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Clinical significance of appendicoliths in conservative treatment of acute complicated appendicitis patients with peri-appendiceal abscess: a single-center retrospective study

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Background: This study aimed to analyze the clinical data of patients who received conservative treatment for acute complicated appendicitis with peri-appendiceal abscess, identify factors influencing the success rate, and improve treatment strategies.
Methods: The clinical data of acute complicated appendicitis patients with peri-appendiceal abscess who received conservative treatment at the Department of Emergency Surgery, Zhongshan Hospital, Fudan University, from January 2016 to March 2023, were retrospectively analyzed.
Results: A total of 80 patients were included in our study. Patients were divided into two groups based on the outcomes of ultrasound-guided drainage: The Drainage group ($n = 28$) and the Antibiotic group ($n = 52$). The baseline characteristics of the two groups were comparable. In the Antibiotic group, the surgery rate was 30.4% for patients with an appendicolith and 6.9% for those without. In the Drainage group, the surgery rate was 33.3% for patients with an appendicolith and 27.3% for those without. The presence of an appendicolith significantly correlated with the need for surgery in the Antibiotic group ($P = 0.026$), but not in the Drainage group ($P = 0.771$). For patients who underwent surgery, the incidence of surgical site infections did not differ significantly ($P = 0.656$), and the median length of postoperative hospital stay was similar between the groups (4.0 days vs. 3.0 days, $P = 0.337$).
Conclusion: The presence of an appendicolith is a risk factor for the failure of antibiotic therapy alone in acute complicated appendicitis patients with peri-appendiceal abscess. However, it does not affect the surgical rate in those who underwent successful drainage.

Keywords: abscess, acute appendicitis, appendicolith, conservative treatment

Introduction

Appendicitis is a common acute surgical condition that, if not treated promptly and effectively, can lead to significant morbidity[1]. Prompt diagnosis and treatment are crucial for preventing complications[2]. For acute uncomplicated appendici tis, antibiotic therapy has emerged as the primary treatment, often allowing patients to avoid surgery[3,4]. However, the man agement of complicated appendicitis requires careful considera tion of various treatment options, and the best treatment options for acute complicated appendicitis with abscess remain a topic of debate[5].

Complicated appendicitis, characterized by the presence of an abscess or perforation, involves acute inflammation of the peri toneum secondary to an infection of the appendix, presenting additional challenges for management[5,6]. Traditionally, the standard treatment for complicated appendicitis has been surgery[7]. However, conservative management, involving anti biotics and drainage, has emerged as a viable alternative for selected patients[8,9]. Recent studies emphasize the importance of selecting appropriate antibiotics based on local resistance pat terns and the patient's clinical condition[10]. Broad-spectrum

HIGHLIGHT

This study examined the clinical significance of appendicoliths in the conservative management of acute complicated appendicitis with peri-appendiceal abscesses. It underscores the importance of appendicoliths as a predictor of failure in conservative treatment using antibiotics alone. However, the presence of appendicoliths does not impact the surgical rate in patients who successfully undergo drainage. These findings provide valuable insights for clinicians managing complicated appendicitis and suggest future research directions to optimize treatment protocols and improve patient outcomes.

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antibiotics, including those targeting anaerobic bacteria, are often preferred[11]. In addition, advances in imaging technology, such as ultrasound or computed tomography (CT)-guided drai nage, have improved the precision and success rates of percuta neous abscess drainage[12]. This minimally invasive approach helps manage localized infections and can prevent the need for immediate surgery.

One factor that has gained significant attention in determining the success of conservative treatment for acute complicated appendicitis is the presence of appendicolith-calcified deposits within the appendix. This study investigated the clinical significance of appendicoliths in the conservative management of acute complicated appendicitis with peri-appendiceal abscesses. This single-center retrospective analysis highlights the importance of the presence of appendicoliths as a predictor of conservative treatment failure when antibiotics are used alone. The presence of appendicoliths underscores the need for careful patient selection and the consideration of adjunctive drainage procedures in this subset of patients. These findings offer valuable insights 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 with acute appendicitis were diagnosed at the Department of Emergency Surgery, Zhongshan Hospital, Fudan University. The analytical data included general patient information, clinical manifestations, comorbidities, preoperative blood test results, imaging examination results, treatment method, surgical approach, length of hospital stay, and prognosis. All patients with acute appendicitis underwent a CT scan of the abdomen and pelvis upon arrival at the emergency department. Patients with peri-appendiceal abscesses larger than 2 cm in diameter on CT scans were selected as candidates for this study. The presence of an appendicolith was primarily identified through preoperative imaging, specifically via CT scans. The radiologic criteria for diagnosing an appendicolith included a high-density structure within the appendix lumen. The identification of an appendicolith was confirmed through a review process involving an emergency surgery doctor and an

