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The effects of sarcopenic obesity on immediate postoperative outcomes after pancreatoduodenectomy: a retrospective cohort study

Jae Hwan Jeong[1,*], Ji Su Kim[2,*], Seung-seob Kim[3], Seung Soo Hong[1], Ho Kyoung Hwang[1], Chang Moo Kang[1], Hyoung-Il Kim[4], Kyung Sik Kim[1,†], Sung Hyun Kim[1,†]

[1]Department of Hepatobiliary and Pancreatic Surgery, Yonsei University College of Medicine, Seoul, Korea
[2]Division of Hepatobiliary, Pancreas, and Abdominal Organ Transplant, Department of Surgery, The Catholic University of Korea Incheon St. Mary's Hospital, Incheon, Korea
[3]Department of Radiology and Research Institute of Radiological Science, Yonsei University College of Medicine, Seoul, Korea
[4]Department of Gastrointestinal Surgery, Yonsei University College of Medicine, Seoul, Korea

Purpose: Several studies have evaluated the impact of sarcopenic obesity (SO) on postoperative complications, including postoperative pancreatic fistula (POPF), in patients undergoing pancreatoduodenectomy (PD). Previous studies have shown that SO increases POPF, but it remains unclear whether SO increases postoperative complications. In this study, we aimed to determine the relationship between SO and immediate postoperative complications.
Methods: From January 2005 to December 2019, the medical records of patients who underwent PD for periampullary cancer were retrospectively reviewed. Skeletal muscle index (SMI) and visceral fat area (VFA) were calculated from preoperative computed tomography images. Patients with high VFA were classified as obese, while those with low SMI were classified as sarcopenic. Patients were divided into 4 groups: normal group, sarcopenia only group, obesity only group, and SO group. Postoperative outcomes were compared between groups, and factors affecting postoperative complications were analyzed by multivariate analysis.
Results: Normal group (n = 176), sarcopenia only group (n = 130), obesity only group (n = 207), and SO group (n = 117) were analyzed retrospectively. SO group had significantly more frequent major complications compared to the normal group (P = 0.006), as well as a significantly more frequent clinically relevant POPF compared to the other groups (P = 0.002). In multivariate analysis, SO was an independent risk factor for major complications (P = 0.008) and clinically relevant POPF (P = 0.003).
Conclusion: SO is a factor associated with poor immediate postoperative outcomes after PD for periampullary cancer.
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Key Words: Body composition, Obesity, Pancreatoduodenectomy, Postoperative complications, Sarcopenia

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Corresponding Author: Sung Hyun Kim
Department of Hepatobiliary and Pancreatic Surgery, Yonsei University College of Medicine, 50-1 Yonsei-ro, Seodaemun-gu, Seoul 03722, Korea
Tel: +82-2-2228-2100, **Fax:** +82-2-313-8289, **E-mail:** ohliebe@yuhs.ac, **ORCID:** https://orcid.org/0000-0001-7683-9687
Co-Corresponding Author: Kyung Sik Kim
Department of Hepatobiliary and Pancreatic Surgery, Yonsei University College of Medicine, 50-1 Yonsei-ro, Seodaemun-gu, Seoul 03722, Korea
Tel: +82-2-2228-2100, **Fax:** +82-2-313-8289, **E-mail:** kskim88@yuhs.ac, **ORCID:** https://orcid.org/0000-0001-9498-284X

*Jae Hwan Jeong and Ji Su Kim contributed equally to this study as co-first authors.
†Kyung Sik Kim and Sung Hyun Kim contributed equally to this study as co-corresponding authors.

INTRODUCTION

Pancreatoduodenectomy (PD) is the gold standard of treatment for periampullary cancer. Although the technique for PD is more advanced than in the past, there is still a high possibility of postoperative morbidity [1]. In particular, the incidence of postoperative complications, such as postoperative pancreatic fistula (POPF), delayed gastric emptying (DGE), and postoperative pancreatic hemorrhage (PPH), is around 30%–60% [2,3]. Many factors contribute to the occurrence of complications after PD [4,5].

