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The effect of frailty on postoperative recovery in patients with cardiovascular surgery

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Abstract

This study aimed to examine the impact of frailty on postoperative morbidity and mortality in patients undergoing cardiovascular surgery, questioning the adequacy of the preoperative American Society of Anesthesiologists (ASA) as the sole assessment tool. In a cohort of 76 patients undergoing cardiovascular interventions, we analyzed demographic data, Edmonton Frail Scale (EFS), ASA scores, Charlson Comorbidity Index values, surgery and hospitalization durations, intraoperative blood pressures, inotropic needs, erythrocyte transfusions, and pre/postoperative hemoglobin levels. Pearson chi-squared and Spearman tests were performed. Correlation of postoperative intensive care unit (ICU) stay, extubation time, ward stay, discharge status, morbidity rates, and ASA and EuroSCORE II results with EFS scores. The demographic profile indicated a mean age of 59.67 ± 13.02 years, with a majority of male patients (59.2%). Frailty status varied, with 48.7% non-frail, 26.3% vulnerable, 18.4% mildly frail, and 6.6% moderately frail. Surgical data revealed an average duration of 300.93 minutes and a mean ICU stay of 54.48 ± 101.16 hours. Statistical analysis showed significant differences in frailty levels based on initial morbidity (χ^2 = 10.612, P = .014) but not in ASA score distribution by morbidity status (χ^2 = 1.634, P = .442). A negative correlation was observed between EFS scores and hemoglobin levels, along with a positive correlation between the EuroSCORE II score and the duration of intubation, extubation, and ICU stay. Frailty significantly contributes to increased morbidity and necessitates evaluation alongside preoperative ASA scores to inform the need for prehabilitation. The ultimate goal extends beyond patient survival, aiming to ensure recovery while maintaining the quality of life and functional independence.

Abbreviations: ASA = American Society of Anesthesiologists, BMI = body mass index, CABG = coronary artery bypass grafting, EFS = Edmonton Frail Scale, Hb = hemoglobin, ICU = intensive care unit, MAP = mean arterial pressure.

Keywords: ASA, cardiovascular surgery, Edmonton Frailty Scale, frailty, patient safety

1. Introduction

Frailty is a vulnerable condition resulting from decreased physiological reserves and disruptions in organ systems, and can be considered a measure of one's sensitivity to the inability to maintain homeostasis. It is a multidimensional concept that encompasses physical, cognitive, psychological, social, and environmental factors.[1] Although aging is a significant factor influencing frailty, it is not the sole determinant, because frailty can be observed across all age groups. Frail patients have weakened adaptability to stressors, such as illness or trauma, owing to diminished reserves.[2] Given the stress of surgical interventions and the decreased tolerance of radical procedures in frail groups, preoperative assessment of frailty can predict the expected morbidity associated with surgery.[3] The preoperative American Society of Anesthesiologists (ASA) score is commonly used, and generally reflects the presence of comorbidities and their outcomes. However, current preoperative assessment methods fail to accurately predict the physiological reserves. Routine frailty assessment can provide a more comprehensive and personalized perioperative risk classification.[3] Identifying frail individuals, especially the elderly population without comorbidities, may be crucial for predicting postoperative complications.[4]

Cardiovascular diseases rank first among all causes of death.[5] While deaths from cardiovascular disease show a decreasing trend in developed Western countries, they are increasing in developing countries. However, with the aging of the population and increase in life expectancy, the number of individuals with cardiovascular disease is increasing in developed countries, along with the associated burden. Although frailty tends to increase with age, assessments using various physical and cognitive tests, nutritional status, and self-reported functional impairments are independent of age and any specific medical condition.

Frailty is strongly associated with postoperative mortality and morbidity, particularly during cardiac surgeries. Frail individuals are more likely to require surgery than their robust counterparts are. Although populations vary significantly, it is reported that 26% to 56% of all elderly surgical patients are

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All data generated or analyzed during this study are included in this published article [and its supplementary information files].

