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Original Article

Does the Geriatric Nutritional Risk Index Play a Predictive Role in Postoperative Atrial Fibrillation and Outcomes in Cardiac Surgery?

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Objectives: Malnutrition is associated with adverse surgical outcomes. The Geriatric Nutritional Risk Index, a nutritional screening tool, could be a predictor of postoperative atrial fibrillation and outcomes in cardiac surgery.
Design: The authors enrolled 292 patients who underwent cardiac surgery and showed postoperative atrial fibrillation during hospitalization, and assessed mortality and readmission during a 90-day follow-up period.
Setting: A large academic hospital in China.
Participants: Participants were divided into low-risk (Geriatric Nutritional Risk Index <98) and no-risk malnutrition groups (Geriatric Nutritional Risk Index ≥98).
Interventions: Univariate and multivariate logistic regression analyses were used to validate the role of the Geriatric Nutritional Risk Index in predicting postoperative atrial fibrillation. Kaplan−Meier analysis was used to examine the effect of Geriatric Nutritional Risk Index scores on mortality and readmission after cardiac surgery.
Measurements and Main Results: A total of 136 patients were in the low-risk malnutrition group. Postoperative atrial fibrillation was more common in the low-risk group (63.2% *v* 28.8%, $p < 0.001$). Duration of intensive care unit stays and hospitalization were significantly longer than in the no-risk group (44 [43] *v* 39 [47] hours, $p < 0.001$; 18 [7] *v* 15 [6] days, $p < 0.001$). Multivariate analysis showed that Geriatric Nutritional Risk Index, age, and NYHA class independently predicted postoperative atrial fibrillation. Kaplan−Meier analysis showed that 90-day all-cause readmission, but not 90-day all-cause mortality, was different between groups based on the Geriatric Nutritional Risk Index (log-rank $p < 0.001$, log-rank $p = 0.09$).
Conclusions: The easily accessible Geriatric Nutritional Risk Index used for nutritional assessment before cardiac surgery has a predictive role in postoperative atrial fibrillation, and is related to short-term readmission.

Key Words: geriatric nutritional risk index; postoperative atrial fibrillation; surgical outcomes; cardiac surgery; malnutrition; nutritional status

POSTOPERATIVE ATRIAL fibrillation (POAF) is the most common complication after cardiac surgery. The overall incidence of POAF is about 20%-to-65%,[1,2] which varies according to the type of cardiac surgery, definition of atrial fibrillation, and duration of monitoring. Due to atrial fibrillation, the heart loses its normal rhythm, resulting in ventricular underfilling and hemodynamic disturbances, thus increasing the risks of thrombosis and embolism, heart failure, and myocardial ischemia.[3] Accordingly, POAF can cause increased risks of stroke and death, average hospital stay, and hospital fees.[4,5] Although some attempts have been made to reduce the

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incidence of POAF, including pharmacologic prevention and operative changes, the incidence of POAF remains around 30%.[6] To reduce the incidence of POAF, a sound preoperative evaluation to identify risk factors to predict the occurrence of POAF is necessary.

Preoperative malnutrition is also prevalent in hospitalized patients; nearly a third of inpatients have malnutrition or are at risk of malnutrition at admission.[7,8] Chronic malnutrition and high risk of malnutrition have been associated with prolonged intensive care unit (ICU) and hospital stays, adverse postoperative complications, and mortality after cardiac surgery.[9-12] Several routine nutritional screening tools are available in clinical practice, ranging from simple measurements, such as weight loss and body mass index, to complex tools, such as the Malnutrition Universal Screening Tool, Nutritional Risk Screening 2002, and the Short Nutritional Assessment Questionnaire.[13-15] However, these nutritional screening tools were not originally developed specifically for cardiac surgery patients and have not demonstrated good sensitivity and specificity.

Since the concept of the Geriatric Nutritional Risk Index (GNRI) was first introduced by Olivier Bouillanne and his colleagues,[16] GNRI has proven its reliability and stability as a simple and easily accessible nutritional assessment tool for elderly patients with heart failure, hemodialysis, or malignancies.[17-20] However, limited studies have investigated the independently predictive value of the GNRI in patients who have undergone cardiac surgery.[21,22] In this study, the authors aimed to evaluate the utility of the GNRI as a preoperative nutritional status assessment before adult cardiac surgery. The authors hypothesized that patients undergoing cardiac surgery with a low-score GNRI would have a higher incidence of POAF and a worse clinical prognosis than those with a high-score GNRI.

