



Prognostic Value of Artificial Intelligence-Driven, Computed Tomography-Based, Volumetric Assessment of the Volume and Density of Muscle in Patients With Colon Cancer

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Objective: The prognostic value of the volume and density of skeletal muscles in the abdominal waist of patients with colon cancer remains unclear. This study aimed to investigate the association between the automated computed tomography (CT)-based volume and density of the muscle in the abdominal waist and survival outcomes in patients with colon cancer.

Materials and Methods: We retrospectively evaluated 474 patients with colon cancer who underwent surgery with curative intent between January 2010 and October 2017. Volumetric skeletal muscle index and muscular density were measured at the abdominal waist using artificial intelligence (AI)-based volumetric segmentation of body composition on preoperative pre-contrast CT images. Patients were grouped based on their skeletal muscle index (sarcopenia vs. not) and muscular density (myosteatorsis vs. not) values and combinations (normal, sarcopenia alone, myosteatorsis alone, and combined sarcopenia and myosteatorsis). Postsurgical disease-free survival (DFS) and overall survival (OS) were analyzed using univariable and multivariable analyses, including multivariable Cox proportional hazard regression.

Results: Univariable analysis showed that DFS and OS were significantly worse for the sarcopenia group than for the non-sarcopenia group ($P = 0.044$ and $P = 0.003$, respectively, by log-rank test) and for the myosteatorsis group than for the non-myosteatorsis group ($P < 0.001$ by log-rank test for all). In the multivariable analysis, the myosteatorsis muscle type was associated with worse DFS (adjusted hazard ratio [aHR], 1.89 [95% confidence interval, 1.25–2.86]; $P = 0.003$) and OS (aHR, 1.90 [95% confidence interval, 1.84–3.04]; $P = 0.008$) than the normal muscle type. The combined muscle type showed worse OS than the normal muscle type (aHR, 1.95 [95% confidence interval, 1.08–3.54]; $P = 0.027$).

Conclusion: Preoperative volumetric sarcopenia and myosteatorsis, automatically assessed from pre-contrast CT scans using AI-based software, adversely affect survival outcomes in patients with colon cancer.

Keywords: Colon cancer; Volumetric sarcopenia; Myosteatorsis; Skeletal muscle index; Muscular density

INTRODUCTION

Colorectal cancer is the third most common cancer and has the second highest mortality rate among cancers globally [1]. The prognosis of colorectal cancer is largely

determined by the molecular characteristics of its tumors; however, several studies have recently shown that host-related factors, such as body composition and nutrition, also affect it [2-6]. Malnutrition and changes in body composition, particularly muscle mass, have prognostic

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values; however, they tend to be neglected in the absence of recognized guidelines [4,7]. Sarcopenia, characterized by the loss of skeletal muscle mass and function, has recently been regarded as an objective risk factor for worse survival outcomes, higher surgical complications, and treatment-related toxicities for several cancer types [8-10]. In a meta-analysis, the prevalence of sarcopenia in patients with gastrointestinal cancer was 34.7% (range, 2.1%–83.3%) [11]. Several studies have investigated the prognostic role of preoperative sarcopenia in colorectal cancer with similar results [2-6,12,13].

There are several techniques for measuring body composition, including bioelectrical impedance analysis, dual-energy radiographic absorptiometry, and computed tomography (CT). CT is a widely used tool because it can quantify body composition components such as muscle and adipose tissue [8,14]. Cross-sectional CT images of the skeletal muscle and visceral adipose tissue areas at the level of the third lumbar vertebral body (L3) have been shown to correspond to whole-body tissue quantities in patients with cancer [4]. In addition, recent technological advances have enabled automated and fast volumetric measurements

of each component of CT scans [8,15,16]. Automated volumetric measurements of body composition may contain more abundant and precise information than single-cut measurements in a cross-sectional image and can also enable the calculation of volumes in less than a few minutes [9,17]. This study aimed to evaluate the associations between the volume and density of skeletal muscles in the abdominal waist obtained from CT-based automated artificial intelligence (AI) volumetric measurements and survival outcomes of patients with colon cancer.

MATERIALS AND METHODS

This study was approved by the Institutional Review Board of Hallym University Sacred Heart Hospital (IRB No. 2020-07-044) and performed according to the principles of the Declaration of Helsinki. The review board waived the requirement for informed consent because of the retrospective nature of the study.

