의학석사 학위논문

국소 신장암 환자에서 근감소증이 환자의 예후에 미치는 영향

Associations of Sarcopenia on Survival of Patients with Organ Confined Renal Cell Carcinoma after Radical Nephrectomy

울산대학교 대학원

의 학 과

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이 논문을 의학석사 학위 논문으로 제출함

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Abstract

Purpose

The aim of this study was to describe the effect of preoperative sarcopenia on oncologic outcomes of organ confined renal cell carcinoma after radical nephrectomy.

Materials and Methods

485 patients who underwent radical nephrectomy with pathologically confirmed organ confined renal cell carcinoma (pT1b-pT2b) between 2004 and 2014 were retrospectively analyzed. Preoperative computerized tomography scans were acquired, and preoperative skeletal muscle index was measured. Gender specific cutoff value of skeletal muscle index at 3rd lumbar spine of 52.4 cm^2/ m^2 for men and 38.5 cm^2/ m^2 for women defined sarcopenia. Progression-free, cancer specific and overall survival was compared with the Kaplan-Meier method and log rank tests. Associations with progression, cancer specific mortality and all cause mortality were analyzed with Cox proportional hazard regression models.

Results

Of 485 patients, 211 (43.5%) patients were classified as sarcopenic. The sarcopenic group

was more advanced in age (57 vs 52; p=0.002) and more predominantly male (75.4% vs 59.5%; p<0.001). Sarcopenic patients had significantly lower BMI (23.0 vs 25.8; p<0.001) and less frequency of obesity (BMI ≥ 25 kg/m^2; 25.1% vs 61.3%; p<0.001). However, both groups showed no statistically significant difference in tumor size, stage and Fuhrman nuclear grade. Median follow up interval was 83 months. Our analysis showed better OS and CSS for non-sarcopenic group (5-year OS 96.2% vs 88.7%; p<0.001 and 5-year CSS 98.4% vs 92.0%; p=0.002) but no significant difference was shown for PFS. Our multivariate analysis showed that presence of sarcopenia is an independent risk factor for all cause mortality (HR, 2.17; p=0.003) and cancer specific mortality (HR, 2.52; p=0.014).

Conclusion

Sarcopenia is an independent risk of all cause mortality and cancer specific mortality after radical nephrectomy for organ confined renal cell carcinoma. Our findings imply the importance of assessing presence of sarcopenia for risk stratification and treatment planning.

Keyword; renal cell carcinoma, sarcopenia, nephrectomy, organ confined

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Introduction

Renal cell carcinoma (RCC) is a fatal urologic malignancy that accounts for 2-3% of all adult malignancies. Statistical analysis conducted in the United States observed 58,000 newly diagnosed patients and approximately 13,000 deaths from RCC every year.[1] Surgical resection, whether nephron sparing or not, is the standard treatment for localized RCCs. However, 30% of patients experience recurrence or metastasis even after radical nephrectomy.[2] Therefore, identifying prognostic factor for the recurrence and mortality of RCCs will provide more accurate scope for patient follow up and timely intervention.

Tumor stage and Furhman grade are thought to be the most important prognostic factors for patients with localized RCC. However, studies revealed that TNM staging and Fuhrman grade alone are not sufficient to accurately predict outcomes of an individual patient.[3] Several prognostic nomograms for localized RCC, such as UCLA Integrated Staging System (UISS), SSIGN (stage, tumor size, Furhman grade and tumor necrosis) and post-operative Karakiewicz's nomogram have been proposed over the years. These nomograms incorporating variables such as TNM stage, performance status, RCC related symptoms, tumor necrosis, tumor size, blood cell counts, and serum chemical markers yielded predictive accuracy of 80-89% in validation studies.[4] To further improve accuracy in predicting patient outcomes, inflammatory markers including neutrophil-lymphocyte ratio and serum C-reactive protein (CRP) as well as various molecular biomarkers have been explored.[5-7]

Sarcopenia is defined as a progressive decline in skeletal muscle mass and is associated

with increased risk of falls and fractures, disabilities and increased risk of death.[8] Recent studies have demonstrated that adverse outcomes of multiple malignancies, including breast, colorectal, pancreatic, hepatobiliary cancer and urothelial carcinoma of bladder were associated with lean muscle deficiency, or sarcopenia.[10-12] The impact of sarcopenia on patients undergoing cytoreductive nephrectomy due to metastatic RCC and its possible use as a prognostic factor have been demonstrated in recent literatures.[13,14] In patients with metastatic RCC treated with sunitinib, sarcopenia and decreased muscle mass after initiation of the therapy were associated with poor survival and lower objective response rate.[15]

The prognostic implication of preoperative sarcopenia on patients with clinically localized RCCs undergoing radical nephrectomy has been described on a retrospective cohort study.[16] The study demonstrated that sarcopenic patients were at more risk of disease progression, death from RCC and death from any cause. However, the cohort in previous study included heterogenous pathologic stage groups, from stage I to IV, therefore biochemical or inflammatory process in advanced disease could have affected the results. Therefore, we aimed to describe the effect of preoperative sarcopenia on oncologic outcomes of clinically organ confined RCC after radical nephrectomy. We hypothesized that presence of sarcopenia in patients with organ confined RCCs would have poorer oncologic outcomes.

