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ORIGINAL RESEARCH

STRUCTURAL

A Geriatric Assessment Score Predicting 1-Year Mortality and Functional Decline After TAVR

The GASS-TAVR Study

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ABSTRACT

BACKGROUND A significant proportion of older adults undergoing transcatheter aortic valve replacement (TAVR) fail to achieve meaningful clinical benefit at 1 year, highlighting the need for improved risk stratification.

OBJECTIVES The aim of this study was to develop and validate a geriatric score to determine 1-year mortality or functional decline.

METHODS A multicenter cohort study was conducted across 3 high-volume academic centers in Italy from January 2020 to December 2022. Consecutive patients ≥75 years of age with severe symptomatic aortic stenosis evaluated for TAVR were enrolled. Participants underwent a comprehensive geriatric assessment, including basic activities of daily living (BADL) and the Mini Nutritional Assessment-Short Form. The Society of Thoracic Surgeons score was also collected. The primary outcome was a composite of all-cause mortality or significant functional decline (loss of ≥2 BADL or failure to improve if already impaired) at 1 year. A logistic regression model identified predictive factors, and a new risk score was derived in a 66% derivation cohort and tested in a 34% validation cohort.

RESULTS Among 562 patients (median age 83 years, 58.5% women), 78 (13.9%) met the primary outcome over 11 months (Q1-Q3: 10-12 months). Mini Nutritional Assessment-Short Form score, BADL, lower estimated glomerular filtration rate, and elevated pulmonary artery systolic pressure were independently associated with the composite outcome. The derived score showed high discrimination (area under the curve, 0.92; 95% CI: 0.88-0.96). In validation, performance remained robust (area under the curve, 0.87; 95% CI: 0.79-0.95), outperforming the Society of Thoracic Surgeons score.

CONCLUSIONS A geriatric assessment-based model significantly improved the prediction of 1-year mortality or functional decline in older TAVR candidates, offering a valuable tool to refine patient selection and avoid procedural futility. (JACC Cardiovasc Interv. 2026;19:813-824) © 2026 The Authors. Published by Elsevier on behalf of the American College of Cardiology Foundation. This is an open access article under the CC BY license (http://creativecommons.org/licenses/by/4.0/).

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ABBREVIATIONS AND ACRONYMS

AUC = area under the receiver-operating characteristic curve

BADL = basic activities of daily living

CGA = comprehensive geriatric assessment

eGFR = estimated glomerular filtration rate

IADL = instrumental activities of daily living

MPI = Multidimensional Prognostic Index

MNA-SF = Mini Nutritional Assessment-Short Form

NPV = negative predictive value

PASP = pulmonary artery systolic pressure

PPV = positive predictive value

STS = Society of Thoracic Surgeons

TAVR = transcatheter aortic valve replacement

Transcatheter aortic valve replacement (TAVR) has transformed the management of symptomatic severe aortic stenosis, offering a lifesaving alternative for intermediate- to high-risk surgical candidates, particularly older adults, and its indications are rapidly evolving.[1,2] Despite its success in improving survival and alleviating symptom burden, up to 30% of high-risk patients experience procedural futility, defined as the absence of meaningful clinical benefit or survival advantage at 1 year postintervention.[3,4] This persistent challenge underscores the need for refined patient selection strategies that go beyond conventional risk stratification.

Existing predictive models rely primarily on conventional demographic, clinical, and instrumental variables.[5-7] However, emerging evidence suggests that frailty and global functional impairment play crucial roles in determining outcomes, making their integration into risk assessment essential.[8] A multidimensional geriatric evaluation, encompassing frailty, comorbidity, and disability, may provide a more comprehensive and clinically relevant framework for risk stratification. However, few published risk scores integrate such an approach, and existing models are often derived from small, single-center cohorts with moderate predictive capacity and generalizability.[8-10]

Moreover, as the indication to TAVR has shifted from initially high-risk to low-risk patients over the past decade,[11,12] thus increasing procedural volumes and health care costs, whether multidimensional, comprehensive geriatric assessment (CGA) may help stratify prognosis in more contemporary TAVR cohorts is unexplored. As such, in the present multicenter study, we aimed to develop and validate a novel risk score designed to improve the prediction of 1-year prognosis (all-cause mortality and physical functional decline) in older adults with severe symptomatic aortic stenosis undergoing TAVR, using data derived from systematic CGA.

METHODS

STUDY DESIGN. The present study included a prospective cohort of older adults diagnosed with severe, symptomatic aortic stenosis, referred FOR TAVR at 3 high-volume referral centers in Italy (Careggi, Padua, and Ferrara university hospitals) from January 2020 to December 2022. As such, the final sample size was determined by the availability of data during the study period.

All consecutive patients with symptomatic severe aortic stenosis were invited to participate in a CGA during cardiovascular evaluation, which is routinely offered at all participating centers prior to discussion or case presentation to the heart team. Geriatricians are part of the heart team at the 3 participating institutions, with a common standardized protocol. The evaluation included an in-depth assessment of basic activities of daily living (BADL) and instrumental activities of daily living (IADL), malnutrition screening via the Mini Nutritional Assessment-Short Form (MNA-SF), cognitive screening (Pfeiffer test), and Pressure Ulcer risk (Exton-Smith Scale), and results were imputed in the Multidimensional Prognostic Index (MPI),[13] with the objective of identifying highly informative geriatric domains that might be associated with postprocedural 1-year all-cause mortality or disability. These may be used in addition to the Society of Thoracic Surgeons (STS) risk score, which is a validated predictive model estimating 30-day mortality and morbidity in cardiac surgery that is now routinely used for TAVR, with scores categorized as low (<4%), intermediate (4%-8%), and high (>8%) risk.[12] All clinical, instrumental, laboratory, and CGA-derived data were stored in a study registry. Supplemental Table 1 summarizes all items and tools used during baseline CGA.

