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Article

Preoperative Sarcopenia Assessment Using Pectoralis Muscle Mass Indicated Poor Mid-term Cardiac Surgery Prognosis

Yojiro Machii[1], Fumihiro Kitashima[1], Yuki Hayashi[1], Atsushi Harada[1], Keita Kamata[1], Naoki Eguchi[1], Masashi Tanaka[1,*]

[1]Department of Cardiovascular Surgery, Nihon University School of Medicine, 173-8610 Tokyo, Japan
*Correspondence: tanaka.masashi@nihon-u.ac.jp (Masashi Tanaka)
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Abstract

Background: Many studies have defined sarcopenia based on psoas muscle mass using abdominal computed tomography (CT). We hypothesized that sarcopenia can be assessed by measuring pectoralis muscle mass on chest CT and aimed to examine its relationship with the postoperative prognosis of cardiac surgery. **Methods**: This retrospective study included 189 patients who underwent cardiac surgery via median sternotomy between July 2020 and June 2022. We excluded patients <70 years old, urgent/emergent cases, no chest CT within 90 days before surgery, and cases in which evaluation of the pectoralis muscle was impossible with CT. The pectoralis muscle area (PMA) was measured using a preoperative chest CT. The sarcopenia cut-off value was defined as the lowest sex-specific tertile in PMA at the level of the 4th thoracic vertebrae. **Results**: Eighty patients were included. The lower tertile were classified as the sarcopenia group (SG) (n = 26) and the rest as the non-sarcopenia group (NSG) (n = 54). In the SG, 1-year survival was significantly worse than that in NSG (NSG: 92.7% *vs*. SG: 54.9%, $p < 0.0001$). In the multivariate model, sarcopenia was an independent risk factor for mid-term all-cause death (hazard ratio, 4.89; 95% confidence interval: 1.14–21.0, $p = 0.033$). **Conclusion**: Preoperative sarcopenia defined using PMA was associated with poor mid-term survival after elective cardiac surgery via median sternotomy. The pectoralis muscle mass observed through a chest CT could be used for preoperative risk scoring in older patients undergoing cardiac surgery.

Keywords

sarcopenia; frailty; pectoralis muscle; cardiac surgery

Introduction

Frailty is a common clinical syndrome in geriatric individuals and reflects a state of decreased physiological reserve and vulnerability to stressors [1,2]. Sarcopenia is defined as the loss of muscle mass and strength with age and is believed to play a major role in the pathogenesis of frailty. It is also known to occur in 6–22% of older adults [3,4]. A systematic study reported that sarcopenia significantly increased the risk of early and late mortality after cardiac surgery [5].

The criteria reported by the European Working Group on Sarcopenia in Older People (EWGSOP) can be used in diagnosing sarcopenia; however, the best method to assess sarcopenia remains a matter of debate [6,7]. It has already been reported that psoas muscle volume on abdominal computed tomography (CT) is associated with prognosis for aortic and off-pump coronary artery graft bypass and valve surgery [7–11] and is currently one of the most used evaluation methods. In contrast, pectoralis muscle mass has been used in predicting prognosis in case of respiratory diseases [12–15]. In addition, Sun *et al*. [16] reported that in patients with non-small cell lung cancer, decreased pectoralis muscle mass on CT was associated with poor overall survival after resection surgery. Using pectoralis muscle area (PMA) to assess sarcopenia has the potential to allow surgeons to assess preoperative frailty more conveniently as opposed to established methods. However, few reports have used pectoralis muscles mass to assess sarcopenia before cardiac surgery.

Routine chest CT before cardiac surgery has been reported to reduce the incidence of postoperative stroke, especially in high-risk patients [17,18], and is often performed prior to cardiac surgery. Therefore, it would be cost-effective if sarcopenia could be assessed using the pectoralis muscles. In addition, pectoralis muscles mass might have a better correlation to respiratory muscle condition than psoas muscle mass. Thus, we aimed to assess the effect of using pectoralis muscle mass to assess sarcopenia before cardiac surgery regarding the mid-term postoperative prognosis. We hypothesized that preoperative sarcopenia could be assessed prior to cardiac surgery using the pectoralis muscle area (PMA) provided from chest CT images. Moreover, this study aimed to explore preoperative sarcopenia assessment methods for cardiac surgery.