Methods

Study Population and Definition

This was a cohort study conducted between January and December 2020. It was approved by the Ethics Committee, and informed consent was waived due to the retrospective nature of the study. The authors enrolled patients older than 18, and who had undergone elective cardiac surgery, including isolated coronary artery bypass grafting (CABG), isolated valve surgery (aortic, mitral, tricuspid), combined surgery, or CABG/valve surgery combined with other surgeries (eg, lobectomy, atrial septal repair, or myxoma). Exclusion criteria were (1) history of atrial fibrillation; (2) terminal illness (life expectancy of no more than 3 months); (3) history of emergency surgery; and (4) death during hospitalization. The authors first included 455 patients and then excluded 50 patients with emergency surgery, 59 with previous atrial fibrillation, 23 younger than 18, and 31 with malignancy. Finally, 292 patients participated in the study.

The hospital's computerized medical record system collected the demographic characteristics, preoperative examination results, procedure information, and clinical outcomes for the 292 eligible patients. The follow-up period was 90 days after discharge from the hospital, via outpatient records and telephone, with death or readmission within 90 days considered as the endpoint of follow-up.

POAF was determined based on the documentation of continuous telemetry, 12-lead electrocardiogram, or Holter monitoring of atrial fibrillation (AF) episodes (duration $\geq$30 seconds) during hospitalization.

Evaluation of the Nutritional Status

The preoperative nutritional status was evaluated using GNRI within 48 hours of admission. GNRI was calculated using the following formula: GNRI = [1.489 $\times$ albumin (g/dL)] + [41.7 $\times$ body weight (kg)/ideal body weight (kg)]. The ideal body weight (kg) for men was calculated as: height (cm) − 100 − [(height (cm) − 150)/4]. For women it was calculated as: height (cm) − 100 − [(height (cm) − 150)/2.5].[16] According to previously described cutoffs for GNRI,[16,23-25] the patients were stratified into 2 groups according to malnutrition risk as: no-risk (GNRI $\geq$98) and low-risk (GNRI <98) groups.

Statistical Analysis

Normally distributed continuous variables were presented as means and standard deviations, and non-normally distributed data were presented as medians with interquartile ranges (IQR). Normally distributed data was analyzed using the Kolmogorov−Smirnov test. The Student's t test was used to analyze normally distributed data, and the Mann−Whitney U test was used to analyze non-normally distributed data. Categorical data were described as frequencies (percentages) and analyzed using the Pearson's Chi-squared test. The potential risk factors of POAF initially were identified by univariate logistic regression analysis. To validate that these factors had independent effects, significant univariate correlates were then added to the multivariate logistic regression. The 90-day all-cause mortality and 90-day all-cause readmission were calculated using the Kaplan−Meier analysis with the log-rank test over time. All statistical analyses were performed using SPSS software (version 26.0; SPSS Inc., Chicago, IL). Statistical significance was defined as a two-sided p value of < 0.05.

Results

Baseline Characteristics of the 2 Groups of Patients

Table 1 summarizes the patients' baseline characteristics. The 292 participants were separated into 2 groups according to GNRI: no-risk (GNRI $\geq$98, n = 156) and low-risk (GNRI < 98, n = 136). The mean age was 59.77 $\pm$ 13.03 years, and 64% of the participants were men. Patients in the low-risk group were older ($p < 0.001$) and had lower body mass indexes ($p < 0.001$) than those in the no-risk group. The 2 groups had different NYHA classes (I-II: 37.5% *v* 60.9%, III-IV: 62.5% *v* 39.1%, respectively).