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frail.[6] Therefore, it is recommended to assess frailty in patients to guide patient expectations and surgical decision-making processes as well as for perioperative optimization strategies for frail patients.[7]

Despite the strong relationship between frailty and adverse outcomes, there is a lack of well-designed studies specifically focusing on perioperative interventions in frail patients undergoing cardiac surgery. We consider that relying solely on age or comorbidity in preoperative assessment is insufficient to predict postoperative morbidity and mortality in frail patients.[8] Early identification of frail patients can help determine treatment and follow-up strategies, both perioperatively and postoperatively. Moreover, implementing preoperative rehabilitative prehabilitation programs can reduce postoperative morbidities. Additionally, reassessing the decision for surgery in severely frail patients at high risk can prevent mortality and unnecessary loss of workforce. The American College of Surgeons and the American Geriatrics Society jointly recommend frailty assessment as part of preoperative evaluation in elderly surgical patients.[9,10] This study aimed to investigate the effects of frailty on postoperative recovery, discharge, and survival in patients aged ≥ 40 years who underwent cardiovascular surgery.

2. Methods

2.1. Ethics approval and consent to participate

After obtaining approval from the Ethics Committee, informed consent was obtained from all the patients before starting the study. The Edmonton Frailty Test was performed. Ethical approval was obtained from the Ethics Committee (date/number 2023/358). All methods were performed in accordance with the relevant guidelines and regulations of the Gulhane Training and Research Hospital, University of Healthy Science, and Turkish guidelines for the ethical conduct of research. Informed consent was obtained from all participants and/or their legal guardians to participate in the study.

2.2. Study design and participants

Patients aged ≥ 40 years scheduled for cardiovascular surgery were included in the study. Emergency patients were excluded from this study. One day before surgery, the Edmonton Frail Scale (EFS) was administered to the patients by the same anesthesiologist at the cardiovascular surgery clinic. Preoperative anesthesia assessment, including the ASA score, was performed by a different physician at the anesthesia outpatient clinic. Patients admitted to the intensive care unit and those who refused to complete the EFS were excluded from the study. The patients' demographic information, cause of surgery, body mass index (BMI, kg/m²), EFS scores, preoperative laboratory values, ASA scores, Charlson Comorbidity Index, duration of hospital stay, duration of surgery, type of surgery (open, minimally invasive, robotic), mean arterial pressure (MAP) during surgery (before and after cardiopulmonary bypass), need for inotropes (dopamine, norepinephrine, adrenaline), and extracorporeal circulation were recorded. In addition, the patients' postoperative parameters, including the duration of stay in the intensive care unit, extubation time (the duration from the time of admission to the intensive care unit until the moment of extubation), intubation time (the duration from when the patient was intubated and connected to the ventilator until the moment they were weaned off the ventilator), length of stay in the ward, discharge status, readmission, and morbidity during the first and last postoperative months, as well as the EuroSCORE II, were statistically evaluated for frailty and ASA scores. The EuroSCORE II measurement was carried out by doctors in the ward where the patients were hospitalized, using the calculation method available at www.EuroSCORE.org. The EuroSCORE II data for the patients and postoperative morbidity follow-up data were obtained from the records and electronic information systems of the cardiovascular surgery clinic.

2.3. Edmonton Frail Scale

Approval was approved for use in the study. The original version of the scale evaluates 9 domains; 2 domains are assessed using performance-based items: the Clock Drawing Test for cognitive impairment and the "Timed Up and Go" test for balance and mobility. Other domains included mood, functional independence, medication use, social support, nutrition, general health status, continence, the burden of medical illness, and quality of life. The maximum possible score is 17 points, indicating a high level of frailty. A scale of 0 to 4 indicates no frailty, 5 to 6 indicates vulnerable, 7 to 8 indicates mild frailty, 9 to 10 indicates moderate frailty, and ≥ 11 indicated severe frailty.

2.4. Data analysis

Descriptive statistics, such as the mean and standard deviation (mean ± SD), were used for continuous variables, and frequencies and percentages were used for categorical variables. Categorical data were analyzed using Pearson chi-squared test. Relationships between variables were evaluated using Spearman correlation analysis, with the following cutoff points used for interpreting correlation coefficients: 0.00 to 0.19 very weak, 0.20 to 0.39 weak, 0.40 to 0.69 moderate, 0.70 to 0.89 strong, and 0.90 to 1.00 very strong relationship. The IBM SPSS 23 software package was used for the data analysis. Statistical analyses were performed at a significance level of $P < .05$.

