ORIGINAL

# Prognostic performance of psoas muscle density in elderly patients undergoing curative surgery for gastric cancer

Masayuki Urabe, Mami Suzuki, Takahiro Fukai, Yui Hasegawa, Emi Terai, Yoshitaka Kiya, Goki Morizono, Masaya Hiyoshi, Toshiyuki Watanabe, and Yojiro Hashiguchi

*Gastrointestinal Surgery Division, Department of Surgery, Japanese Red Cross Omori Hospital, Tokyo, Japan*

**Abstract : Background : The proportion of elderly patients within the gastric cancer (GC)-affected population has been increasing. Accordingly, there is a pressing need for reliable methods to stratify surgical risk in geriatric GC cases. Psoas muscle density (PMD), a parameter indicative of sarcopenia, is readily assessable using standard radiological techniques and has been recognized as a prognostic marker in various malignancies. However, its clinical significance in GC, particularly among elderly patients, remains inadequately defined. Methods : We retrospectively reviewed 110 patients aged ≥75 years who underwent R0 gastrectomy for GC. The prognostic value of preoperative PMD, along with other nutritional indices, was assessed using Cox proportional hazards models. Results : Lower PMD was significantly associated with diffuse-type histology and higher incidence of postoperative complications. On univariate Cox regression analysis, PMD was significantly associated with overall survival. Multivariate analysis confirmed PMD as an independent predictor of overall survival (hazard ratio : 0.57 ; 95% confidence interval : 0.35–0.91 per 10-Hounsfield unit increase), along with other nutritional parameters. Conclusion : Preoperative PMD was significantly associated with postoperative morbidity and independently predicted overall survival in elderly GC patients. Incorporating PMD assessment into preoperative evaluation may enhance risk stratification and guide perioperative management in this vulnerable population. J. Med. Invest. 72 : 396-400, August, 2025**

***Keywords*** **:** *Elderly patients, gastrectomy, gastric cancer, psoas muscle density, sarcopenia*

## INTRODUCTION

Gastric cancer (GC) is the fifth most frequently diagnosed cancer worldwide, claiming approximately 660,000 lives annually (1). Although GC remains such a major threat on public health, its global incidence has gradually declined largely due to the decreased prevalence of *Helicobacter pylori* infection among younger populations (2). Consequently, the proportion of elderly GC patients has reversely increased at an alarming rate. In Japan, of surprise, deaths of individuals with age of 80 years and older now account for the highest proportion of fatalities among all age groups for GC, representing approximately a half of national GC mortality burden (3). This striking demographic shift highlights the urgent need for methodologies to quantify surgical risk in geriatric GC patients, a priority area of interest to gastrointestinal surgeons and a promising direction for future research.

Sarcopenia, a concept initially advocated by Rosenberg in 1989 (4), refers to age-related declines in skeletal muscle mass and function. It is now established as one of the most reliable predictors of clinical outcomes across various malignancies, including GC (5). However, objective assessment of sarcopenia typically relies on specialized equipment, such as bioelectrical impedance analysis or dual-energy X-ray absorptiometry, which limit its routine application in daily practice (6).

In contrast, computed tomography (CT) is widely available and enables practical evaluation of radiologically defined sarcopenia in both primary care and perioperative contexts. Specifically, psoas muscle density (PMD) can be quantified using standard Picture Archiving and Communication System (PACS), which is a universally accessible modality, and does not require additional software packages. Initially recognized as a prognostic marker in colorectal cancer (7, 8), PMD has since gained traction in surgical oncology research. However, its prognostic relevance in GC remains underexplored, particularly in elderly patients, who are disproportionately affected by sarcopenia (9, 10). In this study, we aimed to evaluate the value of preoperative PMD in predicting clinical outcomes in elderly patients undergoing curative surgery for GC.

Received for publication June 18, 2025 ; accepted July 13, 2025.

