ORIGINAL ARTICLE

Efficacy of Non-Operative Management and Risk Factors for Failure in Acute Diverticulitis with Extraluminal Air: A Retrospective Analysis

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Background: Non-operative management (NOM) is increasingly considered for carefully selected cases of perforated diverticulitis with extraluminal air. However, the risk factors associated with failure in such cases remain unclear.

Objective: To evaluate the efficacy of NOM in acute diverticulitis with extraluminal air and to identify clinical and imaging risk factors associated with failure of NOM.

Materials and Methods: A retrospective review was conducted on 30 patients with extraluminal air on computed tomography (CT) imaging who met the inclusion criteria for NOM between January 2012 and December 2022. Baseline characteristics, clinical data, and imaging findings were analyzed. Univariable logistic regression was performed to identify predictors of failure, reported as odds ratios (OR) with 95% confidence intervals (CI).

Results: Of the 30 patients, 22 (73.3%) (95% CI 57.6 to 89.0) successfully underwent NOM, while eight (26.7%), required surgery due to clinical deterioration. Univariable logistic regression identified three significant risk factors for failure, temperature of 37.8 ℃ or greater (OR 3.50, 95% CI 1.03 to 11.87, p=0.044), complicated diverticulitis (OR 4.58, 95% CI 1.35 to 15.51, p=0.014), and distant intra-abdominal fluid (OR 16.67, 95% CI 2.17 to 128.18, p=0.007).

Conclusion: Approximately three-fourths of patients with extraluminal air can be successfully managed non-operatively. However, the presence of distant intra-abdominal fluid, complicated diverticulitis, and an initial temperature of 37.8℃ or greater were observed to be associated with increased risk of failure. These findings highlight the importance of careful risk stratification, close clinical monitoring, and the need for further studies to validate these results and optimize patient outcomes.

Keywords: Right-side colonic diverticulitis; Extraluminal air; Non-operative management

Received 21 March 2025 | Revised 29 July 2025 | Accepted 22 October 2025

J Med Assoc Thai 2025;108(11):892-97

Website: http://www.jmatonline.com

Diverticular disease of the colon is a condition characterized by the presence of pouches or outpouchings in the wall of the large intestine. These pouches may be asymptomatic or present with mild symptoms, but they can also lead to diverticulitis, an inflammatory condition of diverticulum. Diverticulitis can be categorized into uncomplicated and complicated forms.

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How to cite this article:

Supatraku E, Paleekupt J, Chandrachamnong P. Efficacy of Non-Operative Management and Risk Factors for Failure in Acute Diverticulitis with Extraluminal Air: A Retrospective Analysis. J Med Assoc Thai 2025;108: 892-97.

DOI: 10.35755/jmedassocthai.2025.11.892-897-02932

Currently, the best diagnostic method for diverticular disease of the colon is computed tomography (CT) scanning[1]. Abdominal CT imaging serves as a reliable diagnostic tool for accurately identifying the condition and stratifying its severity into distinct stages in accordance with the modified Hinchey classification[2]. These stages range from mild clinical diverticulitis to generalized feculent peritonitis. This classification system is widely used by physicians to make appropriate treatment decisions.

However, it is important to note that the modified Hinchey classification does not specifically address extraluminal air surrounding the affected areas or other locations within the abdomen when categorizing disease severity. Moreover, the presence of extraluminal air often raises concerns about perforated or ruptured diverticulitis, and surgical intervention may be necessary. Despite

this, the associated morbidity in emergency surgery scenarios necessitates non-operative management as an alternative.

The present study aimed to investigate the clinical characteristics associated with an increased risk of non-operative management failure in diverticulitis patients presenting with extraluminal air.

Materials and Methods

Study design and participant

The present study was a retrospective analysis of patients admitted to the hospital with CT-diagnosed acute diverticulitis between January 2012 and December 2022. Patients were included if they were diagnosed with perforated or ruptured acute diverticulitis and initially managed non-operatively with either intravenous antibiotics or percutaneous drainage. Exclusion criteria comprised patients presenting with unstable conditions, such as hypotension or altered consciousness, those with suspected malignant from imaging study, and those with generalized peritonitis. Complicated diverticulitis was defined on CT imaging according to the modified Hinchey classification, including stages Ib to IV, or the presence of pericolic or distant abscess, purulent or fecal peritonitis, or free intraperitoneal fluid.

