Surgery 166 (2019) 297–304

Contents lists available at ScienceDirect

Surgery

journal homepage: www.elsevier.com/locate/surg

Stomach

Myosteatosis predicts prognosis after radical gastrectomy for gastric cancer: A propensity score–matched analysis from a large-scale cohort

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A R T I C L E I N F O

Article history:
Accepted 25 March 2019
Available online 6 May 2019

A B S T R A C T

Background: Increasing evidence has suggested that sarcopenia is linked with cancer prognosis, but only limited data have focused on the impact of myosteatosis on cancer outcomes. This study evaluates the influence of myosteatosis on postoperative complications and survival in those patients who underwent radical resection of gastric carcinoma.

Methods: Patients who underwent elective radical gastrectomy for gastric cancer and had computed tomographic images available were identified from a prospectively collected database between 2008 and 2013. Myosteatosis was diagnosed by the cutoff values obtained from the method of optimum stratification. To obtain 2 well-balanced cohorts for available variables influencing clinical outcomes, the myosteatosis group was matched 1:1 with nonmyosteatosis group by using a propensity score match.

Results: Of 973 patients, 584 were matched for analyses. Compared with the nonmyosteatosis group, the myosteatosis group manifested significantly higher severe postoperative complications rates, shorter overall survival, and disease-free survival. Before matching, multivariate analyses identified that myosteatosis was an independent risk factor for severe postoperative complications, and Cox proportions hazards model showed that myosteatosis was an independent predictor for shorter overall survival and disease-free survival. In addition, subgroup analyses of each muscle phenotype showed that patients with both sarcopenia and myosteatosis had a poorer overall survival and disease-free survival than other patients.

Conclusion: Myosteatosis in gastric cancer is associated with poor prognosis. Classifying the skeletal muscle into subranges of radio density is a promising strategy to understand the impact of skeletal muscle on unfavorable surgical outcomes in gastric cancer patients.

Body composition—the proportion of visceral fat, subcutaneous fat, and skeletal muscle in an individual patient—is linked with the clinical outcomes of patients with the malignant tumors.[1] Noninvasive methods are needed to assess muscle mass and function, bone mineral density, body fluid distribution, and fat distribution. These patterns are difficult to identify using conventional anthropometric measures, such as body mass index, waist-to-hip ratio, or midarm circumference. Recently, the value of body composition measures derived from computed tomography for predicting clinical outcomes has gained interest.[2]

Sarcopenia is one of the most common composition measures in patients and it is associated with worse postoperative outcomes after resection of the solid tumors.[3,4] Several recent studies have found that sarcopenia is an independent predictive factor of increased morbidity and mortality after gastrointestinal surgery.[5] Our previous studies also have investigated the association of

Supported by the National Natural Science Foundation of China (No. 81800795,81770884), Shanghai Science and Technology Committee (No. 16411954200), Shanghai Municipal Commission of Health and Family Planning (No. 20184Y0301), Fundamental Research Funds for the Central Universities (No. 22120180051).

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https://doi.org/10.1016/j.surg.2019.03.020
0039-6060/

sarcopenia with postoperative complications and long-term outcomes after operation for gastric cancer and have obtained consistent results.[6,7]

However, less consideration has been given to myosteatosis. Myosteatosis is described as increased infiltration by inter- and intramuscular fat.[8] In addition to the loss of muscle mass, aging also leads to the redistribution of adipose tissue, where subcutaneous adipose tissue relocates to more detrimental locations, such as intramuscular and intermuscular adipose tissue, or moves between and within muscles and organs.[9] Myosteatosis increases with fatty infiltration and is associated with metabolic abnormalities[10] and decreased physical strength and mobility.[11] If sarcopenia represents muscle content, then myosteatosis reflects the quality of muscle.

Gastric cancer is the fifth most common malignancy and the third leading cause of cancer death worldwide.[12] Surgical resection remains the most effective treatment for potentially curable gastric cancer. Nevertheless, radical gastrectomy is an extensive and complex surgical procedure associated with high incidence of complications and poor survival rates.[13,14] Hence, the identification of sensitive preoperative predictive biomarkers is warranted. The objectives of the current study were to define the prognostic significance of myosteatosis determined by preoperative computed tomography images in a large-scale cohort of patients with gastric cancer, and analyze whether myosteatosis still played a prognostic role when combined with sarcopenia.

Methods

Patients

From a prospectively collected database, consecutive patients with primary gastric cancer undergoing radical gastrectomy at Wenzhou Medical University between December 2008 and August 2013 were identified. Exclusion criteria included cancer metastasis confirmed preoperatively or during surgery, a diagnosis of double cancer or emergency surgery. Subsequently, patients with no preoperative abdominal computed tomography (CT) or incomplete data were excluded. The study was approved by the WENZHOU Institutional Ethical Review Board (ethical no. 2018022).

