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Review Article

Meta-Analysis of the Diagnostic Value of Cardiac Color Ultrasound Combined with Carotid Ultrasound for Coronary Heart Disease

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ABSTRACT

Objective: To evaluate the diagnostic value of cardiac color ultrasound combined with carotid ultrasound for coronary heart disease.

Methods and methods: Computerized search of China Knowledge Network (CKN), Wanfang Medical Network (WMN), Wipo database, Chinese Biomedical Database (CBM), Embase, Pubmed, to retrieve the diagnostic value of cardiac color ultrasound combined with carotid ultrasound on coronary heart disease, the search time is up to August 2023, in accordance with the Quality Assessment of Diagnostic Accuracy Studies (QUADAS) standard for quality evaluation of the included literature, 2 reviewers in accordance with the inclusion and exclusion criteria independently screened the literature, extracted the information and evaluation. After the quality of the included studies was evaluated, meta-analysis was performed using StataSE 15 (64-bit) to summarize the sensitivity and specificity, perform sensitivity analysis and heterogeneity test, and plot the subjects' operating characteristics by Receiver Operating Characteristic curve (ROC).

Results: Eleven papers, including 1432 patients, were finally included. Coronary angiography was used as the standard. Meta-analysis using a random-effects model showed a combined sensitivity of 0.95 [95% CI (0.93, 0.96)], specificity of 0.88 [95% CI (0.70, 0.96)], positive likelihood ratio of 16.8 [95% CI (5.7, 49.1)], and negative likelihood ratio of 0.05 [95% CI (0.03, 0.07)], and the area under the Summary Receiver Operating Characteristics (SROC) curve AUC=0.96.

Conclusion: Cardiac ultrasound combined with carotid ultrasound has good sensitivity and specificity for the diagnosis of coronary artery disease, but in actual clinical practice, it is still necessary to refer to other relevant laboratory tests and specific clinical manifestations for diagnosis.

Keywords: Cardiac ultrasound; Carotid ultrasound; Coronary angiography; Coronary heart disease; Meta-analysis

INTRODUCTION

Coronary atherosclerotic Heart Disease (CHD) is the most common type of cardiovascular disease in the clinic, and its main pathological manifestation is the occlusion or narrowing of the lumen of the coronary artery due to coronary atherosclerosis, and myocardial cells are ischemic, hypoxic and necrotic, which seriously affects the safety of life [1-3]. Coronary Heart Disease (CHD) has a high morbidity and mortality rate in China, posing a serious threat to people's quality of life and safety. In the face of this disease, early intervention can effectively improve the prognosis, so timely diagnosis of this disease is of great significance.

The standard for clinical diagnosis of CHD is coronary angiography, which can clearly indicate whether there is coronary atherosclerosis or not, but its high cost, invasive examination method, allergy to contrast medium and intolerance of the elderly and other factors limit its clinical application [4], based on these factors, the clinic is urgently looking for a more convenient, non-invasive diagnostic methods, ultrasound has the advantages of safety, simplicity, low cost and repeatable examination, and so on. Ultrasound has the advantages of safety, simplicity, low cost, and repeatability in clinical diagnosis; it has been widely used to assess cardiac function [5-8], and there have been more studies in the literature on the diagnostic value of cardiac ultrasound combined

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with carotid ultrasound for coronary heart disease, but there is a lack of multicenter large-sample studies. Therefore, in this study, the clinical application value of cardiac color ultrasound combined with carotid ultrasound for the diagnosis of coronary heart disease was investigated using meta-analysis.

MATERIALS AND METHODS

Source of information

Search strategy: Computerized search of China Knowledge Network (CKN), Wanfang Medical Network (WMN), Wipo database, Chinese Biomedical Database (CBM), Embase, Pubmed, with the search time set from the time of library construction to August 2023.

