

Predictive Value of the Naples Prognostic Score for 30-Day Mortality and Major Adverse Cardiovascular Events in Patients Undergoing Transcatheter Aortic Valve Implantation for Severe Aortic Stenosis

İleri Aort Darlığı Nedeniyle Transkateter Aort Kapak İmplantasyonu Uygulanan Hastalarda 30 Günlük Mortalite ve Majör Kardiyovasküler Olaylar için Naples Prognostik Skorunun Prediktif Değeri

ABSTRACT

Objective: Transcatheter aortic valve implantation (TAVI) has revolutionized the treatment of severe aortic stenosis; however, early mortality risk stratification remains challenging. The Naples Prognostic Score (NPS), which integrates inflammatory and nutritional markers, has shown promise in cardiovascular disease prognosis. This study investigated the relationship between preprocedural NPS and 30-day mortality in patients undergoing TAVI.

Method: This retrospective, single-center study analyzed 308 patients aged ≥ 65 years who underwent elective transfemoral TAVI between August 2012 and December 2022. NPS was calculated using the neutrophil-to-lymphocyte ratio, lymphocyte-to-monocyte ratio, serum albumin, and total cholesterol levels. Patients were stratified into low NPS (0-2) and high NPS (3-4) groups. The primary endpoint was 30-day all-cause mortality.

Results: The mean age was 79.81 ± 7.68 years, and 54.9% patients were female. The high NPS group comprised 191 patients (62.0%), while 117 patients (38.0%) were in the low NPS group. Thirty-day mortality was significantly higher in patients with high NPS (16.8% vs. 4.3%, $P < 0.001$), representing nearly a four-fold increased risk. NPS demonstrated good discriminative ability for mortality prediction (area under the curve: 0.692, 95% confidence interval: 0.611-0.774, $P < 0.001$), performing comparably to established surgical risk scores. Independent predictors of mortality included age (odds ratio [OR] 1.067, $P = 0.039$), neutrophil-to-lymphocyte ratio (OR 1.062, $P = 0.048$), and pulmonary artery pressure (OR 1.039, $P = 0.006$).

Conclusion: The Naples Prognostic Score is a significant predictor of early mortality following TAVI and offers a simple, readily available tool for preoperative risk stratification. Patients with high NPS may benefit from enhanced perioperative monitoring and targeted interventions.

Keywords: Mortality, Naples prognostic score, risk stratification, transcatheter aortic valve implantation

ÖZET

Amaç: Transkateter aort kapak implantasyonu (TAVI), ileri aort darlığı tedavisinde devrim niteliğinde bir gelişme olsa da, erken mortalite riskinin sınıflandırılması hala tartışmalıdır. Enflamatuvar ve nutrisyonel belirteçleri bir araya getiren Naples Prognostik Skoru (NPS), kardiyovasküler hastalıkların prognozunda umut vaat etmektedir. Bu çalışmada, TAVI hastalarında işlem öncesi NPS ile 30 günlük mortalite arasındaki ilişkiyi araştırmıştır.

Yöntem: Bu retrospektif, tek merkezli çalışma, Ağustos 2012 ile Aralık 2022 arasında elektif transfemoral TAVI uygulanan 65 yaş ve üzeri 308 hastayı analiz etmiştir. NPS, nötrofil-lenfosit oranı, lenfosit-monosit oranı, serum albümin ve toplam kolesterol düzeyleri kullanılarak hesaplanmıştır. Hastalar düşük NPS (0-2) ve yüksek NPS (3-4) gruplarına ayrıldı. Birincil sonlanım noktası 30 günlük tüm nedenlere bağlı mortalite idi.

Bulgular: Ortalama yaş $79,81 \pm 7,68$ idi ve hastaların %54,9'u kadındı. Yüksek NPS grubu 191 hastadan (62,0%) oluşurken, düşük NPS grubu 117 hastadan (38,0%) oluşuyordu. 30 günlük mortalite, yüksek NPS hastalarında anlamlı olarak daha yüksekti (16,8% vs 4,3%, $P < 0,001$), bu da yaklaşık dört kat daha yüksek risk anlamına geliyordu. NPS, mortalite tahmini için iyi bir ayırt edici özelliğe sahipti (AUC 0,692, %95 CI 0,611-0,774, $P < 0,001$) ve mevcut cerrahi risk

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skorlarıyla karşılaştırılabilir bir performans sergiledi. Mortalitenin bağımsız belirleyicileri arasında yaş (OR 1,067, P = 0,039), nötrofil-lenfosit oranı (OR 1,062, P = 0,048) ve pulmoner arter basıncı (OR 1,039, P = 0,006) yer aldı.

Sonuç: NPS, TAVI sonrası erken mortalitenin önemli bir belirleyicisi olarak kullanılabilir ve ameliyat öncesi risk sınıflandırması için basit ve kolayca elde edilebilir bir yöntem olabilir. NPS değeri yüksek olan hastalara, perioperatif takip ve hedefe yönelik müdahale şarttır.

Anahtar Kelimeler: Mortalite, Naples prognostik skoru, risk sınıflandırması, transkateter aort kapak implantasyonu

Valvular aortic stenosis (AS) is a progressive, degenerative valve disorder characterized by narrowing of the aortic valve orifice, resulting in obstruction of left ventricular outflow, increased myocardial workload, compensatory hypertrophy, and eventual left ventricular dysfunction. Over time, this hemodynamic burden leads to reduced exercise tolerance, overt heart failure, and an increased risk of mortality. Symptomatic severe AS, if left untreated, carries a dismal prognosis, with survival often measured in months to a few years, depending on symptom severity and ventricular function.¹

The prevalence of AS rises sharply with advancing age. Population-based studies report a prevalence ranging from 0.2% to 9.8%, with markedly higher rates among individuals aged \geq 80 years compared to those aged 50–59 years, making age one of the strongest risk factors for disease occurrence.²

Over the past two decades, transcatheter aortic valve implantation (TAVI) has revolutionized the management of severe, symptomatic AS, particularly in patients considered at high or prohibitive surgical risk for conventional surgical aortic valve replacement (SAVR). Initially developed as an alternative for inoperable patients, TAVI has evolved into a well-established therapeutic option, supported by large randomized trials and registry data demonstrating comparable or superior outcomes to SAVR in selected patient populations. Its indications have expanded to include intermediate- and low-risk groups.³⁻⁵

Early mortality, commonly defined as death within 30 days after the procedure, remains a key endpoint in TAVI research. It reflects procedural safety, influences hospital quality benchmarks, and provides a foundation for developing risk stratification tools. Several clinical, echocardiographic, and procedural parameters, including advanced age, comorbidities, baseline biomarkers, and intraprocedural complications, have been linked to early mortality after TAVI.^{6,7} While established surgical risk models such as the European System for Cardiac Operative Risk Evaluation II (EuroSCORE II) and the Society of Thoracic Surgeons Predicted Risk of Mortality (STS-PROM), as well as TAVI-specific risk scores, offer some prognostic value, their predictive accuracy and applicability in contemporary practice remain suboptimal.^{8,9} Therefore, identifying simple, readily available perioperative markers for risk prediction remains an important clinical priority.

