

Risk Factors for Severe Diverticulitis in Computed Tomography-Confirmed Acute Diverticulitis in Korea

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Background/Aims: Acute complicated diverticulitis can be subdivided into moderate diverticulitis and severe diverticulitis. Although there have been numerous studies on the risk factors for complicated diverticulitis, little research has focused on severe diverticulitis. This study was designed to identify the risk factors for severe diverticulitis in an acute diverticulitis attack using the modified Hinchey classification.

Methods: Patients were included if they had any evidence of acute diverticulitis detected by computed tomography. The patients were subdivided into severe diverticulitis (Hinchey class \geq Ib; abscesses or peritonitis) and moderate diverticulitis (Hinchey class Ia; pericolic inflammation) groups. **Results:** Of the 128 patients, 25 exhibited severe diverticulitis, and 103 exhibited moderate diverticulitis. In a multivariate analysis, age >50 years (odds ratio [OR], 5.27; $p=0.017$), smoking (OR, 3.61; $p=0.044$), comorbidity (OR, 4.98; $p=0.045$), leukocytosis (OR, 7.70; $p=0.003$), recurrence (OR, 4.95; $p=0.032$), and left-sided diverticulitis (OR, 6.92; $p=0.006$) were significantly associated with severe diverticulitis. **Conclusions:** This study suggests that the risk factors for severe diverticulitis are age >50 years, smoking, comorbidity, leukocytosis, recurrent episodes, and left-sided diverticulitis. (**Gut Liver 2013;7:443-449**)

Key Words: Diverticulitis; Severity; Computed tomography; Hinchey classification

INTRODUCTION

Acute colonic diverticulitis is a disease with a wide range of clinical presentations ranging from mild, subclinical inflammation to generalized peritonitis. Most cases of acute diverticulitis

are simple, uncomplicated, and recover well with restriction of oral intake and antibiotics. However, 25% of acute diverticulitis cases progress to complicated diverticulitis with risk of phlegmon, abscess, fistula, obstruction, bleeding, or perforation.¹ Among complicated diverticulitis, the mortality rate of diverticulitis with abscess or perforation reaches 2.3%, while the mortality rate of phlegmonous diverticulitis is essentially zero.^{2,3} Complicated diverticulitis with abscess or perforation usually requires more intensive management such as percutaneous drainage or operative intervention, and prolonged hospital stays. Therefore, complicated diverticulitis could be subdivided into moderate diverticulitis (MD; phlegmonous type) and severe diverticulitis (SD; abscess or perforation type) with regard to patient management and prognosis.

Numerous studies have attempted to identify risk factors for poor outcome in acute diverticulitis. These studies, however, employed different clinical categories and various diagnostic methods for complicated diverticulitis instead of examining single, well-defined conditions.⁴ These discrepancies make it difficult to comprehensively compare the results of studies.

Computed tomography (CT) imaging is the most preferable diagnostic method in acute colonic diverticulitis, with a high sensitivity of 93% to 97% and specificity of up to 100%.^{5,6} Intramural inflammation, the degree of pericolic and intraperitoneal inflammation, abscess, and perforation can all be captured on CT scan. CT can also be predictive of future complications after initial medical treatment and can predict the need for surgical intervention following acute presentation. Therefore, CT is very important in surgical planning.⁷ Hinchey classification is commonly used in grading the severity of acute diverticulitis on CT scan; stage Ia is indicative of confined pericolic inflammation (phlegmon), whereas stages Ib, II, III, and IV indicate

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Received on November 13, 2012. Revised on February 14, 2013. Accepted on March 11, 2013.

pISSN 1976-2283 eISSN 2005-1212 <http://dx.doi.org/10.5009/gnl.2013.7.4.443>

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the presence of an abscess or peritonitis. The morbidity and mortality gradually increase with stage. Mortality is as low as 5% in stages I or II, but it increases to 13% in stage III and 43% in stage IV.⁸ This study was designed to identify the risk factors associated with SD and operated diverticulitis in acute diverticulitis confirmed by CT using the modified Hinchey classification system.