2.4.1. Sample size calculation. Using the G*Power Version 3.1.9.2 software package, with a Type I error of 0.05 and a power of 0.80, a sample size calculation was performed using one-way ANOVA. Before starting the main study, a preliminary study was conducted with a sample of 12 participants. The effect size index, partial eta squared (η^2), was found to be 0.212 (Cohen f = 0.518) as a result of this analysis. Based on the obtained effect size, the required sample size for the study, which was designed with 3 groups, was calculated to be at least 42 participants.

3. Results

3.1. Participant characteristics

A total of 76 patients were included in the study. Of them, 59.2% were male and 40.8% were female, with an average age of 59.67 ± 13.02 years 53.9% were smokers, 31.6% were nonsmokers, and 14.5 % had quit smoking (Table 1). In addition, the patients' mean Charlson Comorbidity Index score was 3.24 ± 1.45, and their mean BMI (kg/m²) was 28.56 ± 4.18.

3.2. Surgical details and frailty assessment

Coronary artery bypass grafting (CABG) was the most common surgery performed in 68% (52 patients), followed by valve operations in 24 patients (mitral, tricuspid, and aortic valves). Considering their frailty status, 48.7% of patients (n = 37) had no frailty, 26.3% were apparently vulnerable, 18.4% were slightly frail, and 6.6% were moderately frail. In addition, 50.0% of the patients had ASA scores of 3, 22.4% had ASA scores of 4, and 27.6% had ASA scores of 2. Atrial fibrillation was present in 15 patients and absent in 61 patients (72%).

Table 1

Socio-demographic data, ASA score and frailty status.

		N	%
Gender	Male	45	59.2
	Female	31	40.8
Smoking	Yes	41	53.9
	No	24	31.6
	Quitted	11	14.5
Frailty	None	37	48.7
	Vulnerable	20	26.3
	Mild frail	14	18.4
	Moderate frail	5	6.6
ASA	II	21	27.6
	III	38	50.0
	IV	17	22.4
Cause of surgery	CABG	52	68
	Valve surgery	24	32

ASA = American Society of Anesthesiologists, CABG = coronary artery bypass grafting, N = number.

Table 2

Data on other variables with descriptive statistics.

Variables	Mean ± standard deviations	
CCI	3.24 ± 1.45	
BMI kg/m²	28.56 ± 4.18	
EuroSCORE II	2.81 ± 2.43	
Length of preoperative hospitalization (day)	3.97 ± 2.32	
Perioperative time (min)	300.93 ± 53.7	
Ventilation time (hour)	13.56 ± 8.40	
Extubation time (min)	446.81 ± 189.67	
Pre-pump MAP (mm Hg)	79.08 ± 9.23	
Post-pump MAP(mm Hg)	71.04 ± 7.58	
Length of Stay in ICU (hour)	54.48 ± 101.16	
Length of stay in the ward (day)	5.47 ± 3	
	N	%
Atrial fibrillation	15	19.5
Sleep problems	55	72.3
Hospitalization in the last year	24	31
Taking 5 or more medicines	31	40
Perioperative ES transfusion	11	14
Postoperative ES transfusion	55	72
Perioperative dopamine infusion	31	40
Perioperative noradrenaline infusion	10	13
reintubation	4	5.2
Reextubation	2	2.6
Rehospitalization in intensive care unit	8	10.4
Mortality	2	2.6

BMI = body mass index, CCI = Charlson Comorbidity Index, ES = erythrocyte suspension, MAP = mean arterial pressure, N = number.

3.3. Operative and postoperative metrics

The mean duration of surgery was 300.93 minutes (standard deviation, 53.7; range, 120–420 minutes). The mean extubation time was 446.81 minutes (standard deviation, 189.67; range, 225–1230 minutes). The mean duration of stay in the intensive care unit was 54.48 ± 101.16 hours. Among the patients, 31 required dopamine and 10 required noradrenaline perioperatively. Eleven patients received erythrocyte suspension transfusions perioperatively, and 55 received transfusions postoperatively. The mean arterial blood pressure before MAP pump placement was 79.08 ± 9.23 mm Hg, which decreased to 71.04 ± 7.58 mm Hg after MAP pump placement. Four extubated patients required reintubation, of which 2 were re-extubated and the other 2 deceased (Table 2).

