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Sarcopenia is poor prognostic factor in older patients with locally advanced rectal cancer who received preoperative or postoperative chemoradiotherapy

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Abstract

Sarcopenia is associated with low muscle mass and low physical performance. Here, we performed to evaluate the sarcopenia as prognostic factor and treatment outcomes in older patients with locally advanced rectal cancer (LARC) who received preoperative or postoperative chemoradiotherapy (CRT).

LARC patients aged ≥65 years who received either preoperative or postoperative CRT were analyzed retrospectively. Preoperative or postoperative CRT consisted of 50.4 Gy and fluoropyrimidine. Surgery was performed at 6 weeks after CRT completion. Postoperative CRT was performed at 4 weeks after surgery. One month after surgery or CRT, adjuvant chemotherapy was given. Overall survival (OS) and disease free survival (DFS), local recurrence (LR), and prognostic factor were evaluated.

Thirty patients received preoperative CRT and 35 patients received postoperative CRT. Five-year OS rate, 5-year DFS rate, or 5-year LR rate was not significantly different between preoperative and postoperative CRT groups (69.0%, 58.5%, and 3.4% vs 73.6%, 67.9%, and 6.9%, $P = .56$, $P = .37$, and $P = .77$, respectively). Age, sex, stage, CEA level, or timing of CRT did not affect OS. However, 5-year OS rate of patients with sarcopenia was significantly lower than those without sarcopenia (38.0% vs 92.5%, $P < .001$). Multivariate analysis showed that sarcopenia was the only independent prognostic factor for overall survival (OS) (hazard ratio [HR]: 6.08, $P = .001$).

There was no difference in survival between preoperative CRT and postoperative CRT in older patients with LARC. Sarcopenia is a poor prognostic factor in older patients with LARC who received preoperative or postoperative CRT.

Abbreviations: CEA = carcinoembryonic antigen, CRT = chemoradiotherapy, DFS = disease free survival, LARC = locally advanced rectal cancer, LR = local recurrence, OS = overall survival.

Keywords: older patient, postoperative chemoradiotherapy, preoperative chemoradiotherapy, prognosis, rectal cancer, sarcopenia

1. Introduction

Preoperative chemoradiotherapy (CRT), the current standard treatment for locally advanced rectal cancer (LARC).[1,2] Preoperative CRT has several potential advantages. It decreases tumor volume, introduces down-staging, increases possibility of R0 resection, reduces radiation induced toxicity, enhances probability of anal sphincter preservation by shrinking large distal tumors, and reduces recurrence.[3,4] In 2004, a German trial compared preoperative and postoperative CRT in patients with stage II and III rectal cancer. Although 5-year local control was significantly improved in preoperative treatment arm in that German trial, overall survival was unchanged.[1] However, that study did not include many older patients, making it difficult to apply it as a standard therapy in older patients.

Sarcopenia is low muscle mass and low physical performance in especially older patients.[5,6] In cancer patients, the prevalence is 15% to 50%.[7] 71% elderly cancer patients showed that body weight loss at hospital admission was more than 10% and fat mass, triceps skinfold, and muscle mass decreased.[8] The factor of sarcopenia was anorexia, reduced food intake, and muscle disuse.[9]

Older patients have high rates of comorbidities. They often have high cancer stage at diagnosis. We tried to analyze more important prognostic factors of CRT in older patients with LARC. Recent studies have reported that sarcopenia is a poor prognostic factor in older people. So, in our study, we analyzed

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sarcopenia as a prognostic factor for older patients with LARC. The objective of this study was to compare treatment outcomes of preoperative CRT with postoperative CRT and identify prognostic factors in older patients >65 years of age with LARC who received preoperative or postoperative CRT.

2. Materials and methods

Patients aged ≥65 years who received either preoperative or postoperative CRT for advanced rectal cancer between January 2005 and August 2015 were analyzed retrospectively. Patients with a pathological diagnosis of rectal adenocarcinoma were included in this study provided that the tumor was located in the distal 15 cm from anal verge. Other inclusion criteria were those diagnosed with rectal cancer T3 or Lymph node positive after surgery. Patients who received ≥1 radiotherapy and chemotherapy during CRT scheduled were enrolled. Patients were excluded from this study if they had radiotherapy only or chemotherapy only during CRT. This study was approved by the Institutional Review Board of Chung-Ang University College of Medicine. The requirement of informed consent was waived as this study was based on retrospective analyses of existing administrative and clinical data. Preoperative clinical staging was performed with thoracic and abdominal computed tomography (CT) or abdominal and pelvic magnetic resonance imaging (MRI). Distances from the inferior aspect of the tumor to the anal verge were determined by colonoscopy. The 7th edition of the American Joint Committee on Cancer TNM system was used for staging.[10]

