Original Article

Preoperative pectoralis muscle radiodensity as a risk factor for postoperative complications after thoracoscopic lobectomy for non-small cell lung cancer

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Background: Skeletal muscle radiodensity is associated with postoperative complications in cancer. However, data on skeletal muscle radiodensity and postoperative complication risk in patients with non-small cell lung cancer (NSCLC) are scarce, and this study investigated the relationship between skeletal muscle radiodensity and postoperative complication risk in patients with NSCLC treated by thoracoscopic lobectomy.

Methods: Quantitative and qualitative measurements of the pectoralis muscle were performed on a single axial slice above the aortic arch in the precontrast computed tomography (CT) scan performed before surgery. Sex-specific cutoffs for the pectoralis muscle mass index (PMI) and pectoralis muscle radiodensity (PMD) were set at the lowest tertile. A Clavien-Dindo grade ≥ III within 30 days of the operation was considered as a major complication, and logistic regression analysis was performed to identify risk factors for postoperative complications.

Results: The records of 163 consecutive patients with NSCLC receiving first-line thoracoscopic lobectomy between March 2016 and October 2019 were retrospectively reviewed and the PMI was found to be positively correlated with PMD ($P<0.001$). The PMI and PMD were significantly higher in men than in women (both $P<0.001$), and 23 (14.1%) patients experienced major postoperative complications. The multivariate analysis showed that male sex ($P=0.032$), lower body mass index (BMI) ($P=0.016$), and low PMD ($P=0.012$) before surgery, but not low PMI, were independent risk factors for major postoperative complications.

Conclusions: Skeletal muscle quality but not muscle mass predicts major complications after thoracoscopic lobectomy for NSCLC. Skeletal muscle measures from the preoperative CT scan may be used to stratify patients with NSCLC into risk categories that can guide clinical decision-making.

Keywords: Non-small cell lung cancer (NSCLC); thoracoscopic surgery; postoperative complications; body composition; computed tomography (CT)

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Introduction

Lung cancer is one of the most common cancers worldwide and a leading cause of cancer-related mortality (1,2). While complete surgical resection is a potentially curative treatment for resectable non-small cell lung cancer (NSCLC), lobectomy by video-assisted thoracoscopic surgery (VATS), also known as thoracoscopic lobectomy, is an effective minimally invasive surgical approach for NSCLC, although the incidence of complications following the latter is 10.3–31.0% (3). Postoperative morbidity is a major clinical challenge in the surgical treatment of cancer, and the decision to perform surgery is made after weighing the benefits versus the potential complications. Thus, preoperative clinical evaluation is critical for the optimal management of cancer patients undergoing surgery.

Sarcopenia is characterized by low skeletal muscle quantity or quality (4), and has been the focus of increasing attention in surgical oncology. Accurately measuring muscle mass and quality is technically difficult, and computed tomography (CT), which is used to image tumors, has been applied to the evaluation of muscle composition and distribution (4). Data on the association between preoperative CT-based measures of muscle mass and morbidity following surgery for NSCLC are inconsistent. The measurements of the pectoralis muscle are readily obtained from CT scans, which are performed as part of standard preoperative assessments and do not require specific research protocols. However, CT-based measurements of pectoralis muscle mass have seldom been used in studies investigating the relationship between muscle quantity and post-treatment outcomes in patients with NSCLC. Furthermore, the contribution of preoperative skeletal muscle radiodensity (quality) to postoperative complication risk in NSCLC patients has never been reported. This study thus investigated the relationship between preoperative pectoralis muscle radiodensity and postoperative complication risk in patients with NSCLC treated by complete resection with the VATS approach. We present the following article in accordance with the STROBE reporting checklist (available at http://dx.doi.org/10.21037/apm-21-902).