Materials and Methods

Participants and Study Design

This retrospective study evaluated the data of patients who underwent cardiac surgery via median sternotomy at the Department of Cardiovascular Surgery, Tokyo Nishi Tokusyukai Hospital (Tokyo, Japan), between July 2020 and June 2022. All surgeries were performed either by a single surgeon or colleagues. We reviewed the medical records of all patients who underwent cardiac surgery via a median sternotomy. Cardiac surgery included coronary artery surgery, valve surgery, thoracic aortic surgery, surgery for complications of myocardial infarction, surgery for cardiac tumors, and combined surgery. We excluded patients <70 years old, urgent/emergent cases, cases in which no preoperative chest CT was performed within 90 days before the surgery, and cases in which evaluation of the pectoralis muscle was impossible with CT. Follow-up data, including survival and complications, were obtained via chart review, and follow-up assessments that had been interrupted or terminated were confirmed by telephone on 31 July 2022. The Tokusyukai Group Research Ethics Committee approved the protocol of this retrospective study (TGE01921-060, 6 April 2022). The ethics committee waived the requirement for informed consent due to the retrospective nature of the study.

Patients below the sex-specific lowest tertile of PMA were classified into the sarcopenia group (SG), according to previous studies [19,20]. Patients who were above the sex-specific lowest tertile of PMA were classified into the non-sarcopenia group (NSG). Subsequently, patient background, in-hospital outcomes (30-day mortality, length of stay in the intensive care unit (ICU), postoperative hospital stay, postoperative complication rates (stroke, re-exploration for bleeding, pneumonia, new onset of atrial fibrillation and mediastinitis), use of circulatory support device (intra-aortic balloon pump and percutaneous cardiopulmonary support) and intubation time), 1-year all-cause mortality and 1-year cardiac death mortality were compared between the groups.

Pectoralis Muscle Measurements

Bilateral pectoralis muscles, including the pectoralis major and pectoralis minor at the level of the 4th thoracic vertebra (Th4) transverse process on axial cross-sectional CT images, were identified and manually plotted using SYNAPSE VINCENT (Fujifilm Medical, Tokyo, Japan) image analysis software (Fig. 1A,B). PMA was quantified based on Hounsfield unit thresholds (–29 to +150) in millimeters squared [21,22].

Statistical Analysis

Data are presented as numbers (percentages), mean ± standard deviations, or medians (interquartile ranges (IQR)). Continuous variables were compared using the *t*-test or Mann–Whitney U test as appropriate. Categorical variables were compared using the chi-squared or Fisher's exact test, as appropriate. Mid-term survival was estimated using the Kaplan–Meier method, and comparisons between the two groups were performed using the log-rank test. Multivariable Cox proportional hazards regression analysis was performed to adjust the effect of sarcopenia on outcomes by possible confounders. Variables included age (year), sex, body surface area (m^2), body mass index (BMI) $<$18.5 kg/m^2, hypertension, diabetes mellitus, atrial fibrillation, cerebrovascular disease, hemodialysis, chronic obstructive pulmonary disease, previous cardiac surgery, left ventricular ejection fraction (%), serum hemoglobin (g/dL), serum albumin (g/dL), serum creatinine (mg/dL), surgical methods, cardiopulmonary bypass time (minutes), aorta cross-clamp time (minutes), and sarcopenia. Variables with p-values < 0.05 in univariate analysis and age and sex were entered into the multivariate Cox proportional hazards regression analysis.

All statistical analyses were performed using EZR (version 1.52, Saitama Medical Center, Jichi Medical University, Saitama, Japan), a graphical user interface for R software (version 3.6.1, The R Foundation for Statistical Computing, Vienna, Austria) that includes frequently used biostatistical functions [23]. Results were considered statistically significant at two-sided p-values < 0.05.

Results

Patient Characteristics

Fig. 2 shows the patient flow diagram. A total of 189 eligible patients were included in this study; 109 patients were excluded. Note that the summation of these values does not add up to 109 persons because duplicates were included. The reasons for exclusion included age <70 years (n = 64), emergent/urgent cases (n = 63), preoperative chest CT over 90 days (n = 9), and cases in which evaluation of the pectoralis muscle was impossible with CT (n = 2). The latter two patients underwent lobectomy for breast cancer with resection of the pectoralis muscles. The final study cohort consisted of 80 patients (43 men, 53.8% and 37 women, 46.3%) with a mean age of 78.2 years. The distribution of pectoralis muscle mass according to sex is shown in Fig. 3. Males had significantly greater PMA (male: 2971.05 ± 829.42 cm^2 *vs*. female: 1864.54 ± 491.50 cm^2, $p < 0.001$). The sex-specific cut-off point for sarcopenia was a PMA of 2422.785 cm^2 for men and 1620.106 cm^2 for women, resulting in 26 patients with sarcopenia in total. The mean follow-up period was 346.7 (±197.2) days, and the follow-up rate was 100%.