The Naples Prognostic Score (NPS) is a recently proposed composite index that integrates inflammatory and nutritional status and is calculated from the lymphocyte-to-monocyte ratio (LMR), neutrophil-to-lymphocyte ratio (NLR), serum albumin, and total cholesterol levels. Originally validated in oncology

ABBREVIATIONS

AS	Aortic stenosis
CT	Computed tomography
DAPT	Dual antiplatelet therapy
EuroSCORE II	European System for Cardiac Operative Risk Evaluation II
HDL	High-density lipoprotein
LDL	Low-density lipoprotein
LMR	Lymphocyte-to-monocyte ratio
LVEF	Left ventricular ejection fraction
NLR	Neutrophil-to-lymphocyte ratio
NPS	Naples Prognostic Score
PCI	Percutaneous coronary intervention
SAVR	Surgical aortic valve replacement
STS-PROM	Society of Thoracic Surgeons Predicted Risk of Mortality
TAVI	Transcatheter aortic valve implantation
TEE	Transesophageal echocardiography
TTE	Transthoracic echocardiography
VARC	Valve Academic Research Consortium
VIF	Variance inflation factor

settings, NPS has demonstrated stronger prognostic utility than individual inflammatory markers in predicting survival across various malignancies.^{10,11} More recently, its prognostic relevance has been investigated in cardiovascular diseases, including acute pulmonary embolism, heart failure, ST-segment elevation myocardial infarction, and TAVI.¹²⁻¹⁵ However, data on its role in predicting early mortality following TAVI remain limited.

This study aimed to investigate the relationship between preprocedural NPS and 30-day mortality in patients undergoing TAVI, with the goal of assessing its potential utility as a simple and clinically accessible prognostic tool.

Materials and Methods

Study Design and Population

This retrospective, observational study analyzed adult patients aged 65 years or older who underwent AS confirmed by multidisciplinary heart team evaluation and had anatomic suitability for transfemoral access, with complete preprocedural and postprocedural clinical data available. Patients with preprocedural cardiogenic shock, documented hepatic dysfunction, emergency procedures, or non-transfemoral access routes were excluded to minimize confounding factors that could impact NPS and short-term outcomes, while ensuring patient safety and data validity.

Pre-Procedural Evaluation

A comprehensive preprocedural assessment was conducted for all patients to determine eligibility, identify procedural risks, and optimize intervention planning. All patients underwent systematic transthoracic echocardiography (TTE) to assess the severity of AS, including aortic valve area and mean and peak gradients; presence and grade of aortic regurgitation; left ventricular ejection fraction (LVEF) and segmental wall motion; aortic valve morphology and calcification severity; and annular dimensions for prosthesis sizing. Invasive coronary angiography was performed in all patients to identify significant obstructive coronary artery disease ($\geq 70\%$ stenosis) and determine the necessity for concomitant percutaneous coronary intervention (PCI) to optimize myocardial perfusion prior to TAVI.

Multidetector computed tomography (CT) angiography provided assessment of the vascular access route, including vessel caliber, tortuosity, and atherosclerotic burden, along with detailed evaluation of aortic root anatomy and annular measurements for optimization of prosthesis sizing and stratification of procedural complication risk. Perioperative risk was quantified using validated scoring systems, including EuroSCORE II and the Society of Thoracic Surgeons (STS) Predicted Risk of Mortality score, supplemented by comprehensive risk evaluation that included frailty assessment using validated tools, renal function evaluation through estimated glomerular filtration rate, pulmonary function assessment via spirometry or clinical evaluation, and cognitive assessment where indicated.

TAVI Procedure Protocol

All procedures were performed under general anesthesia or monitored conscious sedation based on patient hemodynamic status, comorbidities, and multidisciplinary team recommendations, with continuous hemodynamic monitoring and transesophageal echocardiography (TEE) guidance employed when clinically indicated. Primary vascular access was established via the common femoral artery using percutaneous or surgical cut-down techniques, with placement of an 18–22 French introducer sheath under fluoroscopic guidance and contralateral arterial access for hemodynamic support when required.

Catheter-mounted bioprosthetic valves, either balloon-expandable or self-expanding, were selected based on anatomic considerations and navigated to the aortic annulus under real-time fluoroscopic and echocardiographic guidance. Valve deployment was achieved through balloon inflation or self-expansion according to valve type, with multiple fluoroscopic projections used to ensure optimal coaxial alignment within the native annulus. Immediate post-deployment assessment included evaluation of valve function using TTE or TEE, measurement of transvalvular pressure gradients, assessment for paravalvular regurgitation, and repeat coronary angiography in selected cases to confirm ostial patency.

Post-Procedural Management

Following the procedure, patients were transferred to the cardiac intensive care unit (ICU) or high-dependency unit for 24–48 hours of continuous monitoring, including hemodynamic surveillance, continuous telemetry for arrhythmia detection (particularly conduction abnormalities), neurologic assessments for detection of cerebrovascular events, and regular pain assessments using

standardized scoring systems. Post-procedural antiplatelet management included dual antiplatelet therapy (DAPT) with aspirin and clopidogrel for a minimum of six months, with individualized anticoagulation regimens for patients with atrial fibrillation or other indications and therapy modifications based on bleeding risk assessment. Multimodal analgesia protocols were implemented, with regular pain score documentation and pharmacologic adjustments balanced between adequate analgesia and early complication detection.

Data Collection and Naples Prognostic Score

Patient information was obtained from electronic medical records and included demographics such as age, sex, and body mass index; comorbidities including diabetes mellitus, chronic kidney disease, coronary artery disease, atrial fibrillation, and peripheral arterial disease; laboratory parameters including complete blood count and comprehensive metabolic panel; echocardiographic measurements including LVEF, aortic valve area, and transvalvular gradients; and procedural data including contrast volume, fluoroscopy time, and procedural duration.

The Naples Prognostic Score was calculated using four components, each scored as 0 or 1 point: neutrophil-to-lymphocyte ratio, lymphocyte-to-monocyte ratio, total cholesterol level, and serum albumin concentration. In accordance with prior studies validating the prognostic utility of the NPS, patients were categorized into low NPS (0–2) and high NPS (3–4) groups. This binary stratification has been consistently used to differentiate patients with preserved versus impaired inflammatory–nutritional status and has demonstrated prognostic significance in cardiovascular and non-cardiovascular cohorts.^{12,16} All laboratory values were obtained within 48 hours prior to the TAVI procedure using standardized laboratory protocols.

Outcome Definitions

The primary endpoint was all-cause mortality within 30 days following percutaneous TAVI. Secondary endpoints included procedural myocardial infarction, defined according to the Fourth Universal Definition of Myocardial Infarction; new permanent pacemaker implantation required due to conduction abnormalities; stroke, defined as an acute neurologic deficit lasting more than 24 hours with imaging confirmation; major bleeding classified according to Valve Academic Research Consortium (VARC) criteria; and vascular complications categorized according to VARC-2 definitions. All outcomes were adjudicated by independent reviewers blinded to NPS values and followed standardized institutional protocols for event classification.

Ethics Approval and Compliance Statement

The research followed the ethical guidelines specified in the Declaration of Helsinki. There was no utilization of artificial intelligence (AI)-powered tools such as large language models (LLMs), chatbots, or image generators, in developing this article. The study received approval from Istanbul Medipol University Non-Interventional Clinical Research Ethics Committee (Approval Number: 249, Date: 06.03.2025). Given the retrospective design and use of de-identified clinical data, the ethics committee waived the requirement for informed consent.

Statistical Analysis

Continuous variables were assessed for normality using the Shapiro-Wilk test and visual inspection of quantile-quantile plots. Normally distributed variables were expressed as mean \pm standard deviation, while non-normally distributed variables were presented as median with interquartile range (IQR). Categorical variables were presented as frequencies and percentages. Patients were stratified into low NPS and high NPS groups for comparative analysis.

