Liu et al. Perioperative Medicine (2025) 14:44
https://doi.org/10.1186/s13741-025-00527-7

Perioperative Medicine

RESEARCH

Open Access

Clinical value of NT-proBNP, MPO, and NLR combined with echocardiography in prediction of malignant arrhythmia in elderly patients with valvular heart disease

Jianping Liu[1*], Apei Zhou[2], Meiduan Zheng[1], Ling Wang[3] and Ping Zeng[4]

Abstract

Objective We aimed to probe the clinical value of N-terminus pro-brain natriuretic peptide (NT-proBNP), myeloperoxidase (MPO), and neutrophil lymphocyte ratio (NLR) combined with echocardiography in the prediction of malignant arrhythmias (MA) in elderly patients with valvular heart disease (VHD).

Methods MPO, NT-proBNP, and NLR were detected in blood samples. After 1 year of follow-up, receiver operating characteristic curves were analyzed to determine the clinical value of NT-proBNP, MPO, NLR, and echocardiography for predicting MA in patients with VHD.

Results MPO, NT-proBNP, and NLR were higher in the VHD group. MPO, NT-proBNP, and NLR were higher with severe cardiac dysfunction. MPO, NT-proBNP, NLR, and LVESV in the MA group were higher. NT-proBNP was an independent factor influencing the occurrence of MA in elderly patients with VHD. The AUC for predicting MA in elderly patients with VHD using NT-proBNP, MPO, NLR, and echocardiography were 0.782 (sensitivity 61.50%, specificity 94.60%, 95% CI 0.630–0.934), 0.759 (sensitivity 69.20%, specificity 81.10%, 95% CI 0.579–0.938), 0.736 (sensitivity 76.90%, specificity 64.90%, 95% CI 0.562–0.910), and 0.782 (sensitivity 76.90%, specificity 75.70%, 95% CI 0.646–0.918), respectively. The AUC for the combined prediction using NT-proBNP, MPO, NLR, and echocardiography was 0.913 (sensitivity 76.90%, specificity 94.60%, 95% CI 0.820–1.000), higher than that of each parameter alone ($P < 0.05$).

Conclusion The combination of NT-proBNP, MPO, NLR, and echocardiography has a predictive value in detecting MA in elderly VHD patients.

Keywords NT-proBNP, MPO, NLR, Echocardiography, Valvular heart disease, Malignant arrhythmia

*Correspondence:
Jianping Liu
Liujianping9258@163.com
[1] Department of Echocardiography, Quanzhou First Hospital, Quanzhou, Fujian 362000, China
[2] Department of Gastroenterology, Quanzhou First Hospital, Quanzhou, Fujian 362000, China
[3] Cardiovascular Medicine, Quanzhou First Hospital, Quanzhou, Fujian 362000, China
[4] Cardiovascular Medicine, Guangdong Provincial People's Hospital, Guangzhou, Guangdong 519041, China

Introduction

In primary care settings, valvular heart disease (VHD) is a prevalent abnormality. Many causes can contribute to VHD, including congenital, degenerative, infectious, and traumatic factors (Kisling and Gallagher 2024). In the heart, there are four valves (tricuspid, pulmonic, mitral, and aortic) that prevent backward flow between the four chambers of the heart and ensure that the pressure gradients necessary for hemodynamic circulation are maintained (Roth et al. 2020). However, effective pharmacological therapies are limited, and treatment methods have traditionally been confined to surgical techniques such as valve repair or replacement, resulting in inadequate treatment for elderly patients and those with severe complications, frailty, or left ventricular dysfunction (Praz et al. 2024). Additionally, The cardiovascular system progressively deteriorates with age, leading to aortic and/or mitral valve insufficiency and stenosis. Dilation and calcification of the heart, along with fibrosis, can result in various arrhythmic conditions (Eleid et al. 2023). Malignant arrhythmias (MA) are a type of rapid arrhythmia that can lead to hemodynamic abnormalities within a short period, most commonly ventricular tachycardia or ventricular fibrillation, which require prompt management (Chen et al. 2019). Therefore, predicting MA in elderly patients after VHD surgery and taking timely intervention measures are of significant clinical importance for improving prognosis.

Echocardiography, as a routine non-invasive imaging technique for the diagnosis of cardiovascular diseases, can intuitively display the structural and functional status of heart valves, providing an important basis for the diagnosis and evaluation of VHD (Wang et al. 2018; O'Riordan et al. 2023). However, its ability to predict MA post-surgery in patients is often insufficient due to its reliance on real-time monitoring. Consequently, MA in elderly VHD patients has been a hot topic in clinical research. Identifying new indicators to enhance the predictive value of MA in elderly patients with VHD is of great significance.

Studies have indicated that an elevated C-reactive protein-to-albumin ratio (CAR) increases the risk of long-term all-cause mortality in patients with heart failure with reduced ejection fraction (HFrEF) and those with implantable cardiac defibrillators (ICDs) (Cinier et al. 2021a). Additionally, CAR is an inflammatory marker (Header et al. 2022). This highlights the importance of addressing inflammation in the detection and treatment of related heart diseases. Furthermore, it has been reported that a lower prognostic nutritional index (PNI) value predicts all-cause mortality during long-term follow-up in HFrEF patients with secondary ICD implantation (Cinier et al. 2021b). PNI is a simple parameter reflecting a patient's nutritional status, inflammation, and immune status (Shim et al. 2022). This also suggests the significance of considering a patient's inflammatory status and immune status in the detection and treatment of related heart diseases. Moreover, Muammer et al. report that the HALP (hemoglobin, albumin, lymphocyte, and platelet) score may be an important independent predictor of in-hospital mortality in ST-segment elevation myocardial infarction (STEMI) patients undergoing primary percutaneous coronary intervention. The HALP score is a new indicator of nutritional status and systemic inflammation, providing prognostic information (Karakayali et al. 2023). This further emphasizes the importance of monitoring nutritional status and inflammation in related heart diseases.