Follow-up at 1 year was conducted through standardized telephone interviews, performed as part of

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The authors attest they are in compliance with human studies committees and animal welfare regulations of the authors' institutions and Food and Drug Administration guidelines, including patient consent where appropriate. For more information, visit the Author Center.

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routine clinical quality control procedures at all participating centers, and included survival status and assessment of BADL. The study was conducted in accordance with the principles of the Declaration of Helsinki, and the requirement to obtain written informed consent was waived by the ethics committee because of the observational nature of the study and the use of anonymized data. Ethics approval for the heart team at the leading center was granted by AOU Careggi (CEAVC P/903/253); the Transparent Reporting of a Multivariable Prediction Model for Individual Prognosis or Diagnosis checklist is provided in Supplemental Table 2. In accordance with the European Union's General Data Protection Regulation and institutional policies, individual-level data are not publicly available. Deidentified data (with a data dictionary) and analysis code can be obtained from the corresponding authors upon reasonable request, pending a data-use agreement and, where applicable, ethics approval.

STUDY PARTICIPANTS. Consecutive patients with severe, symptomatic aortic stenosis were screened for participation at heart valve clinics. Inclusion criteria were age ≥75 years, candidacy for TAVR, and the provision of informed consent. Exclusion criteria were emergency surgery, concomitant replacement or repair of another heart valve or the aorta, clinical or hemodynamic instability, severe cognitive impairment, language barrier, and any condition leading to ineligibility for TAVR, such as concurrent diseases with expected poor short-term prognosis.

STRUCTURE OF THE CGA. A detailed structure of the CGA is summarized in Supplemental Table 1. BADL included bathing, dressing, toileting, transferring, continence, and eating (with disability generally defined as having 3 or fewer preserved BADL);[14] IADL encompass the ability to use the telephone, shop for necessities, prepare meals, perform housekeeping and laundry tasks, manage transportation, adhere to medication regimens, and handle financial responsibilities.[15]

The MNA-SF evaluates nutritional status in 6 key domains: appetite and food intake, assessing any decline due to loss of appetite, digestive issues, or difficulty chewing or swallowing; recent weight loss, categorizing unintended weight reduction over the past 3 months; mobility, determining whether the patient is bedbound, able to move within the home, or fully independent; psychological stress or acute illness, identifying recent significant health events; neuropsychological problems, screening for dementia or depression; and body mass index or calf circumference, using either body mass index classification or calf circumference as a proxy when body mass index is unavailable. It provides a score ranging from 0 to 14, where scores of 12 to 14 indicates normal nutritional status, 8 to 11 suggest risk for malnutrition, and 0 to 7 reflect overt malnutrition, allowing the early identification of patients who may benefit from nutritional interventions.[13]

The Pfeiffer test is a brief cognitive screening tool that assesses short-term memory, orientation, and calculation abilities, with a total score ranging from 0 to 10; cognitive impairment is categorized as mild (3 or 4 errors), moderate (5-7 errors), or severe (≥8 errors), helping identify patients at risk for dementia.[13]

The Exton-Smith Scale evaluates pressure ulcer risk by assessing mental condition, mobility, activity level, incontinence, and general physical condition, with a total score ranging from 5 to 20; patients scoring ≤15 are classified as high risk, requiring preventive measures to avoid pressure ulcers.[13]

Finally, all information from the CGA was entered into the MPI, a frailty-based prognostic tool scoring patients from 0 to 1, where MPI-1 (≤0.33) indicates low, MPI-2 (0.34-0.66) moderate, and MPI-3 (≥0.67) high risk for mortality.[13]

COVARIATES. Medical records were used to extract cardiac and noncardiac comorbidities, preprocedural laboratory results, echocardiographic data, and information to determine the STS score. Data definitions were based on the standards set forth by the STS Adult Cardiac Surgery Database and the Valve Academic Research Consortium.[16] Observers were trained at the beginning of the study, and all data were reviewed centrally for quality and consistency.

OBJECTIVE. Our primary objective was to develop and validate a rapid cardiogeriatric score to determine the risk for 1-year mortality or functional decline to be administered prior to TAVR referral.

The primary outcome was a composite of: 1) all-cause mortality at 1 year following TAVR; or 2) lack of benefit, defined by loss of ≥2 BADL or lack of improvement from ≤3 BADL or new onset of BADL or IADL disability (≤3 BADL).

STATISTICAL ANALYSIS. Continuous variables are expressed as median (Q1-Q3) and were compared using the Wilcoxon rank sum test. Categorical variables are expressed as proportions and were compared using the chi-square test or Fisher exact test as applicable. CGA items were analyzed primarily in their continuous or categorical form according to commonly accepted a priori cutoffs.

