Utility of monocyte distribution width for diagnosing colonic diverticulitis in the emergency department: a retrospective cohort study

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Abstract

Background

Colonic diverticulitis is a leading cause of abdominal pain. The monocyte distribution width (MDW) is a novel inflammatory biomarker with prognostic significance for coronavirus disease and pancreatitis; however, no study has assessed its correlation with the severity of colonic diverticulitis.

Methods

This single-center retrospective cohort study included patients older than 18 years who presented to the emergency department between November 1, 2020, and May 31, 2021, and received a diagnosis of acute colonic diverticulitis after abdominal computed tomography. The characteristics and laboratory parameters of patients with simple versus complicated diverticulitis were compared. The significance of categorical data was assessed using the chi-square or Fisher's exact test. The Mann–Whitney U test was used for continuous variables. Multivariate regression analysis was performed to identify predictors of complicated colonic diverticulitis. Receiver operator characteristic (ROC) curves were used to test the efficacy of inflammatory biomarkers in distinguishing simple from complicated cases.

Results

Of the 160 patients enrolled, 21 (13.125%) had complicated diverticulitis. Although right-sided was more prevalent than left-sided colonic diverticulitis (70% versus 30%), complicated diverticulitis was more common in those with left-sided colonic diverticulitis (61.905%, \( p = 0.001 \)). Age, white blood cell (WBC) count, neutrophil count, C-reactive protein (CRP) level, neutrophil-to-lymphocyte ratio (NLR), platelet-to-lymphocyte ratio (PLR), and MDW were significantly higher in the complicated diverticulitis group \( (p < 0.05) \). Logistic regression analysis indicated that the left-sided location and the MDW were significant and independent predictors of complicated diverticulitis. The area under the ROC curve (AUC) was as follows: MDW, 0.870 (95% confidence interval [CI], 0.784–0.956); CRP, 0.800 (95% CI, 0.707–0.892); NLR, 0.724 (95% CI, 0.616–0.832); PLR, 0.662 (95% CI, 0.525–0.798); and WBC, 0.679 (95% CI, 0.563–0.795). The MDW had the largest AUC for diagnosing complicated diverticulitis; when the MDW cutoff was 20.38, the sensitivity and specificity were maximized to 90.5% and 80.6%, respectively.

Conclusions

Patients with complicated diverticulitis were significantly older and predominantly had left-sided colonic diverticulitis. A large MDW was a significant and independent predictor of complicated diverticulitis. The MDW may aid in planning antibiotic therapy for patients with colonic diverticulitis in the emergency department.

Background
Colonic diverticulitis is one of the most common causes of abdominal pain and lower gastrointestinal bleeding in the emergency department (ED). The prevalence of colonic diverticulitis is increasing not only in Western countries but also in Asian countries [1]. It is predicted that approximately 50% of individuals aged 60 years or older have diverticulosis, whereas by the age of 80 years, this percentage is predicted to be approximately 70% [2]. Of those who developed diverticulosis, 10–25% experience an acute episode of diverticulitis [3]. Colonic diverticulitis is usually diagnosed in the ED through computed tomography (CT), which can also distinguish simple (uncomplicated) from complicated diverticulitis. Approximately 15% of diverticulitis cases have been reported to be complicated with abscess, stricture, obstruction, or perforation [4, 5]. The current therapeutic options for diverticulitis vary with disease severity, which can be determined on the basis of clinical, radiological, and laboratory findings. Complicated diverticulitis may lead to bacterial translocation, microperforation, and abscess or phlegmon development [6]. Therefore, early assessment of the severity of complicated diverticulitis and adequate resuscitation are important.

The monocyte distribution width (MDW) is a novel hematological parameter assessed as part of the complete blood count (CBC) with the differential count. It helps in determining the size distribution of circulating monocytes, which are the first immune cells to respond to pathogenic organisms [7]. In a multicenter international European study, the MDW in combination with the white blood cell (WBC) count was suggested to be a novel screening test for the early detection of sepsis in the ED [8]. Comparison of diagnostic performance according to the Sepsis-3 criteria revealed that the MDW was not inferior to the C-reactive protein (CRP) or procalcitonin level in terms of area under the receiver operator characteristic (ROC) curve (AUC) values [9]. Few studies have focused on the efficacy of the MDW in diagnosing diseases other than sepsis. To our knowledge, the MDW has been used for the detection of the novel coronavirus disease (COVID-19) [10–12] and pancreatitis [13]. However, there is a lack of evidence on the efficacy of the MDW in early prediction of the severity of other diseases.