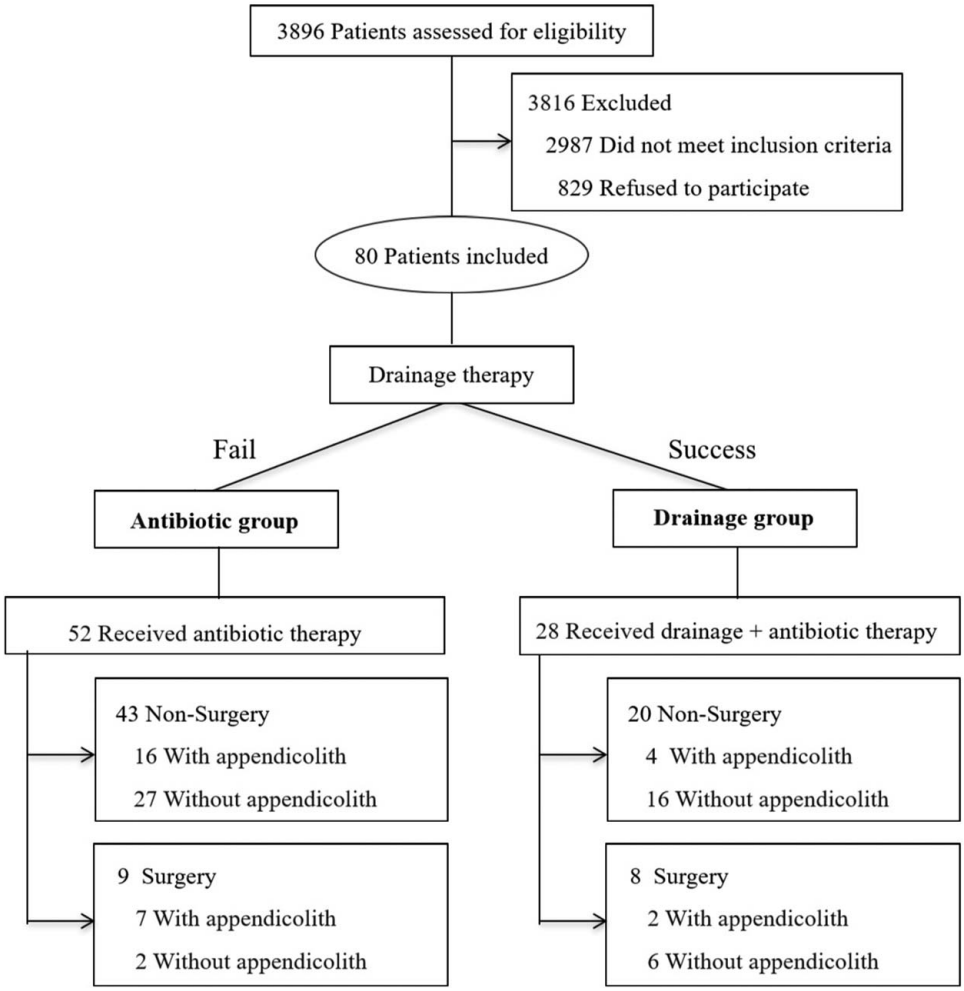

Figure 1. Flowchart of the inclusion process of patients.

independent radiologist. In cases where there was any disagreement, a third senior radiologist was consulted to reach a consensus.

This retrospective study included patients who met the following criteria: who were aged ≥18 years, who were clinically diagnosed with acute appendicitis, who had a peri-appendiceal abscess larger than 2 cm in diameter on CT scan, who agreed to undergo conservative treatment first, and who refused immediate emergency surgery. Patients younger than 18 years, those with malignancies, those with diffuse peritonitis, and those with incomplete clinical or pathological records were excluded from the study. Based on these criteria, a total of 3896 patients were screened, and 80 patients were included in our study, consisting of 48 males and 32 females, with ages ranging from 18 to 86 years (median age 54 years) (Fig. 1).

