DOI: 10.1111/jocs.14550

ORIGINAL ARTICLE

JOURNAL OF CARDIAC SURGERY WILEY

Pre-frailty status increases the risk of rehospitalization in patients after elective cardiac surgery without complication

Miguel K. Rodrigues PT, MSc[1] | Artur Marques PT, BSc[2] | Iracema I.K. Umeda PT, PhD[2] | Denise M.L. Lobo PT, PhD[2,3] | Mayron F. Oliveira PT, PhD[2,4]

[1]VO_2 Care Research Group, Physiotherapy Service Coordinator of Vila Nova Star Hospital, São Paulo, SP, Brazil

[2]Department of Physiotherapy, Intensive Care Unit Center, Dante Pazzanese Institute of Cardiology, São Paulo, SP, Brazil

[3]Physiotherapy Unit, Fametro University Center (UNIFAMETRO), Fortaleza, CE, Brazil

[4]VO_2 Care Research Group, Physiotherapy Research Service Coordinator of Vila Nova Star Hospital, São Paulo, SP, Brazil

Correspondence
Mayron F. Oliveira, Physiotherapy Unit, Hospital Vila Nova Star, São Paulo, Brazil; R. Dr. Alceu de Campos Rodrigues, 126 - Vila Nova Conceição, São Paulo 04544-000, Brazil.
Email: mayronfaria@gmail.com and mayronfaria@hotmail.com

Abstract

Background and Aim: It has been demonstrated that patients with pre-frailty have more adverse outcomes after cardiac surgery; however, data on prognosis and long-term evolution in patients with pre-frailty after elective cardiac surgery without postoperative complications are still scarce. To evaluate the impact of pre-frailty status on functional survival in patients after elective cardiac surgery without surgical complications.

Methods: This was a retrospective study with 141 patients over 65 years old, with an established diagnosis of myocardial infarction or valve disease. Patients were evaluated by Clinical Frailty Scale (CFS) before surgery, according to the hospital protocol, and allocated into two groups: non-frail (CFS, 1–3) and pre-frail (CFS = 4). Patients with adverse cardiovascular events during surgery or at intensive care unit (ICU), mechanical ventilation more than 24 hours, ICU length of stay more than 48 hours, and in-hospital complications were excluded. For all analyses, the statistical significance was set at 5% ($P < .05$).

Results: There were no differences in demographic, anthropometric, surgical procedure, or baseline data on ICU. Pre-frail patients had more adverse events during the 3-year follow-up period with rehospitalization compared to non-frail (39.4% vs 14.3%, respectively). Rehospitalizations in pre-frail patients were in the first year after cardiac surgery ($P < .05$), and higher cumulative events in pre-frail have occurred with increased odds ratio (OR) (2.828, 95% confidence interval [CI]: 1.298-6.160; $P = .001$) and hazard ratio (HR) (3.560, 95% CI: 1.508-84.04; $P = .004$). The OR and HR for stroke or death were similar between groups when analyzed separately.

Conclusion: Pre-frail patients have more adverse events after elective cardiac surgery without complications when compared to non-frail patients.

KEYWORDS

adverse events, aging, cardiac surgery, frailty, rehospitalization

1 | INTRODUCTION

The aging population has become a global public health issue. According to data from World Population Prospects, it is estimated that the global population of elderly people will rise from 962 million in 2017 to 2.1 billion by 2050 and 3.1 billion by 2100.[1] Parallel to the aging population, cardiovascular diseases are the leading cause of death worldwide. Currently, more than

half of all cardiac procedures are performed on the elderly,[2] and despite that the advanced age population is heterogeneous, frailty afflicts elderly patients in decline as they advance in age and has been recognized as an important condition for predicting outcomes. Studies have shown that frail elderly patients are at an increased risk for prolonged hospitalization and mortality after surgery,[3-5] particularly after major medical or surgical events.[2,6] In addition, during the postoperative period, patients with frailty[6,7] and pre-frailty[8] showed longer mechanical ventilation times and hospital stays with an increased risk for adverse events as compared with non-frail patients.

Both pre-frailty and frailty have been described as biological syndromes resulting from the dysregulation of multiple metabolic pathways.[2-4] This multidimensional syndrome is characterized by a decline in physiologic and cognitive status,[2] and therefore, a comprehensive preoperative assessment is essential to determine the relative risk and benefit of the surgical intervention in this patient population.