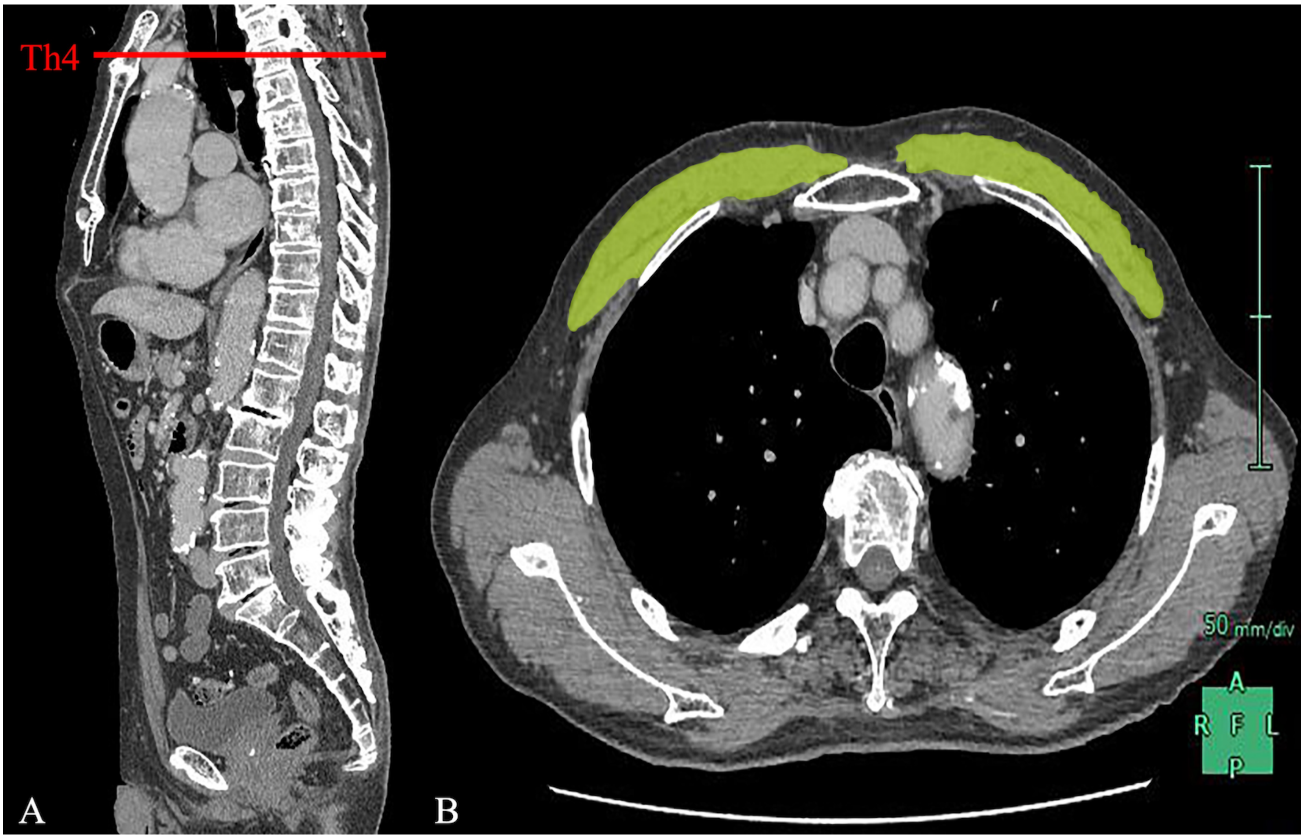

Fig. 1. Illustration of pectoralis muscle area. (A) Chest computed tomography in a patient without sarcopenia. The red line in (A) shows the height of the Th4, while (B) shows an axial image of the same patient at the same height. The pectoralis muscles are indicated in yellow and are quantified based on Hounsfield unit thresholds (–29 to +150) in millimeters squared. Th4, Fourth thoracic vertebra.

