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Computed tomography defined body composition may predict postoperative outcomes and prognosis following gastric cancer surgery

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ABSTRACT

Objective: Loss of muscle mass (sarcopenia) and impaired muscle quality (myosteatosis) associated with poor surgical outcomes. This study aimed to evaluate the impact of sarcopenia and myosteatosis on postoperative short-term outcomes and prognosis in patients with gastric cancer.

Material and Methods: Patients who underwent gastric cancer surgery and had abdominal computed tomography (CT) imaging were included in the study. Skeletal muscle index (SMI) and skeletal muscle density (SMD) were calculated using CT images. Patients were divided into groups based on previously established threshold values: Those with low SMI (indicating sarcopenia) versus those with normal SMI, and those with low SMD (indicating myosteatosis) versus those with normal SMD. Demographics, clinicopathologic characteristics, postoperative outcomes, and survival data were extracted from prospective database.

Results: Among the 237 patients, 87 patients (36.7%) had sarcopenia and 139 patients (58.6%) had myosteatosis. Patients with myosteatosis were characterized by older age, poorer preoperative nutritional status, inferior performance status, and extended hospital stays. Higher severe complication incidence was observed among patients with myosteatosis (18% vs. 10.2%, p=0.09). Overall survival of patients with sarcopenia or myosteatosis was significantly lower than that of patients with a normal SMI or SMD (p=0.03, p<0.001 respectively). Myosteatosis was identified as an independent risk factor for overall survival in multivariate analysis (hazard ratio: 2.20, 95% confidence interval: 1.26-3.86, p=0.006).

Conclusion: This study indicated sarcopenia or myosteatosis is associated with reduced overall survival. Although there were no significant difference severe complication rates are higher in patients with low SMD than in patients with normal SMD, and reporting of SMD from preoperative CT should be considered in preoperative evaluation.

Keywords: Body composition, gastric cancer, sarcopenia, myosteatosis, skeletal muscle index, skeletal muscle density

INTRODUCTION

Gastric cancer is the sixth most prevalent cancer and the third most common cause of cancer-related death worldwide (1). Despite the development of multimodal therapy, surgical therapy is still the primary treatment for gastric cancer. Radical gastrectomy is a complex surgical procedure associated with high morbidity. Approximately 21% of all gastric cancer patients who undergo surgical resection develop a postoperative major complication such as infection, anastomotic leakage, hemorrhage, or organ dysfunction (1-3). Although a few risk factors for postoperative complications and prognosis have been identified, such as age, body mass index (BMI), malnutrition, anemia, presence of comorbidities, and tumor stage, these factors do not entirely clarify the observed wide disparity in postoperative outcomes after gastrectomy (4). Recently, there has been a rising interest in the association between body composition and postoperative outcome (5). Predicting the risk of postoperative complications might help improve the patient's condition preoperatively or avoid surgery in high-risk patients (4).

Sarcopenia is a clinical condition defined as the generalized loss of skeletal muscle mass, strength, and quality (1,6). The other pathologic pattern related to reduced muscle quality is myosteatosis. It is characterized by increased fat infiltration in muscle, which causes reduced muscular strength and subsequently limits physical activity (4,7,8). Although the reasons for sarcopenia are not entirely known, it often occurs due to aging, physical inactivity, malnutrition, and malignancy (7,9,10). Particularly in

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cancer patients, excessive systemic inflammatory response and the insulin resistance, protein hypercatabolism, and metabolic changes caused by it are considered to be responsible (11,12). Furthermore, several studies have reported that insufficient energy and protein intake are independent risk factors for sarcopenia. When considering gastric cancer patients, poor oral intake can lead to severe nutritional depletion compared to other cancer patients (11). The routine uses of computed tomography (CT) in the staging of malignancies and improvements in computer software for CT-based body composition analysis have enabled the measurement of muscle mass and its fat content non-invasively, eliminating extra imaging modalities (13). CT-based sarcopenia is diagnosed using two objective criteria: The skeletal muscular index (SMI) and skeletal muscular density (SMD). While the low SMI reflects loss of muscle mass, the low SMD has been known to reflect increased muscle lipid content, indicating sarcopenia in CT imaging (14). The preceding studies have reported that sarcopenia is associated with increased postoperative complication rates and poor prognosis, especially in colorectal, endometrial, pancreatic, and hepatic surgery (15-18). However, there is uncertainty about postoperative outcomes of patients with gastric cancer, and controversies continue in the literature (9,10). While some studies report adverse effects on both early postoperative outcomes and prognosis, others report that sarcopenia does not have any effect (1). Moreover, no study has evaluated the effect of both SMI and SMD on postoperative outcomes and prognosis after radical gastrectomy.

