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Evaluation Value of Cardiac Color Doppler Echocardiography in Assessing Poor Prognosis in Patients with Coronary Atherosclerotic Heart Disease

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Abstract: *Objective*: To investigate the evaluation value of cardiac color Doppler echocardiography (CDE) in assessing poor prognosis in patients with coronary atherosclerotic heart disease (CAD). *Methods*: A retrospective review was conducted of 106 patients with coronary artery disease (CAD) who were treated in the hospital's cardiovascular department between January 2023 and June 2024. All participants received baseline comprehensive Doppler echocardiography (CDE) assessments. Based on whether they experienced a Major Adverse Cardiovascular Event (MACE) within one year of follow-up, the patients were categorized into either a MACE group or a non-MACE group. The study compared baseline clinical information and CDE parameters, specifically left ventricular ejection fraction (LVEF), wall motion score index (WMSI), and mitral annular E/e' ratio, between the two groups. Independent predictors of MACE were identified using multivariate logistic regression analysis. *Results*: A total of 29 out of the 106 patients experienced MACE during the one-year follow-up. Compared with the non-MACE group, the MACE group had a higher prevalence of diabetes mellitus. In terms of CDE parameters, the MACE group had a lower LVEF than the non-MACE group ($p < 0.05$), while WMSI, average E/e', pulmonary artery systolic pressure (PASP), and mitral regurgitation (MR) proportion were all higher in the MACE group than in the non-MACE group ($p < 0.05$). Multifactor logistic regression analysis revealed that after adjusting for confounding factors such as diabetes, WMSI (OR = 3.003, 95% CI: 1.226–7.356, $p = 0.016$) and mean E/e' (OR = 1.281, 95% CI: 1.006–1.539, $p = 0.008$) were independent predictors of the occurrence of major adverse cardiovascular events (MACE). *Conclusion*: WMSI and E/e' diagnosed by color Doppler echocardiography (CDE) hold significant and independent assessment value for predicting poor prognosis in patients with coronary artery disease (CAD).

Keywords: Coronary atherosclerotic heart disease; Color doppler echocardiography; Poor prognosis; Major adverse cardiovascular events; Ventricular function

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1. Introduction

Coronary atherosclerotic heart disease (CAD) is one of the leading causes of death and disability worldwide [1]. Despite significant advancements in percutaneous coronary intervention and pharmacological treatment techniques in recent years, patients with CAD still face a high risk of recurrence of major adverse cardiovascular events (MACE). Therefore, accurate risk stratification and prognostic assessment of patients with CAD are of great significance for optimizing subsequent individualized treatment strategies and improving long-term patient survival [2]. Currently, coronary angiography (CAG) and coronary computed tomography angiography (CCTA) are primarily used in clinical settings to assess coronary anatomical stenosis. However, CAG, as an invasive procedure, has significant limitations, while CCTA, although non-invasive, also carries risks of ionizing radiation and iodinated contrast agent toxicity. Moreover, the degree of stenosis may not fully correlate with myocardial injury and prognosis, potentially leading to unnecessary downstream functional tests [3,4]. In view of this, this study conducted a retrospective analysis of the clinical data of 106 patients with coronary artery disease (CAD) admitted to the cardiovascular department of our hospital from January 2023 to June 2024, aiming to explore the value of cardiac color Doppler echocardiography in evaluating poor prognosis in CAD patients, with a particular focus on the predictive value of indicators such as regional wall motion abnormality index (WMSI) and elevated left ventricular filling pressure (E/e') for major adverse cardiovascular events (MACE). The findings are reported as follows.

2. Materials and methods

2.1. General information

A retrospective review was performed on the medical records of 106 coronary artery disease (CAD) patients who were admitted to our hospital's cardiology department between January 2023 and June 2024. All patients included in the analysis underwent baseline cardiac Doppler echocardiography (CDE) upon admission and completed a one-year follow-up to collect prognostic information. This work was approved by our hospital's Medical Ethics Committee with a waiver of informed consent.

