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The primary aim of *World Journal of Gastrointestinal Surgery* (WJGS, *World J Gastrointest Surg*) is to provide scholars and readers from various fields of gastrointestinal surgery with a platform to publish high-quality basic and clinical research articles and communicate their research findings online.

WJGS mainly publishes articles reporting research results and findings obtained in the field of gastrointestinal surgery and covering a wide range of topics including biliary tract surgical procedures, biliopancreatic diversion, colectomy, esophagectomy, esophagostomy, pancreas transplantation, and pancreatectomy, *etc.*

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Retrospective Cohort Study

Clinical significance of peri-appendiceal abscess and phlegmon in acute complicated appendicitis patients undergoing emergency appendectomy

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Abstract

BACKGROUND

Although antibiotic therapy has become the primary treatment for acute uncomplicated appendicitis, the management of acute complicated appendicitis necessitates careful consideration of various treatment options.

AIM

To analyze the clinical data of patients who underwent emergency appendectomy for acute complicated appendicitis with peri-appendiceal abscess or phlegmon, identify factors influencing the postoperative length of hospital stay (LOS), and improve treatment strategies.

METHODS

The clinical data of acute complicated appendicitis patients with peri-appendiceal abscess or phlegmon who underwent emergency appendectomy at The Department of Emergency Surgery, Zhongshan Hospital, Fudan University from January 2016 to March 2023 were retrospectively analyzed.

RESULTS

A total of 234 patients were included in our study. The duration of symptoms and the presence of an appendicolith were significantly correlated with the occurrence of peri-appendiceal abscess in patients with acute complicated appendicitis ($P < 0.001$ and $P = 0.015$, respectively). Patients with symptoms lasting longer than 72 h had a significantly longer postoperative LOS compared to those with symptoms

lasting 72 h or less [hazard ratio (HR), 1.208; 95%CI: 1.107-1.319; $P < 0.001$]. Additionally, patients with peri-appendiceal abscesses had a significantly longer postoperative LOS compared to those with phlegmon (HR, 1.217; 95%CI: 1.095-1.352; $P < 0.001$). The patients with peri-appendiceal abscesses were divided into two groups based on the median size of the abscess: Those with abscesses smaller than 5.0 cm ($n = 69$) and those with abscesses 5.0 cm or larger ($n = 82$). Patients with peri-appendiceal abscesses measuring 5.0 cm or larger had a significantly longer postoperative LOS than those with abscesses smaller than 5.0 cm ($P = 0.038$).

CONCLUSION

The duration of symptoms and the presence of an appendicolith are significant risk factors for the formation of peri-appendiceal abscesses in patients with acute complicated appendicitis. Patients with peri-appendiceal abscesses experience a significantly longer postoperative LOS compared to those with peri-appendiceal phlegmon.

Key Words: Acute complicated appendicitis; Abscess; Phlegmon; Appendectomy; Appendicolith

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Core Tip: This study explored the clinical implications of peri-appendiceal abscess and phlegmon in the surgical management of acute complicated appendicitis. Through a single-center retrospective analysis, we found that the presence of a peri-appendiceal abscess significantly predicts an extended postoperative hospital stay for patients with acute complicated appendicitis. These findings highlight the importance of considering conservative treatment options in patients presenting with a peri-appendiceal abscess.

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INTRODUCTION

Appendicitis, characterized by inflammation of the appendix, is the leading cause of emergency abdominal surgery worldwide[1]. The global annual incidence ranges from 96.5 to 100 cases per 100000 adults[2]. Although antibiotic therapy has become the primary treatment for acute uncomplicated appendicitis, often enabling patients to avoid surgery, managing acute complicated appendicitis requires a more nuanced evaluation of treatment options[3,4].

Acute complicated appendicitis, marked by the presence of peri-appendiceal phlegmon or abscess formation, poses additional challenges and typically demands a more comprehensive treatment approach[5,6]. Management strategies have evolved to include both conservative and surgical options, tailored to the patient's specific condition[6]. Typically, surgical intervention is recommended for early-stage acute complicated appendicitis (symptom duration ≤ 72 h) with peri-appendiceal phlegmon. In contrast, late-stage acute complicated appendicitis (symptom duration > 72 h) or cases involving peri-appendiceal abscess formation, are typically managed conservatively, starting with percutaneous drainage and antibiotics[1]. Despite these guidelines, some surgeons and patients still prefer surgical intervention for various reasons[7]. However, there is a notable lack of studies on the outcomes of patients with acute complicated appendicitis who opt for surgery over conservative treatment, highlighting the need for further research.