Radiotherapy was delivered using a 3-dimensional conformal technique. Clinical target volume included the entire macroscopic tumor, the mesorectum, internal iliac, and presacral lymph nodes. Planning treatment volume (PTV) was generated adding a margin of 1 cm in all directions. Boost volume included gross tumor and corresponding mesorectum of 2 cm in craniocaudal direction from the external margin of the tumor in preoperative group or tumor bed with margin including anastomosis in postoperative group. Boost planning treatment volume (B-PTV) was generated by adding 1 cm margin to boost volume in all directions. Total prescribed dose to PTV was 45 Gy delivered in 25 fractions for 5 days a week over 5 weeks. Boost prescribed dose to B-PTV was 5.4 Gy in three fractions. All patients received concurrent chemotherapy with fluorouracil given in an intravenous bolus at a dose of 500 mg/m^2 per day (day 1–day 3) during first and fifth weeks of radiotherapy or capecitabine given at 1650 mg/m^2 twice daily. CRT was performed with identical method in preoperative and postoperative treatment groups.

Lower anterior resection (LAR), ultra LAR, or abdominoperineal resection (APR) was performed based on the surgeon's preference. Surgical resection was performed based on principles of total mesorectal excision. In the preoperative CRT group, surgical resection was suggested 6 to 10 weeks after completion of preoperative CRT and adjuvant chemotherapy was given at 4 weeks after surgery. Adjuvant chemotherapy consisted of 4 cycles of bolus 5-fluorouracil (5-FU) (375 mg/m^2/d) and leucovorin (20 mg/m^2/d) as in the Mayo regimen on days 1 to 5 every 28 days. In the postoperative CRT group, surgery was done at 4 weeks before CRT. Adjuvant chemotherapy was given 4 cycles of adjuvant bolus 5FU (375 mg/m^2/d) and leucovorin (20 mg/m^2/d) after CRT completion.

Age, sex, clinical stage, CEA level, sarcopenia, and preoperative or postoperative CRT were analyzed as prognostic factors. Sarcopenia was defined as 3rd lumbar vertebra (L3) skeletal index which was the cross-sectional area of muscle at the L3 spine level on CT/height^2 (cm^2/m^2) using by Korean specific cutoffs.[11] The cutoffs of the sarcopenia according to the L3 skeletal index were 49 cm^2/m^2 for men and 31 cm^2/m^2 for women.[11] Sarcopenia analysis was performed using pretreatment abdomen pelvis CT.

Overall survival (OS) was defined as the time from the first day of treatment to death by any cause. Disease free survival (DFS) was defined as the time from the first day of treatment to the first recurrence or death. Kaplan–Meier method was used to estimate DFS and OS. Patients were censored at the last follow-up if they were alive and free from disease recurrence. Log-rank test was used to evaluate differences between groups. Hazard ratios (HRs) and their corresponding 95% confidence intervals (CIs) were stratified using Cox proportional hazards regression model. Categorical and continuous variables were compared using Chi-square test. Cumulative incidence local recurrence (LR) rate and distant recurrence rate were defined as the time from diagnosis to the detection of any local or distant recurrence, respectively. All analyses were performed using the Statistical Package for Social Sciences (SPSS) version 24.0 (IBM Corp., Armonk, NY). Statistical significance was defined at $P < .05$.

3. Results

A total of 104 patients aged ≥65 years who received surgery were diagnosed with rectal cancer T3 or lymph node positive. Fourteen patients who did not receive chemotherapy and 25 patients who did not receive adjuvant chemotherapy were excluded. Sixty-five patients who received preoperative CRT or postoperative CRT at one fraction of planned radiation were included. These patients with LARC were treated with preoperative or postoperative CRT between January 2005 and August 2015 at Chung-Ang university hospital, Seoul, South Korea. Thirty patients received preoperative CRT while 35 patients received postoperative CRT (Fig. 1).