Ruptured diverticulitis was defined as the presence of extraluminal air identified on CT scans. Distant air and fluid were classified as air or fluid located more than 5 cm from the inflamed or diseased segment. Treatment failure was defined as cases when patients required surgical intervention following initial non-operative management. The demographic data, CT scan finding, and management of both failure group and success treatment of non-operative management were recorded.

The requirement for informed consent was waived because the dataset did not contain personal identification or other personal identifiers. Ethical approval for the present study was obtained from the Vajira Institutional Review Board (VIRB), Faculty of Medicine Vajira Hospital (Bangkok), number 190/65 E.

Statistical analysis

Continuous variables were compared between groups using the independent t-test for normally distributed data, with results presented as mean and standard deviation (SD). For non-normally distributed data, the Mann-Whitney U test, also known as the rank-sum test, was used, and results were presented as median and interquartile range (IQR). Categorical variables were analyzed using Fisher's exact test, and results were reported as counts (n) and percentages (%). A p-value of less than 0.05 was considered statistically significant. Statistical analyses were performed using Stata Statistical Software, version 16.1 (StataCorp LLC, College Station, TX, USA).

To identify factors associated with the failure of non-operative management, univariable logistic regression analyses were conducted using variables that were statistically significant in the baseline characteristics for $p<0.05$ or considered clinically relevant based on existing literature. The results were reported as odds ratios (OR) with 95% confidence intervals (CI). However, due to the limited sample size in the present study, multivariable logistic regression could not be performed, as the small number of events lacked sufficient statistical power.

Results

Between January 2012 and December 2022, 442 patients were diagnosed with acute diverticulitis. Among them, 42 patients (9.4%) were identified as having ruptured diverticulitis, characterized by the presence of extraluminal air detected on CT imaging. Of these, 30 patients met the inclusion criteria, which required stable vital signs, the absence of generalized peritonitis on abdominal examination, and adherence to the study protocol.

Twelve patients were excluded. Two were excluded due to imaging findings suspicious for malignancy, five due to hemodynamic instability, and five due to generalized peritonitis. The study flow, including inclusion and exclusion details, is illustrated in Figure 1.

Baseline characteristics of the included patients are age, gender, body mass index (BMI), underlying diseases, and disease location, as presented in Table 1. All patients received intravenous antibiotics targeting gastrointestinal flora.

Of the included patients, 22 (73.3%) (95% CI 57.6 to 89.0) successfully underwent non-operative management, while eight (26.7%) required surgical intervention during hospitalization. Surgical decisions for the non-operative failure group were based on clinical deterioration, such as worsening abdominal signs or persistent fever, at the discretion of the attending surgeon. There was no in-hospital mortality observed in either the non-operative management group or the surgical intervention group.

When analyzed by disease location, the success rate of non-operative management was 66.67%