MATERIALS AND METHODS

1. Data collection

We performed a search of the electronic medical and radiological records of patients admitted to Korea University Medical Center for acute colonic diverticulitis between January 1, 2005 and December 31, 2009. Patients were initially included if there was evidence of complicated diverticulitis as diagnosed by abdominal CT. Patients were excluded from analysis based on the following criteria: no evidence of diverticulitis on CT, diverticulitis diagnosis without CT, age under 18 years, final diagnosis with colon cancer, appendicitis, focal colitis with ischemia, or appendagitis diagnosed with the help of radiologists. A total of 412 patients were diagnosed with acute colonic diverticulitis over the study period. After exclusion criteria were applied, 128 patients with CT-confirmed acute colonic diverticulitis were identified and the cases were analyzed. Data including age, gender, body mass index (BMI), current smoking, comorbidity, leukocytosis, location of diverticulitis, number of diverticulum, recurrence of diverticulitis, grade of modified Hinchey classification, and surgical intervention were collected. Diverticulitis was defined as right-sided when it occurred at the cecum, ascending colon, hepatic flexure, or transverse colon. And diverticulitis was defined as left-sided when it was located between the splenic flexure and the rectum. Preexisting comorbidity was defined as cardiovascular, pulmonary, endocrinologic, neurologic, connective tissue diseases, and malignancy. Recurrence of diverticulitis was defined as abdominal pain, fever, and leukocytosis with consistent CT findings after treatment of primary diverticulitis.

All abdominal CT scans were interpreted retrospectively by two expert radiologists blinded to clinical information. The severity of diverticulitis was graded using the modified Hinchey classification. The modified Hinchey classification defines the following stages: stage Ia, pericolic inflammation (phlegmon); stage Ib, pericolic abscess; stage II, distant intraabdominal or retroperitoneal abscess; stage III, generalized peritonitis; and stage IV, fecal peritonitis. In case of disagreement with the initial interpretation about severity, the second interpretation was made with the help of another experienced radiologist. Degree of diverticulitis severity was finally made when three radiologists reached a consensus interpretation.

2. Definition of severity

The degree of severity of acute colonic diverticulitis was defined as either moderate or severe, using the modified Hinchey classification. MD was defined as Hinchey stage Ia (pericolic inflammation), and SD was defined as Hinchey stage Ib or higher (abscess or peritonitis).

3. Statistical analysis

Analysis was performed using SPSS version 18 for Windows (IBM Co., Armonk, NY, USA). For univariate analysis, categorical variables were analyzed by the chi-squared test and continuous variables were analyzed by Student t-test. For multivariate analysis, logistic regression with forward selection (Wald) was used. The p-values <0.05 were considered significant.

RESULTS

1. Baseline patient characteristics

Patients' baseline characteristics are listed in Table 1. In 128

Table 1. Baseline Characteristics of Patients with Computed Tomography-Confirmed Acute Diverticulitis

Characteristic	No. of patients (n=128)
Age, yr	46.4±14.2
Age >50	48 (37.5)
Male	76 (59.3)
BMI*	23.5±3.6
Smoking [†]	48 (37.7)
Comorbidity	17 (13.2)
Leukocytosis	49 (38.5)
Recurrence	17 (13.2)
Location	
Left-sided diverticulitis	20 (15.7)
Right-sided diverticulitis	108 (84.3)
No. of diverticulum	
Single	33 (25.7)
Multiple	95 (74.3)
Hinchey classification	
MD (Ia)	103 (80.4)
SD (Ib)	5 (3.9)
(II)	11 (8.5)
(III)	9 (7.0)
(IV)	0
Operation	23 (17.9)
Operation (due to recurrence)	6 (4.6)

Data are presented as mean±SD or number (%).

BMI, body mass index; MD, moderate diverticulitis; SD, severe diverticulitis.

*Available number of patients, 124 (MD=100, SD=24); [†]Available number of patients, 127 (MD=102, SD=25).

patients with complicated diverticulitis, the age range was 24 to 81 years (mean, 46.4 ± 14.2 years). Forty-eight patients were older than 50 years (37.5%), and the average duration of follow-up was 5.1 years. Seventy-six patients were male (59.3%) and 52 patients were female (40.9%). Additionally, comorbidity, leukocytosis, and recurrent diverticulitis were present in 13.2%, 38.5%, and 13.2% of patients, respectively. Right-sided diverticulitis occurred in 84.3% of patients ($n=108$) and left-sided diverticulitis was found in 15.7% of patients ($n=20$). Among the 23 patients who underwent surgical intervention, six were operated on because of disease recurrence.

