

Research Article

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Lower Preoperative Functional Capacity and Frailty Result in Longer Mechanical Ventilation Time and Hospital Stay in Individuals Undergoing Cardiac Surgery

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ABSTRACT

Introduction: The presence of frailty and/or low Functional Capacity (FC) in the preoperative period may affect the intra-hospital evolution of individuals undergoing Cardiac Surgery (CS).

Objective: To test the hypothesis that low FC and/or frailty in the preoperative period are associated with longer Mechanical Ventilation (MV) time and longer hospital stay in the postoperative period of individuals undergoing CS.

Methods: A prospective and longitudinal study conducted in a private hospital. The sample included individuals of both genders, aged ≥ 18 years, with an indication for conventional elective cardiac surgery via median sternotomy. Functional capacity was measured by the Short Physical Performance Battery (SPPB) test, and frailty was assessed using the Clinical Frailty Scale (CFS) in the preoperative period (M0). An SPPB score between 4 and 6 indicated low FC. A CFS score of 5 or higher indicated frailty. The participants were followed throughout their hospitalization, and the MV time, ICU length of stay, and total hospital stay were evaluated. Statistical analysis used Mann-Whitney or Pearson's Chi-square tests, with significance set at $p < 0.05$.

Results: 68 participants were included in this study (age: 60.4 ± 11.7 years, 53.2% male). The most performed surgical procedure was valve replacement (72.1%), followed by coronary artery bypass grafting (16.2%). Low functional capacity in M0 was observed in 20.6% of participants, and 19.1% were frail. Low FC increased MV time (Yes: 2.0 ± 2.7 vs. No: 1.0 ± 0.1 days, $p = 0.00$). It also increased ICU stay (Yes: 5 [3.0-7.2] vs. No: 3 [3.0-4.2] days, $p = 0.01$) and total hospital stay (Yes: 8 [5.8-14.2] vs. No: 5 [4.8-7.0] days, $p = 0.00$). Frailty increased MV time (Yes: 2.1 ± 2.8 vs. No: 1.0 ± 0.1 days, $p = 0.00$). It also increased ICU stay (Yes: 5 [3.0-7.5] vs. No: 3 [3.0-4.0] days, $p = 0.01$) and total hospital stay (Yes: 9 [6.58-14.5] vs. No: 5 [5.0-7.0] days, $p = 0.00$).

Conclusion: The MV time and hospital stay were longer in individuals with low FC or frailty in the preoperative period of CS.

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increasing vulnerability to adverse events such as infections and postoperative complications [1].

Introduction

Cardiac Surgery (CS) is a common and frequently necessary procedure for the treatment of various cardiac diseases, such as valvular insufficiency and coronary artery disease. However, the postoperative recovery of individuals undergoing this type of surgery can be influenced by several factors, including pre-existing clinical conditions such as low Functional Capacity (FC) and frailty. FC is a crucial indicator of overall physical health and the patient's ability to perform daily activities, reflecting the health status of the musculoskeletal system and the individual's resistance to adverse conditions. On the other hand, frailty is characterized by a generalized decline in physiological functions,

Preoperative frailty is a clinically significant condition in the context of CS, characterized by a decrease in homeostatic reserves and a reduction in the body's FC. This condition is frequently associated with aging, sarcopenia, immune dysfunction, and neuroendocrine dysregulation, all factors that compromise the patient's response to surgical stress. Individuals with lower FC exhibit greater vulnerability to postoperative complications, directly impacting the duration of Mechanical Ventilation (MV) and the length of hospital stay [2]. Previous studies suggest that the presence of preoperative frailty and/or low FC may be associated with poorer postoperative clinical outcomes, including an increase in MV duration, Intensive Care Unit (ICU) length of stay, and

total hospital length of stay. These factors can result in a more prolonged recovery, additional complications, and a higher risk of morbidity and mortality [3].