Their median age was 71 years (range: 65–87 years). Among them, 39 (60%) patients were over 70 years old. There were 46 (70.8%) male patients. Thirty-eight (58.5%) patients were node positive. There was no difference in anal verge location of the tumor between the 2 groups ($P = .387$). Tumors were classified as lower (<5 cm from the anal verge), middle (5–10 cm from the anal verge), and upper (>10 cm from the anal verge) rectal cancer according to their locations. There was no significant difference in body mass index (BMI) ($P = .866$) between the 2 groups. Overall prevalence of sarcopenia was 38.5% (36.7% for preoperative CRT and 40.0% for postoperative CRT). In our study, sarcopenia showed no significant difference between preoperative CRT and postoperative CRT groups ($P = .783$) (Table 1).

Chemotherapy regimen during CRT was somewhat different between the 2 groups. Twenty-one (70.0%) patients received 5-fluorouracil plus leucovorin and 9 (30.0%) patients received capecitabine in the preoperative CRT group while 34 (97.1%) patients received 5-fluorouracil plus leucovorin and 1 (2.9%) patient received capecitabine in the postoperative CRT group. There was different compliance rate for radiotherapy between the 2 groups because 6 patients did not receive radiotherapy in the postoperative CRT group (100% vs 82.9%, $P = .017$). Of these 6 patients in the postoperative CRT group, 5 patients stopped the CRT as grade 3 or 4 diarrhea and 1 patient died of septic shock during CRT. However, there was no significant difference in

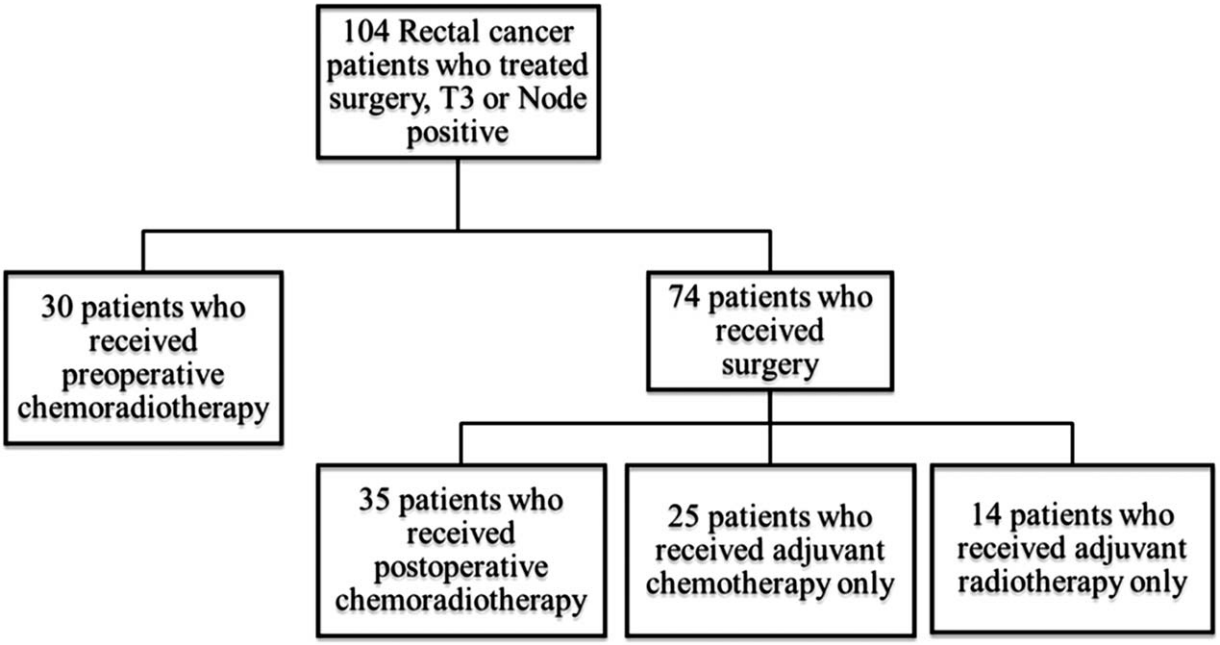

Figure 1. Flow chart showing selection of patients.

compliance rate for chemotherapy during CRT between the 2 groups (90.0% vs 85.7%, $P=.600$).

The compliance rate for adjuvant chemotherapy was not significant difference between the 2 groups either (83.3% vs 91.4%, $P=.322$). In the preoperative CRT group, 5 patients did not receive adjuvant chemotherapy, including 2 patients who refused treatment, 2 patients who did not receive adjuvant chemotherapy due to poor performance, and 1 patient who was relapsed before scheduled adjuvant chemotherapy. In the postoperative CRT group, 3 patients did not receive adjuvant

Table 1

Patient characteristics.

