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The relationship between colonic diverticulosis and abdominal visceral and subcutaneous fat accumulation measured by abdominal CT scan

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Original Article

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ABSTRACT

Background/Aims: Besides age, risk factors for colonic diverticular disease include dietary meat intake and Western lifestyles, which are also risk factors for obesity. However, the association between obesity and colonic diverticular disease, including diverticulosis and diverticulitis, is not well established. The aim of this study was to investigate the relationship between colonic diverticulosis and obesity using abdominal fat quantified by abdominal CT scan and lipid profiles, as well as body mass index (BMI).

Materials and Methods: In this study based on a retrospective case note review, we enrolled 133 subjects (control group (n=55), diverticulosis group (31), and diverticulitis group (47)). Abdominal fat areas (total abdominal fat, visceral fat, subcutaneous fat) were quantified by abdominal CT scan. Serum lipid profiles and BMI were checked. Statistical analysis was performed by independent t-tests, with significance set at $p<0.05$.

Results: In the diverticulosis group, total abdominal fat area, visceral fat area, and abdominal subcutaneous fat area were all larger than those of the control and diverticulitis groups. In the diverticulitis group, total cholesterol, high density lipoprotein (HDL), low-density lipoprotein (LDL), and BMI were lower than in the control and diverticulosis groups. There were no significant differences between the three groups in visceral-to-subcutaneous abdominal fat ratios and serum triglyceride levels.

Conclusion: In conclusion, obesity may predispose one to occurrence of colonic diverticulosis. Abdominal fat measurement by CT scan may be a good method of assessing risk of colonic diverticular disease.

Keywords: Colonic diverticulosis, abdominal fat, obesity, computed tomography

INTRODUCTION

Colonic diverticular disease is relatively common in Western countries, and its prevalence increases with age. According to a survey conducted in the west, the prevalence is less than 10% under the age of 40 but 50%-66% over the age of 80 (1,2). Recently, in several Asian countries, the occurrence of colonic diverticulosis has been steadily increasing, and in Korea, it has reached about 10% according to a national report (3). Colonic diverticular disease can be divided into uncomplicated diverticular diseases, such as diverticulosis, and complicated diverticular diseases, including diverticulitis and diverticular bleeding (1,4,5). Although age is the most powerful risk factor for this disorder, dietary meat intake and Western lifestyles are known to be significantly associated with it. In addition to these risk factors, other researchers have reported that physical inactivity, decreased intake of dietary fiber, genetic factors, and use of aspirin or nonsteroidal anti-inflammatory drugs may be risk factors for diverticulosis or complicated diverticular diseases (6-10). It has also been reported that obesity increases the risk of complicated diverticular diseases, such as diverticulitis or diverticular bleeding (7,11-16). However, Sorser et al. (17) found no relationship between obesity and diverticulitis. Therefore, the matter is controversial. Also, the association between obesity and uncomplicated diverticular disease has not been clearly established. In assessing the relevance of obesity to colonic diverticular disease, previous studies have used body mass index (BMI), dietary habits, or abdominal diameter as parameters to define obesity

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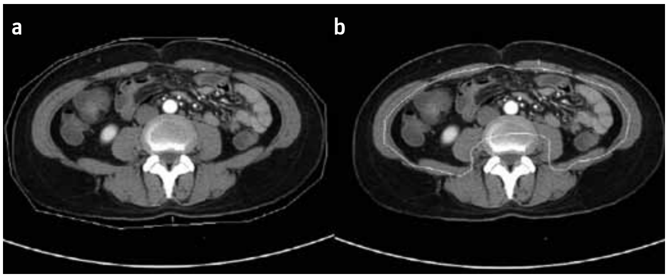

Figure 1. a, b. Measurement of abdominal fat area at the umbilicus. The total fat area was measured by outlining the circumference of the abdominal wall **(a).** The visceral fat area was measured by tracing around the inner margin of the abdominal muscles **(b).**

(11,18). However, recent studies have shown that visceral fat composition and serum cholesterol levels are more relevant to obesity as a health risk factor rather than these other parameters (19). In the present study, we used abdominal visceral fat, subcutaneous fat and lipid profiles, as well as BMI, to analyze the relationship between obesity and colonic diverticular disease.