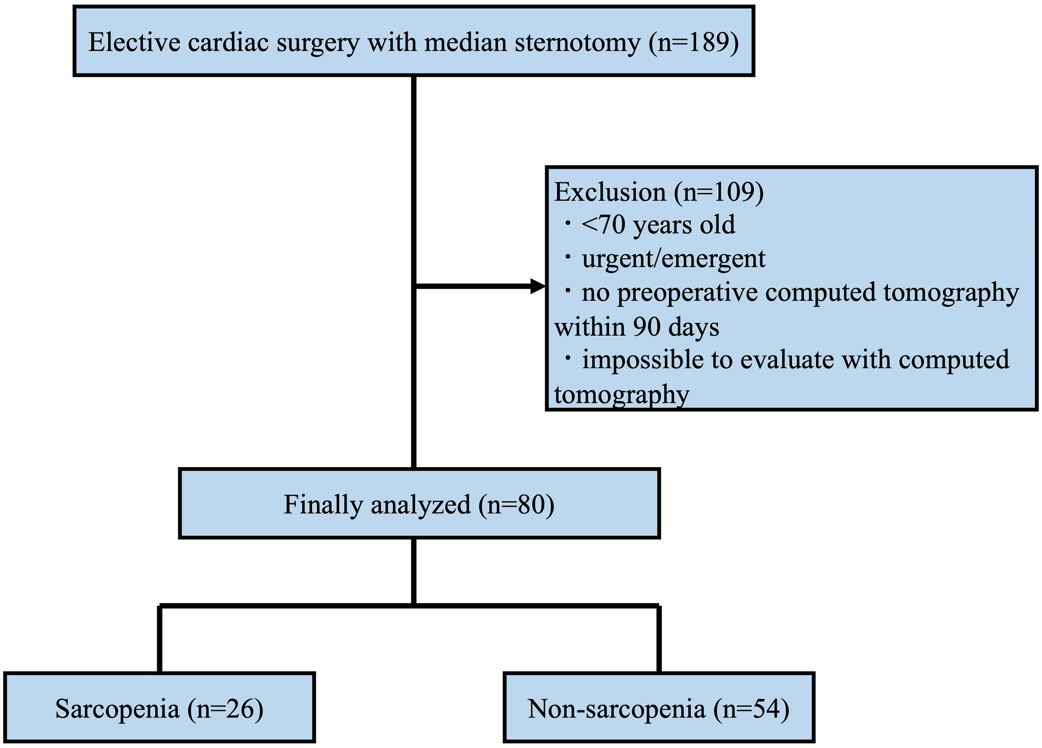

Fig. 2. Patient flow diagram.

Table 1. Preoperative patient characteristics.

Variable	Total (n = 80)	Sarcopenia (n = 26)	Non-sarcopenia (n = 54)	*p*-value
Age, years	78.2 ± 4.4	78.5 ± 4.8	78.1 ± 4.2	0.726
Sex, male	43 (53.8%)	14 (53.8%)	29 (53.7%)	1.000
Body surface area, m^2	1.53 ± 0.17	1.49 ± 0.19	1.54 ± 0.16	0.161
Body mass index, kg/m^2	21.7 ± 2.8	20.9 ± 3.2	22.1 ± 2.6	0.087
Smoking history	43 (53.8%)	14 (53.8%)	29 (53.7%)	0.803
Hypertension	65 (81.3%)	22 (84.6%)	43 (79.6%)	0.763
Diabetes mellitus	33 (41.3%)	13 (50.0%)	20 (37.0%)	0.335
Atrial fibrillation	29 (36.3%)	11 (42.3%)	18 (33.3%)	0.465
Cerebrovascular disease	10 (12.5%)	3 (11.5%)	7 (13.0%)	1.000
Hemodialysis	14 (17.5%)	11 (42.3%)	3 (5.6%)	<0.001*
COPD	3 (3.8%)	1 (3.8%)	2 (3.7%)	1.000
Previous cardiac surgery	5 (6.3%)	2 (7.7%)	3 (5.6%)	0.658
LVEF, %	59.4 ± 12.2	57.6 ± 14.8	60.3 ± 10.8	0.355
Serum hemoglobin, g/dL	11.9 ± 2.0	11.0 ± 1.7	12.3 ± 2.0	0.006*
Serum albumin, g/dL	3.5 ± 0.7	3.3 ± 0.7	3.7 ± 0.6	0.010*
Serum creatinine, mg/dL	0.99 [0.77, 1.71]	1.68 [0.76, 6.38]	0.94 [0.77, 1.2]	0.012*
Pectoralis muscle area, mm^2	2459.3 ± 885.5	1789.7 ± 451.6	2781.7 ± 864.1	<0.001*

Asterisks (*) indicate statistical significance values. Values for continuous variables are expressed as mean ± standard deviation or median [interquartile range]. Values for categorical variables are expressed as numbers (%). COPD, chronic obstructive pulmonary disease; LVEF, left ventricular ejection fraction.

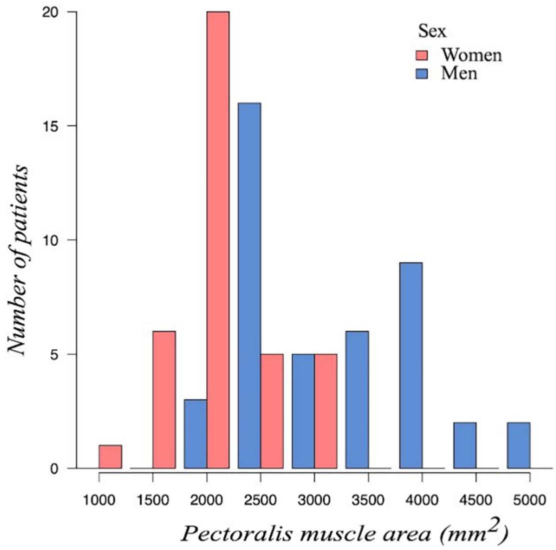

Fig. 3. The distribution of pectoralis muscle mass for each sex.