Address correspondence and reprint requests to Masayuki Urabe, MD, PhD, Gastrointestinal Surgery Division, Department of Surgery, Japanese Red Cross Omori Hospital, 4-30-1 Chuo, Ota-ku, Tokyo 143-8527, Japan and Fax : +81-3-3776-0004. E-mail : m-urabe.ju@omori.jrc.or.jp

## PATIENTS AND METHODS

### *Study population*

From our prospectively-registered database, a total of 147 elderly patients, being aged 75 years or above, who underwent surgical gastrectomy with oncological lymphadenectomy for GC between August 2010 and October 2024 were identified. Of these, 37 were excluded in terms of the reasons as follows : R1/R2 resection ($n$ = 13), cancer of the remnant stomach ($n$ = 5), concurrent malignancies ($n$ = 11), receipt of neoadjuvant chemotherapy ($n$ = 1), postoperative follow-up less than three months ($n$ = 1) and incomplete preoperative data ($n$ = 6). There were no cases with emergency gastrectomy. The final cohort comprised 110 patients.

This study was conducted in line with the requirements of our Institutional Ethics Committee (approval number 24-33). It was exempt from written informed consent collection because of the retrospective design.

### *Clinicopathological data*

Tumor staging followed the eighth edition manual of the TNM classification established by the Union for International Cancer

Control (11). Histological subtypes were categorized based on Lauren's criteria into intestinal and diffuse types (12). Postoperative complications were defined as events occurring within 30 days from surgery and graded as II or higher according to the Clavien–Dindo classification system (13).

All patients underwent postoperative surveillance for a minimum of five years or until death from any cause, in accordance with the guidelines of the Japanese Gastric Cancer Association (14). Follow-up data were obtained through clinical visits or telephone interviews. The study's follow-up period concluded in April 2025.

*Psoas muscle density and nutritional parameters*

Preoperative CT scan images were available for all cases. Muscle density data for each patient were extracted by a single observer (M.U.) using the hospital's standard PACS imaging software (SYNAPSE-PACS, FUJIFILM, Tokyo, Japan). Regions of interest were manually drawn around both psoas muscles on a CT slice at the level of the third lumbar vertebra, where both transverse processes were visible (Fig. 1). The PACS software automatically calculated muscle density, expressed in Hounsfield units (HU), for each region. The PMD was then recorded as the arithmetic mean of the densities from both psoas muscles.

In addition to PMD and other clinicopathological factors, the preoperative prognostic nutritional index (PNI) and geriatric nutritional risk index (GNRI) were evaluated in the study cohort as representative indicators of nutritional status (15, 16). The following formulas were used :

- PNI = [serum albumin level (g/L) + 0.005 × total lymphocyte count (/μL)]
- GNRI = [1.489 × serum albumin level (g/L) + 41.7 × (present weight / ideal weight)]

*Statistical analysis*

All statistical analyses were performed using JMP Student Edition version 18.2.0 (SAS Institute, Cary, NC, USA). All tests were two-tailed, and $P$ values < 0.05 were considered indicative of statistical significance. Continuous variables were compared using the Wilcoxon rank-sum test, while categorical variables were analyzed using either the Fisher's exact test or the chi-square test, as appropriate.

Overall survival (OS) was defined as the interval from the date of surgery to the date of death from any cause. Factors associated with OS were initially assessed using univariate Cox regression analysis. Subsequently, multivariate Cox proportional hazards models were employed to evaluate the independent effects of preoperative PMD, PNI, and GNRI on OS with adjustment of known confounders : age at surgery, gender, type of gastrectomy, tumor depth (pT), and nodal metastasis (pN) (17).

## RESULTS

*Associations of preoperative PMD with baseline demographics*

The relationship between preoperative PMD and clinicopathological variables are summarized in Table 1. Preoperative PMD was significantly correlated with main histology type and the occurrence of postoperative complications. Age at surgery, dichotomized at 80 years, showed a trend toward statistical significance ($P = 0.055$).