We aimed to search for SMI and SMD values for the diagnosis of sarcopenia in CT images in our series and to determine whether they have an impact on postoperative short-term results and prognosis in patients with gastric cancer.

MATERIAL and METHODS

Study Populations

Prospective data from 407 consecutive patients with gastric cancer who underwent radical gastrectomy in January 2017 and December 2020 were analyzed retrospectively. After excluding 170 patients who did not meet the study criteria, a total of 237 patients enrolled in the study.

Inclusion criteria were age older than 18 years, histologically proven gastric adenocarcinoma, and the availability of CT and positron emission tomography (PET) imaging taken within 15 days before surgery. Patients who were younger than 18 years old, had American Society of Anesthesiologists physical status (ASA-PS) 4, had metastatic disease, or had undergone palliative resection and who were followed up in a postoperative intensive care unit were excluded. Patients with insufficient follow-up information whose CT or PET/CT images were unavailable or of poor quality for the third lumbar vertebra skeletal muscle mass index measurement were also excluded. All surgical procedures were conducted by experienced general surgeons, using a standardized surgical technique. Also, a standardized D1 plus lymphadenectomy was carried out in conjunction with radical gastrectomy for all patients.

The Ethics Committee of Marmara University approved the study protocol (date: 05.03.2021, no: 09.2021.248). Written informed consent was obtained from all patients participating in the study.

CT-Based Skeletal Mass Measurements

The measurements were performed on the local PACS (Infinitt, Infinitt Healthcare, Seoul, South Korea).

Skeletal muscle mass is mainly calculated from the total volume of the abdominal muscle on a CT image, generally at the level of the third lumbar vertebra. It was normalized by dividing the measured area (cm^2) by the square of the patient's height (m^2), (SMI). A scale of pre-defined thresholds has been reported in studies from various populations. SMI <52.4 cm^2/m^2 in men and SMI <38.5 cm^2/m^2 in women were considered sarcopenic (19). Patients were divided into a low SMI group and a low SMD group according to the sarcopenia threshold value.

The skeletal muscle density (SMD) can also be calculated from the CT images, and low SMD values support the diagnosis of myosteatosis radiologically. It is defined by mean muscle attenuation under a specified threshold as described in the literature. It was measured in Hounsfield unit (HU) at the level of the third lumbar vertebra, similar to measurements used for sarcopenia. (13) It was derived by averaging HU radiodensity for the total sectional skeletal muscle. Although no universally accepted thresholds exist for defining SMD, the cutoff points for SMD were determined from previous studies as 41 cm^2/m^2 and 33 cm^2/m^2 for BMI less than 25 and BMI ≥25 patients, respectively (20,21). The patients were divided into a low SMD group and a normal SMD group according to the myosteatosis threshold values.

Data Collection

Patient demographics (including age, sex, BMI, performance status, nutritional status, and comorbidities), histopathologic features of tumors (such as localization, TNM stage, grade, and lymphovascular invasion), operative outcomes, postoperative complications, and lengths of hospital stay were retrieved from a prospectively maintained database. ASA-PS was used to classify patients' performance status. The prognostic nutritional index (PNI) was used to determine patients' nutritional status. The SMI and SMD were computed in preoperative body/abdomen CT examinations. The Clavien-Dindo classification was used to evaluate postoperative complications. Severe complications were defined as greater than or equal to Clavien-Dindo grade 3a. Perioperative mortality was defined as death within 30 days

of the operation. Overall survival (OS) was defined as the time from surgery until death or loss of follow-up.