To develop a score to predict the composite outcome, the study population was randomly divided into derivation (66%) and validation (34%) cohorts. Candidate variables were defined a priori on the basis of knowledge of common risk factors among older patients diagnosed with cardiovascular diseases;[17-19] age, sex, NYHA functional class, heart rhythm, malnutrition (MNA-SF), BADL, renal function (estimated glomerular filtration rate [eGFR] using the Chronic Kidney Disease Epidemiology Collaboration), and pulmonary artery systolic pressure (PASP). Given the small number of events in the development cohort, only the most significant associations were selected for the multivariable model, following the principle of that recommends a limitation of 1 covariate per 10 events to avoid overfitting.[20] To select the covariate for the score, a multiple logistic regression with backward selection method based on the Bayesian information criterion in the derivation cohort was used. The weights of the selected covariates are created by scaling between −5 and 5 and rounding at the second decimal the maximum likelihood coefficient estimation of the multiple logistic regression model. As the score is a linear combination of the selected covariates, the intercept, being constant across all individuals, was omitted from the final equation, as it does not influence discrimination or relative risk stratification. The predictive capability of the score was estimated using the area under the receiver-operating characteristic curve (AUC) with its 95% CI. The cutoff for the score was selected using Youden's index. The predictive capability of the score and the cutoff performance were evaluated in the validation cohort.

For model comparison, AUCs of the proposed score vs established scores (STS and MPI) were contrasted using DeLong's test. To quantify reclassification performance, net reclassification improvement was calculated on a continuous scale with its 95% CI using 1,000 bootstrap resamples. Decision curve analysis was conducted to assess net clinical benefit across a range of threshold probabilities. Finally, we computed sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), positive likelihood ratio, and negative likelihood ratio for the derived score cutoff, all reported with corresponding 95% CIs. Missing data were minimal and were handled using complete-case analysis. The significance level was set to 5%. SPSS Statistics for Macintosh version 30.0 (IBM), SAS version 9.4 (SAS Institute), and RStudio 2024.04.2 build 764 (Posit) were used for statistical analyses.

RESULTS

BASELINE CHARACTERISTICS. The study population consisted of 562 patients included over 2 years (median age 83 years; Q1-Q3: 80-87 years), 329 of whom were women (58.5%). Overall, 78 (13.9%) developed the composite outcome within 1 year, with 52 deaths (9.3%). Supplemental Figure 1 presents the Kaplan-Meier survival analysis for all-cause mortality; median survival time was 11 months (Q1-Q3: 10-12 months). The baseline characteristics of those who did or did not develop the composite outcome are reported in **Table 1**. Briefly, patients who experienced the composite outcome had marginally higher STS scores but were more likely to have histories of myocardial infarction, peripheral artery disease, chronic obstructive pulmonary disease, and chronic kidney disease (stage IIIB, Chronic Kidney Disease Epidemiology Collaboration). They also had significantly lower eGFRs, higher PASPs, and slightly lower hemoglobin levels. Overall, a transfemoral approach was used in 91% of patients in both cohorts (data not reported). Among a subset of 360 patients with available data, clinical suspicion of transthyretin cardiac amyloidosis was reported in 35 of patients (9.7%), with 10 patients receiving confirmed diagnoses.CGA

Results of baseline CGAs are summarized in **Table 2**. Patients experiencing worse outcomes were characterized by more advanced disability in both BADL and IADL. Functional status trajectories (restricted to BADL) in the year after TAVR are represented in **Figure 1**. Overall, the number of preserved BADL was inversely associated with the incidence of events at 1 year: 1 BADL (n = 36 [6.4%]; composite outcome: n = 31 [86.9%]), 2 BADL (n = 5 [0.9%]; composite outcome: n = 1 [20.0%]), 3 BADL (n = 26 [4.6%]; composite outcome: n = 6 [23.1%]), 4 BADL (n = 68 [12.1%]; composite outcome: n = 6 [8.8%]), 5 BADL (n = 144 [25.6%]; composite outcome: n = 10 [6.9%]); 6 BADL (n = 283 [50.4%]; composite outcome: n = 24 [8.5%]).

Furthermore, patients with worse outcome had a higher risk for malnutrition and were more frequently cognitively impaired. Accordingly, they also had a higher median MPI.

DERIVATION AND VALIDATION OF A CGA-BASED PREDICTIVE MODEL. **Table 3** presents the results of the multivariable logistic regression analysis, conducted on a randomly selected 66% of the study population. Age, NYHA functional class, and heart

TABLE 1 Baseline Clinical Characteristics of the Study Population by Composite Outcome