Characteristic	Total (N = 65)	Preoperative chemoradiotherapy (n = 30)	Postoperative chemoradiotherapy (n = 35)	*P* value
Age-year				
Median	71	72	70	
Range	65–87	66–87	65–81	
Age ≥70	39 (60%)	19 (54.3%)	19 (66.7%)	.31
Sex- no. (%)				.222
Male	46 (70.8%)	19 (63.3%)	27 (77.1%)	
Female	19 (29.2%)	11 (36.7%)	8 (22.9%)	
Clinical tumor category - no. (%)				
T1 or T2	8 (12.3%)	4 (13.3%)	4 (11.4%)	.074
T3	50 (76.9%)	20 (66.7%)	30 (85.7%)	
T4	7 (10.8%)	6 (20.0%)	1 (2.9%)	
Clinical nodal category - no. (%)				
Node negative	27 (41.5%)	20 (66.7%)	17 (48.6%)	.214
Node positive	38 (58.5%)	10 (33.3%)	18 (51.4%)	
Distance of tumor from anal verge-no. (%)				
<5 cm	18 (27.7%)	9 (30.0%)	9 (25.7%)	.387
5–10 cm	36 (55.4%)	18 (60.0%)	18 (51.4%)	
>10 cm	11 (16.9%)	3 (10.0%)	8 (22.9%)	
Tumor marker				
CEA <4	41 (63.1%)	19 (63.3%)	22 (62.9%)	.643
CEA ≥4	23 (35.4%)	11 (36.7%)	12 (34.3%)	
Unknown	1 (1.5%)	0 (0)	1 (2.9%)	
BMI, kg/m^2	24.4 ± 3.5	20.7 ± 2.5	20.5 ± 2.9	.866
Sarcopenia				
Sarcopenia	25 (38.5%)	11 (36.7%)	14 (40.0%)	.783
Normal	40 (61.5%)	19 (63.3%)	21 (60.0%)	

BMI = body mass Index, CEA = carcinoembryonic antigen.

Table 2

Compliance rates for chemotherapy, postoperative pathologic tumor stage, and type of surgery.

Variable	Total (N = 65)	Preoperative chemoradiotherapy (n = 30)	Postoperative chemoradiotherapy (n = 35)	*P* value
CCRT	65 (100%)	30 (100%)	35 (100%)	
CCRT regimen				.005
FL	55 (84.6%)	21 (70.0%)	34 (97.1%)	
Capecitabine	10 (15.4%)	9 (30.0%)	1 (2.9%)	
Received full dose of radiotherapy	59 (90.8%)	30 (100%)	29 (82.9%)	.017
Received full dose of chemotherapy	37 (87.7%)	27 (90.0%)	30 (85.7%)	.600
Adjuvant chemotherapy	57 (87.7%)	25 (83.3%)	32 (91.4%)	.322
Median cycle	4 (1∼4)	4 (1∼4)	4 (1∼4)	
Histological finding				
Complete response	6 (9.2%)	6 (20.0%)	0	
TNM stage				
I	8 (12.3%)	8 (26.7%)	0	
II	24 (36.9%)	7 (23.3%)	17 (48.6%)	
III	27 (41.5%)	9 (30.0%)	18 (51.4%)	
Type of resection				.121
LAR, uLAR	56 (86.2%)	28 (93.3%)	28 (80.0%)	
APR	9 (13.8%)	2 (6.7%)	7 (20.0%)	
Sphincter preserving surgery performed	13/18* (72.7%)	8/9* (88.9%)	5/9* (45.5%)	.143

APR = abdominoperineal resection, CCRT = concurrent chemoradiotherapy, FL = 5-fluorouracil plus leucovorin, LAR = lower anterior resection, uLAR = ultra-lower anterior resection.
* Patients with distant of tumor from anal verge <5 cm.

chemotherapy, including 2 patients who refused treatment and 1 patient who died of septic shock during CRT. The median number of cycles of adjuvant chemotherapy was 4 for both groups.

Six (20.0%) of 30 patients who had preoperative CRT followed by radical surgery had no residual tumor detected in resected specimens. Nine (30.0%) patients in the preoperative CRT group had positive lymph nodes (stage III) while 18 (51.4%) patients in the postoperative CRT group had positive lymph nodes. Among 18 patients with distant tumor from anal verge <5 cm that required abdominoperineal resection, sphincter preserving surgery was conducted in 8 (88.9%) of 9 patients in the preoperative CRT group and 5 (45.5%) of 9 patients in the postoperative CRT group ($P = .143$) (Table 2).