Muscle analysis

Patients underwent abdominal CT scan 1 month before operation (median 3.5 days), and the CT films were stored in the Picture Archiving and Communication System automatically. Muscle area and mean muscle attenuation were measured at CT workstation (GE ADW 4.5). The third lumbar vertebra (L3) was chosen as a landmark. L3 muscle was evaluated on a single image using tissue-specific HU thresholds of −29 to 150. All slices analysis was performed by 2 trained radiology residents blinded to patient information, clinical treatment, and outcomes. Entire muscle areas were normalized based on patients' height and reported as lumbar skeletal muscle index (SMI; cm^2/m^2). SMI < 34.9 cm^2/m^2 for women and < 40.8 cm^2/m^2 for men were defined as sarcopenia.[7] Myosteatosis was defined according to mean muscle attenuation in HU for the cross-sectional muscle area.

Data acquisition

The prospectively maintained computer database, including patients' electronic medical record and the follow-up records, provided the following information: the patients' demographic and clinicopathologic features, operative characteristics, postoperative complications, and long-term outcomes. Total postoperative complications were defined as complications classified as grade II or higher according to the Clavien–Dindo classification[15] within 30 days after gastrectomy; grade III to V were defined as severe complications. Overall survival (OS) was defined as the time surviving after surgery. Disease-free survival (DFS) was calculated as the period from operation to the date of relapse or death from noncancer cause.

Follow-up

All patients regularly received telephone interviews or outpatient visits. Follow-up investigations were scheduled every 3 months for the first 2 years after surgery and every 6 months thereafter. The follow-up program included investigation of postoperative life, physical examination, laboratory tests, and ultrasonography and CT or endoscopy. If necessary, additional assessment, such as contrast-enhanced magnetic resonance imaging or even positron emission tomography, should be considered to confirm the diagnosis in cases of suspected recurrence. The last follow-up date was August 2018.

Propensity score matching

The propensity score approach was applied to construct a randomized experiment-like situation in which the observation group and control group were comparable for prognostic factors. A propensity score was estimated for each patient from a logistic regression model to fit with the 10 covariates including age, sex, body mass index, American Society of Anesthesiologists (ASA) grade, Charlson Comorbidity Index, hypoproteinemia, sarcopenia, TNM stage, tumor size, tumor location, and type of resection. These covariates were selected because of the potential impact on muscle depletion or prognosis. Then, a 1:1 matching analysis was performed between the myosteatosis and nonmyosteatosis groups based on the estimated propensity scores. After matching, baseline features, including covariates that did not enter into the propensity score model, were compared between groups.

Statistics

Optimal stratification, a statistical method based on log-rank statistics, was used to solve specific threshold values with the continuous covariate (muscle attenuation). The most significant *P* value was found by means of the log-rank χ^2 statistic to derive the sex-specific cutoffs at which patients were best separated with respect to time to mortality. It is appropriate to identify survival-related thresholds using optimal stratification, which was previously described in the literature.[16] The cutoffs obtained by this method were then used to classify patients as myosteatosis or nonmyosteatosis. Differences between the 2 propensity score-matched groups were analyzed using Pearson χ^2 tests.

Univariate analysis was used to assess the relationship between myosteatosis and other categorical variables. Clinically relevant parameters with a *P* value of <.10 in univariate analyses were entered into multivariate logistic regression or Cox proportions hazards model. Kaplan-Meier method was used to establish the effect of myosteatosis on OS and DFS. Receiver operator curve (ROC) analysis was used to compare prediction models of postoperative complications with and without myosteatosis.

Data analysis was conducted by using SPSS statistics (IBM Corp, IBM SPSS Statistics for Windows, Armonk, NY, version 22.0). The calculation and comparison of areas under the ROC curve were completed by using MedCalc Software (MedCalc, Ostend, Belgium, version 15.2). This article follows the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement.[17]