Patients

We retrospectively reviewed the medical records of

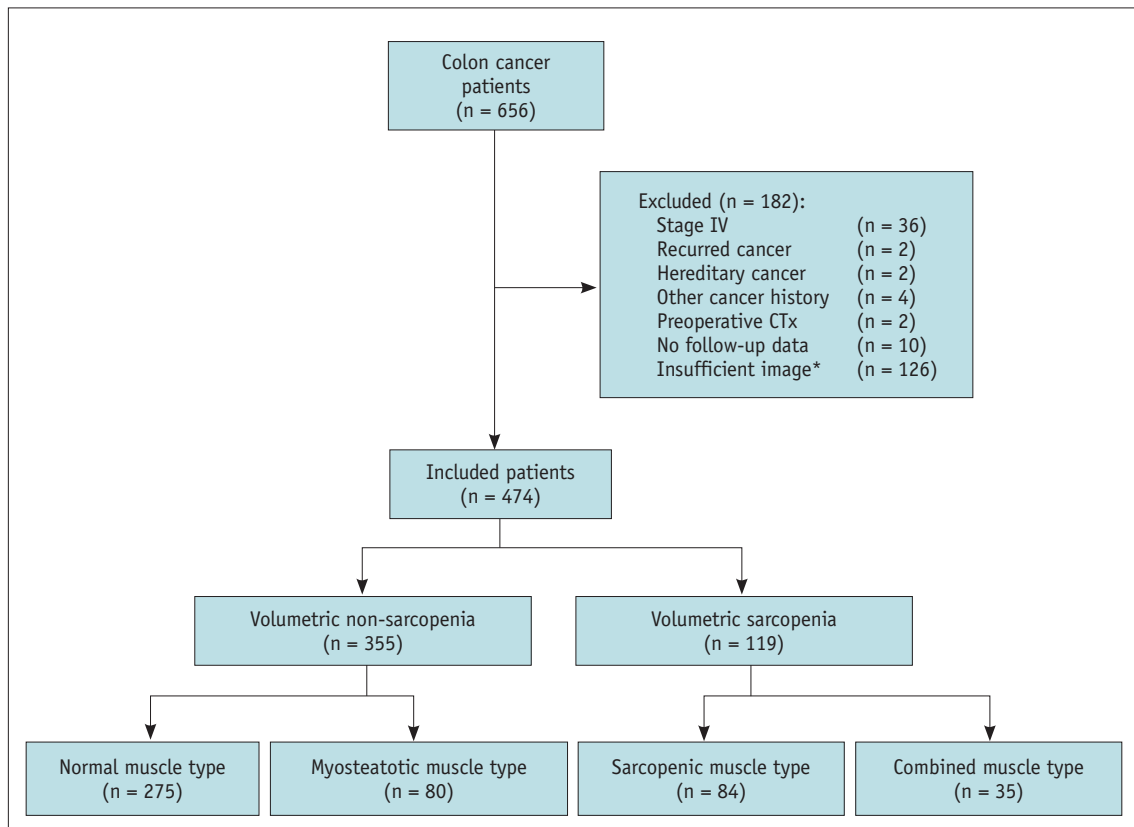


Fig. 1. Flowchart of the study design with inclusion and exclusion criteria. *No pre-contrast images and no full coverage of the abdominal waist. CTx = chemotherapy

patients diagnosed with colon cancer who underwent curative radical resection at the Hallym University Sacred Heart Hospital between January 2010 and October 2017. Patients diagnosed with recurrent or metastatic colon cancer, hereditary colon cancer, or other active malignancies before and at the time of colon cancer diagnosis were excluded. We also excluded patients who received chemotherapy or radiation therapy before surgery, those with incomplete CT (no pre-contrast images and incomplete coverage of the abdominal waist), or those with no follow-up data (Fig. 1).

Clinical Assessment Data

We collected the clinicopathological data of the patients, such as age at diagnosis, body mass index, American Society of Anesthesiologists score, preoperative serum carcinoembryonic antigen level, tumor location, and tumor stage, according to the American Joint Committee on Cancer 8th edition. Post-surgical surveillance was performed using abdominopelvic CT, chest CT every 6 months, and colonoscopy one year after surgery, followed by every 2

years for 5 years.