Methods

Patients

We retrospectively reviewed the data of all consecutive patients who underwent thoracoscopic lobectomy for NSCLC at the Affiliated Cancer Hospital of Guangzhou Medical University between March 2016 and October 2019. Patients who had preoperative treatments, a history of malignancy in other organs, primary tumor >7 cm, regional lymph node status ≥ N2 for the tumor, incomplete VATS, sleeve lobectomy, incomplete resection, and no CT image of pectoralis muscles before surgery were excluded. Clinical staging was based on chest CT scans with contrast, upper abdomen CT or ultrasound, brain CT or magnetic resonance imaging, radionuclide bone scan, and/or positron emission tomography with fluorine-18 fluorodeoxyglucose. Mediastinal and hilar lymph node status was defined as positive if the chest CT showed that the short axis of any node was >1 cm. Mediastinoscopy and endobronchial ultrasound-guided biopsy were not routinely performed. Histopathologic diagnosis of the tumor was based on the World Health Organization (WHO) histologic classification of lung tumors (5) and staging was performed according to the TNM Classification of Malignant Tumors (eighth edition) of the Union for International Cancer Control (6). The ethics committee of the Affiliated Cancer Hospital of Guangzhou Medical University approved this study (ethics approval number 2020-2). All procedures performed in this study involving human participants were in accordance with the Declaration of Helsinki (as revised in 2013). Individual consent for this retrospective analysis was waived.

Data collection

The following data on patients were obtained from medical records (maximum of 30 days before surgery): age; sex; smoking history; body mass index (BMI); Charlson Comorbidity Index score; Eastern Cooperative Oncology Group performance status (PS); preoperative spirometry test values, including percent forced vital capacity (%FVC), percent forced expiratory volume in 1 s (%FEV1.0), and forced expiratory volume in 1 s as a percentage of forced vital capacity (FEV1.0%); preoperative blood examination values, including hemoglobin, neutrophil, lymphocyte, platelet, triglyceride, cholesterol, albumin, creatinine, and C-reactive protein (CRP); tumor site; and operative time. We also recorded the neutrophil-to-lymphocyte ratio (NLR) and platelet-to-lymphocyte ratio. Postoperative complications were graded according to the Clavien-Dindo classification (7) with grade ≥ III within 30 days of the operation considered as a major complication.

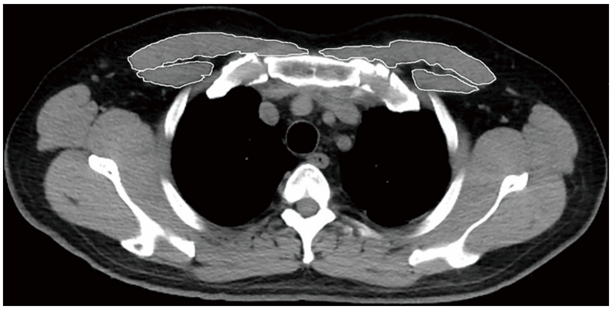

Figure 1 Pectoralis muscle measured by manual tracing on computed tomography scans.

CT scan analysis and study groups

Preoperative CT scans were obtained within 30 days before surgery, and the investigator who performed the measurements was blinded to the postoperative outcome. Quantitative and qualitative measurements of the pectoralis muscle were performed in the picture archive and communication system on a single axial slice of the precontrast phase CT scan above the aortic arch by manual tracing, and the slice used for evaluation was selected by scrolling through images toward the apex of the lungs and identifying the first axial image above the arch (*Figure 1*) (8,9).

The total pectoralis muscle area, presented as the aggregate of the right and left pectoralis major and minor muscles and pectoralis muscle mass index (PMI), was calculated as the total pectoralis muscle area/height^2 (cm^2/m^2). The pectoralis muscle radiodensity (PMD) was assessed as mean radiodensity [Hounsfield unit (HU)] and was calculated as follows: PMD = [(right pectoralis major area × right pectoralis major HU) + (right pectoralis minor area × right pectoralis minor HU) + (left pectoralis major area × left pectoralis major HU) + (left pectoralis minor area × left pectoralis minor HU)]/total pectoralis muscle area (HU) (10).

As measures such as muscle mass and quality depend on stature and vary within patient populations, the cutoff values for PMI and PMD in our cohort were set at the lowest tertile, and as body composition is highly influenced by sex, separate cutoff values were set for men and women.

Statistical analysis

Data were analyzed using SPSS v20 for Windows (IBM, Armonk, NY, USA). Descriptive statistics were computed for patient characteristics and are expressed as median [interquartile range (IQR)] or frequencies and relative frequencies. Differences in patient characteristics were analyzed with the Mann-Whitney U test, Pearson χ^2 test, or Fisher's exact test as appropriate, and Spearman's correlation coefficient (rs) was used to evaluate correlations between variables. Logistic regression was performed for dichotomous outcomes of major postoperative complications, and any variable with a significant association in the univariate analysis was included in the multivariate analysis. Univariate and multivariate odds ratios (ORs) with 95% confidence intervals (CIs) were calculated. Missing data were excluded. All P values were 2-sided, and those <0.05 were considered statistically significant.