N-terminus pro-brain natriuretic peptide (NT-proBNP), secreted primarily by the heart, lungs, kidneys, adrenal gland, and also the brain, is a biomarker for predicting functional outcomes from cardiac events (Srisujikul et al. 2023). In the context of valve disease, NT-proBNP is considered a cornerstone of prognosis (Bergler-Klein 2020) and an effective risk stratifier for elderly patients with VHD (Zhang et al. 2020). Changes in NT-proBNP levels are closely related to the functional status of the heart and can reflect alterations in cardiac structure and impaired function at an early stage (Siebers et al. 2024). It has been reported that a member of the heme peroxidase superfamily, myeloperoxidase (MPO) plays a key role in inflammation-induced cardiovascular disease (CVD) at a molecular and cellular level (Ndrepepa 2019). The use of MPO in animal models of CVD has demonstrated favorable outcomes relating to disease progression (Ramachandra et al. 2020). As a reliable and easily accessible marker of immune response to various infectious and non-infectious stimuli, neutrophil–lymphocyte ratio (NLR) is widely used across almost all medical disciplines today. A dynamic change in NLR may indicate the onset of a pathological process several hours before the clinical state appears (Zahorec 2021; Cupido et al. 2022). In patients with acute coronary syndromes, NLR has been shown to be a predictor of cardiac arrhythmias (Afari and Bhat 2016). Furthermore, studies have shown that MPO levels increase after valve replacement surgery, possibly reflecting heightened inflammatory activity (Pan et al. 2023), and NT-proBNP and NLR levels are elevated in valve patients, potentially indicating enhanced inflammatory activity and immune imbalance (Bergler-Klein 2020; Song et al. 2019). That is, NT-proBNP, MPO, and NLR may reflect the pathophysiological changes of VHD and MA in three dimensions: cardiac function, inflammation, and immune status. These three biomarkers possess diagnostic significance for VHD complicated by MA. Therefore, our intention was to determine the predictive value of NT-proBNP, MPO, and NLR in elderly patients with VHD and MA in conjunction with echocardiography.

Materials and methods

Ethics statement

The selected patients signed the informed consent and were approved by the Ethics Committee of Quanzhou First Hospital and followed the tenets of the Declaration of Helsinki.

Participants

The present study was a cross-sectional study. A total of 50 cases of elderly VHD patients who underwent valve replacement in Quanzhou First Hospital from January 2020 to March 2021 were screened as the VHD group. In the same period, 55 cases of those who underwent health checkups were included as the healthy control group, with no obvious abnormalities in chest radiograph, electrocardiogram and ultrasound, and no chronic diseases such as heart disease, diabetes, hypertension, and so on. There were 30 males and 20 females in the VHD group, with a mean age of 62.20 $\pm$9.36 years; 31 males and 24 females in the healthy control group, with a mean age of 63.47 $\pm$9.98 years.

Criteria

Inclusion criteria: patients with typical clinical symptoms, diagnosed with VHD by echocardiography and treated with aortic or mitral valve replacement; patients aged 60 years and older.

Exclusion criteria: patients with rheumatic heart disease or congenital heart valve insufficiency; patients with severe hepatic or renal dysfunction; patients with other major cardiac diseases or malignant arrhythmias preoperatively; patients with incomplete clinical data or lost to follow-up; patients who were unable to cooperate with the treatment due to mental or language disorders; patients with major diseases of the liver, kidneys, lungs and other vital organs, as well as malignant tumors; patients with hematological diseases; patients with chronic inflammatory diseases or autoimmune diseases.

Indicator test

Fasting venous blood (5 mL) was collected early in the morning of the next day after the admission of elderly VHD patients, and 5 mL of fasting venous blood was extracted from the healthy control group on the day of physical examination. The blood was centrifuged at 3000 r/min for 10 min, and the supernatant was extracted and stored at −80 ℃. MPO level was measured by latex-enhanced turbidimetric immunoassay using an MPO kit (Medicalsystem Biotechnology Co., Ltd.) and detected on the BECKMAN5811 instrument. NT-proBNP level was detected by chemiluminescence method using the NT-ProBNP detection kit (Huachn, Henan, China) and Beckman Coulter DXI800 automatic immunoassay analyzer. NLR was detected using an automatic hemocytometer (Myriad BC- 3600). The mean value was taken from two measurements.

Echocardiography

All procedures and measurements were performed by an experienced echocardiographer not involved in the study, using an IE-type echocardiography machine with a 3D ultrasound X4 probe at a frequency of 2–4 MHz. Patients were positioned in the left lateral decubitus position with simultaneous electrocardiogram display. The apical four-chamber and two-chamber views were obtained from the apical window, and left ventricular end-diastolic volume (LVEDV) and left ventricular end-systolic volume (LVESV) were measured using the biplane Simpson's method. Another cardiologist with special experience in valvular disease performed the review and the two needed to reach a consensus.