In this retrospective cohort study, we aimed to investigate the relationship between the MDW data preceding CT assessment and disease severity in patients who received a diagnosis of colonic diverticulitis in an ED.

**Methods**

Study design and setting

This retrospective cohort study was conducted at a university-affiliated medical center receiving approximately 150,000 ED visits annually. The study was approved by the Hospital Ethics Committee on Human Research. The study protocol was reviewed and qualified as exempt from the requirement to acquire informed consent.

Patient selection

Patients older than 18 years who presented to our ED between November 1, 2020, and May 31, 2021, and who received a diagnosis of acute colonic diverticulitis after abdominal CT was performed were included
in this study. All the enrolled patients received the indicated blood examinations. Patients who had any other concomitant active inflammation or infection, were receiving any antibiotic course, had a final pathological diagnosis other than colonic diverticulitis, or had incomplete medical records or laboratory data were excluded from the study. Data were retrieved from the institutional electronic medical chart of the ED.

Methods and measurements

The collected variables included patient demographics and laboratory data. Blood samples were obtained in the ED before antibiotic treatment and CT scan. The patients’ age; sex; and comorbidities—such as diabetes mellitus, hypertension, ischemic heart disease, heart failure, liver cirrhosis, cholelithiasis, rheumatological disease, asthma, chronic obstructive pulmonary disease, chronic renal insufficiency, urolithiasis, cerebrovascular disease, and existing cancer—were recorded. Moreover, the body temperature upon triage and laboratory findings (including WBC, neutrophil, lymphocyte, and platelet counts; MDW; and hemoglobin, CRP, creatinine, alanine aminotransferase, blood sugar, sodium, and potassium levels) were recorded. The MDW was measured using the UniCel DxH 900 analyzer (Beckman Coulter, Brea, CA, USA). On the basis of the CT findings, the patients were divided into simple colonic diverticulitis and complicated colonic diverticulitis groups.

Statistical analysis

Descriptive statistics were used to compare variables—baseline demographics, laboratory test results, and inflammatory biomarker measurements—between the two groups. Categorical variables are expressed as proportions, and continuous variables are expressed as medians with interquartile ranges (IQRs, quartile 1 through quartile 3). Univariate analysis was performed using the chi-square or Fisher’s exact test for categorical variables and the Mann–Whitney U test for continuous variables in order to identify predictors of complicated colonic diverticulitis. Variables with \( p \)-values < 0.10 in the univariate analysis were then subjected to backward stepwise logistic regression analysis. ROC curves were also used to assess the performance of inflammatory biomarkers—including the WBC count, neutrophil-to-lymphocyte ratio (NLR), platelet-to-lymphocyte ratio (PLR), MDW, and CRP level—in order to distinguish simple from complicated colonic diverticulitis. A \( p \)-value \( \leq 0.05 \) was considered statistically significant. All data were analyzed using SAS (version 9.1; SAS Institute, Cary, NC, USA).

This study was approved by the Institutional Review Board of the Ethics Committee of China Medical University and Hospital (CMUH110-REC3-106). The requirement of informed consent from the patients was waived by the Ethics Committee of China Medical University and Hospital.

Results

From November 1, 2020, to May 31, 2021, 84,173 ED visits were recorded. A total of 176 visits were retrieved from the institutional electronic medical chart during the study period. Of the 16 patients who were excluded from the study, 2 had other concomitant infections, 1 was a repeat patient who had
revisited the ED and was taking oral antibiotics for colonic diverticulitis, 6 had an initial ambiguous diagnosis of colonic diverticulitis on CT scans but a final pathological diagnosis of colon cancer and not diverticulitis, 4 had no CRP data, and 3 had no MDW data because their monocyte count was less than 100/μL. Thus, a total of 160 patients were enrolled in the study: 139 in the simple colonic diverticulitis group and 21 in the complicated colonic diverticulitis group (Fig. 1).