Table 1
Baseline Characteristics of Patients

Variable	Total (N = 292)	GNRI		p Value
		Low Risk <98 (n = 136)	No Risk ≥98 (n = 156)	
Age (y)	59.77 ± 13.03	62.21 ± 12.70	57.29 ± 12.85	<0.001
Male, n (%)	187 (64.0)	92 (67.6)	95 (60.9)	0.230
BMI (kg/m^2)	23.33 ± 2.98	21.37 ± 2.07	25.04 ± 2.57	<0.001
Smoking, n (%)	59 (20.2)	28 (20.6)	31 (19.9)	0.880
Comorbidities, n (%)				
Hypertension	143 (49.0)	62 (45.6)	81 (51.9)	0.280
Diabetes mellitus	39 (13.4)	20 (14.7)	19 (12.2)	0.530
Heart failure	79 (27.1)	43 (31.6)	36 (23.1)	0.100
COPD	3 (1.0)	2 (1.5)	1 (0.6)	0.910
Drugs, n (%)				
ACEI/ARB	69 (23.6)	34 (25.0)	35 (22.4)	0.610
Calcium channel blocker	55 (18.8)	22 (16.2)	33 (21.2)	0.280
Beta-blocker	46 (15.8)	24 (18.2)	22 (14.1)	0.410
Diuretic	77 (26.3)	40 (29.4)	37 (23.7)	0.270
Statin	30 (10.3)	14 (10.3)	16 (10.3)	0.990
GNRI	98.77 ± 8.29	91.88 ± 4.69	104.78 ± 5.65	<0.001
Previous cardiac surgery, n (%)	40 (13.7)	19 (14.0)	21 (13.5)	0.900
NYHA class, n (%)				
I-II	146 (50.0)	51 (37.5)	95 (60.9)	<0.001
III-IV	146 (50.0)	85 (62.5)	61 (39.1)	<0.001
Preoperative laboratory test				
Creatinine (umol/L)	77.85 (23.10)	80.35 (24.50)	76.95 (21.3)	0.120
eGFR (mL/min/1.73m^2)	90.78 ± 22.87	88.66 ± 23.52	92.64 ± 22.21	0.590
Serum potassium (mmol/L)	3.89 ± 0.41	3.98 ± 0.44	3.82 ± 0.37	0.020
Serum sodium (mmol/L)	140.95 ± 3.86	140.32 ± 5.09	141.50 ± 2.20	0.010
Serum magnesium (mmol/L)	0.88 ± 0.13	0.89 ± 0.16	0.88 ± 0.09	0.140
White blood cell count ($\times 10^{12}$/L)	6.14 ± 1.87	6.22 ± 2.21	6.07 ± 1.52	0.001
Lymphocyte count ($\times 10^9$/L)	1.65 ± 0.59	1.52 ± 0.61	1.76 ± 0.56	0.001
Red blood cell count ($\times 10^{12}$/L)	4.32 ± 0.54	4.23 ± 0.54	4.41 ± 0.52	0.005
Hemoglobin (g/L)	130.58 ± 17.30	127.23 ± 17.76	133.49 ± 16.39	0.298
Platelets count ($\times 10^9$/L)	195.02 ± 57.39	184.96 ± 61.02	203.79 ± 52.67	0.005
Echocardiography				
LAD (mm)	41.15 ± 7.43	42.11 ± 8.09	40.31 ± 6.73	0.041
LVEF (%)	62.00 (12.00)	60.50 (12.00)	63.00 (9.00)	0.002
LVIDd (mm)	54.53 ± 9.68	55.17 ± 10.59	53.98 ± 8.81	0.302
LVIDs (mm)	36.84 ± 8.63	37.95 ± 9.42	35.88 ± 7.79	0.043
Type of procedure, n (%)				
CABG	58 (19.9)	27 (19.9)	31 (19.9)	0.871
Aortic valve procedure	63 (21.6)	25 (18.4)	38 (24.4)	0.216
Mitral valve procedure	60 (20.5)	24 (17.6)	36 (23.1)	0.252
Tricuspid valve procedure	2 (1.0)	1 (1.0)	1 (1.0)	1.000
Double valve procedure	43 (14.7)	27 (19.9)	16 (10.3)	0.218
CABG + Valve	23 (7.9)	11 (8.1)	12 (7.7)	0.900
Aortic valve procedure + others*	39 (13.4)	18 (13.2)	21 (13.5)	0.955
Mitral valve procedure + others	4 (1.4)	3 (2.2)	1 (1.0)	0.520
CPB time (min)	144.88 ± 56.40	146.27 ± 48.93	143.69 ± 62.25	0.696
Cross-clamp time (min)	96.50 (52.00)	104.00 (59.00)	93.00 (50.00)	0.161
Operation time (min)	295.43 ± 72.86	297.17 ± 60.64	293.91 ± 82.22	0.698

Abbreviations: ACEI, angiotensin-converting enzyme inhibitor; ARB, angiotensin-receptor blocker; BMI, body mass index; CABG, coronary artery bypass surgery; COPD, chronic obstructive pulmonary disease; CPB, cardiopulmonary bypass; eGFR, estimated glomerular filtration rate; GNRI, Geriatric Nutritional Risk Index; LAD, left atrial diameter; LVEF, left ventricular ejection fraction; LVIDd, left ventricular internal diameter diastolic; LVIDs, left ventricular internal diameter systolic.

