

Prognostic value of Mini Nutritional Assessment—Short Form with aortic valve stenosis following transcatheter aortic valve implantation

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Abstract

Aims Older adults at risk for malnutrition are known to have a high mortality rate. This study aimed to investigate whether the Mini Nutritional Assessment—Short Form (MNA-SF) could predict midterm mortality in patients undergoing transcatheter aortic valve implantation (TAVI).

Methods and results We applied the MNA-SF in 288 patients who had undergone TAVI from January 2016 to June 2019 at the St. Marianna University School of Medicine hospital. Using the MNA-SF cut-off value to indicate the risk of malnutrition, patients were divided into two groups, namely, those with an MNA-SF score ≤ 11 (impaired MNA-SF group) and those with an MNA-SF score ≥ 12 (maintained MNA-SF group). We used this value to investigate the association between the MNA-SF and all-cause mortality. Overall, 188 (65%) and 100 (35%) patients comprised the impaired MNA-SF and maintained MNA-SF groups, respectively, and 41 patients died after TAVI (mean follow-up duration, 458 ± 315 days). Kaplan–Meier analyses showed that patients in the impaired MNA-SF group had a significantly higher incidence of all-cause mortality (hazard ratio 2.67; 95% confidence interval 1.29–6.21; $P = 0.01$). Multivariate Cox regression analyses showed that the MNA-SF score was an independent predictor of all-cause mortality after adjusting for the Society of Thoracic Surgeons risk score, Katz Index, and brain natriuretic peptide test results (hazard ratio 1.14; 95% confidence interval 1.01–1.28; $P = 0.04$).

Conclusions The MNA-SF was useful to screen for the risk of malnutrition in patients with TAVI and in predicting midterm prognoses in patients undergoing TAVI and could predict patient mortality after the procedure.

Keywords Mini Nutritional Assessment—Short Form; Transcatheter aortic valve implantation; Malnutrition; Mortality

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Introduction

In line with the increasing use of minimally invasive treatment due to advances in medical technology, transcatheter aortic valve implantation (TAVI) has been developed as a new catheter-based treatment for severe aortic valve stenosis (AS) that mainly affects high-risk older adults.¹ Before undergoing TAVI, a patient's perioperative risk score is calculated using a conventional surgical risk model, such as the Society of Thoracic Surgeons (STS) risk score.^{2,3} However,

the STS score does not include a nutritional assessment, which may be helpful when assessing various patient characteristics. Malnutrition has previously been reported to be associated with cardiovascular disease⁴; therefore, a preoperative nutritional assessment could predict unfavourable outcomes and identify malnourishment and may eventually contribute to an improved prognosis.

Previous studies have reported the usefulness of objective nutritional indices in patients with TAVI, such as identifying the controlling nutritional status (CONUT) and the geriatric

nutritional risk index (GNRI) in a short follow-up period.^{5,6} The Mini Nutritional Assessment—Short Form (MNA-SF) has been found to be a simple screening tool for malnutrition in older patients^{7,8} and may have superior classification performance in identifying malnutrition compared with GNRI and CONUT.⁹ Recently, the European Society for Clinical Nutrition and Metabolism guidelines recommended using the MNA-SF as a screening tool to assess the risk of malnutrition.¹⁰ However, it is not known whether the MNA-SF is a prognostic marker for patients undergoing TAVI. We hypothesized that nutritional status, assessed using the MNA-SF, would be a prognostic marker in patients undergoing TAVI.

To our knowledge, there are no previous data available on the prognostic value of the MNA-SF in a specific TAVI cohort. Therefore, we aimed to address this research gap through investigating the clinical effects of the MNA-SF on the prognosis of patients undergoing TAVI.

Methods

Study design

We retrospectively evaluated 360 consecutive patients with severe AS who had undergone TAVI between January 2016 and June 2019 at St. Marianna University School of Medicine hospital. After excluding 72 patients (65 patients declined an MNA-SF evaluation, and seven patients underwent emergency TAVI), we included 288 patients scheduled for TAVI in our study. The MNA-SF was administered preoperatively to these patients over a 4 day period.

