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ORIGINAL RESEARCH

Potentially Risk Factors for New Atrial Fibrillation in Patients Undergoing Coronary Artery Bypass Grafting: A Retrospective Cohort Study

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Objective: Our study evaluated the risk factors for new postoperative atrial fibrillation (POAF) by analyzing the data collected from patients who underwent first coronary artery bypass grafting (CABG).

Methods: Our study retrospectively collected data from January 2021 to December 2023 at Changzhi People's Hospital. The perioperative period data were collected, and logistic regression was used to analyze the independent predictors of the occurrence of POAF after CABG and the related predictive values of risk factors were analyzed by using the subjects' work characteristic curve (ROC).

Results: A total of 169 patients were included, and there are 45 patients in the POAF group, with an incidence of 26.6%, and 124 in the non-POAF group. The POAF group was significantly higher than the non-POAF group in terms of age (69.2±8.8 years vs 62.3±9.3 years) and preoperative LAD (42.7±7.2mm vs 36.8±5.5mm), and the difference was significant (P<0.05). Preoperative HDL-C in the POAF group were lower than non-POAF group (1.0±0.5 mmol/l vs 1.4±0.7 mmol/l, P<0.05). The logistic regression analysis revealed a significant correlation between age, LAD, HDL-C and the occurrence of POAF (P<0.05). According to the ROC curve analysis, age >64.5 years, LAD >41mm, and HDL-C <0.9 mmol/l were the cut-off values for predicting the occurrence of POAF (AUC1=0.733; AUC2=0.741; AUC3=0.647, P < 0.05). The combined age + LAD + HDL-C (AUC = 0.755; P < 0.05) had a higher diagnostic value and high sensitivity.

Conclusion: The age, LAD, and HDL-C are independent risk factors for the POAF after CABG, and clinicians should assess these risk factors as much as possible when managing patients in the perioperative period and make corresponding measures to prevent the development of POAF.

Keywords: coronary artery bypass grafting, left atrial diameter, left ventricular ejection fraction, high density lipoprotein cholesterol, atrial fibrillation

Introduction

Coronary artery bypass grafting (CABG) is a common treatment for coronary artery disease in which bypass surgery is performed to improve ischemia due to stenosis or blockage of coronary arteries.[1,2] However, there is a higher incidence of postoperative atrial fibrillation (POAF) after CABG, which undoubtedly increases the suffering of patients and affects the prognosis of patients, resulting in increased mortality and longer hospital stay. Studies have shown that the incidence of new POAF after CABG reaches 20%-35%, which is significantly higher than other complications, such as infections, thrombosis and pseudoaneurysm.[3–5] To date, great progress has been made in the perioperative management of CABG, but there is still controversy regarding the mechanism of POAF. Previous studies have surfaced the possibility that its production may be related to structural and electrical remodeling of the atria, age, and functional status of other important organs, but there is no uniform conclusion.[6–8] And it is particularly important for clinicians to identify potential risk

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factors for POAF after CABG and take timely preventive measures to achieve a better prognosis. In our study, we analyzed the baseline and perioperative data of patients who underwent CABG by collecting and exploring the effect of new POAF with CABG.

Methods

Study design and participants

Our study was conducted from January 2021 to December 2023 at Changzhi People's Hospital to retrospectively collect data from patients who underwent CABG for the first time to treat coronary artery disease and who were transferred to the intensive care unit (ICU) after the surgery. Our study complied with the requirements of the Declaration of Helsinki and was approved by Changzhi People's Hospital ethics committee (CZSRMYY-YXLL-AF-003/01). Written informed consent was obtained from patients or their family members, and patient confidentiality was strictly maintained.

Criteria for Inclusion and Exclusion

Patients eligible for CABG for coronary artery disease. All patients underwent coronary angiography, echocardiography, and laboratory examination before operation. Patients with paroxysmal or persistent atrial fibrillation, recent acute myocardial infarction, valvular disease or other heart disease, autoimmune disease, and history of repeated CABG were excluded. A total of 169 patients were finally included in our study.