Although frailty tends to increase with age, such an evaluation is a factor independent from chronological age or any specific medical condition,[3,4,9,10] and it allows for a better understanding of an individual's ability to maintain homeostasis after a stressful event, making it a useful tool for surgical risk stratification. In addition, frailty is a specific condition that involves malnutrition, weakness, slowness and inactivity, and denotes the patient's real functional capacity, regardless of chronological age. Most studies have evaluated the impact of frailty and pre-frailty in the postoperative period immediately after cardiac surgery, with worse outcomes compared to patients who are non-frail.[7,8,11,12] However, data on the prognosis and long-term evolution in patients who have undergone elective cardiac surgery without postoperative complications are still scarce. Furthermore, the current methods for prediction have a series of limitations[11] and represent the difficulty in predicting long-term survival.[13]

We understand that the accurate prediction of functional survival might guide treatment decisions for the patient, aid in informed consent, guide cardiac surgery, and postoperative care. From this perspective, we performed a retrospective study to evaluate the impact of pre-frailty on functional survival in patients after elective cardiac surgery without any surgery complication.

2 | MATERIALS AND METHODS

A three-year retrospective study based on a hospital database was conducted, and a sample of 141 patients over 65 years of age was enrolled. All of them had an established diagnosis of cardiovascular disease (myocardial infarction, valve regurgitation, or stenosis) determined by previous electrocardiogram and/or Doppler echocardiography, and all had surgical interventions (coronary artery bypass [CAB], valve replacement or valve repair). Patients with prior neurological/muscular disease (previous stroke or muscular dystrophies), cognitive impairment resulting from previous injury, frailty score of ≥ 5, nonelective/emergency surgery procedures, or incomplete data were excluded.

2.1 | Study protocol

According to the hospital protocol, frailty was assessed by the Clinical Frailty Scale (CFS)[14] 24 hours before the scheduled elective surgery. The CFS was based on previous reports with frail definitions into categories: without frailty, pre-frailty, and frailty.[12,15,16] In this line, we assigned patients into two groups based on this score: non-frail (frailty score, 1-3) and pre-frail (frailty score, 4) according to their CFS.

If patients experienced adverse cardiovascular events—both during surgery or at the intensive care unit (ICU)—such as stroke, infection, prolonged mechanical ventilation time (more than 24 hours), ICU stay of more than 48 hours, or in-hospital death, they were excluded.

All included patients were analyzed for 3 years using data from the hospital database, which included medical appointments every 6 months after hospital discharge and major adverse cardiovascular events (atrial fibrillation, pneumonia, pleural effusion, acute myocardial infarction, heart failure, stroke, and death). Moreover, CFS was evaluated after 6 months after hospital discharge, during medical appointment, and after the rehospitalization period.

This retrospective study was approved by the Institutional Ethics Committee (number 2.352.465; following resolution number 466/2012 of the National Health Council and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards). Trial registration at ClinicalTrials.gov: #NCT03949439.

2.2 | Statistical analysis

The statistical analysis was performed using the SPSS program (version 20; SPSS Inc). Data are expressed as mean ± standard deviation and percentage. A Kolmogorov-Smirnov test was used to determine the normality of the data distribution; a *t* test and paired *t* test were used for related samples, and a χ^2 test was used to assess categorical data differences.

The survival variables were compared using a log rank test, and Kaplan-Meier survival curves were constructed, and subsequently, we adjust the pre-frailty for other baseline risk factors and performed the bivariate logistic regression. Follow-up time was calculated in days from the date of the baseline measurement to the date of a major adverse cardiovascular event or the end of the follow-up period. For all of the analyses, the statistical significance was set at 5% ($P < .05$).

3 | RESULTS

A total of 453 patients were screened, and of these, 247 patients were not eligible to participate and were excluded. So 206 were enrolled in this study, however 65 patients were excluded for several

TABLE 1 Patients' baseline characteristics after elective cardiovascular surgery without complications in non-frail and pre-frail patients