Overall, the number of male patients was higher than that of female patients (n = 90/160, 56.25%). Most patients had right-sided colonic diverticulitis (n = 112, 70%): 14 in the cecum (8.75%), 91 in the ascending colon (56.875%), and 7 in the transverse colon (4.375%). Seventeen patients (10.63%) had other diverticula in different segments of the colon. Recurrent colonic diverticulitis was noted in 27 patients (16.88%). Hypertension was the most prevalent comorbidity (n = 30, 18.75%). Comparison of the variables for the two groups revealed that the patients with complicated colonic diverticulitis were older, with a median age of 58 years (IQR: 41–72 years). Conversely, the patients with simple colonic diverticulitis had a median age of 44 years (IQR: 30–59 years; p = 0.008). Complicated colonic diverticulitis was more frequently detected in the left colon than in the right colon (61.905% versus 38.095%). By contrast, simple colonic diverticulitis was more prevalent in the right colon than in the left colon (74.180% versus 25.180%). The location of colonic diverticulitis significantly differed between the two groups (p = 0.001). However, no significant difference was noted in comorbidities between the two groups. Laboratory values—WBC (p = 0.008) and neutrophil (p = 0.003) counts, MDW (p < 0.001), and CRP level (p < 0.001)—were significantly higher in the complicated colonic diverticulitis group. By contrast, lymphocyte count (p = 0.001) and sodium level (p < 0.001) were significantly higher in the simple colonic diverticulitis group (Table 1).

Table 1. (at the end of the document text file)

Univariate and multivariate binary logistic regression analyses (Table 2) revealed that left-sided location and the MDW were the only two variables that were significant predictors of complicated colonic diverticulitis after adjusting for the other variables. The adjusted odds ratio (OR) of complicated colonic diverticulitis was 5.197 (95% confidence interval [CI], 1.651–16.359; p = 0.005) for left-sided location and 1.552 (95% CI, 1.290–1.867; p = 0.002) for the MDW.

Further evaluation through ROC analysis was performed to determine the diagnostic value of the MDW for complicated colonic diverticulitis. The AUC values were as follows: MDW, 0.870 (95% CI, 0.784–0.956); CRP, 0.800 (95% CI, 0.707–0.892); NLR, 0.724 (95% CI, 0.616–0.832); PLR, 0.662 (95% CI, 0.525–0.798); and WBC, 0.679 (95% CI, 0.563–0.795; Fig. 2, Table 3). The largest AUC value was that for the MDW among all the inflammatory biomarkers for diagnosing patients with complicated colonic diverticulitis; when the MDW cutoff was 20.38, the sensitivity and specificity were maximized to 90.5% and 80.6%, respectively.

Discussion
A diverticulum is a herniation through a weak site of the bowel wall that produces a small outpouching [14]. When the diverticular wall is eroded by increased intraluminal pressure or inspissated food particles, diverticulitis may occur [15].

Diverticulitis is classified into simple (uncomplicated) and complicated types. Simple acute diverticulitis is a self-limiting and mild disease. It is defined as localized inflammation without any abscess or perforation [16]. Outpatient treatment is required for patients who have simple nonseptic diverticulitis, are immunocompetent, and can tolerate oral intake. However, patients with complicated diverticulitis must receive treatment specific to their complications, such as bowel obstruction, abscess, fistula, and perforation. When diffuse peritonitis is suspected given the findings of a physical examination, emergency surgery may be required even if imaging shows that the abscess is localized [17].

The gold standard diagnostic tool for acute diverticulitis is CT, in which complications can also be visualized. However, the schedule of CT at an ED may be delayed because of the high number of patients. The optimal use of CT for patients in whom complicated diverticulitis is suspected should be based on clinical and laboratory findings to minimize treatment costs and radiation hazards [18]. Therefore, recognizing the risk factors of complicated diverticulitis and providing the right treatment before CT imaging are crucial.