Data Collection

The perioperative baseline data, relevant laboratory findings and imaging findings were collected consecutively. Patient-related information was extracted from the baseline data, including age, gender, and Body Mass Index (BMI). The chronic obstructive pulmonary disease (COPD), diabetes, hypertension, stroke, smoking history, and cardiac interventional therapy history were also collected. Laboratory findings included white blood cells (WBC), hemoglobin (HB), platelets (PLT), albumin(ALB), triglycerides (TG), low/high density lipoprotein cholesterol (LDL-C/HDL-C), etc. The other data included left atrial diameter (LAD), left ventricular ejection fraction (LVEF), operation time, and hospital stay. Postoperative data included myoglobin (MYO), cardiac troponin I (cTNI), etc. (Table 1) Previous studies have shown that symptomatic or asymptomatic POAF usually occurs 2 to 4 days after surgery. At the same time, 12-lead electrocardiogram or electrocardiographic monitor showed the disappearance of P-wave, which was replaced by a series of rapid atrial fibrillation waves of different sizes and morphologies, with a frequency of about 350–600 beats/min; the RR intervals were irregular; the QRS wave was normal in morphology, and the QRS wave was widened when intraventricular differential conduction occurred. The endpoint event of our study was the likelihood and risk factors of patients developing POAF before discharge. The patients were categorized into POAF group and non-POAF group according to the presence or absence of POAF and the perioperative data were compared between the two groups.

Statistical Analysis

The analysis was performed using SPSS23 for data processing. Measurements were expressed as mean ± standard deviation (x ± s), and independent samples *t*-test was used for comparison between the two groups. Nonparametric tests were used between groups that did not fit the normal distribution, expressed as median (interquartile spacing). Count data were expressed as frequencies and percentages (%), and comparisons between groups were made using the chi-square test. Multifactorial Logistic regression analysis was used to analyze the influences on the occurrence of POAF. $P<0.05$ was considered a statistically significant difference.

Results

A total of 169 patients were enrolled in the study. There were 45 patients in the POAF group with an incidence rate of 26.6%. The 124 patients were in the non-POAF group. There was no significant difference between two groups in terms of gender, BMI, incidence of diabetes, hypertension, and smoking history at baseline data ($P>0.05$, Table 1). There were

Table 1 Comparison of Patient Data Between the Two Groups

	AF group (n= 45 patients)	Non-AF group (n= 124 patients)	t/χ 2	P值
Baseline data				
Age(years)	69.2±8.8	62.3±9.3	4.351	0.001
Sex(male/female)	28/17	89/35	1.647	0.199
BMI(kg/m^2)	25.6±3.3	25±3.0	1.087	0.278
History of interventions	17/28	23/101	7.313	0.007
COPD	12/33	13/111	6.860	0.009
Diabetes	13/32	48/76	1.247	0.264
Hypertension	33/12	79/45	1.368	0.242
Cerebrovascular disease	16/29	22/101	5.877	0.015
Smoking history	24/21	79/45	1.494	0.222
Laboratory findings				
LAD (mm)	42.7±7.2	36.8±5.5	5.682	0.001
LVEF	0.6±0.1	0.6±0.1	0.043	0.966
WBC(*10$^{9/}$l)	6.6±1.8	6.8±2.2	−0.588	0.557
HB(g/l)	100±35.5	107±25.7	−1.406	0.162
PLT(*10$^{9/}$l)	219±66.4	−1.069	0.287	0.287
ALB(g/dl)	40.9±4	42.8±6.4	−1.756	0.081
GLB(g/dl)	25.3±4.4	25.6±4.7	−0.363	0.717
TC(mmol/l)	3.6±1.2	3.8±1.3	−0.852	0.395
TG(mmol/l)	1.7±1.2	1.7±0.8	−0.452	0.652
LDL-C(mmol/l)	3±1.7	3.1±2.1	−0.165	0.869
HDL-C(mmol/l)	1.0±0.5	1.4±0.7	−3.245	0.001
Average operating time(min)	198.0±60.1	190.9±87.1	0.503	0.616
First day after surgery				
MYO (ng/mL))	198.3(136.8,327.1)	192.4(113.1,289.6)		0.415
Troponin I (ng/mL))	129(80.1,261)	131.3(73,204.3)		0.771
Second day after surgery				
MYO (ng/mL))	140.2(49.9,318.9)	93.4(45.9,163.7)		0.153
Troponin I (ng/mL))	147.8(71.9,362.7)	96.1(46,233.1)		0.050

Note: The differences were statistically significant when P < 0:05.
Abbreviations: BMI, Body Mass index; COPD, chronic obstructive pulmonary disease; LAD, left atrial diameter; LVEF, left ventricular ejection fraction; WBC, white blood cells; HB, hemoglobin; PLT, platelet; ALB, albumin; GLB, globulin; TC, total cholesterol; TG, triglyceride; LDL-C, low density lipoprotein cholesterol; HDL-C, high density lipoprotein cholesterol; MYO, myoglobin; SE: standard error.

also no statistically significant differences in perioperative LVEF, WBC, HB, PLt, TG, HDL-C duration of surgery, and postoperative MYO and cTNI.