	Non-frail (n = 42)	Pre-frail (n = 99)	*P* value
Anthropometrics/demographics			
Male, n (%)	27 (64.3%)	59 (59.6%)	.451
Age, y	66 ± 1	69 ± 4	<.0001
Weight, kg	70.2 ± 9.9	71.1 ± 12.9	.687
Height, m	1.66 ± 0.08	1.63 ± 0.10	.084
BMI, kg/m^2	25.3 ± 2.6	26.6 ± 3.9	.058
Clinical data			
LVEF, (%)	53.7 ± 13.1	57.9 ± 10.0	.073
Euro score	4 ± 2	5 ± 2	.320
ASA	2 ± 0	2 ± 0	.931
Hypertension, n (%)	34 (81%)	79 (79.8%)	.845
Type II diabetes, n (%)	17 (40.5%)	33 (33.3%)	.117
Dyslipidemia, n (%)	16 (38.1%)	50 (50.5%)	.03
Smoker, n (%)	8 (19%)	11 (11.1%)	.091
Surgical data			
Coronary artery bypass, n (%)	21 (50%)	62 (62.6%)	.112
Valve replacement, n (%)	17 (40.5%)	29 (29.3%)	.091
Coronary artery bypass + valve replacement, n (%)	4 (9.5%)	8 (8.1%)	.834
Partial thromboplastin time activated, s	27.3 ± 6.3	25.3 ± 8.4	.174
Cardiopulmonary bypass time, min	87.4 ± 21.0	90.0 ± 38.5	.680
Cross-clamp time, min	66.9 ± 15.5	61.4 ± 30.6	.274
Baseline hemodynamic and blood sample			
HR, bpm	94 ± 12	92 ± 16	.498
MAP, mm Hg	91 ± 12	97 ± 15	.614
Hemoglobin, g/dL	11.3 ± 1.7	10.9 ± 1.6	.200
Hematocrit, (%)	35.0 ± 4.7	34.7 ± 8.5	.812
Platelets, mm^3	150,428 ± 53,891	147,353 ± 51,943	.751
Urea, mmol/L	52.6 ± 10.6	43.1 ± 17.1	.002
Creatinine, mg/dL	1.0 ± 0.2	1.2 ± 1.6	.434
hs-CPR, mg/L	8.3 ± 1.2	8.8 ± 0.9	.743
PaO_2, mm Hg	124.8 ± 47.9	120.3 ± 53.2	.802
$PaCO_2$, mm Hg	39.8 ± 5.9	38.0 ± 7.6	.167
HCO_3, mmol/L	22.3 ± 1.7	21.8 ± 3.2	.342
SpO_2, (%)	96 ± 2	97 ± 3	.646
ICU vasopressor			
Noradrenaline, n (%)	16 (38.1%)	33 (33.3%)	.341
Dobutamine, n (%)	5 (11.9%)	9 (9.1%)	.865
Dopamine, n (%)	8 (19%)	14 (14.2%)	.324
Nitroglicerin, n (%)	5 (11.9%)	17 (17.2%)	.258

Note: Values are expressed in mean ± standard deviation or frequency.
Abbreviations: ASA, American society of anesthesiologists; BMI, body mass index; HCO_3, bicarbonate; HR, heart rate; hs-CPR, high sensitive c-reactive protein; ICU, intensive care unit; LVEF, left ventricular ejection fraction; MAP, mean arterial pressure; $PaCO_2$, arterial carbon dioxide pressure; PaO_2, arterial oxygen pressure; SpO_2, oxyhemoglobin saturation by pulse oximetry.

reasons (emergency surgery—17 patients; adverse events during hospitalization—9 patients; lost follow-up—25 patients; incomplete database—14 patients).

As such, 141 postcardiovascular elective surgery patients without complications were enrolled in this study: 42 with non-frailty and 99 with pre-frailty scores. Of these, a higher percentage of male patients were found in both groups. Moreover, no demographic or anthropometric differences between the groups were observed, but the pre-frail group was slightly older than the non-frail group (Table 1). In addition, no differences were found regarding main comorbidities, surgical procedures or baseline data at the ICU (blood sample or ICU vasopressor).

A higher percentage of pre-frail patients required rehospitalization during the follow-up period, and most occurred during the first year after cardiac surgery (pre-frail n = 28 vs non-frail n = 7). On the other hand, the non-frail group demonstrated a reduced length of stay as compared to the pre-frail patients (Table 2). The most of rehospitalizations in both groups were at the ward; however, the pre-frail group had more ICU rehospitalizations, strokes, and deaths compared to the non-frail group (Table 2). In addition, 18 patients (46.1%) in the pre-frail group became frail (CFS> 5) after the rehospitalization period.