Chinese literature search terms: Cardiac color ultrasound, echocardiography, cardiac color ultrasound, carotid ultrasound, carotid color ultrasound, carotid doppler ultrasound, coronary heart disease, coronary atherosclerotic heart disease, true heart pain.

English literature search terms: Echocardiography, ultrasonography, carotid arteries, coronary disease, etc. All searches were performed using a combination of subject terms and free words, and all search strategies were determined by multiple pre-searches. References to relevant reviews or included literature were also traced.

Inclusion and exclusion criteria

Inclusion criteria:

- Patients who used cardiac color ultrasound combined with carotid ultrasound to diagnose coronary artery disease had the standard as a control.
- The standard was coronary angiography.
- For the literature with duplicated data, quantitative methods were applied to screen the data.
- The data of the four-compartment table could be extracted (true-positive, false-positive, true-negative, and false-negative).

Exclusion criteria:

- Non-Chinese and English literature.
- Animal studies, literature excerpts, case reports and conference abstracts.
- Inconsistent data in the original study.

LITERATURE REVIEW

Literature screening and data extraction

Literature screening and information extraction were carried out independently by 2 evaluators and cross-checked, with the third evaluator determining the final program if there were different results after invalid consultation. Information was extracted using a homemade data extraction form, which mainly included first author, year, true positive, false positive, true negative, false negative, and so on.

Evaluation of literature treatment: Two independent evaluators assessed the quality of the literature included in the meta-analysis using the QUAOAS evaluation scale for diagnostic tests proposed by Whiting, the results were yes/no/unclear; in the event of disagreement, after ineffective negotiation, three evaluators determined the final results.

Statistical analysis: Statistical analyses were performed using StataSE 15 (64-bit) software to calculate the combined sensitivity, specificity, and to plot a composite subject work characterization curve and calculate the Area Under Curve (AUC) and Q-index.

Event

Results of literature screening: In accordance with the search strategy, 150 original research papers were initially examined, including 70 in Chinese and 80 in English, and 11 papers were screened to meet the inclusion criteria for inclusion in the meta-analysis of this study (Figure 1). The total number of included cases was 1432. The minimum number of included cases was 50 and the maximum was 256. The process of literature screening is shown in Figure 1, and the basic information of the included studies is shown in Table 1 [9-19].

Literature quality assessment: The results of the evaluation of the quality of the literature of the included studies are shown in Figures 2.

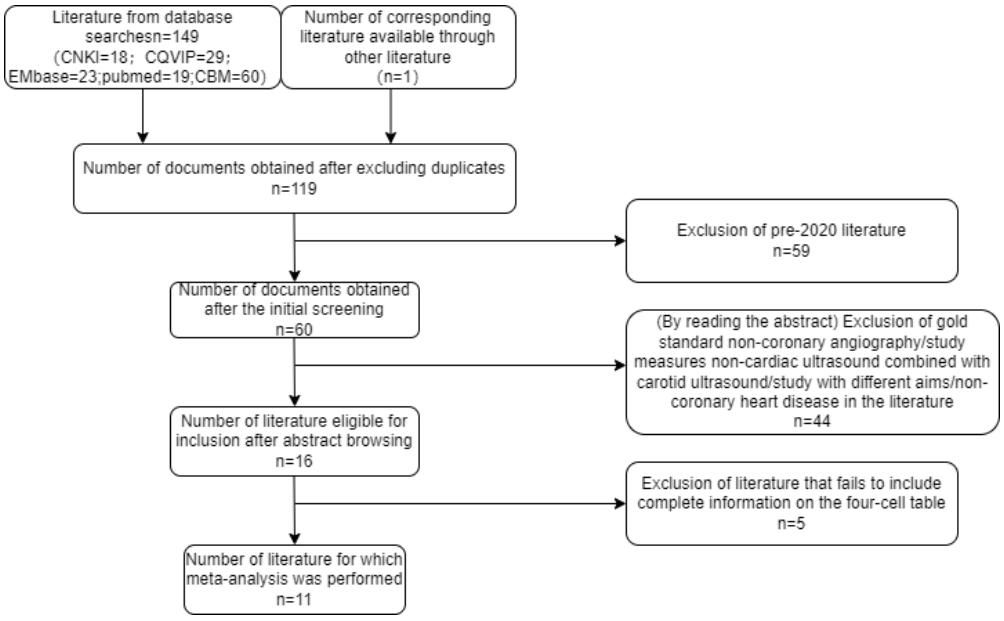

Figure 1: Flowchart of literature screening.