Patients and Methods

Patient Selection

Among 1,623 patients who underwent radical nephrectomy at our institution between January 2004 and December 2014, 579 patients with organ confined RCCs with tumor size over 4 cm were identified. 16 patients with postoperative follow up duration shorter than 1 year were excluded. Review of preoperative imaging was done and 76 patients with either images incompatible with digital imaging and communications in medicine (DICOM) format or analog CT (computed tomography) film were excluded (Figure 1). Two patients with metal braces implanted in their lumbar spines which hindered accurate measurement of axial skeletal muscle area were also excluded, leaving 485 patients in our study group. The design of this study and use of patient medical record data was approved by the Institutional Review Board of Asan Medical Center (IRB Approval Number: 2019-0995). The IRB waived the need to obtain informed consent from the patients due to retrospective nature of the study.

Clinical Variables

Patient demographics such as age at operation, gender, height, weight and body mass index (BMI) were acquired by review of medical records. Patient history of diabetes mellitus, hypertension, smoking and alcohol, and Eastern Cooperative Oncology Group (ECOG) performance state were retrospectively analyzed. Date of CT scan, date of surgery and method of surgical approach were obtained. The pathologic reports of surgical specimens were reviewed for histological subtype, tumor size (cm), Furhman nuclear grades and lymph

node involvement. Pathologic T staging was revised according to 2009 UICC/AJCC TNM staging system for renal cell carcinoma.

Skeletal Muscle Index Analysis

The areas of the lumbar skeletal muscle components (including the psoas, quadratus lumborum, erector spinae, bilateral internal, external, lateral oblique muscles and rectus abdominis) were measured on a single axial CT image of 3rd lumbar spine at the transverse process level, using attenuation thresholds of -29 to +150 Hounsfield unit (Figure 2). CoreSlicer®, an open-source web-based analytic morphomics tool, was used to assist manual tracing of the lumbar skeletal muscle. Patient information was cleared from the image files before processing. Measurement was done by a single investigator (JL) in accordance with previously described standard methodology. Cross-sectional areas (cm^2) was normalized for height (m^2) to provide L3 skeletal muscle index (L3 SMI). A gender-specific cut-offs 52.4 cm^2/ m^2 for men and 38.5 cm^2/ m^2 for women, which showed optimum stratification in a prior population-based study on clinical implications of sarcopenic obesity in patients with solid tumors of the respiratory and gastrointestinal tracts, were used to identify sarcopenic patients.[17]

Statistical analysis

Patients were categorized into sarcopenic and non-sarcopenic groups. Continuous variables were summarized with medians and interquartile ranges. Categorical variables were summarized with frequency counts and percentages. Standard Student t-tests were used

to compare continuous variables. Pearson chi-square tests and Fisher exact tests were used to compare categorical variables.

Overall survival (OS), cancer-specific survival (CSS) and progression free survival (PFS) after surgery were compared with the Kaplan-Meier method. Disease progression was defined by observance of tumor recurrence at nephrectomy site, lymph node or distant metastasis on either radiographic or nuclear imaging studies. Associations of individual clinical covariates with disease progression, cancer-specific mortality and all-cause mortality were assessed by univariate Cox proportional hazard regression model. Multivariate analysis was performed with covariates which showed statistical significance on univariate analysis. P-values below 0.05 were considered statistically significant. Statistical analysis was performed with IBM SPSS Statistics version 25 (IBM SPSS, Armonk, NY).

Results

Patient characteristics

Of 485 patients our study cohort, 211 (43.5%) patients were diagnosed with sarcopenia. The demographic and clinical characteristics of our study cohort are shown on Table 1. The sarcopenic group was more advanced in age (57 vs 52; p=0.002) and more predominantly male (75.4% vs 59.5%; p<0.001). Sarcopenic patients had significantly lower BMI (23.0 vs 25.8; p<0.001) and less frequency of obesity (BMI $\geq$ 25 kg/m2; 25.1% vs 61.3%; p<0.001). However, both groups showed no statistically significant discrepancies in regards of oncologic variates such as tumor size, stage and Fuhrman nuclear grade. ECOG performance status, history of diabetes mellitus, hypertension, smoking and alcohol showed no significant difference between two groups (Table 1).