The cutoff time for analyses was Dec 2017, resulting in a median follow-up duration of 106.8 months. Median follow-up durations for patients who received preoperative and postoperative CRT were 98.2 months (95% CI: 73.5–122.8 months) and 117.4 months (95% CI: 43.6–191.2 months), respectively ($P = .751$). Five-year OS rates in preoperative and postoperative CRT groups were 69.0% and 73.6%, respectively ($P = .561$) (Fig. 2A). Five-year DFS rate was 58.5% in the preoperative CRT group and 67.9% in the postoperative CRT group ($P = .366$) (Fig. 2B). Five-year cumulative incidence of LR was 3.4% in the preoperative CRT group and 6.9% in the postoperative CRT group ($P = .768$) (Fig. 2C). There was no regional recurrence. Five-year cumulative incidence of distant recurrence was 15.7% in the preoperative CRT group and 19.4% in the postoperative CRT group ($P = .638$) (Fig. 2D).

Results of univariate and multivariate analyses of prognostic factor for OS are summarized in Table 3. Univariate analysis showed that sarcopenia was significantly associated with OS (HR: 5.667, 95% CI: 2.315–13.872, $P = .001$). Age, sex, clinical stage, CEA level, preoperative CRT, or postoperative CRT did not affect OS. Multivariate analysis showed that sarcopenia was the only independent poor prognostic factor for OS (HR: 6.087, 95% CI: 2.078 to –17.828, $P = .001$) (Table 3).

The 5-year OS rate in sarcopenia patients was significantly different from that in the normal group (38.0% vs 92.5%, HR: 5.66, 95% CI: 2.31–13.87, $P < .001$). The 5-year DFS rate in sarcopenia patients was also significantly different from that in the normal group (37.4% vs 81.6%, HR: 3.52, 95% CI: 1.62–7.64, $P = .001$) (Fig. 3). There was no difference in compliance of CRT between sarcopenia and normal patients according to chemotherapy regimens (Table 4).

The 5-year OS rate in older patients (age ≥70) in preoperative CRT group was not significantly different from that in the postoperative CRT group (66.1% vs 77.2%, $P = .876$). The 5-year DFS rate in older patients (age ≥70) in postoperative CRT group was not significantly different from that in the preoperative CRT group either (58.5% vs 67.9%, $P = .709$). No significant interaction was observed between age over 70 years and treatment effect for OS or DFS regardless of preoperative CRT or postoperative CRT (Fig. 4).

4. Discussion

We found that sarcopenia is a poor prognostic factor in older patients with LARC who received preoperative or postoperative CRT. And we compared treatment outcomes of preoperative CRT group and postoperative CRT group of patients with LARC who were 65 years of age or older. Compared with postoperative CRT group, preoperative CRT group had no better OS or DFS for older patients with ≥65 years of age or older. For older patients, compliance rate for CRT was good regardless of preoperative or postoperative CRT. LR or sphincter preservation rate (SPR) after radical resection was not significantly different between the 2 groups. However, numerically LR and SPR after radical resection in the preoperative CRT group were better than those in the postoperative CRT group.

We analyzed age, sex, clinical stage, CEA level, timing of CRT, and sarcopenia as prognostic factor. Sarcopenia was the only independent negative prognostic factor for OS in older patients who received preoperative or postoperative CRT for LARC.

Sarcopenia is defined as low muscle mass and lower performance status.[12] It is important to measure the state of muscle mass when judging whether it is sarcopenia. We evaluated sarcopenia using L3 muscle index, one of international standards