Currently, specialists have been seeking alternatives to minimize the impact of low FC and the presence of frailty in surgical patients. Pre-habilitation, addressing the optimization of patients' physical, functional, and psychological status before surgical intervention, has proven to be an effective strategy for improving postoperative outcomes, reducing complications, and accelerating recovery. Particularly for patients undergoing CS, preoperative frailty is directly related to the prolonged need for ventilatory support and longer hospital stays, factors that increase the morbidity and mortality of these individuals. The reduction of FC before surgery, associated with frailty, contributes to a slower recovery, requiring more care and a prolonged recuperation period [4]. The healthcare team assisting the individual in the preoperative phase should, in an assessment prior to surgery, investigate the presence of these factors and take measures to minimize their negative impact. The objective of this study was to evaluate the hypothesis that the presence of low preoperative FC and/or frailty is associated with an increased duration of MV and hospital length of stay in patients undergoing elective conventional CS. The investigation will seek to demonstrate how these preoperative conditions can influence recovery time and the need for postoperative intensive care.

Methods

This was a prospective and longitudinal study conducted at a private hospital. This research was approved by the research ethics committee of the Federal University of Goiás under CAAE number: 68404523.3.0000.5083. The sample included individuals of both sexes, aged ≥18 years, with an indication for elective conventional cardiac surgery via median sternotomy. Functional capacity was measured using the Short Physical Performance Battery (SPPB), and frailty was assessed using the Clinical Frailty Scale (CFS) preoperatively (M0 CFS is a unidimensional instrument that provides a global clinical measure of fitness level and the presence of disabling comorbidities. The application of the CFS involved a detailed anamnesis to collect information on past medical history, usual physical activity level, and independence in performing Activities of Daily Living (ADLs). Based on this information, the assessor made an integrated clinical judgment to classify the patient into one of the CFS categories. A score ≥5 on the CFS was defined as indicative of frailty [5,6]. Functional capacity was measured using the SPPB, a physical performance test composed of three subtests: balance, gait speed, and chair standability. The balance test assessed the ability to maintain balance in three positions (side-by-side, semi-tandem, and tandem) for 10 seconds in each. The gait speed test measured the time required for the individual to walk 4 meters at their usual pace, with two attempts recorded and the fastest time used for analysis. The chair stand test evaluated the time to complete five repetitions of standing up from a chair without the use of arms. Scores on each subtest ranged from 0 to 4, with a total score ranging from 0 to 12. An SPPB score of 4 to 6 indicated low functional capacity [7]. Individuals were followed throughout their hospital stay, and the duration of Mechanical Ventilation (MV), Intensive Care Unit (ICU) length of stay, and total length of hospital stay were evaluated. Statistical analysis utilized Pearson's chi-squared test, with significance set at p<0.05.

Results

The study population consisted of 68 participants, including patients with an age of 60.4±11.7 years (minimum age of 50 years and a maximum age of 70 years), with a predominance of 53.2% being men. The most frequently performed surgical approach

was valve replacement (72.1%), followed by coronary artery bypass grafting (16.2%). The study population characterization is described in Table 1.

Table 1: Sample Characterization

Variables	All (n=68)
Sociodemographic	
Age	60.4±11.7
Men	43 (53.2)
Women	25 (36.8)
Race	
White	39 (57.4)
Black	10 (14.7)
Brown-skinned person	19 (27.9)
Education	
Incomplete high school	1 (1.5)
High school diploma	33 (48.5)
Bachelor's degree	34 (50.0)
Clinics Comorbidities	
Hypertension	51 (75.0)
Dyslipidemia	43 (63.2)
Diabetes	19 (27.9)
Chronic kidney disease	1 (1.5)
Medications	
Anti-hypertensive	51 (75.0)
Diuretic	24 (35.3)
Statin	44 (64.7)
Oral anticoagulant	11 (16.2)
Oral hypoglycemic	19 (27.9)
Diagnosis	
CAD	13 (19.1)
VHD	47 (69.1)
HF	4 (5.9)
CHD	4 (5.9)
LVEF (%)	65 [60.0-68.8]
Surgical	
EuroSCORE II (%)	1.1 [0.7-1.9]
Surgical approach	
CABG	27 (39.7)
SMVR	22 (32.4)
SAVR	3 (4.4)
Combined (CABG + VR)	5 (7.4)
Others	110.5 [99.5-130.0]
CPB time (minutes)	82.5 [73.0-98.2]