Image Analysis

Automatic volumetric segmentation of body composition on CT images was performed using commercially available AI-based software for body composition analysis (DeepCatch version 1.1.3.4586; MEDICALIP Co. Ltd.), which has been proven to provide 97% accuracy relative to manual segmentation as the reference standard [15]. The software was developed by training a three-dimensional U-NET [18,19] for segmentation based on semi-automatic segmentation of the muscle, abdominal visceral fat, and subcutaneous fat; thresholds of -29 to 150 Hounsfield units (HU) were used for skeletal muscle and -190 to -30 HU were used for adipose tissue. An expert radiologist (S.M.L., 15 years of experience in CT analysis) blinded to the clinical information of the patients entered the anonymized abdominal pre-contrast CT images into the software installed on the computer. Subsequently, the software automatically localized the abdominal waist and L3 level and provided the color mapping with body composition

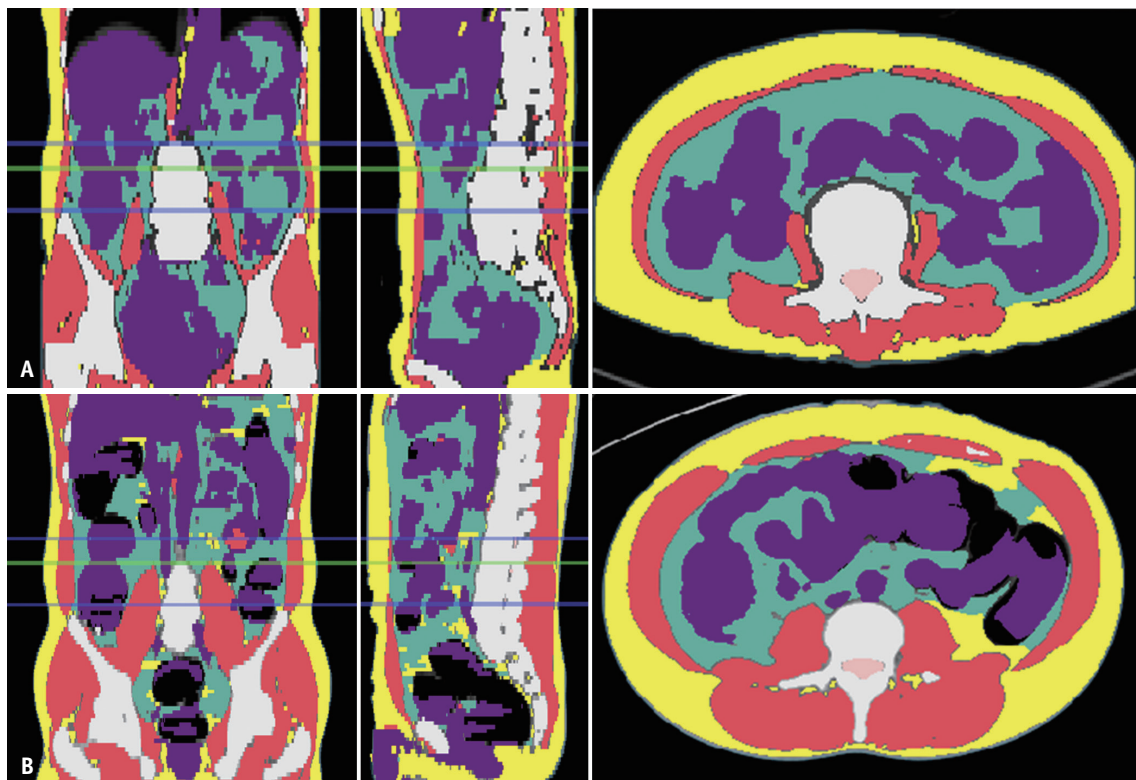


Fig. 2. Evaluation of body composition using computed tomography (CT) images. **A:** CT images of patients with volumetric sarcopenia. **B:** CT images of patients with volumetric non-sarcopenia. The light green line indicates the L3 level, and the body part between the two blue lines is the waist. Skeletal muscle (red), abdominal visceral fat (green), subcutaneous fat (yellow), and visceral organ (purple) are shown in the CT images.

for the skeletal muscle, abdominal visceral fat, and subcutaneous fat (Fig. 2). The abdominal waist was defined as the body part between the lower end of the thoracic ribs and the upper end of the iliac crest based on the World Health Organization guidelines [20]. The results of the automatic segmentation and localization of the abdominal waist and L3 were confirmed and adjusted by a radiologist. This software provided the volume (cm³) of skeletal muscles in the abdominal waist. The muscular density (MD) was automatically provided in HU by averaging the density of the muscle components (e.g., psoas, paraspinal, transversus abdominis, rectus abdominis, quadratus lumborum, and internal and external obliques) in the abdominal waist. MD decreases with the worsening of myosteatosis [21]. The volumetric skeletal muscle index (SMI) was calculated as the waist muscle volume (cm³) divided by height (m³) [8,9]. Few studies have been conducted on volumetric parameters; therefore, the optimal cut-off values of SMI and MD for sarcopenia and myosteatosis were set as the Q1 values by referring to another study [8]. Q1, also known as the first quartile, represents the 25th percentile for the sample and was used as the cutoff value for muscle mass and MD when an optimal cutoff was not established [22-26].