Among them, malnutrition is an emerging risk factor affecting immediate surgical outcomes. With increasing interest in the relationship between nutrition and cancer, several studies have suggested that poor nutritional status is associated with poor surgical outcomes for gastrointestinal cancers, including periampullary cancer, in the hepato-biliary-pancreatic (HBP) field [6,7]. Further, recent data show that malignant diseases in the HBP field, such as hepatocellular carcinoma and pancreatic cancer, have increased steadily in prevalence and make up a large portion of cancer in older patients [8]. Given that the natural aging process is characterized by a gradual loss of lean muscle mass with a concomitant increase in adiposity, a process known as sarcopenia, HBP surgeons have been interested in this issue [9].

Sarcopenic obesity (SO) is a term used to describe a typical state of malnutrition in which low muscle mass and high body fat coexist [10]. Presently, the SO population has increased due to the synergistic effects of the increase in the aging population and physical inactivity [10,11]. By 2050, it is estimated that 100 million–200 millon people will have SO, which is associated with a variety of diseases and is closely linked to a poor quality of life [11].

Several methods for measuring nutritional status have been devised, and body composition can be calculated using imaging techniques, such as CT, which can indirectly determine a patient's nutritional status [12]. Several studies have identified a correlation between malnutrition and postoperative complications in pancreatic surgery, but the evidence is poor [13].

Therefore, in this study, we aimed to determine the SO status of periampullary cancer patients who underwent PD with body composition calculated from CT images, and to investigate the relationship between SO and immediate postoperative outcomes.

METHODS

Ethics statements

This study was approved by the Institutional Review Board of Severance Hospital (No. 4-2023-0674). It was performed in accordance with the Declaration of Helsinki and written informed consent was waived due to its retrospective nature.

Patients and data collection

From January 2005 to December 2019, the medical records of patients who underwent PD for periampullary cancer in Severance Hospital were retrospectively reviewed. Patients who had preoperative CT images available for review were enrolled in the study. Clinical data of age, sex, body mass index (BMI), operative time, estimated intraoperative blood loss (EBL), neoadjuvant treatment status, American Society of Anesthesiologists (ASA) classification, preoperative CA 19-9, postoperative complications, and length of hospital stay were collected. In addition, the alternative fistula risk score (a-FRS) was calculated from pancreatic duct diameter, pancreatic texture, and BMI [14].

Major complications were defined by a Clavien-Dindo morbidity classification score of grade III or higher, and clinically relevant POPF (CR-POPF) was defined as grade B or C as defined by the International Study Group of Pancreatic Fistulae (ISGPF) [15,16]. In addition, diagnoses of DGE, PPH, and bile leakage were defined according to the International Study Group of Pancreatic Surgery (ISGPS) [17,18].

Computed tomography analysis

All preoperative CT images obtained within one month before the surgery were stored in DICOM format and imported into commercial 3-dimensional analysis software. The cross-sectional surface (cm^2) of the visceral fat area (VFA), superficial fat area, and skeletal muscle area (SMA) was automatically quantified at the third lumbar (L3) vertebra using the program for the CT imaging server platform (Aquarius iNtuition Viewer, ver. 4.4.13, TeraRecon Inc.). An image slice at L3 was selected, from which muscle and fat were classified according to Hounsfield units (HU): –29 to +150 HU for skeletal muscle and –190 to –30 HU for adipose tissue [19]. After determining the cross-sectional area of skeletal muscle, this area was divided by the square of the height to obtain the skeletal muscle index (SMI), which compensates for height.

Definition and groups of sarcopenic obesity

Obesity was defined as VFA >100 cm^2, which was in accordance with the Japanese criteria [20], and sarcopenia was defined as SMI ≤49 cm^2/m^2 for male and ≤31 cm^2/m^2 for female, calculated by a regression equation based on the sarcopenia cutoff of appendicular skeletal muscle mass reported in a previous Korean epidemiologic study [21,22]. Using these criteria, patients were divided into 4 groups: (A) normal, with no obesity and no sarcopenia; (B) sarcopenia only, with no obesity and sarcopenia; (C) obesity only, with obesity and no sarcopenia; and (D) SO, with sarcopenia and obesity.

Assessment of postoperative outcomes according to sarcopenic obesity

To investigate the differences between the 4 groups, clinical characteristics and outcomes of EBL, operating time, a-FRS, postoperative complications, and length of hospital stay were compared. In addition, the odds ratio (OR) of SO was assessed with other factors related to postoperative complications after PD (age, neoadjuvant chemotherapy, ASA class, vascular resection, EBL, and a-FRS) [4,5].