Linear regressions were performed to assess the relationships between preoperative PMD and conventional nutritional indicators (PNI and GNRI). A significant, albeit very weak, correlation was observed between preoperative PMD and PNI ($P = 0.033$, $R^2 = 0.041$). No significant correlation was found between preoperative PMD and GNRI ($P = 0.43$, $R^2 = 0.006$). These findings suggested that the risk of multicollinearity in subsequent analyses was likely low.

*Survival analyses*

Cox regression analyses were conducted for OS, treating preoperative PMD, PNI, and GNRI as continuous variables to avoid bias introduced by arbitrary cutoff values (18). In univariate analysis, preoperative PMD was a significant predictor of OS (hazard ratio [HR] 0.61, 95% confidence interval [CI] 0.39–0.98, per 10-HU increase ; $P = 0.040$). Other significant predictors included age, gender, type of gastrectomy, pT classification, pN classification, postoperative complications, preoperative PNI and GNRI (Table 2).

Multivariate analysis confirmed that PMD remained an independent prognostic factor for OS (HR 0.57, 95% CI 0.35–0.91, per 10-HU increase ; $P = 0.020$) (Model 1) (Table 3). Preoperative PNI and GNRI were also independently associated with OS. Even after further adjustment for preoperative PNI and GNRI (Model 2), preoperative PMD retained its independent prognostic significance (HR 0.52, 95% CI 0.32–0.84, per 10-HU increase ; $P = 0.007$).

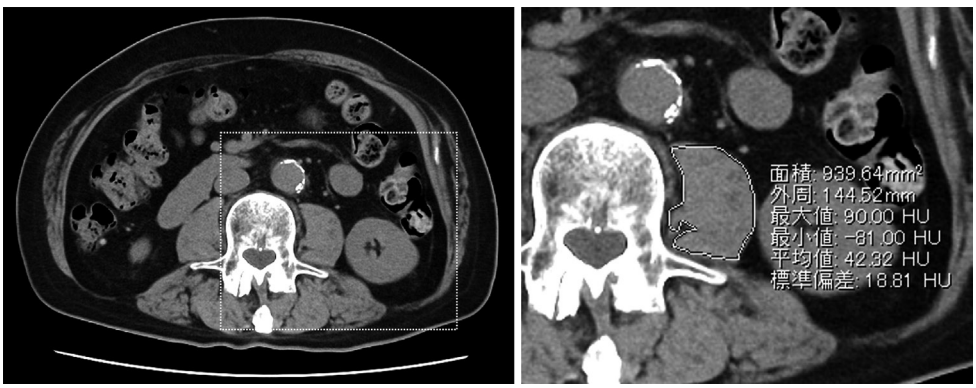


Fig 1. Regions of interest were manually delineated around the psoas muscles on a single axial CT slice at the level of the third lumbar vertebra. Muscle density within the selected regions was automatically calculated using PACS software (displayed in Japanese).

Table 1. Associations between preoperative psoas muscle density and clinicopathological factors