CAD: Coronary Artery Disease; VHD: valvular heart disease; HF: heart failure; CHD: congenital heart disease; LVEF: left ventricular ejection fraction; BMI: body mass index; EuroSCORE II: European System for Cardiac Operative Risk Evaluation II; CABG: coronary artery bypass graft surgery; SMVR: surgical mitral valve replacement; SAVR: surgical aortic valve replacement; VR: valve replacement; CPB: cardiopulmonary bypass.

Table 2: Differences between Mechanical Ventilation Times, according to use and Hospital Stay and Functional Capacity

Variable	Low FC (14 individuals)	Normal FC (54 individuals)	p value*
MV time (days)†	2.0 ± 2.7	1.0 ± 0.1	0.00
ICU time (days)‡	5 (3.0-7.2)	3 (3.0-4.2)	0.01
Hospitalization time (days) ‡	8 (5.8-14.2)	5 (4.8-7.0)	0.00

MV: mechanical ventilation; ICU: intensive care unit; FC: functional capacity.

*Pearson's chi-squared test; †mean; ‡median.

Low preoperative functional capacity was observed in 20.6% of the participants, and 19.1% presented with frailty. The individuals were followed throughout their hospital stay, and the duration of MV, ICU length of stay, and total length of hospital stay were evaluated. Low FC increased the duration of MV (Table 2).

Table 3: Differences in Mechanical Ventilation, ICU and Hospital Stay Times According to the Presence of Frailty

Variable	Frailty (YES) (13 individuals)	Frailty (NO) (55 individuals)	p value*
MV time (days)†	2.1 ± 2.8	1.0 ± 0.1	0.00
ICU time (days)‡	5 (3.0-7.5)	3 (3.0-4.2)	0.01
Hospitalization time (days) ‡	9 (6.58-14.5)	5 (5.0-7.0)	0.00

MV: Mechanical Ventilation; ICU: Intensive Care Unit. * Pearson's chi-squared test; †mean; ‡median.

The presence of frailty increased the duration of MV. It also increased the ICU length of stay and the total length of hospital stay (Table 3).

Discussion

Frailty represents a physiological state of loss of homeostatic reserves, the presence of which, even in middle-aged adults, multiplies the risk of complications and mortality after cardiac surgery; a systematic review involving nearly five thousand patients showed that frail individuals have an almost five times greater probability of major cardiovascular or cerebrovascular events postoperatively [1]. In a subsequent Canadian cohort, it was found that only 10% of surgical candidates were classified as frail, but this minority accounted for average ICU stays nine days longer and in-hospital mortality almost ten times higher than that of non-frail individuals, highlighting the disproportionate effect of this phenotype [2].

In our prospective series of 68 participants, in which 20.6% exhibited low FC-defined by an SPPB of 4 to 6-and 19.1% were frail according to a CFS ≥ 5 , we strongly confirmed the prognostic power of these variables: low FC doubled the average MV duration, extended ICU stay by two days and prolonged total hospital stay by three days; frailty, in turn, increased MV days and raised the median ICU and hospital stays to 5 and 9 days, respectively, compared to 3 and 5 days among non-frail individuals [3]. These increases are closely consistent with multicenter findings in which frail patients required prolonged ventilatory support (odds ratio, 3.0) and had an almost doubled length of intensive care, while meta-analyses of predictive models indicate a modest but consistent improvement in the accuracy of STS and EuroSCORE II scores when a simple functional marker such as gait speed is added [4-8]. From a mechanistic perspective, frailty encompasses sarcopenia, chronic inflammation, neuroendocrine dysregulation, and immune impairment, factors that reduce maximal inspiratory pressure, delay ventilator weaning, and promote infections, a direct reflection of the vulnerability described by Parker and Söderqvist in the pathophysiology of the surgical elderly [3].