Assessment of Clinical Outcomes

We analyzed the postsurgical survival outcomes in terms of disease-free survival (DFS) and overall survival (OS) according to SMI (sarcopenia vs. non-sarcopenia) and MD (myosteatosis vs. non-sarcopenia). DFS was defined as the duration between the date of surgery and colon cancer recurrence or death. OS was defined as the duration between the date of surgery and death from any cause or end of the study.

Statistical Analysis

The baseline characteristics and survival outcomes of the sarcopenia, non-sarcopenia, myosteatosis, and non-myosteatosis groups were compared. Categorical variables were compared using Fisher's exact test, and the continuous variables were compared using Student's *t*-test. The Kaplan-Meier survival curves for DFS and OS were plotted for the SMI and MD groups and muscle types according to the combination of SMI and MD (normal = neither sarcopenia nor myosteatosis; sarcopenic alone; myosteatosis alone; combined = both sarcopenia and myosteatosis) and compared using the log-rank test. Univariable and multivariable analyses of survival outcomes

were performed using the Cox proportional hazards model to calculate adjusted hazard ratios (aHR) and 95% confidence intervals (CI). Statistical significance was set at $P < 0.05$. All statistical analyses were performed using SPSS software (version 25.0; IBM Corp.).

RESULTS

Characteristics of the Patients

A total of 474 patients were enrolled in this study. According to the Q1 cutoff value for volumetric SMI (sarcopenia: SMI < 163 cm³/m³ in females and SMI < 180 cm³/m³ in males), the non-sarcopenia group included 355 patients (74.9%) and the sarcopenia group included 119 patients (25.1%). The clinicopathological characteristics of the patients are presented in Table 1. The mean of volumetric SMI was 145.4 ± 21.9 cm³/m³ for the sarcopenia group and 234.8 ± 45.2 cm³/m³ for the non-sarcopenia group. The patients in the sarcopenia group were older and less obese than those in the non-sarcopenia group ($P = 0.003$ and $P < 0.001$, respectively). The sarcopenia group had fewer patients with American Society of Anesthesiologists scores of 1 or 2 ($P = 0.001$). Obstruction was more common in the sarcopenia group ($P = 0.014$). Pathological status did not differ between the two groups. According to the Q1 cutoff value of volumetric MD (myosteatosis: MD < 12.50 HU in females and MD < 24.01 HU in males), the non-myosteatosis group included 359 patients (75.7%) and the myosteatosis group included 115 (24.3%). The mean of volumetric MD was 8.6 ± 27.4 HU for the myosteatosis group and 29.1 ± 8.6 HU for the non-myosteatosis group. The patients in the myosteatosis group were older than those in the non-myosteatosis group ($P = 0.002$). The pathological status did not differ for the groups.

Association between Volumetric SMI and MD Groups and Survival Outcomes

The median follow-up duration was 42.8 months. DFS was significantly different between the sarcopenia and non-sarcopenia groups divided by the Q1 cutoff value (5-year DFS: 67.4% vs. 74.6%, $P = 0.044$ by log-rank test) (Fig. 3A, B). The OS significantly differed for the two groups (5-year OS: 69.1% vs. 81.5%, $P = 0.003$ by the log-rank test) (Fig. 3C, D). DFS and OS were significantly different for the myosteatosis and non-myosteatosis groups split by the Q1 cutoff value (5-year DFS: 61.2% vs. 76.6%, $P < 0.001$ by log-rank test;