2. Risk factors for SD

There were 103 patients with MD (80.5%) and 25 patients with SD (19.5%). In the SD group, five patients (3.9%) were diagnosed with stage Ib disease, 11 patients (8.5%) had stage II disease, and nine patients (7.0%) had stage III disease. The mean age was significantly higher in the SD group than in the MD group (56.6 ± 18.0 vs 44.0 ± 11.9 , $p=0.003$) (Table 2). Patient gender, however, did not significantly differ between the two groups ($p=0.6$). The presence of comorbidity was found to be significantly associated with SD (32% vs 8.7%, $p=0.005$), and left-sided diverticulitis was also significantly more prevalent in the SD group (44% vs 8.7%, $p<0.001$). There was a statistically

Table 2. Risk Factors for Severe Diverticulitis in a Univariate Analysis

Factor	MD (n=103, 80.5%)	SD (n=25, 19.5%)	p-value
Age, yr	44.0 ± 11.9	56.6 ± 18.0	0.003
Male	60 (58.2)	16 (64)	0.6
BMI*	23.4 ± 3.4	23.7 ± 4.2	0.72
Smoking [†]	37 (36.2)	11 (44)	0.475
Comorbidity	9 (8.7)	8 (32)	0.005
Leukocytosis	34 (33.0)	15 (60)	0.014
Tenderness [‡]	92 (92)	23 (95.8)	>0.999
Rebound tenderness [§]	28 (50.9)	6 (42.8)	0.6
Recurrence	11 (10.6)	6 (24)	0.1
Location of diverticulitis (left/right)	9/94 (8.7/91.3)	11/14 (44/56)	<0.001
No. of diverticulum (single/multiple)	30/73 (29.1/70.9)	3/22 (12/88)	0.079
Operation	11 (10.6)	12 (48)	<0.001

Data are presented as mean \pm SD or number (%).

MD, moderate diverticulitis; SD, severe diverticulitis; BMI, body mass index.

*Available number of patients, 124 (MD=100, SD=24); [†]Available number of patients, 127 (MD=102, SD=25); [‡]Available number of patients, 124 (MD=100, SD=24); [§]Available number of patients, 69 (MD=55, SD=14).

Table 3. Risk Factors for Severe Diverticulitis in a Multivariate Analysis

Factor	No. of patients with SD (n=25)	Adjusted analysis		
		Adjusted OR	95% CI	p-value
Age >50	16 (64)	5.27	1.347-20.682	0.017
Male	16 (64)	1.98	0.500-7.920	0.329
BMI >25*	7 (29.1)	0.31	0.077-1.328	0.116
Smoking	11 (44)	3.61	1.037-12.623	0.044
Comorbidity	8 (32)	4.98	1.034-24.053	0.045
Leukocytosis	15 (60)	7.70	1.980-29.946	0.003
Recurrence	6 (24)	4.95	1.144-21.448	0.032
Location of diverticulitis (left/right)	11/14	6.92	1.752-27.407	0.006
No. of diverticulum (single/multiple)	3/22	1.41	0.257-7.807	0.689

Data are presented as number (%).

SD, severe diverticulitis; OR, odds ratio; CI, confidence interval; BMI, body mass index.

*Available number of patients, 24.

significant relationship between disease severity and both leukocytosis (60% vs 33%, $p=0.014$) and operation (48% vs 10.6%, $p<0.001$). However, BMI ($p=0.72$), smoking ($p=0.475$), recurrence ($p=0.1$), and the number of diverticulum ($p=0.079$) did not differ significantly between the two groups.

The results of multivariate analysis between MD and SD are presented in Table 3. Age greater than 50 years was found to be a significant risk factor for SD (odds ratio [OR], 5.27; 95% confidence interval [CI], 1.347 to 20.682; $p=0.017$). Statistical significance was also noted in patients with a smoking history (OR, 3.61; 95% CI, 1.037 to 12.623; $p=0.044$), comorbidity (OR, 4.98; 95% CI, 1.034 to 24.053; $p=0.045$), leukocytosis (OR, 7.70; 95% CI, 1.980 to 29.946; $p=0.003$), recurrence (OR, 4.95; 95% CI, 1.144 to 21.448; $p=0.032$), and left-sided diverticulitis (OR, 6.92; 95% CI, 1.752 to 27.407; $p=0.006$). Gender, BMI, and the number of diverticulum did not demonstrate statistical significance in the multivariate analysis.

3. Risk factors for operation

In addition to identifying the risk factors for SD in an episode of acute diverticulitis, we analyzed the risk factors associated with colectomy, which was performed emergently or after the failure of initial medical treatment (Table 4). Among 25 cases of SD, 23 patients underwent surgery except two subjects who refused it. Six patients were operated on due to recurrent attacks of diverticulitis even though the degree of diverticulitis was not severe. Therefore they were excluded in the analysis of the risk factors associated with colectomy. Of the 17 cases included in the analysis, eight patients were operated on emergently, and nine patients were not. Modified Hinchey classification $>1b$ (OR, 7.708; 95% CI, 2.209 to 26.894; $p=0.001$) and left-sided diverticulitis (OR, 5.140; 95% CI, 1.396 to 18.922; $p=0.014$) were found to be statistically significant risk factors for colectomy in

episodes of acute diverticulitis.