Patients in the POAF group were significantly higher than those in the non-POAF group, and the difference was significant (69.2 ± 8.8 years vs 62.3 ± 9.3 years, $P < 0.05$, Table 1). Meanwhile, compared with the non-POAF group, the patients in the POAF group had a higher proportion of history of intervention therapy (17/28 vs 23 /101), COPD (12/33 vs 13/111) and stroke (16/29 vs 22/101), and the difference was significant ($P < 0.05$, Table 1). Comparison of preoperative cardiac ultrasound LAD showed a statistically significant difference of 42.7±7.2 mm in the POAF group, which was significantly higher than that of 36.8±5.5 mm in the non-POAF group. Meanwhile, the POAF group had significantly lower preoperative HDL-C than the non-POAF group (1.0±0.5 mmol/l vs 1.4±0.7 mmol/l, $P<0.05$, Table 1).

Multifactorial logistic regression of the occurrence of POAF in both groups: the POAF was the dependent variable, assigned the following values: occurrence=1, non-occurrence=0; Among the binary variable, the occurrence of COPD, stroke and cardiac interventional therapy history was 1, and the non-occurrence was 0. The age, LAD, HDL-C, COPD, stroke, and interventional therapy history with significant differences in univariate analysis were included in regression analysis. Multifactorial Logistic regression analysis revealed that the age, LAD and HDL-C were significantly correlated with the occurrence of POAF (1.143 (1.081–1.209), P=0.001; 1.236 (1.139–1.341), P=0.001; 0.216 (0.077–0.611), P= 0.004, Table 2).

Table 2 Multivariate Regression Analysis of New POAF After CABG

	β	SE	Wald	P	OR (95% CI)
Age	0.132	0.0029	21.3	0.001	1.143(1.081–1.209)
LAD	0.212	0.042	25.1	0.001	1.236(1.139–1.341)
HDL-C	−1.530	0.530	8.348	0.004	0.216(0.077–0.611)
BMI	0.075	0.072	1.071	0.301	1.078(0.925–1.242)
COPD (1)	−0.7	0.5	2.0	0.159	0.503(0.194–1.308)
History of interventions (1)	−0.8	0.4	3.7	0.055	0.453(0.202–1.017)
Stroke (1)	−0.8	0.4	3.6	0.057	0.455(0.202–1.023)

Note: The differences were statistically significant when P < 0:05.
Abbreviations: BMI; Body Mass index; COPD, chronic obstructive pulmonary disease; LAD, left atrial diameter; HDL-C, high density lipoprotein cholesterol; SE: standard error.

Table 3 Predictive Value of Age, LAD, and HDL-C in New POAF After CABG

	AUC	95% CI	P	Cut-off	Sensitivity (%)	Specificity (%)
Age	0.733	0.643–0.823	0.001	64.5	82.2	58.8
BMI	0.573	0.474–0.673	0.147	25.6	53.3	66.4
LAD	0.741	0.646–0.835	0.001	41.0	66.7	77.3
HDL-C	0.647	0.552–0.742	0.007	0.9	80.0	56.7
Age+LAD+HDL-C	0.755	0.661–0.850	0.001	–	93.3	57.8

Note: The differences were statistically significant when P<0.05.
Abbreviations: BMI; Body Mass index; LAD, left atrial diameter; HDL-C, high density lipoprotein; AUC, area under ROC curve; Cut-off, the cut-off value was determined using the Youden method.