Table 1. Characteristics of the patients

Variables	Sarcopenia			Myosteatorsis		
	Non-sarcopenia (n = 355)	Sarcopenia (n = 119)	<i>P</i>	Non-myosteatorsis (n = 359)	Myosteatorsis (n = 115)	<i>P</i>
Volumetric SMI, cm ³ /m ³	234.8 ± 45.2	145.4 ± 21.9	< 0.001	29.1 ± 8.6	8.6 ± 27.4	< 0.001
Age, yr			< 0.001			0.002
< 65	172 (48.5)	24 (20.2)		163 (45.4)	33 (28.7)	
≥ 65	183 (51.5)	95 (79.8)		196 (54.6)	82 (71.3)	
Sex			0.916			0.940
Male	193 (54.4)	64 (53.8)		195 (54.3)	62 (53.9)	
Female	162 (45.6)	55 (46.2)		164 (45.7)	53 (46.1)	
BMI, kg/m ²			< 0.001			0.143
< 25.0	209 (58.9)	100 (84.0)		241 (67.1)	68 (59.1)	
≥ 25.0	146 (41.1)	19 (16.0)		118 (32.9)	47 (40.9)	
ASA score			0.001			0.005
1–2	194 (54.6)	43 (36.1)		193 (53.8)	44 (38.3)	
3–5	161 (45.4)	76 (63.9)		166 (46.2)	71 (61.7)	
CEA, ng/mL			0.571			0.109
< 5.0	244 (68.7)	78 (65.5)		251 (69.9)	71 (61.7)	
≥ 5.0	111 (31.3)	41 (34.5)		108 (30.1)	44 (38.3)	
Location			0.276			0.226
Right colon	131 (36.9)	51 (42.9)		132 (36.8)	50 (43.5)	
Left colon	224 (63.1)	68 (57.1)		227 (63.2)	65 (56.5)	
Obstruction			0.264			0.009
Yes	116 (32.7)	46 (38.7)		111 (30.9)	51 (44.3)	
No	239 (67.3)	73 (61.3)		248 (69.1)	64 (55.7)	
Perforation			0.829			0.902
Yes	22 (6.2)	8 (6.7)		23 (6.4)	7 (6.1)	
No	333 (93.8)	111 (93.3)		336 (93.6)	108 (93.9)	
Stage			0.431			0.068
I	88 (24.8)	25 (21.0)		93 (25.9)	20 (17.4)	
II	138 (38.9)	43 (36.1)		139 (38.7)	42 (36.5)	
III	129 (36.3)	51 (42.9)		127 (35.4)	53 (46.1)	
Cell type			0.705			0.440
WD/MD	326 (91.8)	108 (90.8)		331 (92.2)	103 (89.6)	
PD/MUC/SRC	29 (8.2)	11 (9.2)		28 (7.8)	12 (10.4)	
LVI			0.577			0.653
Yes	118 (33.2)	43 (36.1)		120 (33.4)	41 (35.7)	
No	237 (66.8)	76 (63.9)		239 (66.6)	74 (64.3)	
PNI			0.490			0.969
Yes	39 (11.0)	10 (8.4)		37 (10.3)	12 (10.4)	
No	316 (89.0)	109 (91.6)		322 (89.7)	103 (89.6)	
Adjuvant CTx			0.963			0.387
Yes	153 (43.1)	51 (42.9)		159 (44.3)	45 (39.1)	
No	202 (56.9)	68 (57.1)		200 (55.7)	70 (60.9)	

Data are mean ± standard deviation or number of patients with % in parentheses.

SMI = skeletal muscle index, BMI = body mass index, ASA = American society of anesthesiologist, CEA = carcinoembryonic antigen, WD = well differentiated, MD = moderately differentiated, PD = poorly differentiated, MUC = mucinous, SRC = signet ring cell, LVI = lymphovascular invasion, PNI = perineural invasion, CTx = chemotherapy

