The Impact of Low Muscle Mass in Patients Undergoing Emergency Surgery for Colonic Perforation – A Single-center Experience

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Abstract. *Aim: The aim was to analyze the correlation between psoas muscle mass and mortality, as well as postoperative complications in patients treated for colonic perforation. Patients and Methods: A total of 46 patients met the study criteria. Patients were classified into an elderly (age, ≥ 75 years, $n=24$) and a younger group (age, <75 years, $n=22$). Background factors, postoperative data (including duration of hospital stay and discharge) were collected. The cross-sectional area of the psoas muscle area (PMA) was measured on the same day of operation. Results: The age/length of stay and PMA were significantly correlated in the younger group ($p=0.0015$, 0.023 , respectively). Fifteen and six patients were discharged to return home, and 8 and 16 patients were transferred to another hospital, in the younger and elderly groups, respectively ($p=0.02$). Discharge was not correlated with the PMA in either group. Conclusion: The total psoas muscle mass would be useful as a quick and convenient measure of sarcopenia in younger patients, but not elderly patients.*

Sarcopenia is a syndrome characterized by a progressive and generalized loss of skeletal muscle mass and strength and is associated with an increased risk of adverse outcomes, such as physical disability, a poor quality of life,

and death (1, 2). Recent studies have reported that sarcopenia is associated with worse outcomes in patients undergoing surgical resection of primary and metastatic colorectal cancer, pancreatic cancer, and liver transplantation (3-7). The presence of sarcopenia also predicts greater mortality in patients with liver cirrhosis, melanoma, and those awaiting liver transplantation (8-10). The diagnosis of sarcopenia requires documentation of low skeletal muscle plus either low muscle strength or low physical performance (11). However, it is difficult to evaluate muscle function (strength or performance) in the clinical setting, especially in acute-care surgery. The measurement of sarcopenia in the acute-care surgical population should be quick and convenient. Thus, the psoas muscle mass is often used because the evaluation of the psoas muscle is readily available with existing preoperative imaging, there was precedent in the literature on sarcopenia, and because change in the core muscle has been considered an indication related to global health and chronic illness (3, 12).

Colonic perforation has also been associated with high rates of morbidity and mortality in patients undergoing acute-care surgery. The establishment of an objective and patient-specific predictor of adverse outcomes would be useful for preoperative discussion, decision-making, and postoperative planning for such patients. Furthermore, with the increasing aging population, the number of elderly patients undergoing emergency surgery is increasing. The loss of muscle mass and function with aging is a practical measure of frailty and has been identified as a predictor of outcomes in elderly patients (13, 14).

From this background, we analyzed the correlation between the psoas muscle mass and mortality as well as the development of postoperative complications in younger and elderly patients undergoing emergency surgery for colonic perforation.

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Table I. Patient characteristics.

Characteristic	Younger group (aged ≤74 years)	Elderly group (aged ≥75 years)	p-Value
Male:female, n	13:9	8:16	0.137
Age, years	64.5 (36-74)	81.5 (75-95)	<0.0001
BMI, kg/m ²	22.6 (18.7-36.1)	19.9 (16.1-24)	0.0029
WBC, n/μl	11,250 (2,000-20,600)	6,700 (1,000-21,900)	0.024
CRP, mg/dl	10.2 (0.02-34.5)	4.9 (0.02-39.4)	0.30
Albumin, g/dl	3.6 (2.5-5), n=15	3.1 (1.9-4.1), n=19	0.02
BUN, g/dl	16.7 (5.7-51.3)	19.05 (11.3-79.4)	0.14
Creatinine, g/dl	0.76 (0.46-1.69)	0.75 (0.42-8.05)	0.38
Total psoas area, mm ²	1,622 (681-3,105)	961.5 (606-1,778)	<0.0001

BMI: Body mass index, WBC: White blood cell, CRP: C-reactive protein, BUN: Blood urea nitrogen. Data are the mean (range).

