Nutrition and Frailty Status of Patients Undergoing Cardiovascular Surgery and Its Association With Postoperative Outcomes

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Abstract

BACKGROUND: Malnutrition is a component of frailty syndrome characterized by weakness, poor nutritional status, and reduced cognitive function. Frailty has been recognized to adversely affect post–cardiovascular surgery outcomes, with studies primarily in the elderly. To date, there are no published Philippine data on malnutrition and frailty in cardiac surgery patients.

METHODS: Malnutrition and frailty were assessed preoperatively in 111 adult patients undergoing cardiovascular surgery from October 2020 to February 2021. Nutrition Risk Screening (NRS) tool and Clinical Frailty Scale (CFS) were used for assessment, respectively. Their in-hospital postoperative outcomes were then observed.

RESULTS: There were 57 patients (51%) diagnosed with malnutrition, 26 (23%) of whom were also frail. Advanced age, rheumatic heart disease, heart failure, and chronic kidney disease were significantly higher in the malnutrition and frail group. After multivariate analysis, mortality rate (odds ratio [OR], 7.8; 95% confidence interval [CI], 1.45–41.91; $P = 0.017$), prolonged hospitalization (OR, 5.96; 95% CI, 2.14–16.53; $P = 0.001$), mechanical ventilation (OR, 7.56; 95% CI, 1.81–31.62; $P = 0.006$), and nosocomial infections (OR, 13.57; 95% CI, 4.41–41.76; $P < 0.001$) were found higher in patients with malnutrition and frailty.

CONCLUSION: Evaluation of nutrition and frailty status using NRS and CFS was helpful in predicting postoperative outcomes. With a significant number of this population having malnutrition and frailty, there is a need to strengthen clinical pathways on perioperative nutrition and rehabilitation with the possibility of improving cardiovascular surgery outcomes.

KEYWORDS: malnutrition, frailty, cardiovascular surgery, postoperative outcomes

INTRODUCTION

Malnutrition is broadly defined as nutrition imbalance as a result of overnutrition and undernutrition. Undernutrition is more common in critical illness due to lack of caloric intake and nutrients needed for tissue repair and maintenance.[1] Critical illness also results in increased caloric requirements, poor absorption and utilization, and inflammation. Inflammation results in suboptimal response to nutrition intervention.[2] Postoperative cardiovascular surgery patients in the surgical intensive care are at an increased risk of malnutrition. Unique to patients undergoing cardiopulmonary bypass is the intensity of the inflammatory response from surgical trauma, which may be aggravated by preexisting malnutrition.[3] Chronic heart failure, common in patients undergoing cardiovascular surgery, is associated with intestinal edema, leading to poor absorption compounding the risk of malnutrition.[4]

A diagnosis of malnutrition results in significant use of resources because of its accompanying complications. This results in a prolonged hospital stay with a relative risk of 2.63 for mortality.[5] Malnourished patients who underwent cardiac surgery also have increased risk of prolonged ventilation and nosocomial infection.[6,7]

Despite its effects, malnutrition prevalence is increasing across the world because of underrecognition and aging population.[8] In the hospitalized elderly, malnutrition has a prevalence of 38%.[9] Among patients undergoing cardiac surgery, the range varies from 1.2% to 46.4%. The large variation in prevalence is due to different nutrition screening tools used, regional differences, and socioeconomic aspects of nutrition.[10] In a study in a local hospital in Baguio City, the prevalence of malnutrition was exceedingly high at 73%.[11]

Because of the variation with clinical screening and diagnosis of malnutrition, The European Society of Parenteral Nutrition (ESPEN) has convened together to streamline guidelines in the diagnosis of malnutrition. The Global Leadership Initiative on Malnutrition (GLIM) criteria were formed. However, lack of availability of sarcopenia measurement tools and anthropometric racial differences in Asian populations preclude its widespread use.[12]