The aim of this study was therefore to evaluate the relationship between colonic diverticular diseases and BMI, serum lipid profiles, abdominal subcutaneous fat, and visceral fat, measured by abdominal CT scan.

MATERIALS AND METHODS

Patient population

This study was approved by the institutional review board at our institution. Among the patients undergoing colonoscopy (CF-H260 or CF-H240; Olympus, Tokyo, Japan) for the purpose of health screening in Hanyang University Hospital from 2003 to 2008, we enrolled 55 who had normal endoscopic findings and 31 diagnosed with diverticulosis by endoscopy. We also enrolled another 47 individuals during the same period who were admitted to Hanyang University Hospital with abdominal pain and diagnosed with diverticulitis by abdominal CT (Somatom Plus 4 Siemens or Somatom Sensation 16 Siemens, Erlangen, Germany) and colonoscopy. The medical records were reviewed retrospectively. Cases of colon diverticular disease with polyps or malignant tumors on colonoscopy were excluded.

Definitions

The individuals with normal colonoscopy findings were defined as the control group. Those with colonic diverticula by colonoscopy but who did not complain of any abdominal symptoms were defined as the diverticulosis group, and those who visited the emergency room or outpatient clinic due to abdominal pain and who were confirmed as diverticulitis on colonoscopy and abdominal CT were defined as the diverticulitis group.

Measurement of abdominal fat area (Figure 1)

A single cross-sectional scan at the level of the umbilicus (the fourth and fifth lumbar disc position) was selected for quantification. Adipose tissue was determined by setting the attenuation level between -190 and -30 Hounsfield units, and the acquired image corresponded to the total fat region. The region of visceral fat (unit: cm^2) was defined by manual tracing of its contour, and the total fat region was then divided into visceral and subcutaneous regions (20).

Table 1. Baseline characteristics of the patients

	normal (n=55)	Diverticulosis (n=31)	Diverticulitis (n=47)
Age (year)	52.13±11.76	52.13±10.41	49.57±11.29
Gender (M:F)	27:28	15:16	28:19

M: male; F: female

Chart review

The body mass index (BMI) was calculated by retrospective chart review of subjects from their heights and weights at the time of hospitalization for diverticulitis or when they underwent a health check. Serum triglyceride (TG) levels, total cholesterol, high-density lipoprotein cholesterol (HDL-cholesterol), and low-density lipoprotein (LDL-cholesterol) levels were investigated. A body mass index was assigned to each individual according to the WHO measure (BMI=kg/m^2) (18).

Statistical analysis

Statistical analysis was performed with Windows, SPSS version 12.0 (SPSS Inc., Chicago, IL, USA). The three groups were compared by independent t-tests. P-values of less than 0.05 were considered statistically significant.

RESULTS

Baseline characteristics of the patients

A total of 133 subjects were included in the study. The control group consisted of 55 individuals (27 males), the diverticulosis group consisted of 31 patients (15 males), and the diverticulitis group consisted of 47 patients (28 males) (Table 1). The mean age was 52.1 years in the control group, 52.2 in the diverticulosis group, and 50.7 in the diverticulitis group, with no statistically significant differences between the groups.

Abdominal fat

The mean total fat area was 245.81 cm^2 (95% CI, 144.07-347.55) in the control group, 309.64 cm^2 (95% CI 188.75-430.53) in the diverticulosis group, and 238.30 cm^2 (95% CI 126.34-340.26) in the diverticulitis group. The mean visceral fat area was 108.83 cm^2 (95% CI 40.34-177.32) in the control group, 142.47 cm^2 (95% CI 75.02-209.92) in the diverticulosis group, and 114.34 cm^2 (95% CI 58.29-170.39) in the diverticulitis group. The mean subcutaneous fat area was 136.97 cm^2 (95% CI 84.41-189.53) in the control group, 167.16 cm^2 (95% CI 94.12-240.20) in the diverticulosis group, and 121.32 cm^2 (95% CI, 63.61-179.03) in the diverticulitis group. The mean visceral fat/subcutaneous fat ratio (VSR) was 0.83 (95% CI 0.34-1.32) in the control, 0.93 (95% CI 0.50-1.36) in the diver-