Table 1: Basic information about the included literature [9-19].

First authors	Particular year	tp	fp	fn	tn	Total
[2]	2023	185	3	7	61	256
[9]	2023	102	34	6	25	167
[10]	2023	106	3	4	97	210
[11]	2022	79	0	4	34	117
[12]	2021	58	0	1	21	80
[13]	2022	64	3	5	29	110
[14]	2023	46	0	2	2	50
[15]	2020	54	3	5	24	86
[16]	2023	65	9	3	39	116
[17]	2021	86	0	3	31	120
[19]	2023	63	6	4	47	120

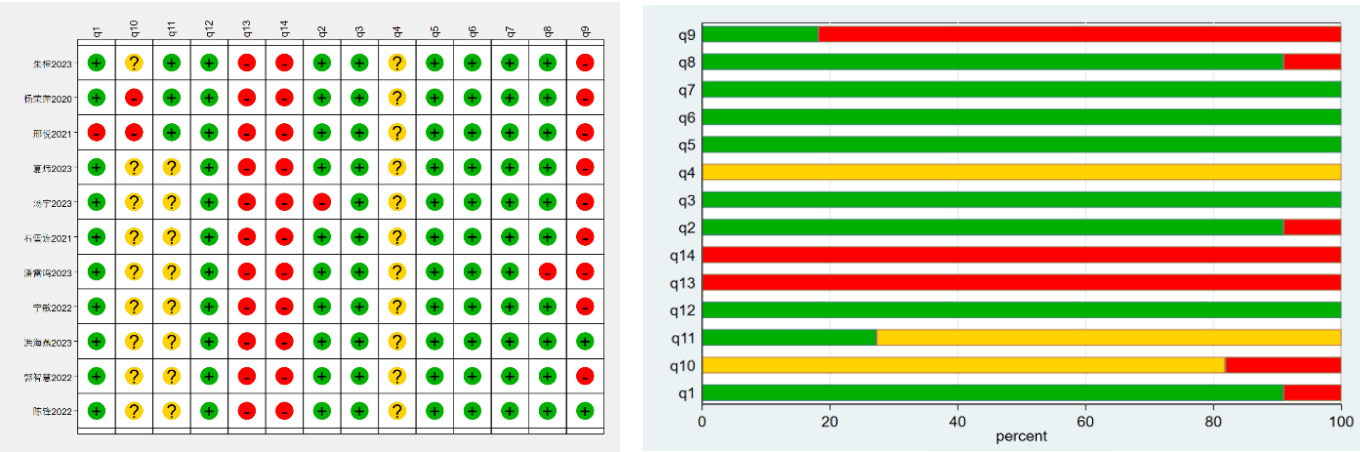

Figure 2: Results of literature quality evaluation. **Note:** (■): No; (■): Unclear; (■): Yes.

RESULTS

Meta-analysis of sensitivity combined effect sizes

The results showed an I^2 of 1.24% for the combined sensitivity and diagnostic ratio, p=0.43, and a sensitivity of 0.95 [95%CI (0.93, 0.96)], with no significant heterogeneity. Detailed results are shown in Figure 2.

