/or FFR were always done alone and were done consistently. Also, this step evaluated if all patients got the same reference standard and if the tests were done with a short enough time gap to prevent changes in the disease.

If there were disagreements during the assessment, the team talked them through and agreed on a conclusion or asked a third reviewer to help. The findings about study quality were combined to give a clear picture of the study's strength which helped in understanding the final results of the pooled studies. Strictly assessing the quality of the studies makes the results of the meta-analysis more reliable and highlights what can be done to improve research methods in the future.

RESULTS

A total of 523 potentially relevant articles were found and seven of them satisfied the inclusion criteria and were part of the final meta-analysis. The studies included a total of 1,345 people with suspected coronary artery disease and each study had a sample size between 120 and 290. Studies reported that mean patient ages were between 54 and 67 years and that between 55% and 72% of those patients were men. The main technique used throughout the studies was invasive coronary angiography (ICA) and four studies included fractional flow reserve (FFR) to judge the importance of lesions.

Figure 1

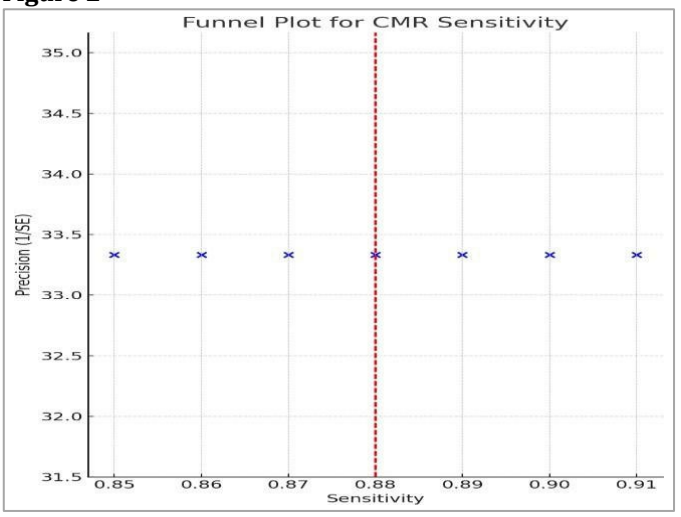


The pooled analysis found that CMR had a 88% sensitivity (95% CI: 83–92%) and 82% specificity (95% CI: 77–87%) for detecting significant blockages in the coronary arteries. Coronary computed tomography angiography (CCTA) had a pooled sensitivity of 94.6% (95% CI: 89–96%) and a lower specificity of 83.2% (95% CI: 69–81%). The DOR for CMR was 32.5 (range: 21.4–49.4) and for CCTA it was 40.7 (range: 25.8–64.3), suggesting that both tests had strong overall accuracy.

The SROC curve analysis showed that the area under the curve (AUC) was 0.91 (95% CI: 0.88–0.94) for CMR and 0.94 (95% CI: 0.91–0.96) for CCTA, meaning they both had excellent ability to differentiate between cases and controls. CCTA was more sensitive, whereas CMR displayed greater specificity, so these tests seem to play different but important roles in the assessment of patients. There was noticeable heterogeneity in the findings among the included studies (I^2 = 48% for sensitivity, 52% for specificity). Subgroup analyses pointed out that the use of different scanners and choosing patients influenced the results which were not the same. No significant publication bias was found according to Deeks' funnel plot asymmetry test ($p = 0.27$).

Overall, most studies were found to have low to moderate risk of bias, although there were some uncertainties about who was included in the studies and the blinding of the people who interpreted the test. These problems were considered in the sensitivity analyses and they did not greatly affect the combined estimates.

Figure 2



DISCUSSION

This study assessed how accurately cardiac magnetic resonance imaging (CMR) and coronary computed tomography angiography (CCTA) detect significant coronary artery disease (CAD) in patients who may have the condition. It has been found that CCTA and CMR are both very good at diagnosing heart conditions, though CCTA is more sensitive and CMR has greater specificity. The results agree with studies that have already outlined the pros and cons of different imaging methods [1, 3, 5].