Patients and Methods

This study was approved by the Ethics Board of our Institute (#1803002). All data were collected in a retrospective manner. The study included consecutive patients who underwent emergency surgery for colonic perforation at our Institute from December 2013 to December 2017. Patients with perforated appendicitis or postoperative leakage were excluded. Patients who were ≥75 years of age were classified into the elderly group, while those 74 years of age and under were classified into the younger group. The patients' baseline characteristics, preoperative data, intraoperative factors, and postoperative outcomes were also collected.

To evaluate sarcopenia, the total psoas area in the superior margin of the L4 vertebra was measured on day of surgery. The total psoas area was measured by determining the total cross-sectional area of the right and left psoas muscles. The level of the fourth lumbar vertebra was chosen based on the literature on sarcopenia (3, 12, 14). The level of the L4 vertebra was identified, and the total psoas area was measured at the superior margin of the L4 vertebra by manually tracing the outline of the muscle. The total psoas area was measured in mm².

Statistical analyses. Chi-squared and Fisher's exact tests were used to compare categorical variables and Student's *t*-test or Mann-Whitney test were used to compare continuous variables, as appropriate. Pearson's correlation coefficient was used to analyze the associations between the psoas muscle mass and age, length of stay and discharge. *p*-Values of less than 0.05 were considered to indicate statistical significance. GraphPad PRISM version 5 software (GraphPad Software, San Diego, CA, USA) was used to perform the statistical analyses and create figures.

Results

A total of 46 patients met our criteria. The patient characteristics are shown in Table I. The study population included 21 male patients and 25 female patients. A total of 22 and 24 patients were classified into younger and elderly groups, respectively. The average age of the patients in the younger and elderly groups was 64.5 (36-74) years and 81.5 (75-95) years, respectively. Body mass index, white blood cell count and albumin values of the elderly group were significantly lower than those of the younger group. The

number of albumin samples was insufficient in both groups (young n=15, elderly n=19). The total psoas area of the younger group was significantly greater (by almost 70%) than that of the elderly group (*p*<0.0001).

The data on the intraoperative factors, including the diagnosis and types of procedure, are shown in Table II. The main causes of colonic perforation in both groups were malignant neoplasm, perforated diverticulitis and perforated colon. Partial colectomy with end colostomy was the most common procedure in this study. There were 16 (72.7%) cases of panperitonitis in the younger group and 20 (76.9%) in the elderly. The operative time of the elderly group was significantly shorter.

Postoperative complications and outcomes, including mortality, duration of hospital stay, and discharge, are shown in Table III. Various types of postoperative complications were experienced. With regard to mortality, one patient in the younger group died; there was no mortality in elderly group. The duration of hospital stay of the two groups did not differ to a statistically significant extent.

With regard to discharge, younger patients tended to return home, while elderly patients tended to be transferred to another hospital for further inpatient care and recovery (*p*=0.02). A significant negative correlation between age and the total psoas area was detected in the younger group (*R*=0.40, *p*=0.0015), but not in the elderly (*R*=0.12, *p*=0.08) (Figure 1A), while a significant negative correlation was observed between the length of stay and the psoas area in the younger group (*R*=0.23, *p*=0.023) (Figure 1B). In elderly group, there were no significant differences between the length of stay and the psoas area (*R*=0.026, *p*=0.45) (Figure 1B). There were no significant differences in total psoas area according to discharge in the elderly (*p*=0.20) nor younger (*p*=0.28) groups (Figure 2).

Discussion

This study demonstrated that a low total psoas muscle mass was associated with an increased postoperative length of stay after emergency surgery for colonic perforation in younger

Table II. *Intraoperative findings.*

Characteristic	Younger group (aged ≤74 years)	Elderly group (aged ≥75 years)
Diagnosis, n		
Malignant neoplasm	6	8
Perforated diverticulitis	9	6
Perforated colon	5	9
Penetrated diverticulitis	2	0
Diverticulitis	0	1
Procedure, n		
Partial colectomy	2	3
Partial colectomy with end colostomy	10	15
Partial colectomy with ileostomy	0	1
Colostomy	6	2
Ileostomy	0	1
Laparoscopic partial colectomy with end colostomy	1	0
Laparoscopic partial colectomy with ileostomy	1	1
Other	2	1
Panperitonitis, n (%)	16 (72.7)	20 (76.9)
Mean operative time (range), min*	217.5 (114-401)	165 (86-276)
Mean blood loss (range), ml [#]	277.5 (5-1,200)	95 (5-1,152)

Significantly different at * $p=0.004$ and $\#p=0.19$.