Statistical Analysis

The statistical analyses were performed with SPSS version 25.0 (SPSS Inc., Chicago, IL, USA). Normally distributed data will be expressed using the mean ± standard deviation, and non-normally distributed data, will be expressed using the median (range) values. Chi-square and Fisher's exact tests will be used to compare categorical data. Student's t-test was used to compare parametric data, and the Mann-Whitney U test was used to compare non-parametric data. The Kaplan-Meier method was used in survival analysis, and the log-rank test was used in univariate analysis. Cox regression models were created with variables that were statistically significant or close to significant ($p<0.05$) in univariate analysis to determine independent prognostic factors for survival. The confidence interval for statistical significance will be accepted as 95%, with a two-tailed p-value <0.05.

RESULTS

Patient Characteristics

Two hundred thirty-seven of 407 curatively treated patients were enrolled in the study. One hundred seventy patients were excluded because the reasons for exclusion included preoperative CT examinations not being available (n=74), metastatic disease (n=64), palliative resection (n=15), benign diseases (n=8), other malignancies (n=7), and ASA 4 patients (n=2). The mean patient age was 61.5±11.5 years; 153 (64.5%) patients were male, and 84 (35.4%) were female. The clinicopathologic features of patients are detailed in Table 1.

Relationship Between Patient Characteristics and Sarcopenia

Eighty-seven (37%) patients have a low SMI values. The male sex and lower BMI were significantly associated with the low SMI group (p=0.0001 and p=0.0001, respectively). The low SMI group included more ASA 2 patients than the normal SMI group (p=0.03). When comparing normal SMI patients to those with proximal-located tumors, patients with proximal-located tumors had a low SMI (p=0.01). Also, the prevalence of low SMI status was found to be significantly higher in patients receiving neoadjuvant treatment. However, age and PNI were not different between the two groups. No surgical or pathological characteristics differed between low SMI and normal SMI groups (Table 2).

Relationship Between Patients' Characteristics and Myosteatosis

One hundred and thirty-nine (58%) of the patients have low SMD values. The older age, higher ASA score, and presence of comorbidities was significantly higher in the low SMD group (p=0.0001, p=0.001, and p=0.0001, respectively). While the PNI mean value was lower in the low SMD group (p=0.001), the hospital stay was also longer in this group (p=0.001) (Table 2).

Short-term Surgical Complications

Regarding short-term surgical outcomes, 62 patients (26%) experienced postoperative complications. While 27 of them (11.3%) involved minor complications, 35 (14.7%) were major complications (greater than or equal to Clavien-Dindo grade 3a). Among patients with major complications, eight (3.4%) died due to complications. There were no significant differences in the rates of major and minor complications in patients with low SMI compared to other patients with normal SMI. Although patients with low SMD experienced approximately twice as many major complications when compared to those with normal SMD, the difference was not statistically significant (p=0.09). Also, although perioperative mortality rates were higher in patients with low SMI (4.6%) and low SMD (5%) compared to those with normal SMI (2.7%) and normal SMD (1%), the difference did not reach statistical significance (p=0.4 and p=0.08, respectively). The length of hospital stay was significantly higher in the low SMD group, but there was no significant difference between low SMI, and normal SMI groups (Table 2). Low SMD was significantly correlated with a higher length of hospital stay (p=0.0001).

Table 1. Clinicopathologic features of all patients

Parameters	All patients (n=237)
Age, years, mean ± SD	61.5±11.5
Sex, n (%) Male Female	 153 (64.6) 84 (35.4)
BMI, kg/m^2, median (range)	25 (16-43.1)
SMI, cm^2/m^2, mean ± SD	50.1±8.8
SMD, HU, mean ± SD	35.4±8.4
ASA-PS score, n (%) I II III	 93 (39.2) 85 (35.9) 59 (24.9)
Neoadjuvant treatment, yes, n (%)	44 (18.5)
Differentiation, n (%) Differentiated Undifferentiated	 74 (31.2) 154 (65)
Stage, TNM, n (%) I II III	 52 (21.9) 50 (21.1) 135 (57)
Complications, CD ≥3a, n (%)	35 (14.8)
Length of the hospital stay, median (range)	7 (1-56)
Overall survival rates, months, mean ± SD	32.7±1.3

SD: Standard derivation, BMI: Body muscle index, SMI: Skeletal muscle index, SMD: Skeletal muscle density, HU: Hounsfield unit, ASA-PS: American Society of Anesthesiologists physical status, CD: Clavien-Dindo classification

However, no significant correlation existed between length of hospital stay and SMI (Figure 1).