Follow-up

Regular monthly outpatient and telephone follow-ups were conducted. Outpatient follow-ups involved electrocardiogram monitoring for the occurrence of MA. The incidence of MA during the 1-year follow-up period in the VHD group was recorded, and patients were divided into two subgroups: the MA group (n= 13, all experiencing MA for the first time) and the non-MA group (n= 37). All researchers involved in the follow-up were uniformly trained. MA refers to arrhythmias that cause severe hemodynamic disturbances and endanger life, potentially leading to cardiac arrest, sudden death, or other serious consequences, with a significant decrease in cardiac output and insufficient blood supply to vital organs (brain, heart, kidneys, etc.). Common types of malignant arrhythmias include ventricular tachycardia, ventricular fibrillation, high-degree atrioventricular block, and polymorphic ventricular tachycardia.

Treatment

If MA occur postoperatively, treatment was administered based on the type of arrhythmia, including removing the precipitating factors, using beta-blockers, digitalis, amiodarone, etc.

Statistical analysis

SPSS 25.0 (IBM, NY, USA) and GraphPad Prism 8.0 software (Graph Pad Inc., CA, USA) were useful for statistical analysis. Measurement data were tested for normality using the Kolmogorov–Smirnov method. All data

Table 1 Comparison of general information between the two groups

Data	VHD group ($n = 50$)	Healthy control group ($n = 55$)	*P*
Age	62.20 ± 9.46	63.47 ± 10.08	0.504
Gender			0.706
Male	30 (60.00)	31 (56.36)	
Female	20 (40.00)	24 (43.64)	
BMI (kg/m^2)	22.52 ± 1.46	22.16 ± 1.34	0.187
Hypertension			
Yes	9 (18.00)		
No	41 (82.00)		
Diabetes			
Yes	13 (26.00)		
No	37 (74.00)		
NYHA classification			–
I-II	35 (70.00)	–	
III-IV	15 (30.00)	–	

VHD Valvular Heart Disease, *BMI* Body Mass Index, *NYHA* New York Heart Association

Table 2 Comparison of cardiac function indices between the two groups

	VHD group ($n = 50$)	Healthy control group ($n = 55$)	*P*
LVEDV (mL)	87.54 ± 14.87	75.41 ± 15.25	< 0.001
LVESV (mL)	54.41 ± 9.92	37.15 ± 8.11	< 0.001

VHD Valvular Heart Disease, *LVEDV* Left Ventricular End-Diastolic Volume, *LVESV* Left Ventricular End-Systolic Volume

Table 3 Comparison of MPO, NT-proBNP, and NLR levels between the two groups

	VHD group ($n = 50$)	Healthy control group ($n = 55$)	*P*
MPO (mg/L)	123.10 ± 39.76	86.59 ± 20.62	< 0.001
NT-proBNP (ng/L)	684.58 ± 145.96	49.37 ± 10.49	< 0.001
NLR	5.73 ± 1.72	2.16 ± 0.43	< 0.001

VHD Valvular Heart Disease, *NT-proBNP* N-terminus pro-Brain Natriuretic Peptide, *MPO* Myeloperoxidase, *NLR* Neutrophil–Lymphocyte Ratio

followed a normal distribution and were expressed as ($\overline{x} \pm$ sd). Independent sample t-tests were used for comparisons between groups. Numeration data were described as (n [%]), and chi-square tests were adopted for comparisons of numeration data between groups. Logistic regression was employed to analyze the influencing factors. The diagnostic performance was analyzed adopting the receiver operator characteristic (ROC) curve analysis and compared using the Delong test. $P < 0.05$ was statistically significant.

Results

General information

Age, gender, body mass index (BMI), and NYHA classification were not significantly different between the VHD group and the healthy control group ($P > 0.05$, Table 1).

Cardiac function indices

LVEDV and LVESV in the healthy control group were 75.41 ± 15.25 mL and 37.15 ± 8.11 mL, respectively. LVEDV and LVESV in the VHD group were 87.54 ± 18.42 mL and 51.41 ± 15.66 mL, respectively. LVEDV and LVESV in the VHD group were higher than those of the healthy control group ($P < 0.05$, Table 2).

MPO, NT-proBNP, and NLR levels

MPO, NT-proBNP, and NLR in the healthy control group were 86.59 ± 20.62 mg/L, 49.37 ± 10.49 ng/L, and 2.16 ± 0.43), respectively; and in the VHD group, MPO, NT-proBNP, and NLR were 123.10 ± 39.36 mg/L, 684.58 ± 144.50 ng/L, and 5.73 ± 1.86, respectively. MPO, NT-proBNP, and NLR in the VHD group were higher than those in the healthy control group ($P < 0.05$, Table 3).