3.4. Postoperative morbidities

Postoperative morbidities observed among the patients included elevated C-reactive protein levels, acute phase reaction elevation, pleural effusion, impaired kidney function, wound site maceration, decreased saturation, cerebrovascular diseases, and ischemic optic neuropathy. The initial morbidity rate (2 weeks after surgery) was 28% (n = 22). The final morbidity rate (1 month after surgery) was 36% (n = 28) (Table 3).

3.5. Frailty and morbidity analysis

The comparison results of the distributions of the groups with no frailty and those with apparent vulnerability, mild, and moderate frailty, as observed in the EFS results of 76 patients who underwent heart surgery due to CABG and other different reasons, both before and after surgery, are shown in Table 3. It has been observed that the distribution of non-frailty, apparently vulnerable, mild, and moderate frailty levels according to the EFS is homogeneous among patients who underwent heart surgery due to CABG and those who underwent heart surgery for other reasons ($\chi^2 = 6.572$, $P = .087$). The percentage of patients who underwent heart surgery due to CABG was higher in the non-frail and apparently vulnerable groups (30 (58.8%) and 11 (21.6%), respectively). The distribution of non-frailty and apparently vulnerable, mild, and moderate frailty levels, according to the EFS, showed a statistically significant difference based on the presence of initial morbidity ($\chi^2 = 10.612$, $P = .014$). The frequency of not having morbidity was found to be higher in the non-frailty and apparently vulnerable groups (29 (53.7%) and 17 (31.5%), respectively). The distribution of non-frailty, apparently vulnerable, mild, and moderate frailty levels according to the EFS showed a statistically significant difference based on the presence of final morbidity ($\chi^2 = 13.543$, $P = .004$). The frequency of non-morbidity was higher in the non-frail and apparently vulnerable groups (30 (62.5%) and 12 (25.0%) patients, respectively).

The comparison results of the average extubation times among the groups with no frailty, apparently vulnerable, mild frailty, and moderate frailty according to the EFS in 76 patients are shown in Table 4. The average extubation times were found to be higher in the moderate frailty and mild frailty groups (507.00 ± 119.25 and 503.57 ± 188.87, respectively) compared to the groups with no frailty and apparently vulnerable (410.81 ± 195.83 and 437.50 ± 168.74, respectively). However, this difference was not statistically significant ($F (3.72) = 1.086$, $P = .360$).

Table 5 presents the distribution of ASA scores among the 76 patients in the groups based on the presence of first and last morbidities. There was no statistically significant difference in the distribution of ASA scores among the patients based on the presence of first and last morbidities ($\chi^2 = 1.634$, $P = .442$). The most common ASA scores in patients with and without morbidity is ASA 3.

The correlation between the patients' EFS scores and their first and last hemoglobin measurement measurements, EuroSCORE II, operation time, intubation time, extubation time, duration of stay in the intensive care unit, and duration of stay in the ward was evaluated using Spearman correlation analysis (Table 6). There was a statistically significant negative moderate (0.557) and weak (0.253) correlation between their EFS scores and the first and last hemoglobin measurements, respectively ($P < .001$) ($P = .028$). A statistically significant moderate positive correlation was found between the EFS and EuroSCORE II results (0.550) ($P < .001$). The P-value between EFS and surgery duration was found to be not significant ($P = .151$). There was no statistically significant correlation between the EFS scores and intubation time (0.217) ($P = .059$). A statistically significant positive weak correlation was found between EFS scores and extubation time (0.352) ($P = .002$). A statistically significant positive weak correlation

Table 3

Comparison of frailty distributions in morbidity groups.

N = 76		No frail n (%)	Apparently vulnerable n (%)	Mild frail n (%)	Moderate frail n (%)	Test statistics
Cause of heart surgery	CABG n = 51	30 (58.8)	11 (21.6)	7 (13.7)	3 (5.9)	χ^2 = 6572 *P* = .087
	The others n = 25	7 (28.0)	9 (36.0)	7 (28.0)	2 (8.0)	
First morbidity	Yes n = 22 (28.9%)	8 (36.4)	3 (13.6)	8 (36.4)	3 (13.6)	*χ^2 = 10.612 *P* = .014
	No n = 54 (71.1%)	29 (53.7)	17 (31.5)	6 (11.1)	2 (3.7)	
Last morbidity	Yes n = 28 (36.8%)	7 (25.0)	8 (28.6)	10 (35.7)	3 (10.7)	χ^2 = 13.543 *P* = .004
	No n = 48 (63.2%)	30 (62.5)	12 (25.0)	4 (8.3)	2 (4.2)	

CABG = coronary artery bypass grafting.
The others: cardiac surgery other than CABG, valve surgery.
First morbidity: morbidity level 2 weeks after surgery.
Final morbidity: morbidity level 1 month after surgery.
* Pearson chi-square test, test-statistic value. Statistical significance $P < .05$.