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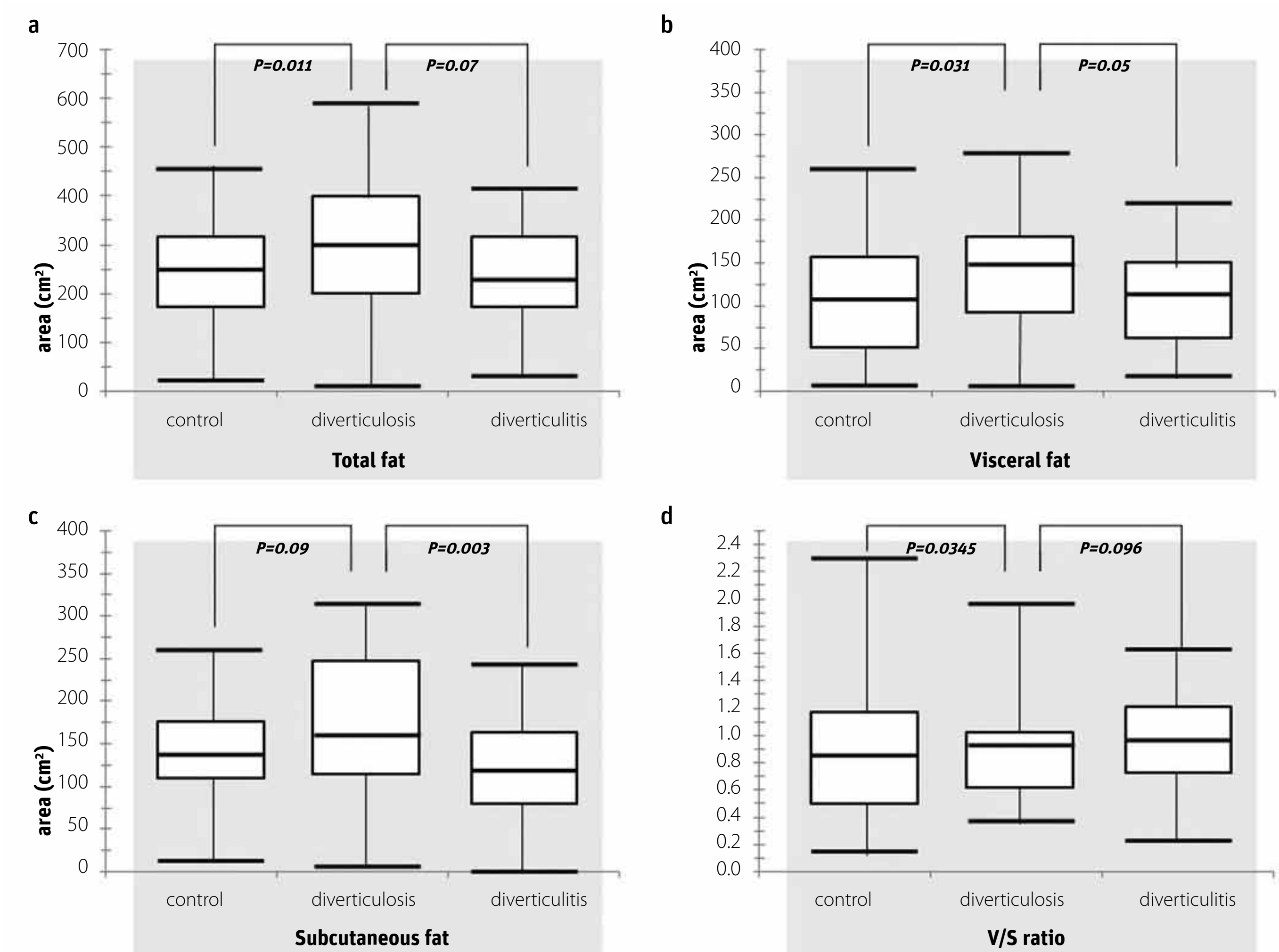