Between-group comparisons were performed using Student's t-test for normally distributed continuous data, the Mann-Whitney U test for non-normally distributed data, and the chi-square test or Fisher's exact test for categorical variables when expected cell counts were less than 5. For variables presented as median (IQR), the Mann-Whitney U test was systematically applied to ensure appropriate nonparametric comparison.

Cox proportional hazards regression was performed to identify independent predictors of 30-day mortality. Variable selection for multivariable analysis followed a systematic approach combining clinical relevance and statistical screening. Candidate predictors were first evaluated in univariable logistic regression, with variables achieving $P < 0.20$ considered for inclusion in multivariable models based on established recommendations for confounder identification. Clinical relevance was determined through literature review and multidisciplinary team consensus, prioritizing variables with established prognostic significance in TAVI outcomes, including demographic factors (age, sex), comorbidities (diabetes, chronic kidney disease, coronary artery disease), cardiac function parameters (LVEF, pulmonary artery pressure), and procedural characteristics.

Prior to multivariable modeling, multicollinearity assessment was performed using variance inflation factor (VIF) analysis, with $VIF > 5$ indicating problematic collinearity and $VIF > 10$ indicating severe multicollinearity requiring variable exclusion. Given the theoretical overlap between individual inflammatory markers (NLR, LMR), nutritional parameters (albumin, total cholesterol), and composite scores incorporating these components (Naples Score, STS Score, EuroSCORE), separate multivariable models were constructed.

Variables with $VIF > 5$ were sequentially removed from the models, prioritizing retention of variables with stronger univariable associations and greater clinical interpretability. Final models were constructed using backward stepwise selection with a retention threshold of $P < 0.05$, and model performance was evaluated using the Hosmer-Lemeshow goodness-of-fit test and the area under the receiver operating characteristic (ROC) curve. Sensitivity analyses were performed to assess model stability across different variable selection approaches.

Receiver operating characteristic analysis was performed to evaluate the discriminatory ability of NPS for predicting 30-day mortality, calculate the area under the curve with 95% confidence intervals, and compare predictive performance with established risk scores, including EuroSCORE II and the STS score. Missing data was handled using complete-case analysis, with sensitivity analyses performed when missing data exceeded 5%. Statistical significance was set at a p -value < 0.05 (two-tailed),

Heart Valve Types Distribution

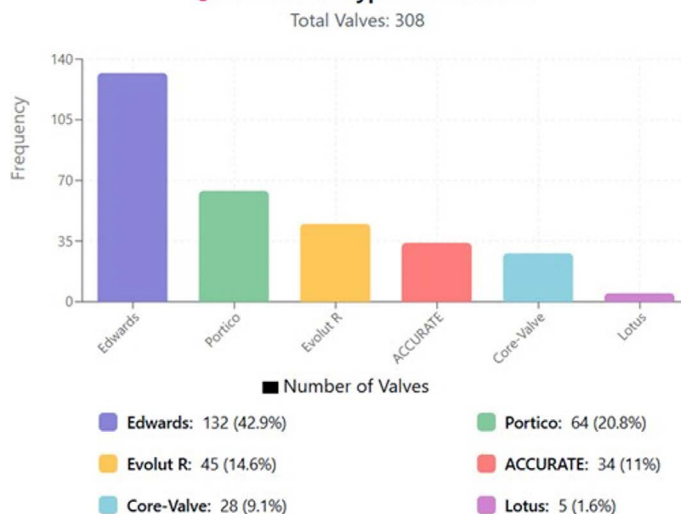


Figure 1. Distribution of transcatheter aortic valve types in the study population.

confidence intervals were calculated at the 95% level for all estimates, and all analyses were performed using SPSS version 28.0 (IBM Corp., Armonk, NY) and R version 4.3.0.

Results

A total of 308 patients undergoing TAVI were included, with a mean age of 79.81 ± 7.68 years; 169 patients (54.9%) were female. Major comorbidities included hypertension in 250 patients (81.2%), coronary artery disease in 226 patients (73.4%), diabetes mellitus in 128 patients (41.6%), and chronic obstructive pulmonary disease (COPD) in 65 patients (21.1%). Previous cardiac surgery was present in 101 patients (32.8%), and pre-TAVI coronary stents were noted in 43 patients (14.0%).

Edwards valves were the most frequently used (132 valves, 42.9%), followed by Portico (64 valves, 20.8%), Evolut R (45 valves, 14.6%), ACCURATE (34 valves, 11.0%), CoreValve (28 valves, 9.1%), and Lotus (5 valves, 1.6%) (Figure 1).

Baseline laboratory values showed a mean albumin level of 3.39 ± 0.69 g/dL and hemoglobin of 11.52 ± 1.64 g/dL. Creatinine demonstrated a non-normal distribution, with a median of 0.96 mg/dL (IQR: 0.78-1.28). Lipid profiles revealed a total cholesterol level of 171.44 ± 51.76 mg/dL, high-density lipoprotein (HDL) cholesterol of 41.82 ± 13.48 mg/dL, and low-density lipoprotein (LDL) cholesterol of 104.54 ± 41.40 mg/dL. Triglycerides showed a median of 113 mg/dL (IQR: 84-157).

Complete blood count parameters included a white blood cell count of $7.89 \pm 2.54 \times 10^3/\mu\text{L}$, with differential counts showing neutrophils at $5.36 \pm 2.87 \times 10^3/\mu\text{L}$, lymphocytes at $1.58 \pm 0.78 \times 10^3/\mu\text{L}$, and monocytes at $0.68 \pm 0.31 \times 10^3/\mu\text{L}$. Inflammatory markers demonstrated non-normal distributions, with a median NLR of 3.12 (IQR: 2.24-4.89) and a median LMR of 2.67 (IQR: 1.85-4.12).

The mean NPS was 2.74 ± 1.01 , distributed as Score 0 (1.6%), Score 1 (10.7%), Score 2 (25.6%), Score 3 (36.0%), and Score 4 (26.0%). Patients were categorized into Group 1 (Naples Score 0-2, $n = 117$, 38.0%) and Group 2 (Naples Score 3-4, $n = 191$,