Table 4

Comparison of extubation distribution in groups of Edmonton Frailty Test.

N = 76	No frail (n = 37)	Apparently vulnerable (n = 20)	Mild frail (n = 14)	Moderate frail (n = 5)	Test statistics
Extubation time (minute) mean ± SD†	410.81 ± 195.83	437.50 ± 168.74	503.57 ± 188.87	507.00 ± 119.25	*F (3.72) = 1.086 *P* = .360

Extubation time: the duration from the moment of admission to the intensive care unit until the moment of extubation.
* One-way ANOVA test statistic. Statistical significance.
† Mean and standard deviations.

Table 5

Comparison of ASA score distributions in morbidity groups.

ASA Score		2 n (%)	3 n (%)	4 n (%)	Test statistics
First morbidity	Yes n = 22	5 (22.7)	10 (45.5)	7 (31.8)	χ^2 = 1.634 *P* = .442*
	No n = 54	16 (29.6)	28 (51.9)	10 (18.5)	
Last morbidity	Yes n = 28	5 (17.9)	15 (53.6)	8 (28.6)	χ^2 = 2.409 *P* = .300*
	No n = 48	16 (33.3)	23 (47.9)	9 (18.8)	

ASA = American Society of Anesthesiologists.
First morbidity: morbidity level after 2 weeks later from surgery.
Final morbidity: morbidity level after 1 month later from surgery.
* Pearson chi-square test, test-statistic value. Statistical significance $P < .05$.

Table 6

Correlation analysis results.

		Initial Hb	Final Hb	EuroSCORE II	Operation time	Intubation time	Extubation time	LSIC	LSIW
EFS	rho	-0.557	-0.253	0.550	-0.166	0.217	0.352	0.252	0.327
	P	.000*	.028*	.000*	.151	.059	.002*	.028*	.004*

EFS = Edmonton Frail Scale, Final Hb = Hb level after 1 month later from surgery, Hb = hemoglobin, Initial Hb = Hb level after 2 weeks later from surgery, LSIC = length of stay in intensive care, LSIW = length of stay in the ward.
* Spearman test-statistic value. Statistical significance ($P < .05$).

was found between the EFS scores and duration of stay in the intensive care unit (0.252) ($P = .028$). A statistically significant positive weak correlation was found between EFS scores and the duration of stay in the ward (0.327) ($P = .004$).

4. Discussion

In our study, patients who were apparently vulnerable or frail had significantly higher morbidity rates in the first week than did non-frail patients ($\chi^2 = 10.612$, $P = .014$). Although numerically higher, the morbidity rates in frail patients in the previous month were not statistically significant. A similar study on the relationship between frailty and mortality and morbidity after cardiac surgery found that death, nondischarge to home, transfusion, low cardiac output syndrome, sepsis, pneumonia, delirium, prolonged ventilation, postoperative renal failure, and prolonged length of hospital stay were more common in frail patients than in non-frail ones.[11] In the present study, frailty was found to be independent of age. The effect of frailty on mortality and morbidity is expected, owing to the decreased physiological reserve and capacity to maintain homeostasis in frail patients. The decreased ability of frail patients to move and walk may explain their susceptibility to postoperative pneumonia, reintubation, and urinary tract infections owing to prolonged catheterization. Another similar study in elderly patients undergoing cardiac surgery showed that factors such as age-related decline in physical reserve, cognitive and mental functions, and decreased activity in the hospital environment were associated with hospital-acquired morbidities.[12] A study of elderly patients with EuroSCORE II found a statistically significant relationship between high-risk groups and intensive care unit mortality.[13] And determined a statistically significant relationship between high EuroSCORE risk, early low cardiac output, and length of stay in the intensive care unit. In our study, the average EuroSCORE II was 2.81 ± 2.43, and 16 patients had a EuroSCORE II score of 5 or higher. In this group, only 2 patients were not frail, 7 were frail, and 7 were apparently vulnerable. Considering EuroSCORE II and frailty together preoperatively may be important for predicting postoperative morbidity and mortality. Another study highlighting the inadequacy of EuroSCORE II in predicting postoperative outcomes in elderly patients with aortic stenosis and advanced age suggested considering both biological and physical functional status as well as cognitive activities and other factors.[14] This underscores the importance of the preoperative EFS in our study.