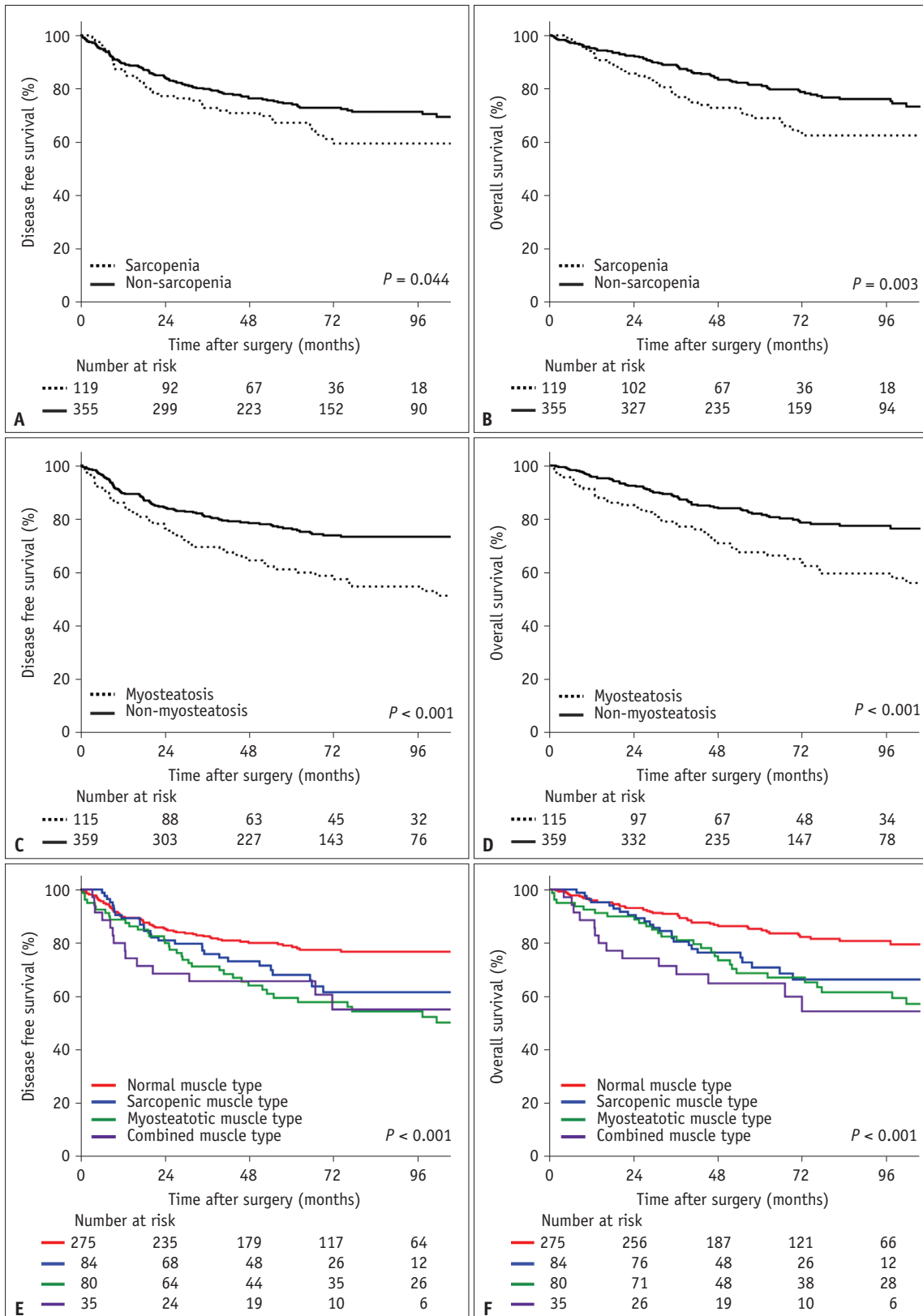


Fig. 3. Kaplan–Meier curves for disease-free survival (DFS) and overall survival (OS). **A, B:** DFS and OS according to volumetric skeletal muscle index (SMI) (sarcopenia vs. not). **C, D:** DFS and OS according to volumetric muscular density (MD) (myosteatosi vs. not). **E, F:** DFS and OS according to the combinations of volumetric SMI and MD groups (normal, sarcopenic, myosteatotic, and combined). P -values are from the log-rank test.

Survival Impact of Volumetric Body Composition in Colon Cancer

and 5-year OS: 67.6% vs. 82.0%, $P < 0.001$ by log-rank test, respectively). The patients were divided into four groups according to the Q1 cutoff values of volumetric SMI and MD: 1) normal muscle type ($n = 275$); 2) sarcopenic muscle type ($n = 84$); 3) myosteatotic muscle type ($n = 80$); and 4) combined muscle type ($n = 35$) (Fig. 1). The normal muscle type showed significantly better DFS and OS than the other muscle types ($P < 0.001$ and $P < 0.001$, respectively, log-rank test) (Fig. 3E, F).

Table 2 shows the factors associated with survival outcomes based on univariable and multivariable analyses. Multivariable analysis showed that muscle type, age, stage,

and perineural invasion were associated with DFS and OS. The myosteatotic muscle type was associated with worse DFS (aHR, 1.89 [95% CI, 1.25–2.86]; $P = 0.003$) and OS (aHR, 1.90 [95% CI, 1.84–3.04]; $P = 0.008$) than the normal muscle type. The combined muscle type was associated with worse OS than the normal muscle type (aHR, 1.95 [95% CI, 1.08–3.54]; $P = 0.027$).

DISCUSSION

This study highlights the importance of skeletal muscle mass in predicting the survival outcomes of patients

Table 2. Univariable and multivariable Cox proportional hazard analyses of the factors associated with postsurgical survival