Changes in MPO, NT-proBNP, and NLR levels in VHD patients with different disease grade

In the VHD group, there were 35 patients in grades I–II, including 22 males and 13 females, with an average age of 62.40 ± 9.15 years and a BMI of 22.46 ± 1.38 kg/m^2. Six patients had hypertension, and nine had diabetes. There were 15 patients in grades III–IV, including 8 males and 7 females, with an average age of 61.73 ± 10.46 years and a BMI of 22.67 ± 1.68 kg/m^2. Three patients had hypertension, and four had diabetes. There were no statistically significant differences in the general characteristics between the I–II group and III–IV group ($P > 0.05$), allowing for comparability. MPO, NT-proBNP, and NLR were 102.37 ± 23.59 mg/L, 648.68 ± 128.09 ng/L, and 5.35 ± 1.57 in the grade I–II group, respectively; and in the grade III–IV group, MPO, NT-proBNP, and NLR were 171.47 ± 24.49 mg/L, 768.33 ± 154.89 ng/L, and 6.63 ± 1.76, respectively. MPO, NT-proBNP, and NLR were higher in the grade III–IV group than in the grade I–II group ($P < 0.05$, Table 4).

MPO, NT-proBNP, and NLR levels in MA patients

After 1 year of follow-up, 13 patients who experienced malignant arrhythmias were considered as the MA group, including 8 males and 5 females, with an average age of 61.15 ± 10.62 years and a BMI of 22.92 ± 1.50 kg/m^2. Four patients had hypertension, and six had diabetes.

Table 4 Changes in MPO, NT-proBNP, and NLR level in VHD patients

	MPO (mg/L)	NT-proBNP (ng/L)	NLR
I-II grade (n = 35)	102.37 ± 23.59	648.68 ± 128.09	5.35 ± 1.57
III-IV grade (n = 35)	171.47 ± 24.49	768.33 ± 154.89	6.63 ± 1.76
P	< 0.001	0.007	0.014

VHD Valvular Heart Disease, *NT-proBNP* N-terminus pro-brain natriuretic peptide, *MPO* Myeloperoxidase, *NLR* Neutrophil–Lymphocyte Ratio

Table 5 Changes in MPO, NT-proBNP, and NLR Levels in MA patients

	Non-MA group (n = 37)	MA group (n = 13)	P
MPO (mg/L)	108.16 ± 28.41	137.51 ± 35.54	0.003
NT-proBNP (ng/L)	621.49 ± 128.36	772.13 ± 138.72	< 0.001
NLR	5.16 ± 1.23	6.47 ± 1.47	0.002
LVEDV (mL)	80.36 ± 26.45	94.48 ± 20.32	0.082
LVESV (mL)	45.62 ± 13.16	56.94 ± 16.38	0.013

MA Malignant Arrhythmias, *NT-proBNP* N-terminus pro-brain natriuretic peptide, *MPO* Myeloperoxidase, *NLR* Neutrophil–Lymphocyte Ratio, *LVEDV* Left Ventricular End-Diastolic Volume, *LVESV* Left Ventricular End-Systolic Volume

Additionally, a total of 37 patients without arrhythmias were considered as the non-MA group, including 22 males and 15 females, with an average age of 62.57 ± 9.14 years and a BMI of 22.38 ± 1.44 kg/m^2. Five patients had hypertension, and seven had diabetes. There were no statistically significant differences in the general characteristics between the two groups (P > 0.05), allowing for comparability. MPO, NT-proBNP, and NLR in the non-MA group were 108.16 ± 28.41 mg/L, 621.49 ± 128.36 ng/L, and 5.16 ± 1.23, respectively, and LVEDV and LVESV were 80.36 ± 26.45 mL and 45.62 ± 13.16 mL, respectively. MPO, NT-proBNP, and NLR in the MA group were 137.51 ± 35.54 mg/L, 772.13 ± 138.72 ng/L, and 6.47 ± 1.47, respectively, and LVEDV and LVESV were 94.48 ± 20.32 mL and 56.94 ± 16.38 mL, respectively. MPO, NT-proBNP, NLR, and LVESV were higher in the MA group compared to the non-MA group (P < 0.05, Table 5).

Multifactorial logistic regression analysis and ROC curve analysis

Whether MA occurred in elderly patients with VHD was used as the dependent variable (MA = 1, no MA = 0), and MPO, NT-proBNP, and NLR were used as independent variables (all included with actual values) in a multivariate logistic regression analysis model using a stepwise regression method. The results showed that NT-proBNP was an independent factor influencing the occurrence of MA in elderly patients with VHD (P < 0.05, Table 6). ROC curve analysis showed that the area under the curve (AUC) in predicting MA in elderly VHD patients of MPO was 0.759, with a sensitivity of 0.692 and a specificity of 0.811, that of NT-proBNP was 0.782, with a sensitivity of 0.615 and a specificity of 0.946, and that of NLR was 0.736, with a sensitivity of 0.769 and a specificity of 0.649. The AUC for echocardiography was 0.782, with a sensitivity of 0.769 and a specificity of 0.757. The AUC for the combination of these four was 0.913, with a sensitivity of 0.769 and a specificity of 0.946. The Delong test showed that the AUC of the combined diagnosis was greater than that of MPO, NT-proBNP, and NLR alone (Z = 2.140, 1.986, 2.386, P < 0.05) (Table 7; Fig. 1).

Discussion

Structural and functional abnormalities in the valves can profoundly impact cardiac function and the conduction system, resulting in the emergence of severe coexisting conditions like heart failure and arrhythmias (Rees et al. 1988). This trial evaluated the clinical value of combining NT-proBNP, MPO, NLR, and echocardiography for predicting MA in elderly patients with VHD. Our study found that the combination of NT-proBNP, MPO, NLR, and echocardiography has good predictive value for detecting MA in elderly patients with VHD. This study adopts a novel perspective by combining NT-proBNP, MPO, NLR, and echocardiography to predict the risk of MA in elderly patients with VHD. By jointly detecting multiple indicators, doctors can identify high-risk patients earlier and adopt more aggressive treatment measures to improve patient outcomes. This approach is innovative.