One of the endorsed nutrition screening tools by ESPEN was the Nutrition Risk Screening 2002 (NRS-2002). NRS-2002 is one of the most widely used and validated screening tools used in the community and hospital. It has been validated for screening malnutrition for in-hospital patients in Asian populations[11,13] and for preoperative cardiac surgery evaluation.[7] It is used for identifying and monitoring nutrition intervention. It uses body mass index (BMI), weight loss, reduced dietary intake, and intensive care admission as screening tools. Nutrition risk assessment is then completed using the following criteria: weight loss, food intake, gastrointestinal symptoms, functional capacity, degree of stress, physical examination, subjective global assessment grade, BMI, and total lymphocyte count. A score of 1 to 2 indicates mild to moderate malnutrition, whereas a score of 3 or greater indicates severe malnutrition.[14] Even though there is evidence of poor outcomes among cardiac surgery patients with malnutrition, there continues to be lack of specific guidelines for improving nutrition in this population.[10]

Malnutrition is a central component of clinical frailty, which is a syndrome characterized by weakness, poor nutritional status, and reduced cognitive function, resulting in susceptibility to stressors.[15] It is more common in aging individuals as part of age-related decline. However, in contradistinction to aging, frailty is associated with increased inflammatory markers with higher odds of dying compared with nonfrail individuals.[15,16]

Frailty has been recognized as a condition that affects cardiac surgery outcomes. A higher risk of complications arises among patients with frailty undergoing cardiac surgery and is associated with prolonged care postoperatively.[17–19] The effects of frailty on critical illness are now frequently observed because of increasing number of older individuals admitted to the critical care units.[19] Hence, evaluation for frailty is important not only for prognosis but also as a modifiable risk factor in improving outcomes by rehabilitation.[20]

There are a number of validated tools to screen and classify frailty, which resulted in variability in assessing frailty measures such as muscle strength, movement, cognitive decline, and activities of daily living.[21] Some tools use equipment and imaging to define muscle strength and volume, rendering it less feasible for routine assessment for in-hospital setting.[16] Hence, the Canadian Society of Health and Aging developed the Clinical Frailty Scale (CFS) as a simple tool for determining the level of frailty.[22] It can be incorporated in the usual clinical assessment without any use of specialized equipment or training. The CFS is a 9-point examination, with frailty being defined as a score of greater than 4. It involves history of the patients' mobility, self-care, cognitive domain, and activities that require higher order of thinking.[22] It is highly correlated with the more comprehensive Frailty Index and has been well validated.[23–25] Frailty has a pooled prevalence of 30% in a systematic review, with a relative risk of mortality at 1.71.[24]

Studies of frailty in developed countries included population with advanced age (>60 years old).[24,25] The most common comorbidities were heart failure from coronary artery disease, hypertension, and degenerative aortic stenosis.[24] In contrast, younger patients are expected with local data, with earlier onset at degenerative disease as explained by epidemiologic transition of cardiovascular disease as economies and preventive health care develop.[26]

To date, there are no published Philippine data on malnutrition and frailty in cardiac surgery patients. There is paucity of data in frailty in the young. The use of frailty has recently been applied to pediatric patients with congenital heart disease, and more data are needed on how it affects clinical outcomes.[27] To date, there are no published data specifically on frailty in the younger adult (<60 years old).

This study aims to determine the in-hospital postoperative outcomes of patients with malnutrition and frailty admitted for cardiovascular surgery

METHODOLOGY

Study Maneuver

This study was a prospective cohort study conducted in the hospital from October 2020 to February 2021. Online census was accessed daily. All eligible patients who underwent surgery were screened with the following inclusion and exclusion criteria. Purposive sampling was done.

Inclusion criteria were as follows: all adult patients 19 years or older admitted for cardiovascular surgery.

Exclusion criteria were as follows: refusal to give informed consent, inability of the patient and his/her relative to answer questions from CFS, NRS-2002.

Once eligibility criteria were met, informed consent was obtained from the patient. Once given, the data collection form was used to interview, examine, and collect data. NRS-2002 was used to determine the nutrition status. The CFS was used to determine frailty status. Medical records were reviewed for prior weight. Patients were then followed up daily, until the outcomes of interests were achieved: prolonged hospitalization, prolonged intubation, nosocomial infection, and in-hospital mortality.