Table 1. Baseline characteristics of the study population

Patient characteristic	Values	Patient characteristic	Values
Demographics		Score 2	79 (25.6)
Age (years), mean ± SD	79.81 ± 7.68	Score 3	111 (36.0)
Female sex, n (%)	169 (54.9)	Score 4	80 (26.0)
Comorbidities		Category 1 (0-2)	117 (38.0)
Hypertension, n (%)	250 (81.2)	Category 2 (3-4)	191 (62.0)
Diabetes mellitus, n (%)	128 (41.6)	STS score, mean ± SD	7.06 ± 5.60
Coronary artery disease, n (%)	226 (73.4)	Logistic EuroSCORE, mean ± SD	20.40 ± 12.82
Smoking, n (%)	39 (12.7)	Rhythm and conduction	
Pulmonary arterial hypertension, n (%)	25 (8.1)	Pre-TAVI sinus rhythm, n (%)	212 (68.8)
COPD, n (%)	65 (21.1)	Atrial fibrillation (pre-procedure), n (%)	87 (28.2)
Previous cardiac surgery, n (%)	101 (32.8)	AV block (pre-procedure), n (%)	7 (2.3)
Pre-TAVI coronary stent, n (%)	43 (14.0)	Echocardiographic parameters	
Laboratory values		Left atrium (mm), mean ± SD	44.70 ± 7.49
Albumin (g/dL), mean ± SD	3.39 ± 0.69	LVEF (%), mean ± SD	50.58 ± 11.25
Lactate (mmol/L), mean ± SD	1.59 ± 1.94	Aortic valve area (cm ²), mean ± SD	0.72 ± 0.13
Total cholesterol (mg/dL), mean ± SD	171.44 ± 51.76	Mean gradient (mmHg), mean ± SD	49.71 ± 13.50
Triglycerides (mg/dL), mean ± SD	120.82 ± 64.76	Maximum velocity (m/s), mean ± SD	4.41 ± 0.56
HDL cholesterol (mg/dL), mean ± SD	41.82 ± 13.48	Ascending aorta (mm), mean ± SD	35.68 ± 4.41
LDL cholesterol (mg/dL), mean ± SD	104.54 ± 41.40	TEE aortic annulus (mm), mean ± SD	24.75 ± 3.67
Hemoglobin, pre-procedure (g/dL), mean ± SD	11.52 ± 1.64	Mitral stenosis, n (%)	
Hematocrit, pre-procedure (%), mean ± SD	34.90 ± 4.75	None	290 (94.2)
MPV, pre-procedure (fL), mean ± SD	9.03 ± 1.56	Mild	14 (4.5)
Neutrophil count (×10 ³ /μL), mean ± SD	5.41 ± 5.49	Moderate	4 (1.3)
Lymphocyte count (×10 ³ /μL), mean ± SD	1.58 ± 0.81	Mitral regurgitation, n (%)	
Monocyte count (×10 ³ /μL), mean ± SD	0.85 ± 3.41	None/trivial, n (%)	48 (15.6)
Platelet count, pre-procedure (×10 ³ /μL), mean ± SD	225.74 ± 70.06	Mild, n (%)	114 (37.0)
LMR, mean ± SD	3.23 ± 2.78	Moderate, n (%)	113 (36.7)
NLR, mean ± SD	4.36 ± 5.60	Severe, n (%)	33 (10.7)
Creatinine (mg/dL), mean ± SD	1.14 ± 0.75	Aortic regurgitation, n (%)	
INR, mean ± SD	1.27 ± 0.58	None/trivial, n (%)	94 (30.5)
Risk scores		Mild, n (%)	121 (39.3)
Naples score, mean ± SD	2.74 ± 1.01	Moderate, n (%)	68 (22.1)
Score 0	5 (1.6)	Severe, n (%)	25 (8.1)
Score 1	33 (10.7)		

Continuous variables are presented as mean ± standard deviation, and categorical variables as number (percentage). COPD, Chronic obstructive pulmonary disease; HDL, High-density lipoprotein; LDL, Low-density lipoprotein; LMR, Lymphocyte-to-monocyte ratio; LVEF, Left ventricular ejection fraction; MPV, Mean platelet volume; NLR, Neutrophil-to-lymphocyte ratio; STS, Society of Thoracic Surgeons; TAVI, Transcatheter aortic valve implantation; TEE, Transesophageal echocardiography.

62.0%). The mean STS score was 7.06 ± 5.60, and the logistic EuroSCORE was 20.40 ± 12.82. Table 1 presents comprehensive baseline characteristics.

Comparative Analysis Between Naples Score Groups

Demographic analysis showed no significant difference in age (78.97 ± 7.85 vs. 80.32 ± 7.55 years, P = 0.134); however, Group 1 had a higher proportion of female patients (73 patients, 62.4%

vs. 96 patients, 50.3%). Comorbidity distribution was generally similar between groups, with coronary artery disease slightly more prevalent in Group 1 (93 patients, 79.5% vs. 133 patients, 69.6%, P = 0.052).

Group 2 patients demonstrated significantly more compromised nutritional and inflammatory status compared to Group 1. Albumin levels were markedly lower in Group 2 (3.22 ± 0.61

Table 2. Pre-procedural patient characteristics stratified by Naples Prognostic Score in patients undergoing TAVI

Variables	Group 1 (n = 117)	Group 2 (n = 191)	Total (n = 308)	P
Demographics				
Age, years	78.97 ± 7.85	80.32 ± 7.55	79.82 ± 7.67	0.134
Female sex, n (%)	73 (62.4)	96 (50.3)	169 (54.9)	0.115
Comorbidities				
Hypertension, n (%)	94 (80.3)	156 (81.7)	250 (81.2)	0.172
Diabetes mellitus, n (%)	51 (43.6)	77 (40.3)	128 (41.6)	0.456
Coronary artery disease, n (%)	93 (79.5)	133 (69.6)	226 (73.4)	0.052
Smoking, n (%)	16 (13.7)	23 (12.0)	39 (12.7)	0.072
Pulmonary arterial hypertension, n (%)	13 (11.1)	12 (6.3)	25 (8.1)	0.065
COPD, n (%)	19 (16.2)	46 (24.1)	65 (21.1)	0.742
Previous cardiac surgery, n (%)	41 (35.0)	60 (31.4)	101 (32.8)	0.145
Laboratory values				
Albumin, g/dL	3.66 ± 0.73	3.22 ± 0.61	3.38 ± 0.68	<0.001
Lactate, mmol/L	1.44 ± 1.39	1.69 ± 2.21	1.59 ± 1.94	0.277
Total cholesterol, mg/dL	199.25 ± 52.44	154.40 ± 43.39	171.16 ± 49.73	<0.001
Triglycerides, mg/dL	140.65 ± 82.94	108.67 ± 46.76	120.73 ± 63.09	<0.001
HDL cholesterol, mg/dL	45.15 ± 13.67	39.79 ± 12.98	41.83 ± 13.47	0.001
LDL cholesterol, mg/dL	124.28 ± 43.11	92.45 ± 35.33	104.85 ± 40.63	<0.001
Creatinine, mg/dL	1.09 ± 0.49	1.17 ± 0.87	1.14 ± 0.75	0.349
Hemoglobin (pre-procedure), g/dL	11.71 ± 1.52	11.41 ± 1.71	11.53 ± 1.64	0.111
Hematocrit (pre-procedure), %	35.20 ± 4.59	34.71 ± 4.84	34.90 ± 4.75	0.376
Platelet count (pre-procedure), ×10 ³ /μL	217.03 ± 58.99	231.08 ± 75.70	225.77 ± 69.73	0.088
Lymphocyte count, ×10 ³ /μL	1.99 ± 1.01	1.34 ± 0.52	1.59 ± 0.77	<0.001
Neutrophil count, ×10 ³ /μL	4.19 ± 1.81	6.15 ± 6.73	5.40 ± 5.36	0.002
Monocyte count, ×10 ³ /μL	1.22 ± 5.52	0.63 ± 0.26	0.86 ± 3.59	0.143
Inflammatory markers				
LMR (lymphocyte-to-monocyte ratio)	4.65 ± 3.93	2.35 ± 1.04	3.26 ± 2.75	<0.001
NLR (neutrophil-to-lymphocyte ratio)	2.33 ± 1.07	5.61 ± 6.77	4.35 ± 5.45	<0.001
Echocardiographic parameters				
LVEF, %	51.48 ± 10.76	50.03 ± 11.53	50.60 ± 11.25	0.272
Aortic valve area, cm ²	0.72 ± 0.12	0.72 ± 0.13	0.72 ± 0.13	0.951
Mean gradient, mmHg	51.07 ± 12.94	48.88 ± 13.80	49.70 ± 13.49	0.169
Peak velocity, m/s	4.43 ± 0.54	4.39 ± 0.58	4.41 ± 0.56	0.637
Risk scores				
STS score	6.94 ± 5.47	7.13 ± 5.70	7.06 ± 5.60	0.778
Logistic EuroSCORE	19.80 ± 12.48	20.77 ± 13.04	20.39 ± 12.81	0.523
Rhythm disorders				
Pre-TAVI sinus rhythm, n (%)	96 (82.1)	116 (60.7)	212 (68.8)	<0.001
Atrial fibrillation (pre-procedure), n (%)	20 (17.1)	67 (35.1)	87 (28.2)	<0.001
AV block (pre-procedure), n (%)	2 (1.7)	5 (2.6)	7 (2.3)	0.242

