Turkish Journal of Geriatrics
2025; 28(2):150–158

DOI: 10.29400/tjgeri.2025.431

Murat KOÇ[1]
Ufuk MUNGAN[1]
Kaan KAYA[1]
Özer KANDEMİR[1]
Bahadır GÜLTEKİN[1]
Süleyman SÜRER[1]
Mustafa SEREN[1]
İbrahim DUVAN[1]
Emre KAYMAKÇI[1]
Burçin ÇAYHAN KARADEMİR[1]
Renda CIRCI[1]
Hasan KARAYAKA[1]
Ferit ÇİÇEKÇİOĞLU[1]

[1] University of Health Sciences, Ankara Etlik City Hospital, University of Health Sciences, Ankara Etlik City Hospital, Department of Cardiovascular Surgery, Ankara, Turkey

Correspondence

Murat KOÇ
Phone : +903127970000
e-mail : drmuratkoc@yahoo.com

Received : May 17, 2025
Accepted: May 25, 2025

Cite this article as:
Koç M, Mungan U, Kaya K et al. The Impact of the Clinical Frailty Scale on Prosthesis Selection and Early Mortality in Elderly Patients Undergoing Aortic Valve Replacement. Turkish Journal of Geriatrics2025;28(2):150–158.doi:10.29400/tjgeri.2025.431

ORIGINAL ARTICLE

THE IMPACT OF THE CLINICAL FRAILTY SCALE ON PROSTHESIS SELECTION AND EARLY MORTALITY IN ELDERLY PATIENTS UNDERGOING AORTIC VALVE REPLACEMENT

Abstract

Introduction: This study explored the impact of the Clinical Frailty Scale on prosthesis selection and early postoperative outcomes in elderly patients undergoing surgical aortic valve replacement.

Materials and Method: In this retrospective cohort study conducted at a single center, patients aged ≥ 65 years who underwent isolated aortic valve replacement between January 2023 and January 2025 were examined. The Clinical Frailty Scale was used to evaluate preoperative frailty and categorize patients into three frailty levels. Data on implanted valves (mechanical, conventional bioprosthesis, and sutureless bioprosthesis), operative details, and 30-day mortality were collected. Multivariate regression models were used to identify significant associations.

Results: A total of 122 patients were included in the study. Patients with higher Clinical Frailty Scale scores were more likely to receive sutureless valves ($p<0.001$). Clinical Frailty Scale was a moderate predictor of early mortality, with an odds ratio of 3.66 and 95% confidence interval of 1.31–10.18 ($p = 0.010$), outperforming EuroSCORE II in predictive accuracy (AUC 0.71 compared to 0.63). Patients with sutureless valves had shorter intensive care unit and hospital stays ($p<0.001$), whereas complications remained consistent across the valve types. A weak but significant positive correlation was observed between prosthesis size/ body surface area ratio and 30-day mortality (Spearman's $\rho=0.186$; $p=0.040$).

Conclusion: The Clinical Frailty Scale is a significant indicator of valve selection and prediction of early postoperative mortality in elderly patients undergoing aortic valve replacement. Incorporating frailty evaluation into pre-surgery planning could improve outcomes in this at-risk group.

Keywords: Transcatheter Aortic Valve Replacement; Frailty; Aged; Mortality; Heart Valve Prosthesis; Risk Assessment.

INTRODUCTION

By 2030, one in every six people in the world will be aged 60 years or older, according to the World Health Organization (WHO) (1). As the population ages and life expectancy increases, the number of elderly patients requiring cardiac surgical interventions will also increase. Aortic stenosis is one of the most common valvular heart diseases across all age groups, but particularly among individuals > 65 years of age, surgical aortic valve replacement (AVR) is the most effective therapy (2). However, for older patients, the decision to proceed with AVR is increasingly complicated because of aging-associated health burdens and frailty.