The STS risk score, which is a conventional surgical risk model for predicting the risk of mortality, was calculated for each patient. A multidisciplinary cardiac team, including cardiothoracic surgeons, anaesthesiologists, interventional cardiologists, and echocardiography cardiologists, selected the valve type and decided on the other procedural strategies. TAVI was performed in a hybrid operating room under general anaesthesia. Clinical, laboratory, and echocardiographic data, as well as patient characteristics and procedural variables, were examined. Baseline characteristics, procedural outcomes, and cumulative mortality rates were compared between two MNA-SF groups. In laboratory data, brain natriuretic peptide (BNP) levels were adjusted by one-sixth of the N-terminal pro-BNP level in patients who did not have BNP data.¹¹ The Katz Index was used to assess and record basic activities of daily living and functional status.¹² Information concerning the success of the device was obtained from Valve Academic Research Consortium-2 criteria.

This study was approved by the Human Investigation Committee of St. Marianna University School of Medicine (Study Protocol No. 4499).

Outcomes

The primary outcome was an all-cause mortality rate that was determined through assessing electronic medical records, maintaining telephone contact with patients and their next of kin, and linking the obtained information with administrative data sources.

Evaluation of Mini Nutritional Assessment—Short Form (nutritional screening)

Prior to the TAVI procedure, a trained research assistant administered the MNA-SF according to its standardized protocol. The MNA-SF comprises simple measurements and six questions. Information on anthropometric measurements (body mass index and weight loss), global assessment (mobility), dietary questions, and subjective factors (food intake, neuropsychological issues, and acute disease) was collected in this survey. A total score of <8, 8–11, and >11 indicated malnutrition, at risk of malnutrition, and no malnutrition, respectively. Patients were divided into two groups, namely, a group with an MNA-SF score ≤ 11 (impaired MNA-SF group) and a group with an MNA-SF score ≥ 12 (maintained MNA-SF group), according to a previous study.¹³

Statistical analysis

Categorical data were presented as counts and percentages. The normality of distribution for continuous variables was evaluated using a Shapiro–Wilk test. An independent sample *t*-test was used for comparison. Quantitative variables of the impaired MNA-SF and maintained MNA-SF groups were expressed as average values with standard deviations, whereas qualitative variables were expressed as numbers with percentages. A Mann–Whitney *U* test was used to analyse the quantitative variables, and Fisher's exact test was used for the qualitative variables. A two-sided value of $P < 0.05$ was considered statistically significant. Univariate and multivariate Cox regression analyses were performed to obtain hazard ratios (HRs) and 95% confidence intervals (CIs) for all-cause mortality rates during the follow-up period. Survival variables were compared using a log-rank test, and Kaplan–Meier survival curves were constructed to represent the same. Receiver operating characteristic (ROC) analyses were generated to investigate the prognostic accuracy of the MNA-SF and the Katz Index for all-cause mortality. Youden's index was used with the ROC analysis to determine an optimal cut-off of the score.^{14,15} Statistical analyses were performed using JMP Pro 14 software (SAS Institute Inc., Cary, NC, USA) for Windows.

Results

The mean follow-up duration in our study was 458 ± 315 days. The mean age of the patients was 83.5 ± 5.7 years, and 67%

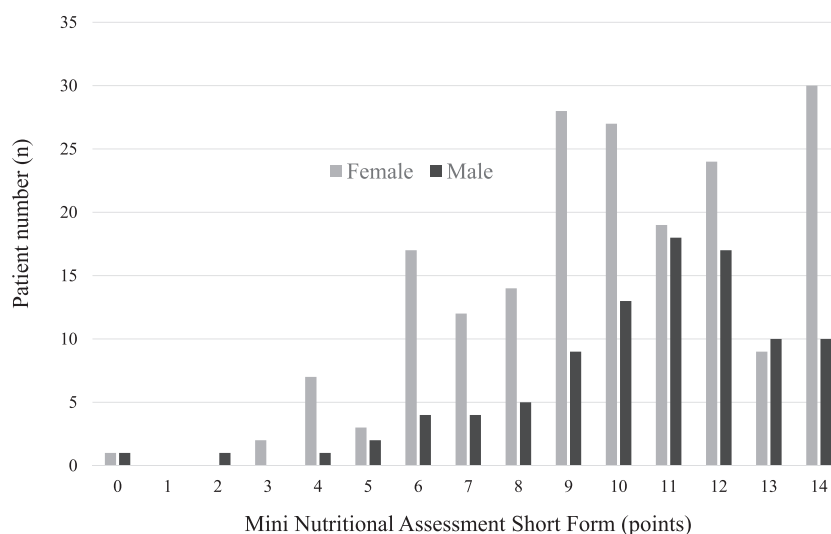
of the patients were female. Of 288 included patients, 41 patients (14%) died, with nine patients succumbing to cardiovascular death after TAVI. The baseline characteristics of all the enrolled study patients are shown in *Table 1*. The mean MNA-SF score was 10.0 ± 2.9 . *Figure 1* shows the MNA-SF

