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Factors that predict abscess formation during conservative management of appendicular mass in children in Baghdad Medical City

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Abstract
Background: Acute appendicitis is the most common surgical emergency in children, with appendicular mass being a common complication in improperly treated cases.
Aim: This study aimed to identify factors contributing to abscess formation during the conservative management of appendicular mass.
Methods: A prospective study was conducted on 55 children younger than 14 years with appendicular mass managed at Baghdad Children Welfare Hospital. Clinical factors including age, gender, symptom duration, nausea/vomiting, diarrhea, fever, mass size, appendicolith presence on ultrasonography, CRP titer, total WBC count, bandemia, and antibiotic regimen were evaluated. Patients who developed abscesses were treated surgically or medically.
Results: The mean age of patients was 8.94±2.86 years, with males comprising 60%. Abdominal pain duration averaged 3.64±1.6 days. Nausea/vomiting occurred in 87.27%, diarrhea in 18.18%, and fever in 12.73% of cases. Elevated CRP levels (mean: 68.53±62.34 mg/dl) and leukocytosis (76.36%) were noted. Appendicolith was present in 10.91%, and the mean mass size was 18.69±14.94 cm². Antibiotic regimens primarily included vancomycin, amikacin, and metronidazole (63.64%). Abscess formation occurred in 23.64% of patients, with 46.15% of these requiring surgical intervention for abscesses >50 ml.
Conclusion: Factors predictive of abscess formation include fever, diarrhea, WBC count >15×10³/ml, bandemia > 10%, CRP > 70 mg/dl, appendicolith presence, and mass size >20 cm². Effective antibiotic regimens targeting gram-negative and anaerobic organisms are crucial. Drainage decisions depend on clinical status and abscess size, with interventions required for abscesses >50 ml. Early identification of risk factors can guide therapeutic adjustments to prevent complications.

Keywords: Abscess formation, conservative management, appendicular mass, children

Introduction

Acute appendicitis is the most common surgical emergency in children, accounting for 7-8% of all surgical emergencies worldwide [1, 2]. Early diagnosis and treatment are critical to avoid complications, especially in younger children, where clinical presentations can be nonspecific, poorly expressed due to age, or influenced by familial and social factors, making diagnosis more challenging compared to adults [3]. The prevalence of acute appendicitis among children presenting with abdominal pain to emergency departments is estimated at 1-8% [4, 5]. Its incidence ranges from 1-6 per 10,000 children under 4 years to 19-28 per 10,000 among those aged 5-14 years, with boys being more frequently affected [6, 7]. Children under six often present with advanced disease, including perforation, due to delayed diagnosis caused by nonspecific symptoms [8, 9]. The appendix emerges during embryogenesis as a continuation of the cecum's inferior tip, reaching its final position by late childhood. It is intraperitoneal in 95% of cases but exhibits varied final positions, including pelvic and retrocecal locations [10, 11]. In neonates and young children, unique anatomical features, such as a funnel-shaped appendix and an underdeveloped omentum, contribute to a rapid progression of appendicitis [3]. Appendicitis typically begins with luminal obstruction due to fecal material, foreign bodies, or lymphoid hyperplasia, leading to inflammation, ischemia, and eventual perforation if untreated. Common pathogens include *E. coli*, *Bacteroides fragilis*, and *Pseudomonas* species [12, 13]. The clinical presentation includes periumbilical pain migrating to the right lower quadrant, anorexia, nausea, vomiting, fever, and localized tenderness. Perforation increases the risk of diffuse peritonitis,

particularly in younger children [11, 12].

Laboratory tests such as elevated WBC, bandemia, and CRP are useful but lack sensitivity. Imaging studies, particularly ultrasonography, play a crucial role in diagnosis, showing features such as an appendiceal diameter >6 mm or localized abscess formation. CT and MRI are second-line imaging modalities with high diagnostic accuracy [14, 15]. Treatment includes intravenous fluids and broad-spectrum antibiotics, with management options ranging from nonoperative treatment for uncomplicated cases to appendectomy. Complicated appendicitis may require interval appendectomy, immediate surgery, or conservative management, with treatment tailored based on clinical presentation and imaging findings [16]. Despite advancements, challenges remain in balancing timely intervention with minimizing complications such as abscess formation, wound infection, or bowel obstruction [11, 17, 18]. Aim of the study: to determine factors that play role in abscess formation during conservative management of appendicular mass.