Figure 2. a-d. Abdominal fat areas of the control group, diverticulosis group, and diverticulitis group. Total fat area **(a),** visceral fat **(b),** subcutaneous fat **(c),** and V/S ratio **(d).**

Table 2. Abdominal fat and lipid profiles in controls and patients with diverticulosis

	Normal (n=55)	Diverticulosis (n=31)	p
BMI (kg/m^2)	23.89±3.12	25.03±3.84	0.14
total fat (cm^2)	245.81±101.74	309.64±120.89	0.011
visceral fat (cm^2)	108.83±68.49	142.47±67.45	0.031
subcutaneous fat (cm^2)	136.97±52.56	167.16±73.04	0.029
V/S ratio	0.83±0.49	0.93±0.43	0.345
total cholesterol	197.58±39.70	198.55±27.80	0.905
TG	136.29±161.18	112.42±48.32	0.424
HDL-C	49.59±13.27	48.63±12.80	0.749
LDL-C	111.59±29.68	115.63±28.22	0.545

V/S ratio: visceral fat:subcutaneous fat ratio; TG: triglyceride; HDL-C: high-density lipoprotein cholesterol; LDL-C: low-density lipoprotein cholesterol

ticulosis group, and 0.96 (95% CI 0.63-1.29) in the diverticulitis group. Total, visceral, and subcutaneous fat areas were greater in the diverticulosis group than in the control (Table 2) (Figure 2) but not significantly different from the control in the diverticulitis group (Table 3, 4) (Figure 2). There were no significant differences between the three groups with respect to VSR (Figure 2).

Serum lipid profiles

Serum lipid profiles in the diverticulosis group did not differ from the control (Table 2) (Figure 3). However, in the diverticulitis group, total cholesterol, HDL, and LDL were lower than in the control and diverticulosis groups (Table 3, 4) (Figure 3). There were no significant differences between the three groups with respect to TG (Figure 3).

Body mass index

Mean BMI was 23.89 kg/m^2 (95% CI 20.77-27.01) in the control, 25.03 kg/m^2 (95% CI 21.19-28.87) in the diverticulosis group, and 22.27 kg/m^2 (95% CI 18.61-25.93) in the diverticulitis group. There was no significant difference in mean BMI between the control and the diverticulosis group (Table 2), but the mean BMI of the diverticulitis group was lower than those of the other two groups (Table 3, 4) (Figure 4).