The area under the curve (AUC) for age was 0.733, sensitivity 82.2%, specificity 58.8%, and cutoff value 64.5, which was slightly higher than the AUC for LAD (AUC 0.741, sensitivity 66.7%, specificity 77.3%, and cutoff value 41) and for HDL-C (AUC 0.647, sensitivity 80.0%, specificity 56.7%, and cutoff value 0.9, Table 3). However, there was no statistical difference in the diagnostic value of age compared to the other two indicators (Z1 = 0.109, p = 0.913; Z2 = 1.188, p = 0.235). However, the sensitivity of age (82.2%) was high. The combined age + LAD + HDL-C evaluation (AUC 0.755, sensitivity 93.3%, specificity 57.8%, P=0.001; Z = 2:612, P = 0:009, Table 3; Figure 1) had a higher diagnostic value and high sensitivity. There was also a correlation between history of intervention, stroke, and the occurrence of POAF among the binary variables (P=0.055; P=0.057).

Discussion

CABG is a bypass surgery in which healthy blood vessels are grafted to narrowed or blocked coronary arteries to improve blood supply to the heart muscle, allowing patients with coronary artery disease to benefit from the procedure.[9,10] However, during the development of CABG in the last decade, a proportion of patients develop various postoperative complications. The POAF is one of the most common postoperative complications, and although the vast majority of AF can be restored with medication, this arrhythmia undoubtedly increases the risk of stroke in the postoperative period and may lead to a reduction in cardiac output and even myocardial infarction.[6] The study by Rezk et al found that POAF was associated with an increased risk of long-term mortality, ischemic stroke, thromboembolism, hospitalization for heart failure, and recurrence of AF.[5,11] This can lead to reduced patient satisfaction, prolonged hospitalization, increased healthcare expenditures, and a greater financial burden on the patient's family and society. Therefore, refined management of perioperative patients, prevention or early intervention of risk factors, and reduction or avoidance of postoperative related complications can help improve the care and quality of life of surgical patients. This is extremely important for healthcare professionals. In our study, we analyzed and studied the impact of new POAF after CABG from the patients' perioperative point of view by collecting the preoperative and postoperative data of patients who underwent CABG.