Methods

This prospective cohort study was conducted at the Pediatric Surgery Department of Children Welfare Teaching Hospital, Baghdad Medical City, Iraq, from January 2022 to January 2023. A total of 55 children younger than 14 years with appendicular mass were included. Patients with other right iliac fossa masses, such as lymphoma, complicated Meckel's diverticulum, Crohn's disease, Mycobacterium tuberculosis, ovarian pathology, or enteric duplication, were excluded. Appendicular mass was diagnosed based on history, clinical examination, abdominal ultrasonography, and/or examination under general anesthesia. Data collected included patient demographics (age, gender), clinical features (abdominal pain duration, presence of nausea/vomiting, diarrhea, fever), laboratory findings (CRP titer, WBC count, band cells), imaging results (mass size, presence of appendicolith on ultrasound), and antibiotic regimen. All patients underwent initial conservative management, including intravenous fluids, antibiotics, and close monitoring. Patients who developed abscesses, diagnosed clinically and radiologically, were divided into two groups:

- **Group A:** Required emergency surgical intervention, including abscess drainage with or without appendectomy. Samples from the drained abscess were sent for culture and sensitivity testing.
- **Group B:** Managed conservatively with adjusted antibiotic therapy based on clinical condition and abscess size.

Surgical procedures were performed via gridiron incision with placement of a pelvic tube drain. Statistical Analysis: Data were analyzed using SPSS version 25. Continuous variables were expressed as mean±standard deviation and analyzed using the Student's t-test, while categorical variables were analyzed using the Chi-square test. Factors significantly associated with abscess formation in univariate analysis were entered into a binary logistic regression model to calculate odds ratios (OR) and 95% confidence intervals (CI). A p-value < 0.05 was considered statistically significant.

Results

The mean age of the patients was 8.94±2.86 years (range 3-13 years). Males were more common than females (60% vs. 40%). clinical data of the studied patients. The mean duration of abdominal pain was 3.64±1.6 days. Nausea/vomiting and diarrhea were reported in 87.27% and 18.18% of the patients, respectively. The mean core body temperature was 37.15±0.48 ºC, with the minority of patients (12.73%) were feverish. The combination of vancomycin, amikacin and metronidazole was the most commonly used treatment (63.64%) followed by meropenem, amikacin and metronidazole (20%). The mean leukocyte count was 14.76±4.2 $\times 10^3$/ml, with more than 3/4 (three-fourth) of patients (76.36%) had leukocytosis. The mean bandemia was 11.38±8.71% (range= 1.0-34%). All patients had an elevated serum level of CRP with a mean of 68.53±62.34 mg/dl (range= 3.0-212 mg/dl). The mean size of appendicular mass was 18.69±14.94 cm^2. Appendicolith was reported in 10.91% of the patients. As in table 1.

Table 1: Patients' demographic, Clinical findings, Laboratory findings, Radiological findings