Sample Size

A minimum of 91 patients were required for this study based on 38.03% prevalence of undernourished (malnourished and at risk of malnutrition) measured by NRS-2002, with 5% level of significance and 10% desired half-width of the confidence interval (CI).[9,28]

Definition of Terms

Independent Variables

a. Malnutrition—NRS-2002 score of 3 or greater (severe malnutrition) after graded assessment of weight loss, food intake, gastrointestinal symptoms, functional capacity, degree of stress, subjective global assessment, BMI, albumin, and total lymphocyte count.
b. Frailty—CFS score of 5 or greater. A score of 4 indicates the patient is at risk.

Dependent Variables

a. Prolonged hospitalization—hospital stay of more than 7 days
b. Prolonged intubation—intubation for more than 48 hours
c. Nosocomial infection—signs and symptoms of infection with a microbial growth during the hospital stay.

Statistical Analysis

Descriptive statistics was used to summarize the demographic and clinical characteristics of the patients. Frequency and proportion were used for categorical variables, median and interquartile range for non–normally distributed continuous variables, and mean and SD for normally distributed continuous variables. One-way analysis of variance, Kruskal–Wallis test, and Fisher exact test were used to determine the difference of mean, rank, and frequency, respectively, within different nutritional and frailty status. Odds ratios (ORs) and their corresponding 95% CIs from binary logistic regression were computed to determine significant factors of the outcomes. Shapiro–Wilk was used to test the normality of the continuous variables. Missing variables were neither replaced nor estimated. Null hypotheses were rejected at the α level of significance of 0.05. STATA 13.1 (StataCorp, College Station, Texas, USA) was used for data analysis.

Ethical Considerations and Data Management

The study was conducted upon approval of the Technical Review Board and Ethics Review Board. There were no direct benefits for the subjects joining this study, with indirect benefits for future patients. This is a minimal risk study because only interview, physical examination, and records review were done. The benefit–risk ratio is favorable.

Before a subject's participation, a written informed consent was given after adequate explanation of the aims, methods, benefits, and potential risks of the study. The informed consent was signed and personally dated by the patient. If by any means the patient is unable to provide consent, the legally authorized representative was the one to give consent. One copy of the signed informed consent was given.

The investigator preserved the confidentiality and anonymity of all subjects taking part in the study. The risk to the subject's privacy was minimal. The investigator ensured that the subject's anonymity was maintained. All data were encoded using a password-protected Excel spreadsheet (Microsoft Inc, Redmond, Washington, USA). A code number was assigned for each patient, with a separate password-protected spreadsheet that links the study code to the patient's name. Only the principal investigator had access to this file. After encoding, all data collection forms were kept in a secured cabinet. The researchers adhered fully to the provisions of the Data Privacy Act of 2012.

Only those stated in the protocol are the data that were obtained. No patient-relation compensation was given, nor any direct benefits to the patients were provided. After the study, all data were disposed after 3 years.

The principal investigators had no conflict of interest in any form (financial, proprietary, professional) with the study, coinvestigators, or the site. The principal investigators had undergone training in Good Clinical Practice and have reviewed these guidelines prior to the writing of this protocol.

RESULTS

The diagnosis of malnutrition was noted in 51% of patients admitted. Malnutrition was found in older patients with a mean age of 57 years. Surgery for rheumatic heart disease, mitral valve, and multivalve surgery had a higher prevalence of malnutrition at 73%. Among comorbidities, heart failure, atrial fibrillation, and chronic kidney disease were significantly associated with malnutrition. Lymphopenia and higher creatinine were diagnostic of association with malnutrition (Table 1).

Clinical frailty was diagnosed in 23% of patients, with additional 16% at risk. Consistent with findings in malnutrition, higher age, rheumatic heart disease, mitral valve or multivalve surgery, heart failure, chronic kidney disease, lymphopenia, and increased creatinine have a higher prevalence in frail patients (Table 2).

All patients with frailty have malnutrition, putting them at a different classification to those with malnutrition alone. Patients with malnutrition and frailty were associated with increased occurrence of outcomes of interest (Table 3).