Frailty is a multifactorial syndrome characterized by an age-related decline in physiological reserves, leading to increased vulnerability to stressors. It is not just a function of age and may vary significantly between people of the same age. It has been widely documented that frailty independently predicts poor surgical outcomes in older adults, including longer length of stay, higher complication rates, and higher mortality (3-5).

Risk assessment tools, such as EuroSCORE II and the Society of Thoracic Surgeons (STS) score, analyze patient demographics and pre-existing comorbidities to determine surgical risk. However, frailty is often omitted from these models, which may underestimate perioperative risks in patients, especially in older and frail populations (6).

The Clinical Frailty Scale (CFS) is a simple and widely used measure of frailty (7). This scale, which ranges from 1 (very fit) to 9 (terminally ill), covers a 9-point spectrum and enables rapid assessment of a patient's frailty at the bedside. The CFS is a sensitive clinical test for predicting postoperative complications and mortality (8-10); therefore, it is increasingly incorporated into preoperative evaluations. The increasing prevalence of aortic valve disease in the aging population necessitates a comprehensive approach to preoperative risk assessment, with a particular focus on frailty, as chronological age alone is not a sufficient indicator of surgical suitability (11).

Although frailty is gaining recognition as an essential factor, limited data exist regarding its impact on prosthetic valve choice in this population undergoing surgical AVR. Age, life expectancy, comorbidities, and anatomical characteristics generally dictate the decision of mechanical versus traditional stented bioprosthetic versus sutureless valves. However, the impact of frailty on clinical decision-making has yet to be fully studied (12).

This study aimed to evaluate the impact of CFS on prosthetic valve selection and early postoperative outcomes, particularly 30-day mortality, in elderly patients undergoing AVR. We hypothesized that higher frailty scores would be associated with poor early outcomes and a higher tendency to choose less invasive valve types in this high-risk cohort.

MATERIALS AND METHOD

This retrospective observational cohort study was a single-center study conducted at a tertiary cardiac surgery center. Ethical approval was granted by the institutional ethics committee before data collection (approval number: AEŞH-BADEK-2025-0660).

All patients aged ≥ 65 years who underwent surgical AVR at our center between January 2023 and January 2025 were included in the study. Patients who underwent emergency surgery, had active malignancy, had incomplete preoperative or postoperative data, or did not have documented CFS evaluation were excluded. After excluding patients based on these criteria, 122 patients were included in the final analysis.

Preoperative frailty was measured using the Clinical Frailty Scale (CFS) derived from the Canadian Study of Health and Aging (CSHA) (Table 1) (10). The CFS is measured on a 9-point scale, where scores can range from 1 (very fit) to 9 (terminally ill), allowing for a quick assessment of frailty in patients. The patients were classified into three groups according to their

Table 1. Canadian Study of Health and Aging (CSHA) Clinical Frailty Scale.

CFS Score	Clinical Description
1	Very fit
2	In good condition
3	Well managed
4	Vulnerable (mild frailty)
5	Mild frailty
6	Moderate frailty
7	Severe frailty
8	Very severe frailty
9	Terminally ill

CFS = Clinical Frailty Scale

CFS scores: low (1–3), moderate (4–5), and high (≥ 6) frailty. These assessments were conducted by trained personnel from the cardiovascular surgery team during the preoperative evaluation. The individual EuroSCORE II was calculated to estimate the surgical risk (13). Transthoracic echocardiography was performed before surgery in all patients to evaluate valvular problems and left ventricular function. The body surface area (BSA) was calculated using the Mosteller formula, and the prosthesis size/BSA ratio was calculated for each patient.