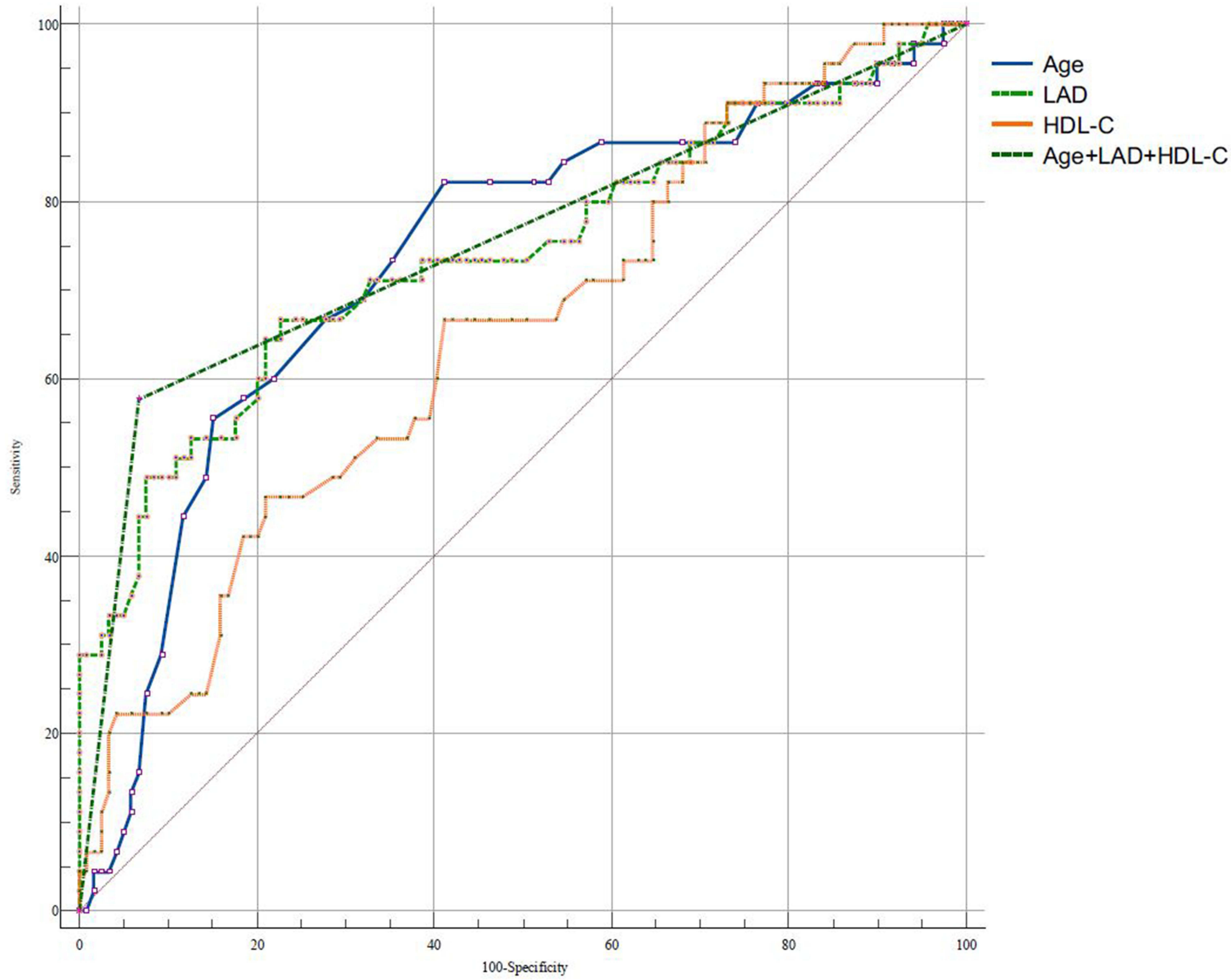

Figure 1 ROC curve of age, LAD and HDL-C predicting new POAF after CABG.

In this study, 45 patients out of a total of 169 CABG patients developed POAF, with an incidence rate of 26.6%, mostly within 4–5 days after surgery. It is basically consistent with the incidence of new POAF after CABG in domestic and international studies.[3–5] By analyzing the perioperative factors related to the preoperative and postoperative periods, we found that age and LAD were independent risk factors for the development of POAF after CABG. Previous studies have shown that people over 60 years of age have a higher chance of developing POAF. The heart structure may change with age, especially in elderly patients over 60 years of age.[12] Due to the progressive apoptosis of cardiomyocytes, structural remodeling of the heart is caused, including hypertrophy of atrial myocytes, interstitial fibrosis, and changes in the extracellular matrix of the cardiomyocytes, and these structural changes can cause the development and maintenance of AF.[13] Meanwhile, the degeneration of the cardiovascular system in elderly patients leads to myocardial ischemia and hypoxia, which further affects the sarcoplasmic reticulum leading to myocardial fibrosis. These degenerative changes may alter the electrophysiological properties of atrial tissue by shortening the effective refractory period of atrial electrical conduction and modifying conduction pathways, thereby increasing the susceptibility to the formation of reentrant circuits that induce atrial fibrillation.[14] Choi et al evaluated 327 patients with coronary artery disease without preoperative AF who were treated with CABG and found that POAF occurred most often within the second postoperative day, and in their stratified analysis of age, age>70 years was an independent risk factor for the development of POAF.[15] And in our study, similar findings were exhibited by logistic regression analysis. The Cutoff value of 64.5 years, with a sensitivity of 82.2%, implies that the relative risk of POAF is higher at ages greater than 64.5 years. At the same time, it has been shown that there is a progressive decline in lung function and an increase in residual airflow in elderly patients due to COPD or other factors, which affects cardiopulmonary hemodynamic changes and consequently slows atrial conduction. Some studies have suggested that COPD is a predictor of the development of POAF after CABG.[15,16] A meta-analysis included 6173 participants in a total of 10 papers to assess the occurrence of POAF after CABG, and the study showed that the risk factors most strongly associated with POAF were COPD and decreased partial pressure of oxygen on air.[17] However no significant results were obtained in our study. This factor should not be ignored, and lung function should be considered as much as possible during the perioperative evaluation of patients.