Results

Study population and general characteristics

During the study period, 163 cases comprising 97 males and 66 females met the inclusion criteria and were selected for analysis. The median age was 60 years (range, 22–86 years). The median BMI was 23.4 kg/m^2 (range, 14.9–34.1 kg/m^2), with 13 (8.0%) patients having a BMI <18.5 kg/m^2, 103 (63.2%) a BMI of 18.5–24.9 kg/m^2, 41 (25.2%) a BMI of 25–29.9 kg/m^2, and 6 (3.7%) a BMI >30 kg/m^2. Data for the preoperative spirometry test and complete blood counts were available for 159 (97.5%) and 162 (99.4%) cases, respectively, and data on albumin and CRP were not available for 1 (0.6%) case. The demographic and clinical characteristics of the study population are shown in *Table 1*.

Pectoralis muscle mass and radiodensity

The median PMI and PMD were 11.23 cm^2/m^2 (IQR, 4.99 cm^2/m^2) and36.3 HU (IQR, 11.1 HU), respectively (*Figure 2*), and PMI was positively correlated with PMD (rs=0.459, P<0.001; *Figure 3*). The median PMI was significantly higher in male patients (13.08 cm^2/m^2; IQR, 5.05 cm^2/m^2) than in female patients (9.55 cm^2/m^2; IQR, 2.10 cm^2/m^2) (P<0.001; *Figure 2A*), and PMI <11.56 cm^2/m^2 in male patients and 8.98 cm^2/m^2 in female patients was defined as low PMI. The median PMD was significantly higher in male patients (39.3 HU; IQR, 8.6 HU) than in female patients (31.4 HU; IQR, 10.5 HU) (P<0.001; *Figure 2B*), and PMD <36.6 HU in male patients and 21.8 HU in female patients was defined as low PMD.

Table 1 Demographic and clinical characteristics of the cohort according to pectoralis muscle radiodensity status

Characteristic	Total (n=163)	Low PMD (n=54)	Normal PMD (n=109)	P value
Sex, n (%)				0.964
Male	97 (59.5)	32 (59.3)	65 (59.6)	
Female	66 (40.5)	22 (40.7)	44 (40.4)	
Age, years	60 [13]	61 [13]	60 [13]	0.143
Smoking status, n (%)				0.088
Current smoker	52 (31.9)	22 (40.7)	30 (27.5)	
Former smoker/never smoked	111 (68.1)	32 (59.3)	79 (72.5)	
BMI (kg/m^2)	23.4 (4.3)	23.5 (3.8)	23.4 (4.7)	0.398
PS, n (%)				0.617
0	126 (77.3)	43 (79.6)	83 (76.1)	
1	37 (22.7)	11 (20.4)	26 (23.9)	
CCI, n (%)				0.368
0	54 (33.1)	18 (33.3)	36 (33.0)	
1	54 (33.1)	18 (33.3)	36 (33.0)	
2	39 (23.9)	10 (18.5)	29 (26.6)	
3	15 (9.2)	7 (13.0)	8 (7.3)	
4	1 (0.6)	1 (1.9)	0 (0.0)	
%FVC	96.74 (19.00)	94.00 (18.00)	98.00 (19.00)	0.391
%FEV1.0	95.00 (23.00)	92.50 (18.00)	96.75 (24.00)	0.100
FEV1.0%	80.03 (11.31)	79.00 (10.87)	80.00 (11.80)	0.218
Lymphocytes, 10^9/L	1.82 (0.90)	1.825 (0.92)	1.815 (0.93)	0.895
Albumin, g/L	43.0 (5.3)	43.05 (5.1)	43.0 (5.8)	0.459
CRP, mg/L	1.2 (2.6)	1.4 (2.8)	0.9 (2.2)	0.173
Cholesterol, mmol/L	5.085 (1.40)	5.235 (1.63)	5.00 (1.29)	0.295
Triglyceride, mmol/L	1.32 (0.90)	1.485 (1.31)	1.26 (0.84)	0.076
Creatinine, μmol/L	67 [22]	65 [24]	69 [22]	0.797
NLR	2.08 (1.48)	2.30 (1.55)	2.04 (1.33)	0.149
PLR	123.30 (70.99)	132.65 (77.47)	120.80 (62.39)	0.350
Operation time (min)	223 [86]	230.0 [125]	220 [78]	0.319
Tumor site, n (%)				0.303
Right upper lobe	63 (38.7)	16 (29.6)	47 (43.1)	
Right middle lobe	17 (10.4)	9 (16.7)	8 (7.3)	
Right lower lobe	29 (17.8)	10 (18.5)	19 (17.4)	
Left upper lobe	25 (15.3)	9 (16.7)	16 (14.7)	
Left lower lobe	29 (17.8)	10 (18.5)	19 (17.4)	