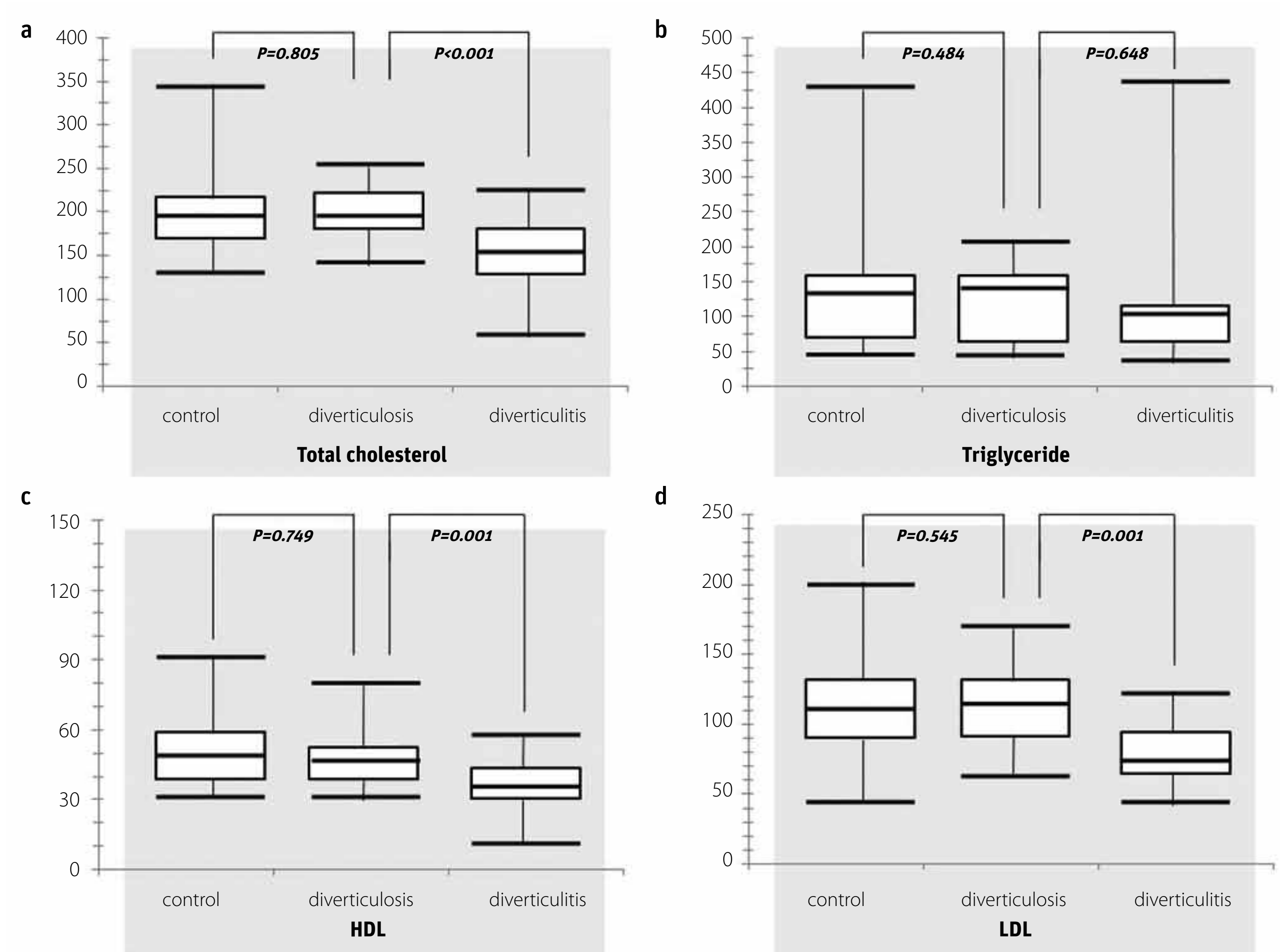

Figure 3. a-d. Lipid profiles of the control group, diverticulosis group, and diverticulitis group. Total cholesterol **(a),** triglyceride **(b),** HDL **(c),** and LDL **(d).**

Table 3. Abdominal fat and lipid profiles in normal persons and patients with diverticulitis

	Normal (n=55)	Diverticulosis (n=47)	p
BMI (kg/m^2)	23.89±3.12	22.27±3.66	0.02
total fat (cm^2)	245.81±101.74	238.30±101.96	0.713
visceral fat (cm^2)	108.83±68.49	114.34±56.05	0.663
subcutaneous fat (cm^2)	136.97±52.56	121.32±57.71	0.155
V/S ratio	0.83±0.49	0.96±0.33	0.117
total cholesterol	197.58±39.70	153.77±35.85	<0.001
TG	136.29±161.18	116.15±94.26	0.557
HDL-C	49.59±13.27	37.48±12.26	<0.001
LDL-C	111.59±29.68	78.56±19.02	<0.001

V/S ratio: visceral fat:subcutaneous fat ratio; TG: triglyceride; HDL-C: high-density lipoprotein cholesterol; LDL-C: low-density lipoprotein cholesterol

Table 4. Abdominal fat and lipid profiles in patients with diverticulosis and patients with diverticulitis