| Characteristics | # | Psoas muscle density (HU) (median, IQR) | *P* value |
|---|---|---|---|
| Total | 110 | 43.3 (39.4-48.8) | |
| *Age at surgery (years)* | | | |
| ≤79 | 50 | 45.9 (39.5-49.6) | 0.055 |
| ≥80 | 60 | 42.2 (39.2-46.2) | |
| *Gender* | | | |
| Male | 70 | 43.3 (38.6-49.2) | 0.57 |
| Female | 40 | 43.3 (40.6-48.3) | |
| *Main histology* | | | |
| Intestinal | 71 | 44.5 (39.9-49.4) | 0.026* |
| Diffuse | 39 | 42.2 (37.3-45.4) | |
| *Type of gastrectomy* | | | |
| Partial | 82 | 43.7 (39.5-48.9) | 0.36 |
| Total | 28 | 42.9 (38.8-45.9) | |
| *Surgical approach* | | | |
| Open | 98 | 43.1 (39.2-48.6) | 0.31 |
| Laparoscopic/robotic | 12 | 46.0 (40.5-49.1) | |
| *pT classification* | | | |
| T1 | 42 | 43.9 (39.5-48.1) | 0.72 |
| T2-4 | 68 | 42.8 (38.8-49.1) | |
| *pN classification* | | | |
| N0 | 71 | 44.1 (39.4-49.2) | 0.54 |
| N1-3 | 39 | 43.1 (39.2-47.0) | |
| *Lymphovascular involvement* | | | |
| Absent | 40 | 44.3 (39.5-48.6) | 0.80 |
| Present | 70 | 43.1 (39.1-48.8) | |
| *Postoperative chemotherapy* | | | |
| Absent | 99 | 43.0 (39.4-47.8) | 0.29 |
| Present | 11 | 45.4 (39.2-50.6) | |
| *Postoperative complications* | | | |
| Absent | 80 | 44.1 (39.9-49.2) | 0.023* |
| Present | 30 | 41.3 (35.4-46.3) | |

HU, Hounsfield unit ; IQR, interquartile range.
*$P < 0.05$

Table 2. Univariate Cox regression analyses for overall survival

| Characteristics | Overall survival | |
|---|---|---|
| | HR (95% CI) | *P* value |
| *Age at surgery (≥80 years)* | 2.89 (1.39-5.99) | 0.004* |
| *Gender (male)* | 2.13 (1.04-4.36) | 0.040* |
| *Main histology (intestinal)* | 1.20 (0.62-2.31) | 0.60 |
| *Type of gastrectomy (total)* | 2.32 (1.23-4.37) | 0.009* |
| *Surgical approach (open)* | 3.14 (0.43-22.9) | 0.26 |
| *pT classification (T2-4)* | 2.60 (1.23-5.49) | 0.012* |
| *pN classification (N1-3)* | 2.31 (1.24-4.31) | 0.008* |
| *Lymphovascular involvement (present)* | 1.87 (0.91-3.84) | 0.086 |
| *Postoperative chemotherapy (present)* | 1.44 (0.60-3.46) | 0.41 |
| *Postoperative complications (present)* | 2.40 (1.26-4.57) | 0.008* |
| *Preoperative PNI (per 10-unit increase)* | 0.42 (0.26-0.68) | < 0.001* |
| *Preoperative GNRI (per 10-unit increase)* | 0.60 (0.47-0.77) | < 0.001* |
| *Preoperative PMD (per 10-HU increase)* | 0.61 (0.39-0.98) | 0.040* |

CI, confidence interval ; GNRI, geriatric nutritional risk index ; HR, hazard ratio ; HU, Hounsfield unit ; PMD, psoas muscle density ; PNI, prognostic nutritional index.
*$P < 0.05$

Table 3. Multivariate Cox regression analyses for overall survival

[Model 1]

| | Adjusted HR (95% CI)† | *P* value |
|---|---|---|
| *Preoperative PNI (per 10-unit increase)* | 0.51 (0.30-0.86) | 0.010* |
| *Preoperative GNRI (per 10-unit increase)* | 0.64 (0.49-0.85) | 0.002* |
| *Preoperative PMD (per 10-HU increase)* | 0.57 (0.35-0.91) | 0.020* |

†Adjusted with age (≥80 years), gender, type of gastrectomy (total), pT classification (T2-4) and pN classification (N1-3).

[Model 2]

| | Adjusted HR (95% CI)† | *P* value |
|---|---|---|
| *Preoperative PMD (per 10-HU increase)* | 0.52 (0.32-0.84) | 0.007* |

†Adjusted with age (≥80 years), gender, type of gastrectomy (total), pT classification (T2-4), pN classification (N1-3), preoperative PNI and GNRI.