Table 1 (*continued*)

Table 1 (*continued*)

Characteristic	Total (n=163)	Low PMD (n=54)	Normal PMD (n=109)	P value
Histology, n (%)				0.441
ADC	123 (75.5)	44 (81.5)	79 (72.5)	
SCC	29 (17.8)	7 (13.0)	22 (20.2)	
Other	11 (6.7)	3 (5.5)	8 (7.3)	
Pathologic stage, n (%)				0.903
I	135 (82.7)	45 (83.3)	90 (82.6)	
II/III[a]	28 (17.2)	9 (16.7)	19 (17.4)	

Data are presented as median (interquartile range) unless otherwise indicated. [a], stage III, n=1. PMD, pectoralis muscle radiodensity; BMI, body mass index; PS, Eastern Cooperative Oncology Group performance status; CCI, Charlson Comorbidity Index score; %FVC, percent forced vital capacity; %FEV1.0, percent forced expiratory volume in 1 s; FEV1.0%, forced expiratory volume in 1 s as a percentage of forced vital capacity; CRP, C-reactive protein; NLR, neutrophil-to-lymphocyte ratio; PLR, platelet-to-lymphocyte ratio; ADC, adenocarcinoma; SCC, squamous cell carcinoma.

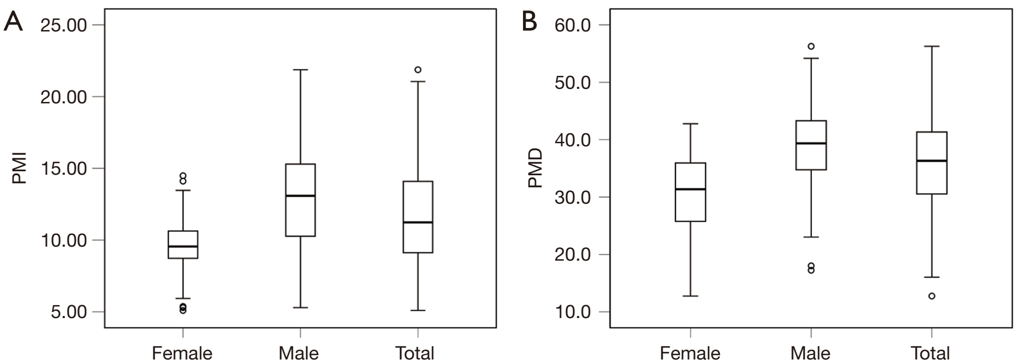

Figure 2 Computed tomography-derived pectoralis muscle measures. (A) Pectoralis muscle mass index (PMI, cm^2/m^2); (B) pectoralis muscle radiodensity (PMD, HU) (total, n=163; female, n=66; male, n=97). ◦: outlier points.

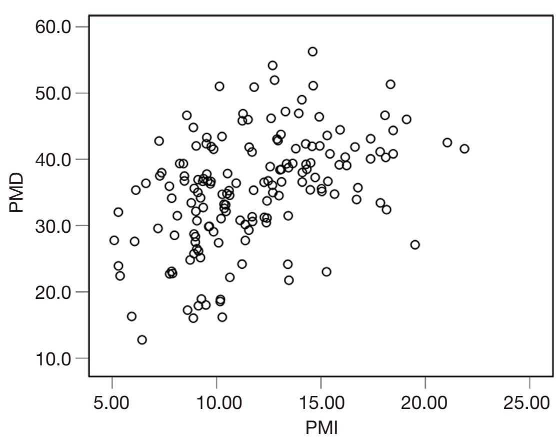

Figure 3 Scatter plots for the correlation between pectoralis muscle mass index (PMI, cm^2/m^2) and pectoralis muscle radiodensity (PMD, HU) (n=163).