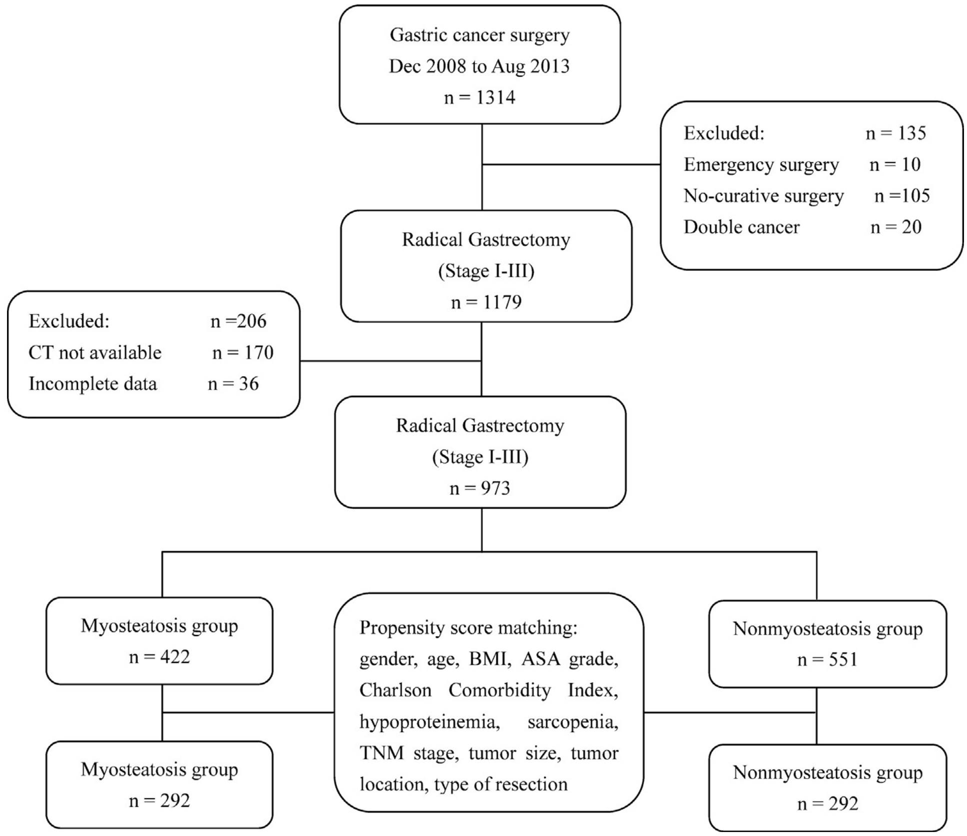

Fig 1. Flow diagram describing the patient matching process.

Results

Population

From December 2008 to August 2013, a total of 1,314 patients were analyzed and 341 were excluded. Thus, the total sample size included 973 patients who received radical surgery for gastric cancer. An overview of patient selection process is shown in Fig 1. There were 460 deaths; the median follow-up time was 80 months. Patients' demographic and clinicopathologic characteristics are listed in Table I.

The sex-specific cutoff values for L3 mean muscle attenuation associated with OS were 38.5 HU for men and 28.6 HU for women. Using these cutoff values, myosteatosis was present in 422 patients (43.4 %). Patients with myosteatosis had an older age ($P < .001$), a lower L3 SMI ($P < .001$), a lower albumin level ($P < .001$), and a higher ASA grade ($P < .001$) than those without myosteatosis. As for tumor characteristics, patients with myosteatosis had a larger tumor size ($P = .001$), a more advanced TNM stage ($P = .002$), and higher proportion of total gastrectomy ($P = .011$) than those without myosteatosis. After propensity score matching for myosteatosis, 292 matched pairs were selected (Table I). After matching, the characteristics of the patients were conserved and no statistically significant differences were present between the myosteatosis and nonmyosteatosis groups.

Postoperative complications

The distribution of postoperative complications is listed in Table II. Total postoperative complications occurred in 227 (24.2%) patients. The incidence of total complications and severe complications in patients with myosteatosis was significantly higher than those in patients with normal muscle attenuation ($P < .001$). After matching, myosteatosis was associated with grade III to IV complications ($P = .001$; $P = .03$) but was not associated with grade II complications.

Multivariate analysis showed that myosteatosis was one of the independent risk factors for severe complications (Table III) and ROC curves showed the prediction ability of multivariable model. The area under the ROC curve for the model including myosteatosis was 0.743 (95% confidence interval [CI], 0.715–0.771), whereas the model excluding myosteatosis was 0.678 (95% CI, 0.648–0.708). The difference was statistically significant ($P = .023$).

Oncologic outcome

The 1-, 3-, and 5-year OS rates were 80.1%, 55.7%, and 45.7% respectively, for patients with myosteatosis and 89.7%, 70.2%, and 63.0%, respectively, for those without myosteatosis. The 1-, 3-, and 5-year DFS rates were 76.2%, 55.2%, and 51.7%, respectively, for patients with myosteatosis, and 83.9%, 68.9%, and 64.8%, respectively, for those without myosteatosis. The survival curves for patients with and without myosteatosis are shown in Fig 2. Patients with myosteatosis showed a significantly poorer OS and DFS than the nonmyosteatosis group ($P < .01$). After matching, the difference of OS and DFS between myosteatosis and nonmyosteatosis group remained constant ($P < .01$).