	Overall (N = 562)	Composite Outcome: No (n = 484, 86.1%)	Composite Outcome: Yes (n = 78, 13.9%)	*P* Value
Age at referral, y	83 (80-86)	83 (80-87)	83 (80-86)	0.766
Female	328 (58.4)	290 (60.1)	38 (48.7)	0.058
NYHA functional class	2 (2-3)	2 (2-3)	3 (2-3)	0.384
STS risk score	3.78 (2.57-6.12)	3.59 (2.46-5.03)	4.12 (2.79-6.50)	0.021
Low risk	331 (58.9)	299 (61.8)	32 (41.0)	
Intermediate risk	170 (30.2)	134 (27.7)	36 (46.2)	
High risk	61 (10.9)	51 (10.5)	10 (12.8)	
BMI, kg/m^2	26.3 (24.1-29.5)	27.2 (24.8-29.6)	25.5 (23.0-29.4)	0.058
Previous myocardial infarction	63 (11.2)	45 (9.3)	14 (17.9)	0.002
Previous cardiac surgery[a]	31 (7.7)	26/348 (7.4)	5/54 (9.3)	0.646
Moderate to severe liver disease	4 (0.7)	2 (0.4)	2 (2.5)	0.102
Peripheral artery disease	100 (17.8)	79 (16.4)	21 (27.2)	0.049
Cerebrovascular disease	43 (7.7)	35 (7.2)	8 (10.2)	0.201
Stroke/TIA[a]	16 (3.9)	12/348 (3.4)	4/54 (7.4)	0.122
COPD	51 (9.1)	38 (7.8)	13 (16.6)	0.001
Diabetes mellitus	95 (16.9)	78 (16.1)	17 (21.8)	0.068
eGFR, mL/min/1.73 m^2	61 (46-74)	68 (51-80)	47 (37-63)	<0.001
CKD stage > IIIb (KDIGO)	126 (22.4)	91 (18.8)	35 (44.9)	<0.001
Atrial fibrillation	74 (13.2)	58 (12.0)	16 (20.5)	0.038
LVEF, %	56 (47-60)	57 (48-62)	54 (44-59)	0.094
Aortic valve area, cm^2	0.47 (0.37-0.58)	0.46 (0.37-0.57)	0.50 (0.38-0.61)	0.051
Mean aortic gradient, mm Hg	45 (33-61)	45 (31-59)	46 (37-65)	0.199
Low-flow low-gradient aortic stenosis	55 (9.8)	46 (9.5)	9 (11.5)	0.575
Moderate/severe mitral regurgitation[a]	57/402 (14.2)	47/348 (13.5)	10/54 (18.5)	0.326
PASP, mm Hg	40 (31-48)	35 (30-41)	46 (38-57)	<0.001
Hemoglobin, g/dL	11.8 (10.4-12.9)	12.0 (10.8-13.0)	11.1 (9.6-12.5)	0.010

Values are median (Q1-Q3), n (%), or n/N (%). [a]Available for 402 patients.

BMI = body mass index; CKD = chronic kidney disease; COPD = chronic obstructive pulmonary disease; KDIGO = Kidney Disease: Improving Global Outcomes; LVEF = left ventricular ejection fraction; GFR = estimated glomerular filtration rate; PASP = pulmonary artery systolic pressure; STS = Society of Thoracic Surgeons; TIA = transient ischemic attack.

rhythm were not associated with the composite outcome. By contrast, higher MNA-SF score, preserved BADL, and higher eGFR were linked to a lower likelihood of the composite outcome, whereas elevated PASP was associated with an increased risk (Bayesian information criterion = 184,55).

Scaled and rounded coefficients from the model were used to derive a formula for a risk score, GASS-TAVR (Geriatric Assessment Score for Transcatheter Aortic Valve Replacement) (**Central Illustration**), to predict the composite outcome as follows:

$$\text{GASS-TAVR} = -3.40 \times \text{MNA-SF score} - 5.00 \times \text{BADL} - 0.35 \times \text{eGFR} + 1.20 \times \text{PASP}.$$

In the derivation cohort, the score demonstrated strong discrimination, with an AUC of 0.92 (95% CI: 0.88-0.96) (**Figure 2A**). Net reclassification improvement over STS (continuous) was 0.670 (95% CI: 0.557-0.783).

A cutoff of −28.30, identified using Youden's index (J = 0.72), yielded sensitivity of 86.0% (95% CI: 73.3%-94.2%), specificity of 86.3% (95% CI: 82.0%-89.8%), PPV of 49.4% (95% CI: 38.5%-60.4%), NPV of 97.5% (95% CI: 95.0%-99.0%), positive likelihood ratio of 6.26 (95% CI: 4.44-8.83), and negative likelihood ratio of 0.16 (95% CI: 0.08-0.31). Score values were significantly lower among patients with favorable outcomes (−46.33 [95% CI: −57.43 to −35.35] vs -7.66 [95% CI: −24.70 to 15.05]; *P* < 0.001) (Supplemental Figures 2A and 3A).

Decision curve analysis confirmed superior net clinical benefit of the GASS-TAVR over the STS score and the MPI across relevant threshold probabilities.

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TABLE 2 Comprehensive Geriatric Assessment at Baseline

	Overall (N = 562)	Composite Outcome: No (n = 484, 86.1%)	Composite Outcome: Yes (n = 78, 13.9%)	*P* Value
Preserved BADL	5 (3-6)	6 (5-6)	4 (1-6)	<0.001
Preserved IADL	6 (5-8)	6 (5-8)	5 (4-7)	0.078
MNA-SF score	11 (10-12)	12 (10-13)	9 (9-10)	<0.001
Pfeiffer test score >3	112 (19.9)	79 (16.4)	33 (42.3)	<0.001
Exton-Smith Scale score	19 (17-20)	19 (17-20)	18 (16-20)	0.587
Number of drugs	7 (5-9)	7 (5-9)	8 (6-9)	0.133
MPI	0.31 (0.25-0.38)	0.31 (0.25-0.38)	0.43 (0.31-0.50)	<0.001
Low risk	363 (64.6)	339 (70.0)	24 (30.8)	<0.001
Intermediate risk	191 (34.0)	141 (29.1)	50 (64.1)	
High risk	8 (1.4)	4 (0.9)	4 (5.1)	

Values are median (Q1-Q3) or n (%).

BADL = basic activities of daily living; IADL = instrumental activities of daily living; MNA-SF = Mini Nutritional Assessment–Short Form; MPI = Multidimensional Prognostic Index.

Correlation with STS score was weak (Pearson's $r = 0.16$; 95% CI: 0.06-0.26), indicating that the score captures distinct risk information. Event distribution plots showed adverse outcomes clustered above the threshold of −28.3 regardless of STS category (Supplemental Figure 4A).