In practice, it is crucial to have a comprehensive discussion with patients about the benefits and risks associated with all treatment options[8]. The decision between surgical intervention and a conservative treatment-first approach should be based on the patient's clinical and radiographic findings, along with their treatment expectations and preferences[9]. This study explored the impact of peri-appendiceal abscess and phlegmon in the surgical management of acute complicated appendicitis. Our single-center retrospective analysis revealed that the presence of a peri-appendiceal abscess is a significant predictor of prolonged postoperative length of hospital stay (LOS) for patients with acute complicated appendicitis. These findings underscore the importance of conservative treatment in patients with peri-appendiceal abscess. These insights are valuable for clinicians managing complicated appendicitis and suggest directions for future research to optimize treatment protocols and improve patient outcomes.

MATERIALS AND METHODS

Study design and patients

We prospectively recruited consecutive patients with acute appendicitis, collected their clinicopathological data, and retrospectively analyzed the clinicopathological features correlated with prognosis to improve treatment strategies. Between January 2016 and March 2023, 3896 patients were diagnosed with acute appendicitis at The Department of

Emergency Surgery, Zhongshan Hospital, Fudan University (Shanghai, China). The analytical data included general patient information, clinical manifestations, preoperative blood test results, imaging examination results, treatment method, surgical approach, LOS, and prognosis. All patients with acute appendicitis underwent a computed tomography (CT) scan of the abdomen and pelvis upon arrival at the emergency department. A peri-appendiceal phlegmon is characterized by an inflammatory mass composed of inflamed and adherent tissues, including the appendix, adjacent bowel loops, and omentum. On imaging, it manifests as a poorly defined area of inflammation, with thickened, adherent bowel loops and adjacent fat stranding, but notably, it lacks a clear, fluid-filled cavity. In contrast, a peri-appendiceal abscess is a localized collection of pus resulting from an infection. It appears on imaging as a well-defined, fluid-filled cavity with an enhancing wall, often accompanied by adjacent inflammatory changes and sometimes air-fluid levels within the cavity. Patients with peri-appendiceal abscesses or phlegmon on CT scans were selected as candidates for this study.

This retrospective study included patients who met the following criteria: Aged 18 years or older, clinically diagnosed with acute appendicitis, had a peri-appendiceal abscess or phlegmon on a CT scan, opted for immediate emergency surgery as their primary choice, and refused conservative treatment (antibiotic therapy and ultrasound/CT-guided drainage). The exclusion criteria were patients younger than 18 years, those with a history of prior malignancies, those with diffuse peritonitis, and those with incomplete clinical or pathological records. Based on these criteria, 3896 patients were screened, and 234 patients were included in our study. The cohort consisted of 134 males and 100 females, with ages ranging from 18 to 87 years (median age 60 years) (Figure 1).

Based on the findings from the CT scan, patients were divided into two groups: Peri-appendiceal abscess group ($n = 151$) and peri-appendiceal phlegmon group ($n = 83$) (Figure 1). All patients underwent surgical intervention and received postoperative antibiotic treatment (second-generation cephalosporins plus metronidazole) until recovery and discharge from the hospital. All procedures were performed by highly trained and experienced emergency surgeons in our hospital.

The primary endpoint of this study was the postoperative LOS. The discharge criteria included the resolution of symptoms such as pain and fever, stable vital signs, the ability to tolerate oral intake, normalization of laboratory parameters (e.g., white blood cell count), and the absence of postoperative complications. The secondary endpoints included postoperative complications, such as surgical site infections (SSI), incisional hernias, and the surgical approach used. Ethical approval for this study was granted by The Clinical Research Ethics Committee of Zhongshan Hospital, Fudan University (Shanghai, China). Informed consent was obtained from all patients for the collection and use of anonymized clinical data.