CI, confidence interval ; GNRI, geriatric nutritional risk index ; HR, hazard ratio ; HU, Hounsfield unit ; PMD, psoas muscle density ; PNI, prognostic nutritional index.
*$P < 0.05$

## DISCUSSION

This study demonstrated that preoperative PMD was independently associated with postoperative morbidity and long-term survival in elderly patients undergoing curative gastrectomy for GC. These findings supported its role as a clinically meaningful prognostic marker, complementing established nutritional indicators such as PNI and GNRI.

Evidence from studies across various cancer types, including breast, bladder, and prostate carcinomas, has shown that low PMD independently predicts unfavorable survival outcomes (19-21). With respect to GC, however, only a limited number of studies have explored the clinical significance of PMD (9, 10). These investigations failed to demonstrate a robust association with long-term survival and did not specifically address elderly populations, in whom sarcopenia is prevalent and prognostically significant (22). Our findings uniquely highlighted the prognostic utility of preoperative PMD in elderly patients with resectable GC, underscoring the need for further research in this area.

Although numerous screening tools exist for assessing sarcopenia, many are impractical in routine clinical settings due to reliance on complex questionnaires and detailed anthropometric data collection (6). While bioelectrical impedance analysis and dual-energy X-ray absorptiometry provide accurate assessments of body composition, their clinical utility is limited by the requirement for specialized equipment. In contrast, PMD, quantified via cross-sectional CT, offers a retrospective, and readily accessible measure of muscle quality. Unlike the skeletal muscle index, which quantifies muscle volume, PMD reflects muscle quality and can be assessed using standard imaging systems such as PACS, without the need for dedicated software (23).

The use of skeletal muscle radiodensity as a surrogate marker for muscle quality is supported by large-scale clinical studies (24, 25). Lower muscle radiodensity is considered indicative of intramuscular adipose infiltration and reduced functional capacity. Notably, single-slice cross-sectional areas at the L3 vertebral level are strongly correlated with whole-body muscle and adipose tissue volumes and have been widely adopted in prior research (26). Emerging evidence suggests that muscle quality reflects not only nutritional status but also immunological function, reinforcing its clinical relevance (27). These characteristics make PMD a promising candidate for integration into multimodal prognostic models that incorporate nutritional markers, performance status, and tumor burden to facilitate personalized treatment planning. Recognizing sarcopenia in this context may inform decisions on surgical candidacy, perioperative optimization, and the intensity of adjuvant therapy. Additionally, our findings provide a rationale for investigating interventions that preserve or enhance muscle quality, such as resistance training, tailored prehabilitation, and structured postoperative care (28).

This study has several limitations. First, it was a retrospective analysis. Second, all patients were recruited from a single institution, potentially limiting generalizability. Third, the methodology for PMD quantification lacks standardization and requires external validation. Nonetheless, our findings provide compelling evidence for PMD's prognostic value in elderly GC patients and support its potential utility in broader clinical practice.

In summary, preoperative PMD was a practical, CT-derived biomarker of muscle quality with significant prognostic value in elderly patients undergoing curative surgery for GC. Its incorporation into clinical workflows may enhance patient stratification, guide sophisticated decision-making, and contribute to improved outcomes in the aging GC population.

## CONFLICTS OF INTEREST

The authors declare that they have no potential conflicts of interest to disclose.

## ACKNOWLEDGMENT

None declared.

## FUNDING

This research received no specific grants from funding agencies in the public, commercial, or not-for-profit sectors.

## AUTHOR CONTRIBUTIONS

MU contributed to the conception and design of the study. All authors acquired data. MU performed data interpretation and drafted the manuscript. YK, GM, MH, TW and YH critically revised the manuscript. All authors read and approved the final version prior to submission.