Some findings of the present study are in accordance with previous findings. In particular, right-sided diverticulitis was more prevalent than left-sided diverticulitis (70% versus 30%); this finding is compatible with reports from other Asian countries [19–21]. However, a higher number of patients with complicated diverticulitis had left-sided diverticulitis than right-sided diverticulitis (61.905% versus 38.095%); this finding is similar to the findings of previous Japanese and Korean studies [1, 19]. We also found that patients with complicated diverticulitis were older than those with simple diverticulitis (median age, 58 versus 44 years); this finding is also compatible with previous findings. For instance, in a Japanese retrospective multicenter study involving 1,112 patients, although right-sided colonic diverticulitis was more prevalent among the study population (70.1%), left-sided colonic diverticulitis was significantly more common among elderly patients (61.0%) [22]. Right-sided diverticulitis differs from left-sided diverticulitis in many respects. While right-sided diverticulitis is usually congenital and solitary [23, 24], left-sided diverticulitis is usually associated with secondary causes, including dietary factors, constipation, increased colonic pressure, defecation habits, and an irritable bowel. Consequently, left-sided diverticulitis more commonly occurs in older patients [25].

In our study, the WBC and neutrophil counts, MDW, and CRP level were higher in the complicated colonic diverticulitis group ($p < 0.05$, Table 1); however, only the MDW was found to have a statistically significant association with complicated diverticulitis in the multivariate binary logistic regression analysis ($p < 0.001$, Table 2). The WBC count and CRP level are the most common indicators of the severity of intra-abdominal inflammation in the ED. A higher WBC count or CRP level usually indicates a higher level of inflammation. Several studies [18, 26–28] have attempted to calculate the optimal threshold for the WBC
count and CRP level in distinguishing complicated diverticulitis from simple diverticulitis; however, so far, no consensus has been reached.

In addition to the WBC count and CRP level, two easily accessible hemogram-derived parameters, namely the NLR and PLR, have been used to predict complicated diverticulitis [29–31]. One study reported that the NLR could predict the need for surgical intervention more accurately than the CRP level and WBC count [29]. Palacios Huatuco et al. recently found that the NLR cutoff of 4.2 to be the best diagnostic approach, with sensitivity of 80% and specificity of 64%, for detecting complicated diverticulitis [30]. Mari et al. found that the PLR had a lower diagnostic accuracy than the NLR (AUC values, 0.67% and 0.75%, respectively) [31].

Circulating neutrophils and monocytes are the first response to pathogenic organisms. The MDW is a parameter that describes the size distribution of circulating monocytes. Several studies have reported that the MDW can be used for the early diagnosis of sepsis in the ED [7, 8, 32, 33]. Similarly, Şenlikci et al. found that the MDW can be used to differentiate mild pancreatitis from nonmild pancreatitis [13]. However, little known is about the efficacy of the MDW in detecting acute complicated diverticulitis. In our cohort, the MDW cutoff of 20.38 had a sensitivity of 90.5% and a specificity of up to 80.6%. Moreover, it had the largest AUC value (0.870) for the diagnosis of acute complicated diverticulitis. The AUC value of the MDW for complicated diverticulitis was higher than those of other inflammatory biomarkers—CRP (0.800), NLR (0.724), WBC (0.679), and PLR (0.662; Table 3 and Fig. 2).

The diagnostic accuracy of the MDW for complicated diverticulitis noted in our study was comparable with that of procalcitonin. In a previous study, the AUC of procalcitonin for complicated diverticulitis was 0.867, with a sensitivity of 81% and specificity of 91% [34]. However, procalcitonin is not routinely used as a biomarker in EDs. In Taiwan, the national health insurance reimbursement price for procalcitonin tests is 1,000 New Taiwan dollars (NT$) [35], which is approximately four times the price for CBC determination (NT$270, including differential WBC count and MDW) [36, 37]. Therefore, procalcitonin testing is preserved as an auxiliary test for patients with ambiguous diagnoses of sepsis or bacterial infection, which cannot be verified on the basis of the WBC count, NLR, or CRP level.