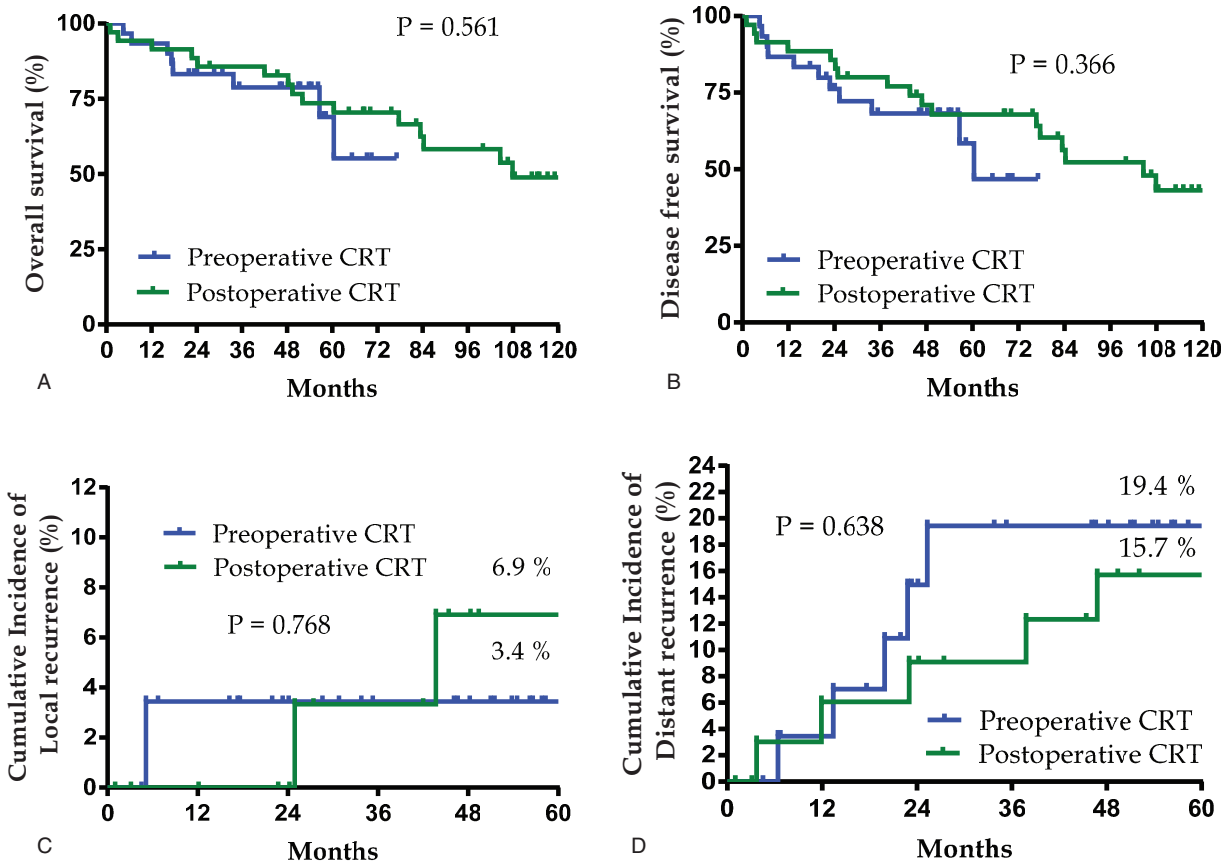

Figure 2. Overall survival (OS) (A), disease free survival (DFS) (B), cumulative incidence of local recurrence (C), and cumulative incidence of distant recurrence (D) in older patients with rectal cancer who received postoperative or preoperative chemoradiotherapy (CRT).

for measuring sarcopenia.[13] According to the international consensus of cancer cachexia, sarcopenia was defined as a L3 muscle index of $<55\,cm^2/m^2$ for men and of $<39\,cm^2/m^2$ for women.[12] However, it is inaccurate for sarcopenia in older patients with cancer in Korea. We used the L3 muscle index cutoff values for Korean men and women ($49\,cm^2/m^2$ for men and 31 cm^2/m^2 for women, respectively) used in a Korean study reporting that sarcopenia could predict prognosis in small cell lung cancer.[11]

In our study, the prevalence of sarcopenia at the time of diagnosis of patients with rectal cancer was 38%, similar to results reported in other papers. Several studies have demonstrated that sarcopenia is a negative prognostic factor for esophageal cancer, gastric cancer,[14] and colorectal cancer.[15]

Table 3

Univariate and multivariable analysis of overall survival.

Variables	Univariate analysis			Multivariable analysis		
	HR	95% CI	*P* value	HR	95% CI	*P* value
Age >70 years	1.818	0.812–4.069	.146	1.656	0.600–4.570	.330
Female	0.769	0.325–1.818	.550	1.027	0.342–3.086	.962
T stage						
T2	reference					
T3	2.263	0.530–9.665	.270	0.884	0.182–4.297	.884
T4	2.009	0.282–14.324	.486	0.789	0.094–6.601	.827
Node positive	1.226	0.573–2.624	.600	1.128	0.409–3.108	.816
CEA ≥4	1.020	0.990–1.052	.193	1.246	0.492–3.156	.642
CRT regimen						
FL	reference					
Capecitabine	1.447	0.310–6.768	.638	1.153	0.230–5.790	.863
Postoperative CRT	reference					
Preoperative CRT	1.325	0.512–3.430	.562	0.936	0.271–3.233	.917
Sarcopenia	5.667	2.315–13.872	.001	6.059	2.069–17.747	.001

CEA = carcinoembryonic antigen, CRT = chemoradiotherapy, FL = 5-fluorouracil plus leucovorin.