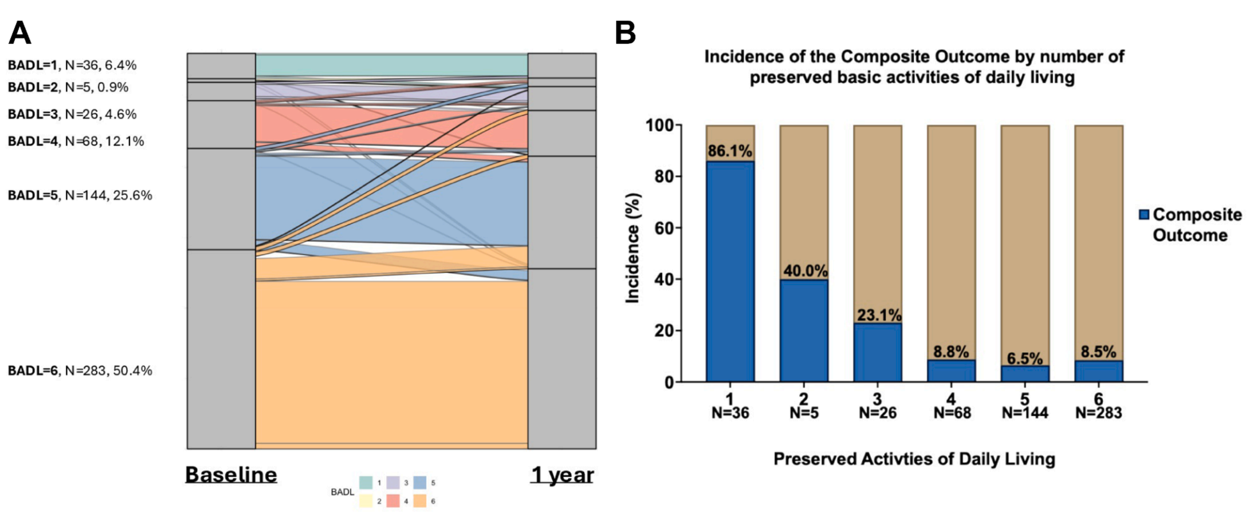
In the validation cohort (34% [n = 190]), the score remained highly discriminatory, with an AUC of 0.87 (95% CI: 0.79-0.95), again outperforming the STS score (categorical AUC, 0.54 [95% CI: 0.44-0.64]; continuous AUC, 0.44 [95% CI: 0.33-0.55]) and the MPI (categorical AUC, 0.71 [95% CI: 0.61-0.81]; continuous AUC, 0.71 [95% CI: 0.60-0.82]; $P < 0.001$ for all). Net reclassification improvement vs STS (continuous) was 0.595 (95% CI: 0.423-0.766).

At the same cutoff of −28.30, sensitivity was 76.9% (95% CI: 56.4%-91.0%), specificity 82.9% (95% CI: 76.3%-88.3%), PPV 41.7% (95% CI: 27.6%-56.8%), NPV 95.8% (95% CI: 91.0%-98.4%), positive likelihood ratio 4.50 (95% CI: 2.91-6.97), and negative likelihood ratio 0.28 (95% CI: 0.13-0.58). The score was again significantly lower in patients without events (−45.83 [95% CI: −54.66 to −34.48] vs −11.63 [95% CI: −23.92 to 3.41]; $P < 0.001$) (Supplemental Figure 4B) and maintained a weak correlation with STS score.

DISCUSSION

In our contemporary multicenter cohort study of 562 older adults undergoing TAVR, 78 patients (13.9%) met the composite outcome of all-cause mortality, lack of functional improvement, or significant functional decline at 1 year. To improve risk stratification, we developed and validated a novel risk score integrating components of the CGA that can be readily

FIGURE 1 Functional Status Trajectories After Transcatheter Aortic Valve Replacement



This figure illustrates how functional status changed during the year after transcatheter aortic valve replacement. (A) Sankey diagram depicting transitions in the number of preserved basic activities of daily living (BADL) from baseline to 1-year follow-up; dark pathways represent patients who died. (B) Incidence of the composite outcome across baseline BADL categories. The figure highlights the prognostic relevance of baseline disability and its association with adverse clinical outcomes.

obtained during routine assessment along with traditional cardiovascular risk factors. Notably, as also demonstrated in previous studies, although age is a marker for increased risk for adverse events in the long term,[21] it should not be a definitive inclusion or exclusion criterion, as it is not an actionable risk marker;[22] our findings reaffirm that chronological age alone does not significantly affect 1-year prognosis in older TAVR candidates. Our score had higher predictive accuracy compared with the STS score and the MPI (which includes additional CGA components such as IADL, cognitive profile, pressure ulcer risk, and polypharmacy). These results emphasize the added value of CGA in refining prognostic assessment for TAVR candidates beyond conventional surgical risk models.

IMPLICATIONS FOR CLINICAL MANAGEMENT. Conventional surgical risk models, such as the STS score, focus primarily on short-term mortality risk and neglect key geriatric domains such as functional independence and nutritional status, both critical items for older individuals. The present results align with a previous experience in our center on elective cardiac surgery candidates, in which it was shown that STS score performance was limited in older adults and that predictive accuracy improved when geriatric domains such as physical performance were emphasized over traditional surgical metrics.[23] It should be acknowledged, however, that the STS score was originally developed to predict in-hospital and perioperative (ie, 30-day) surgical mortality and has not been calibrated for 1-year outcomes or for transcatheter procedures, though the STS score was used in the 2016 and 2021 European Society of Cardiology guidelines to identify high-, intermediate-, and low-risk candidates for TAVR;[12,24] thus, direct comparison with our 1-year model should be interpreted with caution.