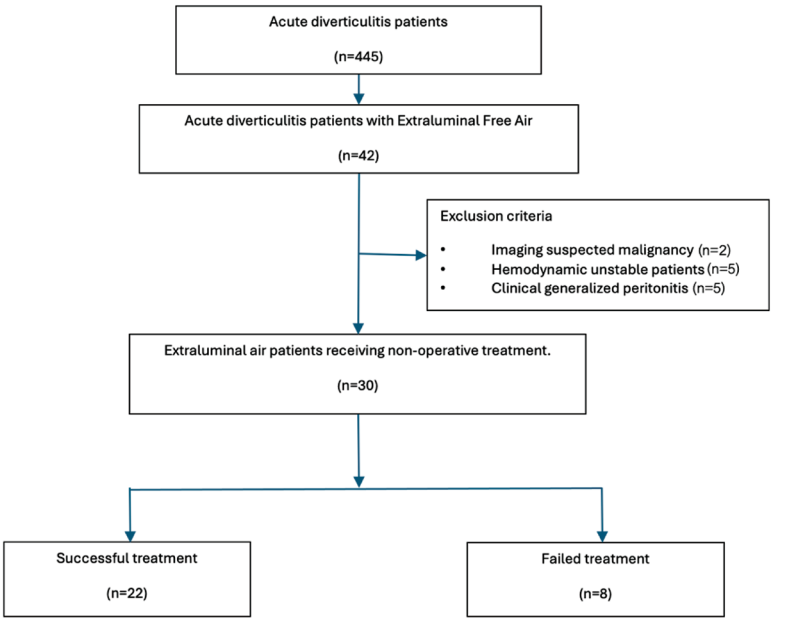

Figure 1. The diagram of patient selection and study flow.

Table 1. Baseline characteristics

Parameters	Failure (n=8)	Success (n=22)	p-value
Age (years); mean [SD]	61.38 [15.00]	62.18 [13.08]	0.750
Sex; n (%)			1.000
Male	5 (62.50)	12 (54.55)	
Female	3 (37.50)	10 (45.45)	
BMI (kg/m^2); mean [SD]	25.60 [5.16]	26.38 [5.09]	0.717
Underlying disease; n (%)			
Diabetes mellitus	4 (50.00)	6 (27.27)	0.384
Hypertension	5 (62.50)	11 (50.00)	0.689
Hyperlipidemia	5 (62.50)	5 (22.73)	0.078
Obesity	2 (25.00)	5 (22.73)	1.000
Chronic kidney disease	0 (0.00)	2 (9.09)	1.000
Coronary arterial disease	1 (12.50)	3 (13.64)	1.000
ASA classification; n (%)			1.000
1	3 (37.50)	8 (36.36)	
2	3 (37.50)	9 (40.91)	
3	2 (25.00)	4 (18.18)	
4	0 (0.00)	1 (4.55)	
Location; n (%)			0.709
Ascending	2 (25.00)	5 (22.73)	
Transverse	1 (12.50)	1 (4.55)	
Descending	0 (0.00)	3 (13.64)	
Sigmoid	5 (62.50)	13 (59.09)	
Side; n (%)			0.666
Right	3 (37.50)	6 (27.27)	
Left	5 (62.50)	16 (72.73)	

BMI=body mass index; ASA=American Society of Anesthesiologists; SD=standard deviation

for right-sided diverticulitis, or the ascending and transverse colon, and 76.19% for left-sided diverticulitis, or the descending and sigmoid colon. There was no statistically significant difference in failure rates between the two locations. The only significant clinical factor that differed between the success and failure groups was temperature, which was higher in the failure group with 37.74°C versus 37.08°C ($p<0.05$). Other clinical factors, including heart rate, systemic inflammatory response syndrome (SIRS), and white blood cell count (WBC), showed no significant differences between the groups.

Imaging findings demonstrated a significantly higher proportion of complicated diverticulitis in the failure group at 50%, compared to the success group at 4.55% ($p<0.05$). Among patients with extraluminal air, the success rate of non-operative management was 81.82% in those with pericolic air only and 50% in those with distant free air. However, the difference was not statistically significant. When considering intra-abdominal fluid location, the success rate was 92.3% in patients without intra-abdominal fluid, 80% in those with pericolic fluid only, and 28.57% in those with distant fluid (Table 2).

The univariable logistic regression analysis to predict failure of non-operative management in diverticulitis patients with pneumoperitoneum is summarized in Table 3. Three variables were identified as statistically significant predictors of failure, temperature of 37.8°C or greater (OR

Table 2. Clinical characteristic affect the treatment result of non-operative management in acute diverticulitis patients