All patients initially underwent ultrasound-guided drainage for peri-appendiceal abscesses. Based on the outcomes of this procedure, patients were divided into two groups: the Drainage group ($n=28$), comprising those who experienced successful drainage, and the Antibiotic group ($n=52$), consisting of those for whom the drainage was unsuccessful (Fig. 1). All patients received antibiotic treatment (second-generation cephalosporins + metronidazole) until they either recovered and were discharged from the hospital or required surgery. Additionally, standard clinical care protocols were followed, and patients were administered analgesics for pain relief and antipyretics for fever control, as needed. These treatments were given at the discretion of the surgeons based on the patients' symptoms and clinical conditions. If, after treatment, the patient experienced elevated inflammatory markers, worsening abdominal pain, or if CT scans revealed enlarged abscesses, surgical intervention was carried out based on the emergency surgeon's judgment. The patient continued receiving antibiotic therapy postoperatively until discharge.

The primary endpoint was the resolution of acute appendicitis, which resulted in discharge from the hospital without the need for surgical intervention during a minimum follow-up of 3 months, specifically the success rate of conservative treatment. The secondary endpoints included postoperative complications, such as surgical site infections (SSI), incisional hernias, length of postoperative hospital stay, and surgical approach, for patients who underwent surgery. The Clinical Research Ethics Committee of Zhongshan Hospital, Fudan University, granted ethical approval for this study. The study was reported in line with the strengthening the reporting of cohort, cross-sectional, and case–control studies in surgery (STROCSS) criteria[13]. Informed consent was obtained from all patients for the collection and use of anonymized clinical data.

Statistical analysis

Statistical analysis was performed using SPSS Software (version 27.0; SPSS Inc.). Normally distributed data are presented as the mean ± 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. A P-value <0.05 was considered to indicate statistical significance.

Results

Clinical characteristics of the patients at baseline

A total of 80 acute appendicitis patients with peri-appendiceal abscesses larger than 2 cm were included in our study. Patients were divided into two groups based on the outcomes of ultrasound-guided drainage: the Drainage group ($n=28$) and the Antibiotic group ($n=52$). The baseline characteristics of the two groups were comparable. In the Drainage group, the median age was 56 years (range 21–79), while in the Antibiotic group, the median age was 54 years (range 18–86). The Drainage group consisted of 17 females and 11 males, while the Antibiotic group included 31 females and 21 males. In the Drainage group, the average white blood cell (WBC) count was 13.2×10^9/l, with neutrophils comprising an average of 84.6%, and the median duration of symptoms was 7.2 h. In the Antibiotic group, the average WBC count was 13.5×10^9/l, with neutrophils comprising an average of 81.2%, and the median duration of symptoms was 6.5 h. The mean abscess size in the Drainage group was 7.0 cm, compared to 4.5 cm in the Antibiotic group. Additionally, 21.4% of patients in the Drainage group had an appendicolith, whereas 44.2% of patients in the Antibiotic group had this condition (Table 1).

Correlations with the presence of appendicoliths in the drainage group and antibiotic group

The presence of appendicolith is a significant factor influencing the treatment outcomes of acute appendicitis patients. In this study, we analyzed the correlation between the presence of an appendicolith and various clinicopathological factors in both the Drainage and Antibiotic groups.

In the Drainage group, six patients had appendicoliths, while 22 did not. In the Antibiotic group, 23 patients had appendicoliths, and 29 did not. There were no significant differences in age or sex distribution between patients with and without appendicoliths in either group. Regarding abscess size, in the Drainage group, one patient with an appendicolith had an abscess size less than 5.0 cm, compared to six patients without an appendicolith. Additionally, five patients with appendicoliths had abscess sizes of 5.0 cm or greater, compared to 16 patients without. In the Antibiotic group, 13 patients with appendicoliths had abscess sizes of less than 5.0 cm, compared to 20 without. Conversely, 10 patients with appendicoliths had abscess sizes of 5.0 cm or

Table 1

Clinical characteristics of the patients at baseline.

Characteristic	Drainage group $N=28$	Antibiotic group $N=52$
Age, median (range), year	56 (21–79)	54 (18–86)
Sex		
Female	17	31
Male	11	21
WBC count, mean (SD), $\times10^9$/l	13.2 (5.7)	13.5 (4.9)
Percentage of neutrophils, mean (SD), %	84.6 (6.8)	81.2 (7.2)
Duration of symptoms, median (25th–75th %), hour	7.2 (5.1–7.8)	6.5 (4.5.1–7.2)
Abscess size, mean (SD), cm	7.0 (2.9)	4.5 (1.3)
Appendicolith	21.4%	44.2%

WBC, white blood cell.

greater, compared to nine without. Other factors, such as temperature, WBC count, percentage of neutrophils, C-reactive protein levels, and procalcitonin levels, showed no significant correlation with the presence of appendicoliths in either group (Table 2).