AV, Atrial ventricular; COPD, Chronic obstructive pulmonary disease; HDL, High-density lipoprotein; LDL, Low-density lipoprotein; LMR, Lymphocyte-to-monocyte ratio; NLR, Neutrophil-to-lymphocyte ratio; STS, Society of Thoracic Surgeons; TAVI, Transcatheter aortic valve implantation.

vs. 3.66 ± 0.73 g/dL, P < 0.001). Lipid metabolism parameters also differed significantly, with Group 2 showing lower total cholesterol (154.40 ± 43.39 vs. 199.25 ± 52.44 mg/dL, P < 0.001), lower HDL cholesterol (39.79 ± 12.98 vs. 45.15 ± 13.67

mg/dL, P = 0.001), and lower LDL cholesterol (92.45 ± 35.33 vs. 124.28 ± 43.11 mg/dL, P < 0.001). Triglyceride levels were also significantly lower in Group 2 (108.67 ± 46.76 vs. 140.65 ± 82.94 mg/dL, P < 0.001).

Group 2 patients exhibited significantly elevated systemic inflammation compared to Group 1. White blood cell count was higher in Group 2 (8.21 ± 2.67 vs. $7.38 \pm 2.25 \times 10^3/\mu\text{L}$, $P = 0.006$). Differential counts showed significantly higher neutrophil counts in Group 2 (6.15 ± 3.15 vs. $4.19 \pm 1.81 \times 10^3/\mu\text{L}$, $P = 0.002$) and significantly lower lymphocyte counts (1.34 ± 0.52 vs. $1.99 \pm 1.02 \times 10^3/\mu\text{L}$, $P < 0.001$). Monocyte counts were also significantly higher in Group 2 (0.74 ± 0.34 vs. $0.58 \pm 0.24 \times 10^3/\mu\text{L}$, $P < 0.001$).

Given the non-normal distribution of inflammatory ratios, these are reported as median (IQR). The NLR was markedly higher in Group 2 [median 4.58 (IQR: 3.21–7.12) vs. 2.15 (IQR: 1.68–2.89), $P < 0.001$], while the LMR was significantly lower in Group 2 [median 1.82 (IQR: 1.34–2.67) vs. 3.84 (IQR: 2.89–5.43), $P < 0.001$]. These differences represent the defining characteristics separating the two Naples Score groups.

Echocardiographic parameters showed no significant differences between groups in LVEF ($50.03 \pm 11.53\%$ vs. $51.48 \pm 10.76\%$, $P = 0.272$), aortic valve area (0.72 ± 0.13 vs. $0.72 \pm 0.12 \text{ cm}^2$, $P = 0.951$), or mean gradient (48.88 ± 13.80 vs. $51.07 \pm 12.94 \text{ mmHg}$, $P = 0.169$). However, pulmonary artery pressure was significantly higher in Group 2 (46.76 ± 14.70 vs. $43.43 \pm 12.48 \text{ mmHg}$, $P = 0.042$). Rhythm disorders differed significantly between groups, with Group 1 showing a higher prevalence of pre-TAVI sinus rhythm (96 patients, 82.1% vs. 116 patients, 60.7%, $P < 0.001$) and Group 2 demonstrating higher rates of pre-procedural atrial fibrillation (67 patients, 35.1% vs. 20 patients, 17.1%, $P < 0.001$). Table 2 presents the detailed comparison between Naples Score Group 1 and Group 2.

Procedural Characteristics and Immediate Post-Procedural Changes

The majority of procedures were performed via percutaneous closure (259 patients, 84.1%), with surgical closure in 48 patients (15.6%). Hospital length of stay showed a non-normal distribution, with a median of 5 days (IQR: 3–7 days), and no significant difference between Naples Score groups [Group 1: 5 days (IQR: 3–6) vs. Group 2: 5 days (IQR: 3–8), $P = 0.156$]. Immediate post-procedural hemodynamics demonstrated effective valve function, with a post-procedural maximum gradient of $17.10 \pm 5.45 \text{ mmHg}$, representing a substantial reduction from pre-procedural values.

Vascular complications showed varied patterns between Naples Score groups, reflecting different pathophysiological mechanisms. Pseudoaneurysm occurred more frequently in Group 2 (11 patients, 5.8% vs. 4 patients, 3.4%, $P = 0.341$), as did hematoma formation (22 patients, 11.5% vs. 3 patients, 2.6%, $P = 0.005$). Conversely, femoral dissection was significantly more common in Group 1 (9 patients, 7.7% vs. 5 patients, 2.6%, $P = 0.014$).

The higher rate of femoral dissection in the low NPS group, despite their better overall outcomes, likely reflects procedural or anatomical factors independent of inflammatory-nutritional status. Femoral dissection may be related to vascular calcification patterns, vessel tortuosity, or technical aspects of access rather than systemic inflammation. Importantly, femoral dissections in this cohort were generally managed successfully without

Table 3. Procedural characteristics and immediate post-procedural changes

Procedural and post-procedural parameter	Values
Procedure approach	
Percutaneous closure, n (%)	259 (84.1)
Surgical closure, n (%)	48 (15.6)
Hospitalization	
Length of hospital stay (days), mean \pm SD	6.11 \pm 5.72
Immediate post-procedural hemodynamics	
Post-procedural maximum gradient (mmHg), mean \pm SD	17.10 \pm 5.45
Post-procedural hematological changes	
Hemoglobin after procedure (g/dL), mean \pm SD	10.00 \pm 1.57
Hemoglobin difference, mean \pm SD	1.52 \pm 1.46
Hematocrit after procedure (%), mean \pm SD	30.12 \pm 4.87
Platelet count after procedure ($\times 10^3/\mu\text{L}$), mean \pm SD	177.01 \pm 72.41
Creatinine after procedure (mg/dL), mean \pm SD	1.18 \pm 0.75
Rhythm and conduction complications	
New atrial fibrillation, n (%)	85 (27.6)
New AV block requiring pacemaker implantation, n (%)	33 (10.7)
Procedural complications	
Procedural failure, n (%)	7 (2.3)
Second valve implantation required, n (%)	6 (1.9)
Vascular complications	
Any bleeding, n (%)	106 (34.4)
Minor bleeding, n (%)	66 (21.4)
Major bleeding, n (%)	36 (11.7)
Life-threatening bleeding, n (%)	16 (5.2)
Pseudoaneurysm, n (%)	15 (4.9)
Hematoma, n (%)	25 (8.1)
Femoral dissection, n (%)	14 (4.5)
Valve-related complications	
Valve stenosis, n (%)	19 (6.2)
Overall complications	
Major complications, n (%)	51 (16.6)
Minor complications, n (%)	31 (10.1)
Early clinical outcomes	
Stroke, n (%)	7 (2.3)
In-hospital mortality, n (%)	37 (12.0)
Acute kidney injury, n (%)	33 (10.7)
Rehospitalization, n (%)	30 (9.7)

SD: Standard deviation.

contributing significantly to mortality, whereas hemorrhagic complications (pseudoaneurysm, hematoma) associated with high NPS carried greater clinical consequences, potentially explaining the differential mortality between groups despite this isolated finding.