Parameter	Disease free survival				Overall survival			
	Univariable		Multivariable		Univariable		Multivariable	
	cHR (95% CI)	P	aHR (95% CI)	P	cHR (95% CI)	P	aHR (95% CI)	P
Muscle type		< 0.001		0.026		< 0.001		0.032
Normal muscle type	1 [Reference]		1 [Reference]		1 [Reference]		1 [Reference]	
Sarcopenic muscle type	1.61 (1.03–2.52)	0.039	1.27 (0.80–2.00)	0.309	1.89 (1.15–3.09)	0.012	1.39 (0.84–2.31)	0.201
Myosteatotic muscle type	2.19 (1.45–3.30)	< 0.001	1.89 (1.25–2.86)	0.003	2.25 (1.42–3.58)	0.001	1.90 (1.84–3.04)	0.008
Combined muscle type	2.38 (1.37–4.14)	0.002	1.61 (0.91–2.83)	0.102	3.22 (1.82–5.70)	< 0.001	1.95 (1.08–3.54)	0.027
Age								
< 65	1 [Reference]		1 [Reference]		1 [Reference]		1 [Reference]	
≥ 65	2.25 (1.55–3.28)	< 0.001	2.24 (1.51–3.33)	< 0.001	2.74 (1.78–4.22)	< 0.001	2.66 (1.69–4.21)	< 0.001
Sex								
Male	1 [Reference]				1 [Reference]			
Female	1.25 (0.90–1.74)	0.182			1.32 (0.92–1.90)	0.138		
CEA								
< 5.0	1 [Reference]		1 [Reference]		1 [Reference]			
≥ 5.0	1.95 (1.40–2.73)	< 0.001	1.34 (0.95–1.89)	0.096	1.72 (1.19–2.49)	0.004		
Stage		< 0.001		< 0.001		< 0.001		< 0.001
I	1 [Reference]		1 [Reference]		1 [Reference]		1 [Reference]	
II	2.75 (1.49–5.06)	0.001	2.13 (1.14–3.97)	0.017	2.05 (1.09–3.84)	0.026	1.92 (1.01–3.67)	0.048
III	4.76 (2.64–8.57)	< 0.001	3.29 (1.77–6.11)	< 0.001	3.80 (2.09–6.90)	< 0.001	3.63 (1.84–7.17)	< 0.001
Cell type								
WD/MD	1 [Reference]				1 [Reference]			
PD/MUC/SRC	1.40 (0.80–2.43)	0.236			1.47 (0.81–2.68)	0.206		
LVI								
Negative	1 [Reference]		1 [Reference]		1 [Reference]		1 [Reference]	
Positive	2.04 (1.47–2.84)	< 0.001	1.41 (0.99–2.03)	0.060	1.94 (1.34–2.79)	< 0.001	1.46 (0.97–2.19)	0.068
PNI								
Negative	1 [Reference]		1 [Reference]		1 [Reference]		1 [Reference]	
Positive	2.61 (1.70–4.01)	< 0.001	2.01 (1.27–3.16)	0.003	2.29 (1.41–3.72)	0.001	2.09 (1.24–3.53)	< 0.001
CTx								
No	1 [Reference]				1 [Reference]		1 [Reference]	
Yes	1.44 (1.04–2.01)	0.03			1.13 (0.79–1.63)	0.5	0.67 (0.43–1.04)	0.072

cHR = crude hazard ratio, aHR = adjusted hazard ratio, CI = confidence interval, CEA = carcinoembryonic antigen, WD = well differentiated, MD = moderately differentiated, PD = poorly differentiated, MUC = mucinous, SRC = signet ring cell, LVI = lymphovascular invasion, PNI = perineural invasion, CTx = chemotherapy

with colon cancer treated with radical resection. Unlike previous studies that determined the presence of sarcopenia at the L3 level cross-section, this study is the first to associate volumetric SMI with colon cancer, which can be automatically measured using AI and can provide more accurate information. This demonstrates that preoperative volumetric SMI and MD affect survival outcomes in patients with stage I–III colon cancers.

CT-determined sarcopenia and myosteatosis have been reported to be poor prognostic factors for colorectal cancer, although the cutoff values vary among studies. Sarcopenia refers to low muscle mass, and myosteatosis refers to low muscle quality [23]. There are several cutoff values for sarcopenia and myosteatosis [23]. Several studies have reported that L3 sarcopenia, as classified by Martin's cutoff value [27], is an independent prognostic factor for worse DFS and OS in patients with colorectal cancer [3–6]. L3 myosteatosis has also been reported to affect DFS and OS in patients with malignancies [5,28]. Other studies on Asian patients reported that L3 sarcopenia, classified by the Q1 cutoff value, was an independent prognostic factor for worse DFS and OS in patients with colorectal cancer [22,24]. Only a few studies have reported that volumetric sarcopenia has a worse prognostic impact on gynecologic malignancies [8,9,29]. A single cross-sectional CT image at the L3 level, which reflects whole-body tissue quantities, is a well-established method for body composition analysis [27]. This study showed that sarcopenia and myosteatosis, according to volumetric measurements, were significantly associated with worse survival outcomes. Compared with L3 SMI, volumetric SMI may better reflect the presence of sarcopenia [9]. Analysis of body composition from single-cut images is limited because the contents of the gastrointestinal tract constantly shift, and there is no guarantee that two repeated L3 sections will capture the same anatomy. In addition, the muscle area varies at different levels of the abdomen and is sometimes twice the true value. Therefore, volumetric measurements may be more precise than single-cut measurements at the L3 level [8,17]. There are no studies on the cut-off values for volumetric sarcopenia or myosteatosis in patients with colon cancer. Some studies used the Q1 cutoff value for L3 SMI to investigate the impact of sarcopenia on survival outcomes in patients with colon cancer [22,24]. Han et al. [8] reported that volumetric sarcopenia, using the Q1 cutoff value, affected the survival outcomes of gynecologic malignancies. Further studies are warranted to determine

the optimal cut-off value for volumetric sarcopenia.