Primary outcomes in the drainage group and antibiotic group

The primary endpoint was the success rate of conservative treatment, specifically the rate of nonsurgical treatment. Table 3 presents the primary outcomes of patients in the Drainage and Antibiotic groups based on the necessity for surgery. In the Drainage group, eight patients required surgery, while 20 did not. In the Antibiotic group, nine patients required surgery, while 43 did not. Additionally, age, sex, and abscess size did not significantly differ between the two groups.

However, the presence of an appendicolith was significantly correlated with the need for surgery in the Antibiotic group ($P = 0.026$), but not in the Drainage group ($P = 0.771$). As illustrated in Figure 2, in the Antibiotic group, the surgery rate for patients with appendicolith was 30.4%, while for those without an appendicolith, it was significantly lower at 6.9%. In the Drainage group, the surgery rate for patients with an appendicolith was 33.3%, and for those without an appendicolith, it was slightly lower at 27.3%, this difference was not statistically significant.

Table 2

Correlation with appendicolith in drainage group and antibiotic group.

	Drainage group Appendicolith			Antibiotic group Appendicolith		
Characteristic	**Yes**	**No**	***P***	**Yes**	**No**	***P***
All patients	6	22		23	29	
Age (years)[a]			0.264			0.068
≤60	4	19		16	26	
>60	2	3		7	3	
Sex			0.595			0.686
Female	5	12		13	18	
Male	1	10		10	11	
Abscess size (cm)[a]			0.201			0.355
<5.0	1	6		13	20	
≥5.0	5	16		10	9	
Temperature			0.190			0.182
≤37°C	3	17		10	18	
>37°C	3	5		13	11	
WBC count, $\times 10^9$/l			0.748			0.386
≤9.5	1	5		4	8	
>9.5	5	17		19	21	
Percentage of neutrophils			0.099			0.510
≤80%	1	12		9	14	
>80%	5	10		14	15	
C-reactive protein, mg/l			0.157			0.278
≤10	2	3		10	17	
>10	4	19		13	12	
Procalcitonin, μg/l			0.357			0.730
≤0.1	4	10		14	19	
>0.1	2	12		9	10	

[a]Split at median.
WBC, white blood cell.

Table 3

Primary outcomes in drainage group and antibiotic group.

	Drainage group			Antibiotic group		
Characteristic	**Surgery**	**Nonsurgery**	***P***	**Surgery**	**Nonsurgery**	***P***
All patients	8	20		9	43	
Age (years)[a]			0.533			0.238
≤60	6	17		6	36	
>60	2	3		3	7	
Sex			0.903			0.785
Female	5	12		5	26	
Male	3	8		4	17	
Abscess size (cm)[a]			1.000			0.588
<5.0	2	5		5	28	
≥5.0	6	15		4	15	
Appendicolith			0.771			**0.026**
Yes	2	4		7	16	
No	6	16		2	27	

[a]Split at median.

Secondary outcomes in the drainage group and antibiotic group

Table 4 summarizes the secondary outcomes for patients in the Drainage and Antibiotic groups, with eight patients in the Drainage group and nine in the Antibiotic group requiring surgery. In terms of surgical site infections (SSIs), the Drainage group reported one superficial infection, one deep incisional infection, and one organ/space infection. In the Antibiotic group, there were two superficial infections and two deep incisional infections, with no organ/space infections. The difference in the SSI rate between the groups was not statistically significant ($P = 0.656$). Neither group had any cases of incisional hernias. The median length of postoperative hospital stay was 4.0 days in the Drainage group and 3.0 days in the Antibiotic group, with no significant