Survival Analysis

The median follow-up was 15 (0-47) months. The OS of patients with a low SMI was significantly lower than that of patients with a normal SMI (28 vs. 34 months, p=0.03). Similarly, regarding SMD, there was a significant difference between the normal and low groups in the survival analysis (36 vs. 29 months; p=0.0007) (Figure 2). Univariate analysis showed that low SMI and SMD, ASA-PS score, and poor pathologic features (higher stage, poor differentiation, presence of lymphovascular and perineural invasion, and positive resection margin) were significant risk factors for overall survival. However, in the multivariate analysis, low SMD, high ASA-PS score, and positive resection margin were significant risk factors for OS (Table 3).

DISCUSSION

Although many risk factors for postoperative complications and prognosis have been identified in patients with gastrointestinal cancers, these factors do not entirely clarify the observed wide disparity in postoperative outcomes and prognosis after surgical treatment. There has been a rising interest in finding preoperative predictive factors in patients with gastrointestinal cancer; the body composition of patients is one of the leading research topics.

Sarcopenia has been described as low muscle mass, poor muscle strength, and weak physical performance by the

Table 2. Comparison of patients regarding skeletal muscular index (SMI) and skeletal muscular density (SMD)

Parameters	SMI		p-value	SMD		p-value
	Low SMI (n=87)	Normal SMI (n=150)		Low SMD (n=139)	Normal SMD (n=98)	
Age, years, mean ± SD	62.9±12.9	60.6±10.7	0.1	64.9±10.1	56.6±11.7	0.0001
Sex, n (%) Male Female	 70 (80.5) 17 (19.5)	 83 (55.3) 67 (44.7)	0.0001	 83 (59.7) 56 (40.3)	 70 (71.4) 28 (28.6)	0.06
BMI, kg/m^2, median (range)	23.6 (16-36.3)	26.2 (17.3-43.1)	0.0001	24.2 (16.1-40)	25.7 (16-43.1)	0.1
PNI, median (range)	46.5 (26.5-64.5)	48 (27-63)	0.3	47 (26.5-64.5)	48.7 (31.5-62)	0.007
ASA-PS score, n (%) I II III	 52 (34.7) 63 (42) 35 (23.3)	 41 (47.1) 22 (25.3) 24 (27.6)	0.03	 48 (34.5) 44 (31.7) 47 (33.8)	 45 (45.9) 41 (41.8) 12 (12.2)	0.001
Comorbidities, yes, n (%)	41 (47.1)	76 (50.7)	0.5	83 (59.7)	34 (34.7)	0.0001
Neoadjuvant treatment, yes, n (%)	22 (25.3)	22 (14.7)	0.04	29 (20.9)	15 (15.3)	0.2
Differentiation, n (%) Differentiated Undifferentiated	 24 (28.6) 60 (71.4)	 50 (34.7) 94 (65.3)	0.3	 45 (33.6) 89 (66.4)	 29 (30.9) 65 (69.1)	0.6
Stage, TNM, n (%) I II III	 14 (16.1) 18 (20.7) 55 (63.2)	 38 (25.3) 32 (21.3) 80 (53.3)	0.2	 33 (23.7) 29 (20.9) 77 (55.4)	 19 (19.4) 21 (21.4) 58 (59.2)	0.7
Localization, n (%) Upper Middle Lower Whole	 21 (24.1) 36 (41.1) 21 (24.1) 9 (10.3)	 38 (25.3) 39 (26) 63 (42) 10 (6.7)	0.01	 38 (27.3) 42 (30.2) 49 (35.3) 10 (7.2)	 21 (21.4) 33 (33.7) 35 (35.7) 9 (9.2)	0.7
Surgery type, n (%) Total Subtotal	 37 (42.5) 50 (57.5)	 56 (37.3) 94 (62.7)	0.4	 57 (41) 82 (59)	 36 (36.7) 62 (63.3)	0.5
Complications, CD ≥3a, n (%)	17 (19.5)	18 (12)	0.1	25 (18)	10 (10.2)	0.09
Length of the hospital stay, median (range)	5 (3-41)	5 (1-56)	0.7	6 (1-41)	5 (3-56)	0.001
Overall survival rates, months, mean ± SD	28.3±2.3	34.7±1.6	0.03	29.9±1.8	36.3±1.8	0.007