DISCUSSION

In the present study we retrospectively analyzed the risk factors for SD and operated diverticulitis in subjects who underwent abdominal CT scans, applying the modified Hinchey classification criteria. The factors related to SD were found to be age over 50 years, smoking, comorbidity, leukocytosis, recurrence, and left-sided diverticulitis. There is a considerable difference between these results and those in Western populations. In Western countries where diverticulitis is much more prevalent than in Asia and there are well-established guidelines and practice parameters for acute diverticulitis,^{9,10} risk factors for severe clinical manifestations were found to be younger age, smoking, obesity, nonsteroidal anti-inflammatory drugs or corticosteroid use, multiple comorbidities (including immunosuppression), and right-sided diverticulitis.¹¹⁻²⁰

The analysis of risk factors suggested that the association of location of diverticulitis with severity was different between Asian and Western populations. In Western countries where sigmoid colonic diverticulitis is more prevalent, right-sided diverticulitis is usually thought to run a more complicated course.¹³ On the contrary, the current study showed that left-sided diverticulitis was more severe than right-sided diverticulitis with an OR of 6.92 (95% CI, 1.752 to 27.407; $p=0.006$). This result is consistent with most other Asian studies, which showed that left-sided diverticulitis was considered a major risk factor for complicated diverticular disease and poor prognosis, though those studies did not analyze SD.^{21,22} One recent retrospective study that stratified the severity of diverticulitis with clinical categories determined that left-sided colonic diverticulitis was a risk factor for SD, with an odds ratio of 6.23.²³ In another

Table 4. Risk Factors for Operation in a Multivariate Analysis

Factor	No. of operated patients (n=17)*	Adjusted analysis		
		Adjusted OR	95% CI	p-value
Age >50	12 (70.6)	3.806	0.710-20.407	0.119
Male	8 (47.1)	1.504	0.304-7.438	0.617
BMI >25	5 (29.4)	0.629	0.117-3.372	0.588
Smoking	3 (17.6)	0.215	0.028-1.666	0.141
Comorbidity	7 (41.2)	3.096	0.393-24.401	0.283
Leukocytosis	8 (47.1)	0.610	0.117-3.192	0.558
Recurrence	4 (23.5)	9.883	0.950-85.611	0.078
Hinchey class $\geq 1b$	11 (64.7)	7.708	2.209-26.894	0.001
Location of diverticulitis (left/right)	9/8 (52.9/47.1)	5.140	1.396-18.922	0.014
No. of diverticulum (single/multiple)	5/12 (29.4/70.6)	0.180	0.027-1.203	0.077

Data are presented as number (%).

OR, odds ratio; CI, confidence interval; BMI, body mass index.

*Excludes operations performed due to recurrence, n=6.

study, Komuta *et al.*²⁴ reported the outcome of medical therapy for patients with acute right colonic diverticulitis. The authors concluded that medical management is effective because of the disease's benign course. Therefore, in contrast to Western countries, it is hypothesized that left-sided diverticulitis is closely associated with the development of SD in Asian countries.

The current study showed that smoking, comorbidity, and leukocytosis were also risk factors for SD, and this is largely in accordance with findings reported in the Western literature. However, while most Western studies have described diverticulitis in young patients as more aggressive and virulent with an increased risk of perforation and recurrence,^{11,25} old age (>50) was found to be a risk factor for SD in this study. This result supports the findings of other Asian researchers that diverticulitis in older patients is usually more complicated. Kim *et al.*²¹ reported that patients with right-sided diverticulitis in Korea were significantly younger and had lower complication rates. In another study conducted in Hong Kong, right-sided diverticulitis was associated with younger age, and correlated with low mortality and morbidity.²² Therefore, it is likely that diverticulitis in older patients has a more severe and virulent course in Asian countries, suggesting that there is a geographic difference in the impact of age on diverticulitis severity.

The present study also analyzed the relationship between diverticulitis severity and disease recurrence. While some reports suggest an increased risk of complications and a higher mortality rate in recurrent episodes,²⁶⁻²⁸ no link between recurrence and complicated diverticulitis was noted in newer studies.²⁹⁻³¹ In this study, there were 17 patients (13.2%) with recurrent diverticulitis, and the OR for SD was 4.95. It is not certain whether this discrepancy originates from differences of inclusion criteria or diagnostic method, because the present study enrolled patients who undertook CT. Further large-scale studies using CT evidence of diverticulitis are required to identify the association between severity and recurrence of disease.