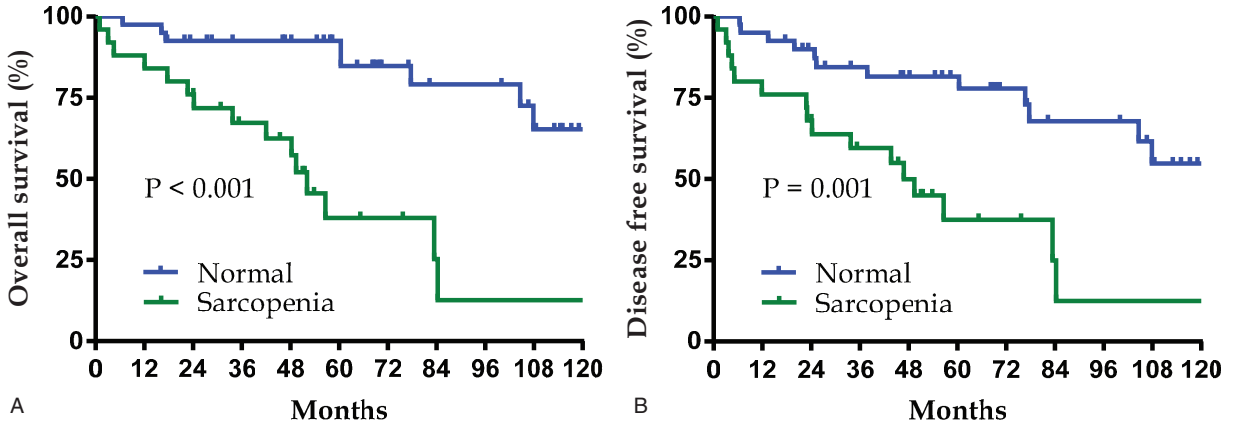

Figure 3. Overall survival (A) and disease free survival (B) according to sarcopenia.

Table 4

Compliance of CRT between sarcopenia and normal patients according to chemotherapy regimens.

Variable	Total (N = 65)	Sarcopenia (n = 25)	Normal (n = 40)	*P* value
CRT regimen				
FL	55 (84.6%)	20 (80.0%)	35 (87.5%)	.415
Capecitabine	10 (15.4%)	5 (20.0%)	5 (12.5%)	
Received full dose of radiotherapy	59 (90.8%)	21 (84.0%)	38 (95.0%)	.136
Received full dose of chemotherapy	56 (87.5%)	20 (80.0%)	36 (92.3%)	.146

CRT = chemoradiotherapy, FL = 5-fluorouracil plus leucovorin.

Although sarcopenia has been reported to be a negative prognostic factor after curative resection of colorectal cancer,[15] there has been no previous study showing that sarcopenia is a prognostic factor in older patients with LARC receiving CRT.

There have been efforts to reduce of incidence of sarcopenia known as a poor prognostic factor in patients with cancer. Yamamoto et al[16] have performed preoperative exercises and nutritional support programs for older patients with gastric cancer to reduce sarcopenia by postoperative complications in patients with gastric cancer. Currently, we are also planning a study to introduce exercise programs with a 6- to 10-week rest period between preoperative CRT and surgery in LARC patients.

In a German trial, the preoperative CRT group was associated with a significantly higher rate of 5-year DFS (64.7% vs 53.4%; $P = .001$) and a trend of having better OS (74.5% vs 65.6%; $P = .065$) than the postoperative CRT group.[1] In another Korean study, 5-year DFS rate was 72.1% vs 48.6% ($P = .05$) while 5-year OS was 76.2% versus 69.0% ($P = .23$) in the preoperative and postoperative CRT group, respectively.[17] In our study, the 5-year OS rate and 5-year DFS rate were not significantly different between preoperative and postoperative CRT groups (69.0% and 58.5% vs 73.6% and 67.9%, $P = .56$ and $P = .37$, respectively). Numerical OS and DFS in the postoperative CRT group were better than those in the preoperative CRT group. The better survival in postoperative CRT group might be due to good