In addition, we divided the patients into 4 groups: patients with normal muscle, patients with only sarcopenia, patients with only myosteatosis, and patients with both sarcopenia and myosteatosis. Figure 3 showed the Kaplan-Meier curve for OS and DFS in the 4 groups. No matter before or after matching, patients with both sarcopenia and myosteatosis had a poorer OS and DFS than patients in other 3 groups ($P < .001$), and the OS and DFS of patients with

Table I
Patient demographic and clinical characteristics

Characteristics	Overall (N = 973)					Propensity score–matched pairs (N = 584)				
	Myosteatosis (n = 422)		Nonmyosteatosis (n = 551)		*P* value	Myosteatosis (n = 292)		Nonmyosteatosis (n = 292)		*P* value
	n	%	n	%		n	%	n	%	
Age, y					<.001					.7
<65	114	27.0	368	66.8		114	39.0	110	37.7	
≥65	308	73.0	183	33.2		178	61.0	182	62.3	
Sex					<.001					.5
Female	65	15.4	154	27.9		52	17.8	59	20.2	
Male	357	84.6	397	72.1		240	82.2	233	79.8	
BMI, mean (SD), kg/m^2					.5					.2
≤18.5	54	12.8	80	14.5		43	14.7	59	20.2	
18.5–25	303	71.8	399	72.4		203	69.5	192	65.8	
>25	65	15.4	72	13.1		46	15.8	41	14.0	
Hypoproteinemia					<.001					.7
No	329	78.0	477	86.6		236	80.8	232	79.5	
Yes	93	22.0	74	13.4		56	19.2	60	20.5	
Sarcopenia					<.001					.3
No	214	50.7	372	67.5		164	56.2	176	60.3	
Yes	208	49.3	179	32.5		128	43.8	116	39.7	
ASA grade					<.001					.8
I–	19	4.5	65	11.8		14	4.8	17	5.8	
II	338	80.1	437	79.3		234	80.1	229	78.4	
III	65	15.4	49	8.9		44	15.1	46	15.8	
Charlson Comorbidity Index					.3					1.0
0	325	77.0	446	80.9		226	77.4	227	77.7	
1	69	16.4	78	14.2		46	15.8	46	15.8	
≥2	28	6.6	27	4.9		20	6.8	19	6.5	
TNM stage					.002					.3
I	95	22.5	180	32.7		83	28.4	97	33.2	
II	106	25.1	114	20.7		77	26.4	64	21.9	
III	221	52.4	257	46.6		132	45.2	131	44.9	
Tumor size					.004					.2
≤50 mm	287	68.0	420	76.2		91	31.2	78	26.7	
>50 mm	135	32.0	131	23.8		201	68.8	214	73.3	
Combined resection					.6					.6
No	379	89.8	500	90.7		263	90.1	267	91.4	
Yes	43	10.2	51	9.3		29	9.9	25	8.6	
Tumor location					.2					.9
Upper	85	20.1	94	17.1		61	20.9	60	20.5	
Not upper	337	79.9	457	82.9		231	79.1	232	79.5	
Type of reconstruction					.011					.4
Roux-en-Y	180	42.7	188	34.1		115	39.4	116	39.7	
Billroth I	104	24.6	162	29.4		81	27.7	70	24.0	
Billroth II	130	30.8	177	32.1		90	30.8	94	32.2	
Others	8	1.9	24	4.4		6	2.1	12	4.1	
Extent of node dissection					.3					.2
D0–1	24	5.7	41	7.4		14	4.8	21	7.2	
≥D2	398	94.3	510	92.6		278	95.2	271	92.8	
Type of resection					.011					1.0
Subtotal gastrectomy	247	58.5	366	66.4		176	60.3	176	60.3	
Total gastrectomy	175	41.5	185	33.6		116	39.7	116	39.7	

The values given are number of patients unless indicated otherwise.
BMI, body mass index; *NRS*, nutritional risk screening; *SD*, standard deviation; *VFA*, visceral fat area.