In our study, the MDW was the only inflammatory biomarker that was found to be a significant predictor of complicated colonic diverticulitis after adjusting for other covariables in multivariate binary logistic regression analysis ($p < 0.001$, Table 2). In previous studies, the MDW was found to have some advantages over other biomarkers. In particular, the MDW can be easily measured from the CBC through a blood test in the ED. In addition, the results are obtained faster than those of a biochemistry panel. Use of the MDW has been reported to improve both the clinical and economic outcomes of patients with sepsis in the ED, with the estimated time to antibiotic administration being reduced from 3.98 h to 2.07 h and US$3,460 being saved per hospitalization (US$23,466 versus US$26,926) [38]. By using a combination of the MDW and advanced imaging (CT), ED physicians will be able to diagnose complicated diverticulitis more accurately and in a timely manner, to initiate antibiotic therapy, and to convince surgeons regarding early intervention. Recent guidelines have recommended avoiding the use of
antibiotics for otherwise healthy patients with simple diverticulitis [39]. Hence, an early and accurate diagnosis of simple diverticulitis by using the MDW will help reduce the use of antibiotics.

Limitations

To our knowledge, this is the first study to evaluate the utility of the MDW for diagnosing colonic diverticulitis in the ED. However, our study has some limitations. First, the MDW cannot be measured when the peripheral blood sample for a patient has a monocyte count < 100/µL. In our study, three patients' MDW data were unavailable; these patients had simple diverticulitis. Second, because this was a retrospective study, medical records were not designed for research purposes and did not contain all parameters of interest to the investigators. For instance, the procalcitonin level was not measured for comparison with the MDW. Third, our classification of colonic diverticulitis was based on CT findings. CT has an accuracy of 98% in diagnosing acute diverticulitis; thus, misdiagnosis may occur in 2% of cases [40]. Nevertheless, abdominal CT imaging is still considered the gold standard for diagnosing acute diverticulitis and its complications [41]. Finally, this was a single-center study conducted in only one ED in East Asia; therefore, our finding that diverticulitis was more prevalent in the right colon may not be generalizable to all EDs and other populations. Further prospective studies with larger numbers of patients from multiple centers are needed to more accurately assess the role of the MDW in differentiating simple from complicated colonic diverticulitis.

Conclusions

Our study revealed that acute colonic diverticulitis was more prevalent in the right colon than in the left colon in Taiwanese patients. Patients with complicated diverticulitis were significantly older and predominantly had left-sided diverticulitis. In addition, a large MDW was found to be a significant and independent predictor of complicated diverticulitis preceding CT assessment in the ED. The MDW may aid in initiating early antibiotic therapy for patients with complicated diverticulitis and in decreasing antibiotic use in patients with simple diverticulitis.

Abbreviations

AUC
Area under the ROC curve
CBC
Complete blood count
CI
Confidence interval
CT
Computed tomography
ED
Emergency department
Declarations

Ethics Approval and Consent to Participate

All methods were carried out in accordance with the relevant guidelines and regulations in accordance with the Declaration of Helsinki. The need to obtain informed consent from participants was waived because this is a purely retrospective study that does not affect patient care. This waiver was approved by the China Medical University Institutional Review Board in conjunction with the China Medical University Ethics Committee. This study was approved by the research ethics committee of China Medical University and Hospital (Institutional Review Board No. CMUH110-REC3-106)

Consent for publication

Not applicable

Availability of data and materials

The datasets generated and analyzed during the current study are not publicly available due to the non-disclosure agreement in IRB restrictions. However, they are available on reasonable request. Please contact Dr. Tai-Yi Hsu for details.

Competing Interests

The authors declare that they have no competing interests.

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Authors’ contributions

CYC and TYH contributed equally to the work. CYC: data curation, writing the original draft, review, and editing. TYH: conceptualization, investigation, data curation, formal analysis, funding acquisition, and editing. YFT and GYH: writing, review, and editing. HMS: project administration, review, and editing. SHW: review and editing. FWH: methodology, formal analysis, and project administration. PCC and WCT: review and supervision. All authors have read and approved the final manuscript.