Table 4. Pre-and post-procedural changes in clinical and laboratory variables

Variables	Mean difference	SE	95% CI (lower)	95% CI (upper)	P
AF (before - after)	0.006	0.015	-0.024	0.036	0.671
AV block (before - after)	-0.084	0.018	-0.121	-0.048	<0.001
Hemoglobin (before - after)	1.518	0.083	1.355	1.681	<0.001
Hematocrit (before - after)	4.773	0.257	4.267	5.278	<0.001
Platelet count (before - after)	48.736	4.034	40.798	56.674	<0.001
Creatinine (before - after)	-0.045	0.028	-0.099	0.010	0.109

AF, Atrial fibrillation; AV, Atrial ventricular; CI, Confidence interval; SE, Standard error.

Significant hematological changes occurred following the procedure. Hemoglobin levels decreased from 11.52 ± 1.64 to 10.00 ± 1.57 g/dL (mean difference 1.518 g/dL, 95% confidence interval [CI]: 1.355-1.681, $P < 0.001$). Hematocrit similarly decreased from $34.90 \pm 4.75\%$ to $30.12 \pm 4.87\%$ (mean difference 4.773%, 95% CI: 4.267-5.278, $P < 0.001$). Platelet count decreased from 225.74 ± 70.06 to $177.01 \pm 72.41 \times 10^3/\mu\text{L}$ (mean difference $48.736 \times 10^3/\mu\text{L}$, 95% CI: 40.798-56.674, $P < 0.001$). Post-procedural creatinine levels showed minimal change (1.14 ± 0.75 to 1.18 ± 0.75 mg/dL, $P = 0.109$).

New rhythm complications developed post-procedurally, with new atrial fibrillation occurring in 85 patients (27.6%) and new atrioventricular (AV) block requiring pacemaker implantation in 33 patients (10.7%). Paired analysis showed a significant increase in AV block incidence (mean difference: -0.084, 95% CI: -0.121 to -0.048, $P < 0.001$), while changes in atrial fibrillation incidence were not statistically significant ($P = 0.671$). Tables 3 and 4 detail the procedural parameters and post-procedural changes.

Clinical Complications and Adverse Outcomes

Overall bleeding complications occurred in 106 patients (34.4%), with similar rates between Group 1 and Group 2 (39 patients, 33.3% vs. 67 patients, 35.1%). However, the severity distribution differed, with Group 2 experiencing higher rates of life-threatening bleeding (13 patients, 6.8% vs. 3 patients, 2.6%) and major bleeding (26 patients, 13.6% vs. 10 patients, 8.5%). Vascular complications showed varied patterns between groups. Pseudoaneurysm occurred more frequently in Group 2 (11 patients, 5.8% vs. 4 patients, 3.4%), as did hematoma formation (22 patients, 11.5% vs. 3 patients, 2.6%). Conversely, femoral dissection was more common in Group 1 (9 patients, 7.7% vs. 5 patients, 2.6%).

Procedural failure occurred in 7 patients (2.3%) overall, with similar rates between groups (2 patients, 1.7% in Group 1 vs. 5 patients, 2.6% in Group 2). Second valve implantation was required in 6 patients (1.9%). Stroke occurred in 7 patients (2.3%), predominantly in Group 2 (6 patients, 3.1% vs. 1 patient, 0.9%). Rehospitalization rates were similar between groups (13 patients, 11.1% in Group 1 vs. 17 patients, 8.9% in Group 2).

In-hospital mortality occurred in 37 patients (12.0% overall), with a striking difference between Naples Score groups. Group 1 experienced mortality in 5 patients (4.3%), whereas Group 2 had significantly higher mortality in 32 patients (16.8%), representing a nearly fourfold increase in risk. Table 5 provides a comprehensive analysis of complications and clinical outcomes stratified by Naples Score groups.

Table 5. Comparison of complications and clinical outcomes between Group 1 and Group 2

Complication	Group 1 (n = 117) n (%)	Group 2 (n = 191) n (%)	P
Bleeding complications			
Any bleeding	39 (33.3)	67 (35.1)	0.344
Minor bleeding	27 (23.1)	39 (20.4)	0.214
Major bleeding	10 (8.5)	26 (13.6)	0.117
Life-threatening bleeding	3 (2.6)	13 (6.8)	0.016
Vascular complications			
Pseudoaneurysm	4 (3.4)	11 (5.8)	0.015
Hematoma	3 (2.6)	22 (11.5)	0.025
Femoral dissection	9 (7.7)	5 (2.6)	0.014
Procedural complications			
Closure failure	2 (1.7)	5 (2.6)	0.723
Second valve implantation required	2 (1.7)	4 (2.1)	0.619
Clinical outcomes			
Stroke	1 (0.9)	6 (3.1)	0.023
Rehospitalization	13 (11.1)	17 (8.9)	0.309
Mortality	5 (4.3)	32 (16.8)	0.012
Major complications	17 (14.5)	34 (17.8)	0.116
Minor complications	12 (10.3)	19 (9.9)	0.311

Predictors of Mortality and Major Adverse Cardiovascular Events (MACE)

Independent predictors of in-hospital mortality included age (odds ratio [OR]: 1.067, 95% CI: 1.003-1.135, $P = 0.039$), indicating that each additional year of age increased mortality risk by 6.7%. The NLR also emerged as a significant predictor (OR: 1.062, 95% CI: 1.001-1.126, $P = 0.048$), with each unit increase associated with a 6.2% higher mortality risk. Pulmonary artery pressure was independently predictive (OR: 1.039, 95% CI: 1.011-1.068, $P = 0.006$), with each mmHg increase conferring a 3.9% higher mortality risk (Table 6).

Overall, major adverse cardiovascular events occurred in 85 patients (27.6% of the total cohort). Group 1 experienced MACE in 27 patients (23.1%), whereas Group 2 had MACE in 58 patients (30.4%), representing a 32% relative increase in MACE risk. Male sex showed a protective effect (OR: 0.340, 95% CI: 0.119-0.969, $P = 0.044$), reducing MACE risk by 66%. Pre-TAVI

Table 6. Independent predictors of 30-day mortality and major adverse cardiovascular events after transcatheter aortic valve implantation