Table II
Details of postoperative complications according to the Clavien-Dindo classification

Grade	Overall (N = 973)					Propensity score-matched pairs (N = 584)				
	Myosteatosis (n = 422)		Nonmyosteatosis (n = 551)		*P* value	Myosteatosis (n = 292)		Nonmyosteatosis (n = 292)		*P* value
	n	%	n	%		n	%	n	%	
Grade II	91	21.6	82	14.9	.007	59	20.2	51	17.5	.397
Grade III	26	6.2	8	1.5	<.001	19	6.5	3	1.0	.001
Grade IV	14	3.3	4	0.7	.003	11	8.8	3	1.0	.030
Grade V	6	1.4	4	0.7	.456	1	0.3	3	1.0	.616
Severe complications	46	10.9	16	2.9	<.001	31	10.6	9	3.1	<.001

Table III
Univariate and multivariate logistic regression analysis for severe postoperative complications

Factors	Univariable analysis		Multivariate analysis	
	Case with complication, *n* (%)	*P* value	OR (95% CI)	*P* value
Myosteatosis				
Yes/no	46 (10.9)/16 (2.9)	<.001	3.522 (1.944–6.380)	<.001
Sarcopenia				
Yes/No	39 (10.1)/23 (3.9)	<.001	2.329 (1.347–4.028)	.002
Charlson Comorbidity Index				
1/0	17 (11.6)/37 (4.8)	.005	2.635 (1.414–4.910)	.002
≥2/0	8 (14.5) /37 (4.8)	.011	3.089 (1.089–7.171)	.009
ASA grade				
≥III/II, I	13 (11.4)/49 (5.7)	.019		

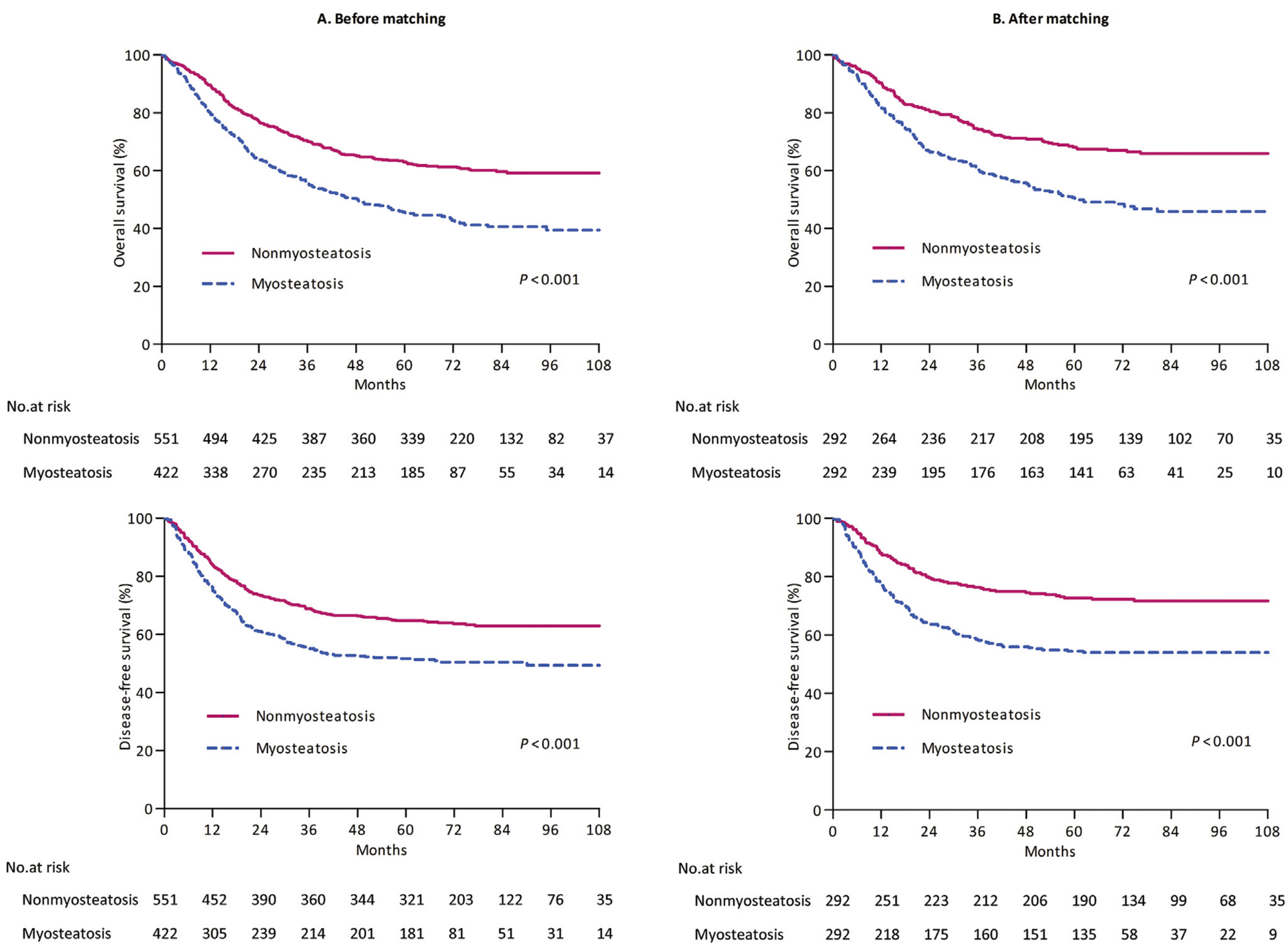

Fig 2. Kaplan-Meier curves for overall survival and disease-free survival, according to myosteatosis. (*A*) Before and (*B*) after matching.

normal muscle were the best. However, there was no statistical difference in OS and DFS between the patients with only sarcopenia and with only myosteatosis.