## REFERENCES

1. Bray F, Laversanne M, Sung H, Ferlay J, Siegel RL, Soerjomataram I, Jemal A : Global cancer statistics 2022 : GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. CA Cancer J Clin 74(3) : 229-263, 2024
2. Morgan E, Arnold M, Camargo MC, Gini A, Kunzmann AT, Matsuda T, Meheus F, Verhoeven RHA, Vignat J, Laversanne M, Ferlay J, Soerjomataram I : The current and future incidence and mortality of gastric cancer in 185 countries, 2020-2040 : A population-based modelling study. eClinicalMedicine 47, 2022
3. Asaka M, Kobayashi M, Kudo T, Akino K, Asaka Y, Fujimori K, Kikuchi S, Kawai S, Kato M : Gastric cancer deaths by age group in Japan : Outlook on preventive measures for elderly adults. Cancer Sci 111(10) : 3845-3853, 2020
4. Rosenberg IH : Summary comments. Am J Clin Nutr 50(5) : 1231-1233, 1989
5. Ongaro E, Buoro V, Cinausero M, Caccialanza R, Turri A, Fanotto V, Basile D, Vitale MG, Ermacora P, Cardellino GG, Nicoletti L, Fornaro L, Casadei-Gardini A, Aprile G : Sarcopenia in gastric cancer : When the loss costs too much. Gastric Cancer 20(4) : 563-572, 2017
6. Nishikawa H, Asai A, Fukunishi S, Takeuchi T, Goto M, Ogura T, Nakamura S, Kakimoto K, Miyazaki T, Nishiguchi S, Higuchi K : Screening tools for sarcopenia. In Vivo 35(6) : 3001-3009, 2021
7. Herrod PJJ, Boyd-Carson H, Doleman B, Trotter J, Schlichtemeier S, Sathanapally G, Somerville J, Williams JP, Lund JN : Quick and simple ; psoas density measurement is an independent predictor of anastomotic leak and other complications after colorectal resection. Tech Coloproctol 23(2) : 129-134, 2019
8. Xiao YZ, Wen XT, Ying YY, Zhang XY, Li LY, Wang ZC, Su MG, Zheng XW, Miao SL : The psoas muscle density as a predictor of postoperative complications in elderly patients undergoing rectal cancer resection. Front Oncol 13 : 1189324, 2023
9. Lu J, Zheng ZF, Li P, Xie JW, Wang JB, Lin JX, Chen QY,