The surgical approach was through median sternotomy with cardiopulmonary bypass and moderate hypothermia. Decisions regarding prosthetic valves (mechanical, stented bioprosthetic, or sutureless bioprosthetic) were based on patient age, concomitant illness, anatomical features, and frailty status. Prosthesis selection was not dictated by a rigid institutional algorithm; rather, it was informed by a combination of clinical judgment and consensus among the attending surgeons. Considerations included patient age, anatomical suitability, comorbid burden, functional capacity, and notably, frailty status as assessed by the CFS. Patients and their families participated in the final shared decision-making process, consistent with institutional patient-centered care protocols. Postoperative care was performed according to the institution's standardized protocol. The primary endpoint was all-cause mortality 30 days post-surgery. The secondary outcomes were notable complications after the procedure (bleeding, arrhythmia, and infection), duration of intensive care unit (ICU) stay, and total hospital stay length. Surgical complications were defined according to the Society of Thoracic Surgeons (STS) criteria (14).

Statistical Analysis

IBM SPSS Statistics software (version 26; IBM Corp., Armonk, NY, USA) was used for statistical analyses. Continuous variables were evaluated for normality using the Kolmogorov–Smirnov and Shapiro–Wilk tests. Continuous variables are presented as mean ± standard deviation, and categorical variables are presented as frequencies and percentages. Depending on the valve type, group comparisons were made for continuous variables: CFS, EuroSCORE II, ICU and hospital stay, and prosthesis size/BSA ratio. Normally distributed variables were analyzed using one-way analysis of variance (ANOVA), whereas the Kruskal–Wallis test was applied to non-normally distributed variables. For post-hoc tests, we used Tukey's test after ANOVA and the Mann–Whitney U test after the Kruskal–Wallis test. Independent predictors of prosthetic valve type were identified using a multinomial logistic regression approach, and the independent variables included CFS, EuroSCORE II score, age, sex, and significant comorbidities (diabetes mellitus, chronic obstructive pulmonary disease, and chronic kidney disease). Multivariable analysis using logistic regression was performed to identify 30-day mortality predictors, with results presented as odds ratios (ORs) and 95% confidence intervals (CIs).

Receiver operating characteristic (ROC) curve analysis was used to assess the power of the CFS and EuroSCORE II in predicting 30-day mortality, with the AUC calculated. The relationships between the selected variables were evaluated using Spearman's rank correlation coefficient. The Youden Index was used to establish the optimal cutoff points in the ROC analysis. A p-value of less than 0.05 was considered statistically significant.

Our cohort analysis revealed significant findings regarding the impact of frailty on surgical outcomes.

RESULTS

The baseline demographic and clinical characteristics of the 122 patients included in the study are summarized and organized according to their frailty levels in Table 2. There was a notable correlation between increased frailty and older age; individuals in the high frailty category (CFS ≥6) had an average age of 72.6 ± 3.9 years, whereas those in the low frailty category (CFS 1–3) had an average age of 68.1 ± 3.5 years ($p < 0.001$). Additionally, EuroSCORE II values increased with the severity of frailty, with the high frailty group showing an average of 5.2 ± 1.3%, compared to 1.9 ± 0.8% in the low frailty group ($p < 0.001$), suggesting a heightened surgical risk for frail patients.

Patients with frailty exhibited a higher incidence of comorbidities. Hypertension and diabetes mellitus were notably more common in individuals with moderate-to-high frailty than in those with low frailty ($p = 0.046$ and $p = 0.049$, respectively). Conversely, there were no significant differences between the groups regarding sex distribution or prevalence of chronic obstructive pulmonary disease (COPD) ($p = 0.673$ and $p = 0.121$, respectively).

Table 3 outlines the postoperative outcomes categorized according to the valve type. Patients received days and hospital stay, with an average stay of 1.6 ± 0.6 days, and the hospital stay averaged 5.1 ± 1.9 days. In comparison, those with conventional bioprosthetic valves experienced longer ICU stays (2.4 ± 0.8 days) and hospital stays (7.6 ± 2.4 days).