The results of univariate and multivariate analysis of factors associated with OS and DFS are shown in Table IV. Myosteatosis remained independently associated with decreased OS (hazard ratio = 1.379, P = .001) and DFS (hazard ratio = 1.297, P = .012). The independent predictors of OS included myosteatosis, sarcopenia, advanced TNM stage, severe complications, ASA grade ≥III, and total gastrectomy. Myosteatosis, sarcopenia, undifferentiated histologic type, advanced TNM stage, and total gastrectomy were the independent predictors of DFS.

Discussion

Muscle depletion is characterized by reduced muscle size (termed sarcopenia[18]) and declined muscle quality (termed myosteatosis[8]), which is distinct from ordinary weight loss or cachexia and can occur in patients in any weight category, from underweight to obese.[16,19] These pathologic phenomena usually are associated with physical disability and impaired survival in cancer patients.[20,21] The predictive role of muscle mass is well established; however, less is known about the relationship between muscle quality and clinical outcomes, especially in patients with gastric cancer.

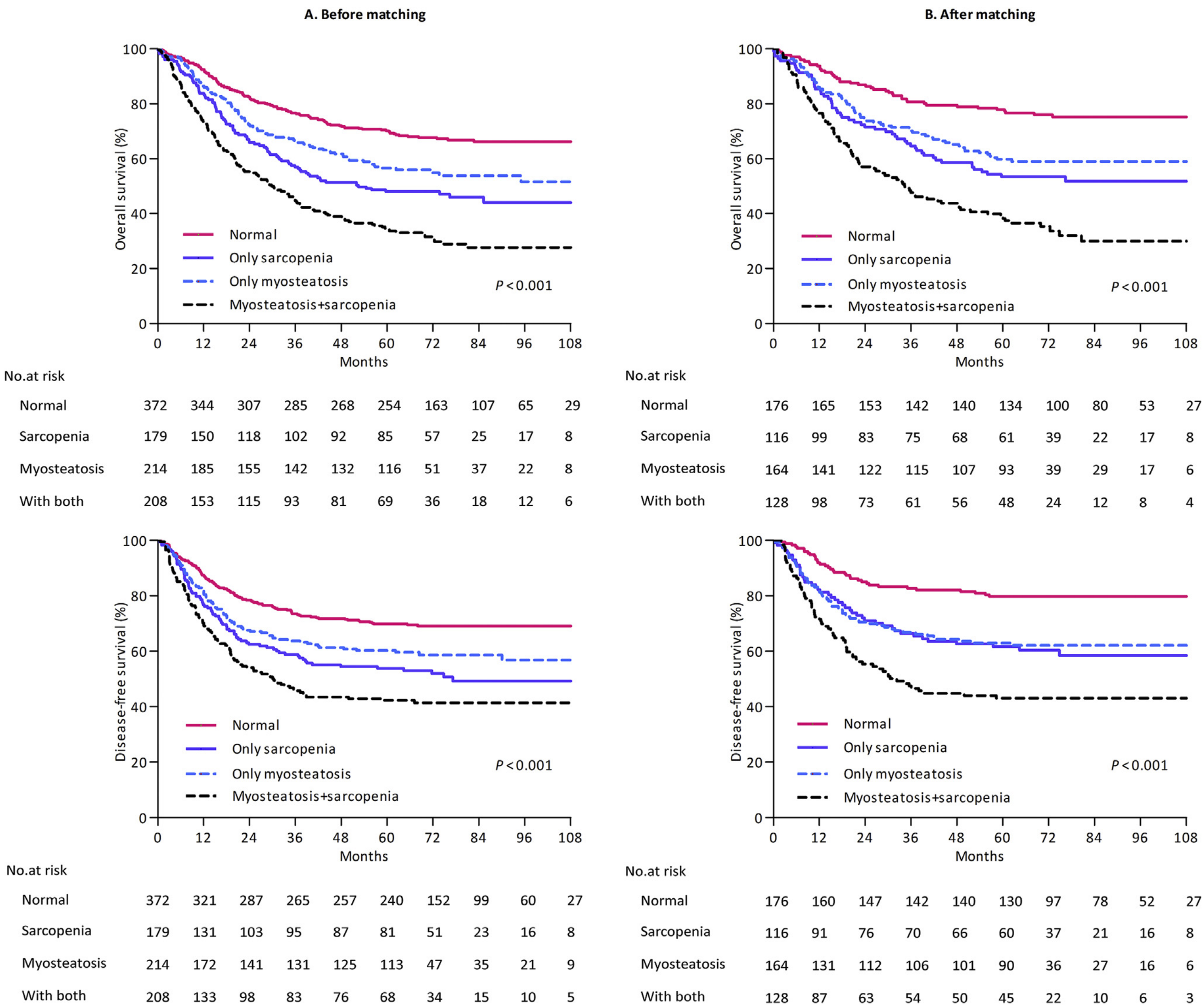

Fig 3. Kaplan-Meier curves for overall survival and disease-free survival, according to 4 skeletal muscle phenotypes. (*A*) Before and (*B*) after matching.

Our study first showed that myosteatosis, assessed on preoperative CT, was a novel biomarker of postoperative complications and long-term survival in patients with gastric cancer, independent of other established prognostic factors, such as tumor stage and sarcopenia. A propensity score-matched analysis was used to reduce inherent selection biases and provide more reliable evidence. This more rigorous and scientific analysis revealed that myosteatosis was still a significant prognostic indicator of clinical outcomes, which suggested that myosteatosis was not only an anthropometric index influenced by age, physique, and nutritional status, but also a tumor-related factor independent of basic clinical characteristics. Moreover, the present study provided long-term follow-up data as all patients were followed up for >5 years. The predictive power of myosteatosis for clinical outcomes can potentially improve patient selection and informed consent before surgical resection.

Currently, only a few researches have focused on the effects of skeletal muscle quality on short-term outcomes in surgical patients with solid tumor. Malietzis et al suggested that presence of myosteatosis was related to prolonged primary hospital stay in patients undergoing elective resection of colorectal cancer.[22] Analogously, Silva de Paula et al found that muscle quality was an indicator of major postoperative surgical complication and was associated with early mortality in women with ovarian and endometrial cancer who underwent oncologic surgery.[23]