Parameters	Failure (n=8)	Success (n=22)	p-value
Temperature (°C); mean [SD]	37.74 [0.78]	37.08 [0.68]	0.032*
Pulse rate; mean [SD]	101.13 [19.09]	90.18 [17.19]	0.145
SIRS; n (%)			0.300
No	5 (62.50)	19 (86.36)	
Yes	3 (37.50)	3 (13.64)	
White blood cell count (cell/mL); n (%)			0.078
≤10,000	5 (62.50)	5 (22.73)	
>10,000	3 (37.50)	17 (77.27)	
Creatinine; median [IQR]	0.90 [0.81 to 1.45]	0.95 [0.84 to 1.04]	0.815
Complicated diverticulitis; n (%)	4 (50.00)	1 (4.55)	0.011*
Fluid; n (%)			0.092
No	1 (12.50)	12 (54.55)	
Yes	7 (87.50)	10 (45.45)	
Location of air; n (%)			0.158
Pericolic	4 (50.00)	18 (81.82)	
Distant	4 (50.00)	4 (18.18)	
Location of fluid; n (%)			0.010*
No	1 (12.50)	12 (54.55)	
Pericolic	2 (25.00)	8 (36.36)	
Distant	5 (62.50)	2 (9.09)	

SIRS=systemic inflammatory response syndrome; SD=standard deviation; IQR=interquartile range
* Statistical significance, p<0.05

Table 3. Univariable logistic regression analysis of factors affecting failure in non-operative management of rupture diverticulitis

Variable	Odds ratio	95% CI	p-value
Age ≥50 years (age 50)	0.667	0.0965 to 4.6047	0.681
BMI ≥25 kg/m^2 (BMI 25)	0.968	0.8175 to 1.1462	0.706
Female	0.720	0.1370 to 3.784	0.698
Diabetes mellitus	2.667	0.5002 to 14.2174	0.251
Temperature ≥37.8°C	3.504	1.0340 to 11.8706	0.044*
Left side	0.625	0.1130 to 3.460	0.590
SIRS	3.800	0.5803 to 24.8838	0.164
WBC >10,000 cell/mL	0.176	0.0308 to 1.0099	0.051
Distant air	4.500	0.7749 to 26.1330	0.094
Complicated diverticulitis	4.583	1.3541 to 15.5086	0.014*
Fluid	8.400	0.8791 to 80.2649	0.065
Distant fluid	16.667	2.1672 to 128.1762	0.007*

BMI=body mass index; SIRS=systemic inflammatory response syndrome; WBC=white blood cell; CI=confidence interval
* Statistical significance, p<0.05

3.50, 95% CI 1.03 to 11.87, p=0.044), complicated diverticulitis (OR 4.58, 95% CI 1.35 to 15.51, p=0.014), and distant fluid (OR 16.67, 95% CI 2.17 to 128.18, p=0.007).

Despite these significant findings, the limited sample size of 30 patients, and low number of failure events with eight, precluded the use of multivariable logistic regression. This limitation restricted the ability to adjust for potential confounders or assess the independent effects of each predictor, underscoring the need for larger studies to validate these findings.

Discussion

The present retrospective study evaluated the outcomes of non-operative management in patients with acute diverticulitis presenting with extraluminal air. Among the 30 patients included, non-operative management was successful in 73.3%, while 26.7% required surgical intervention due to clinical deterioration. Univariable analysis identified three factors associated with non-operative management failure, which are an initial temperature of 37.8°C or greater, complicated diverticulitis, and the presence of distant intra-abdominal fluid. These findings emphasize the importance of careful patient selection and close monitoring when non-operative management is pursued in this clinical context.

Acute diverticulitis is a significant challenge in the colorectal department. The prevalence of diverticular disease varies with age. Approximately 5% of individuals aged 40 may have diverticulosis, a figure that can increase to as high as 80% in those

aged 80[3]. Complications such as diverticulitis occur in around 4% to 15% of cases[4]. Factors contributing to the development of diverticular disease include male gender, smoking, low-fiber diet, and obesity. CT is used as a main diagnostic tool. The presence of extraluminal air often raises concerns about perforated or ruptured diverticulitis, which undergo surgical intervention.

The management of diverticulitis with extraluminal air or perforated diverticulitis has been a topic of debate, with concerns about the potential need for surgical intervention that emergency surgery for acute diverticulitis can lead to mortality rates of up to 10.6% to 16.7%[5,6]. However, the present study suggests that selected patients with extraluminal air may be suitable candidates for non-operative management. The authors found that 73.3% of patients with extraluminal air on CT scan could be successfully treated with antibiotics or percutaneous drainage, without requiring emergency surgery.