Table 2. Baseline Characteristics of Patients by Frailty Group (CFS)

Characteristic	CFS 1–3 (n=27)	CFS 4–5 (n=58)	CFS ≥6 (n=37)	p-value
Age (mean ± SD)	68.1 ± 3.5	70.3 ± 4.2	72.6 ± 3.9	<0.001
Male sex (%)	66.7%	65.5%	59.5%	0.673
EuroSCORE II (%)	1.9 ± 0.8	3.6 ± 1.1	5.2 ± 1.3	<0.001
Hypertension (%)	55.6%	70.7%	78.4%	0.046
Diabetes Mellitus (%)	18.5%	31.0%	40.5%	0.049
COPD (%)	7.4%	13.8%	18.9%	0.121

P-values were calculated using ANOVA or chi-square tests as appropriate. CFS: Clinical Frailty Scale, SD: Standart Deviation, COPD: Chronic Obstructive Pulmonary Disease

Table 3. Postoperative Outcomes by Valve Type

Outcome	Mechanical (n=45)	Bioprosthetic (n=41)	Sutureless (n=36)	p-value
ICU stay (days, mean ± SD)	2.9 ± 1.0	2.4 ± 0.8	1.6 ± 0.6	<0.001
Hospital stay (days)	8.3 ± 2.7	7.6 ± 2.4	5.1 ± 1.9	<0.001
Post-op complications (%)	22.2%	17.1%	16.7%	0.622
30-day mortality (%)	8.9%	9.8%	13.9%	0.547

ICU: Intensive Care Unit

Similarly, individuals with mechanical valves spent 2.9 ± 1.0 days in the ICU and 8.3 ± 2.7 days in the hospital ($p < 0.001$ for both comparisons). These data suggest that sutureless valves may promote more rapid recovery.

Postoperative complication rates were not significantly different between the groups ($p = 0.622$). Major complications, including atrial arrhythmias and sternal wound infections, occurred at comparable rates across all groups. The 30-day mortality rate was similar across valve types, with mechanical valves at 8.9%, conventional bioprosthetic valves at 9.8%, and sutureless valves at 13.9 %($p = 0.547$), suggesting that sutureless valves may enhance operative efficiency without affecting short-term safety. Prosthesis–patient mismatch was assessed using the prosthesis size-to-body surface area (size/BSA) ratio. This ratio was highest in patients with conventional bioprostheses (mean, 12.97) and slightly lower in those with mechanical and sutureless valves. Among the valve types, patients with mechanical valves exhibited significant variations in size/BSA ratios (Kruskal–Wallis H = 8.53, $p = 0.014$).

Analysis of the relationship between the size/BSA ratio and 30-day mortality revealed a weak but statistically significant positive correlation (Spearman $\rho = 0.186$, $p = 0.040$). This finding indicates that smaller ratios may be associated with increased early mortality rates. Conversely, no significant correlation was observed between the size/BSA ratio and incidence of complications. The optimal cutoff for the size/BSA ratio, determined through ROC analysis, was 11.17, which resulted in 100% sensitivity but only 29% specificity. While this suggests a theoretical potential for identifying high-risk patients, its practical value in discrimination may be limited owing to its low specificity. The overall 30-day in-hospital mortality rate was 10.7% (13 of 122 patients). In the multivariable logistic regression analysis, CFS emerged as the sole significant independent predictor of early mortality (odds ratio [OR], 3.66; 95% CI: 1.31–10.18; $p = 0.010$). Neither EuroSCORE II nor valve type was independently associated with 30-day mortality ($p = 0.185$ and $p = 0.481$, respectively) (Table 4). The size/BSA ratio approached statistical significance ($p = 0.098$).

In the ROC analysis assessing the predictive capabilities of CFS and EuroSCORE II, CFS demonstrated a superior AUC of 0.71 (95% CI: 0.61–0.81) compared to EuroSCORE II, which had an AUC of 0.63 (95% CI: 0.56–0.71) (Figure 1). Notably, the group with moderate frailty (CFS 4–5) exhibited the highest 30-day mortality rate at 13.8%, followed by the high frailty group (CFS ≥6) at 10.8% and the low frailty group (CFS 1–3) at 3.7%. A regression model was developed to explore this nonlinear pattern, which included both CFS and its squared term (CFS^2) in the model. Both variables were statistically significant ($p = 0.039$ for CFS and $p = 0.047$ for CFS^2), suggesting a nonlinear inverse U-shaped relationship between frailty and early mortality.