In this study, low preoperative hemoglobin (Hb) levels were associated with frailty. Decreased reserves in frail patients may be associated with anemia. Among the 31 patients with Hb levels below 13, only 4 were not frail. The 14th patient was mildly frail, and 13 were apparently vulnerable. In another study, low preoperative Hb levels were evaluated as a standalone factor affecting the length of stay in the intensive care unit.[15] In our study, preoperative variables were also considered when examining the patients' postoperative outcomes in relation to their EFS. In the literature, these studies were mostly retrospective, with few prospective studies available. Additionally, Hb level in the first month postoperatively was found to be associated with frailty. Frail patients had longer intubation times, intensive care unit stays, and hospital stays. In another study on frailty, high frailty scores were found to be associated with longer hospital stays after transcatheter aortic valve replacement than low frailty scores.[16] Similarly, by using the EFS, another study found that hospital mortality, 1-month mortality, and prolonged hospital care were strongly and independently associated with each other.[17]

Another study supporting our research emphasized the importance of conducting frailty assessments in the preoperative evaluation of frail elderly patients, suggesting that frailty tests could be effective in prehabilitation and decision-making during the surgical process.[18–20] Afilalo et al proposed a 4-item short scale, including lower extremity weakness, cognitive impairment, anemia, and hypoalbuminemia.[21] Similarly, in our study, 12 of the 17 patients with albumin levels < 4 were mildly to moderately frail or apparently vulnerable. Ten patients with low albumin levels also had anemia. This suggests that EFS is reliable for evaluating preoperative errors in this regard.

Although the ASA score, which classifies patients' physical conditions preoperatively, is widely used in the literature, our study did not find a statistically significant relationship between patients' ASA scores and postoperative morbidity frequency. However, in 2 studies conducted on patients undergoing minimally invasive pituitary and mandibular surgeries, the ASA score was statistically significant in predicting morbidity.[22,23] The difference in our study population, which consisted of patients undergoing cardiovascular surgery, may be associated with the higher prevalence of frailty among patients. This could explain the significant association between postoperative frailty status and morbidity frequency.[24]

Our study highlights the integral role of frailty in predicting postoperative morbidity in patients undergoing cardiovascular surgery and advocates the incorporation of comprehensive frailty assessment into preoperative evaluations. The nuanced interplay between frailty, traditional risk scores, and specific clinical parameters underscores the complexity of managing patient demographics and the need for tailored surgical and postoperative care strategies.[25–27] In our study, it was important to assess frailty in patients aged ≥ 50 years. In a study conducted in China on adult patients aged > 30 years, frailty in patients aged < 50 years predicted mortality more strongly than frailty in those aged > 50 years did. This study examined the importance of frailty in patients aged < 50 years old.[28] Frailty is commonly studied in individuals > 65 years of age. Our study included patients aged > 40 years old. A limitation of our study is that frailty assessments could have been conducted in patients over 18 years of age, independently of age, in relation to heart disease. Additionally, the study was conducted at a single center. Another limitation is that only the Edmonton Frailty Scale was used preoperatively in this study.

5. Conclusion

Preoperative assessment using ASA score alone may not be sufficient to identify decreased reserves in frail patients undergoing cardiac surgery. Frail patients with diminished cognitive function may have difficulty following directives, especially during postoperative respiratory therapy, leading to delayed postoperative mobilization, longer stay in the intensive care unit and hospital ward, and increased costs. Therefore, it is recommended that both ASA and EFS scores be considered together in the assessment of frailty.

Identifying frailty enables the planning of preoperative rehabilitation and prehabilitation programs to address reversible factors. A multidisciplinary approach involving clinicians, dietitians, and physiotherapists can be implemented to design a preoperative improvement program for elective surgery. The goal should not only be to ensure patient survival following cardiac surgery but also to preserve an acceptable quality of life and functional independence in the postoperative period.

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