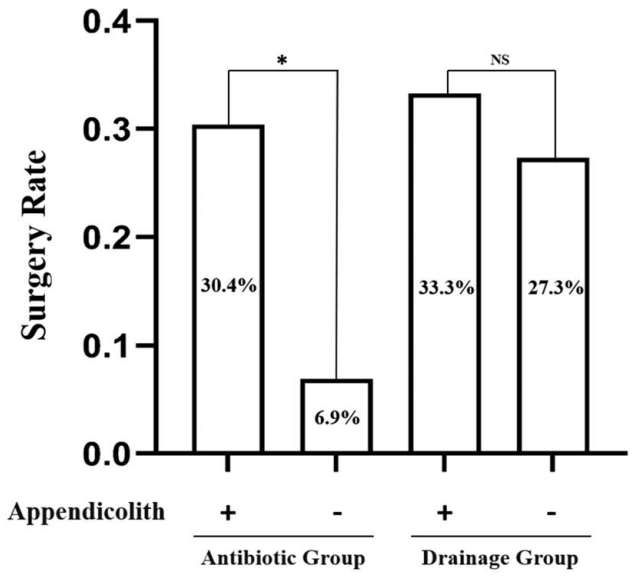

Figure 2. Surgery rate in Drainage group and Antibiotic group. In the Antibiotic group, the surgery rate for patients with an appendicolith was 30.4%, significantly higher than the 6.9% rate for those without ($P = 0.026$). In the Drainage group, the surgery rate was 33.3% for patients with an appendicolith and 27.3% for those without, showing no significant difference. *$P < 0.05$.

Table 4

Secondary outcomes in drainage group and antibiotic group.

Characteristic	Drainage group	Antibiotic group	P
All patients	8	9	
Surgical site infections by type, No.			0.656
Superficial	1	2	
Deep incisional	1	2	
Organ/space	1	0	
Incisional hernias, No.	0	0	1.000
Length of postoperative hospital stay, median (25th–75th %), days	4.0 (2.0–7.5)	3.0 (2.0–6.5)	0.337
Surgery			0.363
Laparoscopic appendectomy	7	6	
Open appendectomy	1	1	
Ileocecal resection	0	2	

difference between the groups ($P = 0.337$). Regarding surgical approaches, the Drainage group underwent seven laparoscopic appendectomies and one open appendectomy, with no ileocecal resections. In the Antibiotic group, there were six laparoscopic appendectomies, one open appendectomy, and two ileocecal resections, with no significant difference observed ($P = 0.363$).

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, necessitating timely intervention to prevent complications[14]. For a long time, the standard treatment for acute appendicitis has been an appendectomy, which can be performed either through open surgery or laparoscopically[2]. In cases of uncomplicated appendicitis, there is growing interest in nonsurgical management[15]. Antibiotic therapy alone has been explored as an initial treatment, potentially allowing selected patients to avoid surgery[3,4]. Several studies have shown that antibiotic treatment can effectively manage uncomplicated appendicitis, although there remains a risk of recurrence[3,4,16,17]. This approach necessitates careful patient selection and follow-up.

Complicated appendicitis, characterized by perforation or abscess formation, presents additional challenges and often requires a more comprehensive treatment approach[18]. Management strategies have evolved to incorporate both conservative and surgical treatments, tailored to the patient's condition[8]. Conservative management typically involves the use of antibiotics and percutaneous abscess drainage[19]. For patients with large abscesses, immediate emergency surgery is often avoi ded due to the high risk of complications[20]. Instead, a step-by-step hybrid approach is utilized, beginning with percutaneous drainage to stabilize the patient, followed by an interval appen dectomy if necessary[21]. Advances in imaging technology, such as ultrasound and CT-guided drainage, have significantly improved the precision and success rates of percutaneous abscess drainage, facilitating the effective management of localized infections[22,23]. This approach can effectively control infection and inflammation, minimize surgical risks, and improve overall outcomes. Despite advances in conservative management, clear indications for sur gical intervention remain[24]. Persistent or worsening symptoms and failure to respond to conservative treatment often necessitate surgery[25]. The timing of surgery is also crucial, while immediate surgery may not be advisable for some patients, interval appen dectomy performed 6–8 weeks after initial conservative treatment can be safer and more effective[26].