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35. Medical service payment items and payment standard inquiry: Procalcitonin

36. Medical service payment items and payment standard inquiry: CBC

37. Medical service payment items and payment standard inquiry: WBC differential count


**Tables**

Table 1. Distributions of baseline variables by colonic diverticulitis group
<table>
<thead>
<tr>
<th>Variables</th>
<th>Total</th>
<th>Simple Diverticulitis</th>
<th>Complicated Diverticulitis</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patients, n (%)</td>
<td>160 (100)</td>
<td>139 (86.875)</td>
<td>21 (13.125)</td>
<td></td>
</tr>
<tr>
<td>Female sex, n (%)</td>
<td>70 (43.75)</td>
<td>62 (44.604)</td>
<td>8 (38.095)</td>
<td>0.642</td>
</tr>
<tr>
<td>Age in years, median (IQR)</td>
<td>45 (31.25–60)</td>
<td>44 (30–59)</td>
<td>58 (41–72)</td>
<td>0.008*</td>
</tr>
<tr>
<td>Body Temperature (°C), median (IQR)</td>
<td>36.8 (36.5–37.375)</td>
<td>36.8 (36.5–37.3)</td>
<td>37.2 (36.45–37.5)</td>
<td>0.273</td>
</tr>
<tr>
<td>Recurrent diverticulitis, n (%)</td>
<td>27 (16.875)</td>
<td>21 (15.108)</td>
<td>6 (28.571)</td>
<td>0.129</td>
</tr>
<tr>
<td>Multiple locations of diverticula, n (%)</td>
<td>17 (10.625)</td>
<td>15 (10.791)</td>
<td>2 (9.524)</td>
<td>1.000</td>
</tr>
<tr>
<td>Location of diverticulitis, n (%)</td>
<td></td>
<td></td>
<td></td>
<td>0.001*</td>
</tr>
<tr>
<td>Right colon</td>
<td>112 (70)</td>
<td>104 (74.820)</td>
<td>8 (38.095)</td>
<td></td>
</tr>
<tr>
<td>Cecum</td>
<td>14 (8.750)</td>
<td>14 (10.072)</td>
<td>0 (0)</td>
<td></td>
</tr>
<tr>
<td>Ascending colon</td>
<td>91 (56.875)</td>
<td>85 (61.151)</td>
<td>6 (28.571)</td>
<td></td>
</tr>
<tr>
<td>Transverse colon</td>
<td>7 (4.375)</td>
<td>5 (3.597)</td>
<td>2 (9.524)</td>
<td></td>
</tr>
<tr>
<td>Left colon</td>
<td>48 (30)</td>
<td>35 (25.180)</td>
<td>13 (61.905)</td>
<td></td>
</tr>
<tr>
<td>Descending colon</td>
<td>24 (15)</td>
<td>19 (13.669)</td>
<td>5 (23.810)</td>
<td></td>
</tr>
<tr>
<td>Sigmoid colon</td>
<td>24 (15)</td>
<td>16 (11.511)</td>
<td>8 (38.095)</td>
<td></td>
</tr>
<tr>
<td>Comorbidities, n (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>10 (6.25)</td>
<td>9 (6.475)</td>
<td>1 (4.762)</td>
<td>1.000</td>
</tr>
<tr>
<td>Hypertension</td>
<td>30 (18.75)</td>
<td>25 (17.986)</td>
<td>5 (23.810)</td>
<td>0.551</td>
</tr>
<tr>
<td>Ischemic heart disease</td>
<td>8 (5)</td>
<td>7 (5.036)</td>
<td>1 (4.762)</td>
<td>1.000</td>
</tr>
<tr>
<td>Heart failure</td>
<td>2 (1.25)</td>
<td>2 (1.439)</td>
<td>0 (0)</td>
<td>1.000</td>
</tr>
<tr>
<td>Liver cirrhosis</td>
<td>1 (0.625)</td>
<td>1 (0.719)</td>
<td>0 (0)</td>
<td>1.000</td>
</tr>
<tr>
<td>Cholelithiasis</td>
<td>10 (6.25)</td>
<td>9 (6.475)</td>
<td>1 (4.762)</td>
<td>1.000</td>
</tr>
<tr>
<td>Rheumatologic disease</td>
<td>2 (1.25)</td>
<td>1 (0.719)</td>
<td>1 (4.762)</td>
<td>0.246</td>
</tr>
<tr>
<td>Asthma / COPD</td>
<td>2 (1.25)</td>
<td>1 (0.719)</td>
<td>1 (4.762)</td>
<td>0.246</td>
</tr>
<tr>
<td>Chronic renal</td>
<td>4 (2.5)</td>
<td>3 (2.158)</td>
<td>1 (4.762)</td>
<td>0.434</td>
</tr>
<tr>
<td>Condition</td>
<td>Univariate Analysis</td>
<td>Multivariate Analysis</td>
<td></td>
<td></td>
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<tr>
<td>----------------------------------------</td>
<td>---------------------</td>
<td>-----------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urolithiasis</td>
<td>10 (6.25)</td>
<td>7 (5.036)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cerebrovascular disease</td>
<td>1 (0.625)</td>
<td>1 (0.719)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Existing cancer</td>
<td>4 (2.5)</td>
<td>4 (2.878)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Laboratory Data, median (IQR)**