Table III. *Postoperative complications and outcomes.*

Demographics	Younger group (aged ≤74 years)	Elderly group (aged ≥75 years)
Postoperative complications, n	12	12
DIC	3	5
Abscess	2	2
Aspiration pneumoniae	1	2
Re-perforation	1	0
Paralytic ileus	2	0
Surgical site infection	1	0
Stoma complication	1	0
Cardiac complication	0	2
Urinary infection	0	1
Sepsis	2	0
Unknown fever	1	0
Mortality	1	0
Mean hospital stay (range), days*	20 (9-60)	19 (13-76)
Discharged, n [#]		
Home	15	8
Another hospital	6	16

DIC: Disseminated intravascular coagulation. Significantly different at * $p=0.72$ and $\#p=0.02$.

patients. On the other hand, in elderly patients, there was no correlation between the length of stay and the total psoas muscle mass, while the mortality, postoperative complications and the length of hospital stay were comparable to those of the younger population. We, therefore, consider the total psoas muscle mass to be useful as a quick and convenient measure that can be applied in the clinical setting – especially acute care surgery – to assess

sarcopenia in younger patients but not elderly patients.

As a marker of sarcopenia, the psoas muscle area has the advantage of being easily measured from available clinical computed tomographic (CT) data, irrespective of the patient's condition. Cross-sectional abdominopelvic CT images have most commonly been used as a surrogate for overall skeletal muscle mass (15). As preoperative abdominopelvic CT studies are usually performed in patients

Figure 1. A: Correlation between age and the total psoas muscle area. Correlation was significant in the younger group ($R=0.40$, $p=0.0015$), but not in the elderly group ($R=0.12$, $p=0.08$). B: Correlation between the length of stay and psoas area. Correlation was significant in the younger group ($R=0.23$, $p=0.023$), but not in the elderly group ($R=0.026$, $p=0.45$).

who have clinical signs of peritonitis in the Emergency Department, these images are readily available for evaluation of the psoas muscle mass. In a previous study, sarcopenia was significantly associated with worse patient outcomes, including mortality, complications, and discharge in patients who underwent emergency operations (13, 16). Furthermore, Zuckerman *et al.* demonstrated that a low psoas muscle area was associated with an increased postoperative length of stay after cardiac surgery (17). From these points, we hypothesized that the psoas muscle mass would also be useful for evaluating postoperative outcomes, including postoperative complications, mortality, length of stay, and discharge of acute care surgery patients of all ages. However, in the present study, the psoas muscle mass was not useful for evaluating the postoperative outcomes of elderly patients. The following reasons may explain these results. Firstly, many elderly patients would have sarcopenia, regardless of

their psoas muscle mass. Thus, there was no correlation between the length of hospital stay and the psoas muscle area. Secondly, the length of stay in the present study was only measured until the patient was discharged from our hospital. Many of the elderly patients were transferred to another hospital for further care and recovery. Thus, the length of stay of elderly patients was underestimated. These factors would have influenced the results for the elderly patient group.

A low psoas muscle mass would have a negative impact on the length of stay even in younger patients. The psoas muscle better reflects lower extremity muscle strength and mobility than do the lumbar and thoracic muscle groups. The psoas is a flexor of the lower extremity and a stabilizer of the lumbar vertebral column and hip joint; it therefore plays a crucial role in walking, standing from a seated position, and maintaining balance (18). Accordingly, the psoas muscle is

Figure 2. Total psoas area according to whether patients were discharged to their home or to another hospital. There was no significant association between the total psoas area and discharge in the elderly ($p=0.20$) nor the younger ($p=0.28$) group.

related to mobilization and regaining physical functions after an operation. Miller *et al.* reported that a larger psoas muscle area is associated with decreased odds of postoperative deficits in activities of daily living or instrumental activities of daily living after general surgery (19). Patients with a larger psoas muscle area are considered to be more capable and consequently more likely to achieve early mobilization, thereby reducing their length of hospital stay.