SD: Standard derivation, BMI: Body muscle index, SMI: Skeletal muscle index, SMD: Skeletal muscle density, PNI: Prognostic nutritional index, ASA-PS: American Society of Anesthesiologists physical status, CD: Clavien-Dindo classification

European Working Group on Sarcopenia in Older People and the Asian Working Group for Sarcopenia (22,23). Sarcopenia working groups recommended the hand grip strength test to measure muscle strength in sarcopenia diagnosis (22). Then, it has been reported that measuring increased intramuscular lipid content, called myosteatosis, which contributes to muscle weakness, gives more objective information about muscular strength (14). The routine uses of CT in the staging of malignancies and

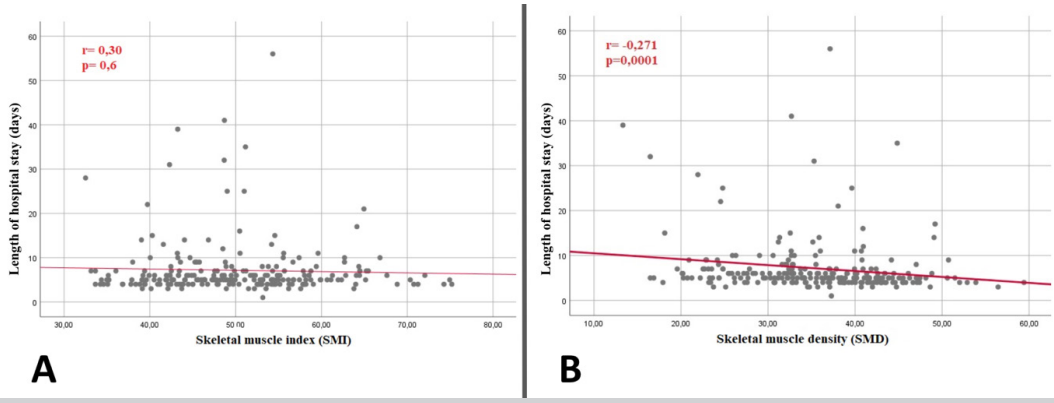

Figure 1. Correlation analyses with Spearman's Rho test: A: between SMI and length of hospital stay, B: between SMD and length of hospital stay.
SMI: Skeletal muscle index, SMD: Skeletal muscle density

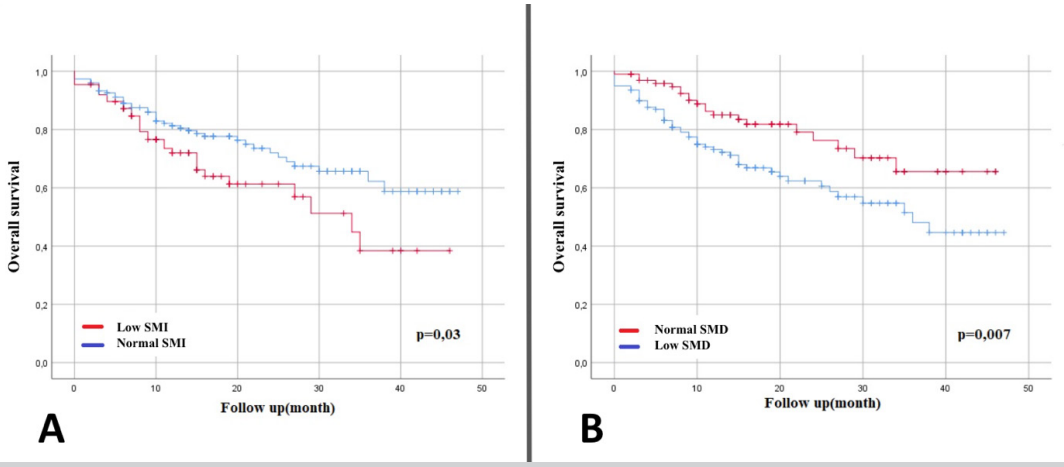

Figure 2. Kaplan-Meier survival Logrank analyses. Patients with low SMI (A) and low SMD (B) have poorer overall survival compared to patients with normal SMI and SMD.
SMI: Skeletal muscle index, SMD: Skeletal muscle density