Table 4. Multivariate Logistic Regression for 30-day mortality

Variable	Odds Ratio (OR)	95% CI	p-value
Clinical Frailty Score	3.66	1.31 – 10.18	0.010
EuroSCORE II	1.19	0.92 – 1.54	0.185
Valve Type (Sutureless vs others)	1.44	0.52 – 3.98	0.481
Size/BSA	2.03	0.87 – 4.75	0.098

CI: Confidence Interval; BSA: Body Surface Area

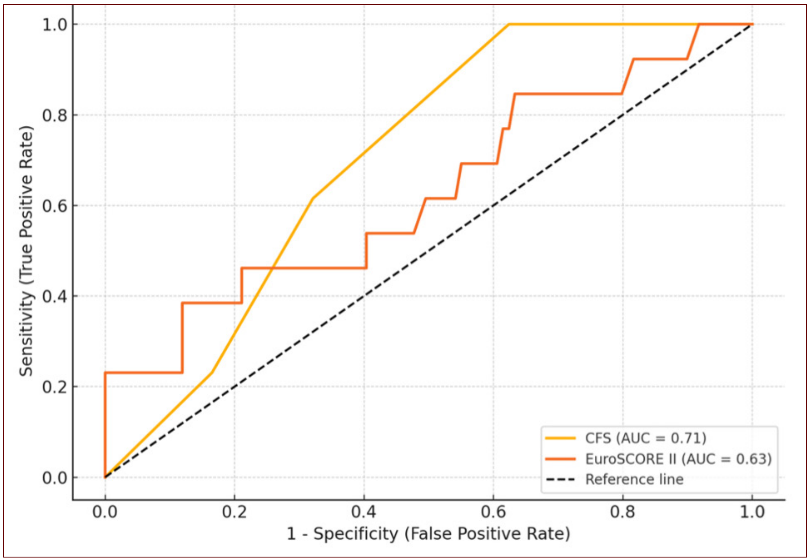

Figure 1. Receiver operating characteristic (ROC) curves comparing the predictive performance of the Clinical Frailty Score (CFS) and EuroSCORE II for 30-day mortality. The CFS demonstrated better discrimination with an AUC of 0.71 compared to EuroSCORE II (AUC = 0.63). The reference line represents the performance of the non-informative classifier.

DISCUSSION

As the global population ages, the number of elderly patients presenting with aortic stenosis and requiring surgical intervention is expected to rise substantially, making the accurate assessment of surgical risk in this vulnerable population increasingly critical. The aging process results in greater susceptibility to frailty, a multifaceted syndrome characterized by decreased physiological reserve and increased vulnerability to stressors. Frailty is not merely a consequence of age but a distinct clinical entity that significantly impacts surgical outcomes, leading to increased morbidity and mortality and prolonged hospital stays (8).

This study explored the association between frailty and early postoperative outcomes in older patients undergoing isolated surgical aortic valve replacement (AVR). Our results emphasize that frailty, as measured by the Clinical Frailty Scale (CFS), is not only a crucial indicator of early mortality but also significantly influences prosthesis selection. The notably higher use of sutureless bioprosthetic valves in patients with higher CFS scores indicates a conscious choice to reduce operative time and invasiveness in frail individuals with aortic stenosis. This is consistent with increasing evidence supporting sutureless valves as a suitable option for high-risk groups, mainly because they can decrease cardiopulmonary bypass and aortic cross-clamp duration. Filip et al. also showed that sutureless valves provide hemodynamic benefits and promote quicker recovery in frail patients (15).