Preoperative patient characteristics are shown in Table 1. Patients in the SG were more likely to have hemodialysis, lower levels of hemoglobin and albumin, higher levels of creatinine, and lower PMA. The intraoperative data were not significantly different between the SG and NSG groups (Table 2).

Early Outcomes

The in-hospital outcomes are presented in Table 3. Two deaths (2.5%) occurred within 30 days after surgery, similar to in-hospital mortality, with no significant difference between the two groups (SG: 3.8% *vs.* NSG: 1.9%, p = 0.547). The cause of early death was sepsis (n = 1) in the SG and multiple organ failure (n = 1) in the NSG. Patients in the SG had significantly longer initial intubation time (median = 917.5 minutes, IQR: 292.5–1125.0 *vs.* median = 335.0 minutes, IQR: 240.0–933.8, $p = 0.036$) and longer length of postoperative hospital stay (median = 27 days, IQR: 20.0–41.0 *vs.* median = 19 days, IQR: 12.0–22.0, $p = 0.001$) than those in the NSG. Discharge to healthcare facilities was also significantly more frequent in the SG (SG: 8 *vs.* NSG: 5, $p = 0.023$). There was no significant difference in postoperative complication rates between the two groups.

Survival Analysis

During the follow-up period, late death occurred in 11 of 78 survivors (16.3%), and cardiac death occurred in 5 patients (7.7%) due to infective endocarditis (n = 1), graft infection (n = 1), and sudden death (n = 3). The survival and freedom from cardiac death results are shown in Fig. 4. The rates of 1-year overall survival and freedom from cardiac death were significantly lower in the SG group than in the NSG group (survival: 54.9% *vs.* 92.7%, $p < 0.0001$; freedom from cardiac death: 81.7% *vs.* 97.2%, $p = 0.016$).

The results of Cox regression analysis of overall survival are shown in Table 4. Univariate analysis revealed that sarcopenia (hazard ratio (HR): 6.98, 95% confidence

Table 2. Intraoperative data.

Variable	Total (n = 80)	Sarcopenia (n = 26)	Non-sarcopenia (n = 54)	*p*-value
Surgical methods				0.331
Valve	31 (38.8%)	13 (50.0%)	18 (13.3%)	
Aorta	9 (11.3%)	1 (3.8%)	8 (14.8%)	
Coronary	18 (22.5%)	6 (23.1%)	12 (22.2%)	
Combined	18 (22.5%)	6 (23.1%)	12 (22.2%)	
Others	4 (5%)	0 (0%)	4 (7.4%)	
CPB time, min	150.4 ± 56.2	157.4 ± 54.1	148.0 ± 57.5	0.518
Aorta cross clamp time, min	113.7 ± 45.2	119.1 ± 44.2	112.0 ± 45.9	0.554

Values for continuous variables are expressed as mean ± standard deviation, and values for categorical variables are expressed as numbers (%). CPB, cardiopulmonary bypass.

Table 3. In-hospital outcomes.

Variable	Total (n = 80)	Sarcopenia (n = 26)	Non-sarcopenia (n = 54)	*p*-value
30-day mortality	2 (2.5%)	1 (3.8%)	1 (1.9%)	0.547
Stroke	3 (3.8%)	1 (3.8%)	2 (3.7%)	1.000
Re-exploration for bleeding	5 (6.3%)	3 (11.5%)	2 (3.7%)	0.323
Pneumonia	4 (5%)	2 (7.7%)	2 (3.7%)	0.592
New onset of atrial fibrillation	17 (21.3%)	5 (19.2%)	12 (22.2%)	1.000
Mediastinitis	1 (1.3%)	1 (3.8%)	0 (0%)	0.325
Intubation time, min	375.0 [242.3, 963.8]	917.5 [292.5, 1125.0]	335.0 [240.0, 933.8]	0.036*
IABP or PCPS use	2 (2.5%)	1 (3.8%)	1 (1.9%)	0.547
Length of ICU stays, d	3.5 [2.0, 5.0]	4.0 [3.0, 7.0]	3.0 [2.0, 5.0]	0.074
Postoperative hospital stays, d	20.0 [13.8, 29.0]	27.0 [20.0, 41.0]	19.0 [12.0, 22.0]	0.001*
Discharge to health care facility	13 (16.3%)	8 (30.8%)	5 (9.3%)	0.023*

Asterisks (*) indicate statistical significance values. Intubation time is defined as the initial ventilator management time. Continuous variables are expressed as median [interquartile range], and categorical variables are expressed as numbers (%). ICU, intensive care unit; IABP, intra-aortic balloon pump; PCPS, percutaneous cardiopulmonary support.

interval (CI): 1.92–25.4, $p = 0.003$), BMI <18.5 kg/m^2, serum creatinine level, and hemodialysis were significant risk factors for overall survival. The multivariate Cox hazard analysis revealed that sarcopenia is an independent risk factors for decreased overall survival (HR: 4.89; 95% CI: 1.14–21.0, $p = 0.033$) as well as hemodialysis (HR: 3.94; 95% CI: 1.01–15.4, $p = 0.049$).