One important consideration in acute diverticulitis is the need for surgical management. Therefore, we intended to identify the risk factors for predicting operative intervention. There were 23 total patients (17.9%) who underwent colectomy, and of these, six patients (26%) underwent surgery because of disease recurrence. Recent reports, however, have consistently recommended against surgical intervention for repeated episodes of uncomplicated diverticulitis.^{32,33} Moreover, the new edition of the practice parameters of the American Society of Colon and Rectal Surgeons from 2006 no longer recommends elective surgery after two or more uncomplicated episodes of diverticulitis.⁹ Thus, we excluded the cases of recurrent diverticulitis in analyzing the risk factors for operation. Eleven patients out of the seventeen included in the analysis were Hinchey class Ib or higher, and this was found to be a significant risk factor for operation (OR, 7.708; 95% CI, 2.209 to 26.894; $p=0.001$). Furthermore, nine patients had left-sided diverticulitis and the OR for operation was

5.14, which was significant (95% CI, 1.396 to 18.922; $p=0.014$). To the best of our knowledge, we do not know any Asian study that reported an association between the location of diverticulitis and colectomy. There were only several studies to suggest a favorable course of right-sided diverticulitis,³⁴⁻³⁶ implying that left-sided diverticulitis necessitates operation more frequently than right diverticulitis. Our study not only demonstrated that left-sided diverticulitis progressed virulently, but also frequently necessitated surgical management. This finding is in contrast to Western reports indicating that right-sided diverticulitis requires surgical intervention more frequently.^{37,38} Therefore, we can only assume that left-sided diverticulitis is strongly associated with operated diverticulitis as well as SD in Asia.

Our current study only enrolled patients whose CT result was confirmed positive for diverticulitis. Numerous researchers have attempted to identify the risk factors for complicated diverticulitis and poor clinical outcomes, but the data were not consistent and there were contradictory conclusions. The inconsistency may be due to the relatively small sample sizes or the heterogeneity of the categories that were investigated as opposed to an examination of single, well-defined conditions.⁴ In addition, various diagnostic methods were employed (including CT, abdominal sonography, barium studies, colonoscopy, or operations) and other studies used clinical indexes such as abscess, perforation, recurrence, or systemic inflammatory response syndrome as a determination of severity. For these reasons, it is very difficult to make comprehensive comparisons between studies. Therefore, the fact that we enrolled only patients with diverticulitis that was confirmed by CT likely made this study more homogeneous and allowed for a more objective grading of the severity of diverticulitis compared to previous studies.

Another attribute of our study is that we subdivided complicated diverticulitis into moderate and severe. Ambrosetti³⁹ suggested that complicated diverticulitis be stratified into moderate and severe based on CT imaging because of the differing prognoses; MD was defined as a localized colonic wall thickening greater than 5 mm with signs of inflammation in the pericolonic fat, and SD was defined as colonic wall thickening with the presence of an abscess and/or extraluminal air and/or contrast leakage. In addition, Kaiser *et al.*³ demonstrated that the morbidity and mortality of patients with either Hinchey stage 0 or Ia disease were 4.4% and 0%, respectively, whereas patients with stage Ib or higher had significantly more complications (32.3%) and fatal outcomes (2.3%). Therefore, we subdivided complicated diverticulitis into two categories: MD was defined as stage Ia, while SD was defined as stage Ib or higher.

The clinical implications of this study require further investigation because of several drawbacks. This single tertiary center study is not representative of the entire Korean population. Additionally, since not all patients with episodes of acute diverticulitis underwent an abdominal CT scan, selection bias could affect the results.

In summary, there are considerable literatures detailing the risk factors related to complicated diverticulitis and poor clinical outcomes, but the data are not consistent because of the diversity in clinical categories of disease and the methods used for diagnosis. This study was performed only using patients whose CT imaging confirmed acute diverticulitis in order to achieve objectivity and homogeneity.

Conclusively, old age, smoking, comorbidity, leukocytosis, recurrent episode of diverticulitis, and left-sided disease were all associated with SD. Left-sided diverticulitis was also found to be an important risk factor in undergoing surgical treatment for an acute episode of diverticulitis. These clinical parameters should be taken into consideration for the management of acute colonic diverticulitis, being aware that there are considerable differences between Asian and Western populations. Moreover, given that the morbidity and mortality are quite different between moderate and severe stages of diverticulitis, we suggest that it is necessary to subdivide complicated diverticulitis into MD and SD, based on CT findings.

CONFLICTS OF INTEREST

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

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