Correlations of L3 SMI with age and BMI

Linear regression analysis of L3 SMI versus age and BMI was performed to investigate correlations (Figure 4). Gender-specific analysis was also done. There was statistically significant correlation between L3 SMI and patient age (R2=0.021; p=0.001). Gender-specific analysis showed similar results for men (R2=0.053; p<0.001) but not for women (R2=0.017; p=0.055). BMI showed stronger correlation with SMI (R2=0.278; p<0.001). The association were similar in both men (R2=0.389; p<0.001) and women (R2=0.286; p<0.001). We were able to construct a multivariate linear regression model to estimate L3 SMI using age, gender and BMI. The model's R2 was 0.584 and p-value was below 0.001.

Survival Analysis

Median follow up interval was 83 months (IQR: 58-114). A total of 71 (14.6%) patients expired and 34 (7.0%) patients expired due to RCC-related causes. 89 (18.4%) patients had progression of RCC after nephrectomy. Estimated 5-year OS were 96.2% for non-sarcopenic group and 88.7% for sarcopenic group. 10-year OS were 94% and 83% respectively. 5-year CSS were 98.4% for non-sarcopenic group and 92.0% for sarcopenic group. 10-year CSS were 96.7% and 90.3%. 5-year PFS were 88.3% and 88.4%. 10-year PFS were 85.5% and 83.3% (Table 2). OS, CSS and PFS of both groups were compared with survival curves generated by Kaplan-Meier method and log-rank tests. Our analysis showed better OS and CSS for non-sarcopenic group ($p<0.001$ and $p=0.002$) but no significant difference was shown for PFS (Figure 5).

Risk Factors of Poor Overall and Progression Free Survival

Univariate analysis of OS showed that age, BMI, L3 SMI, sarcopenia, pathologic stage of T2, Fuhrman nuclear grade 4 and tumor size statistically significant risk factors (all; $p<0.05$). Subsequent multivariate analysis showed that presence of sarcopenia is a significant risk factor (HR, 2.17; 95%-CI, 1.36-3.61; $p=0.003$). Comparable results on CSS was obtained with univariate analysis. Once again, age, BMI, L3 SMI, sarcopenia, pathologic stage of T2, Fuhrman nuclear grade 4 and tumor size were statistically significant risk factors (all, $p<0.05$). Multivariate analysis of CSS also demonstrated sarcopenia as significant risk factor (HR, 2.52; 95% CI 1.20-5.30; $p=0.014$, Table 3 and 4).

Discussion

Sarcopenia is an emerging body composite indicator for risk assessment of multiple malignancies. The mechanisms and pathophysiology of sarcopenia are not clearly defined. Declines in hormones and numbers of neuromuscular junctions, inflammation, declines in activity and adequate nutrition are considered as possible causes of this condition. Risk factors for sarcopenia include age, gender and level of physical activity.[9] The European Working Group on Sarcopenia in Older People (EWGSOP) suggests diagnosis of sarcopenia to be made with presence of low skeletal muscle mass and either low muscle strength or low muscle performance.[8]

The term 'sarcopenic obesity' refers to a condition in which a patient's lean body mass is decreased while fat mass is increased or preserved.[9] Such condition has been observed to be an independent risk factor for poor outcomes of solid organ malignancies in several studies since the original one in 2009, including this study in which 25.1% of the patients classified as sarcopenia had BMI of 25 kg/m^2 or more.[17] The existence of sarcopenic obesity is an indicator that BMI may be insufficient to accurately represent physical reserve or fragility of a patient.

The aim of this study was to identify associations between deficiency of preoperative skeletal muscle mass quantified by L3 SMI with oncologic outcomes of organ confined RCC over 4cm in size. This study only included organ confined RCC to minimize effects of tumor factors such as lymph node or distant metastasis, venous thrombosis or perirenal invasion on

patient's oncologic outcomes. RCCs with size of 4 cm or less (pT1a) were excluded to minimize dilution of our results since organ confined pT1a RCC yields a 5-year overall survival of 90-100%.[19] 482 patients underwent radical nephrectomy for pT1a RCC during our study period. Therefore, inclusion of pT1a would have affected our results. We also excluded patients who underwent partial nephrectomy to exclude factors that can be affected by different operative techniques, such as positive resection margin. Our cohort consisted of 485 patients with 43.5% of the patients classified sarcopenic by gender specific cutoff, which is in line with a previous study conducted by Prado and colleagues.[9] Patients with sarcopenia tended to be older, more likely to be male, less obese than those without sarcopenia. The presence of sarcopenia was independently associated with poor overall survival and cancer specific survival in both univariate and multivariate analysis.

The impact of BMI on survival and progression free survival in patients with RCC has been previously documented.[18] BMI was a statistically significant risk factor of RCC on both overall survival and cancer specific survival on our univariate analysis (p=0.018 and 0.022). Our statistical analysis showed strong linear correlations of L3 skeletal muscle index with age and BMI. However, in multivariate analysis including sarcopenia, there were no significant correlations (p=0.232 and 0.202). We hypothesized there is a possibility, that in previous study, non-sarcopenic patients tended to have higher BMI as in our study cohort and sarcopenia acted as a confounding factor.