The recent study indicates that severe complications were present in >10% of patients with myosteatosis who underwent gastrectomy. Myosteatosis was identified to be independently associated with postoperative severe complications, generating an area under the curve of 0.743 by ROC curve. ROC curve is a valuable tool to evaluate the performance of a diagnostic test. The model that included myosteatosis has preferable prediction performance than the model excluded myosteatosis.

Muscle wasting is part of the frailty complex present in cancer patients, which is caused by cumulative declines across multiple physiologic systems and is characterized by a state of impaired functional capacity, decreased reserve, resistance to stressors, and predisposition to poor outcomes.[24] Moreover, previous reports have shown that the ectopic lipid accumulation in skeletal muscles is an important feature of energy metabolic diseases, such as type 2 diabetes[25] and insulin resistance.[26] Taken together, such metabolic disorders may result in reduced tolerance for surgical trauma and stress. In fact, in this study, patients with myosteatosis had an older age, a lower L3 SMI, a lower

Table IV
Univariable and multivariable Cox regression analyses for overall and disease-free survival

Factors	Overall survival				Disease-free survival			
	Univariable analysis		Multivariate analysis		Univariable analysis		Multivariate analysis	
	HR (95% CI)	*P* value	HR (95% CI)	*P* value	HR (95% CI)	*P* value	HR (95% CI)	*P* value
Myosteatosis								
Yes/no	1.715 (1.428–2.061)	<.001	1.379 (1.143–1.664)	.001	1.540 (1.263–1.878)	<.001	1.297 (1.060–1.588)	.012
Sarcopenia								
Yes/no	2.113 (1.759–2.539)	<.001	1.866 (1.546–2.253)	<.001	1.834 (1.503–2.237)	<.001	1.614 (1.318–1.977)	<.001
ASA grade								
≥III/II, I	1.617 (1.256–2.083)	<.001	1.356 (1.051–1.750)	.019	1.366 (1.022–1.825)	.035		
Histologic type								
Undifferentiated/differentiated	1.218 (0.987–1.502)	.066			1.580 (1.273–1.961)	<.001	1.253 (1.007–1.560)	.043
TNM stage								
II/I	2.975 (2.072–4.273)	<.001	2.433 (1.685–3.515)	<.001	4.119 (2.693–6.301)	<.001	3.485 (2.267–5.357)	<.001
III/I	7.056 (5.145–9.676)	<.001	5.967 (4.326–8.230)	<.001	9.285 (6.329–13.624)	<.001	7.778 (5.263–11.494)	<.001
Type of resection								
Total/subtotal	1.898 (1.580–2.280)	<.001	1.464 (1.214–1.766)	<.001	1.801 (1.476–2.198)	<.001	1.357 (1.107–1.662)	.003
Severe complications								
Yes/no	1.599 (1.142–2.237)	.006	1.441 (1.022–2.031)	.037	1.381 (0.934–2.042)	.105		

albumin level, and a higher ASA grade. Myosteatosis reflects a chronic detriment of general physical condition in patients with gastric cancer.