Statistical analysis

Statistical analyses were conducted using statistical package for social science software (version 27.0; Inc., Chicago, IL, United States). Normally distributed data are presented as the mean \pm SD, while skewed data are presented as the median (interquartile range). Categorical variables are expressed as counts and percentages. Differences in distribution were assessed using Pearson's χ^2 test or Fisher's exact test for categorical variables, and Student's t -test for continuous variables. Univariate analyses were performed using the Cox proportional hazards regression model. Kaplan-Meier survival analysis was performed utilizing postoperative LOS as the "survival time", and survival curves were compared using the log-rank test. A P value < 0.05 was considered to indicate statistical significance.

RESULTS

Clinical characteristics of the patients at baseline

A total of 234 patients with acute complicated appendicitis accompanied by peri-appendiceal abscess or phlegmon were included in our study. The patients ranged in age from 18 years to 87 years, with a median age of 60 years; 57.3% were males and 42.7% were females. The mean white blood cell (WBC) count was $13.4 \times 10^9/L$, and the mean granulocyte percentage was 88.9%. Appendicoliths were present in 56.4% of patients ($n = 132$). Peri-appendiceal abscesses were found in 64.5% of patients ($n = 151$), while peri-appendiceal phlegmon was observed in 35.5% ($n = 83$). The vast majority of patients were diagnosed with acute appendicitis ($n = 228$, 97.4%). Additionally, there were cases of appendiceal adenocarcinoma ($n = 4$, 1.7%), appendiceal neuroendocrine neoplasm ($n = 1$, 0.4%), and appendiceal mucinous neoplasm ($n = 1$, 0.4%) (Table 1).

Correlations between clinical factors and peri-appendiceal abscess or phlegmon

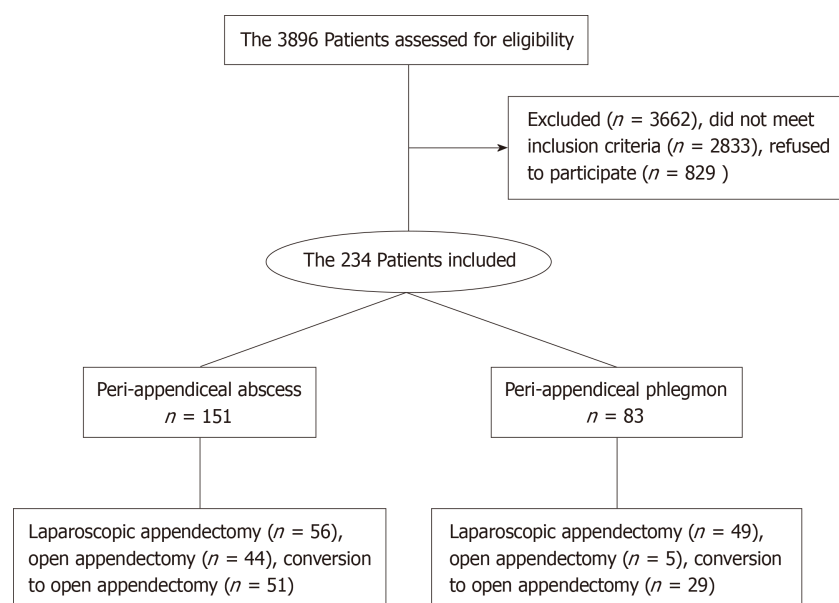
The correlations between clinical factors and the presence of peri-appendiceal abscess or phlegmon among the 234 patients are summarized in Table 2. The duration of symptoms was significantly different between the two groups ($P < 0.001$). Specifically, among patients with symptoms lasting ≤ 72 h, 69 had abscesses, and 71 had phlegmons. In contrast, among those with symptoms lasting > 72 h, 82 had abscesses, while only 12 had phlegmons. The presence of an appendicolith was also significantly correlated with the presence of abscesses ($P = 0.015$); 94 patients with appendicoliths had abscesses compared to 38 with phlegmons, while among those without appendicoliths, 57 had abscesses and 45 had phlegmons. There was no significant difference in age ($P = 0.947$) or sex ($P = 0.897$) between patients with abscesses and those with phlegmons. Additionally, temperature ($P = 0.923$), WBC count ($P = 0.668$), and granulocyte percentage ($P = 0.557$) did not significantly differ between the two groups.