Table 1 Baseline patient characteristics

Characteristic	Overall (n = 288)	Maintained MNA-SF (n = 100)	Impaired MNA-SF (n = 188)	P-value
Age (years)	83.5 ± 5.7	82.4 ± 4.6	84.0 ± 6.1	0.01
Male	95 (33)	37 (37)	58 (30)	0.29
Hypertension	240 (83)	80 (80)	160 (85)	0.43
Diabetes mellitus	73 (25)	26 (26)	47 (25)	0.80
Dyslipidaemia	149 (12)	66 (66)	83 (44)	<0.01
COPD	37 (13)	11 (11)	26 (14)	0.51
Atrial fibrillation	44 (15)	17 (17)	27 (14)	0.56
PAD	19 (7)	5 (5)	14 (7)	0.40
Previous PCI	62 (22)	25 (25)	37 (20)	0.30
Prior stroke	37 (13)	7 (2)	30 (10)	0.02
Previous PMI	21 (7)	10 (10)	11 (6)	0.23
NYHA class, III or IV	96 (33)	29 (29)	67 (36)	0.24
BMI (kg/m^2)	22.5 ± 4.0	24.2 ± 2.8	21.5 ± 4.2	<0.01
STS score (mortality)	5.9 ± 4.5	4.89 ± 3.5	6.49 ± 4.8	<0.01
Katz Index	5.1 ± 1.3	5.5 ± 1.0	4.8 ± 1.4	<0.01
Haemoglobin (g/dL)	11.3 ± 1.6	12.0 ± 1.6	11.0 ± 1.5	<0.01
Albumin (g/dL)	3.7 ± 0.6	3.9 ± 0.6	3.7 ± 0.6	<0.01
eGFR ($\text{mL}/\text{min}/1.73 \text{ m}^2$)	52.8 ± 18.1	54.5 ± 15.8	51.9 ± 19.2	0.22
BNP (pg/mL)	352 ± 566	206 ± 271	429 ± 659	<0.01
HbA1c (%)	5.9 ± 0.8	6.0 ± 0.9	5.9 ± 0.7	0.61
CRP (mg/dL)	1.3 ± 1.9	0.7 ± 0.8	1.5 ± 2.2	<0.01
LVEF (%)	64.0 ± 12.4	65.8 ± 9.8	62.9 ± 11.7	0.04
Peak velocity (m/s)	4.3 ± 1.0	4.3 ± 0.9	4.2 ± 1.0	0.39
Aortic valve area (cm^2)	0.7 ± 1.9	0.6 ± 0.1	0.8 ± 2.4	0.54
Mean aortic pressure gradient (mmHg)	43.8 ± 21.1	44.6 ± 20.5	43.6 ± 20.9	0.70
MNA-SF score	10.0 ± 2.9	13.0 ± 0.9	8.5 ± 2.3	<0.01

BMI, body mass index; BNP, brain natriuretic peptide; COPD, chronic obstructive pulmonary disease; CRP, C-reactive protein; eGFR, estimated glomerular filtration rate; HbA1c, glycated haemoglobin; LVEF, left ventricular ejection fraction; MNA-SF, Mini Nutritional Assessment—Short Form; NYHA, New York Heart Association; PAD, peripheral artery disease; PCI, percutaneous coronary intervention; PMI, pacemaker implantation; STS, Society of Thoracic Surgeons. Values are mean \pm standard deviation (median) or n (%).

FIGURE 1 Distribution of the Mini Nutritional Assessment—Short Form in the male and female population. The Mini Nutritional Assessment—Short Form score was distributed according to the sex of patients undergoing transcatheter aortic valve implantation.



point distribution divided according to sex. A total of 188 patients (65%) were in the impaired MNA-SF group, and 100 patients (35%) were in the maintained MNA-SF group.