Cao LL, Lin M, Tu RH, Zheng CH, Huang CM : A novel preoperative skeletal muscle measure as a predictor of postoperative complications, long-term survival and tumor recurrence for patients with gastric cancer after radical gastrectomy. Ann Surg Oncol 25(2) : 439-448, 2018
10. Lin J, Zhang W, Chen W, Huang Y, Wu R, Chen X, Shen X, Zhu G : Muscle mass, density, and strength are necessary to diagnose sarcopenia in patients with gastric cancer. J Surg Res 241 : 141-148, 2019
11. Brierley JD, Gospodarowicz MK, Wittekind C : TNM classification of malignant tumours, 8th edn. Wiley-Blackwell, Oxford 2017
12. Lauren P : The two histological main types of gastric carcinoma : Diffuse and so-called intestinal-type carcinoma. An attempt at a histo-clinical classification. Acta Pathol Microbiol Scand 64 : 31-49, 1965
13. Dindo D, Demartines N, Clavien PA : Classification of surgical complications : A new proposal with evaluation in a cohort of 6336 patients and results of a survey. Ann Surg 240(2) : 205-213, 2004
14. Japanese Gastric Cancer Association : Japanese gastric cancer treatment guidelines 2021 (6th edition). Gastric Cancer 26(1) : 1-25, 2023
15. Onodera T, Goseki N, Kosaki G : Prognostic nutritional index in gastrointestinal surgery of malnourished cancer patients. Nihon Geka Gakkai Zasshi 85(9) : 1001-1005, 1984
16. Bouillanne O, Morineau G, Dupont C, Coulombel I, Vincent JP, Nicolis I, Benazeth S, Cynober L, Aussel C : Geriatric nutritional risk index : A new index for evaluating at-risk elderly medical patients. Am J Clin Nutr 82(4) : 777-783, 2005
17. Katai H, Ishikawa T, Akazawa K, Isobe Y, Miyashiro I, Oda I, Tsujitani S, Ono H, Tanabe S, Fukagawa T, Nunobe S, Kakeji Y, Nashimoto A, Registration Committee of the Japanese Gastric Cancer Association : Five-year survival analysis of surgically resected gastric cancer cases in Japan : A retrospective analysis of more than 100,000 patients from the nationwide registry of the Japanese Gastric Cancer Association (2001–2007). Gastric Cancer 21(1) : 144-154, 2018
18. Royston P, Altman DG, Sauerbrei W : Dichotomizing continuous predictors in multiple regression : A bad idea. Stat Med 25(1) : 127-141, 2006
19. Yao H, Dohzono S, Sasaoka R, Takamatsu K, Nakamura H : Prognostic value of psoas major muscle density in patients with breast cancer metastases to bone : A retrospective single-center cohort study. Jpn J Clin Oncol 52(1) : 8-13, 2022
20. Huang LK, Lin YC, Chuang HH, Chuang CK, Pang ST, Wu CT, Chang YH, Yu KJ, Lin PH, Kan HC, Chu YC, Hung WK, Hsieh ML, Shao IH : Body composition as a predictor of oncological outcome in patients with non-muscle-invasive bladder cancer receiving intravesical instillation after transurethral resection of bladder tumor. Front Oncol 13 : 1180888, 2023
21. Iwamoto G, Kawahara T, Miyai T, Yasui M, Hasumi H, Miyoshi Y, Yao M, Uemura H : A lower psoas muscle index predicts a poorer prognosis in metastatic hormone-naïve prostate cancer. BJUI Compass 2(1) : 39-45, 2021
22. Shachar SS, Williams GR, Muss HB, Nishijima TF : Prognostic value of sarcopenia in adults with solid tumours : A meta-analysis and systematic review. Eur J Cancer 57 : 58-67, 2016
23. Muraki I. Muscle mass assessment in sarcopenia : A narrative review. JMA J 6(4) : 381-386, 2023
24. Caan BJ, Cespedes Feliciano EM, Prado CM, Alexeeff S, Kroenke CH, Bradshaw P, Quesenberry CP, Weltzien EK, Castillo AL, Olobatuyi TA, Chen WY : Association of muscle and adiposity measured by computed tomography with survival in patients with nonmetastatic breast cancer. JAMA Oncol 4(6) : 798-804, 2018
25. Kroenke CH, Prado CM, Meyerhardt JA, Weltzien EK, Xiao J, Cespedes Feliciano EM, Caan BJ : Muscle radiodensity and mortality in patients with colorectal cancer. Cancer 124(14) : 3008-3015, 2018
26. Shen W, Punyanitya M, Wang Z, Gallagher D, St-Onge MP, Albu J, Heymsfield SB, Heshka S : Total body skeletal muscle and adipose tissue volumes : Estimation from a single abdominal cross-sectional image. J Appl Physiol 97(6) : 2333-2338, 2004
27. Xiao J, Caan BJ, Weltzien E, Cespedes Feliciano EM, Kroenke CH, Meyerhardt JA, Baracos VE, Kwan ML, Castillo AL, Prado CM : Associations of pre-existing co-morbidities with skeletal muscle mass and radiodensity in patients with non-metastatic colorectal cancer. J Cachexia Sarcopenia Muscle 9(4) : 654-663, 2018
28. Mareschal J, Hemmer A, Douissard J, Dupertuis YM, Collet T-H, Koessler T, Toso C, Ris F, Genton L : Surgical prehabilitation in patients with gastrointestinal cancers : Impact of unimodal and multimodal programs on postoperative outcomes and prospects for new therapeutic strategies—A systematic review. Cancers 15(6) : 1881, 2023