Cox regression analysis for postoperative LOS

Cox regression analysis of postoperative LOS among patients revealed that the duration of symptoms and the presence of

Table 1 Baseline clinical characteristics of the patients, *n* (%)

Characteristic	
All patients	234 (100)
Age, median (range), years	60 (18-87)
Sex	
Female	100 (42.7)
Male	134 (57.3)
White blood cell count, mean (SD), $\times 10^9/L$	13.4 (5.2)
Granulocyte percentage, mean (SD)	88.9 (4.8)
Appendicolith	132 (56.4)
Peri-appendiceal abscess	151 (64.5)
Peri-appendiceal phlegmon	83 (35.5)
Pathology	
Acute appendicitis	228 (97.4)
Appendiceal adenocarcinoma	4 (1.7)
Appendiceal neuroendocrine neoplasm	1 (0.4)
Appendiceal mucinous neoplasm	1 (0.4)

**Figure 1** Flowchart of the inclusion process of patients.

a peri-appendiceal abscess significantly influenced the LOS. Patients with symptoms lasting ≤ 72 h had a median postoperative LOS of 5 d, whereas those with symptoms lasting > 72 h had a median postoperative LOS of 7 d [hazard ratio (HR), 1.208; 95%CI: 1.107-1.319; $P < 0.001$]. Additionally, patients with a peri-appendiceal abscess had a median postoperative LOS of 6 d, compared to 5 d for those with peri-appendiceal phlegmon (HR, 1.217; 95%CI: 1.095-1.352; $P < 0.001$). Other factors, such as age, sex, temperature, WBC count, granulocyte percentage, and the presence of an appendicolith, did not show significant correlations with postoperative LOS. Specifically, patients with a granulocyte percentage $\leq 80\%$ had a median postoperative LOS of 5 d, whereas those with a granulocyte percentage $> 80\%$ had a median postoperative LOS of 6 d (HR: 1.081, $P = 0.097$). Although this difference was not statistically significant, there appeared to be an observable trend (Table 3).

To evaluate the clinical prognostic significance of peri-appendiceal abscess or phlegmon on postoperative LOS for patients in this study, Kaplan-Meier survival analyses were performed. As shown in Figure 2, Kaplan-Meier survival curves were generated to compare the postoperative LOS between patients with peri-appendiceal abscess and those with peri-appendiceal phlegmon. The findings revealed that patients with peri-appendiceal abscess had a significantly longer

Table 2 Correlation between clinical factors and peri-appendiceal abscess or phlegmon

Characteristic	Peri-appendiceal		χ^2	P value
	Abscess	Phlegmon		
All patients	151	83		
Age (years) ¹			0.004	0.947
≤ 60	83	46		
> 60	68	37		
Sex			0.017	0.897
Female	65	35		
Male	86	48		
Temperature			0.009	0.923
≤ 37 °C	50	28		
> 37 °C	101	55		
White blood cell count, × 10 ⁹ /L			0.183	0.668
≤ 9.5	44	22		
> 9.5	107	61		
Granulocyte percentage			0.142	0.557
≤ 80%	36	17		
> 80%	115	66		
Duration of symptoms			17.663	< 0.001
≤ 72 h	69	71		
> 72 h	82	12		
Appendicolith			5.908	0.015
Yes	94	38		
No	57	45		

¹Split at median.

postoperative LOS than those with phlegmon (Figure 2A, $P < 0.001$). Additionally, based on the median size of the abscess, patients with peri-appendiceal abscesses were categorized into two groups: Those with abscesses smaller than 5.0 cm ($n = 69$) and those with abscesses 5.0 cm or larger ($n = 82$). Both abscess groups exhibited significantly longer postoperative LOS than the phlegmon group ($P < 0.001$ for both comparisons), and the difference between the two abscess size groups was also statistically significant ($P = 0.038$; Figure 2B). These results suggest that the presence of a peri-appendiceal abscess, especially a larger abscess, is associated with prolonged hospital stays compared to the presence of peri-appendiceal phlegmon.