Variables	Values
Age, years	
Mean±SD	8.94±2.86
Range	3.0-13.0
Gender	
Male	33(60%)
Female	22(40%)
Duration of abdominal pain (days)	
Mean±SD	3.64±1.6
Range	1.0-10.0
Nausea and vomiting	
No	7(12.73%)
Yes	48(87.27%)
Diarrhea	
No	45(81.82%)
Yes	10(18.18%)
Core body temperature, ºC	
Mean±SD	37.15±0.48
Range	35.5-38.0
Fever (core body temperature >37.8˚C)	
No	48(87.27%)
Yes	7(12.73%)
Treatment	
Vancomycin+amikacin+metronidazole	34(63.64%)
Meropenem+ amikacin+ metronidazole	11(20%)
Ceftriaxone + metronidazole	5(9.09%)
Tazocin + metronidazole	2(3.64%)
Meropenem+ vancomycin+ metronidazole	2(3.64%)
Gentamycin + metronidazole	1(1.82%)
WBC count, $\times 10^3$/ml	
Mean±SD	14.76±4.2
Range	6.8-26.4
Leukocytosis (WBC count >11×10^3/ml)	
No	13(23.64%)
Yes	42(76.36%)
Bandemia%	
Mean±SD	11.38±8.71
Range	1.0-34
Median	9.0
C-Reactive protein	
Mean±SD	68.53±62.34
Range	3.0-212
Median	48.0
Size of appendicular mass, cm^2	
Mean±SD	18.69±14.94
Range	1.92-76.0
Median	14.8
Appendicolith on US	
No	49(89.09%)
Yes	6(10.91%)

Out of 55 patients, 13 (23.64%) developed appendicular abscess during the treatment, while the other 42 patients (76.36%) had no abscess (Figure 1). The mean abscess size was 57.86±37.22 ml (range= 8.0-100 ml)

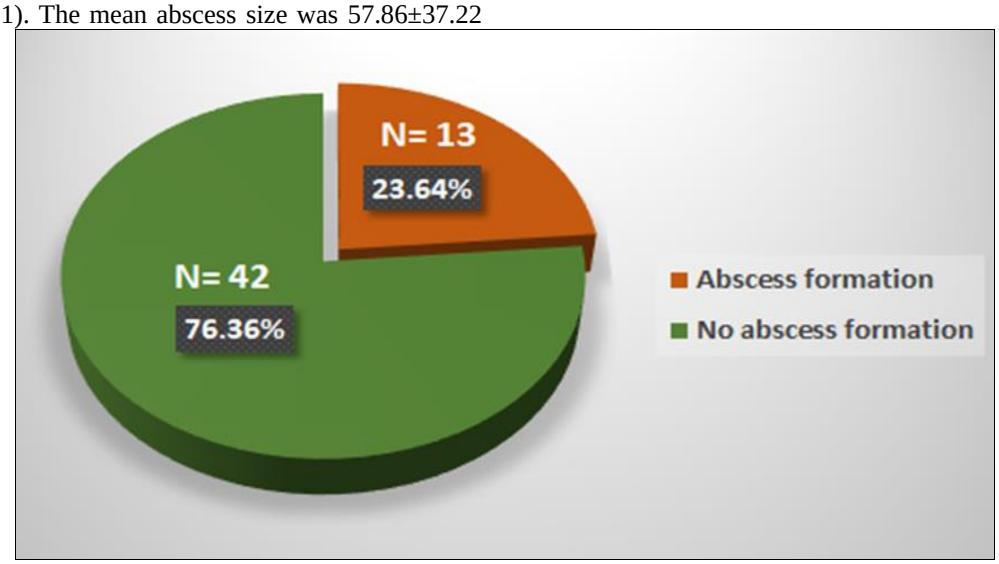

Fig 1: The frequency of abscess formation in patients with appendicular mass

Table 2 show none of included demographic characteristics had a significant association with abscess formation in patients with appendicular mass. Two clinical factors demonstrated a significant association with abscess formation. Diarrhea was found in 53.85% of patients with abscess, compared with 7.14% in patients without abscess, with a significant difference. Furthermore, six patients among those with abscess (46.15%) had fever versus one patient (2.38%) among those without abscess, with a highly significant difference. The mean leukocyte count in patients with abscess was 17.57±4.63 $\times 10^3$/ml which was far higher than that of patients without abscess (13.89±3.71 $\times 10^3$/ml) with a highly significant difference. Moreover, patients who developed abscess had higher median percentage of bandemia than those without abscess (23.0% vs. 8%) with a highly significant difference. Finally, the median CRP level in patients with abscess was 160 mg/dl, compared with 35 mg/dl in those without abscess with a highly significant difference. The median size of appendicular mass in patients with abscess was 28.5 cm^2 which was far greater than that of patients without abscess (10.25 cm^2) with a highly significant difference. Appendicolith was more frequent in patients with than those without abscess (30.77% vs. 4.76%) with highly significant difference.