Meta-analysis of specificity combined effect sizes

The results in Figure 3, showed that there was obvious heterogeneity in specificity, and the I^2 of the combined specificity and diagnostic ratio was 93.78%, p<0.001, which surfaced that there was heterogeneity caused by non-threshold effects among studies, and that a random-effects volume model was needed to perform a combined meta-analysis; meta-analysis of the specificity of the 11 included studies was performed with a random-effects model, and the results showed that the specificity was 0.88 [95%CI (0.70, 0.96)], and the I^2 of its diagnostic ratio was 91.00%, p<0.001, which was considered to be related to the fact that 4 of the 11 included papers had 0 false positives. Detailed results are shown in Figure 4.

Sensitivity analysis

As can be seen from the Figure 5, the sensitivity analysis was performed after eliminating each result one by one, and the results showed that the combined sensitivity and specificity did not change significantly, indicating that the results were stable. See Figure 5, for details.

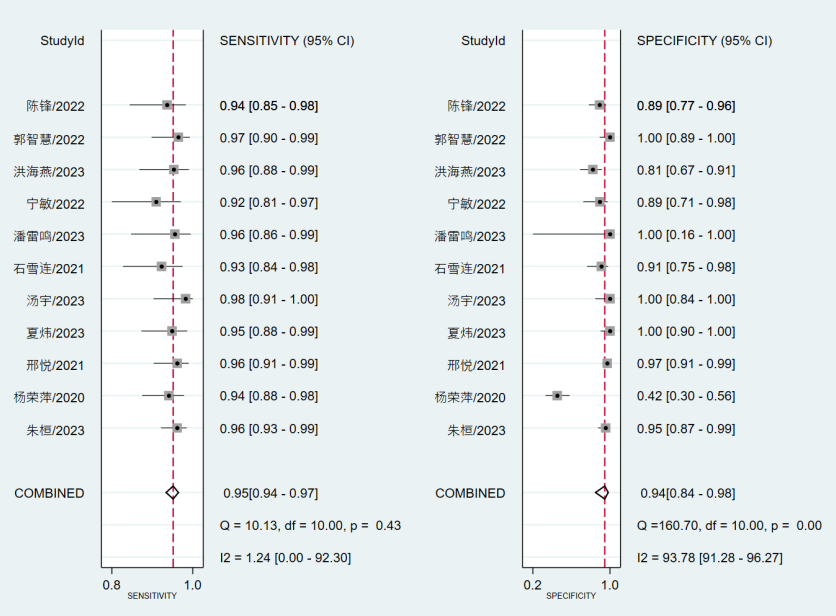

Figure 3: Detailed results of heterogeneity analysis.

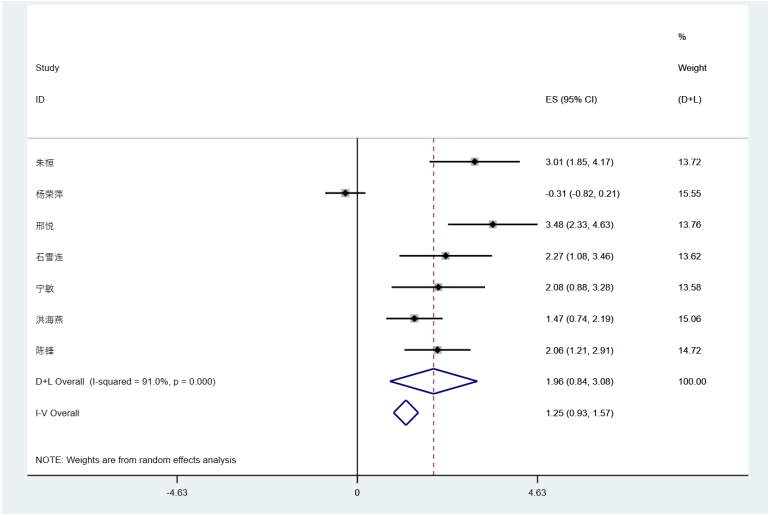

Figure 4: Meta-analysis of merger specificity.