Correlations between surgical factors and peri-appendiceal abscess or phlegmon

The analysis of surgical factors related to peri-appendiceal abscess or phlegmon revealed several significant findings. There was a significant correlation between the type of SSI and the presence of peri-appendiceal abscess or phlegmon ($P < 0.001$). Among the patients with peri-appendiceal abscess, there were 14 cases of superficial infections, 6 cases of deep incisional infections, and 2 cases of organ/space infections. In contrast, patients with peri-appendiceal phlegmon had only 1 case of superficial infection and no cases of deep incisional or organ/space infections. There was no significant difference in the occurrence of incisional hernias between the two groups, with only 1 patient with a peri-appendiceal abscess developing an incisional hernia and none with phlegmon. The type of surgery performed was also significantly correlated with the presence of abscess or phlegmon ($P < 0.001$). Among the patients with peri-appendiceal abscesses, 56 underwent laparoscopic appendectomy, 44 underwent open appendectomy, and 51 required conversion to open appendectomy. Among the patients with phlegmon, 49 underwent laparoscopic appendectomy, 5 underwent open appendectomy, and 29 required conversion to open appendectomy (Table 4).

Table 3 Cox regression analyses for postoperative length of hospital stay

Characteristic	Length of hospital stay (d)	Hazard ratio (95%CI)	P value
Age (years) ¹			0.913
≤ 60	6.0 (4.0, 8.0)	1.000 (reference)	
> 60	6.0 (4.0, 8.0)	0.997 (0.946-1.050)	
Sex			0.327
Male	6.0 (4.0, 8.0)	1.000 (reference)	
Female	6.0 (4.0, 8.0)	1.027 (0.974-1.083)	
Temperature			0.745
≤ 37 °C	6.0 (4.0, 7.0)	1.000 (reference)	
> 37 °C	6.0 (4.0, 8.0)	1.009 (0.954-1.068)	
WBC count, × 10 ⁹ /L			0.981
≤ 9.5	6.0 (4.0, 7.0)	1.000 (reference)	
> 9.5	6.0 (4.0, 8.0)	1.001 (0.945-1.060)	
Granulocyte percentage			0.097
≤ 80%	5.0 (3.0, 7.5)	1.000 (reference)	
> 80%	6.0 (4.0, 8.0)	1.081 (0.986-1.185)	
Duration of symptoms			< 0.001
≤ 72 h	5.0 (4.0, 7.0)	1.000 (reference)	
> 72 h	7.0 (5.0, 10.0)	1.208 (1.107-1.319)	
Appendicolith			0.699
No	6.0 (4.0, 8.0)	1.000 (reference)	
Yes	6.0 (4.0, 8.0)	1.010 (0.959-1.064)	
Peri-appendiceal			< 0.001
Phlegmon	5.0 (4.0, 7.0)	1.000 (reference)	
Abscess	6.0 (5.0, 8.0)	1.217 (1.095-1.352)	

¹Split at median.**Table 4 Correlation between surgical factors and peri-appendiceal abscess or phlegmon**

Characteristic	Peri-appendiceal		χ^2	P value
	Abscess	Phlegmon		
Surgical site infections by type			21.254	< 0.001
Superficial	14	1		
Deep incisional	6	0		
Organ/space	2	0		
Incisional hernias	1	0	0.552	0.457
Surgery			19.438	< 0.001
Laparoscopic appendectomy	56	49		
Open appendectomy	44	5		
Conversion to open appendectomy	51	29		

DISCUSSION

Appendicitis remains one of the most common and urgent surgical conditions worldwide, with a lifetime risk of 8.6% in men and 6.9% in women[10]. Prompting intervention is crucial for preventing complications and improving prognosis[11]. Traditionally, the standard treatment for acute appendicitis has been an appendectomy, performed either through open surgery or laparoscopically[12]. However, there is growing interest in nonsurgical management for patients with uncomplicated appendicitis. Several studies have demonstrated the efficacy of antibiotic therapy as a nonsurgical alternative for patients with acute uncomplicated appendicitis, reducing the immediate need for surgery[3,4]. Despite its effectiveness, there remains a risk of recurrence, necessitating careful patient selection and diligent follow-up[13,14].