2.2. Inclusion criteria

(1) Patients confirmed by imaging examination to have at least one major coronary artery with ≥ 50% luminal stenosis
(2) Aged 18 years or older
(3) Complete baseline data and clear imaging data images

2.3. Exclusion criteria

(1) Patients with severe primary valvular heart disease, congenital heart disease, restrictive cardiomyopathy, or other non-ischemic myocardial diseases
(2) Patients with a history of heart valve replacement or coronary artery bypass grafting
(3) Patients with persistent atrial fibrillation, frequent premature ventricular contractions, or other severe arrhythmias
(4) Patients with severe infections or diseases in other organs
(5) Patients with malignant tumors or autoimmune diseases

(6) Patients with poor baseline CDE image quality that makes it impossible to accurately identify the endocardial border

2.4. Methods

A color Doppler ultrasound diagnostic apparatus (State Import Drug Registration No. 20193062262, model and specification: EPIQ 7C; State Import Drug Registration No. 20173060626, model and specification: Vivid E95) was used. The patient was placed in a left lateral recumbent position and connected to an electrocardiogram. The left ventricular ejection fraction (LVEF) was calculated using the biplane Simpson's method, and semi-quantitative scoring of the ventricular wall motion was performed to calculate the wall motion score index (WMSI). The early diastolic mitral flow velocity (E wave) was measured using pulse Doppler, and the myocardial tissue motion velocity (e wave) was measured in combination with tissue Doppler imaging to calculate the E/e' ratio. Continuous Doppler was used to measure the peak velocity of tricuspid regurgitation to estimate the pulmonary artery systolic pressure (PASP). The degree of mitral regurgitation (MR) was assessed using color Doppler.

2.5. Statistical methods

Data analysis was performed using SPSS 22.0 statistical software. After confirming normal distribution via the Shapiro-Wilk test, measurement data were expressed as mean ± standard deviation ($\overline{x} \pm s$) and analyzed using the *t*-test. Count data were presented as percentages and analyzed using the χ^2 test or Fisher's exact test. Variables showing a univariate association with $p < 0.01$ were entered into a multivariate logistic regression model. Statistical significance was defined as a two-sided *p*-value of less than 0.05.

3. Results

3.1. Comparison of baseline data between the two groups of patients

Among the 106 CAD patients included in this study, 29 patients (27.36%) experienced MACE during a one-year follow-up, while 77 patients (72.64%) did not experience MACE. A review of baseline characteristics found no significant differences between the MACE and non-MACE groups in terms of age, sex, body mass index, history of hypertension, smoking status, or prevalence of multivessel disease. The only exception was comorbid diabetes, which was significantly more prevalent in the MACE group ($p < 0.05$). See **Table 1**.

Table 1. Comparison of baseline data between the two groups of patients [$\overline{x} \pm s$, n(%)]

Variable	MACE group (n = 29)	Non-MACE group (n = 77)	Statistical value (χ^2/t)	*p*-value
Age (years)	65.12 ± 9.42	63.88 ± 10.15	0.571	0.569
Gender (Male, %)	20 (68.97)	55 (71.43)	0.062	0.804
BMI (kg/m^2)	25.05 ± 3.14	24.66 ± 2.98	0.592	0.555
Hypertension (%)	21 (72.41)	43 (55.84)	2.418	0.120
Diabetes (%)	15 (51.72)	19 (24.68)	7.074	0.008
Smoking history (%)	14 (48.28)	30 (38.96)	0.753	0.386
Multivessel disease (%)	18 (62.07)	32 (41.56)	3.556	0.059

3.2. Comparison of CDE diagnostic parameters between the two groups of patients

Patients who experienced MACE demonstrated significantly poorer cardiac function across multiple measures compared to the non-MACE group. This included impaired systolic function (lower LVEF and higher WMSI), diastolic dysfunction (higher average E/e'), and adverse hemodynamics (higher PASP and a greater proportion of MR). All differences were statistically significant ($p < 0.05$). See **Table 2**.

Table 2. Comparison of CDE diagnostic parameters between the two groups of patients [$\overline{x} \pm s$, n(%)]

Parameter	MACE group (n = 29)	Non-MACE group (n = 77)	Statistical value (χ^2/t)	*p*-value
Systolic function				
LVEF (%)	48.15 ± 6.22	55.60 ± 5.19	-6.233	< 0.001
WMSI	1.51 ± 0.24	1.18 ± 0.15	8.474	< 0.001
Diastolic function				
E/e' (average)	15.25 ± 3.11	10.90 ± 2.65	7.178	< 0.001
Hemodynamics				
PASP (mmHg)	42.10 ± 8.16	33.50 ± 6.97	5.400	< 0.001
Moderate-to-severe MR (%)	10 (34.48)	11 (14.29)	5.409	0.020

3.3. Multivariate logistic regression analysis of MACE occurrence

Diabetes, multivessel disease, LVEF, WMSI, E/e', PASP, and moderate to severe MR from the univariate analysis were included in the multivariate Logistic regression model for analysis. The results showed that diabetes, WMSI, and mean E/e' were independent predictors of MACE occurrence ($p < 0.05$). See **Table 3**.