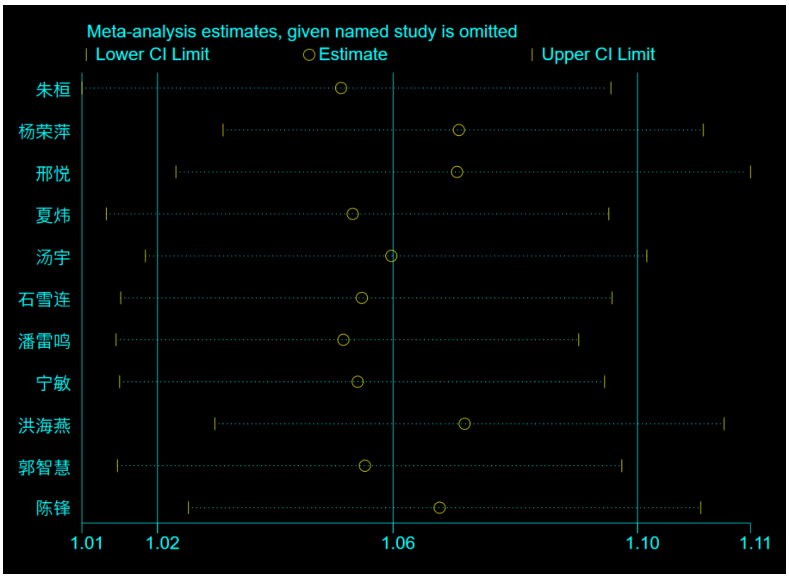

Figure 5: Results of combined sensitivity and specificity analysis.

SROC curve

Based on the plotting of the SROC curve, it can be seen that the area under the SROC curve AUC=0.96, indicating that the accuracy of the diagnosis of cardiac color ultrasound combined with carotid ultrasound is as high as 96%, p<0.05. From this, it can be known that the accuracy of cardiac color ultrasound combined with carotid ultrasound is very close to the transcendental standard. See Figure 6, for details.

Bias testing: As can be learned from the figure, p>0.05, there is no publication bias. See Figure 7, for details. From the above data, it can be concluded that cardiac color ultrasound combined with carotid ultrasound has good sensitivity and high diagnostic value for coronary heart disease.

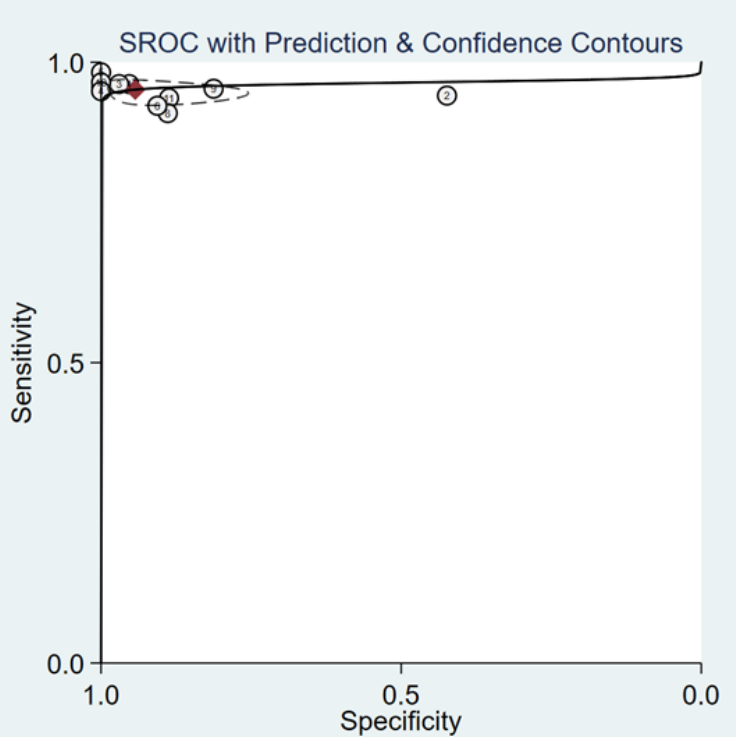

Figure 6: SROC curve with prediction and confidence contours. **Note:** (○): Observed data; (◆): Summary operating point SENS=0.95 [0.94-0.97] SPEC=0.94 [0.84-0.98]; (▬): SROC curve AUC=0.96 [0.94-0.98]; (–): 95% confident contour; (···):95% Prediction contour.