Patients with malnutrition were found to have a 2.96 times' odds of prolonged hospitalization, 6.95 times' odds of prolonged mechanical ventilation, and 6.92 times' odds of nosocomial infection, with mortality not achieving statistical significance. Presence of frailty on top of malnutrition has higher odds of outcomes, compared with normal and malnutrition alone. These patients have 7.8 times' odds for mortality, 5.96 times' odds of prolonged hospitalization, 7.56 times' odds of prolonged mechanical ventilation, and 13.56 times' odds of nosocomial infection (Table 4).

DISCUSSION

Patients with malnutrition and frailty were consistently observed to have worse outcomes compared with normal patients. Clinical profile that was seen in malnutrition and frailty patients is as follows: advanced age, heart failure, chronic kidney disease, and rheumatic valvular heart disease undergoing valvular surgery. Lymphopenia and increased creatinine were diagnostic parameters more common in malnourished and frail patients. The increased odds for mortality were not seen in malnutrition, but the other outcomes of interest—prolonged hospitalization, mechanical ventilation, and nosocomial infection—were all increased. Frailty on top of malnutrition has higher odds of all outcomes including mortality.

The prevalence of malnutrition is 51% in this study, which is higher compared with the review of related literature of 1.2% to 46.4% for patients undergoing cardiac surgery.[10] Several reasons for this include a significant proportion of rheumatic valvular heart disease, comprising 18% of the total cohort. Rheumatic heart disease parallels malnutrition as highly prevalent in the earlier stages of epidemiological transition of cardiovascular disease, expected in low- to middle-income countries.[26]

Another possible reason is that this study was done during the COVID-19 pandemic last year, resulting in schedule delays. This resulted in prolonged symptoms of heart failure. Heart failure is a known risk factor for developing malnutrition and is associated with weight loss and sarcopenia. The chronic inflammatory condition, cytokine dysfunction, reduced intake, and bowel edema are part of the mechanisms contributory to heart failure cachexia.[29] Renal insufficiency and increased creatinine were also consistently associated with malnutrition as seen in other studies and have also been established to be closely linked with heart failure.[10] The study by Unosawa et al[17] showed 3.44 times' odds of mortality for patients with malnutrition, which was not significant in patients with malnutrition alone, but in a subset of combined malnutrition and frailty, the OR for mortality is 7.8 times. With more than half of patients having malnutrition, undergoing surgery underscores the need for strengthening nutrition support perioperatively.

The prevalence of frailty in this study is 23% using the CFS. This is a slightly lower prevalence compared with a systematic review of 30% in a general medical intensive care unit (ICU) population, but within the range for cardiovascular surgery populations of 4.1% to 46%.[26,31,32] The wide prevalence range was due to age cutoffs and different screening tools used.[31,32] Systematic reviews on frailty involved predominantly developed countries with geriatric population age of 65 to 79 years with atherosclerotic cardiovascular disease and calcific aortic stenosis.[18,32] The age is relatively younger in this study, with a mean age of 59 years. Possible explanations include earlier onset at atherosclerotic cardiovascular disease compared with that in developed countries, with contribution of rheumatic valvular heart disease occurring in younger patients. The composite outcome for events in this study was 11.97 (3.57 to 40.15), higher than the reported OR in the systematic review of 4.89.[25]

The clinical implication of a high prevalence of malnutrition and frailty in cardiovascular surgery is the importance of screening and management. Strengthening clinical pathway and tailoring a specific nutrition therapy for these patients are also recommended. Cardiac rehabilitation starting preoperatively to mitigate frailty syndrome cannot be overemphasized, as it is also associated with improved outcomes.[33]

LIMITATIONS AND RECOMMENDATIONS

Frailty scales and CFS lack validation in the younger population. Frailty in general is a disease of the elderly, with most systematic reviews involving population age 65 years or older.[24,25] Although association was significant, CIs were wide because of the small sample size; hence, larger studies are needed.

There is a newer GLIM guideline that was endorsed by ESPEN as a criterion for the diagnosis of malnutrition. We recommend that the dual-energy x-ray absorptiometry and bioelectrical impedance analysis be used for a numerical assessment of reduced muscle mass for succeeding research. It was not used in this paper because of lack of immediate availability for perioperative use, as well as validation in the Filipino population..