Sarcopenia may also reflect nutritional status, and predict infection and the ability to recover from surgery (13). A low nutritional status, also has a negative impact in relation to postoperative complications, length of stay, and discharge. At present, albumin is generally used as a measure of visceral protein and the skeletal muscle mass in clinical or nursing home settings as an evaluation of nutritional status; a low preoperative albumin level was significantly associated with poor patient outcomes (20). However, albumin is not always measured in patients undergoing emergency operations, as was shown in our study. Thus, we consider the measurement of psoas muscle mass to be a practical tool for evaluating the preoperative nutritional status. Before surgery, it is also necessary to explain the perioperative information, including the patient's condition, the treatment policy and the predicted prognosis, as well as obtaining informed consent from the patient and family, based on limited information. In this regard, the psoas muscle mass would be easy to introduce as it is a convenient and versatile measurement that can even be applied in cases involving emergency treatment. In addition, it is important to show this information to colleagues for preoperative discussion. These discussions can be used to plan tailored preventive strategies or for postoperative rehabilitation.

One limitation of the present study was the small number of patients with colonic perforation. As such, further investigations will be needed to confirm these findings.

Conclusion

Measurement of the psoas muscle area may be useful for predicting outcomes, including the length of stay in younger patients, but not for predicting the outcomes of emergency surgery in elderly patients. Assessments of the postoperative physical function are needed to further understand sarcopenia.

Disclosure

The Authors declare no conflicts of interest in association with the present study.

References

- Goodpaster BH, Park SW, Harris TB, Kritchevsky SB, Nevitt M, Schwartz AV, Simonsick EM, Tyllavsky FA, Visser M and Newman AB: The loss of skeletal muscle strength, mass, and quality in older adults: The Health, Aging and Body Composition Study. *J Gerontol A Biol Sci Med Sci* 61(10): 1059-1064, 2006.
- Delmonico MJ, Harris TB, Lee JS, Visser M, Nevitt M, Kritchevsky SB, Tyllavsky FA, Newman AB; Health, Aging and Body Composition Study: Alternative definitions of sarcopenia, lower extremity performance, and functional impairment with aging in older men and women. *J Am Geriatr Soc* 55(5): 769-774, 2007.
- Englesbe MJ, Patel SP, He K, Lynch RJ, Schaubel DE, Harbaugh C, Holcombe SA, Wang SC, Segev DL and Sonnenday CJ: Sarcopenia and mortality after liver transplantation. *J Am Coll Surg* 211(2): 271-278, 2010.