Complicated appendicitis presents unique challenges, often requiring a more comprehensive treatment strategy than uncomplicated cases[15]. Conservative management typically involves antibiotics and percutaneous abscess drainage[16]. For patients with large abscesses, immediate emergency surgery is often avoided due to the high risk of complications[17]. Instead, a step-by-step hybrid approach is employed, starting with percutaneous drainage to stabilize the patient, followed by an interval appendectomy if necessary[18]. Advances in imaging techniques, such as ultrasound and CT-guided drainage, have greatly enhanced the precision and success of percutaneous abscess drainage, making it a key tool in effectively managing localized infections[19,20]. This approach not only controls infection and inflammation but also reduces surgical risks and improves overall patient outcomes[21]. However, despite these advances in conservative management, there are still clear indications for surgical intervention[22]. Persistent or worsening symptoms, along with a failure to respond to conservative treatment, often necessitate surgery. The timing of surgery is also critical; while immediate surgery may not be advisable for some patients, an interval appendectomy performed 6-8 wk after the initial conservative treatment can be safer and more effective[23].

Even with the advancements in conservative management, some surgeons and patients still prefer surgical intervention for various reasons, such as resolving the patient's issue in a single procedure and avoiding the prolonged duration of conservative treatment[7]. Typically, surgical treatment is advised for early-stage appendicitis (symptom duration ≤ 72 h) with peri-appendiceal phlegmon due to the effectiveness of immediate intervention in preventing further complications. Conversely, for late-stage appendicitis (symptom duration > 72 h) or cases involving peri-appendiceal abscess formation, an initial conservative approach involving antibiotics and percutaneous drainage is often favored to manage the condition effectively[6]. For patients who refuse conservative treatment initially, surgery becomes the only viable option. However, is surgery the right option? In our study, patients with peri-appendiceal abscesses had a significantly longer LOS compared to those with phlegmon. Additionally, we divided the patients with peri-appendiceal abscesses into two groups based on the median size of the abscess: Those with abscesses less than 5.0 cm and those with abscesses 5.0 cm or larger. Both groups with abscesses had a significantly longer LOS than patients with phlegmon, and patients with peri-appendiceal abscess measuring 5.0 cm or larger had a significantly longer LOS than those with abscess smaller than 5.0 cm. These data suggest that the presence of a peri-appendiceal abscess, especially a larger abscess, is associated with longer hospital stays compared to the presence of peri-appendiceal phlegmon.

When reviewing the treatment approach for patients with acute complicated appendicitis with peri-appendiceal abscess or phlegmon, different strategies are recommended based on the patient's condition[11]. For patients with peri-appendiceal phlegmon, immediate surgical intervention is typically advised[24]. In contrast, for patients with peri-appendiceal abscesses, especially larger abscesses, an initial conservative treatment approach is recommended[16,17]. This involves the use of antibiotics and percutaneous drainage to manage infection and inflammation[25]. The efficacy of conservative treatment for peri-appendiceal abscesses was highlighted in another clinical study (No. NCT06469086), which concluded that conservative treatment can effectively reduce the need for immediate surgery and minimize complications for selected patients.

The presence of an appendicolith, a calcified deposit within the appendix, significantly affects the progression and severity of acute appendicitis and the formation of peri-appendiceal abscesses[26]. An appendicolith can obstruct the appendix lumen, leading to increased pressure, bacterial overgrowth, and inflammation, often delaying symptom relief. This obstruction is also a major risk factor for localized perforation and abscess formation, necessitating more complex treatment approaches[27]. In this study, we found that the presence of an appendicolith is a risk factor for peri-appendiceal abscess formation in patients with acute complicated appendicitis. Our previous research demonstrated that identifying an appendicolith through imaging helps stratify patients by risk, guiding treatment decisions such as early surgical intervention to prevent severe complications or conservative management with antibiotics and drainage for abscess formation. Understanding the relationship between appendicoliths and these complications is crucial for improving patient outcomes, emphasizing the need for careful diagnosis, appropriate management strategies, and further research into effective treatment protocols.