Table 1. Basic patient characteristics

Characteristic	Data
No. of patients	630
Age (yr)	64.82 ± 9.14
No. of older patients[a]	349 (55.4)
Sex	
Male	378 (60.0)
Female	252 (40.0)
Body mass index (kg/m²)	23.27 ± 6.16
Type of cancer	
Pancreatic cancer	308 (48.9)
Bile duct cancer	311 (49.4)
Ampulla of Vater cancer	2 (0.3)
Others	9 (1.4)
ASA class ≥III	241 (38.3)
Neoadjuvant treatment +	118 (18.7)
Preoperative CA 19-9 (U/mL)	382.87 ± 1294.49
Visceral fat area (cm²)	113.38 ± 63.32
Skeletal muscle area (cm²)	118.43 ± 27.03
Skeletal muscle index (cm²/m²)	42.69 ± 6.63
Operation time (min)	546.45 ± 159.00
Estimated blood loss (mL)	503.44 ± 479.65
Pancreatic texture	
Soft	346 (54.9)
Hard	284 (45.1)
Pancreatic duct diameter (mm)	3.47 ± 1.44
a-FRS (%)	12.06 ± 8.83
CR-POPF	73 (11.6)
Major complication[b]	95 (15.1)
Sarcopenia	247 (39.2)
Obesity	324 (51.4)
Sarcopenic obesity	117 (18.6)

Values are presented as number only, mean ± standard deviation, or number (%).
ASA, American Society of Anesthesiologists; a-FRS, alternative fistula risk score; CR-POPF, clinically relevant postoperative pancreatic fistula.
[a]Above 65 years old. [b]Clavien-Dindo classification ≥III.

Statistical analysis

Continuous variables were expressed as mean and standard deviation (SD), and comparisons of variables between groups were performed using a 1-way analysis of variance and the Fisher least significant difference *post hoc* test in cases of significant differences. Clinically known variables were selected for univariate analysis, and logistic regression analysis was used to determine their relationship with complications. Variables that were significant ($P < 0.05$) in the univariate analysis were tested in a multivariate logistic regression model to test the independence of risk and associated factors. For all tests, a P-value less than 0.05 was considered significant. All analyses were performed with IBM SPSS Statistics ver. 26.0 (IBM Corp.).

RESULTS

Basal characteristics of the enrolled patients

A total of 630 patients were reviewed, and patient characteristics are summarized in Table 1. The mean age of the study population was 64.82 years (SD, ±9.14). Two hundred forty-seven patients (39.2%) were classified as having sarcopenia, and 324 patients (51.4%) were classified as having obesity. Patients were divided into (A) normal group (n = 176, 27.9%), (B) sarcopenia only group (n = 130, 20.6%), (C) obesity only group (n = 207, 32.9%), and (D) SO group (n = 117, 18.6%) (Fig. 1). There were 95 patients (15.1%) with major complications and 73 patients (11.6%) with CR-POPF.

Comparison of basal characteristics between the enrolled groups

When comparing the 4 groups, there were significant

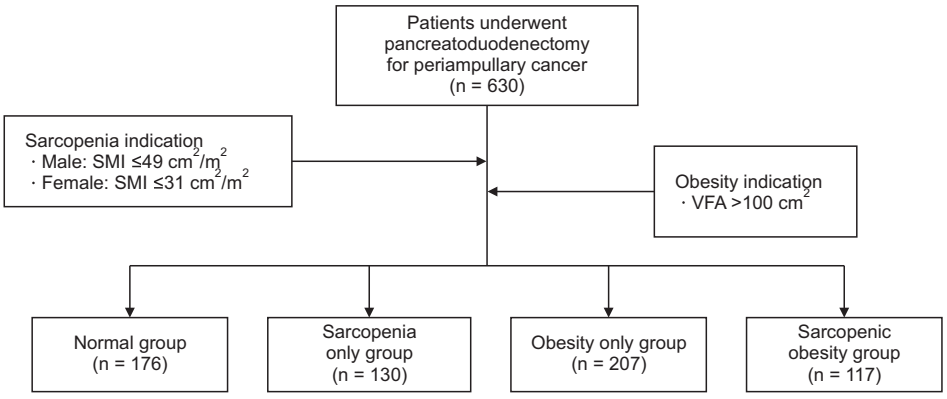

Fig. 1. Study flow diagram. SMI, skeletal muscle index (skeletal muscle area/height); VFA, visceral fat area.