- 4 Peng PD, van Vledder MG, Tsai S, de Jong MC, Makary M, Ng J, Edil BH, Wolfgang CL, Schulick RD, Choti MA, Kamel I and Pawlik TM: Sarcopenia negatively impacts short-term outcomes in patients undergoing hepatic resection for colorectal liver metastasis. *HPB* 13(7): 439-446, 2011.
- 5 Lieffers JR, Bathe OF, Fassbender K, Winget M and Baracos VE: Sarcopenia is associated with postoperative infection and delayed recovery from colorectal cancer resection surgery. *Br J Cancer* 107(6): 931-936, 2012.
- 6 Peng P, Hyder O, Firoozmand A, Kneuert P, Schulick RD, Huang D, Makary M, Hirose K, Edil B, Choti MA, Herman J, Cameron JL, Wolfgang CL and Pawlik TM: Impact of sarcopenia on outcomes following resection of pancreatic adenocarcinoma. *J Gastrointest Surg* 16(8): 1478-1486, 2012.
- 7 van Vledder MG, Levolger S, Ayez N, Verhoef C, Tran TC and Ijzermans JN: Body composition and outcome in patients undergoing resection of colorectal liver metastases. *Br J Surg* 99(4): 550-557, 2012.
- 8 Sabel MS, Lee J, Cai S, Englesbe MJ, Holcombe S and Wang S: Sarcopenia as a prognostic factor among patients with stage iii melanoma. *Ann Surg Oncol* 18(13): 3579-3585, 2011.
- 9 Montano-Loza AJ, Meza-Junco J, Prado CM, Lieffers JR, Baracos VE, Bain VG and Sawyer MB: Muscle wasting is associated with mortality in patients with cirrhosis. *Clin Gastroenterol Hepatol* 10(2): 166-173, 173.e1, 2012.
- 10 Tandon P, Ney M, Irwin I, Ma MM, Gramlich L, Bain VG, Esfandiari N, Baracos V, Montano-Loza AJ and Myers RP: Severe muscle depletion in patients on the liver transplant wait list: Its prevalence and independent prognostic value. *Liver Transpl* 18(10): 1209-1216, 2012.
- 11 Cruz-Jentoft AJ, Baeyens JP, Bauer JM, Boirie Y, Cederholm T, Landi F, Martin FC, Michel JP, Rolland Y, Schneider SM, Topinkova E, Vandewoude M, Zamboni M and European Working Group on Sarcopenia in Older People: Sarcopenia: European consensus on definition and diagnosis: Report of the European Working Group on Sarcopenia in Older People. *Age Ageing* 39(4): 412-423, 2010.
- 12 Hasselager R and Gogenur I: Core muscle size assessed by perioperative abdominal ct scan is related to mortality, postoperative complications, and hospitalization after major abdominal surgery: A systematic review. *Langenbecks Arch Surg* 399(3): 287-295, 2014.
- 13 Du Y, Karvellas CJ, Baracos V, Williams DC, Khadaroo RG, Acute C and Emergency Surgery G: Sarcopenia is a predictor of outcomes in very elderly patients undergoing emergency surgery. *Surgery* 156(3): 521-527, 2014.
- 14 Dirks RC, Edwards BL, Tong E, Schaheen B, Turrentine FE, Shada A and Smith PW: Sarcopenia in emergency abdominal surgery. *J Surg Res* 207: 13-21, 2017.
- 15 Levolger S, van Vugt JL, de Bruin RW and JN IJ: Systematic review of sarcopenia in patients operated on for gastrointestinal and hepatopancreatobiliary malignancies. *Br J Surg* 102(12): 1448-1458, 2015.
- 16 Matsushima K, Inaba K, Jhaveri V, Cheng V, Herr K, Siboni S, Strumwasser A and Demetriades D: Loss of muscle mass: A significant predictor of postoperative complications in acute diverticulitis. *J Surg Res* 211: 39-44, 2017.
- 17 Zuckerman J, Ades M, Mullie L, Trnkus A, Morin JF, Langlois Y, Ma F, Levental M, Morais JA and Afilalo J: Psoas muscle area and length of stay in older adults undergoing cardiac operations. *Ann Thorac Surg* 103(5): 1498-1504, 2017.
- 18 Yoshio M, Murakami G, Sato T, Sato S and Noriyasu S: The function of the psoas major muscle: Passive kinetics and morphological studies using donated cadavers. *J Orthop Sci* 7(2): 199-207, 2002.
- 19 Miller AL, Min LC, Diehl KM, Cron DC, Chan CL, Sheetz KH, Terjimanian MN, Sullivan JA, Palazzolo WC, Wang SC, Hall KE and Englesbe MJ: Analytic morphomics corresponds to functional status in older patients. *J Surg Res* 192(1): 19-26, 2014.
- 20 Lidsky ME, Thacker JK, Lagoo-Deenadayalan SA and Scarborough JE: Advanced age is an independent predictor for increased morbidity and mortality after emergent surgery for diverticulitis. *Surgery* 152(3): 465-472, 2012.

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