Odds ratio and hazard ratio (HR) were only calculated for the pre-frail patients, who had an increase in both for adverse outcomes. In addition, the Kaplan-Meier analysis demonstrated higher cumulative events (Figure 1) in patients with pre-frailty.

4 | DISCUSSION

We performed a study to evaluate the impact of pre-frailty on long-term survival after elective cardiac surgery in patients who had received a hospital discharge without complications (intraoperative or in-hospital postoperative). To the best of our knowledge, this is the first study that identifies pre-frail patients after elective cardiac surgery without postoperative complications presenting greater long-term deleterious repercussions than no-frail patients.

In a recently study, our group have demonstrated that pre-frail patients had worse outcomes after cardiac surgery in a short period of time.[8] So, we have questioned if these finds could be extended to those without any surgical complications. Therefore, all patients analyzed in our study were discharged from the hospital without any limitations. Indeed, while they had no complications, we observed that these patients had higher incidence of re-hospitalization as compared to non-frail patients. This fact may be related to exposure to a stressful event—cardiac surgery—, which probably imposes a deleterious effect greater in pre-frail patients than in non-frail, since they had higher incidence of rehospitalization for a period of 6 to 12 months with a significant worsening of the previous functional status.

Almost 50% of pre-frail patients become frail during the re-hospitalization period. Such mechanism has been previously described for patients with frailty, in which similar stress events cause a greater deterioration as compared to non-frail patients, possibly requiring a longer period of functional dependence or often without returning to baseline homeostasis.[4] Therefore, precisely determining the presence of pre-frailty during the preoperative period becomes extremely important since frailty may predict the risk of cumulative events (stroke or in-hospital death).[8] In addition, pre-frailty is a condition that predisposes and directly precedes frailty.[17] Although this assertion is well established, the effect of a stressor event on long-term pre-frail patients was not clear. A previous study with frail patients undergoing cardiac surgery has shown that the presence of preoperative frailty is associated with a twofold to threefold to fivefold higher risk of poor functional survival 1 year after of cardiac surgery.[2,18]

In this line, our study adds new important evidence that even pre-frail patients without postoperative complications have higher adverse events after hospital discharge. In addition, besides the higher incidence of re-hospitalizations, our study has also demonstrated that they were more severe in these patients, requiring a longer hospitalization time and intensive care and, consequently, experiencing a higher incidence of cumulative events, like stroke and death.

Some studies have demonstrated that frail patients have a reduced midterm survival after cardiac surgery.[19-21] Recently Reichart et al[22] reported on a very large series of patients undergoing coronary surgery and were one the firsts to demonstrate the clinical impact of pre-frailty (CFS 3-4 for midterm mortality: HR 2.02, 95% confidence interval, 1.43-2.85) in patients undergoing cardiac surgery. They showed that a large number of pre-frail patients have had a higher mortality rate in both 30/day and after a 1-year follow-up of cardiac surgery. Moreover, the authors suggest that CFS was able to predict early and mid term mortality after cardiac surgery (CAB grafting)[22]. In addition, the authors demonstrated that CFS improved the prediction of adverse events when associated to EuroSCORE II. However, our study evaluated only patients who survived cardiac surgery without complications and we believe that our results have gone one step further on this theme, and reinforce that pre-frail patients also require intensive care after elective cardiac surgery without complications due to an increased number of rehospitalizations during the first year.

Despite being outside the scope of our study, this fact raises an important point regarding multidisciplinary attention to these patients[17,23] as rehabilitation programs are able to reduce

TABLE 2 Follow-up data after hospital discharge in non-frail and pre-frail patients after elective cardiovascular surgery without complications

	Non-frail (n = 42)	Pre-frail (n = 99)	*P* value
Rehospitalization, n (%)	6 (14.3%)	39 (39.4%)	<.0001
Ward, n (%)	5 (83.3%)	31 (79.5%)	.001
ICU, n (%)	1 (16.6%)	8 (20.5%)	.001
Main causes of rehospitalizations, n (%)			
Atrial fibrillation, n (%)	3 (50%)	8 (20.5%)	.07
Pleural effusion, n (%)	1 (16.6%)	5 (12.8%)	.03
AMI, n (%)	0	5 (12.8%)	.03
Heart failure, n (%)	0	4 (10.2%)	.01
Stroke, n (%)	1 (16.6%)	10 (25.6%)	<.0001
Deaths, n (%)	1 (16.6%)	7 (17.9%)	.001
Length of stay, days	8 ± 3	14 ± 2	.02

Note: Values are expressed in mean ± standard deviation or frequency.
Abbreviations: AMI, acute myocardial infarction; ICU, intensive care unit.