Table 2. Comparison of clinical characteristics between normal and SO groups

Characteristic	A: Normal group (n = 176)	B: Sarcopenia only group (n = 130)	C: Obesity only group (n = 207)	D: SO group (n = 117)	P-value			
					Total	A *vs.* B	A *vs.* C	A *vs.* D
Age (yr)	63.80 ± 9.48	64.58 ± 8.76	64.70 ± 9.44	66.82 ± 8.29	0.048	0.457	0.339	0.006
No. of older patients[a)]	89 (50.6)	69 (53.1)	117 (56.5)	74 (63.2)	0.175	0.662	0.243	0.033
Sex					<0.001	<0.001	<0.001	<0.001
Male	42 (23.9)	117 (90.0)	107 (51.7)	112 (95.7)				
Female	134 (76.1)	13 (10.0)	100 (48.3)	5 (4.3)				
Body mass index (kg/m^2)	21.99 ± 2.06	20.46 ± 2.12	26.07 ± 9.60	23.47 ± 2.36	<0.001	0.025	<0.001	0.034
VFA (cm^2)	66.93 ± 23.23	53.94 ± 27.50	162.94 ± 44.73	161.63 ± 50.68	<0.001	0.003	<0.001	<0.001
SMA (cm^2)								
Male	145.59 ± 13.09	117.54 ± 16.89	151.88 ± 16.58	121.88 ± 16.57	<0.001	<0.001	0.035	<0.001
Female	96.12 ± 15.76	64.98 ± 19.97	107.47 ± 21.16	74.72 ± 6.49	<0.001	<0.001	<0.001	0.010
SMI (cm^2/m^2)								
Male	52.92 ± 3.02	42.56 ± 4.46	54.47 ± 5.07	43.28 ± 4.56	<0.001	<0.001	0.061	<0.001
Female	39.47 ± 5.12	26.74 ± 8.01	43.18 ± 6.16	29.79 ± 0.94	<0.001	<0.001	<0.001	<0.001
Operating time (min)	514.70 ± 148.73	525.30 ± 160.29	573.96 ± 149.96	569.38 ± 177.75	0.001	0.578	<0.001	0.006
EBL (mL)	469.26 ± 442.97	432.27 ± 415.67	515.85 ± 493.80	611.97 ± 553.84	0.019	0.503	0.341	0.012
Vascular resection	33 (18.8)	26 (20.0)	36 (17.4)	19 (16.2)	0.872	0.780	0.731	0.586
ASA class ≥III	55 (31.3)	56 (43.1)	90 (43.5)	53 (45.3)	0.037	0.037	0.015	0.016
Neoadjuvant chemotherapy +	37 (21.0)	24 (18.5)	32 (15.5)	25 (21.4)	0.458	0.571	0.165	0.941
Preoperative CA 19-9 (U/mL)	348.34 ± 1,127.94	326.76 ± 1,137.96	270.23 ± 739.52	694.69 ± 2,147.91	0.034	0.886	0.557	0.025
a-FRS (%)	10.55 ± 7.32	9.57 ± 6.56	14.83 ± 10.72	12.18 ± 8.14	<0.001	0.323	<0.001	0.113

Values are presented as mean ± standard deviation or number (%).
SO, sarcopenic obesity; VFA, visceral fat area; SMA, skeletal muscle area; SMI, Skeletal muscle index; EBL, estimated blood loss; ASA, American Society of Anesthesiologists; a-FRS, alternative fistula risk score.
[a)]Above 65 years old.

differences in age (P = 0.048). In the *post hoc* analysis, there were significant differences in age between the normal group and SO group (63.80 years *vs.* 66.82 years, P = 0.006). Operative time (P = 0.001) and EBL (P = 0.019) were significantly different between groups. In particular, when comparing operative time, there was a significant difference between the normal group and obesity only group (514.70 minutes *vs.* 573.96 minutes, P < 0.001), and between the normal group and SO group (514.70 minutes *vs.* 569.38 minutes, P = 0.006). When comparing EBL, there was also a significant difference between the normal group and SO group (469.26 mL *vs.* 611.97 mL, P = 0.012). ASA class III or higher (P = 0.037) was significantly different between groups. The proportion of ASA class III or higher was lower in the normal group compared to the other groups (normal group, 31.3%; sarcopenia only group, 43.1%; obesity only group, 43.5%; and SO group 45.3% [normal group *vs.* sarcopenia only group, P = 0.037; normal group *vs.* obesity only group, P = 0.015; normal group *vs.* SO group, P = 0.025]) (Table 2).