Importantly, the presence of myosteatosis was associated with poor survival compared with the patients without abnormal muscle attenuation. Martin et al defined threshold associations between muscle attenuation and survival of patients with gastrointestinal or respiratory tract cancer, and they found that patients with low muscle attenuation shared a poor prognosis.[27] This commonly accepted method (optimal stratification) also was adopted to find the most significant cutoffs for mean muscle attenuation in the current study. We considered that using these thresholds would lead to more accurate results because predefined cutoffs validated in a different population do not suit our cohort, most of which are advanced gastric cancer patients. On the basis of these cutoffs, myosteatosis was demonstrated to be associated with a poor 5-year OS and PFS that seem to be obvious (both had a $P < .001$). Rodrigues et al recently published interesting results.[28] They constructed 4 skeletal muscle phenotypes according to skeletal muscle index and average muscle radiation attenuation to predict 1-year mortality in patients with endometrial cancer and found that classifying skeletal muscle into subranges of radio density had an additional value compared with using the skeletal muscle area alone. In the present study, skeletal muscle was divided into 3 subgroups and the skeletal muscle phenotype of sarcopenia and myosteatosis showed most adverse prognostic effect on OS and DFS. These results reinforce the need to investigate skeletal muscle phenotypes and myosteatosis is one of the indispensable components. Combination of unfavorable phenotypes of skeletal muscle can worsen the impact on clinical outcomes and improve prediction accuracy.

The mechanisms by which myosteatosis confers increased risk of tumor relapse and mortality are still unclear; however, it can be attributed to the following reasons. First, skeletal muscle has been identified as a secretory organ and cytokines and other peptides secreted from muscle cells can influence the growth and metastasis of tumor cells.[29] Accordingly, reduced muscle quality may lead to an altered myokine response and deficient regulation of tumor cells. Second, as a measure of intermuscular fat, myosteatosis is associated with abnormalities in glucose metabolism,[10] vitamin D deficiency,[30] and levels of interleukin (IL)-6[31], all of which may facilitate cancer progression. In the present study, myosteatosis was validated to be associated with advanced tumor stage and larger tumor size. Moreover, myosteatosis has been proven to be directly related to host systemic inflammatory response in patients undergoing primary colorectal cancer surgery.[32] The systemic inflammatory response, as defined by several inflammation-based prognostic scores, has been proven to be an important indicator of poor OS and DFS.[33] However, there is no evidence available to support this conclusion in the field of gastric cancer. In addition, a previous study has shown that severe postoperative complications are associated with lower survival rate in gastric cancer patients.[34] Therefore, we speculate that the higher complication rate in myosteatosis patients could lead to worse long-term prognosis after radical gastrectomy.

Our results indicated that myosteatosis could be a potential therapeutic target for improving prognosis, and it is necessary to develop appropriate interventions to increase or prevent further decline of skeletal muscle attenuation. A randomized controlled trial suggested that regular physical activity prevents the age-related increase in muscle fat infiltration in the elderly with moderate functional limitations.[35] In another study of 80 postmenopausal women, hormone replacement therapy increased Hounsfield units of both the quadriceps compartment and quadriceps muscles.[36] However, no such treatment can improve the clinical outcome after surgery. The effect of early intervention or muscle training on postoperative outcomes for gastric cancer patients with myosteatosis should be subject to future investigation.

This study had some potential limitations. First, this was a single-center retrospective study, although a large sample size was included. The results should be verified by a multicenter, prospective analysis. In addition, a subset of patients was excluded because of the inadequacy of the electronic data. However, there was no significant difference in baseline characteristics between excluded patients and those included in the analysis cohort.

In conclusion, we first identified the diagnostic cutoff values for muscle attenuation in patients with gastric cancer. Myosteatosis adversely affects the surgical outcomes of gastrectomy, specifically postoperative severe complications and long-term survival. Our study is a new step in determining the value of preoperative CT-derived muscle quality to risk stratification and shared decision making in patients receiving surgery for gastric cancer.

Conflicts of interest

The authors have indicated that they have no conflict of interest regarding the content of this article.

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