To our knowledge, this study is with the largest cohort compared to similar studies on

impact of sarcopenia on prognosis of RCC and is the first one to assess impact of sarcopenia on oncologic outcomes of organ confined RCC. Psutka and colleagues described poor overall survival and cancer specific survival of sarcopenic patients who underwent radical nephrectomy for RCC, regardless of stage.[16] Our study confirmed that even in organ confined RCC, sarcopenia is an independent risk factor for all-cause mortality and cancer specific mortality after radical nephrectomy.

The causality, whether sarcopenia leads to poor outcomes of RCC or sarcopenia is a manifestation of heavier oncologic burden, cannot be determined by this study. In our subgroup analysis that excluded patients with recurrence or follow-up loss within two years after the nephrectomy, we observed poorer overall survival of sarcopenic patients ($p=0.008$) but failed to observe statistically significant difference in cancer specific survival. This might be an indicator that sarcopenia is a manifestation of heavier oncologic burden invisible to radiographic imaging, such as molecular biomarkers or circulating tumor cells (CTCs). Serial analysis of skeletal muscle volume of RCC patients or correlation analysis of sarcopenia with molecular biomarkers or CTCs can be suggested in this context to confirm this hypothesis.

The limitations of our study are mainly related to its retrospective study design. Possible selection bias may have affected our results since we excluded unavailable CT image or CT images that cannot be accurately measured. This study only includes experience of single tertiary referral center. As a tertiary institution, patients were often referred to local

institutions for follow-ups, systemic therapy or terminal care. The follow-up loss due to patient referral may have caused underestimation of cancer-specific mortality.

In this study, sarcopenia was only defined by L3 skeletal muscle index. Muscle mass is only one of original definition of sarcopenia. Accurate diagnosis of sarcopenia should include decrease in muscle mass, muscle strength and physical performance. We used gender specific cutoffs generated in previous study by Prado and colleagues.[17] There was no pre-defined specific cutoffs of L3 SMI for northeast Asian or Korean populations. Available Japanese and Chinese studies used measurements of psoas muscle area. Population-based study on sarcopenia conducted in South Korea utilized skeletal muscle volume acquired with dual-energy X-ray absorptiometry. Development of ethnically specified cutoffs is necessary to conduct more accurate further studies. Finally, we have failed to demonstrate quantitative effect of sarcopenia on oncologic outcomes. We suspect strong linear correlations with age and BMI are accountable. A prospective study with age or BMI matched analysis is necessary to accurately describe effect of sarcopenia on oncologic outcomes of RCC.

Conclusion

Sarcopenia assessed by preoperative CT imaging, in addition to patient's age at surgery and tumor size, was an independent risk factor for patient undergoing radical nephrectomy for organ confined pT1a and pT2 RCC. Sarcopenia is easily assessible and remains unchanged by short term change in patients' medical condition. It might be an important component of future prognostic models. Further prospective study is necessary to increase accuracy of risk assessment with sarcopenia and determine causality of sarcopenia with poorer oncologic outcomes of RCC.

Table 1. Patient characteristics compared with Student's t-tests for continuous variables and χ-square tests for categorical variables.

	All	Non-sarcopenic	Sarcopenic	p-value
N (%)	485 (100)	274 (56.5)	211 (43.5)	
Age (years, IQR)	54 (46-64)	52 (45-60)	57(48-69)	0.002
Male gender (%)	322 (66.4)	163 (59.5)	159 (75.4)	<0.001
Diabetes mellitus (%)	63 (13.0)	41 (15.0)	22 (10.4)	0.141
Hypertension (%)	148 (30.5)	82 (29.9)	66 (31.3)	0.748
Smoking (%)	175 (36.1)	101 (36.9)	74 (35.1)	0.684
Alcohol (%)	189 (39.0)	108 (39.4)	81 (38.4)	0.818
Height (cm, IQR)	165.4 (158.1-171.2)	164.4 (156.9-170.8)	166.6 (160.0-171.8)	0.009
Weight (kg, IQR)	67.1 (59.3-74.1)	69.6 (61.5-77.5)	64.6 (55.8-70.8)	<0.001
BMI (kg/m^2, IQR)	24.6 (22.5-26.8)	25.8 (24.0-27.9)	23.0 (21.2-25.0)	<0.001
BMI $\geq$ 25 kg/m^2 (%)	221 (45.6)	168 (61.3)	53 (25.1)	<0.001
ECOG (%)				0.689
0	436 (89.9)	245 (89.4)	191 (90.5)	
$\geq$1	49 (10.1)	29 (10.6)	20 (9.5)	
Pathologic stage (%)				0.139
pT1b	339 (70.2)	201 (73.4)	138 (66.0)	
pT2a	96 (19.9)	46 (16.8)	50 (23.9)	
pT2b	48 (9.9)	27 (9.9)	21 (10.0)	
Fuhrman Grade (%)				0.597*
1	9 (1.9)	5 (1.9)	4 (1.9)	
2	215 (45.4)	114 (42.7)	101 (48.8)	
3	215 (45.4)	128 (47.9)	87 (42.0)	
4	35 (7.4)	20 (7.5)	15 (7.2)	
Missing data	11 (2.3)	7 (2.6)	4 (1.9)	
Tumor size (cm, IQR)	6.0 (5.0-7.5)	6.0 (5.0-7.5)	6.0 (5.0-8.0)	0.526
Histology (%)				
Clear cell	382 (78.8)	219 (79.9)	163 (77.3)	
Non-clear cell	103 (21.2)	55 (20.1)	48 (22.7)	
Operation (%)				0.009
Open	173 (35.7)	81 (29.6)	92 (43.6)	
HALS	154 (31.8)	93 (33.9)	61 (26.5)	
Laparoscopic	155 (32.0)	99 (36.1)	56 (28.9)	
SMA at L3 (cm^2, IQR)	134.5 (106.2-158.2)	152.4 (109.4-169.1)	125.6 (98.5-141.8)	<0.001
L3 SMI (cm^2/m^2, IQR)	49.2 (42.4-55.2)	54.1 (45.3-58.9)	44.7 (38.0-49.3)	N/A