CONCLUSION

Frailty and malnutrition status are associated with worse in-hospital outcomes in patients undergoing cardiovascular surgery. The hospital had a high prevalence of both diagnoses, not only in the elderly but also in younger patients. The diagnosis is associated with higher risk of in-hospital mortality and prolonged ICU utilization/hospitalization, increasing health care cost. Recognition and management of these conditions in this population are therefore essential.

Table 1. Clinical Profile of Malnutrition Patients

	No Malnutrition (Normal to Moderate Risk) n = 54 (49%)	Malnutrition (High Risk) n = 57 (51%)	*P* Value
	Frequency (%), Mean ± SD, Median (IQR)		
Age, y	47.83 ± 15.66	57.21 ± 14.77	0.002
Sex			
• Male	30 (55.56)	36 (63.16)	0.445
• Female	24 (44.44)	14 (36.84)	
Surgery			
• CABG	24 (44.44)	30 (52.63)	0.449
• Valvular surgery			
o Rheumatic heart disease	6 (11.11)	16 (28.07)	0.032
o Mitral	8 (14.81)	22 (38.60)	0.006
o Aortic	9 (16.67)	16 (28.07)	0.177
o Multivalve	4 (7.41)	15 (26.	0.011
• Congenital surgery			
o ASD	7 (12.96)	0 (0)	0.005
o VSD	1 (1.85)	1.75	1.000
o SOVA	1 (2.86)	0 (0)	0.486
• Vascular surgery			
o Infrarenal AAA	2 (3.70)	3 (5.26)	1.000
o Thoracic AAA	2 (3.70)	1 (1.75)	0.611
o Ascending AAA	1 (1.85)	2 (3.51)	0.520
• Cardiac tumor surgery	3 (5.56)	3 (5.26)	1
Comorbidities			
• Hypertension	29 (53.70)	36 (63.16)	0.340
• Heart failure (ejection fraction <40)	1 (1.85)	21 (36.84)	<0.001
• Atrial fibrillation	2 (3.70)	9 (15.79)	0.054
• Chronic kidney disease	4 (7.41)	19 (33.33)	0.001
• Chronic diver disease	0 (0)	3 (5.26)	0.244
• Chronic lung disease	3 (5.56)	2 (3.51)	4.50
• Diabetes	9 (16.67)	8 (14.04)	0.795
• Thyroid	1 (1.85)	1 (1.75)	1.00
• Cancer	0	0	
Laboratory data			
• WBCs, /μL	8.06 ± 2.46	8.91 ± 3.17	0.117
• Lymphocytes, /μL	27.79 ± 8.41	19.63 ± 9.21	<0.001
• Total protein, g/dL	59.18 ± 13.22	47.51 ± 4.19	0.156
• Creatinine, mmol/L	0.08 (0.06–0.09)	0.09 (0.07–0.14)	0.003

ASD=atrial septal defect; CABG=coronary artery bypass graft; IQR=interquartile range; SOCA=sinus of Valsalva aneurysm; VSD=ventricular septal defect; WBCs=white blood cells.

Table 2. Clinical Profile of Patients With Frailty (>4)