The clinical significance translates into substantial direct costs, estimated at up to three thousand dollars per extra day of ICU, and functional outcomes: a Japanese study demonstrated that preoperative frailty status triples the chance of delayed independent ambulation beyond the seventh day [9]. These data reinforce the rationale for pre-habilitation programs: a recent review highlights those multimodal interventions, initiated weeks before surgery, combining aerobic and resistance training, hyperproteic nutritional support, and psychosocial approach, reduces arrhythmias, respiratory complications, and length of stay, although standardized randomized trials are still needed [10]. Interestingly, although frail individuals accumulate greater immediate morbidity, they also exhibit the greatest absolute gain in quality of life over six months, according to a Spanish multicenter follow-up, reinforcing that optimizing this population results in tangible long-term benefits [11,12].

In the context of our study, whose sample, although single center, reflects a typical distribution of valve surgeries (72.1%) and myocardial revascularization (16.2%), the combined application of CFS and SPPB proved feasible in the outpatient routine; both tests require less than five minutes but early signaled the subset of patients who would consume a greater number of postoperative resources [13]. The mandatory incorporation of these instruments into the pre-anesthetic checklist would allow for the rectification of risk estimates underestimated by traditional scores, the proactive allocation of ICU beds, and the targeting of pre-habilitation programs to those who need them most, a strategy aligned with the recommendations of contemporary guidelines and supported by Fried's classic phenotypic description, in which gait speed < 0.8 m/s and weak handgrip strength comprise an integrated marker of systemic decline [14,15]. Fragility, or frailty, is a complex geriatric syndrome, and various tools exist to assess it [15]. While Fried's Frailty Phenotype is widely utilized in research and is considered a cornerstone for identifying frailty,

its implementation can be resource-intensive and time-consuming [5]. In contrast, the Clinical Frailty Scale (CFS), developed by Rockwood and based on the cumulative deficit model, offers a more practical and quicker assessment, gaining traction in clinical settings. Both Fried and Rockwood are pivotal figures in frailty research, each championing distinct approaches to its identification. This difference in methodology has, at times, led to a notable “battle” of ideas between the two, highlighting the ongoing debate and evolution in understanding and measuring frailty. In summary, by demonstrating that only one-fifth of our sample concentrated significant ventilatory and hospital burden, we confirmed that frailty and low FC are independent determinants of clinical evolution in CS and, therefore, should migrate from the investigative field to the daily practice of perioperative stratification and intervention.

Such incorporation not only refines risk stratification beyond traditional scores but also creates an opportunity for targeted pre-habilitation interventions capable of mitigating complications, reducing costs, and improving the recovery trajectory. In the future, multicenter randomized trials should elucidate the cost-effectiveness of multimodal functional optimization programs and establish which combination of exercise, nutritional support, and psychosocial approach yields the greatest benefit in frail individuals and those with low FC. Until then, the systematic screening of these states of vulnerability is an essential step towards truly personalized perioperative medicine centered on the patient’s physiological reserve.

Despite the relevant findings, this study has limitations that should be considered in the interpretation of the results. As it is a single-center cohort with a limited number of participants, there are restrictions on the generalization of the data to other populations and institutional realities. The heterogeneity of surgical procedures and the absence of multivariate analysis prevent the exact quantification of the isolated impact of frailty and functional capacity on the observed outcomes. Furthermore, the use of clinical instruments such as CFS and SPPB, although practical and validated, may be subject to inter-observer variability, especially in the absence of standardized training. Multicenter studies with larger samples and analysis adjusted for relevant covariates are necessary to consolidate these findings and define operational protocols that systematically incorporate functional stratification into the preoperative routine of CS.

Conclusion

Low functional capacity assessed by SPPB and frailty determined by CFS, even in middle-aged adults undergoing elective cardiac surgery, constitute strong determinants of prolonged MV, longer ICU stays, and extended hospitalizations. By demonstrating that only one-fifth of the sample concentrated most of the healthcare burden, our findings underscore the urgency of incorporating rapid functional screening tools into the routine preoperative protocol.

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Disclosure Statement

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