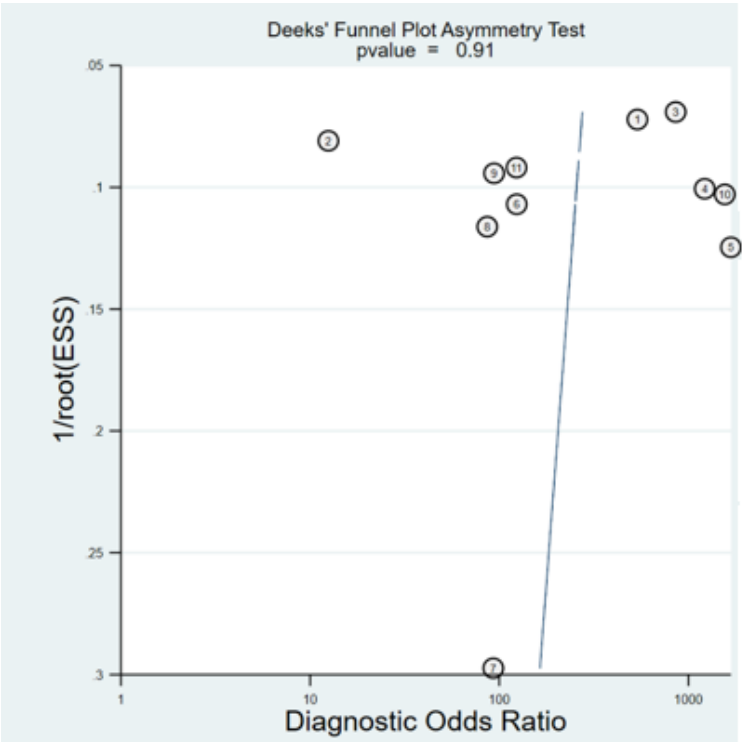

Figure 7: Publication bias by Deeks funnel plot asymmetric test. **Note:** (○): Study; (– – – –): Regression line.

DISCUSSION

The incidence of coronary heart disease has increased significantly with the change of china's demographic structure in recent years, posing an increasing threat to the health of the population [7]. After the onset of coronary heart disease, if there is no timely and effective treatment, its cure rate is often not optimistic, and easy to complicate heart failure and other end-stage cardiac diseases, which increases the difficulty of clinical diagnosis and treatment and aggravates the risk of patient death [20]. Therefore, early diagnosis plays an important role in the diagnosis and treatment of coronary heart disease.

At present, the standard for the diagnosis of coronary heart disease is coronary angiography, and the clear coronary artery images obtained by coronary angiography can clarify whether there is stenosis of coronary arteries, but at present, coronary angiography is expensive and requires arterial puncture and injection of contrast medium, which is an invasive examination, and is mostly used clinically as a final diagnostic means, and it is not recommended to be used as a means of preliminary diagnosis [21]. At present, non-invasive means commonly used in clinical diagnosis of coronary heart disease are electrocardiogram, cardiac enzymes, and cardiac ultrasound. Pre-diagnostic electrocardiogram is mostly conventional electrocardiogram, which is simple in operation and low in cost, but it is unable to continuously monitor the changes of patients electrocardiogram, and missed diagnosis is more common [22], cardiac enzymes can only react to the recent situation of patients onset of disease, and they cannot be clearly diagnosed in previous cases and patients with the situation of 3-5 days, with the development of ultrasound technology this year, cardiac ultrasound is playing a more and more important role in the diagnosis of cardiac heart lesions, and its development of ultrasound technology this year, cardiac ultrasound plays an increasingly important role in the diagnosis of heart disease, and its frequency of application is also gradually increasing; through the application of ultrasound probes to obtain multiple cardiac section images, it can be used to measure the parameters related to cardiac function at the same time, and to determine whether or not the anatomical structure of the heart of the patient has been altered; therefore cardiac ultrasound is not only used for the diagnosis of myocardial ischemia, but also used to determine the damage to cardiac function caused by ischemic lesions.