Pectoralis muscle radiodensity and demographic and clinical characteristics

The association between PMD and demographic and clinical characteristics is shown in *Table 1*. No significant differences were observed between patients with low PMD *vs*. normal PMD.

Postoperative complications

A total of 23 (14.1%) patients experienced major postoperative complications, 18 (11.0%) of whom were grade III (data on albumin and CRP were missing in 1case), 3 (1.8%) were grade IV and were admitted to the intensive care unit (ICU), and 2 (1.2%) were grade V and died within 30 days of the operation because of postoperative

Table 2 Postoperative complications according to pectoralis muscle mass index and pectoralis muscle radiodensity

Complication	Total (n=163)	PMI			PMD		
		Low (n=54)	Normal (n=109)	P value	Low (n=54)	Normal (n=109)	P value
Major	23 (14.1)	12 (22.2)	11 (10.1)	0.036	12 (22.2)	11 (10.1)	0.036
Clavien-Dindo grade III	18 (11.0)	10 (18.5)	8 (7.3)	0.032	7 (13.0)	11 (10.1)	0.582
Clavien-Dindo grade IV	3 (1.8)	1 (1.9)	2 (1.8)	1.000	3 (5.6)	0 (0.0)	0.035
Clavien-Dindo grade V	2 (1.2)	1 (1.9)	1 (0.9)	1.000	2 (3.7)	0 (0.0)	0.108

All values are shown as n (%). PMI, pectoralis muscle mass index; PMD, pectoralis muscle radiodensity.

complications. Low PMI was significantly associated with more major postoperative complications (P=0.036) and grade III complications (P=0.032), whereas low PMD was associated with more major postoperative complications (P=0.036) and grade IV complications (P=0.035) (*Table 2*).

Risk factors for major postoperative complications

Univariate logistic regression analysis indicated that male sex (OR =8.842, 95% CI: 1.997–39.156; P=0.004), older age (OR =1.058, 95% CI: 1.004–1.115;P=0.035), smoking (OR =5.220, 95% CI: 2.046–13.318; P=0.001), lower BMI (1 kg/m^2 increase, OR =0.816, 95% CI: 0.702–0.950; P=0.009), PS (OR =3.219, 95% CI: 1.276–8.120; P=0.013), lower %FVC (1% increase; OR =0.958, 95% CI: 0.929–0.987; P=0.005), lower %FEV1.0 (1% increase; OR =0.970, 95% CI: 0.946–0.995; P=0.017), low PMI (OR =2.545, 95% CI: 1.041–6.226; P=0.041), and low PMD (OR =2.545, 95% CI: 1.041–6.226; P=0.041) before surgery were significantly associated with an increased risk of major postoperative complications (*Table 3*). Multivariate analysis confirmed that male sex (OR =7.663, 95% CI: 1.186–49.501; P=0.032), lower BMI (1 kg/m^2 increase, OR =0.760, 95% CI: 0.607–0.951; P=0.016), and low PMD (OR =4.311, 95% CI: 1.383–13.442; P=0.012) before surgery were independent risk factors for major postoperative complications (*Table 4*).

Discussion

This is the first study to investigate the relationship between skeletal muscle radiodensity and postoperative complication risk in patients with NSCLC who have undergone thoracoscopic lobectomy. In our disease- and treatment-specific cohort, the multivariate analysis revealed that low pectoralis muscle radiodensity measured on the first axial CT image above the aortic arch and expressed as PMD was a significant independent risk factor for major complications after first-line VATS lobectomy, whereas low pectoralis muscle mass expressed as PMI was not.

Previous studies have reported conflicting findings on the association between preoperative muscle mass and complications after surgery in NSCLC patients (8,9,11-17), and there may be several reasons for this discrepancy. First, a variety of methods have been used to measure the quantity of muscle across studies. For example, it was suggested that the psoas muscle area, which has been used in some studies (9,12,14,15), is not representative of total skeletal muscle area (18,19). Additionally, although body muscle composition is highly influenced by sex, Miller *et al*. did not perform a sex-specific analysis in their study (11). Second, the definition of postoperative complications was not consistent across studies. These differences likely resulted in significant heterogeneity in the findings, including the association between skeletal muscle mass and postoperative complications. Finally, most of the studies did not perform covariate-adjusted analysis (9,12-14,17).