<table>
<thead>
<tr>
<th>Test</th>
<th>Median</th>
<th>IQR</th>
<th>Median</th>
<th>IQR</th>
<th>Median</th>
<th>IQR</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>WBC × 10^9 /L</td>
<td>11.15 (8.7–13.775)</td>
<td>10.9 (8.6–13.6)</td>
<td>13.3 (11.0–15.45)</td>
<td>0.008*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neutrophils (%)</td>
<td>76.75 (69.825–82)</td>
<td>75.2 (68.8–81.4)</td>
<td>80.1 (76.8–86.3)</td>
<td>0.003*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lymphocytes (%)</td>
<td>14.2 (9.7–20.05)</td>
<td>14.9 (10.5–20.9)</td>
<td>9.5 (5.9–14.25)</td>
<td>0.001*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MDW</td>
<td>18.78 (17.44–20.6475)</td>
<td>18.56 (17.21–19.77)</td>
<td>22.66 (20.655–24.465)</td>
<td>&lt;0.001*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Platelets × 10^9 /L</td>
<td>243 (196–286)</td>
<td>244 (197–286)</td>
<td>227 (188.5–310)</td>
<td>0.893</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NLR</td>
<td>5.357 (3.478–8.363)</td>
<td>5.040 (3.305–7.524)</td>
<td>8.372 (5.431–15.057)</td>
<td>0.001*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PLR</td>
<td>152.383 (121.295–207.622)</td>
<td>148.457 (120.351–196.479)</td>
<td>206.860 (141.476–366.163)</td>
<td>0.017*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CRP (mg/dL)</td>
<td>3.835 (0.9675–9.06)</td>
<td>3.46 (0.67–6.08)</td>
<td>12.14 (5.235–15.42)</td>
<td>&lt;0.001*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alanine aminotransferase (U/L)</td>
<td>18.5 (12–26.75)</td>
<td>18 (12–26)</td>
<td>19 (12–34.5)</td>
<td>0.750</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Creatinine (mg/dL)</td>
<td>0.8 (0.6525–0.9575)</td>
<td>0.79 (0.66–0.95)</td>
<td>0.86 (0.61–1.135)</td>
<td>0.471</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sodium (mmol/L)</td>
<td>139 (137–140)</td>
<td>139 (138–140)</td>
<td>137 (136–138)</td>
<td>&lt;0.001*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potassium (mmol/L)</td>
<td>3.7 (3.5–3.9)</td>
<td>3.7 (3.6–3.9)</td>
<td>3.7 (3.4–3.9)</td>
<td>0.251</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glucose (mg/dL)</td>
<td>104.5 (94–123)</td>
<td>105 (94–123)</td>
<td>103 (92–135)</td>
<td>0.860</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

IQR = interquartile range; COPD = Chronic obstructive pulmonary disease; WBC = white blood count; MDW = monocyte distribution width; NLR = neutrophil to lymphocyte ratio; PLR = platelet to lymphocyte ratio; CRP = C-reactive protein; ALT = Alanine aminotransferase;  
* P < 0.05.