Patients in the impaired MNA-SF group were considerably older and had a higher STS mortality score and higher BNP and C-reactive protein levels, a significant history of prior stroke, an absence of dyslipidaemia, a lower Katz Index, lower haemoglobin and albumin levels, and a lower left ventricular ejection fraction compared with patients in the maintained MNA-SF group.

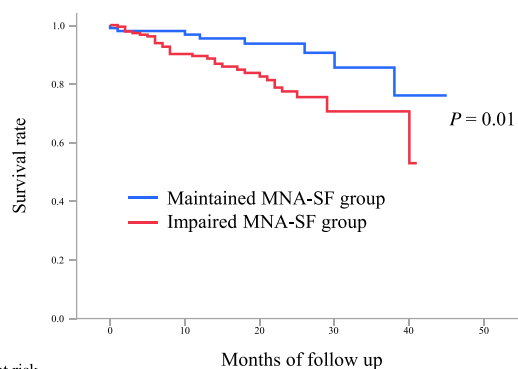
Procedural characteristics and outcomes are shown in *Table 2*. Mortality at 30 days after TAVI was 0%. All patients had undergone the TAVI procedure under general anaesthesia. The mean hospital stay after TAVI was 10.0 ± 7.9 days. Patients in the impaired MNA-SF group underwent a significantly higher number of transfemoral approaches during surgery and experienced a longer hospital stay after TAVI than those in the maintained MNA-SF group.

Table 2 Procedural patient characteristics

Characteristic	Overall (n = 288)	Maintained MNA-SF (n = 100)	Impaired MNA-SF (n = 188)	P-value
Transfemoral approach	276 (96)	99 (99)	177 (94)	0.02
Alternative approach	12 (4)	1 (1)	11 (6)	0.02
Self-expandable type	48 (17)	13 (13)	35 (17)	0.22
Balloon expandable type	240 (83)	87 (87)	153 (81)	0.22
Length of hospital stay after TAVI (days)	10.0 ± 7.9	7.8 ± 4.7	11.1 ± 8.9	<0.01
Device success	221 (77)	76 (76)	145 (77)	0.83
Early safety at 30 days				
Death	0 (0)	0 (0)	0 (0)	
All stroke	4 (1)	1 (1)	3 (2)	0.66
Life-threatening bleeding	5 (2)	1 (1)	4 (2)	0.44
Acute kidney injury	1 (1)	0 (0)	1 (1)	0.47
Coronary obstruction	0 (0)	0 (0)	0 (0)	
Major vascular complication	14 (5)	5 (5)	9 (5)	0.94
Pacemaker implantation after TAVI	25 (9)	5 (5)	20 (11)	0.11

MNA-SF, Mini Nutritional Assessment—Short Form; TAVI, transcatheter aortic valve implantation. Values are mean \pm standard deviation (median) or n (%).

FIGURE 2 Kaplan–Meier curves for all-cause mortality in the two Mini Nutritional Assessment—Short Form (MNA-SF) groups. The patients were divided into two groups: one group with an MNA-SF score of ≤ 11 (impaired MNA-SF group) and another group with an MNA-SF score of ≥ 12 (maintained MNA-SF group). Using the MNA-SF, the Kaplan–Meier analysis showed that the patients with a lower MNA-SF score had a lower survival rate ($P = 0.01$).



No. of patients at risk	0	10	20	30	40	50
Maintained MNA-SF group	100	80	49	18	5	1
Impaired MNA-SF group	188	136	68	29	4	3

Kaplan–Meier analysis in the impaired Mini Nutritional Assessment—Short Form and maintained Mini Nutritional Assessment—Short Form groups

The Kaplan–Meier analysis indicated that the 3 year survival rates were 0.86 ± 0.06 and 0.71 ± 0.05 for patients in the maintained MNA-SF and impaired MNA-SF groups, respectively. In terms of the Kaplan–Meier analysis for all-cause mortality, the survival rate was significantly lower for patients in the impaired MNA-SF group ($P = 0.01$; *Figure 2*).