* Lobectomy, atrial septal repair, or myxoma operation.

Patients in the low-risk group had higher levels of serum potassium, white blood cell count, left atrial diameter (LAD), and left ventricular internal diameter systolic than those in the no-risk group ($p < 0.05$). Patients in the low-risk group had lower serum sodium levels, lymphocyte count, red blood cell count, platelet count, lymphocyte and red blood cell counts, and left ventricular ejection fraction than those in the no-risk group ($p < 0.05$). However, the type of procedure,

Table 2
POAF and Outcome

Variable	Total (N = 292)	GNRI		p Value
		Low Risk <98 (n = 136)	No Risk ≥98 (n = 156)	
POAF, n (%)	131 (44.9)	86 (63.2)	45 (28.8)	<0.001
Duration of ICU stays (h)	42.5 (45.0)	44.0 (43.0)	39.0 (47.0)	<0.001
Hospitalization period (d)	16.0 (6.0)	18.0 (7.0)	15.0 (6.0)	<0.001
90-day all-cause mortality, n (%)	3 (1.0)	3 (1.0)	0 (0)	<0.001
90-day all-cause readmission, n (%)	40 (13.7)	31 (22.8)	9 (5.8)	<0.001
Infection, n (%)				
Incision infection	7 (2.4)	6 (4.4)	1 (0)	0.086
Pneumonia	8 (2.7)	6 (4.4)	2 (1.3)	0.202
Heart failure	6 (2.1)	4 (2.9)	2 (1.3)	0.560
Pleural/pericardial effusion	4 (1.4)	3 (2.2)	1 (0)	0.520
Acute kidney injury	3 (1.0)	3 (2.2)	0 (0)	0.200
Bleeding	5 (1.7)	4 (2.9)	1 (0)	0.290
Stroke	7 (2.4)	5 (3.7)	2 (1.3)	0.342

Abbreviations: ICU, intensive care units; POAF, postoperative atrial fibrillation.

cardiopulmonary bypass time, aortic cross-clamp time, and surgery time were not different between the groups.

POAF and Outcome

As shown in Table 2, 131 patients developed POAF during hospitalization (overall incidence of approximately 40%), 86 (63.2%) in the low-risk group, and 45 (28.8%) in the no-risk group. The incidence of POAF was significantly different between the 2 GNRI groups ($p < 0.001$). Median (IQR) duration of ICU stays and hospitalization period were 44 hours (43) and 18 days (7), respectively, for participants in the low-risk group. This was significantly longer than those for participants in the no-risk group ($p < 0.001$).

The 90-day all-cause mortality was 1.0% (n = 3) in both groups. Causes of death included acute myocardial infarction (n = 1) and acute kidney injury (n = 2); all deaths occurred in the low-risk group. At the 90-day follow-up, about 14% of patients were readmitted for infections (incision infection/pneumonia), heart failure, pleural effusion/pericardial effusion that required drainage, acute kidney injury, bleeding, or stroke. The reasons for readmission were not statistically different between the 2 groups. However, the overall 90-day all-cause readmission was higher in the low-risk group than in the no-risk group ($p < 0.001$). Kaplan−Meier analysis showed that the 90-day all-cause readmission was significantly different between the groups based on GNRI; however, this was not true for the 90-day all-cause mortality (Figs. 1 and 2).

Risk Factors of POAF

The potential risk factors of POAF were initially identified by univariate logistic regression analysis. As shown in Table 3, age, serum potassium levels, LAD, NYHA class, hospitalization period and GNRI were significantly associated with POAF (all $p < 0.05$). Multivariate logistic regression analysis, which included age, serum potassium level, LAD, hospitalization period, NYHA class, and GNRI, showed that only age (adjusted odds ratio [OR], 1.03; 95% confidence interval [CI] 1.02-1.07; p = 0.010), hospitalization period (adjusted OR, 1.10; 95% CI 1.04-1.15; $p < 0.001$), NYHA class (adjusted OR, 2.54; 95% CI 1.44-4.49; p = 0.001, *v* NYHA class I-II), and GNRI (adjusted OR, 2.78; 95% CI 1.61-4.82; $p < 0.001$, *v* GNRI ≥98) independently predicted POAF.

Discussion

In this study, the authors investigated the relationship between preoperative nutrition evaluated by GNRI in POAF and outcome after cardiac surgery. The authors found that GNRI was considered to have a predictive role in POAF and was associated with an increase in the 90-day all-cause readmission rate.