Table 6 Multifactor logistic regression analysis

	B	S.E	Wald	Sig	Exp(B)	95% C.I.for EXP(B)	
						Lower	Upper
MPO	0.024	0.016	2.201	0.138	1.024	0.992	1.056
NT-proBNP	0.006	0.003	4.305	0.038	1.006	1	1.011
NLR	0.599	0.392	2.336	0.126	1.821	0.844	3.925

NT-proBNP N-terminus pro-brain natriuretic peptide, *MPO* Myeloperoxidase, *NLR* Neutrophil–Lymphocyte Ratio

Table 7 Results of ROC curve analysis

Test result variable (s)	Area	Std. error	*P*	Asymptotic 95% confidence interval		Sensitivity	Specificity	Cut-off value
				Lower bound	Upper bound			
MPO	0.759	0.092	0.006	0.579	0.938	0.692	0.811	134.59 mg/L
NT-proBNP	0.782	0.078	0.003	0.630	0.934	0.615	0.946	765.57 ng/L
NLR	0.736	0.089	0.012	0.562	0.910	0.769	0.649	5.720
Echocardiography	0.782	0.069	0.003	0.646	0.918	0.769	0.757	
The four combined	0.913	0.047	0.000	0.814	1.000	0.769	0.946	

ROC Receiver Operator Characteristic, *NT-proBNP* N-terminus pro-brain natriuretic peptide, *MPO* Myeloperoxidase, *NLR* Neutrophil–Lymphocyte Ratio

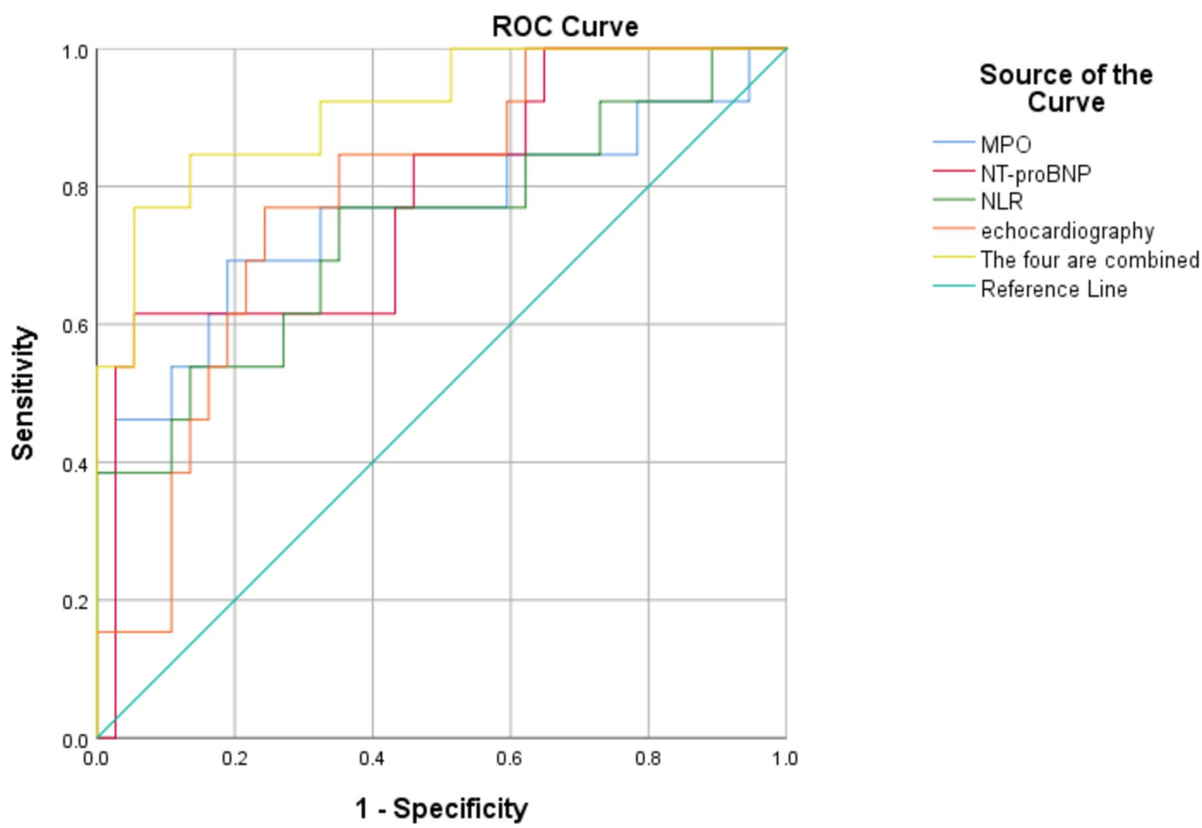

Fig. 1 ROC curves for the combined prediction of MA by NT-proBNP, MPO, NLR, and echocardiography in elderly patients with VHD

It is known that NT-proBNP production in the ventricles increases in cardiac failure and locally as a consequence of myocardial infarction (Panagopoulou et al. 2013). Moreover, a high level of NT-proBNP is associated with abnormal left ventricular dimensions, abnormal left ventricular function, and VHD (Vaes et al. 2010). A relevant paper has determined that NT-proBNP level is higher in patients with heart failure accompanied by MA compared to those without MA (Ozmen et al. 2017). A significant association has been found between NT-proBNP and atrial fibrillation (AF), a common form of MA (Werhahn et al. 2022). Furthermore, NT-proBNP predicts recurrent AF (Staszewsky et al. 2021).