Variables	30-day mortality			MACE		
	Odds ratio	95% CI	P	Odds ratio	95% CI	P
Sex (male vs. female)	0.738	0.319-1.709	0.478	0.340	0.119-0.969	0.044
Age	1.067	1.003-1.135	0.039	1.027	0.963-1.096	0.418
LMR	1.108	0.963-1.274	0.153	0.800	0.558-1.146	0.224
NLR	1.062	1.001-1.126	0.048	0.834	0.627-1.109	0.212
Hypertension	1.014	0.332-3.094	0.981	1.004	0.292-3.456	0.995
Diabetes mellitus	1.653	0.696-3.923	0.254	1.935	0.758-4.943	0.168
CAD	1.169	0.444-3.078	0.751	1.494	0.476-4.693	0.491
COPD	0.781	0.280-2.177	0.636	1.597	0.585-4.365	0.361
Previous cardiac surgery	0.520	0.164-1.644	0.265	2.186	0.756-6.322	0.149
Pre-TAVI sinus rhythm	0.981	0.407-2.364	0.965	0.295	0.112-0.776	0.013
Pre-procedure Hgb	0.892	0.701-1.133	0.348	0.837	0.610-1.149	0.271
Creatinine	1.400	0.931-2.106	0.106	1.280	0.771-2.128	0.340
Mean gradient	0.989	0.959-1.021	0.502	0.946	0.907-0.987	0.010
PAP	1.039	1.011-1.068	0.006	0.989	0.954-1.026	0.549

CAD, Coronary artery disease; COPD, Chronic obstructive pulmonary disease; LMR, Lymphocyte-to-monocyte ratio; NLR, Neutrophil-to-lymphocyte ratio; TAVI, Transcatheter aortic valve implantation; PAP, Pulmonary artery pressure; MACE, Major adverse cardiovascular events.

sinus rhythm was also protective (OR: 0.295, 95% CI: 0.112-0.776, $P = 0.013$), reducing MACE risk by 70.5%. Mean gradient demonstrated a protective effect (OR: 0.946, 95% CI: 0.907-0.987, $P = 0.010$), with each mmHg increase associated with a 5.4% reduction in MACE risk (Table 6).

ROC Analysis for 30-Day Mortality Prediction

ROC curve analysis was performed using the continuous Naples Score (range: 0-4) as the predictor variable for 30-day all-cause mortality. The Naples Score demonstrated good discriminative ability, with an area under the curve (AUC) of 0.692 (standard error: 0.042, 95% CI: 0.611-0.774, $P < 0.001$). The optimal cut-off value was identified as a Naples Score ≥ 2.5 , yielding a sensitivity of 86.5% (95% CI: 71.2-95.5%) and a specificity of 47.6% (95% CI: 41.7-53.5%), with a positive predictive value of 16.8% and a negative predictive value of 96.6%.

For comparison, established surgical risk scores showed the following performance: the STS score achieved an AUC of 0.559 (95% CI: 0.486-0.633, $P = 0.107$; not statistically significant) with an optimal cut-off of 7.5% (sensitivity: 54.1%, specificity: 60.4%), and the logistic EuroSCORE demonstrated an AUC of 0.559 (95% CI: 0.488-0.631, $P = 0.107$; not statistically significant) with an optimal cut-off of 18.5% (sensitivity: 59.5%, specificity: 54.2%). The superior AUC and statistical significance of the Naples Score suggest better discriminative performance compared to traditional risk scores in our TAVI cohort (Figure 2).

ROC Analysis for MACE Prediction

ROC analysis using the continuous Naples Score for MACE prediction demonstrated limited discriminative ability, with an AUC of 0.549 (standard error: 0.036, 95% CI: 0.479-0.619, $P = 0.185$), which did not reach statistical significance. The optimal

cut-off value of Naples Score ≥ 2.5 yielded a sensitivity of 68.2% (95% CI: 57.4-77.8%) and a specificity of 43.9% (95% CI: 37.5-50.5%), with a positive predictive value of 30.4% and a negative predictive value of 79.5%.

Similarly, traditional risk scores showed comparable modest performance for MACE prediction: the STS score (AUC: 0.526, 95% CI: 0.453-0.598, $P = 0.460$) and the logistic EuroSCORE (AUC: 0.537, 95% CI: 0.465-0.609, $P = 0.301$), neither of which reached statistical significance. The limited discriminative ability of all scores for MACE prediction likely reflects the heterogeneous nature of composite endpoints and the multifactorial etiology of various adverse cardiovascular events (Figure 2).

Discussion

This study represents one of the largest single-center investigations evaluating the prognostic utility of the NPS in predicting early mortality following TAVI. Our findings demonstrate that the NPS, which incorporates inflammatory and nutritional parameters, serves as a significant predictor of 30-day mortality in patients undergoing TAVI, with those in the high NPS group (scores 3-4) experiencing a nearly fourfold increase in mortality risk compared to patients in the low NPS group (scores 0-2).

The utility of the NPS in cardiovascular disease has been increasingly recognized, with recent studies demonstrating its prognostic value across various cardiac conditions.¹⁰ Our results align with emerging evidence supporting the role of combined inflammatory-nutritional indices in predicting cardiovascular outcomes. The observed mortality rates of 4.3% in the low NPS group versus 16.8% in the high NPS group underscore the clinical relevance of this scoring system for