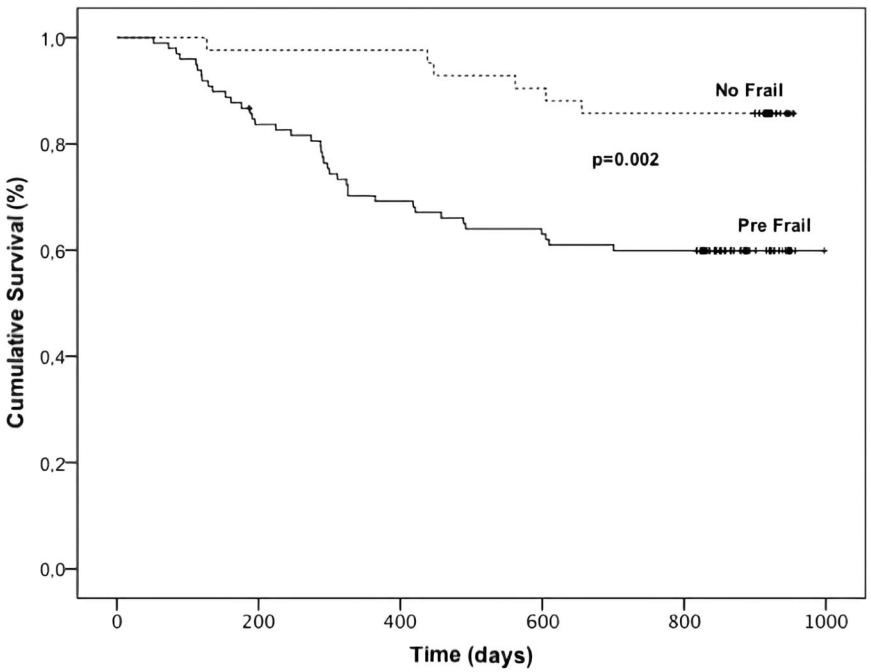

FIGURE 1 Cumulative survival for adverse outcomes (atrial fibrillation, pleural effusion, angina, heart failure, stroke and death) between non-frailty and pre-frailty groups after cardiac elective surgery without complications

rehospitalizations and promote a better recovery from cardiac surgery.[24] It is already demonstrated that pre-frail status is a condition that is possibly reversible or modifiable by interventions.[25-28] Previous research on nonpharmacological interventions, such as physical exercise and nutritional interventions, have shown promising effects on frailty status and functional survival,[23,28,29] and may even prevent or slow down frailty steps,[30] demonstrating the real need to study the long-term behaviour individuals in the early stages of frailty.

Furthermore, how presurgical physiotherapy could reduce adverse events during hospitalization and after hospital discharge, both in frail and pre-frail patients, is still unknown. Finally, an accurate prediction of long-term survival can guide treatment decisions for the patient, cardiac surgery and the necessary postoperative care and aid in informed consent.

4.1 | Clinical implications

Rodrigues et al[8] recently demonstrated that pre-frail patients are predisposed to increased hospitalization time and mortality after cardiac surgery. Therefore, the early detection of frailty and pre-frail in patients undergoing cardiac surgery is critical for presurgical interventions to preserve their functional status.[17,31] In our study, we have gone substantially further on this topic. We demonstrated higher incidence of adverse outcomes in this patient population after elective cardiac surgery, and its role as a risk factor for cardiac surgical interventions has not been investigated previously. In addition, we suggest that pre-frailty is an independent predictor of readmission mortality and reduced medium-term survival as compared to non-frail patients.

As the main result of our research, both patients and multidisciplinary teams might be better informed about potential adverse outcomes and add better presurgical interventions before cardiac surgery, improving rehabilitation, and nutrition before a planned intervention.[17,32] Moreover, a close follow-up after hospital discharge can reduce the number of readmissions and consequently the costs for these patients.