Table 2: Association of clinical factors with abscess formation, laboratory findings with abscess formation, radiological findings with abscess formation

Variables	Abscess (N=13)	No Abscess (N=42)	P-Value
Age, years	9.31±2.32	8.82±3.02	0.597
Gender			
Male	8(61.54%)	25(59.52%)	0.897
Female	5(38.46%)	17(40.48%)	
Duration of abdominal pain (days)	4.23±1.59	3.45±1.58	0.127
Nausea and vomiting			
No	2(15.38%)	5(11.9%)	0.742
Yes	11(84.62%)	37(88.1%)	
Diarrhea			
No	6(46.15%)	39(92.86%)	<0.001
Yes	7(53.85%)	3(7.14%)	
Core body temperature, ºC	37.84±0.16	36.94±0.3	<0.001
Fever (core body temperature >37.8 ˚C)			
No	7(53.85%)	41(97.62%)	<0.001
Yes	6(46.15%)	1(2.38%)	
Treatment			
Vancomycin+amikacin+metronidazole	9(69.23%)	25(59.52%)	
Meropenem+ amikacin+ metronidazole	1(7.69%)	10(23.81%)	
Ceftriaxone + metronidazole	2(15.38%)	3(7.14%)	0.567
Tazocin + metronidazole	1(7.69%)	1(2.38%)	
Meropenem+ vancomycin+ metronidazole	0(0%)	2(4.76%)	
Gentamycin + metronidazole	0(0%)	1(2.38%)	
WBC count, $\times 10^3$/ml	17.57±4.63	13.89±3.71	0.005
Leukocytosis			
No	2(15.38%)	11(26.19%)	0.423
Yes	11(84.62%)	31(73.81%)	
Bandemia%	23.0(17-34.0)	8.0(1.0-30.0)	<0.001
C-Reactive protein, mg/dl	160.0(18.0-212.0)	35.0(3.0-146.0)	<0.001
Size of appendicular mass, cm^2	28.5(6.0-76.0)	10.25(1.92-34.0)	<0.001

Appendicolith on US No Yes	 9(69.23%) 4(30.77%)	 40(95.24%) 2(4.76%)	 0.009

In order to find the magnitude of each factor as predictor for abscess formation, multivariate analysis was used. For this analysis, all factors that had a significant association with abscess formation in univariate analysis were entered the model. Continuous variables were categorized into binomial variables using appropriate cut off values. The results are shown in (table 3.9). Each of size of appendicular mass >20 cm (OR=9.39, 95%CI=2.18-4053, P=0.021), presence of diarrhea (OR=15.17, 95% CI=3.05-75.31, P=0.032), presence of appendicolith (OR=8.9, 95%, CI=1.4-56.25, P=0.020), fever (OR=18.2, 95% CI=3.65-38.7, P=0.014), bandemia >10% (OR=27.0, 95% CI=7.85-59.96, p<0.001), WBC count >15$\times10^3$/ml (OR=8.33, 95% CI=1.95-35.65, P=0.011) and CRP level> 70 (OR=24.2, 95% CI=6.68-72.2, P=0.11) are independent risk factors for development of abscess in patients with appendicular mass treated with conservative treatment. As in Table 3.