Costi et al.[7] studied 411 patients with acute diverticulitis and found that 44 (10.7%) had extraluminal air. Among them, five patients underwent surgery within the first 24 hours due to unstable vital signs, while the remaining 39 (88%) were managed non-operatively. Of these, 36 patients had successful non-operative management. The study concluded that the presence of extraluminal air was not a factor leading to unsuccessful non-operative management. The present study indicated that acute diverticulitis patients with extraluminal air can safely manage with non-operative treatment.

Titos-García et al.[8] found that patients with distant extraluminal air, away from the disease site, were five times more likely to have unsuccessful non-operative management. This finding aligns with the study by Sallinen et al.[9], which identified air pockets larger than 1 by 1 cm or more than 2 cm wide and distant retroperitoneal air as factors contributing to unsuccessful non-operative management, with odds ratios of 6.5 and 5.6, respectively. Similarly, Colas et al.[10] found that the presence of intra-abdominal air was a factor associated with the failure of non-operative management.

From the present study, the location of the extraluminal air did not significantly impact the success rate of non-operative management, with comparable rates between pericolic air only at 81.82% and distal free air at 50%. However, the presence and location of intra-abdominal fluid were a crucial factor. Patients with no intra-abdominal fluid or pericolic fluid only had high success rates of 92.3% and 80%, respectively. In contrast, those with distant fluid collections had a significantly lower success rate of 28.57%. This finding suggests that the extent of intra-abdominal contamination, as indicated by distant fluid, may be a better predictor of treatment failure than the presence of extraluminal air alone.

Body temperature at presentation also emerged as a significant factor, with higher temperatures associated with failed non-operative management. This may reflect more severe inflammatory responses or a higher bacterial burden, necessitating surgical intervention. However, it is essential to interpret this finding cautiously, as fever can be influenced by numerous factors, including the timing of temperature measurement and the use of antipyretics.

While the present study supports the potential for non-operative management in selected cases, it is crucial to exercise caution and closely monitor patients for signs of clinical deterioration. Factors such as worsening abdominal signs, persistent fever, or increasing inflammatory markers may necessitate surgical intervention. Additionally, the decision-making process should involve a multidisciplinary team, considering the patient's overall clinical status, comorbidities, and preferences.

Limitations of the present study include its retrospective nature and the small sample size, which may limit the generalizability of the findings. The present study did not evaluate the volume of extraluminal air, which may have prognostic implications as suggested by previous studies[8,10]. Future studies with quantitative air assessment are warranted to determine whether the amount of air influences clinical decision-making. Furthermore, the decision to pursue non-operative management or surgery was based on the treating physicians' clinical judgment, which could introduce potential selection bias. Prospective studies with larger patient cohorts and standardized treatment protocols are warranted to further validate and refine the criteria for non-operative management in diverticulitis with extraluminal air or perforation.

Conclusion

The present study demonstrates that carefully selected patients with extraluminal air on CT imaging can be effectively managed with non-operative treatment, with approximately three-fourths (75%) achieving successful outcomes. However, factors such as the presence of distant intra-abdominal fluid, complicated diverticulitis, and an initial temperature of 37.8°C or higher were identified as significant

predictors of failure in non-operative management. Imaging findings, particularly the presence and location of intra-abdominal fluid, may serve as critical indicators for risk stratification.

These results underscore the importance of a selective approach to surgical intervention in perforated diverticulitis, which could potentially reduce the morbidity associated with emergency surgeries. Nevertheless, due to the limited sample size and the inability to perform multivariable logistic regression, further studies with larger cohorts are warranted to validate these findings. Close clinical monitoring and a multidisciplinary approach remain essential to ensure patient safety and optimize outcomes in this challenging patient population.

What is already known about this topic?

Perforated diverticulitis with extraluminal free air can be managed non-operatively in selected patients.

What does this study add?

This study identifies distant intra-abdominal fluid, complicated diverticulitis, and an initial temperature of 37.8°C or higher as significant predictors of non-operative management failure, emphasizing the importance of thorough risk assessment and close monitoring in patient management.

Conflicts of interest

The authors declare no conflict of interest.

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