Comparison of postoperative outcomes between the enrolled groups

The occurrence of POPF was significantly different between groups (P = 0.018); especially, there was a significant difference between the normal group and obesity only group (29.6% *vs.* 38.6%, P = 0.016), and between the normal group and SO group (29.6% *vs.* 38.5%, P = 0.012). CR-POPF was more frequent in the SO group compared to the other groups (normal group, 6.3%; sarcopenia only group, 8.5%; obesity only group, 13.5%; and SO group 19.7% [normal group *vs.* sarcopenia only group, P = 0.037; normal group *vs.* obesity only group, P = 0.033; normal group *vs.* SO group, P = 0.038]). Major complications (P = 0.043) were significantly different between groups. There was a significant difference between the normal group and SO group in the occurrence of major complications (11.4% *vs.* 23.1%, P = 0.006). Postoperative hospital stay (normal group, 21.55 days; sarcopenia only group, 21.87 days; obesity only group, 20.70 days; and SO group, 21.19 days; P = 0.947) and readmission within 90 days (normal group, 3.4%; sarcopenia only group, 3.8%; obesity only group, 3.9%; and SO group, 7.7%: P = 0.306) were not significantly different between groups (Table 3).

Independent prognostic factors after pancreatoduodenectomy

In the univariate analysis of SO, a-FRS was associated with a significantly higher frequency of major complications and CR-POPF (Supplementary Table 1). In the multivariate analysis, SO (OR, 1.971 [95% CI, 1.193–3.257]; P = 0.008) and a-FRS (OR, 1.025 [95% CI, 1.002–1.049]; P = 0.032) were independent factors for major complications. For the occurrence of CR-POPF, SO and a-FRS were also independent risk factors (OR, 2.312 [95% CI, 1.335–4.004]; P = 0.003 and OR, 1.049 [95% CI, 1.021–1.077]; P <0.001, respectively) (Table 4). In multivariate analyses with sarcopenia and obesity instead of SO, named the sarcopenia model and the obesity model, sarcopenia (OR, 1.765 [95% CI, 1.130–2.756]; P = 0.013) was an independent factor for major complications but not for CR-POPF in the sarcopenia model, and obesity (OR, 2.058 [95% CI, 1.198–3.534]; P = 0.009) was an independent factor for CR-POPF but not for major complications

Table 3. Comparison of complications between normal and SO groups

Characteristic	A: Normal group (n = 176)	B: Sarcopenia only group (n = 130)	C: Obesity only group (n = 207)	D: SO group (n = 117)	P-value			
					Total	A *vs.* B	A *vs.* C	A *vs.* D
POPF					0.018	0.743	0.016	0.012
No POPF	124 (70.5)	97 (74.6)	127 (61.4)	72 (61.5)				
BL	41 (23.3)	22 (16.9)	52 (25.1)	22 (18.8)	0.262	0.182	0.666	0.362
Grade B	10 (5.7)	4 (3.1)	22 (10.6)	22 (18.8)				
Grade C	1 (0.6)	7 (5.4)	6 (2.9)	1 (0.9)				
CR-POPF[a]	11 (6.3)	11 (8.5)	28 (13.5)	23 (19.7)	0.002	0.037	0.033	0.038
Bile leakage	9 (5.1)	5 (3.8)	13 (6.3)	3 (2.6)	0.461	0.607	0.594	0.316
DGE	59 (33.5)	37 (28.5)	68 (32.9)	46 (39.3)	0.396	0.590	0.896	0.222
PPH	3 (1.7)	8 (6.2)	5 (2.4)	6 (5.1)	0.110	0.036	0.705	0.118
Complication	166 (94.3)	111 (85.4)	196 (94.7)	114 (97.4)	0.001	0.002	0.886	0.295
Major complication[b]	20 (11.4)	20 (15.4)	28 (13.5)	27 (23.1)	0.043	0.330	0.554	0.006
Total hospital stay (day)	29.41 ± 57.32	27.83 ± 15.60	26.54 ± 12.63	27.82 ± 11.25	0.860	0.672	0.385	0.679
Postoperative hospital stay (day)	21.55 ± 29.97	21.87 ± 14.27	20.70 ± 10.88	21.19 ± 9.98	0.947	0.881	0.658	0.873
Readmission within 90 days	6 (3.4)	5 (3.8)	8 (3.9)	9 (7.7)	0.306	0.855	0.829	0.082

Values are presented as number (%) or mean ± standard deviation.
SO, sarcopenic obesity; POPF, postoperative pancreatic fistula; CR, clinically relevant; DGE, delayed gastric emptying; PPH, postpancreatectomy hemorrhage.
[a]POPF ≥grade B. [b]Clavien-Dindo classification ≥III.