**Fisher's exact tests*

Table 2. Overall survival, cancer specific survival and progression free survival of patients without sarcopenia and with sarcopenia.

	Without Sarcopenia	With Sarcopenia
5-year OS	96.2%	88.7%
10-year OS	94%	83%
5-year CSS	98.4%	92.0%
10-year CSS	96.7%	90.3%
5-year PFS	88.3%	88.4%
10-year PFS	85.5%	83.3%

Table 3. Risk factors affecting overall survival analyzed with Cox proportional hazard model.

Variables	Univariate			Multivariate		
	HR	95%CI	P-value	HR	95%CI	P-value
Age	1.05	1.03-1.07	<0.001	1.04	1.02-1.06	<0.001
Male gender	1.26	0.75-2.14	0.379			
DM	1.47	0.82-2.64	0.219			
Hypertension	1.28	0.79-2.08	0.320			
Smoking	1.15	0.71-1.86	0.564			
Alcohol	0.93	0.57-1.50	0.758			
BMI	0.91	0.84-0.98	0.018	0.95	0.86-1.04	0.232
ECOG ≥1	1.58	0.80-3.09	0.210			
L3 SMI	0.97	0.94-1.00	0.020	1.02	0.98-1.06	0.368
Sarcopenia	2.63	1.61-4.31	<0.001	2.17	1.36-3.61	0.003
pT2	1.80	1.12-2.90	0.016	1.37	0.62-3.03	0.432
FG 4	2.14	1.02-4.51	0.045	1.59	0.75-3.37	0.230
Tumor size	1.09	1.02-1.17	0.013	1.11	1.03-1.20	0.004
Clear cell	0.84	0.45-1.57	0.578			
Open surgery	1.52	0.93-2.47	0.099			

Table 4. Risk factors affecting cancer specific survival analyzed with Cox proportional hazard model.

Variables	Univariate			Multivariate		
	HR	95%CI	P-value	HR	95%CI	P-value
Age	1.04	1.01-1.07	0.014	1.03	1.00-1.06	0.047
Male gender	1.17	0.56-2.45	0.671			
DM	1.61	0.70-3.72	0.256			
Hypertension	1.06	0.52-2.18	0.872			
Smoking	1.32	0.68-2.62	0.422			
Alcohol	1.26	0.64-2.49	0.497			
BMI	0.88	0.78-0.98	0.022	0.92	0.80-1.05	0.202
ECOG ≥1	0.60	0.14-2.51	0.481			
L3 SMI	0.96	0.92-0.99	0.022	1.00	0.95-1.06	0.874
Sarcopenia	2.89	1.41-5.93	0.004	2.52	1.20-5.30	0.014
pT2	2.63	1.34-5.17	0.005	1.49	0.51-4.42	0.468
FG 4	2.73	1.04-7.12	0.041	2.09	0.79-5.53	0.140
Tumor size	1.15	1.05-1.26	0.006	1.18	1.07-1.30	0.001
Clear cell	0.69	0.27-1.78	0.440			
Open surgery	2.00	1.00-3.97	0.052			