In addition, our study found that the LAD was also a significant predictor of POAF, with a Cutoff value of 41 mm, suggesting that preoperative left atrial remodeling has a crucial role in the occurrence of POAF. Gao et al found that LAD was closely related to the occurrence of POAF by analyzing 113 patients with coronary artery disease treated with CABG.[18] For every 30% increase in LAD, the risk of developing AF increases by 43%.[19] Enlargement of the left atrial chamber due to aging and cardiac insufficiency may lead to a series of structural remodeling and electrophysiological changes, including abnormal expression or dysregulation of ion channels such as sodium, potassium, and calcium. An increase in left atrial diameter may shorten the effective refractory period of atrial electrical conduction, increasing the likelihood of atrial electrical conduction abnormalities. At the same time, electrophysiologically, it may alter the conduction pathways within the atrium, generating ectopic foci and reentrant circuits, thereby triggering atrial fibrillation.[20] Aviles et al demonstrated in their study that enlargement of the left atrium is closely associated with inflammatory responses and oxidative stress. These conditions influence the electrophysiological properties of the heart, promoting atrial remodeling and fibrosis, which subsequently increase the risk of AF.[21]

In our study, HDL-C was also an independent risk factor for the new POAF after CABG. HDL-C is synthesized primarily in the liver, which mediates reverse cholesterol transport, and is anti-inflammatory, antioxidant, and anti-thrombotic.[22,23] Studies have shown that HDL-C levels are strongly associated with the risk of developing AF, with a negative correlation. The low levels of HDL-C lead to reduced anti-inflammatory and antioxidant effects and promote the development of atrial fibrosis. Alvaro et al studied 7142 people from the Multi-Ethnic Study of Atherosclerosis, showing that lower levels of HDL-C are associated with a higher risk of atrial fibrillation. AF is one of the major complications after CABG, and preoperative assessment of patients' HDL-C levels is of great significance.[24] In recent years, a monocyte to high-density lipoprotein ratio (MHR) has emerged as a new biomarker of inflammation and oxidative stress with some success in predicting AF. In a recent study, Wang et al statistically analyzed 204 patients with nonalcoholic fatty liver disease (NAFLD) and found that MHR was closely associated with the development of AF.[22] As for the occurrence of POAF after CABG, preoperative MHR is associated with POAF and mortality after CABG.[25,26] Therefore, preoperative assessment of HDL-C level or MHR ratio is informative for the prevention of POAF. In subsequent studies, we will also summarize the further analysis of MHR and so on. Combined with the above discussion, we conducted a joint analysis of three significant risk factors, age, LAD, and HDL-C, and found that AUC was 0.755, P=0.001, which had significance in predicting POAF after CABG. Therefore, during the perioperative phase of CABG, it is crucial to develop appropriate patient management strategies and education to reduce the risk of postoperative atrial fibrillation (POAF).[15] This includes using antiarrhythmic and anticoagulant drugs, opting for minimally invasive CABG procedures with real-time ECG monitoring, managing comorbidities such as hypertension, diabetes, and COPD, encouraging patients to quit smoking, limit alcohol intake, maintain a balanced diet, and engage in regular physical activity. Additionally, scheduling regular postoperative follow-ups and providing continuous health education and psychological support are essential.

At the same time, we found that dichotomous variables such as preoperative history of intervention and history of stroke were statistically significant in the one-way chi-square test but did not reach a statistical difference in the logistic regression analysis (P1=0.055; P2=0.057). In previous studies, it has also been reported that stroke causes a series of inflammatory responses promoting myocardial damage as well as inducing AF by affecting the central nervous system.[27] A study by Choi et al found that a history of stroke was an independent risk factor for the development of POAF after CABG.[15] However, the related mechanism of influence is still unclear and needs to be further investigated.

Our study has certain limitations. Our study was retrospective and only collected and analyzed the available clinical data and lacked the collection of novel markers such as MHR, neutrophil lymphocyte ratio in recent years, and lacked long-term postoperative follow-up measures to assess relevant factors. We did not assess left atrial reservoir strain using speckle tracking echocardiography in our study. This novel technique may offer greater diagnostic and prognostic value compared to traditional echocardiographic parameters.[28,29] Subsequent larger sample sizes and prospective studies are needed to explore the associated risk factors in order to better guide clinical work for the benefit of patients.

Conclusions

In summary, elderly patients, LAD, and HDL-C are independent risk factors for the development of POAF after CABG, and clinicians should assess these risk factors as much as possible when managing patients in the perioperative period and make corresponding measures to prevent the development of POAF. This in turn improves the quality of care and patient satisfaction.

Disclosure

The authors declare that they have no competing interests in this work.

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