Table 4. Multivariate analysis results for major complication and CR-POPF

Predictor	For major complication[a]		CR-POPF[b]	
	OR (95% CI)	P-value	OR (95% CI)	P-value
Age	1.019 (0.992–1.046)	0.176	0.985 (0.957–1.015)	0.325
Neoadjuvant treatment +	1.323 (0.733–2.390)	0.353	0.663 (0.304–1.448)	0.302
ASA class ≥III	1.014 (0.633–1.624)	0.953	1.239 (0.730–2.104)	0.426
Vascular resection	1.054 (0.575–1.931)	0.864	0.662 (0.300–1.460)	0.307
EBL	1.000 (1.000–1.001)	0.559	1.000 (1.000–1.001)	0.349
a-FRS	1.025 (1.002–1.049)	0.032	1.049 (1.021–1.077)	<0.001
Sarcopenic obesity	1.971 (1.193–3.257)	0.008	2.312 (1.335–4.004)	0.003

CR-POPF, clinically relevant postoperative pancreatic fistula; OR, odds ratio; CI, confidence interval; ASA, American Society of Anesthesiologists; EBL, estimated blood loss; a-FRS, alternative fistula risk score.
[a]Clavien-Dindo classification ≥III. [b]International Study Group of Pancreatic Fistulae grade ≥B.

in the obesity model (Supplementary Table 2).

DISCUSSION

This study showed immediate postoperative outcomes of patients who underwent PD for periampullary cancer and were classified as having SO according to the body composition parameters calculated by preoperative CT images. The SO group had significantly longer operative time and greater EBL compared to the normal group. The SO group had significantly more frequent major complications and significantly more frequent CR-POPF compared to the normal group. In the multivariate analysis, SO was a significant independent factor for predicting major complications and CR-POPF. These results suggest that body composition obtained from preoperative CT can be used to classify patients with SO to help predict immediate postoperative outcomes.

SO is a combination of obesity and sarcopenia. Increased body fat tissue promotes the secretion of proinflammatory cytokines, such as tumor necrosis factor-alpha and interleukin-6, creating a chronic inflammatory state that inhibits wound healing and physical recovery after surgery, increasing the risk of various complications [23]. In patients with sarcopenia, the secretion of cytokines such as myokines that counteract proinflammatory adipokines is reduced, increasing the risk of complications in a similar manner as described above [24]. Low muscle mass indicates malnutrition, and malnourished patients have a weakened immune system, impaired tissue healing, and increased susceptibility to infection, all of which contribute to an increased incidence of complications [25]. For a combination of these reasons, SO could affect postoperative outcomes.

Some previous studies have reported that age affects postoperative outcomes [4,5]. In our study, the SO group was significantly older than the normal group; however, the difference was only about 3 years, so it is unlikely to have a clinical impact. Furthermore, multivariate analysis also showed that age did not affect postoperative outcomes. Additionally, obese patients had greater EBL and longer operative times. In this study, the obesity groups (obesity only and SO groups) had longer mean operative time and greater EBL compared to the other groups. The reason for the large amount of EBL in patients with a relatively high proportion of adipose tissue is due to the difficulty in visualizing the vascular structure of the mesentery and the limited space in the abdominal cavity. Moreover, a large amount of EBL leads to a longer operative time [26].