Figure1. Patient selection algorithm

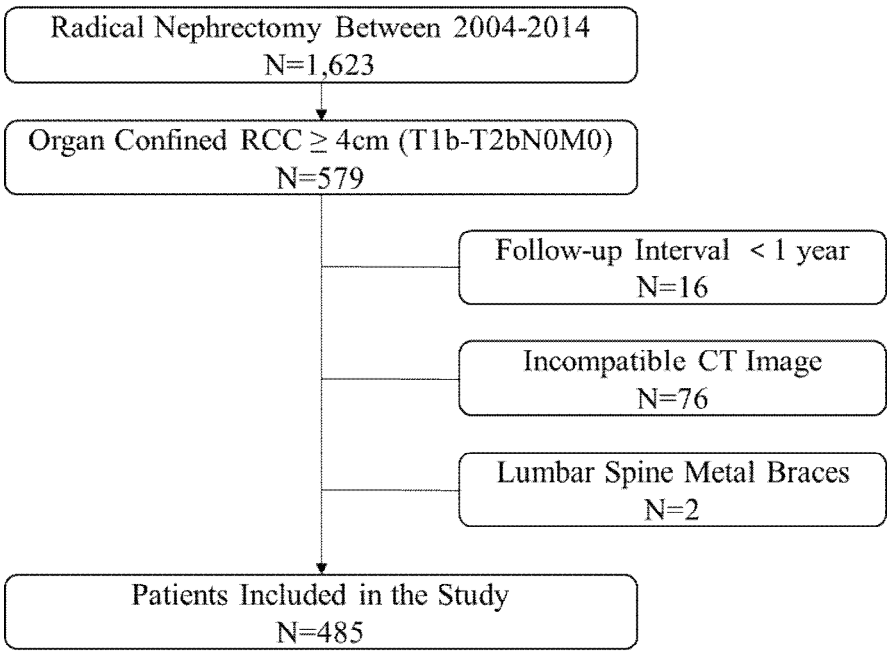
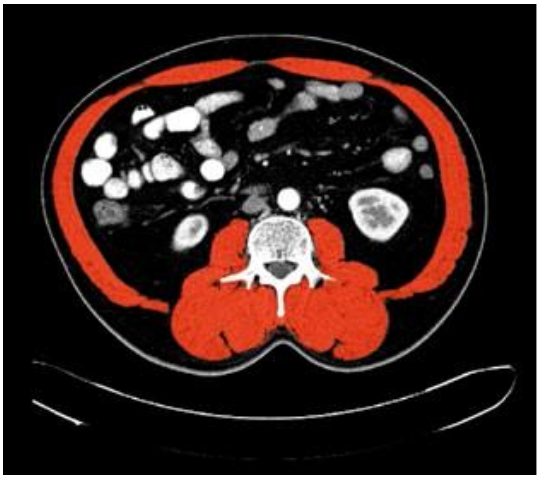


Figure 2 A. L3 level axial CT image of a 61 years-old male without sarcopenia. Skeletal muscle area=195 cm^2, L3 skeletal muscle index=77.32 cm^2/m^2

Figure 2 B. L3 level axial CT image of a 65 years-old male with sarcopenia. Skeletal muscle area=118 cm^2, L3 skeletal muscle index=45.1 cm^2/m^2

2 A



2 B

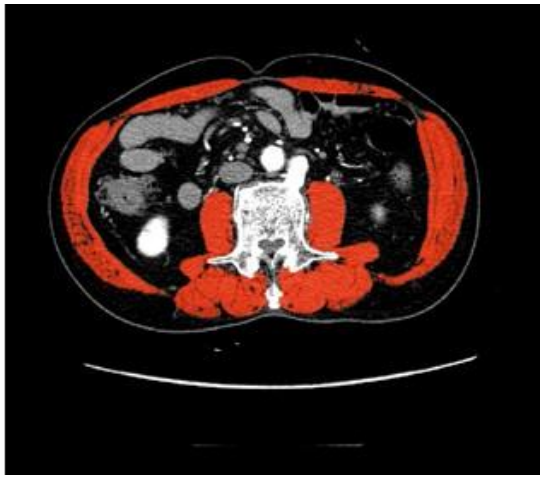


Figure 3. 3rd lumbar spine level skeletal muscle index (L3SMI) by gender represented with mean and 5 percentile and 25 percentiles.