	Clinical Frailty Score			*P* Value
	Score <4 n = 67 (60%)	Score 4 n = 18 (16%)	Score >4 n = 26 (23%)	
	Frequency (%), Mean ± SD, Median (IQR)			
Age, y	50.04 ± 16.67	53.22 ± 14.26	58.96 ± 13.23	0.050
Sex				
• Male	39 (58.21)	12 (66.67)	15 (57.69)	0.857
• Female	28 (41.79)	6 (33.33)	11 (42.31)	
Surgery				
• CABG	32 (47.76)	8 (44.44)	14 (53.85)	0.862
• Valvular surgery				
○ Rheumatic heart disease	8 (11.94)	6 (33.33)	8 (30.77)	0.034
○ Mitral	11 (16.42)	7 (38.89)	12 (46.15)	0.007
○ Aortic	14 (20.90)	2 (11.11)	9 (34.62)	0.189
○ Multivalve	7 (10.45)	4 (22.22)	8 (30.77)	0.050
• Congenital surgery				
○ ASD	7 (10.45)	0	0	0.129
○ VSD	2 (2.99)	0	0	1.000
○ SOVA	1 (2.22)	0	0	1.000
• Vascular surgery				
○ Infrarenal AAA	4 (5.97)	1 (5.56)	0	0.548
○ Thoracic AAA	3 (4.48)	0	0	0.741
○ Ascending AAA	2 (2.99)	0	1 (3.85)	1.000
• Cardiac tumor surgery	3 (4.48)	1 (5.56)	2 (7.69)	0.842
Comorbidities				
• Hypertension	27 (40.30)	9 (50.00)	10 (38.46)	0.739
• Heart failure (ejection fraction <40)	6 (8.96)	5 (27.78)	11 (42.31)	0.001
• Atrial fibrillation	4 (5.97)	3 (16.67)	4 (15.38)	0.182
• Chronic kidney disease	7 (10.45)	5 (27.78)	11 (42.31)	0.002
• Chronic liver disease	1 (1.49)	1 (5.56)	1 (3.85)	0.345
• Chronic lung disease	3 (4.48)	1 (5.56)	1 (3.85)	1.000
• Diabetes	9 (13.43)	5 (27.78)	3 (11.54)	0.269
• Thyroid	0	2 (11.11)	0	0.025
Laboratory data				
• WBCs, /μL	8.17 ± 2.45	9.08 ± 3.03	8.92 ± 3.71	0.341
• Lymphocytes, /μL	26.30 ± 9.21	18.31 ± 9.18	20.28 ± 8.99	0.001
• Total protein, g/dL	57 ± 12.95	41.36 ± 18.33	50.11± 19.69	0.188
• Creatinine	0.08 (0.06–0.1)	0.09 (0.08–.2)	0.09 (0.07–.14)	0.001

ASD=atrial septal defect; CABG=coronary artery bypass graft; IQR=interquartile range; SOCA=sinus of Valsalva aneurysm; VSD=ventricular septal defect; WBCs=white blood cells.

Table 3. Outcome of the Patients Based on Malnutrition and Frailty Status

Outcome	Normal n = 54	Malnutrition n = 31	Malnutrition and Frailty n = 26	*P* Value
Mortality, n = 9 (8%)	2 (3.70)	1 (3.23)	6 (23.08)	0.009
Duration of confinement, d				
• ICU stay	2 (2–2)	2 (2–4)	2.5 (2–5)	0.007
• Hospital stay	9 (6–12)	12 (8–22)	16 (10–30)	0.001
Prolonged hospitalization, n = 45 (41%)	13 (24.07)	15 (48.39)	17 (65.38)	0.001
Duration of mechanical vent, d	1 (1–1)	2 (1–2)	2 (1–3)	<0.001
Prolonged mechanical ventilation	3 (5.56)	9 (29.03)	8 (30.77)	0.003
Nosocomial infection				
• UTI, n = 5 (5%)	1 (1.85)	4 (12.90)	0 (0)	0.052
• Pneumonia, n = 41 (37%)	8 (14.81)	16 (51.61)	17 (65.38)	<0.001
• Sternal osteomyelitis, skin and soft tissue infection, n = 4 (4%)	1 (1.85)	2 (6.45)	1 (3.85)	0.568
• Sepsis, n = 10 (9%)	0	2 (6.45)	8 (30.77)	<0.001

ICU=intensive care unit; UTI=urinary tract infection.

Table 4. Association of Nutrition and Frailty Status With Outcomes of Interest

Outcome	Normal	Malnutrition OR (95% CI)	*P* Value	Malnutrition and Frailty OR (95% CI)	*P* Value
Mortality	(Reference)	0.87 (0.80–9.96)	0.910	7.8 (1.45–41.91)	0.017
Prolonged hospitalization	(Reference)	2.96 (1.15–7.58)	0.024	5.96 (2.14–16.53)	0.001
Prolonged mechanical ventilation	(Reference)	6.95 (1.71 -28.17)	0.007	7.56 (1.81–31.62)	0.006
Nosocomial infection	(Reference)	6.92 (2.52 – 19.1)	<0.001	13.57 (4.41 – 41.76)	<0.001
Composite outcome	(Reference)	5.32 (2.03–13.96)	0.001	11.97 (3.57–40.15)	<0.001

CI=confidence interval; OR=odds ratio.

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