We focused on the pectoralis muscle as data are readily obtained from CT scans which are performed as part of standard preoperative assessments and do not require specific research protocols. Until recently, CT-based measurements of pectoralis muscle mass were seldom used in studies investigating the relationship between muscle quantity and posttreatment outcomes in patients with NSCLC. One study reported that a smaller pectoralis muscle area was associated with worse overall survival (8); in another cohort of 283 of patients with small cell lung cancer and NSCLC and 16 with lung metastasis who underwent lobectomy (of which 278 were performed by VATS), the height-adjusted cross-sectional area of the pectoralis muscle was not associated with overall complication rates, rate of pneumonia, readmission, or length of stay in the ICU (11).

Table 3 Univariate logistic regression analysis of potential predictors of major postoperative complications

Variable	OR	95% CI	P value
Male sex[a]	8.842	1.997–39.156	0.004
Age (years)	1.058	1.004–1.115	0.035
Current smoker[b]	5.220	2.046–13.318	0.001
BMI (kg/m^2)	0.816	0.702–0.950	0.009
PS	3.219	1.276–8.120	0.013
CCI	1.312	0.851–2.023	0.218
%FVC	0.958	0.929–0.987	0.005
%FEV1.0	0.970	0.946–0.995	0.017
FEV1.0%	0.998	0.942–1.036	0.604
Lymphocytes (10^9/L)	0.807	0.414–1.570	0.527
Albumin (g/L)	0.977	0.870–1.098	0.699
CRP (mg/L)	1.019	0.998–1.051	0.221
Cholesterol (mmol/L)	0.641	0.405–1.015	0.058
Triglyceride (mmol/L)	0.787	0.481–1.289	0.342
Creatinine (μmol/L)	1.005	0.994–1.017	0.365
NLR	1.038	0.815–1.320	0.764
PLR	1.000	0.992–1.008	0.935
Operation time (min)	1.001	0.995–1.006	0.764
Tumor site[c]			0.680
Right upper lobe	0.404	0.118–1.382	0.148
Right middle lobe	0.821	0.177–3.820	0.802
Right lower lobe	0.613	0.153–2.453	0.489
Left upper lobe	0.730	0.181–2.951	0.659
Histology[d]			0.793
SCC	1.299	0.436–3.868	0.638
Other	0.624	0.075–5.187	0.662
Pathologic stage II/III[e]	1.413	0.477–4.190	0.533
Low PMI[f]	2.545	1.041–6.226	0.041
Low PMD[g]	2.545	1.041–6.226	0.041

[a], reference category: female; [b], reference category: former smoker/never smoked; [c], reference category: left lower lobe; [d], reference category: adenocarcinoma; [e], reference category: pathologic stage I; [f], reference category: normal PMI; [g], reference category: normal PMD. OR, odds ratio; CI, confidence interval; BMI, body mass index; PS, Eastern Cooperative Oncology Group performance status; CCI, Charlson Comorbidity Index score; %FVC, percent forced vital capacity; %FEV1.0, percent forced expiratory volume in 1 s; FEV1.0%, forced expiratory volume in 1 s as a percentage of forced vital capacity; CRP, C-reactive protein; NLR, neutrophil-to-lymphocyte ratio; PLR, platelet-to-lymphocyte ratio; SCC, squamous cell carcinoma; PMI, pectoralis muscle mass index; PMD, pectoralis muscle radiodensity.

Table 4 Multivariate logistic regression analysis of potential predictors of major postoperative complications

Variable	OR	95% CI	P value
Male sex[a]	7.663	1.186–49.501	0.032
Age (years)	0.999	0.935–1.066	0.965
Current smoker[b]	1.306	0.351–4.859	0.690
BMI (kg/m^2)	0.760	0.607–0.951	0.016
PS	2.972	0.860–10.266	0.085
%FVC	0.958	0.906–1.013	0.135
%FEV1.0	1.016	0.968–1.066	0.530
Low PMI[c]	0.852	0.233–3.107	0.808
Low PMD[d]	4.311	1.383–13.442	0.012

[a], reference category: female; [b], reference category: former smoker/never smoked; [c], reference category: normal PMI; [d], reference category: normal PMD. OR, odds ratio; CI, confidence interval; BMI, body mass index; PS, Eastern Cooperative Oncology Group performance status; %FVC, percent forced vital capacity; %FEV1.0, percent forced expiratory volume in 1 s; PMI, pectoralis muscle mass index; PMD, pectoralis muscle radiodensity.