Discussion

The key findings of this study revealed that sarcopenia, defined by quantitative PMA on chest CT, was associated with poor overall survival after elective cardiac surgery with median sternotomy. In addition, sarcopenia has been shown to prolong intubation time after cardiac surgery and the postoperative length of hospital stay. Moreover, patients with sarcopenia were significantly more likely to be discharged to a healthcare facility.

Various assessment methods for sarcopenia exist, yet the economics and feasibility of the methods are major issues. The simple five-item questionnaire recommended by the International Clinical Practice Guidelines for Sarcopenia is very economical, but it is not widely used before cardiac surgery. However, assessing sarcopenia via chest CT would be highly feasible. This is evidenced by the already widely accepted preoperative sarcopenia assessment method that assesses psoas muscle mass by abdominal CT before cardiac surgery.

Preoperative sarcopenia in cardiac surgery, including transcatheter aortic valve implantation, is usually assessed using the psoas muscle and its association with postoperative outcomes has been reported [9,10,20,24]. However, abdominal CT is not mandatory for the preoperative evaluation of cardiac surgery, and we consider that it is not a versatile evaluation method for sarcopenia. Okamura *et al.* [10] reported that a limitation of their study was that among 1119 patients who underwent heart valve surgery, 121 (10.8%) did not undergo abdominal CT within 3 months before surgery. In contrast, routine chest CT has been reported to reduce the incidence of postoperative stroke, especially in high-risk patients [25,26]. In our study, preoperative chest CT was performed in all 189 patients, and only 9 (4.8%) had not undergone CT within 90 days before surgery. Thus, we believe that this method is valuable as it allows the surgeon to assess sarcopenia using tests with which are familiar to them and are likely to be performed preoperatively.