In recent years, despite the improvement of transcatheter aortic valves, simplification of the procedure, and reduction of procedural risk (<1% at experienced centers), 1-year all-cause mortality in low-risk TAVR patients has remained stable at approximately 10%, highlighting a residual risk that persists despite successful valve correction. Evidence suggests that clinical complexity not captured by sole cardiovascular assessment and defined even by the number of comorbidities may already slightly improve the estimation of mortality risk (eg, the recently published TARI score[25]). In these cases, however, diagnostic and therapeutic inertia for specific conditions, such as chronic obstructive pulmonary disease, may limit generalizability of these models. In contrast, poor preprocedural functional status seems a strong determinant of both mortality and functional decline at 1 year regardless of procedural success, as recently shown in a prospective cohort study of 246 patients undergoing TAVR or surgical aortic valve replacement.[26]

TABLE 3 Multivariable Logistic Regression Analysis Model for the Derivation of a Score to Predict the Composite Outcome

	Derivation Cohort (N = 372, 66%)			
	Logistic Regression Estimates	OR (95% CI)	Coefficient, Scaled and Rounded	*P* Value
Age	–	–	–	0.064
Female	–	–	–	0.209
NYHA functional class	–	–	–	0.589
Rhythm (AF vs SR)	–	–	–	0.068
MNA-SF score	−0.342	0.71 (0.58-0.87)	−3.40	0.0007
BADL	−0.505	0.60 (0.47-0.77)	−5.00	<0.001
eGFR	−0.036	0.96 (0.95-0.98)	−0.35	0.003
PASP	0.124	1.13 (1.08-1.18)	1.20	<0.001
Intercept				0.499

AF = atrial fibrillation; SR = sinus rhythm; other abbreviations as in Tables 1 and 2.

Several geriatric domains and multidomain indexes may improve risk prediction post-TAVR in varying ways.[27] However, most require physical performance assessments and cognitive tests, which are relatively time consuming and impose formal training for accurate reproduction and interpretation.

For instance, the Clinical Frailty Scale (a semiquantitative tool) slightly improved the predictive value of the STS score in a cohort of more than 1,200 patients in the OCEAN-TAVI (Optimized Transcatheter Valvular Intervention) study.[17] In another mixed cohort of more than 1,000 TAVR and surgical aortic valve replacement patients, a frailty model incorporating lower extremity weakness, cognitive impairment, anemia, and hypoalbuminemia improved the poor predictive value of 1-year mortality of the STS score, yielding a final C statistic of 0.78.[28] Along a similar line, a frailty index based on cognition, mobility, nutrition, IADL, and BADL was found to be associated with functional decline at 6 months post-TAVR.[29] Subsequent analysis in more contemporary cohorts showed that key items such as

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CENTRAL ILLUSTRATION The GASS-TAVR for 1-Year Risk Stratification After TAVR

GASS-TAVR Score for Predicting 1-Year Mortality or Disability in Older Adults Undergoing TAVR

Patients Characteristics

- 562 adults ≥75 years from 3 Italian TAVR centers
- Median age 83 years
- 58% women
- Median STS 3.78
- Median follow-up 11 months

Score Components

Malnutrition
Mini Nutritional Assessment-Short Form

Renal Function
CKD-EPI

Functional Capacity
Basic Activities of Daily Living

Pulmonary Pressure
Echocardiography

Study Characteristics

- Prospective registry 2020-2022
- Primary outcome: 1-year mortality or ≥2 BADL decline
- Score development (random sampling) derivation: n = 372; validation: n = 190

Main Results

- Primary outcome occurred in 78 patients (13.9%); 1-year mortality occurred in 52 patients (9.3%)
- GASS-TAVR Score = −3.40 × MNASF -5.00 × BADL −0.35 × eGFR + 1.20 × PASP
- AUC: Derivation 0.92 (95% CI: 0.88-0.96); Validation 0.87 (95% CI: 0.79-0.95)
- A cutoff of -28.3 yielded a sensitivity of 86.0%, specificity of 86.3 and NPV 97.5% in the derivation cohort; performance remained robust in validation cohort (NPV 95.8%)

- A simple 4-item cardiogeriatric score (MNA-SF, BADL, eGFR, PASP) accurately predicted 1-year mortality or functional decline after TAVR (AUC: 0.92).
- The score outperforms traditional models and shows a high negative predictive value (>95%).
- By capturing biologic vulnerability, the GASS-TAVR score may support Heart Teams in reducing futility and guiding targeted prehabilitation strategies.