Table 2. Univariate and multivariate binary logistic regression analyses showing independent predictors of complicated diverticulitis
### Table 1. Logistic regression analysis of factors associated with complicated diverticulitis

<table>
<thead>
<tr>
<th>Variables</th>
<th>Unadjusted OR (95% CI)</th>
<th>P value</th>
<th>Adjusted OR (95% CI)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>1.037 (1.009–1.066)</td>
<td>0.010*</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Left colon</td>
<td>4.829 (1.848–12.616)</td>
<td>0.001*</td>
<td>5.197 (1.651–16.359)</td>
<td>0.005*</td>
</tr>
<tr>
<td>WBC</td>
<td>1.189 (1.051–1.346)</td>
<td>0.006*</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>CRP</td>
<td>1.166 (1.083–1.256)</td>
<td>&lt;0.001*</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>MDW</td>
<td>1.584 (1.304–1.923)</td>
<td>&lt;0.001*</td>
<td>1.552 (1.290–1.867)</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>NLR</td>
<td>1.063 (1.003–1.127)</td>
<td>0.038*</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>PLR</td>
<td>1.005 (1.002–1.008)</td>
<td>0.004*</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Sodium</td>
<td>0.718 (0.594–0.867)</td>
<td>0.001*</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>

Variables with \( p < 0.10 \) in Table 1 were selected into logistic regression. Neutrophils and lymphocytes were eliminated because of their multicollinearity with NLR and PLR.

WBC = White blood count; CRP = C-reactive protein; MDW = Monocyte distribution width; NLR = neutrophil-to-lymphocyte ratio; PLR = platelet-to-lymphocyte ratio; OR = odds ratio; CI = confidence interval; * \( P < 0.05 \).

### Table 3. Area under the curve (AUC) values of the inflammatory biomarkers for complicated diverticulitis

<table>
<thead>
<tr>
<th>Inflammatory biomarkers</th>
<th>AUC</th>
<th>Standard error</th>
<th>P value</th>
<th>95% Confidence interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>MDW</td>
<td>0.8698</td>
<td>0.0448</td>
<td>&lt;0.001</td>
<td>0.7819–0.9577</td>
</tr>
<tr>
<td>CRP</td>
<td>0.7996</td>
<td>0.0481</td>
<td>&lt;0.001</td>
<td>0.7053–0.8938</td>
</tr>
<tr>
<td>NLR</td>
<td>0.7242</td>
<td>0.0559</td>
<td>0.001</td>
<td>0.6146–0.8339</td>
</tr>
<tr>
<td>WBC</td>
<td>0.6790</td>
<td>0.0603</td>
<td>0.008</td>
<td>0.5607–0.7973</td>
</tr>
<tr>
<td>PLR</td>
<td>0.6615</td>
<td>0.0712</td>
<td>0.017</td>
<td>0.5219–0.8011</td>
</tr>
</tbody>
</table>

MDW = monocyte distribution width; CRP = C-reactive protein; NLR = neutrophil lymphocyte ratio; WBC = white blood cell; PLR = platelet to lymphocyte ratio.

**Figures**
From November 01, 2020 to May 31, 2021, 84,173 visits of emergency department, 176 visits with initial diagnosis of colonic diverticulitis on computed tomography.

- Excluded 2 patients with other concomitant infection
- Excluded 1 revisiting patient under oral antibiotic therapy for colonic diverticulitis
- Excluded 6 patients with final pathological diagnosis of colon cancer
- Excluded 7 patients with incomplete laboratory data:
  • 4 patients had no C-reactive protein value
  • 3 patients had no monocyte distribution width value

Total 160 eligible patients:
• 139 patients with simple colonic diverticulitis
• 21 patients with complicated colonic diverticulitis

Figure 1

The flowchart of the enrolled study patients.
Receiver Operator Characteristics (ROC) analysis of MDW and other inflammatory biomarkers (MDW = monocyte distribution width; CRP = C-reactive protein; NLR = neutrophil lymphocyte ratio; WBC = white blood cell; PLR = platelet to lymphocyte ratio.)