	Diverticulosis (n=31)	Diverticulitis (n=47)	p
BMI (kg/m^2)	25.03±3.84	22.27±3.66	0.003
total fat (cm^2)	309.64±120.89	238.30±101.96	0.007
visceral fat (cm^2)	142.47±67.45	114.34±56.05	0.050
subcutaneous fat (cm^2)	167.16±73.04	121.32±57.71	0.003
V/S ratio	0.93±0.43	0.96±0.33	0.696
total cholesterol	198.55±27.80	153.77±35.85	<0.001
TG	112.42±48.32	116.15±94.26	0.848
HDL-C	48.63±12.80	37.48±12.26	<0.001
LDL-C	115.63±28.22	78.56±19.02	<0.001

V/S ratio: visceral fat:subcutaneous fat ratio; TG: triglyceride; HDL-C: high-density lipoprotein cholesterol; LDL-C: low-density lipoprotein cholesterol

DISCUSSION

According to a 2003 report of the WHO, more than 3 billion people are obese worldwide due to high caloric intake and physical inactivity (19). Western lifestyles play a role in the prevalence of obesity in the general population of Korea (21). Obesity has been reported to be related to a variety of diseases, including metabolic syndrome, various cancers, and digestive diseases. Central obesity, via insulin resistance and hyperinsu-

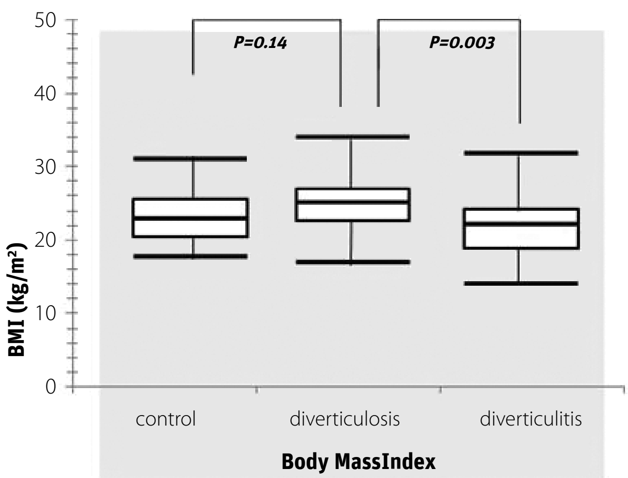

Figure 4. Body mass indexes of the control group, diverticulosis group, and diverticulitis group.

linemia, has been shown to have harmful cardiovascular effects (21), and obesity has been shown to play a role in the increasing incidence of colonic diverticulitis (11-16,22). However, whether or not colonic diverticulosis is related to obesity remains a matter of controversy because of the limited number of relevant studies.

In the present study, we have shown that colonic diverticulosis, but not diverticulitis, is associated with obesity. In our analysis, total abdominal fat, abdominal visceral fat, and abdominal subcutaneous fat measured by abdominal CT scan were significantly higher in the diverticulosis group than in the controls. However, serum lipid profiles and BMI in the diverticulosis group were not different from the controls. We conclude that measurement of abdominal fat is more suitable as an indicator of risk of diverticulosis than BMI or lipid profiles.

We found no positive association between diverticulitis and obesity. Our study showed that total, visceral, and subcutaneous fat areas did not differ between the diverticulitis and control groups (Figure 2). Serum lipid profiles and BMI were significantly lower in the diverticulitis group than in the diverticulosis and control groups (Figure 3, 4). In contrast, a large prospective cohort study showed that all obesity parameters were elevated in subjects with diverticulitis (16,22). This opposite outcome can be explained by the fact that the abdominal CT and blood tests were performed during the acute phase of diverticulitis. Lipid catabolism may be induced during the acute phase, and this may have been responsible for the reduced BMI and serum lipid levels.

The visceral-to-subcutaneous fat ratio showed a tendency to increase in the order of control, diverticulosis, and diverticulitis. Although the differences between the groups were not statistically significant, visceral obesity may still be related to colonic diverticulosis and diverticulitis, and this would be in agreement with previous studies demonstrating an association between obesity and complicated diverticular diseases. Further large-scale studies are needed to establish whether VSR reflects severity of complicated diverticular diseases.