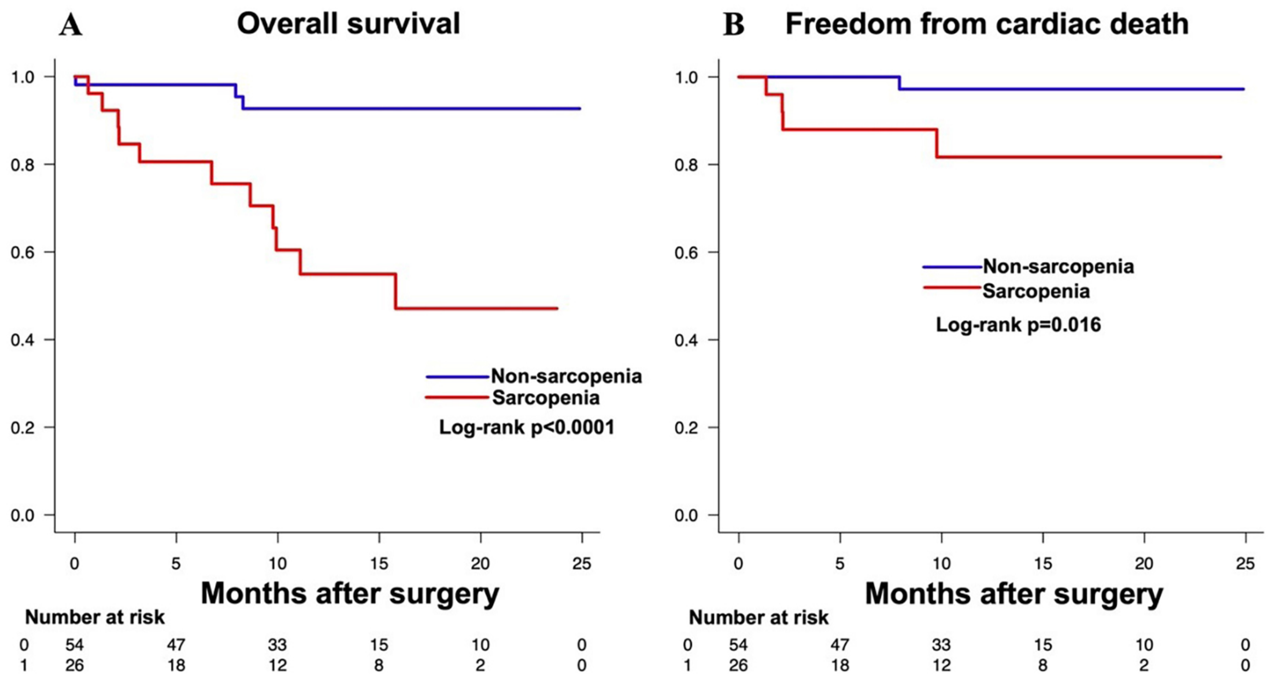

Fig. 4. Survival analyses in patients with and without sarcopenia. Kaplan–Meier curves for the (A) survival of and (B) freedom from cardiac death in patients with and without sarcopenia. CI, confidence interval.

Table 4. Cox proportional hazards analysis of the independent risk factors for mid-term mortality.

Variable		Univariate		Multivariate	
		HR (95% CI)	*p*-value	HR (95% CI)	*p*-value
All-cause mortality					
Age, years		1.02 (0.91–1.16)	0.710	1.15 (0.98–1.34)	0.078
Sex (female)		0.57 (0.19–1.70)	0.312	0.27 (0.06–1.11)	0.070
Body surface area, m^2		0.60 (0.03–11.5)	0.699		
Body mass index <18.5 kg/m^2		3.56 (1.19–10.6)	0.023*	3.30 (0.95–11.4)	0.059
Hypertension		0.47 (0.15–1.53)	0.212		
Diabetes mellitus		0.97 (0.33–2.79)	0.948		
Atrial fibrillation		1.91 (0.67–5.45)	0.226		
Cerebrovascular disease		1.79 (0.50–6.43)	0.371		
Hemodialysis		5.56 (1.94–15.9)	0.001*	3.94 (1.01–15.4)	0.049*
COPD		1.69 (0.22–12.9)	0.615		
Previous cardiac surgery		1.11 (0.15–8.53)	0.917		
LVEF, %		0.96 (0.93–1.00)	0.073		
Serum hemoglobin, g/dL		0.82 (0.63–1.07)	0.149		
Serum albumin, g/dL		0.49 (0.23–1.06)	0.071		
Serum creatinine, mg/dL		1.23 (1.08–1.40)	0.002*		
Sarcopenia		8.42 (2.35–30.2)	0.001*	4.89 (1.14–21.0)	0.033*
Surgical method	Valve	Reference			
	Aorta	0.63 (0.07–5.65)	0.679		
	Coronary	1.16 (0.26–5.21)	0.843		
	Combined	2.06 (0.58–7.33)	0.264		
CPB time, m		1.01 (1.00–1.02)	0.103		
Aorta cross clamp time, m		1.01 (1.00–1.02)	0.233		

Asterisks (*) indicate statistical significance values. HR, hazard ratio; CI, confidence interval; COPD, chronic obstructive pulmonary disease; LVEF, left ventricular ejection fraction; CPB, cardiopulmonary bypass.

The method of assessing sarcopenia using PMA is mainly used in the respiratory region and is associated with the prognosis of lung diseases, including pneumonia, COVID-19, and non-small cell lung cancer [12–16,25]. There have been reports on the use of pectoralis muscle mass for sarcopenia assessment before left ventricular assist device implantation and isolated tricuspid surgery. However, the number of such studies is limited [26,27]. Zuckerman *et al*. [24] stated that there was no association between thoracic muscle mass and length of hospital stay, but their study differed from ours in that they did not evaluate the pectoralis muscle mass alone. Although the present study did not examine the relationship between PMA and the psoas muscle area, which has often been used to define sarcopenia in cardiac surgery, van Heusden *et al*. [28] showed an association between the cross-sectional area at the level of Th4 and L3 (r = 0.791, $p < 0.05$). Thus, we think there is validity in using PMA as an indicator of sarcopenia in cardiac surgery.

With respect to the height of the pectoralis muscle, some studies have used the height of the upper aortic arch [13,26], but in this study, the height of Th4 was used in accordance with several previous studies [12,16]. This was because measuring the upper aortic arch could introduce error, as spinal compression fractures are often seen in the elderly, and this study included patients with aortic aneurysms.

The pectoralis muscle is divided into the pectoralis major and pectoralis minor. The pectoralis major's function is related to the upper limb movement and that of pectoralis minor to the respiratory support. Yokosuka *et al*. [13] showed that pectoralis minor muscle mass had a greater association with hospital mortality than pectoralis major muscle mass in patients with pneumonia, suggesting that the pectoralis minor muscle is more related to respiratory status and ability to expectorate. Moon *et al*. [29] also reported that elderly ICU patients with low thoracic muscle mass had prolonged ventilation. In this study, it was determined that assessing the pectoralis major and minor muscles separately would be technically difficult and may not provide accurate data. Thus, decreased PMA may be associated with both decreased physical activity and decreased respiratory function. Future research should evaluate the muscles separately to provide further detailed insight into the mechanism.