In the present study, low PMI was a risk factor for major postoperative complications in the univariate analysis but not in the multivariate analysis.

Muscle quality is a relatively new term that encompasses muscle architecture and composition. Although there is no standard method for its clinical assessment, the value of muscle quality as determined from CT images for predicting postoperative outcomes has received increasing attention in surgical oncology. Lower muscle density was found to be associated with a higher risk of postoperative complications in patients with gastric, colorectal, periampullary, and pancreatic cancers (10,20-31), and low skeletal muscle radiodensity was linked to shorter survival in advanced NSCLC patients receiving first-line palliative chemotherapy (32). Our study is a first step in determining whether preoperative skeletal muscle radiodensity can be used to stratify patients with NSCLC undergoing first-line VATS lobectomy according to postoperative complication risk.

In the present study, PMI was positively correlated with PMD. The skeletal muscle mass index was recently shown to be related to skeletal muscle density in CT images at the level of the third lumbar vertebra in patients with colorectal cancer (20). However, other studies reported that skeletal muscle radiodensity, but not muscle mass, predicted complications after surgery for colorectal cancer (21-24) and periampullary cancer (30). We also found that low PMD, but not PMI, was an independent risk factor for major complications following VATS lobectomy. Low skeletal muscle radiodensity reflects a decrease in muscle quality due to increased intramuscular lipid deposition (33,34), and a higher muscle lipid content has been linked to loss of muscle strength (35). Increased muscle mass is not necessarily associated with enhanced function (36), and skeletal muscle strength was shown to be superior to skeletal muscle mass for predicting adverse outcomes (4). This could explain why skeletal muscle quality and not muscle mass was an independent risk factor for major postoperative complications in our analysis.

As a hallmark of cachexia, systemic inflammatory response is a well-established prognostic factor in cancer (37). Low skeletal muscle radiodensity was related to low albumin and elevated CRP and NLR in patients with colorectal cancer (38) and pancreatic-biliary cancer (39,40). We did not find any association between pectoralis muscle radiodensity and systemic inflammation, but this finding should be interpreted with caution, as we did not have any data pertaining to obstructive pneumonitis.

In a study of patients who underwent lobectomy for primary lung cancer, overall postoperative complication and mortality rates were significantly higher in underweight patients and lower in preobese and obese patients than in those with normal BMI (41). A similar relationship was recently reported in patients undergoing lobectomy for NSCLC (42). In the present study, in which 8.0% of patients had a BMI <18.5 kg/m^2 and 3.7% had a BMI ≥30 kg/m^2, lower BMI was identified as an independent risk factor for major complications following VATS lobectomy.

In a study of 238 patients who underwent lobectomy for NSCLC in which 14 (5.1%) patients underwent pneumonectomy, 3 (1.1%) underwent segmentectomy, 151 (55.5%) underwent minimally invasive surgery using the VATS approach, and 18 (6.6%) underwent neoadjuvant chemotherapy, male sex was associated with a higher rate of overall complications (16). Similarly, our study found male sex to be an independent risk factor for major complications after first-line VATS lobectomy for NSCLC.

In addition to male sex, lower BMI and low PMD before first-line VATS lobectomy were revealed to be independent risk factors for major postoperative complications in our study. BMI and sarcopenia are potentially modifiable risk factors; thus, to reduce postoperative complications, patients with NSCLC should receive preoperative assessment of BMI and diagnosis of sarcopenia before first-line thoracoscopic lobectomy and should then undergo preoperative exercise and nutritional support (43,44).

This study had some limitations. First, because of its retrospective nature, other direct measures of sarcopenia were not available. Second, the Clavien-Dindo classification is becoming one of the more commonly used methods to capture surgical complication data, but limits its measurement to the highest-grade complication and does not capture the interplay between multiple complications. It was recently reported that CT-derived body muscle composition measures may be linked to specific complications, but this was not examined in our study. Finally, because it was a single-center study, there was an inherent bias in the results attributable to factors such as surgical technique and postoperative management. Future larger, prospective study should conducted for verification.

In conclusion, inpatients undergoing first-line VATS lobectomy for NSCLC, low muscle quality but not low muscle mass predicted major postoperative complications. Thus, preoperative CT-derived skeletal muscle measures may be used to stratify patients with NSCLC into risk categories to facilitate clinical decision-making.

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Footnote

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