The research of Karakayalı et al. demonstrates that the white blood cell count to mean platelet volume ratio (WMR) can provide supportive data for early risk stratification and optimization methods in STEMI patients. WMR has become an indicator of inflammation in atherosclerotic diseases and plays a crucial role in identifying high-risk patients (Karakayalı et al. 2023). Similarly, as a biomarker reflecting inflammatory and oxidative stress status, chronic activation of MPO may lead to random protein alterations, causing tissue damage and being associated with sudden cardiovascular events. Chronic activation of MPO may result in random protein alterations, leading to tissue damage, and is linked to sudden cardiovascular events (Staszewsky et al. 2021). Increasing evidence has captured the notion that MPO-related atrial remodeling is a physiologic substrate for AF (Liu et al. 2023). It is interestingly observed that patients with future onset AF have increased MPO compared with non-AF patients (Meulendijks et al. 2023), and plasma MPO is independently associated with ventricular arrhythmias including AF at baseline (Mollenhauer et al. 2017; Wang et al. 2023).

Furthermore, a higher rate of recurrence of AF is associated with NLR, a marker of oxidative stress and inflammation (Silva and Borges 2023). A comprehensive meta-analysis has recognized that NLR level, whether baseline or post-surgical/procedure, is associated with the risk of recurrence/occurrence of AF (Shao et al. 2015). Furthermore, NLR is associated with a higher level of myocardial injury markers and arrhythmia events in acute myocardial infarction (Zhang et al. 2023).

The findings of this study further support the aforementioned views. Specifically, our results revealed that MPO, NT-proBNP, and NLR levels were higher in VHD patients compared to the healthy control group. Among VHD patients, levels of MPO, NT-proBNP, and NLR were higher in the NYHA grade III-IV group than in the grade I-II group. This suggests that elevated levels of MPO, NT-proBNP, and NLR may reflect the presence of inflammation, impaired cardiac function, and immune imbalance in VHD patients. As the severity of the disease increases, the levels of these biomarkers also rise accordingly. Importantly, our data indicated that MPO, NT-proBNP, NLR levels, and LVESV were higher in VHD patients who experience MA. This suggests that these indicators have certain value in predicting MA in VHD patients. Furthermore, NT-proBNP was an independent influencing factor for MA in elderly patients with VHD. The AUC of the combined diagnosis using MPO, NT-proBNP, NLR, and echocardiography was greater than that of individual diagnoses. This indicates that the combined diagnosis has higher sensitivity and specificity in predicting MA in VHD patients, allowing for more accurate identification of high-risk patients.

Although MPO, NT-proBNP, NLR, and echocardiography demonstrate certain value in predicting MA, the specific mechanisms of action and interrelationships of these different indicators still require further exploration. For example, the specific pathways of MPO and NLR in VHD, as reflectors of inflammation and immune status, are not fully understood. Additionally, although the combined diagnosis shows advantages in predicting MA, the construction and optimization of the model still need further investigation. Notably, the rapid development of artificial intelligence (AI) and machine learning (ML) technologies in recent years provides new possibilities for this. For example, a study demonstrates the powerful capabilities of ML in analyzing electrocardiogram features. This study not only improved prediction accuracy but also provided more refined evidence for clinical decision-making (Yilmaz et al. 2023). Furthermore, another study used deep learning technology to predict short-term mortality in patients with acute pulmonary embolism, further demonstrating the predictive potential of AI in complex clinical scenarios. These studies not only showcase the broad prospects of AI and ML in medical prediction but also provide ideas and methods for improving current prediction models. Therefore, future research can explore integrating AI and ML technologies into the joint analysis of biomarkers and imaging features such as NT-proBNP, MPO, NLR, and echocardiography to establish more precise and personalized prediction models. Such models can not only improve prediction accuracy but also dynamically adjust based on the specific conditions of patients, providing stronger support for clinical decision-making.

In conclusion, our study shows that the combined use of NT-proBNP, MPO, NLR, and echocardiography has good predictive value for the occurrence of MA in elderly patients with VHD. For elderly patients with VHD, the occurrence of MA is often accompanied by high rates of disability and mortality. Therefore, early and accurate prediction of MA is crucial for guiding clinical treatment and improving prognosis. By combining multiple biomarkers and echocardiographic indicators, this study aims to provide a more effective prediction tool for clinicians to better assess patient risk and develop more personalized treatment plans. However, this study has some limitations. For example, the sample size is small, and the follow-up time is limited, which may not fully reflect the complex situation of MA in elderly patients with VHD. Additionally, this study is a single-center, retrospective study without prospective validation, potentially introducing selection bias. Future research should expand the sample size to improve the generalizability of the results; consider multi-center collaborations to validate the broad applicability of the prediction model; and conduct prospective studies with longer follow-up times to more accurately assess the prognostic value of the prediction model.

Authors' contributions

J.P.L. finished the study design, A.P.Z finished the experimental studies, M.D.Z finished the data analysis, L.W. and P.Z. finished the manuscript editing. All authors read and approved the final version of the manuscript.