Table 3. Multivariate logistic regression analysis of MACE occurrence

Variable	β	SE	Wald χ^2	*p*-value	OR	95% CI
Diabetes	0.851	0.399	4.545	0.033	2.341	1.071–5.117
LVEF (%)	-0.037	0.051	0.525	0.469	0.964	0.873–1.064
Multivessel disease	0.377	0.408	0.853	0.356	1.458	0.655–3.245
WMSI	1.100	0.457	5.788	0.016	3.003	1.226–7.356
E/e' (average)	0.248	0.094	6.979	0.008	1.281	1.006–1.539
PASP (mmHg)	0.045	0.036	1.528	0.216	1.046	0.974–1.123
Moderate-to-severe MR	0.484	0.547	0.785	0.376	1.623	0.556–4.738

4. Discussion

Coronary artery disease (CAD) has now emerged as a significant global public health challenge. Research data indicate that its incidence among individuals under 50 years old in China has increased by nearly 30% in the past three years, with a more pronounced trend towards younger age groups [5]. Due to its non-invasive nature, lack of radiation exposure, high convenience, and strong reproducibility, Cardiac Doppler Echocardiography (CDE) has become the first-line choice for assessing cardiac structure and function. However, its risk assessment for CAD

patients largely relies on LVEF. Since LVEF is an indicator significantly influenced by preload and afterload conditions, it only reflects the overall ventricular pumping capacity. Even when patients may have already developed significant subclinical myocardial damage and diastolic dysfunction, LVEF may still remain within the normal range [6]. Therefore, this study primarily employs a multiparametric model integrating the Wall Motion Score Index (WMSI) and E/e' to explore the value of cardiac color Doppler ultrasound in predicting major adverse cardiac events (MACE) within one year in patients with coronary artery disease (CAD) from both ventricular wall mechanics and hemodynamic perspectives.

The findings of this study indicate that although the left ventricular ejection fraction (LVEF) in the MACE group is significantly lower than that in the non-MACE group, it does not demonstrate independent predictive value in the multivariate model. In contrast, WMSI is confirmed as an independent predictor of MACE occurrence. The reason for this is that when myocardial contraction in CAD patients weakens or even ceases due to ischemia, the myocardium in other regions supplied by normal coronary arteries can exhibit compensatory enhanced contraction through the Frank-Starling mechanism. Consequently, the calculated LVEF value cannot fully reflect the true ischemic burden [7]. In comparison, WMSI can precisely quantify the extent and severity of regional ventricular wall motion abnormalities caused by ischemia. This means that even if LVEF remains compensatorily normal, a high WMSI not only indicates a larger infarct size but also reflects a high risk of myocardial remodeling and arrhythmias [8]. In addition, this study also observed the value of the E/e' ratio in the prognostic evaluation of CAD. Myocardial ischemia and fibrosis caused by CAD will lead to impaired diastolic function and an increase in LVFP. The elevated LVFP further results in pulmonary congestion and heart failure, thereby triggering MACE. As an important non-invasive indicator for evaluating left ventricular filling pressure, E/e' plays a crucial measurement point in the process of CAD leading to heart failure [9]. In this study, the continuous elevation of E/e' in the MACE group suggests that the patients' left ventricles are in a highly stiff state, and the heart requires higher end-diastolic pressure to maintain filling. Over time, this can easily lead to the abnormal transmission of stress in the reverse direction to the pulmonary circulation, increasing the risk of pulmonary congestion and pulmonary arterial hypertension, which are also core factors triggering heart failure and MACE [10]. Park et al. found in their study that an E/e' ratio $\geq$ 15 was the strongest predictor of cardiac death in patients with acute myocardial infarction, which is consistent with the findings of this study [11]. Although PASP and MR in this study did not demonstrate statistical independence in the regression model, their significantly high levels in the MACE group to some extent indicate the downstream effects of cardiac dysfunction. The elevation of E/e' can be transmitted in the reverse direction, triggering left ventricular remodeling and pulmonary arterial hypertension, thereby leading to an increase in PASP. Its independence may be overshadowed by upstream indicators such as E/e' in clinical practice, but it should still be considered an important reference for the overall risk assessment of MACE.

5. Conclusion

In conclusion, the comprehensive CDE evaluation strategy incorporating WMSI and E/e' has high clinical value in assessing poor prognosis in CAD patients and can provide strong guidance for actively formulating and adjusting precise treatment strategies and follow-up plans in clinical practice.

Disclosure statement

The author declares no conflict of interest.

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