An association between obesity and diverticulitis has been demonstrated in a number of retrospective and case-control studies (11-15). In a study using BMI, the incidence of obesity was higher in patients with recurrent diverticulitis or diverticulitis-associated perforation or abscess than in patients with diverticulosis or a single episode of diverticulitis (11). This suggests that obesity itself contributes to complicated diverticular diseases. However, since abdominal obesity can be accompanied by low BMI, it is difficult to infer an association between obesity and colonic diverticular diseases by examining only BMI. Furthermore, visceral fat is thought to play a more important role in hyperinsulinemia, insulin resistance, and hypertension than total abdominal fat (23).

Two prospective cohort studies have demonstrated that symptomatic diverticular diseases are related to obesity (16,22). One study described a relationship between BMI and the incidence of symptomatic diverticular diseases, while the other reported that diverticulitis and diverticular bleeding are associated with waist circumference and waist-to-hip ratio, as well as BMI. On the other hand, low intake of dietary fiber and high intake of total fat and red meat, as well as physical inactivity, have been reported to increase the risk of symptomatic diverticular diseases (6,7). These results indirectly suggest that obesity or metabolic syndrome may increase diverticular complications.

Central obesity is more closely related to the metabolic syndrome, including insulin resistance, hyperinsulinemia, dyslipidemia, hypertension, and cardiovascular disease, than general obesity (23,24). A number of studies have assessed different tools for measuring body fat distribution, and abdominal CT scan has been shown to be one of the best methods for quantifying abdominal fat (20). Therefore, in the present study, we used abdominal CT scan to measure obesity in addition to BMI and serum lipid profiles. The basis of the association between obesity and colonic diverticular complications is unclear. Since many cytokines are secreted by fat tissue, obesity may affect the inflammatory process in diverticulitis (25). Furthermore, recent studies showing a difference in the intestinal microbiota of subjects with normal versus increased body weights suggest that changes in intestinal microbiota could influence the development of diverticulitis (26). In addition, obesity may disrupt vascular integrity, resulting in diverticular hemorrhage.

Our study had several limitations. We showed that patients with diverticulitis had low levels of total cholesterol, HDL, LDL, and BMI. However, as mentioned earlier, these low levels seem to reflect the acute phase of diverticulitis. The patients may have been in a poor nutritional state, and their disease may have induced lipid catabolism. This limitation could be avoided by serially repeated measurements of lipid profiles and BMI. In addition, we have not adjusted for potential confounders, such as physical activity, and intake of dietary fiber, lipids, red meats, NSAIDs, and acetaminophen, although these are probable risk factors for diverticular complications. Another problem is the small sample size, and this could be overcome by large-scale multicenter studies. The fourth limitation is the possibility of selection bias between outpatients and inpatients. Finally, according to a previous report, the BMI of recurrent colonic diverticulitis patients is higher than that of first-onset patients, and we did not distinguish between recurrent diverticulitis and first-onset diverticulitis.

In conclusion, obesity may predispose one to the occurrence of colonic diverticulosis, and abdominal fat measurement by CT scan may be a useful method of assessing the risk of colonic diverticular disease. Large-scale prospective studies are required to confirm these conclusions.

Ethics Committee Approval: Ethics committee approval was received for this study from the Institutional Review Board of our institution.

Informed Consent: Written informed consent was obtained from patients who participated in this study.

Peer-review: Externally peer-reviewed.

Author contributions: Concept - S.P.L., O.Y.L., K.N.L., W.S., H.L.L., D.W.J., B.C.Y., H.S.C.; Design - S.P.L., O.Y.L., K.N.L., W.S., H.L.L., D.W.J., B.C.Y., H.S.C.; Supervision - O.Y.L.; Resource - S.P.L.; Materials - S.P.L., Y.W.A.; Data Collection&/or Processing - S.P.L., Y.W.A.; Analysis&/or Interpretation - S.P.L., O.Y.L., K.N.L., W.S., H.L.L., D.W.J., B.C.Y., H.S.C.; Design - S.P.L., O.Y.L., K.N.L., W.S., H.L.L., D.W.J., B.C.Y., H.S.C.; Literature Search -S.P.L., Y.W.A.; Writing -S.P.L., Y.W.A.; Critical Reviews - Y.W.A., O.Y.L.

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