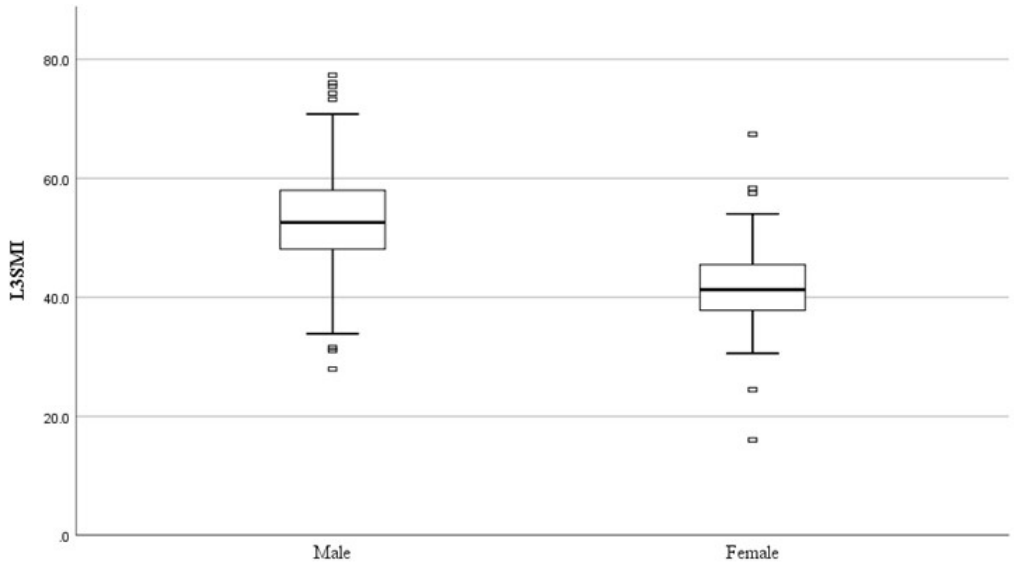


Figure 4. Correlations of Sarcopenia with Age and BMI. (A1,2) All cohorts, (B1,2) Males, (C1,2) Females.

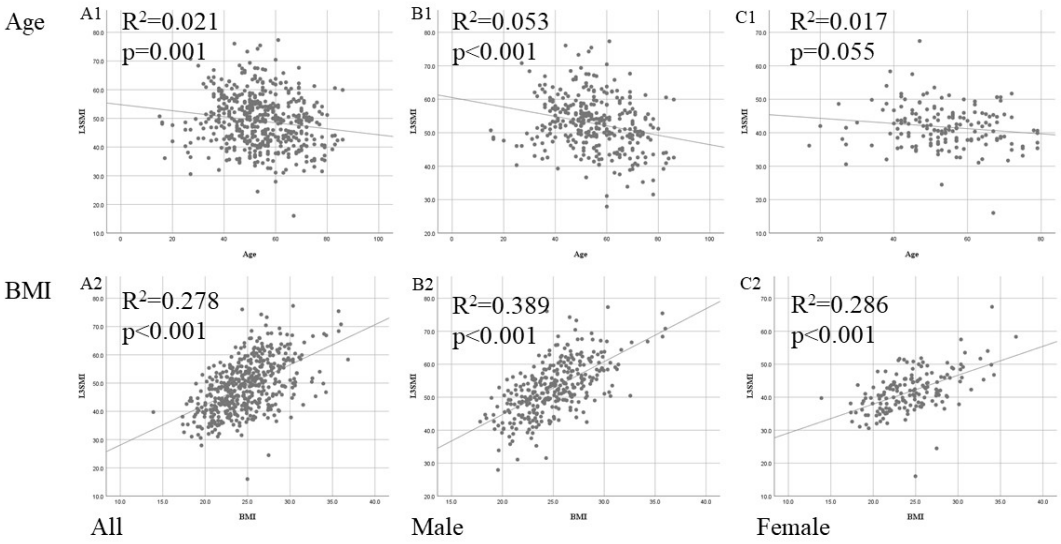
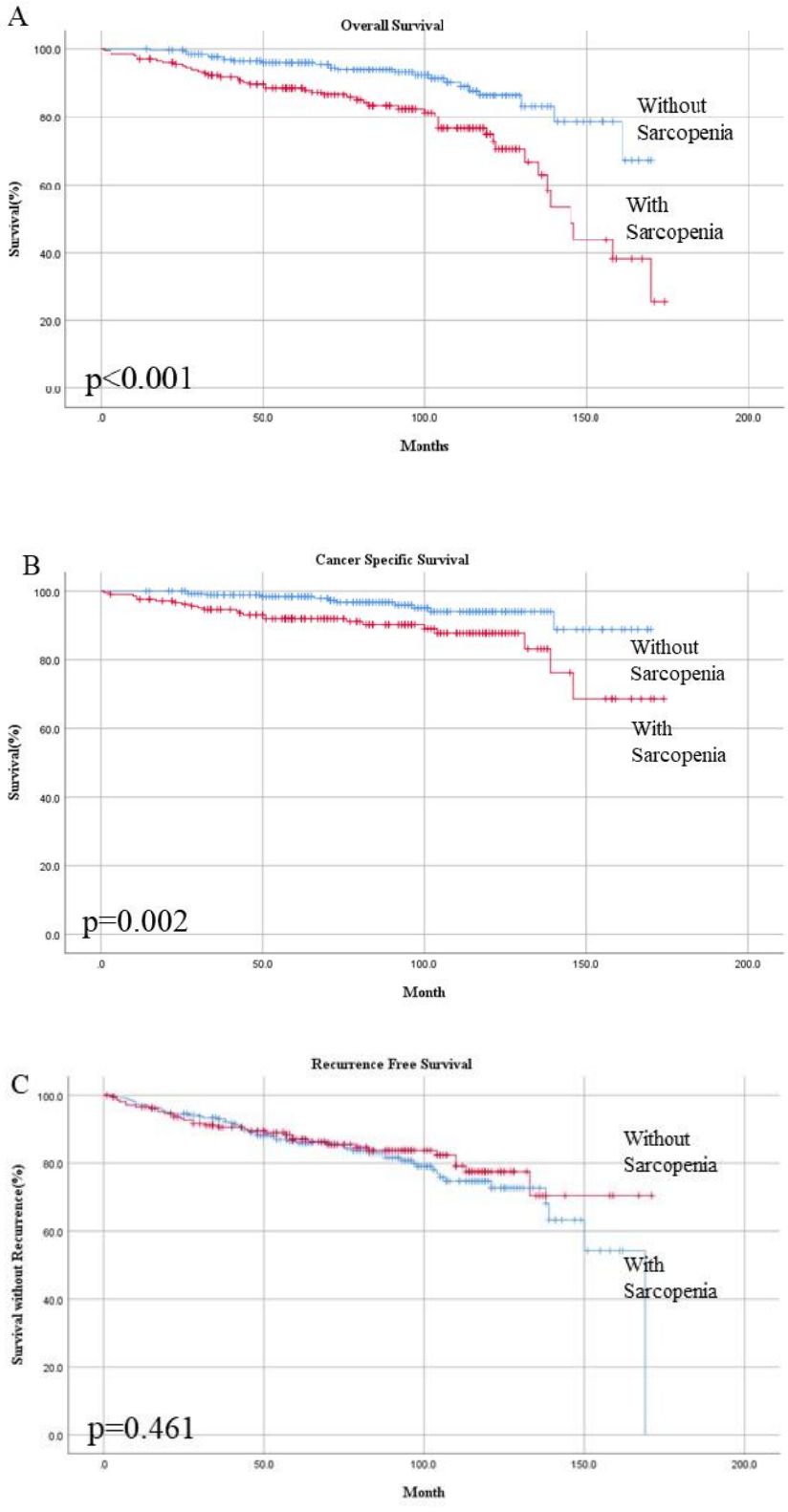