Table 3. Univariate and multivariate analyses of variables that predict overall survival

Variables	Univariate analysis			Multivariate analysis		
	HR	95% CI	p-value	HR	95% CI	p-value
SMI (low/normal)	1.63	1.01-2.62	0.04	1.24	0.74-2.07	0.3
SMD (low/normal)	1.98	1.18-3.33	0.009	2.20	1.26-3.86	0.006
ASA-PS score (I/II/III)	1.84	1.04-3.25	0.03	2.07	1.10-3.88	0.02
TNM stage (I/II/III)	3.89	1.77-8.56	0.001	2.63	0.89-7.75	0.07
Differentiation (well/poor)	2.85	1.46-5.58	0.002	1.96	0.92-4.17	0.07
Lymphatic invasion (yes/no)	2.46	1.13-5.39	0.02	0.60	0.21-1.65	0.3
Vascular invasion (yes/no)	2.70	1.56-4.66	0.0001	1.31	0.67-2.54	0.4
Perineural invasion (yes/no)	2.73	1.49-4.99	0.001	1.20	0.56-2.58	0.6
Resection margin (positive/negative)	4.21	2.58-6.84	0.0001	3.45	1.95-6.10	0.0001

HR: Hazard ratio, CI: Confidence interval, SMI: Skeletal muscle index, SMD: Skeletal muscle density, ASA-PS: American Society of Anesthesiologists physical status

improvements in computer software to establish CT-based body composition analysis has enabled measuring muscle mass and its fat content non-invasively and eliminated the need for extra imaging modalities (13,24). Previous studies have reported that sarcopenia is associated with increased postoperative complication rates, excess chemotherapy toxicity, and poor prognosis, especially in colorectal, endometrial, pancreatic, and hepatic surgery (15-18,25). However, when considering patients with gastric cancer, although some studies reported that it has adverse effects on both early postoperative outcomes and prognosis, others reported that it does not have any effect. Therefore, there is uncertainty about postoperative outcomes regarding patients with gastric cancer. Two objective criteria for the diagnosis of CT-based sarcopenia are SMI and SMD. While the low SMI reflects loss of muscle mass, the low SMD reflects increased muscle lipid content, indicating sarcopenia in CT imaging (14). Although there are many studies on SMI and SMD in the literature, it is not fully understood which one better reflects patients' physiological reserve capacities or whether they affect postoperative results, especially in elderly patients. On the other hand, as far as we know, no study has evaluated the effect of both SMI and SMD on postoperative outcomes and prognosis after radical gastrectomy. In the present study, we aimed to assess SMI and SMD values for the diagnosis of sarcopenia in CT images from our series and determine whether they have an impact on postoperative short-term results and prognosis in patients with gastric cancer.

Sarcopenia is an age-related syndrome that usually starts in the fifth decade of life and progresses at a rate of 0.8% annually (26). In our study, the age of incidence of sarcopenia was the seventh decade of life. According to low SMI and low SMD, the mean ages of sarcopenia were 62 and 64 years, respectively. Both parameters of sarcopenia are consistent with other studies in the literature. The total muscle mass in the body is different between males and females. Thus, SMI measurements can be more sensitive in males than SMD measurements. Sarcopenia is not limited to individuals who appear weak or slim. Indeed, our study population was characterized by body weights with a mean BMI (23-26 kg/m^2), the upper limit of average weight, bordering on overweight. Our findings support that theory because patients with a normal BMI show low SMI and low SMD values, which describe sarcopenia. Typical or near-normal fat tissue may cause misperception (15). Adequate protein intake is crucial for maintaining muscle mass and is expected to be reflected in the PNI (1). In patients with gastric cancer, poor oral intake due to dysphagia, obstruction, or nausea can induce more severe nutritional depletion compared to patients with other types of malignancy. In our series, the patients with low SMD have a significantly lower mean value of PNI. Factors such as age, comorbidity, and frailty are considered some of the main reasons for referrals from other centers to tertiary hospitals. Since our center is a tertiary hospital, most patients have ASA-PS II and ASA-PS III scores. We have excluded ASA-PS IV and above patients from the study. The physical disability caused by the comorbidity will lead to muscle weakness. The low SMI and SMD values of our patients with ASA-PS II/III scores may be related to this. We found no relationship between muscular parameters, tumor stage, and tumor differentiation grade. Patients with distal gastric tumors have significantly lower SMI levels without affecting SMD. We were unable to comment on the reasons for this result.