Previous studies reported that sarcopenia and myosteatosis were age-related changes in muscle mass and quality [30,31]. Aging appears to result in an imbalance between muscle protein anabolic and catabolic pathways, leading to an overall loss of skeletal muscle [32]. Sarcopenia and myosteatosis are associated with age. Age was associated with survival outcomes in a multivariable analysis; sarcopenia was associated with survival outcomes but this was not statistically significant, while myosteatosis was significantly associated. The molecular mechanisms underlying the effects of sarcopenia and myosteatosis on survival outcomes other than age in cancer patients are unclear. Sarcopenia is a phenotypic feature of catabolic states that leads to inflammatory states in the presence of cancer [33]. Fleming et al. [2] reported that patients who develop cancer recurrence and sarcopenia have significantly higher systemic levels of interleukin (IL)-6, vascular endothelial growth factor, and expression of the cell surface receptor CD14 [2]. Higher expression of CD14 triggers various cellular responses, including the synthesis and release of various inflammatory mediators such as tumor necrosis factor α , IL-1b, and IL-6, which, if unregulated, can promote oncogenesis and metastatic development [34]. Higher CD14 expression in patients with sarcopenia may activate dormant circulating tumor cells and promote cell migration and invasion for metastasis [2].

Patients with volumetric sarcopenia and myosteatosis can easily be identified during the preoperative staging workup for colon cancer via abdominopelvic CT using automated volumetric measurements. Early recognition and intervention may be helpful for the treatment of patients with colon cancer [35]. The concept of prehabilitation is of significant interest in these patients. Prehabilitation involves preoperative physical, nutritional, and psychosocial interventions to prevent muscle loss owing to the catabolic status of cancer; this results in reduced operative morbidity and improved quality of life [2,36]. Some authors have reported that prehabilitation for patients with cancer is helpful and clinicians should be aware of prehabilitation before definitive surgery [37]. Additionally, some preoperative targeted anti-inflammatory therapies have shown promise for suppressing the catabolic effects of cancer [38].

This study had several limitations. First, this was a retrospective study; therefore, selection bias was inevitable, and muscle function tests could not be included. A relatively

large number of patients were excluded because of the lack of pre-contrast CT of the waist, which also contributed to selection bias. This selection bias is unavoidable because intravenous contrast may substantially affect the automated measurement of MD [39]. Second, information on changes in skeletal muscle mass could not be obtained because not all CT scans could be obtained during a certain period after surgery. Third, the exact underlying mechanisms of poor survival outcomes due to volumetric sarcopenia and myosteatosis were not identified in this study. Fourth, the cutoff value for myosteatosis was lower than that reported in a previous study. This study included only Asians, and the percentage of patients with myosteatosis was lower (24.3%) than that reported by other studies [23,25]. To our knowledge, this is the first study to investigate the prognostic value of volumetric sarcopenia and myosteatosis in colon cancer. Volumetric measurements with a large sample size provided more and precise information than single-cut measurements, and the evaluation was easier with automated calculations.

In conclusion, the present study found that preoperative volumetric sarcopenia combined with myosteatosis, automatically assessed by pre-contrast CT using AI-based software, was associated with poor postsurgical survival outcomes in patients with colon cancer. These volumetric body composition parameters can be assessed preoperatively, and patients with poor prognostic features can receive greater attention during post-surgical surveillance.

Availability of Data and Material

The datasets generated or analyzed during the study are available from the corresponding author on reasonable request.

Conflicts of Interest

The authors have no potential conflicts of interest to disclose.

Author Contributions

Conceptualization: Bo Young Oh. Data curation: Bo Young Oh, Sang Min Lee. Formal analysis: Minsung Kim. Funding acquisition: Bo Young Oh. Investigation: Sang Min Lee. Methodology: Sang Min Lee. Project administration: Bo Young Oh. Resources: Bo Young Oh, Il Tae Son. Software: Sang Min Lee. Supervision: Bo Young Oh, Il Tae Son. Validation: Bo Young Oh. Visualization: Minsung Kim, Sang

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