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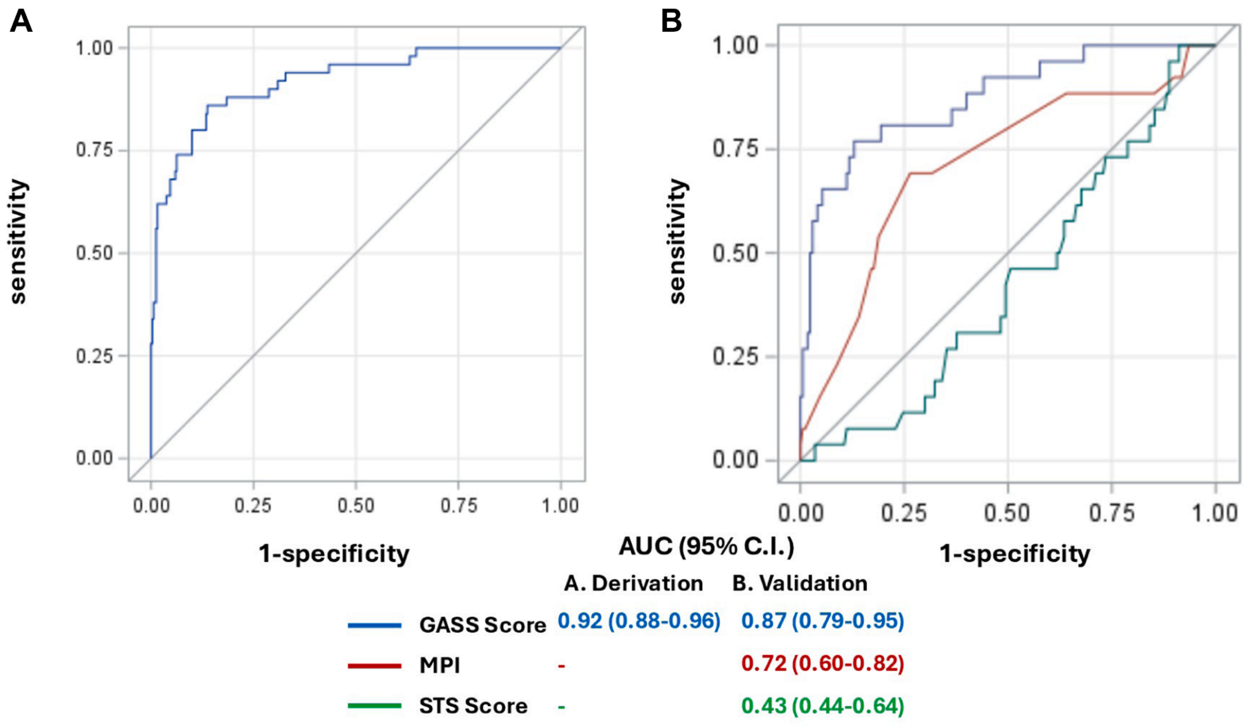
The GASS-TAVR (Geriatric Assessment Score for Transcatheter Aortic Valve Replacement) integrates 4 routinely available domains—malnutrition (Mini Nutritional Assessment-Short Form [MNA-SF] score), basic activities of daily living (BADL), renal function (estimated glomerular filtration rate [eGFR]), and pulmonary artery systolic pressure (PASP)—to predict 1-year risk for mortality or disability. A threshold of −28.3 identifies patients at high risk, potentially guiding heart team discussions and individualized treatment decisions. The score demonstrated high predictive accuracy (area under the receiver-operating characteristic curve [AUC], 0.92), superior to the Society of Thoracic Surgeons (STS) risk score and the Multidimensional Prognostic Index (MPI). CKD-EPI = Chronic Kidney Disease Epidemiology Collaboration; NPV = negative predictive value; TAVR = transcatheter aortic valve replacement.

loss of >1 BADL or risk for malnutrition according to the MNA-SF led to a more than doubled risk for mortality.[19] Along the same line, functional and metabolic frailty was found to be predictive of 1-year survival post-TAVR.[30] Although our present validation was focused on comparing the GASS-TAVR with the STS and MPI models, future multicenter analyses are warranted to directly benchmark the GASS-TAVR against other available frailty-based and procedural scores to confirm its external performance, generalizability, and potential implementation in clinical practice.

Following a similar principle of carefully selecting a limited set of meaningful variables, our score achieved further improvements in sensitivity and specificity through a streamlined baseline assessment of malnutrition (MNA-SF score), functional capacity (BADL), renal function (eGFR), and PASP, which can

FIGURE 2 Discriminative Performance of the GASS-TAVR Score



This figure evaluates receiver-operating characteristic curves for the GASS-TAVR (Geriatric Assessment Score for Transcatheter Aortic Valve Replacement). (A) Performance in the derivation cohort. (B) Performance in the validation cohort compared with the Society of Thoracic Surgeons (STS) risk score and the Multidimensional Prognostic Index (MPI). The purpose is to demonstrate the strong discriminative ability of the GASS-TAVR and its superiority to established prognostic tools. AUC = area under the receiver-operating characteristic curve.

be promptly and easily obtained during aortic stenosis assessment. Although PASP is not formally part of the traditional CGA, it was retained in the score because of its strong and reproducible association with adverse outcomes after TAVR, particularly in the presence of right heart dysfunction or tricuspid regurgitation.[31,32] Our model obtained a C statistics of 0.92 in the derivation cohort and 0.87 in the validation cohort, suggesting significantly higher predictive capacity of combined functional, nutritional, laboratory, and echocardiographic parameters. Of note, in our cohort, the choice to focus on BADL rather than IADL was supported by their stronger prognostic performance and clinical reproducibility across sites. Although IADL were initially considered, their predictive utility was limited, likely because of gender-related variability, their collinearity with cognitive profile, and their dependency on social context rather than biological reserve.

Interestingly, in our work, the MPI, despite incorporating a broader range of geriatric variables, performed significantly worse than the novel score. This could be attributed to several factors. Originally developed to predict outcomes in acutely hospitalized patients, among whom it achieved an AUC of 0.75,[13] the MPI does not integrate cardiac or cardiovascular risk factors, which are crucial in defining the prognosis of patients with heart valve disease.