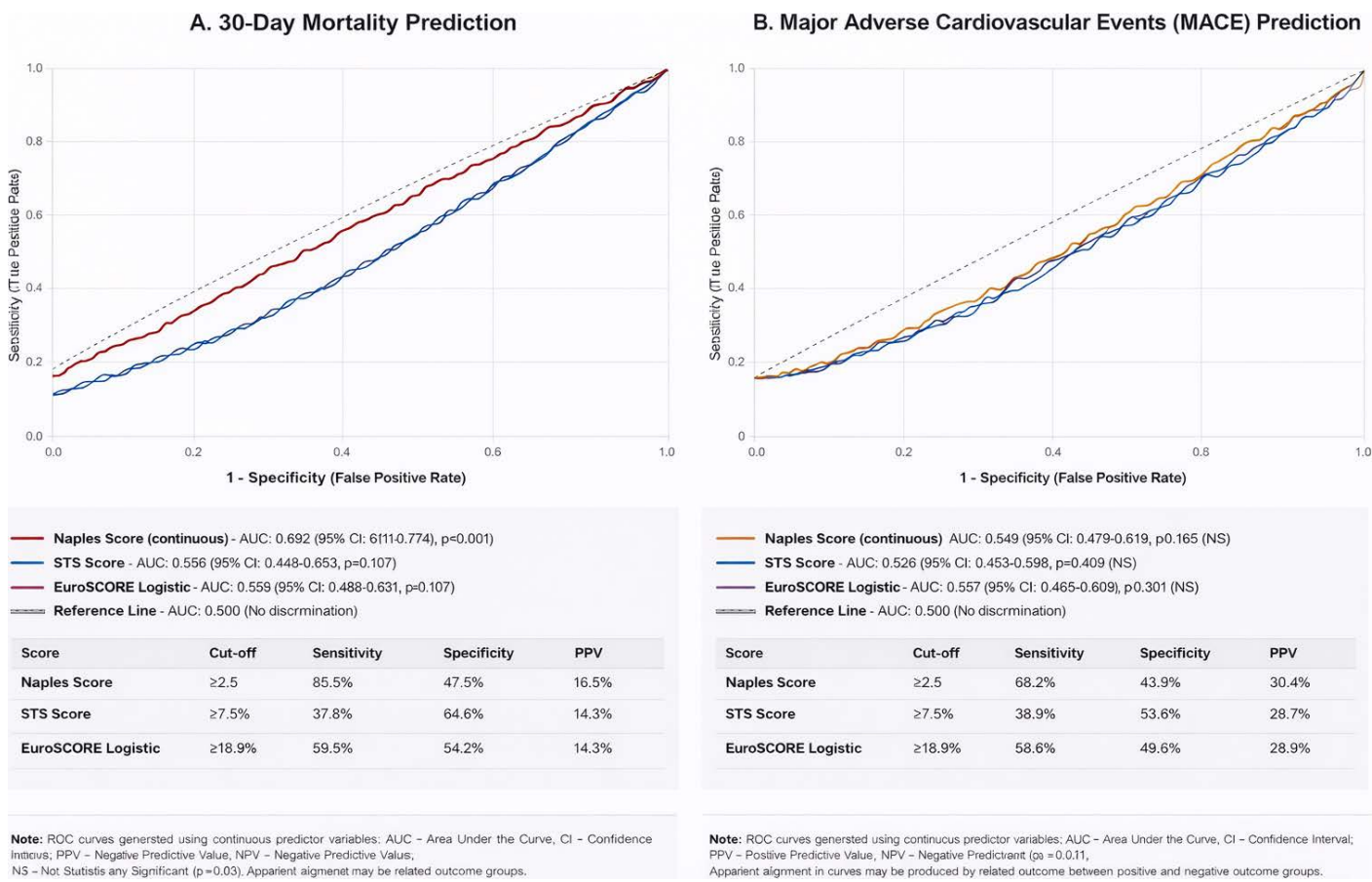


Figure 2. Receiver operating characteristic curves demonstrating the performance of the Naples Score in predicting mortality and major adverse cardiovascular events (MACE).

risk stratification in TAVI patients. The ROC analysis provided important insight into the discriminative performance of the Naples Score across different outcomes. For prediction of 30-day mortality, the Naples Score demonstrated statistically significant discriminative ability (AUC: 0.692, P < 0.001), with high sensitivity (86.5%) but modest specificity (47.6%) at the optimal cut-off value of ≥ 2.5. Notably, the Naples Score outperformed both the STS score and the logistic EuroSCORE, neither of which achieved statistical significance in our cohort (both AUC: 0.559, P = 0.107). This superior performance may reflect the Naples Score's ability to capture acute inflammatory and nutritional status, which may be more relevant for early post-procedural outcomes than traditional surgical risk models designed for broader patient populations. However, the Naples Score demonstrated limited discriminative ability for MACE prediction (AUC: 0.549, P = 0.185), performing similarly to traditional risk scores. This differential performance underscores an important distinction: while inflammatory-nutritional status strongly influences early mortality risk, the heterogeneous nature of MACE—encompassing myocardial infarction, stroke, bleeding complications, and vascular events—likely requires a multidimensional risk assessment incorporating procedural, anatomical, and patient-specific factors beyond inflammation and nutrition alone.^{17,18} The modest specificity of the Naples Score for mortality prediction (47.6%) suggests that while it effectively identifies high-risk patients, approximately half of

low-risk patients would be misclassified, limiting its utility as a standalone decision-making tool but supporting its role as part of a comprehensive risk assessment.^{19,20}

The prognostic utility of the NPS likely reflects the complex interplay between systemic inflammation, nutritional status, and cardiovascular outcomes. Patients with elevated NPS demonstrated significantly higher NLRs and lower LMRs, indicating heightened systemic inflammation and impaired immune function. This inflammatory milieu has been associated with increased procedural complications, impaired wound healing, and enhanced thrombotic risk following cardiac interventions.^{21,22} The nutritional component of the NPS, reflected by lower albumin and cholesterol levels in the high NPS group, suggests compromised metabolic status and reduced physiological reserve. Hypoalbuminemia, in particular, has been consistently associated with poor outcomes in cardiac surgery and interventional procedures, reflecting not only nutritional deficiency but also underlying inflammatory processes and reduced oncotic pressure that may compromise hemodynamic stability.^{23,24}

Interestingly, our study revealed comparable discriminative performance between the NPS and established surgical risk scores (STS score and logistic EuroSCORE) for predicting early mortality, with all achieving similar AUC values around 0.55-0.56. This finding suggests that simple inflammatory-nutritional

markers may provide prognostic information comparable to complex, multivariable risk prediction models. The practical advantage of the NPS lies in its simplicity and the routine availability of its components in standard preoperative laboratory panels, potentially making it a more accessible tool for real-time risk assessment.^{5,25} The modest performance of all risk scores in our cohort may reflect the evolving nature of TAVI patient populations and procedural techniques. As TAVI indications have expanded to lower-risk patients and procedural outcomes have improved, traditional risk models developed for higher-risk surgical populations may require recalibration or supplementation with novel biomarkers.^{4,26}

While the NPS demonstrated significant utility in predicting early mortality, its performance in predicting major adverse cardiovascular events was more limited. This differential performance may reflect the heterogeneous nature of MACE endpoints, which encompass various complications with distinct pathophysiological mechanisms. The protective effects observed for male sex, sinus rhythm, and higher mean gradients in MACE prediction suggest that procedural and anatomical factors may be more relevant for composite endpoints than inflammatory-nutritional status alone.^{17,18} The integration of the NPS into clinical practice could enhance preoperative risk assessment and patient counseling. Patients with high NPS scores might benefit from enhanced perioperative monitoring, optimized nutritional support, and potentially modified procedural approaches. Furthermore, identification of high-risk patients through the NPS could facilitate targeted interventions to improve nutritional status and reduce systemic inflammation before elective procedures.^{27,28}

The observed association between high NPS and increased rates of life-threatening bleeding and vascular complications suggests that these patients may require modified anticoagulation strategies and enhanced vascular access site management. Such risk-stratified approaches could potentially improve procedural outcomes and reduce complications in high-risk subgroups.^{29,30}

Limitations

Several limitations warrant consideration when interpreting our results. The retrospective, single-center design limits generalizability and introduces potential selection bias. The exclusion of patients with non-transfemoral access routes, while reducing confounding, may limit the applicability of our findings to the broader TAVI population. Additionally, the relatively short 30-day follow-up period, while clinically relevant for early mortality assessment, does not capture longer-term prognostic implications of elevated NPS.

The moderate sample size, while adequate for primary endpoint analysis, may have limited power to detect associations with less frequent complications. Furthermore, the study period spanning more than a decade encompasses significant evolution in TAVI techniques, device technology, and patient selection criteria, potentially introducing temporal confounding factors.

Our ROC analysis revealed modest AUC values for MACE prediction, indicating limited discriminative ability for composite endpoints. This limitation highlights that inflammatory-

nutritional markers alone may be insufficient for predicting the heterogeneous array of complications encompassed by MACE, and that multidimensional risk models incorporating anatomical, procedural, and clinical factors may be necessary for comprehensive risk stratification.

Conclusion

This single-center retrospective study of 308 patients demonstrates that the NPS serves as a significant predictor of 30-day mortality following TAVI, with patients having high NPS scores (3-4) experiencing a nearly fourfold increase in mortality risk compared to those with low NPS scores (0-2). The NPS achieved good discriminative ability for mortality prediction (AUC: 0.692, $P < 0.001$), performing comparably to established surgical risk scores while offering the advantages of simplicity and routine laboratory availability through its incorporation of NLR, LMR, serum albumin, and total cholesterol levels. These findings suggest that preoperative NPS assessment could enhance risk stratification, patient counseling, and perioperative management strategies in patients undergoing TAVI, with high-risk individuals potentially benefiting from targeted interventions, including nutritional optimization and enhanced monitoring protocols. Future multicenter, prospective studies are warranted to validate these findings and to investigate whether interventions designed to modify NPS components can improve clinical outcomes in this growing patient population.

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Informed Consent: Given the retrospective design and use of de-identified clinical data, the ethics committee waived the requirement for informed consent.

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