The study had numerous strengths, specifically regarding the clinical significance. Using pectoralis muscle mass as a criterion for evaluating frailty provides novel knowledge and understanding while highlighting a possible prognosis predictor for treatment success in high-risk patients. PMA has the potential to be easily evaluated using chest CT, which is more feasible than current alternatives. Furthermore, using PMA means that sarcopenia can be assessed preoperatively. Preoperative interventions could change the prognosis, including exercise, nutritional management, and respiratory rehabilitation. Based on the association with the respiratory region, we believe that respiratory rehabilitation could provide particular preoperative benefits. Additionally, for high-risk patients, treatment options that consider frailty are greatly important; thus, by providing an indicator of preoperative sarcopenia, our method could ensure the most suitable treatment option is employed.

This study also had several limitations. First, it was a single-center retrospective study with a small sample size, increasing the likelihood of selection bias and reducing reproducibility. Therefore, future studies should employ a multicenter design to improve the generalizability of the findings. Second, the area of the pectoralis muscle tends to vary with the angle of the arm during CT imaging. The protocol at our institution is to elevate both upper extremities during imaging; however, this is not possible in all patients. This may result in an inaccurate pectoralis muscle mass at the Th4 height. In contrast, the area of the psoas muscle can be quantified more accurately because it is thought to be less affected by the body position. Third, in this study, sarcopenia was defined as below the lowest tertile, as in previous studies; however, different cut-off values may have been more appropriate. We used the lowest tertile as the cut-off value of sarcopenia because it ensured the category containing the median was not divided. We believe that the cut-off value obtained in this study does not provide values that can be used in the general population. Fourth, there may be a confounding effect between sarcopenia and hemodialysis. Bueno *et al*. [30] reported that patients undergoing hemodialysis had lower thicknesses of the pectoralis major (5.92 ± 0.35 mm *vs*. 8.35 ± 0.62 mm, $p < 0.001$) compared to those in healthy participants. This is because patients undergoing dialysis are reported to be at high risk for nutritional status for numerous reasons, including uremia, dietary restrictions, low physical activity, chronic inflammation, comorbidities, and metabolic disorders. Furthermore, an imbalance between anabolism and catabolism of muscle protein is thought to be a contributing factor [31,32]. Given that hemodialysis is related to muscle atrophy, accurate assessment of sarcopenia using pectoralis muscles may be difficult for patients undergoing hemodialysis. Fifth, the measurement of PMA represents only one of the many facets of sarcopenia. By defining sarcopenia solely in terms of PMA, the study used a definition that differed from those already established, such as that by the EWGSOP [6]. However, we do not believe it can replace such definitions. Therefore, future studies should assess PMA along with other known indicators of sarcopenia to better predict patients' prognosis. Finally, the aim of the study was to assess the mid-term postoperative prognosis of the patients and although the study provided a concrete base and motivation for future studies, longitudinal studies are required to further elucidate the long-term prognosis.

Conclusion

Preoperative sarcopenia, defined by PMA, was associated with poor mid-term overall survival and freedom from cardiac death after elective cardiac surgery via median sternotomy. Evaluation of pectoralis muscle mass on chest CT could be used for preoperative risk scoring in older patients undergoing cardiac surgery to ensure the most suitable treatment plan is created, including possible preoperative interventions. Future research areas include the analysis of more endpoints, such as pectoralis muscle quality and postoperative complications, while employing longitudinal, multicenter, and large sample study designs.

Abbreviations

BMI, body mass index; CI, confidence interval; CT, computed tomography; HR, hazard ratio; ICU, intensive care unit; IQR, interquartile ranges; NSG, non-sarcopenia group; PMA, pectoralis muscle area; SG, sarcopenia group; Th4, 4th thoracic vertebra.

Availability of Data and Materials

The data that support the findings of this study are available from the corresponding author, MT, upon reasonable request.

Author Contributions

YM designed the research study. YM and FK performed the research. YH, AH, KK,NE and MT are substantial contributions to interpretation of data for the work. YM analyzed the data. All authors contributed to editorial changes in the manuscript. All authors read and approved the final manuscript. All authors have participated sufficiently in the work and agreed to be accountable for all aspects of the work.

Ethics Approval and Consent to Participate

The Tokusyukai Group Research Ethics Committee approved the protocol of this retrospective study (TGE01921-060, 6 April 2022). The ethics committee waived the requirement for informed consent due to the retrospective nature of the study.

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Conflict of Interest

The authors declare no conflict of interest.

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