However, frequent mechanical valve implantation in patients with low CFS scores indicates an expected longer lifespan and a remarkable ability to manage lifelong anticoagulation therapy. This trend supports the growing perspective that treatment choices should be based on a detailed evaluation of functional status and biological reserves rather than age (16, 17). Notably, the group with moderate frailty (CFS 4–5) experienced the highest 30-day mortality rate, which was unexpected, as it was not the severely frail group. This surprising outcome might be due to a “selective patient effect,” where those with severe frailty were more thoroughly screened, optimized before surgery, or given nonsurgical treatment options (18, 19). In contrast, those with moderate frailty might be marginally operable but still have significant physiological risks. These findings imply that the link between frailty and mortality may not be straightforward but could follow an inverse U-shaped pattern, a theory supported by our regression analysis that includes both linear and quadratic CFS terms. It is important to note that less invasive valve implantation options should be considered, especially in patients with moderate fragility.

Moreover, CFS showed a more remarkable ability to predict early mortality than EuroSCORE II, as indicated by the higher AUC in the ROC analysis. These results align with those of earlier studies, such as that of Afilalo et al., who found that frailty offers additional prognostic value beyond conventional surgical risk scores (20). In our multivariate analysis, CFS was identified as a significant independent predictor of 30-day mortality, highlighting its importance as a vital element in the preoperative evaluation of older adult patients undergoing cardiac surgery. This implies that including frailty assessments in risk stratification can improve the accuracy of predicting surgical results, enabling clinicians to make better decisions and customize treatment plans for each patient (21).

Although the prosthesis size-to-BSA ratio (size/BSA) was not an independent predictor of mortality, it exhibited a slight but significant link to 30-day mortality rates. This ratio may indicate prosthesis–patient mismatch (PPM), which has been associated with poor hemodynamics and unfavorable long-term outcomes, particularly in individuals with smaller body surface areas (22). However, its low specificity at the determined threshold limits its effectiveness as a standard tool in clinical settings. The shorter ICU and hospital stays observed in the sutureless valve group have practical implications for healthcare systems, indicating the potential for decreased resource utilization and cost savings. These operational benefits, coupled with similar safety profiles, could support the broader adoption of sutureless technology in certain elderly and frail patients (23). It is essential to recognize that the selection of prostheses was guided by individualized clinical judgment rather than standardized institutional protocols. While this approach reflects real-world decision-making, it introduces the potential for selection bias. For example, surgeons may have opted for sutureless valves for more frail patients to minimize cross-clamp and bypass durations. Although this aligns with pragmatic care strategies, it complicates causal inference regarding the relationship between valve type and early outcomes. Future research should consider stratifying valve selection within protocolized frameworks to better isolate treatment effects. Overall, our findings advocate for the inclusion of frailty assessment in routine preoperative evaluation. The CFS can facilitate more tailored decision-making and risk assessment owing to its simplicity and clinical significance. Incorporating frailty into surgical planning may enhance patient outcomes and boost system efficiency in the context of an aging population with increasingly complex health needs.

However, certain limitations should be recognized. The retrospective nature of this study, which was conducted at a single location, may limit its applicability to broader contexts. A significant methodological limitation of this study is the reliance solely on the Clinical Frailty Scale (CFS) for assessing frailty. Although the CFS is a validated and expedient bedside tool commonly utilized in cardiovascular surgery, alternative frailty indices, such as the Fried Frailty Phenotype, which focuses on physical performance, and the Edmonton Frailty Scale, which includes broader multidimensional domains (e.g., cognition, mood, social support), could have offered a more comprehensive evaluation (24). The lack of comparative assessment may constrain the generalizability and robustness of the findings across diverse geriatric populations.

Additionally, the study did not evaluate outcomes beyond a 30-day period, leaving the long-term effects unexamined.