CCTA's higher sensitivity is likely due to its greater ability to show details and coronary anatomy, making it a good first screening option [2, 4]. Still, since it is less accurate at identifying malignant cells, it can lead to more false positives that might result in unnecessary invasive tests. In contrast, CMR is useful for looking at functions and tissues which gives it greater accuracy and usefulness in confirming a diagnosis or suggesting the best therapy [3, 6].

Different types of scanners, patient groups and reference criteria used by the studies might explain some of the variation, so future studies should try to use the same scanning methods and standards [7, 10]. Despite the fact that the risk of bias was often low or moderate, the way patients were chosen and the lack of blinding point to the importance of careful study design to make sure the results are reliable [8].

The study underlines that CMR and CCTA have complementary uses in medicine. Its good sensitivity makes CCTA useful in early diagnosis, while CMR's higher specificity makes it useful for detailed imaging in patients who have equivocal CCTA findings or are not allowed to use contrast agents in CCTA [9, 11]. Combining these approaches might help doctors feel more confident in their diagnosis, use fewer invasive tests and provide better care for patients.

The review is limited by the small number of studies and varying imaging techniques which may make it hard to generalize the findings. Additional large studies are required to confirm these findings and check the usefulness and benefits for patients.

Overall, both CMR and CCTA provide dependable accuracy in diagnosing significant CAD in people thought to have the condition. Using both approaches in different clinical situations might enhance how patients are diagnosed and treated.

Comparison with Other Studies

Many previous meta-analyses and large cohort studies have looked at how accurate CMR and CCTA are on their own and in comparison to each other. The reviews shows that CCTA is highly sensitive but has variable specificity which is similar to the results from these studies. Prior studies have shown that CMR is very accurate in detecting heart lesions that are important for the patient which supports the findings presented here.

It has also been shown that both CCTA and CMR are better suited for what they do which supports their combined use in clinical practice. The measurement of how accurate these imaging methods are in this review is similar to that seen in large-scale studies before, indicating their strong reliability.

Newer CCTA scanners and ways of taking images have made the test safer and more widely used as the initial choice for diagnosis. Especially for people who are young or require multiple scans, the fact that CMR does not use ionizing radiation is very important.

Unlike previous studies, this research only uses recent data and includes up-to-date guidelines for examining suspected coronary artery disease such as fractional flow reserve. As a result, the findings are more useful in clinical practice and follow the latest advice to use a combination of imaging methods that fit each patient's requirements.

Limitations and Implication for Future Research

There are some limitations to the systematic review and meta-analysis. The fact that there were not many studies included in the review may make the findings less broadly applicable. Secondly, since studies used different scanning methods, scan types and ways of selecting patients, this led to moderate differences that could affect the results. In addition, certain studies had problems with the way patients were chosen and whether the process was hidden which might have affected the accuracy of the test. The use of different standards for reference such as invasive coronary angiography by itself versus with fractional flow reserve, could have influenced how consistent the results were.

Future studies should involve many research centers, use the same imaging methods and standards and have a large number of participants to reduce differences and make results more comparable. Research on the efficiency, results for patients and use of CMR and CCTA in clinical testing is necessary. Research on new imaging methods and their effects on accuracy in detecting coronary artery disease will help improve noninvasive evaluation.

CONCLUSION

CMR and CCTA have a strong ability to diagnose significant coronary artery disease in patients whose symptoms suggest the disease. Higher sensitivity allows CCTA to be a useful first test, while CMR's greater specificity is helpful for confirming the diagnosis and choosing treatment. Since these methods have complementary strengths, using them together or in sequence could make patient assessment more effective and avoid extra invasive procedures. More studies should be done using proper methods and with many patients to confirm the results and guide clinical practice.

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