Univariate and multivariate analysis

The results of the Cox regression analyses undertaken to evaluate the association between all-cause mortality and MNA-SF are presented in *Table 3*. In the univariate Cox regression

Table 3 Predictor of all-cause death in univariate and multivariate Cox regression analyses

	Univariate analysis			Multivariate analysis		
	HR	95% CI	P-value	Adjusted HR	95% CI	P-value
Age (years)	1.08	1.02–1.14	<0.01			
Male	1.52	0.81–2.82	0.19			
MNA-SF (every 1-point decrease)	1.16	1.05–1.28	<0.01	1.14	1.01–1.28	0.04
STS score (every 1% increase)	1.06	1.01–1.09	0.02	1.05	0.99–1.10	0.08
Katz Index (every 1-point decrease)	1.30	1.05–1.60	0.02	1.22	0.97–1.51	0.09
Log BNP	2.11	1.15–3.90	0.02	1.24	0.60–2.61	0.56

BNP, brain natriuretic peptide; CI, confidence interval; HR, hazard ratio; MNA-SF, Mini Nutritional Assessment—Short Form; STS, Society of Thoracic Surgeons.

model, the MNA-SF, BNP, STS scores, and the Katz Index were significantly associated with all-cause mortality. After adjusting the STS score, the Katz Index, and BNP, the MNA-SF score emerged as an independent predictor of all-cause mortality (HR 1.14; 95% CI 1.01–1.28; $P = 0.04$).

Receiver operating characteristic analysis

Receiver operating characteristic analysis was undertaken to obtain a c -statistic to assess the MNA-SF and the Katz Index for predicting mortality. The area under the curve (AUC) was not significantly different between the MNA-SF and the Katz Index ($P = 0.92$). The AUC for all-cause mortality was 0.70 (95% CI 0.61–0.78) for the MNA-SF score on the STS score and 0.69 (95% CI 0.61–0.78) for the Katz Index on the STS score. The MNA-SF score was 11 points, with a highest Youden's J value of 0.37. The Katz Index was a score of 4 points, with a highest Youden's J value of 0.32.

Kaplan–Meier analysis using Mini Nutritional Assessment—Short Form scores of <8, 8–11, and >11

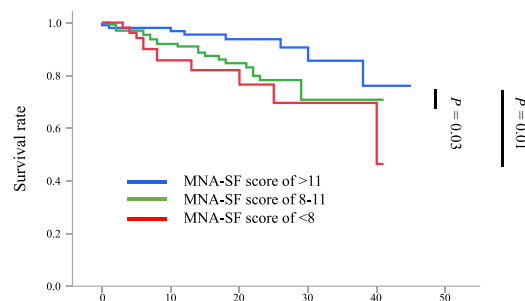
The Kaplan–Meier analysis for all-cause mortality in patients with MNA-SF scores of <8, 8–11, and >11 indicated that the 3 year survival rates were 0.86 ± 0.06 (in patients with a score of >11), 0.71 ± 0.07 (in patients with a score of 8–11), and 0.70 ± 0.10 (in patients with a score of <8). In this analysis, the survival rate was significantly higher in the patients with a score of >11 (MNA-SF score >11 vs. 8–11, HR 2.49, $P = 0.03$; MNA-SF score >11 vs. <8, HR 3.22, $P = 0.01$; Figure 3).

Discussion

To our knowledge, our study is the first to have performed nutritional screening for malnutrition in patients who had undergone TAVI and is the first to demonstrate that the MNA-SF can accurately predict patient mortality following the TAVI procedure. Our study findings showed that the MNA-SF scores indicating malnutrition were significantly associated with midterm mortality after TAVI. Even after adjusting for BNP, the Katz Index, and the STS scores, patients at risk of malnutrition showed a significantly increased risk of mortality.

Factors associated with malnutrition

Aortic valve stenosis is a chronic, progressive disease with a prolonged inflammatory process that may contribute to reduced mobility, loss of muscle mass, decreased appetite, and poor nutritional status.^{15,16} Malnutrition is a known risk factor for mortality in older community-dwelling or nursing home-resident adults who have undergone surgery or

FIGURE 3 Kaplan–Meier curves for all-cause mortality with Mini Nutritional Assessment—Short Form (MNA-SF) score of <8, 8–11, and >11. The Kaplan–Meier analysis showed that the patients with a lower MNA-SF score had a lower survival rate.