CONCLUSION

This study highlights that the Clinical Frailty Scale (CFS) serves as a strong and independent indicator of prosthesis choice and early mortality in older patients undergoing surgical aortic valve replacement (AVR). Unlike traditional surgical risk models, such as EuroSCORE II, CFS offers a more precise biological resilience and functional reserve assessment, allowing for more detailed risk stratification in this susceptible group. Our findings indicate that patients with higher frailty scores were more inclined to receive sutureless valves, which were linked to notably shorter stays in the ICU and hospital without compromising early safety. Notably, the highest early mortality rate was observed in the moderately frail group, indicating a nonlinear association between frailty and negative outcomes, underscoring the importance of more detailed preoperative evaluations.

Regularly incorporating frailty assessments, especially using a practical and scalable tool such as the CFS, can aid in tailoring treatment plans, optimizing resource use, and ultimately improving surgical outcomes in older adults. Frailty should be evaluated along with traditional risk scores to guide valve selection and surgical strategy. Future multicenter prospective studies are needed to confirm these findings, evaluate long-term survival and quality of life outcomes, and create standardized protocols for integrating frailty into surgical decision-making processes. As cardiac surgery advances in the aging population, adopting approaches that consider frailty will be crucial for providing high-value and patient-centered care.

Conflict of Interest Statement: All authors declare no conflicts of interest regarding the publication of this article. The study's findings and conclusions are solely based on the data analyzed and have not been influenced by any financial, personal, or professional relationships.

Funding Statement: This study did not receive any specific grants from funding agencies in the public, commercial, or not-for-profit sectors. This research was conducted independently, without financial support from any external sources.

REFERENCES

1. Koc M. Artificial Intelligence In Geriatrics Turkish Journal of Geriatrics. 2023;26(4):352-60. doi:10.29400/tjgeri.2023.362
2. Arora S, Misenheimer JA, Ramaraj R. Transcatheter Aortic Valve Replacement: Comprehensive Review and Present Status. Tex Heart Inst J. 2017;44(1):29-38. doi:10.14503/THIJ-16-5852
3. Falk Erhag H, Guethnadottir G, Alfredsson J, et al. The association between the clinical frailty scale and adverse health outcomes in older adults in acute clinical settings–a systematic review of the literature. Clinical Interventions in Aging. 2023;18:249-61. doi:10.2147/CIA.S388160
4. Watt J, Tricco AC, Talbot-Hamon C, et al. Identifying older adults at risk of harm following elective surgery: a systematic review and meta-analysis. BMC medicine. 2018;16(1):1-14. doi:10.1186/s12916-017-0986-2
5. Zalan J, Wilson R, McMullen M, Ross-White A. Frailty indices as a predictor of postoperative outcomes: a systematic review protocol. JBI Database System Rev Implement Rep. 2015;13(8):30-40. doi:10.11124/jbisrir-2015-2192
6. Duchnowski P, Hryniewiecki T, Kusmierczyk M, Szymanski P. Performance of the EuroSCORE II and the Society of Thoracic Surgeons score in patients undergoing aortic valve replacement for aortic stenosis. Journal of Thoracic Disease. 2019;11(5):2076. doi:10.21037/jtd.2019.04.48
7. Rockwood K, Song X, MacKnight C, et al. A global clinical measure of fitness and frailty in elderly people. Cmaj. 2005;173(5):489-95. doi:10.1503/cmaj.050051
8. McIsaac DI, MacDonald DB, Aucoin SD. Frailty for perioperative clinicians: a narrative review. Anesthesia & Analgesia. 2020;130(6):1450-60. doi:10.1213/ANE.0000000000004602
9. Pulok MH, Theou O, van der Valk AM, Rockwood K. The role of illness acuity on the association between

frailty and mortality in emergency department patients referred to internal medicine. Age and ageing. 2020;49(6):1071-9. doi:10.1093/ageing/afaa089

10. Rockwood K, Theou O. Using the clinical frailty scale in allocating scarce health care resources. Canadian Geriatrics Journal. 2020;23(3):210. doi:10.5770/cgj.23.463

11. Shan L, Saxena A, McMahon R, Wilson A, Newcomb A. A systematic review on the quality of life benefits after aortic valve replacement in the elderly. The Journal of thoracic and cardiovascular surgery. 2013;145(5):1173-89.