Funding

No funds, grants, or other support was received.

Data availability

The experimental data used to support the findings of this study are available from the corresponding author upon request.

Declarations

Ethics approval and consent to participate

The selected patients signed the informed consent and were approved by the Ethics Committee of Quanzhou First Hospital and followed the tenets of the Declaration of Helsinki. Informed consent was obtained from all individual participants included in the study.

Consent for publication

The participant has consented to the submission of the case report to the journal.

Competing interests

The authors declare no competing interests.

Received: 20 February 2025 Accepted: 8 April 2025
Published online: 22 April 2025

References

Afari ME, Bhat T. Neutrophil to lymphocyte ratio (NLR) and cardiovascular diseases: an update. Expert Rev Cardiovasc Ther. 2016;14(5):573–7.1. 21.Afari, M.E. and T. Bhat, Neutrophil to lymphocyte ratio (NLR) and cardiovascular diseases: an update. Expert Rev Cardiovasc Ther, 2016. 14(5): p. 573-7.

Bergler-Klein J. NT-proBNP as a cornerstone for prognosis in valve disease: all we need is blood. J Am Coll Cardiol. 2020;75(14):1673–5.2. 14.Bergler-Klein, J., NT-proBNP as a cornerstone for prognosis in valve disease: all we need is blood. J Am Coll Cardiol, 2020. 75(14): p. 1673-1675.

Chen DQ, Shen XB, Zhang SH, Ye GY, Xu SH. Malignant Arrhythmia with Variants of Desmocollin-2 and Desmoplakin Genes. Int Heart J. 2019;60(5):1196–200.3. 5.Chen, D.Q., X.B. Shen, S.H. Zhang, G.Y. Ye, and S.H. Xu, Malignant Arrhythmia with Variants of Desmocollin-2 and Desmoplakin Genes. Int Heart J, 2019. 60(5): p. 1196-1200.

Cinier G, Hayiroglu MI, Kolak Z, Tezen O, Yumurtas AC, Pay L, et al. The value of C-reactive protein-to-albumin ratio in predicting long-term mortality among HFrEF patients with implantable cardiac defibrillators. Eur J Clin Invest. 2021a;51(8):e13550.

Cinier G, Hayiroglu MI, Pay L, Yumurtas AC, Tezen O, Eren S, et al. Prognostic nutritional index as the predictor of long-term mortality among HFrEF patients with ICD. Pacing Clin Electrophysiol. 2021b;44(3):490–6.

Cupido AJ, Kraaijenhof JM, Burgess S, Asselbergs FW, Hovingh GK, Gill D. Genetically predicted neutrophil-to-lymphocyte ratio and coronary artery disease: evidence from Mendelian Randomization. Circ Genom Precis Med. 2022;15(1): e003553.

da Silva R, Borges LE. Neutrophil-lymphocyte ratio and red blood cell distribution width in patients with atrial fibrillation and rheumatic valve disease. Curr Vasc Pharmacol. 2023;21(6):367–77.

Eleid MF, Nkomo VT, Pislaru SV, Gersh BJ. Valvular Heart Disease: New Concepts in Pathophysiology and Therapeutic Approaches. Annu Rev Med. 2023;74:155–70.

Header DA, Aboelwafa RA, Elkeleny MR, Bedewy ES, Ellakany AI. C-reactive protein/albumin ratio (CAR) as a marker for detecting acute severe ulcerative colitis in Egyptian patients. Rev Gastroenterol Mex (Engl Ed). 2022;87(4):447–54.

Karakayali M, Omar T, Artac I, Ilis D, Arslan A, Altunova M, et al. The prognostic value of HALP score in predicting in-hospital mortality in patients with ST-elevation myocardial infarction undergoing primary percutaneous coronary intervention. Coron Artery Dis. 2023;34(7):483–8.

Karakayalı M, Omar T, Artac I, Rencüzoğulları İ, Karabağ Y, Hamideyin, et al. The white blood cell count to mean platelet volume ratio (WMR) is associated with syntax score in patients with ST-segment elevation myocardial infarction. Kafkas J Med Sci. 2023;13(2):173–8.

Kisling A, Gallagher R. Valvular heart disease. Prim Care. 2024;51(1):95–109.

Liu Y, Yu M, Wu Y, Wu F, Feng X, Zhao H. Myeloperoxidase in the pericardial fluid improves the performance of prediction rules for postoperative atrial fibrillation. J Thorac Cardiovasc Surg. 2023;165(3):1064-1077 e8.

Meulendijks ER, Al-Shama RFM, Kawasaki M, Fabrizi B, Neefs J, Wesselink R, et al. Atrial epicardial adipose tissue abundantly secretes myeloperoxidase and activates atrial fibroblasts in patients with atrial fibrillation. J Transl Med. 2023;21(1):366.

Mollenhauer M, Friedrichs K, Lange M, Gesenberg J, Remane L, Kerkenpass C, et al. Myeloperoxidase mediates postischemic arrhythmogenic ventricular remodeling. Circ Res. 2017;121(1):56–70.

Ndrepepa G. Myeloperoxidase - A bridge linking inflammation and oxidative stress with cardiovascular disease. Clin Chim Acta. 2019;493:36–51.