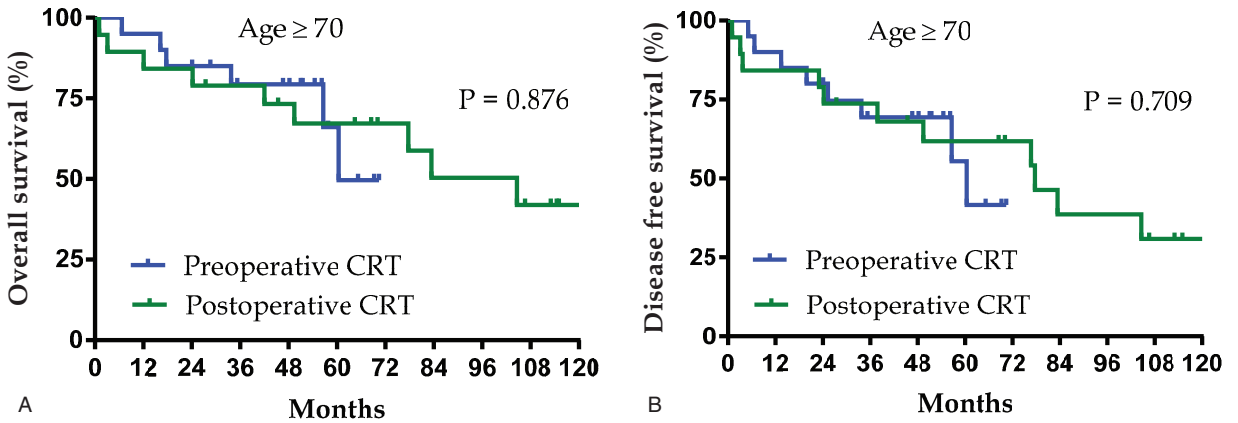

Figure 4. Overall survival (A) and disease free survival (B) in patients 70 years or older.

compliance to CRT. Although clinical T4 stage had more patients in the preoperative CRT group than that in the postoperative CRT group, node positive had more patients in the postoperative CRT group than that in the preoperative CRT group. These factors did not affect survival in multivariate analysis.

We found that compliance rate with postoperative CRT in our study was as good as 85.7% even in older patients. In another Korean study on preoperative versus postoperative CRT for LARC, the compliance with postoperative CRT was good at 81.7%.[17] These compliance rates with postoperative CRT of Korean studies are better than those of Western study.[1,18] The superior compliance with postoperative CRT might have contributed to better treatment outcomes in our study. However, we cannot accurately explain the excellent compliance with postoperative CRT even in older patients in our study. As shown in Fig. 1, patients with poor performance in the postoperative CRT group received either chemotherapy alone or radiotherapy alone during the CRT period. It was possible that only patients with good performance were selected and received full dose of CRT.

A prospective randomized trial from NSABP R-03 comparing preoperative CRT versus postoperative CRT in 267 patients with LARC showed similar locoregional recurrence of 10.7% in both groups.[19] Analysis of long-term follow-up data in the German trial showed no difference in LR between preoperative CRT and postoperative CRT except for patients who did not receive CRT.[18] Our study showed no difference in cumulative incidence of LR rate between preoperative CRT and postoperative CRT groups either.

Several studies have reported that preoperative CRT has higher frequency SPR after radical resection than postoperative CRT.[1,20] Among patients who were considered to require an APR in preoperative CRT in other studies, SPR after radical resection was 39% to 68%.[1,17,20] In our study, SPR after radical resection in postoperative CRT group was relatively 45.5%. It was 88.9% in the preoperative CRT group. However, there was no statistically significant difference in SPR between the 2 groups.

This study has limitation in that it was retrospective study with small number of patients. Thus, lower statically power was low. Selection bias might be involved when using subjects of a university hospital. However, to the best of our knowledge, this is the first study that compares treatment outcomes between preoperative CRT and postoperative CRT in older patients with LARC. In addition, this study revealed that sarcopenia was a poor prognostic factor in older patients with LARC.

5. Conclusion

In summary, sarcopenia was a poor prognostic factor in older patients with LARC who received preoperative or postoperative CRT. There was no significant difference in survival between preoperative CRT and postoperative CRT in older patients with LARC. These results need to be confirmed by additional large-scale prospective randomized controlled trials. And further studies are required to improve sarcopenia through interventions such as exercise and diet.

Author Contributions

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