Another remarkable finding is the high NPV of our model, which supports its clinical usefulness in identifying patients who are most likely to benefit from TAVR. This not only enhances patient selection but also prevents the inappropriate allocation of resources in patients unlikely to obtain any mid-term procedural benefit, an aspect increasingly emphasized in European and U.S. guidelines, which recommend paying particular attention to the issue of futile procedures.[2,11] Our findings also reinforce the growing recognition that chronological age alone is an inadequate determinant of surgical candidacy and that, because of their prognostic impact through competitive mortality, geriatric syndromes play a more central role in decision-making.

FUTURE DIRECTIONS. As TAVR indications continue to expand in lower risk populations, traditional surgical risk scores are becoming increasingly inadequate, highlighting the need for refined predictive models that reflect the changing demographics and epidemiology of the general population.[8] Although our work contributes to addressing this gap, further external validation in larger and more diverse populations is essential to confirm the generalizability of our findings. Although our study did not directly assess social or family support, the observed associations between disability and outcomes are likely to remain robust across different cultural contexts, although intergenerational support structures, such as those more common in southern Europe, may influence the lived experience and mitigate the negative impact of functional decline and dependence.

Additionally, our study raises important questions regarding potential interventional strategies ahead of TAVR. Unlike static risk factors such as age—which is only marginally relevant, as confirmed by the literature and our findings—certain components of our model are modifiable and could aid clinicians during heart team discussions: higher scores may represent an opportunity for structured prehabilitation programs to optimize patients before TAVR, potentially improving outcomes and reducing procedural futility. Targeted interventions, such as nutritional supplementation and renal function optimization, could be systematically incorporated into preprocedural care pathways and also represent a novel research perspective.

In this context, ongoing trials such as the PERFORM-TAVR (Protein and Exercise to Reverse Frailty in Older Men and Women Undergoing Transcatheter Aortic Valve Replacement) trial[18] are expected to provide valuable insights into the potential benefits of pre-TAVR nutritional supplementation and exercise in reversing frailty. Future research should evaluate whether implementing such interventions on the basis of our predictive model could further enhance post-TAVR functional recovery and survival outcomes.

STUDY LIMITATIONS. First, the low event rate in the validation cohort led to a relatively low PPV, though this was mitigated by the high NPV, making our novel score useful to rule out poor outcomes and, hence, to reduce futility as strongly recommended by European and U.S. guidelines.[2,11]

Second, our sample size was limited to 3 high-volume centers, which may affect the results' generalizability, but the multicenter design still enhances external validity. External validation in international cohorts and at both academic and nonacademic centers would be essential to assess broader applicability. Although our cohort included a high proportion of elderly women, the relatively elevated transvalvular gradients likely reflect referral patterns to high-volume tertiary centers. This also may limit the generalizability of our findings to populations with low-gradient aortic stenosis. In addition, not all participating centers performed a systematic screening for transthyretin cardiac amyloidosis, leading to potential miss of dual pathology. Although the Italian context is characterized by traditionally strong family support structures, recent studies have shown that loneliness and social isolation are independently associated with worse cardiovascular outcomes and may exacerbate frailty.[33,34] Although we did not directly assess social support, the strong prognostic value of frailty and disability observed suggests these associations are likely generalizable across different health care systems and sociocultural settings. Nonetheless, future studies should further examine how social connectedness may influence vulnerability and outcomes in older TAVR candidates. Fairness analysis was not performed, because of the number of events. Furthermore, study enrollment started at the beginning of the COVID-19 pandemic, and this may have limited the overall sample size. Patients with severe cognitive impairment were excluded from the present analysis, which may explain the low prevalence of patients at high MPI risk in our cohort, which in turn may be responsible for the low predictive power of the MPI altogether. Moreover, data on delirium and length of stay were not collected by study design.

Finally, our model did not incorporate objective physical performance tests such as the Short Physical Performance Battery, though functional status was assessed through validated BADL measures, which remain highly relevant to geriatric risk stratification.

CONCLUSIONS

In this multicenter study, a simplified risk score based on geriatric assessment outperformed traditional surgical models in predicting 1-year hard outcomes for older patients undergoing TAVR. By integrating essential factors such as nutrition, functional status, renal function, and echocardiographic parameters, this approach may enhance patient selection and optimize resource allocation. Further validation in external international cohorts is necessary to confirm our preliminary findings.

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PERSPECTIVES

WHAT IS KNOWN? TAVR is increasingly offered to older adults with severe aortic stenosis, but a significant proportion derive limited survival or functional benefit at 1 year. Conventional risk models, such as the STS score, inadequately capture geriatric factors such as malnutrition, disability, and frailty, which are known to affect prognosis.

WHAT IS NEW? This multicenter study introduces and validates the GASS-TAVR, a simple, geriatric-based tool integrating nutritional status (MNA-SF score), basic activities of daily living (BADL), renal function, and pulmonary pressure to predict 1-year mortality or functional decline. The score outperforms traditional risk models and demonstrates high discrimination across derivation and validation cohorts.

WHAT IS NEXT? Future studies should externally validate this model across diverse populations and investigate whether interventions targeting modifiable components such as nutrition or renal optimization can improve outcomes. Integration of geriatric domains into standard pre-TAVR pathways may help minimize procedural futility and guide personalized treatment decisions.

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APPENDIX For supplemental figures and tables, please see the online version of this paper.