This study has several limitations that should be considered. First, as a retrospective analysis, it is inherently prone to selection biases, despite utilizing data from a prospectively recruited database. The retrospective nature of the study limits the ability to control for all potential confounding variables, which might impact the generalizability of the findings. Second, the lack of long-term follow-up data restricts our ability to assess the long-term outcomes of the treatment strategies evaluated. This absence makes it challenging to determine the durability of the results and the potential for late complications, which are crucial for a comprehensive understanding of treatment efficacy. Third, the analysis did not incorporate various subjective factors, such as sociocultural influences, which can significantly affect treatment outcomes, particularly in the context of China[28,29]. Moreover, the study's focus on clinical and demographic factors without considering the broader socioeconomic context may overlook important variables that influence health outcomes. Factors such as access to healthcare, economic constraints, and educational levels can also play a significant role in the success of treatment and patient adherence to medical advice.

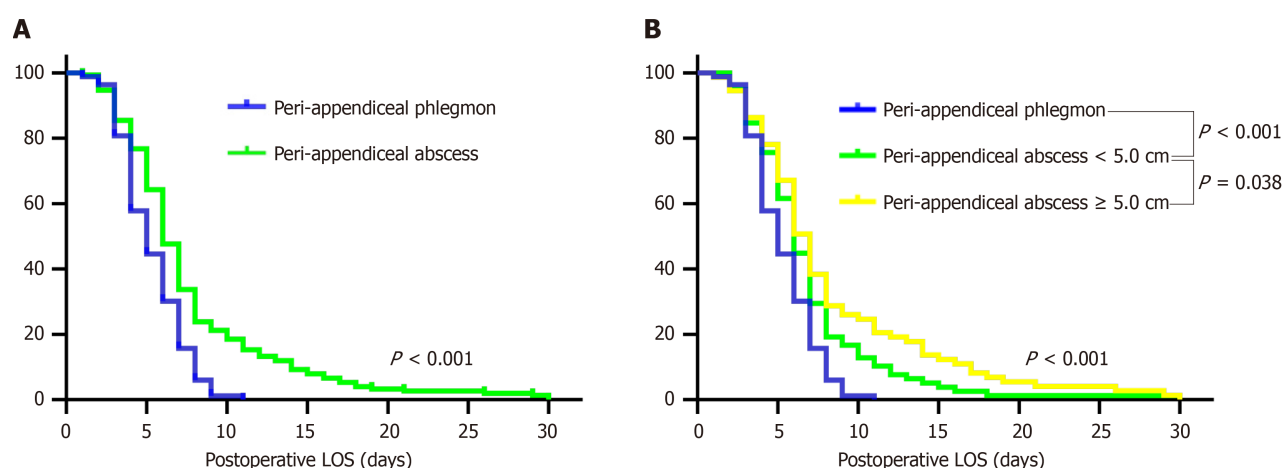


Figure 2 Kaplan-Meier survival curve analysis of postoperative length of hospital stay between patients with peri-appendiceal abscess and those with peri-appendiceal phlegmon. A: Kaplan-Meier analysis of postoperative length of hospital stay (LOS) comparing patients with peri-appendiceal abscess vs those with phlegmon; B: Kaplan-Meier analysis of postoperative LOS comparing patients with peri-appendiceal phlegmon, abscesses less than 5.0 cm, and abscesses 5.0 cm or larger. *P* values were calculated using the log-rank test. LOS: Length of hospital stay.

CONCLUSION

The duration of symptoms and the presence of an appendicolith are significant risk factors for the formation of peri-appendiceal abscesses in patients with acute complicated appendicitis. Clinical data show that patients with peri-appendiceal abscesses have a significantly longer postoperative LOS compared to those with peri-appendiceal phlegmon. Understanding the complex interplay between appendicoliths, abscess formation, and patient outcomes is essential for optimizing management strategies and improving overall clinical outcomes in patients with acute complicated appendicitis.

FOOTNOTES

Author contributions: Min LQ and Lu J contributed equally to this work, and they collected and analyzed the data and wrote the manuscript; He HY designed the study and edited the manuscript; all authors have read and approved the final manuscript.

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