4.2 | Study limitations

Our study has some limitations that should be addressed: (a) The inclusion criteria might limit the sample size of this study, but, we believe that this is the first study design to evaluate pre-frail patients without complications after elective cardiac surgery. We decided to exclude patients with CFS more than five, as our objective was to evaluate pre-frail patients without any surgical complications as our group recently had demonstrated that pre-frail patients had worse outcomes after cardiac surgery in a short period of time.[8] So, this new study offers new perspectives for the future, as new protocols that include provisions for pre-frail patients without complications. In addition, both pre and postsurgical interventions, as exercise/early mobilization in main outcomes should be studied; (b) Due to the design of our study, the extrapolation of our findings to patients with cardiac surgical complications should be viewed with caution. We understand that longer term risk of rehospitalization and deaths is similarly important for those with surgical complications, so this study opens a large perspective of studies to identify the risk of rehospitalization, death, and other clinical endpoints in these patients; (c) We performed a retrospective study at a single centre, so a prospective multicentre-study should be addressed to confirm our

data; (d) Finally, whether it is pre-frailty per se that is actually the driving factor for predicting long-term outcomes or if there are some other confounding factors remains unknown. Some patients had a worsened frailty status during the follow up, but it is unclear how changes in frailty levels postsurgery influence outcomes. Larger further studies in this population should address these questions.

5 | CONCLUSION

Pre-frail patients after elective cardiac surgery without complications have more rehospitalizations and cumulative adverse events, mainly during the first year, as compared to non-frail patients.

CONFLICT OF INTERESTS

The authors declare that there are no conflict of interests.

AUTHOR CONTRIBUTIONS

MKR, AM, IIKU, and MFO contributed to conception design. MKR and AM collected data. IIKU and DMLL were involved in data analysis and interpretation. AM, IIKU, and DMLL were involved in conception of tables and figures. MKR, AM, and DMLL drafted the manuscript. MFO revised the manuscript. All authors read and approved the final manuscript.