Malnutrition is common in hospitalized patients and is characterized by a decline in physical function caused by insufficient body intake, resulting in changes in body composition (decreased fat-free mass) and cell mass.[26] Recent data from

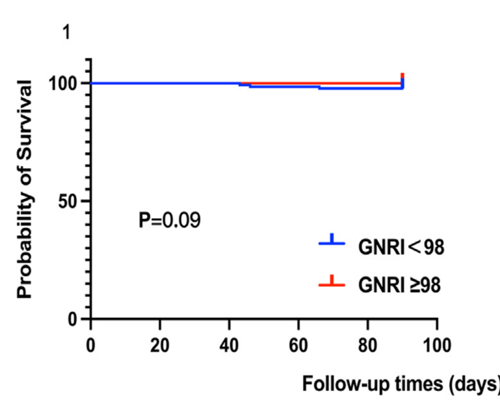

Fig 1. Kaplan-Meier analysis for 90-day all-cause mortality. GNRI, Geriatric Nutritional Risk Index.

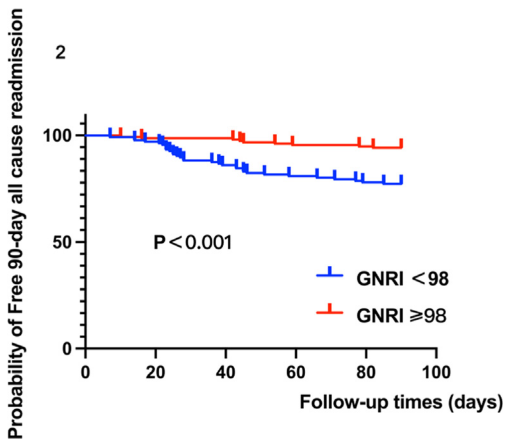

Fig 2. Kaplan-Meier analysis for 90-day all-cause readmission; p > 0.05 was considered statistically significant. GNRI, Geriatric Nutritional Risk Index.

the United States of America and Europe[7,8] showed that nearly one-third of inpatients have malnutrition or are at risk of malnutrition at admission, and nearly half of cardiac surgery patients were malnourished preoperatively.[27] Because of the prevalence of malnutrition and its influence on the length of ICU/hospital stay, mortality rate, readmission rate, and hospitalization costs of patients, early detection and initiation of nutritional intervention are important.

The GNRI is a widely accepted and easily accessible nutritional assessment tool for the geriatric patient.[16,28] Using the formula to calculate GNRI through serum albumin, actual body weight, and ideal body weight index is very simple and easy in clinical practice. There are also many studies on the relationship between GNRI and cardiovascular diseases. Some studies[23,24,29] have reported that lower GNRI was associated independently with midterm and long-term mortality in patients undergoing transcatheter aortic valve replacement and surgical aortic valve replacement. Therefore, the authors chose the GNRI for nutritional screening before cardiac surgery. Although several studies[30,31] investigated the prognosis after cardiac surgery using different nutritional assessment methods (including GNRI), to the best of the authors' knowledge, this was the first study to illustrate the predictive role of GNRI in the development of POAF in patients after cardiac surgery.

POAF is a common complication after cardiac surgery, associated with increased risk of all-cause mortality and associated comorbidities, such as ischemic stroke and heart failure. The incidence of POAF after cardiac surgery has been reported to be approximately 20%-to-65%.[1,2] In this study, POAF occurred in 44.9% of patients. This result agreed with those previously reported. The association between malnutrition and POAF is unclear. However, studies on malnutrition and transcatheter radiofrequency ablation of AF have found that preoperative

Table 3
Risk factors of POAF as Determined by Univariate and Multivariate Logistic Regression Analyses