12. Ashwat E, Ahmad D, Sa MP, et al. Age-Based Outcomes After Surgical Aortic Valve Replacement With Bioprosthetic Versus Mechanical Valves. The American Journal of Cardiology. 2024;226:72-9. doi:10.1016/j.amjcard.2024.07.004

13. Pascual F, Martí CP, Pajares A, Argente P, Alvarova O. Preoperative Risk Assessment In Cardiac Surgery. Euroscore I And Euroscore II In A Modern Cohort Journal of Cardiothoracic and Vascular Anesthesia. 2022;36:S42. doi:10.1053/j.jvca.2022.09.068

14. Jawitz OK, Raman V, Thibault D, et al. Complications after Ravitch versus Nuss repair of pectus excavatum: a society of thoracic surgeons (STS) general thoracic surgery database analysis. Surgery. 2021;169(6):1493-9. doi:10.1016/j.surg.2020.12.023

15. Filip G, Litwinowicz R, Kapelak B, et al. Mid-term follow-up after suture-less aortic heart valve implantation. Journal of Thoracic Disease. 2018;10(11):6128. doi:10.21037/jtd.2018.10.10

16. Arnold SV, Zhao Y, Leon MB, et al. Impact of frailty and prefrailty on outcomes of transcatheter or surgical aortic valve replacement. Circulation: Cardiovascular Interventions. 2022;15(1):e011375.

17. Chan J, Narayan P, Fudulu DP, Dong T, Vohra HA, Angelini GD. Long-term clinical outcomes in patients between the age of 50–70 years receiving biological versus mechanical aortic valve prostheses. European Journal of Cardio-Thoracic Surgery. 2025;67(2):ezaf033. doi:10.1093/ejcts/ezaf033

18. Green P, Woglom AE, Genereux P, et al. The impact of frailty status on survival after transcatheter aortic valve replacement in older adults with severe aortic stenosis: a single-center experience. JACC: Cardiovascular Interventions. 2012;5(9):974-81. doi:10.1016/j.jcin.2012.06.011

19. Kim DH, Kim CA, Placide S, Lipsitz LA, Marcantonio ER. Preoperative frailty assessment and outcomes at 6 months or later in older adults undergoing cardiac surgical procedures: a systematic review. Annals of internal medicine. 2016;165(9):650-60. doi:10.7326/M16-0652

20. Afilalo J, Alexander KP, Mack MJ, et al. Frailty assessment in the cardiovascular care of older adults. Journal of the American College of Cardiology. 2014;63(8):747-62. doi:10.1016/j.jacc.2013.09.070

21. Berastegui Garcia E, Camara Rosell ML, Moret Ruiz E, et al. The impact of frailty in aortic valve surgery. BMC Geriatrics. 2020;20(1):426. doi:10.1186/s12877-020-01716-3

22. Pibarot P, Dumesnil JG. Hemodynamic and clinical impact of prosthesis–patient mismatch in the aortic valve position and its prevention. Journal of the American College of Cardiology. 2000;36(4):1131-41. doi:10.1016/s0735-1097(00)00859-7

23. Phan K, Tsai YC, Niranjan N, et al. Sutureless aortic valve replacement: a systematic review and meta-analysis. Annals of cardiothoracic surgery. 2015;4(2):100. doi:10.3978/j.issn.2225-319X.2014.06.01

24. Chong E, Ho E, Baldevarona-Llego J, Chan M, Wu L, Tay L. Frailty and risk of adverse outcomes in hospitalized older adults: a comparison of different frailty measures. Journal of the American Medical Directors Association. 2017;18(7):638. e7-. e11. doi:10.1016/j.jamda.2017.04.011