O'Riordan CE, Trochet P, Steiner M, Fuchs D. Standardisation and future of preclinical echocardiography. Mamm Genome. 2023;34(2):123–55.

Ozmen C, Deniz A, Deveci OS, Cagliyan CE, Celik AI, Yildiz I, et al. Association among tenascin-C and NT-proBNP levels and arrhythmia prevalence in heart failure. Clin Invest Med. 2017;40(6):E219–27.

Pan T, Jiang CY, Zhang HT, Zhang H, Liu C, Mi L, et al. Prognostic value of perioperative change of neutrophil elastase and myeloperoxidase in coronary circulation on perioperative myocardial injury and clinical outcome of patients underwent surgical valve replacement. Zhonghua Xin Xue Guan Bing Za Zhi. 2023;51(4):400–6.

Panagopoulou V, Deftereos S, Kossyvakis C, Raisakis K, Giannopoulos G, Bouras G, et al. NTproBNP: an important biomarker in cardiac diseases. Curr Top Med Chem. 2013;13(2):82–94.

Praz F, Beyersdorf F, Haugaa K, Prendergast B. Valvular heart disease: from mechanisms to management. Lancet. 2024;403(10436):1576–89.

Ramachandra CJA, Ja K, Chua J, Cong S, Shim W, Hausenloy DJ. Myeloperoxidase as a multifaceted target for cardiovascular protection. Antioxid Redox Signal. 2020;32(15):1135–49.

Rees DJ, Jones IM, Handford PA, Walter SJ, Esnouf MP, Smith KJ, et al. The role of beta-hydroxyaspartate and adjacent carboxylate residues in the first EGF domain of human factor IX. EMBO J. 1988;7(7):2053–61.

Roth GA, Mensah GA, Fuster V. The global burden of cardiovascular diseases and risks: a compass for global action. J Am Coll Cardiol. 2020;76(25):2980–1.

Shao Q, Chen K, Rha SW, Lim HE, Li G, Liu T. Usefulness of neutrophil/lymphocyte ratio as a predictor of atrial fibrillation: a meta-analysis. Arch Med Res. 2015;46(3):199–206.

Shim SR, Kim SI, Kim SJ, Cho DS. Prognostic nutritional index as a prognostic factor for renal cell carcinoma: a systematic review and meta-analysis. PLoS ONE. 2022;17(8): e0271821.

Siebers P, Gembruch U, Merz WM, Recker F, Muller A, Strizek B, et al. Fetal NT-proBNP levels and their course in severe anemia during intrauterine treatment. Arch Gynecol Obstet. 2024;309(4):1341–51.

Song J, Zheng Q, Ma X, Zhang Q, Xu Z, Zou C, et al. Predictive roles of neutrophil-to-lymphocyte ratio and C-reactive protein in patients with calcific aortic valve disease. Int Heart J. 2019;60(2):345–51.

Srisujikul P, Thiankhaw K, Tanprawate S, Soontornpun A, Wantaneeyawong C, Teekaput C, et al. Serum NT-proBNP level for predicting functional outcomes after acute ischemic stroke. Sci Rep. 2023;13(1):13903.

Staszewsky L, Meessen J, Novelli D, Wienhues-Thelen UH, Disertori M, Maggioni AP, et al. Total NT-proBNP, a novel biomarker related to recurrent atrial fibrillation. BMC Cardiovasc Disord. 2021;21(1):553.

Vaes B, Delgado V, Bax J, Degryse J, Westendorp RG, Gussekloo J. Diagnostic accuracy of plasma NT-proBNP levels for excluding cardiac abnormalities in the very elderly. BMC Geriatr. 2010;10:85.

Wang LW, Kesteven SH, Huttner IG, Feneley MP, Fatkin D. High-frequency echocardiography - transformative clinical and research applications in humans, mice, and zebrafish. Circ J. 2018;82(3):620–8.

Wang Y, Jia Y, Xu Q, Wang R, Sun L, Guo D, et al. Association between myeloperoxidase and the risks of ischemic stroke, heart failure, and atrial fibrillation: A Mendelian randomization study. Nutr Metab Cardiovasc Dis. 2023;33(1):210–8.

Werhahn SM, Becker C, Mende M, Haarmann H, Nolte K, Laufs U, et al. NT-proBNP as a marker for atrial fibrillation and heart failure in four observational outpatient trials. ESC Heart Fail. 2022;9(1):100–9.
Yilmaz A, Hayiroglu MI, Salturk S, Pay L, Demircali AA, Coskun C, et al. Machine learning approach on high risk treadmill exercise test to predict obstructive coronary artery disease by using P, QRS, and T waves' features. Curr Probl Cardiol. 2023;48(2): 101482.
Zahorec R. Neutrophil-to-lymphocyte ratio, past, present and future perspectives. Bratisl Lek Listy. 2021;122(7):474–88.
Zhang B, Xu H, Zhang H, Liu Q, Ye Y, Hao J, et al. Prognostic value of N-terminal pro-B-type natriuretic peptide in elderly patients with valvular heart disease. J Am Coll Cardiol. 2020;75(14):1659–72.
Zhang JL, Yang R, Zhu Y, Shao Y, Ji Y, Wang FF. Association between the neutrophil-to-lymphocyte ratio and risk of in-hospital heart failure and arrhythmia in patients with acute myocardial infarction. Front Cardiovasc Med. 2023;10:1275713.

Publisher's Note