Some studies have found that the carotid artery intima is the most common site of atherosclerosis [23], the carotid artery is in the superficial part of the body, shallow location, ultrasound is easy to explore, can be determined by measuring the carotid artery Intima-Media Thickness (IMT) to determine the atherosclerosis and the presence of plaque formation, can suggest the risk of systemic atherosclerosis, thus indirectly reflecting coronary artery sclerosis [21]. At present, although cardiac ultrasound can detect most of the coronary lesions, patients with coronary artery disease with abnormal ventricular wall motion are often difficult to be detected by a single cardiac ultrasound, and it is easy to be missed or misdiagnosed, carotid ultrasound can indirectly reflect coronary arterial sclerosis, so the use of cardiac ultrasound combined with carotid ultrasound can be used in the determination of coronary atherosclerosis based on dynamic understanding of the carotid artery, thus assisting in the determination of atherosclerosis and then auxiliary diagnosis.

There is a lack of multicenter large-sample studies, and in order to study the value of cardiac ultrasound combined with carotid ultrasound in the diagnosis of coronary artery disease, we conducted a meta-analysis of the relevant literature. A total of 11 papers were included in this study, and their case composition and related basic characteristics were relatively consistent, which could meet the requirements of the QUADAS scale for literature evaluation. A good diagnostic method usually requires a good sensitivity to avoid missing suspected cases and a high specificity to exclude relevant suspected cases. The results of this study showed a combined sensitivity of 0.95 [95%CI (0.93, 0.96)], specificity of 0.88 [95%CI (0.70, 0.96)], positive likelihood ratio of 16.8 [95%CI (5.7, 49.1)], and negative likelihood ratio of 0.05 [95%CI (0.03, 0.07)], which is a good combination of sensitivity and specificity. The AUG of this Meta-analysis=0.96, based on this meta-analysis of 11 papers, it can be concluded that the accuracy of cardiac color ultrasound combined with carotid ultrasound diagnosis is as high as 96%. This study shows that cardiac color ultrasound combined with carotid ultrasound has high diagnostic value, high specificity and good sensitivity for coronary artery disease.

Limitations of this study

Some of the literature in this inclusion did not mention whether the patients contained confusing cases, causing the specificity of their diagnostic results to be exaggerated; many of the literature in the inclusion did not mention whether the diagnostic results of the diagnostic modality to be studied were made in the presence of an unknown standard diagnostic result, causing the positive results to be exaggerated; the inclusion of the literature for this inclusion did not mention whether there were withdrawn cases and the reasons for the withdrawal. Whether there is publication bias due to such factors has to be agreed upon; the database screening was conducted only in Chinese and English databases, although the relevant research literature was collected in a comprehensive manner and the evaluators independently screened the literature and extracted the data according to the pre-established inclusion and exclusion criteria, there is still a risk of omission, and there may still be a certain degree of selection bias.

CONCLUSION

Cardiac ultrasound combined with carotid ultrasound has good sensitivity and specificity for the diagnosis of coronary artery disease. This meta-analysis provides valuable insights into the potential of multimodal imaging strategies in improving the diagnostic landscape of CHD, thereby contributing to more effective patient management and better cardiovascular outcomes. The findings suggest that the combination of cardiac and carotid ultrasound enhances diagnostic accuracy, potentially leading to earlier detection and intervention for individuals at risk of CHD. But in actual clinical practice, it is still necessary to refer to other relevant laboratory tests and specific clinical manifestations for diagnosis.

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