No. of patients at risk	Months of follow up					
	0	10	20	30	40	50
MNA-SF score of >11	100	80	49	18	5	1
MNA-SF score of 8–11	133	99	53	19	1	0
MNA-SF score of <8	55	38	15	10	3	0

hospitalization for acute decompensated heart failure.^{17–19} Furthermore, length of hospital stay has been reported to be longer in patients who are malnourished.^{18,19} Our study findings showed that two-thirds of at-risk patients in the impaired MNA-SF group stayed in hospital for a longer period than those in the maintained MNA-SF group. Patients with a history of stroke were significantly represented in the impaired MNA-SF group. The prevalence of malnutrition after stroke has been reported to range widely, from 6.1% to 62%, and elderly patients with stroke are known to be malnourished because of dysphagia.^{20,21} Furthermore, a previous study has reported that malnutrition can predict death and further cardiovascular events in patients with stroke.²²

Usefulness of the Mini Nutritional Assessment—Short Form as a prognostic factor

In our study, patients who had a low MNA-SF score showed an increased risk of mortality even after adjusting for BNP, the Katz Index, and the STS scores, whereas the AUC did not differ significantly between the MNA-SF and the Katz Index in the ROC analysis. Given the small sample size in this study, we only evaluated the MNA-SF, BNP, the Katz Index, and the STS scores using multivariate analysis. Given the eligibility criteria, patients undergoing TAVI procedures are mostly older adults with a high risk of eventual open-heart surgery.²³ A previous report stated that the causes of death after TAVI were predominantly non-cardiac and mostly due to infection and cancer.²⁴ Therefore, we considered that the patients who had a poor prognosis after TAVI also suffered from non-cardiac co-morbidities. Moreover, when an assessment of psychological stress and mobility was combined with the MNA-SF scores, this combination was significantly associated with an accurate frailty grading.²⁵ Therefore, we postulated that patients undergoing TAVI might be readily affected because of a decline in their nutritional status or physical function, which could predict disease progression in elderly patients.

Clinical and research scope of the study in future

This study raises the question of whether preoperative and post-operative nutritional interventions should be recommended in malnourished patients undergoing TAVI with the aim of improving post-operative outcomes. In a previous study, protein supplementation was observed to increase post-absorptive protein synthesis rates in malnourished patients, which further resulted in increased lean body mass.^{26,27} A multicentre randomized controlled trial, comprising 650 malnourished older adults who had been hospitalized with acute cardiovascular and respiratory conditions, reported that patients receiving a high-protein oral diet showed

an improved nutritional profile and a substantial reduction in the 90 day mortality rate.²⁸ However, it has also been shown that, during the catabolic perioperative period, the anabolic effects of perioperative nutrition may be attenuated.²⁹ Additionally, aortic stenosis is characterized with an ensuing left ventricular remodelling response.³⁰ When these factors are considered in conjunction, it is possible to infer that delayed intervention for AS may lead to a worsening prognosis for TAVI patients; therefore, post-operative nutritional intervention is preferable and important.

In future studies, we recommend that preoperative or post-operative nutritional interventions be undertaken for patients who are undergoing TAVI and for those at risk of malnutrition, involving larger and more diverse cohorts, to further verify our findings and confirm which nutritional interventions could be best applied in clinical practice.

Study limitations

This study had some limitations. First, this was a single-centre, retrospective, and observational study. Second, we were not able to evaluate the nutritional status of the patients who could not be followed up after having undergone the MNA-SF screening. This was a limitation as these patients were likely to have had the most negatively affected nutritional profile. Third, our study involved a homogeneous Japanese population; therefore, our results should be applied to different populations with caution. Fourth, we did not determine the utility of the MNA-SF compared with that of other nutritional indicators. We considered that the MNA-SF had superior classification performance in identifying malnutrition compared with objective nutritional assessments. Serum albumin levels, along with objective nutritional assessments such as GNRI and CONUT, may reflect both poor nutritional status and an inflammatory response, and AS is a disease involving chronic inflammation as one complex pathophysiological factor.^{31,32} Therefore, the effectiveness of objective nutritional assessments in relation to AS is limited. However, it could not be confirmed that the MNA-SF was the best prognostic predictor for patients undergoing TAVI procedures in this study. Finally, our study did not include patients who had not undergone TAVI procedures.

Conclusions

Patients at risk of malnutrition preoperatively are likely to have poor post-operative outcomes. Therefore, it is important to evaluate the nutritional status of at-risk patients prior to undertaking TAVI. Our findings indicated that the MNA-SF is a useful, non-invasive, and accurate nutritional tool that can be effectively used for patients undergoing TAVI.

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Conflict of interest

None declared.

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