Furthermore, the development of criteria for patient selection has refined the decision-making process between conservative and surgical management[27]. Enhanced criteria for determining whether patients should undergo conservative management or surgery take into account various factors such as abscess size and location, patient age, comorbidities, and the presence of appendicoliths[4,28]. For instance, peri-appendiceal abscesses, especially those that are multiloculated or involve extensive sur rounding inflammation, may not respond adequately to percuta neous drainage alone, thereby necessitating surgical intervention[29]. Appendicoliths play a significant etiological role in certain cases of appendicitis. The theory that an appendicolith could dislodge or pass unnoticed is plausible and may explain why some patients present with appendicitis despite no appendi colith being detected on imaging or during surgery. Other mechanisms, such as lymphoid hyperplasia, fecal stasis, or bac terial overgrowth, may also contribute to the development of appendicitis in patients where no appendicolith is demonstrable. In our study, the results showed that the presence of appendico liths significantly impacted the outcomes of conservative man agement. The presence of appendicolith was associated with increased failure rates of antibiotic-only treatments, likely because they contribute to persistent inflammation or obstruc tion, reducing the effectiveness of antibiotic therapy. However, the addition of percutaneous drainage mitigated this impact, resulting in similar surgical rates regardless of the presence of appendicoliths. This finding underscores the importance of drai nage in effectively managing localized abscesses and reducing the inflammatory burden, thereby improving outcomes for patients with appendicoliths. These findings highlight the need for a nuanced approach for treating complicated appendicitis, empha sizing personalized treatment strategies. Incorporating percuta neous drainage in the presence of appendicoliths appears to enhance the success of conservative management, providing a viable option to reduce the necessity for immediate surgery and its associated risks.

This tailored approach ensures that patients receive the most appropriate and effective treatment based on their specific clinical presentations, ultimately leading to better health outcomes. Alongside conservative treatment, the choice of surgical method is determined by the patient's individual circumstances[30]. Compared to open surgery, laparoscopic appendectomy remains the preferred method for treating complicated appendicitis due to its benefits, including shorter recovery times, reduced postoperative pain, and lower complication rates[31]. Advances in single-incision laparoscopic surgery (SILS) techniques have shown promising results, offering potentially better cosmetic outcomes and similar efficacy to traditional laparoscopy[32]. However, for patients with large peri-appendi ceal abscesses, laparoscopic surgery may be impractical due to the extended time between onset and surgery[33]. In these cases, open surgery is sometimes required to remove the appendix and fully drain the abscess[34]. Additionally, patients with gangrene at the appendix root may require partial ileocecal resection for surgical safety[35]. In this study, two patients in the Antibiotic group required partial ileocecal resection due to gangrene and perforation of the appendix root. Despite the

increased difficulty, there was no increase in postoperative complications.

This study has several limitations that should be considered. First, as a retrospective analysis, it is inherently prone to selection biases, even though it utilizes 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 or recurrences, which are crucial for a comprehensive understanding of treatment efficacy. Third, the analysis did not incorporate various subjective factors, such as patients' personal preferences and sociocultural influences, which can significantly affect treatment outcomes. In the context of acute appendicitis, patient preferences regarding treatment options, pain tolerance, and willingness to adhere to follow-up care can be as critical as objective clinical factors. This is particularly pertinent in the context of China, where cultural attitudes toward medical interventions and patient-doctor interactions might differ significantly from those in Western countries. 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.

Conclusions

The presence of an appendicolith is a risk factor for the failure of antibiotic therapy alone in patients with acute complicated appendicitis and peri-appendiceal abscess. Patients with appendicoliths experience higher rates of antibiotic therapy failure, emphasizing the need for careful patient selection and consideration of adjunctive drainage procedures in this subset. These findings offer valuable insights for clinicians managing complicated appendicitis and suggest directions for future research to optimize treatment protocols and improve patient outcomes.

Ethical approval

The Clinical Research Ethics Committee of Zhongshan Hospital, Fudan University (Shanghai, China) granted ethical approval for this study (B2024-321).

Consent

Written informed consent was obtained from the patient for publication of this case report and accompanying images. A copy of the written consent is available for review by the Editor-in-Chief of this journal on request.

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Author contribution

H.H.: conceived, designed, and refined the study protocol, as well as edited the manuscript; L.M. and J.L.: were responsible for data collection and analysis; L.M. and J.L.: drafted the manuscript; L.M. and J.L.: contributed equally to this work as co-first authors.

Conflicts of interest disclosure

The authors have no conflicts of interest.

Research registration unique identifying number (UIN)

Name of the registry: Appendicoliths in Acute Complicated Appendicitis Patients With Abscess.
Unique identifying number or registration ID: NCT06469086.
Hyperlink to your specific registration (must be publicly accessible and will be checked): https://register.clinicaltrials.gov/prs/app/action/SelectProtocol?sid=S000EMI9&selectaction=Edit&uid=U0003619&ts=2&cx=jc4n41.

Guarantor

Hongyong He.

Data availability statement

There is no additional data available to share with the readers. The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Provenance and peer review

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