Figure 5. Patients' Overall Survival (A), Cancer Specific Survival (B), Recurrence Free Survival (C), Represented with Kaplan-Meier curves and compared with log-rank test.



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국문요약

연구 목적

본 연구는 근치적 신장 절제술을 시행한 비전이성 신장암 환자에서 수술 전 근감소증, 즉 근육량의 감소가 환자의 수술 후 예후에 미치는 영향을 기술하고자 하였다. 본 연구는 수술 전 근감소증이 있는 환자에서 수술 후 예후가 좋지 않을 것을 가정하였다.

연구 방법

2004 년에서 2014 년까지 서울아산병원 비뇨의학과에서 근치적 신장 절제술을 시행한 환자 중 비전이성 신장암 (T 병기 pT1b-pT2b)로 수술 후 조직검사를 통하여 확진된 환자 485 명을 후향적으로 분석하였다. 수술 전 컴퓨터단층사진을 통하여 수술 전 골격근지수를 측정하였고 남성에서 52.4 cm^2/m^2, 여성에서 38.5 cm^2/m^2 의 절단값을 사용하여 근감소증을 정의하였다. 각 환자군의 생존률, 질병특이생존률, 무병생존률은 Kaplan-Meier 방법과 로그순위검정을 통하여 비교하였고 근감소증과 생존률, 질병특이생존률, 무병생존률의 관계는 Cox 비례위험모형을 통하여 분석하였다.

결과

485 명의 환자 중 211 명 (43.5%)의 환자가 근감소증으로 분류되었다. 근감소증 환자군은 고령 (57 vs 52; p=0.002), 남성 (75.4% vs 59.5%; p<0.001)에서 빈도가 더 높았으며 낮은 BMI (23.0 vs 25.8; p<0.001)와 낮은 비만율 (BMI ≥ 25 kg/m^2; 25.1% vs 61.3%; p<0.001)을 보였다. 그러나 두 군 사이 종양의 크기, 병기, Fuhrman 핵분화도는 통계적으로 유의미한 차이를 보이지 않았다. 추적관찰 기간의 중간값은 83 개월이었으며 5 년 생존률은 비근감소증 군에서 96.2%, 근감소증군에서 88.7% 였다. 비근감소증 환자

군에서 우월한 생존률($p<0.001$)과 질병특이생존률($p=0.002$)을 보였으나 무병생존률에는 통계적으로 유의한 차이가 없었다. Cox 비례위험모형을 이용한 다변량 분석에서는 근감소증의 존재가 모든 요인에 의한 사망(HR 2.17; $p=0.003$) 및 신장암으로 인한 사망(HR 2.52; $p=0.014$)의 독립적인 위험인자였다.

결론

근감소증은 비전이성 신장암 환자에서 근치적 신절제술 시행 후 모든 요인에 의한 사망 및 신장암으로 인한 사망의 독립적인 위험인자이다. 이러한 결과는 비전이성 신장암 환자의 수술 전 근감소증의 확인이 위험도 분류 및 치료계획에 중요함을 의미한다.