ORCID

Mayron F. Oliveira http://orcid.org/0000-0001-7378-4094

REFERENCES

1. United Nations. *World Economic and Social Survey 2007: Development in an Ageing World*. New York, NY: United Nations; 2007. http://www.un.org/en/development/desa/policy/wess/wess_archive/2007wess.pdf. Accessed 4 December 2019.
2. Sergi G, Veronese N, Fontana L, et al. Pre-frailty and risk of cardiovascular disease in elderly men and women: the Pro.V.A. study. *J Am Coll Cardiol*. 2015;65(10):976-983.
3. Afilalo J, Alexander KP, Mack MJ, et al. Frailty assessment in the cardiovascular care of older adults. *J Am Coll Cardiol*. 2014;63(8):747-762.
4. Clegg A, Young J, Iliffe S, Rikkert MO, Rockwood K. Frailty in elderly people. *Lancet*. 2013;381(9868):752-762.
5. Chen MA. Frailty and cardiovascular disease: potential role of gait speed in surgical risk stratification in older adults. *J Geriatr Cardiol*. 2015;12(1):44-56.
6. Makary MA, Segev DL, Pronovost PJ, et al. Frailty as a predictor of surgical outcomes in older patients. *J Am Coll Surg*. 2010;210(6):901-908.
7. Le Maguet P, Roquilly A, Lasocki S, et al. Prevalence and impact of frailty on mortality in elderly ICU patients: a prospective, multicenter, observational study. *Intensive Care Med*. 2014;40(5):674-682.
8. Rodrigues MK, Marques A, Lobo DML, Umeda IIK, Oliveira MF. Pre-frailty increases the risk of adverse events in older patients undergoing cardiovascular surgery. *Arq Bras Cardiol*. 2017;109(4):299-306.
9. Stolz E, Mayerl H, Freidl W. Fluctuations in frailty among older adults. *Age Ageing*. 2019;48:547-552.
10. Hewitt J, Carter B, McCarthy K, et al. Frailty predicts mortality in all emergency surgical admissions regardless of age. An observational study. *Age Ageing*. 2019;48:388-394.
11. Sepehri A, Beggs T, Hassan A, et al. The impact of frailty on outcomes after cardiac surgery: a systematic review. *J Thorac Cardiovasc Surg*. 2014;148(6):3110-3117.
12. Baldwin MR, Reid MC, Westlake AA, et al. The feasibility of measuring frailty to predict disability and mortality in older medical intensive care unit survivors. *J Crit Care*. 2014;29(3):401-408.
13. Barili F, Pacini D, Capo A, et al. Does EuroSCORE II perform better than its original versions? A multicentre validation study. *Eur Heart J*. 2013;34(1):22-29.
14. Rodrigues MK, Rodrigues IN, Vasconcelos Gomes da Silva DJ, Pinto JM, Oliveira MF. Clinical frailty scale: translational and cultural adaptation into the Brazilian Portuguese language. *J Frailty Aging*. 2020. https://doi.org/10.14283/jfa.2020.7
15. Fried LP, Tangen CM, Walston J, et al. Frailty in older adults: evidence for a phenotype. *J Gerontol A Biol Sci Med Sci*. 2001;56(3):M146-M156.
16. Rockwood K, Song X, MacKnight C, et al. A global clinical measure of fitness and frailty in elderly people. *CMAJ*. 2005;173(5):489-495.
17. Sacha J, Sacha M, Sobon J, Borysiuk Z, Feusette P. Is it time to begin a public campaign concerning frailty and pre-frailty? A review article. *Front Physiol*. 2017;8:484.
18. Lytwyn J, Stammers AN, Kehler DS, et al. The impact of frailty on functional survival in patients 1 year after cardiac surgery. *J Thorac Cardiovasc Surg*. 2017;154(6):1990-1999.
19. Lee DH, Buth KJ, Martin BJ, Yip AM, Hirsch GM. Frail patients are at increased risk for mortality and prolonged institutional care after cardiac surgery. *Circulation*. 2010;121(8):973-978.
20. Ad N, Holmes SD, Halpin L, Shuman DJ, Miller CE, Lamont D. The effects of frailty in patients undergoing elective cardiac surgery. *J Card Surg*. 2016;31(4):187-194.
21. Koh LY, Hwang NC. Frailty in cardiac surgery. *J Cardiothorac Vasc Anesth*. 2019;33(2):521-531.
22. Reichart D, Rosato S, Nammas W, et al. Clinical frailty scale and outcome after coronary artery bypass grafting. *Eur J Cardiothorac Surg*. 2018;54(6):1102-1109.
23. Esteban-Cornejo I, Cabanas-Sánchez V, Higueras-Fresnillo S, et al. Cognitive frailty and mortality in a national cohort of older adults: the role of physical activity. *Mayo Clin Proc*. 2019;94:1180-1189.
24. Plüss CE, Billing E, Held C, et al. Long-term effects of an expanded cardiac rehabilitation programme after myocardial infarction or coronary artery bypass surgery: a five-year follow-up of a randomized controlled study. *Clin Rehabil*. 2011;25(1):79-87.
25. Cameron ID, Fairhall N, Gill L, et al. Developing interventions for frailty. *Adv Geriatr*. 2015;2015:845356.
26. Gill TM, Gahbauer EA, Allore HG, Han L. Transitions between frailty states among community-living older persons. *Arch Intern Med*. 2006;166(4):418-423.
27. Xue QL. The frailty syndrome: definition and natural history. *Clin Geriatr Med*. 2011;27(1):1-15.
28. Cadore EL, Rodriguez-Manas L, Sinclair A, Izquierdo M. Effects of different exercise interventions on risk of falls, gait ability, and balance in physically frail older adults: a systematic review. *Rejuvenation Res*. 2013;16(2):105-114.
29. Gine-Garriga M, Roque-Figuls M, Coll-Planas L, Sitja-Rabert M, Salva A. Physical exercise interventions for improving performance-based measures of physical function in community-dwelling, frail older adults: a systematic review and meta-analysis. *Arch Phys Med Rehabil*. 2014;95(4):753-769.e3.

30. Rizzoli R, Reginster JY, Arnal JF, et al. Quality of life in sarcopenia and frailty. *Calcif Tissue Int*. 2013;93(2):101-120.
31. Wong TY, Massa MS, O'Halloran AM, Kenny RA, Clarke R. Cardiovascular risk factors and frailty in a cross-sectional study of older people: implications for prevention. *Age Ageing*. 2018;47(5):714-720.
32. Kocman D, Regen E, Phelps K, et al. Can comprehensive geriatric assessment be delivered without the need for geriatricians? A formative evaluation in two perioperative surgical settings. *Age Ageing*. 2019;48:644-649.

How to cite this article: Rodrigues MK, Marques A, Umeda IIK, Lobo DML, Oliveira MF. Pre-frailty status increases the risk of rehospitalization in patients after elective cardiac surgery without complication. *J Card Surg*. 2020;1–7.
https://doi.org/10.1111/jocs.14550