Postoperative complications continue to exist substantially in older adults because of comorbidities and the decline of functional reserve associated with aging (26). Recently, some studies have reported that sarcopenia may be one of the most critical factors affecting postoperative complications in older people (26-29). However, other studies could not show a relationship with short-term outcomes; nonetheless, a significant relationship was found with long-term survival (1,11,30,31). Our study revealed no significant differences between SMI and SMD values with respect to major postoperative complications (p=0.1, p=0.09, respectively). However, there was a significant difference between low SMD and normal SMD values in the length of hospital stay (p=0.01). Joglekar et al. (29) reported that muscle density, but not muscle mass, is a significant predictor of major postoperative complications in pancreatic cancer. Although there were no significant differences, in line with this information, the major complication rates in our study were higher in patients with low SMD than those with higher SMD. These results explain why patients with low SMD have statistically significant longer hospital stays. Our series showed a significant reduction in OS in patients with both low SMI and low SMD. This finding is consistent with other studies that have also been reported by oncologic cohort groups in the literature (9,32). While Murnane et al. (32) attributed that result to the relationship between anastomotic leakage and myosteatosis, some authors referred to the failure of postoperative adjuvant therapy due to chemotherapy toxicity caused by sarcopenia (25). Even though there were no significant differences, the major complication rates in our study were higher in sarcopenic patients than in non-sarcopenic patients. The other theory is that sarcopenia may be a reflection of the increased metabolic activity of a more aggressive tumor biology, and the increased metabolic activity leads to more major systemic inflammation and subsequently results in muscle wasting (27,33). We thought that all these reasons could affect the OS rates. Our univariate results found that low SMI, low SMD, ASA-PS score, TNM stage, differentiation grade, lymphovascular and perineural invasion, and a positive resection margin were associated with poor OS in patients with gastric cancer. In multivariate analysis, SMD,

ASA-PS score, and positive resection margin were found to be independent prognostic factors for OS.

Integrating SMD calculation into preoperative risk stratification and prognostic models may facilitate the identification of sarcopenic patients. Then, it can help select patients for nutritional support and physical activity to increase muscle strength before surgical treatment. This might be particularly suitable for patients with gastric cancer who require neoadjuvant chemotherapy. In a study that analyzed the change in body composition in patients after neoadjuvant chemotherapy for esophagogastric cancer, there was a statistically significant increase in the number of patients with sarcopenia post-chemotherapy (9,34).

Study Limitations

This study has several limitations. First, this retrospective, single-center study may exhibit selection bias. Second, minor and other complications, such as pulmonary, renal, and cardiac complications, were not recorded. It would have been better if we had recorded the length of stay in the intensive care unit, completion of adjuvant therapy, and disease-free survival. Therefore, a prospective multicenter and multidisciplinary study with a larger patient population may be necessary to clarify the relationship between muscular density and postoperative outcomes in specific subgroups of patients undergoing curative resection for gastric cancer.

CONCLUSION

This study demonstrated that, in patients undergoing curative resection for gastric cancer, there was a statistically significant association between myosteatosis and decreased overall survival. Even though there was no difference in muscular density, the major complication rates in our study are higher in patients with low SMD than in patients with normal SMD. Reporting of SMD from preoperative CT should be considered for patient preparation purposes.

Ethics

Ethics Committee Approval: The Ethics Committee of Marmara University approved the study protocol (date: 05.03.2021, no: 09.2021.248).

Informed Consent: Written informed consent was obtained from all patients participating in the study.

Footnotes

Author Contributions

Concept - A.A., T.K.U; Design - A.A., T.K.U; Materials - T.K.U., O.B., M.K.; Data Collection or Processing - A.A., O.B., M.K.; Analysis or Interpretation - A.A., T.K.U., O.B.; Literature Search - A.A., T.K.U.; Critical Review - A.A., T.K.U., A.E.A.; Writing - A.A., T.K.U., A.E.A.

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