In this study, we divided the immediate postoperative outcomes into CR-POPF, which is the most important complication that can occur after PD, and major complications. Also, we analyzed the factors that affected the occurrence of each, including SO. Previous studies have focused on POPF, and it is controversial whether SO affects major complications after PD [14,15]. It is generally accepted that POPF is an inevitable event during pancreatectomy, and surgeons focus on CR-POPF, which affects the clinical outcomes of patients. Therefore, we focused on CR-POPF rather than POPF in this study and found that the occurrence of CR-POPF was more frequent in the SO group than in the normal group. Multivariate analysis with obesity instead of SO showed that obesity was an independent predictor of CR-POPF. The occurrence of POPF is influenced by the soft texture of the pancreas, with a soft, fatty pancreas being particularly common in patients with severe visceral obesity. This is known to increase the risk of leakage and thus the occurrence of CR-POPF [14,26,27].

On the other hand, sarcopenia reflects the nutritional status of the patient and is an important predictor of surgical and oncologic outcomes in several cancers by the mechanisms previously explained. Sarcopenia has been found to be associated with a poorer overall prognosis, particularly with an increased incidence of postoperative complications [7,28]. In PD, sarcopenia has also been reported to be associated with increased postoperative complications and slower recovery after PD [29]. In this study, multivariate analysis with sarcopenia

instead of SO showed that sarcopenia was an independent predictor of major complications.

In the case of SO, the 2 factors, obesity and sarcopenia, may have acted synergistically to influence immediate postoperative outcomes. This means that one cause can lead to complications and the other can exacerbate them. In the case of POPF, there was a difference in the incidence of CR-POPF between the normal and SO groups in this study, but no difference was found in the incidence of biochemical leak (BL) POPF. This means that except for technical failure, the normal group overcame POPF with rapid natural healing and often recovered to the level of BL POPF. However, in the SO group, recovery was slow and POPF eventually progressed to CR-POPF. This suggests that the occurrence of CR-POPF in SO might be more highly related to recovery or relief of POPF rather than its occurrence. In addition, although sarcopenia was not an independent factor in the occurrence of CR-POPF and obesity was not an independent factor in the occurrence of major complications in the multivariate analysis, this may be due to the small number of patients studied and it is expected that a study with a larger number of patients may obtain more significant results.

Although this study showed the clinical impact of preoperative SO after PD, it had several limitations. First, this was a retrospective study conducted in a single center by various surgeons with differences in the method of surgery (e.g., open or laparoscopic) or postoperative management. This may have resulted in selection bias. In addition, when classifying sarcopenia, this study only evaluated SMA obtained from preoperative CT and did not comprehensively analyze muscle area, muscle strength, or physical performance due to its retrospective design [30]. Second, this study was performed with a small sample size. Although more than 600 patients were enrolled in this study, the division of enrolled patients into 4 groups may have limited the analysis due to the small number of patients in each group. Third, the cutoff values used to define obesity and sarcopenia were adapted according to the characteristics of Koreans. This could be a strength of the study in that it enhanced precision. However, in terms of generalization, these results should be validated for patients of other countries or races. Further studies including large populations and various races were required.

In conclusion, differentiating a group of patients with SO by preoperative CT and following these patients more closely postoperatively may help to predict and prevent postoperative complications. In addition, it is thought that improving the condition of SO by supporting nutritional aspects and increasing the amount of muscle mass through exercise before surgery will reduce the incidence of postoperative complications.

SUPPLEMENTARY MATERIALS

Supplementary Tables 1 and 2 can be found via https://doi.org/10.4174/astr.2024.107.4.203.

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Conflict of Interest

No potential conflict of interest relevant to this article was reported.

ORCID iD

Jae Hwan Jeong: https://orcid.org/0009-0006-8863-9176
Ji Su Kim: https://orcid.org/0000-0002-9501-9665
Seung-seob Kim: https://orcid.org/0000-0001-6071-306X
Seung Soo Hong: https://orcid.org/0000-0001-9913-8437
Ho Kyoung Hwang: https://orcid.org/0000-0003-4064-7776
Chang Moo Kang: https://orcid.org/0000-0002-5382-4658
Hyoung-Il Kim: https://orcid.org/0000-0002-6134-4523
Kyung Sik Kim: https://orcid.org/0000-0001-9498-284X
Sung Hyun Kim: https://orcid.org/0000-0001-7683-9687

Author Contribution

Conceptualization, Methodology, Formal Analysis: JHJ, JSK, KSK, SHK
Investigation: JHJ, JSK, SK, HIK, KSK, SHK
Project Administration, Supervision: SSH, HKH, CMK, KSK, SHK
Writing – Original Draft: JHJ, JSK, KSK, SHK
Writing – Review & Editing: All authors

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