Variable	Univariate		Multivariate	
	OR (95% CI)	p Value	OR (95% CI)	p Value
Age (y)	1.05 (1.03-1.07)	<0.001	1.03 (1.02-1.07)	0.010
Sex (male)	0.79 (0.49-1.28)	0.340		
Hypertension	1.11 (0.70-1.76)	0.664		
Diabetes mellitus	0.74 (0.38-1.46)	0.388		
Previous cardiac surgery	0.62 (0.32-1.22)	0.168		
Serum potassium (mmol/L)	2.33 (1.29-4.20)	0.005	1.79 (0.91-3.56)	0.094
LAD (mm)	1.05 (1.02-1.08)	0.005	1.04 (1.00-1.08)	0.750
LVIDd (mm)	1.00 (0.98-1.03)	0.942		
LVIDs (mm)	1.02 (0.99-1.05)	0.163		
Operation time (min)	1.00 (0.99-1.00)	0.504		
CPB time (min)	1.00 (0.99-1.02)	0.777		
Cross-clamp time (min)	1.00 (0.99-1.01)	0.662		
Type of procedure, n (%)				
CABG	Reference	Reference		
Aortic valve procedure	0.66 (0.32-1.37)	0.263		
Mitral valve procedure	0.77 (0.37-1.59)	0.473		
Tricuspid valve procedure	1.15 (0.07-19.25)	0.923		
Double valve procedure	1.45 (0.66-3.20)	0.358		
CABG + valve	1.05(0.40-2.77)	0.917		
Aortic valve procedure + others*	1.09 (0.48-2.46)	0.834		
Mitral valve procedure + others	1.15 (0.15-8.71)	0.894		
Hospitalization period (d)	1.13 (1.08-1.19)	<0.001	1.10 (1.04-1.15)	<0.001
Higher NYHA class (I-II *v* III-IV)	4.39 (2.68-7.19)	<0.001	2.54 (1.44-4.49)	0.001
GNRI	0.93 (0.90-0.96)	<0.001	0.96 (0.92-0.99)	0.012
Lower GNRI (<98 *v* ≥98)	4.24 (2.60-6.94)	<0.001	2.78 (1.61-4.82)	<0.001

Abbreviations: CABG, coronary artery bypass surgery; CI, confidence interval; CPB, cardiopulmonary bypass; GNRI, Geriatric Nutritional Risk Index; LAD, left atrial diameter; LVIDd, left ventricular internal diameter diastolic; LVIDs, left ventricular internal diameter systolic; OR, odds ratio; POAF, postoperative atrial fibrillation.

* Lobectomy, atrial septal repair, or myxoma operation.

malnutrition affects the recurrence of atrial fibrillation. Kaneko et al.[32] assessed the nutrition status using GNRI of 538 patients with atrial fibrillation who underwent catheter ablation, and found that malnutrition was an independent risk factor for AF recurrence. Until recently, the data regarding the association between GNRI and POAF after cardiac surgery have been lacking. In the present study, GNRI was an independent predictor of POAF. The results also suggested that lower GNRI might affect early postoperative clinical outcomes (90-day all-cause readmission). Ninety-day all-cause mortality was not significantly different between the low-risk and non-risk groups for malnutrition; this discrepancy with the results of previous studies may have been due to the small sample size and short follow-up.

Advanced age has been recognized as a risk factor for AF. With aging, atrial cellular fibrosis and collagen deposition increase, thus altering the atrial electrophysiologic structure. This process is fundamental and makes POAF possible when exposed to external stimuli, such as interventional procedures.[33] The authors found that poor cardiac function is also a risk factor for the development of POAF. In a large retrospective study of 5,588 patients in the United Kingdom, Cole et al.[34] concluded that New York Heart Association class ≥III was associated with POAF. This observation was consistent with the authors' results.

AF and heart failure share common pathophysiologic mechanisms, and the interaction between them exacerbates the development of both AF and heart failure. Pre-existing heart failure may contribute to the development of AF through mechanisms such as the renin-angiotensin system, calcium handling, and profibrotic and proinflammatory pathways, thus promoting electrical and structural remodeling.[35]

It is unclear whether their poor nutritional status accelerates POAF occurrence or if manipulation during cardiac interventional procedures is responsible for POAF development. In conclusion, assessment of patients' nutritional status and prompt nutritional support may be a good periprocedural strategy to diminish the risk of POAF and improve outcomes.

Limitations

First, this was a single institutional retrospective study with a small sample size (292 patients), which may not be representative. Therefore, a multicenter and prospective randomized controlled trial with a large sample size is required for further validation. Second, the authors only investigated the relationship between the nutritional status and POAF and did not further investigate the outcome after nutritional improvement. In future studies, this relationship should be investigated after the nutritional status has improved, with a larger sample from multiple centers. Finally, intraoperative data that may affect outcomes were not collected in this study because of the limited availability of resources.

Conclusion

The easily accessible GNRI used for preoperative nutritional assessment before cardiac surgery can predict the incidence POAF and is related to short-term readmission rates.

Conflict of Interest

None.

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