Table 3: Multivariate analysis

Variables	Abscess (N=13)	No abscess (N=42)	P-Value	OR(95%CI)
Size of appendicular mass, cm^2 ≤20 >20	 3(23.08%) 10(76.92%)	 31(73.81%) 11(26.19%)	 0.021	 1.0 9.39(2.18-40.53)
Diarrhea No Yes	 6(46.15%) 7(53.85%)	 39(92.86%) 3(7.14%)	 0.032	 1.0 15.17(3.05-75.31)
Appendicolith on US No Yes	 9(69.23%) 4(30.77%)	 40(95.24%) 2(4.76%)	 0.020	 1.0 8.9(1.4-56-25)
Fever No Yes	 7(53.85%) 6(46.15%)	 41(97.62%) 1(2.38%)	 0.014	 1.0 18.2(3.65-38.7)
Bandemia,% ≤10 >10	 0(0%) 13(100%)	 36(85.71%) 6(14.29%)	 <0.001	 1.0 27.0(7.85-59.96)
WBC count, $\times10^3$/ml ≤15 >15	 3(23.08%) 10(76.92%)	 30(71.43%) 12(28.57%)	 0.012	 1.0 8.33(1.95-35.65)
C-Reactive protein, mg/dl ≤70 >70	 1(7.69%) 12(92.31%)	 35(83.33%) 7(16.67%)	 0.011	 1.0 24.2(6.68-72.2)

OR=Odds Ratio, CI=Confidence Interval

Total 13 patients who developed appendicular abscess during treatment, only 6 patients required surgical intervention (abscess drainage and/or appendectomy) with their abscess size being greater than 50 ml. Accordingly, drainage was used as part of treatment for 6 patients (46.15%) with abscess (Figure 2).

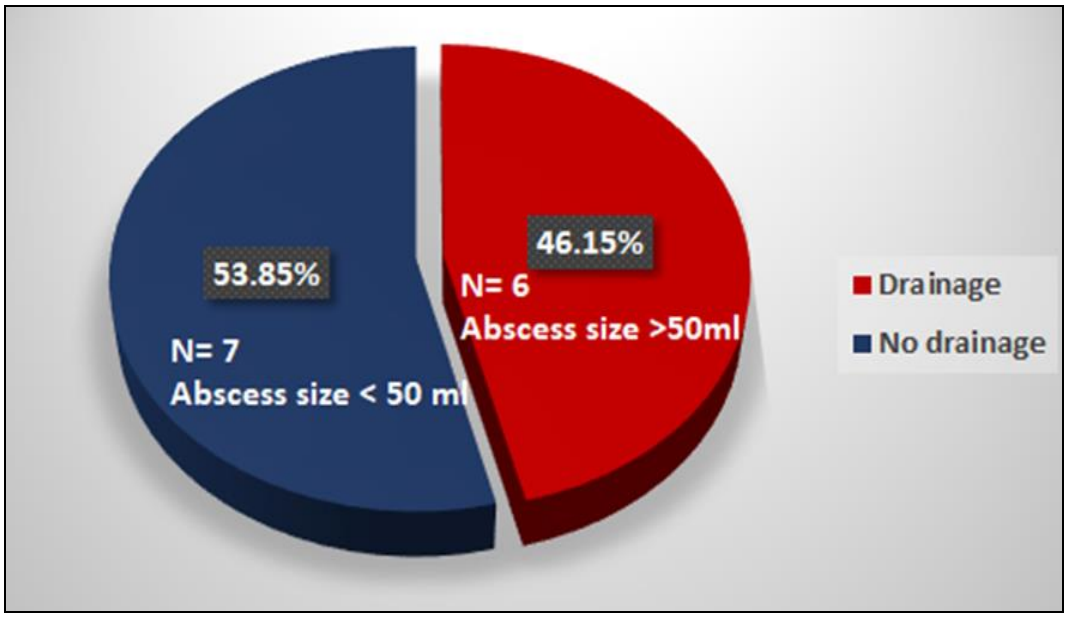

Fig 2: Proportion of abscess drainage

Discussion

Appendicular mass with or without abscess is a known complication of delayed diagnosis of acute appendicitis, often due to atypical presentations or delays in seeking medical care. In this prospective study, potential predictive factors for abscess formation during the conservative management of appendicular

mass were evaluated. Out of 55 patients, 13 (23.64%) developed abscesses during conservative treatment, with only six (46.15%) requiring surgical intervention. Surgical drainage was reserved for those with persistent abdominal pain, fever, and diarrhea, and abscess size >50 ml on ultrasound. Patients with smaller abscesses responded well to adjusted antibiotic therapy. Demographic Factors: The mean age was 8.94±2.86 years, with no significant association between age and abscess development (P=0.597). This contrasts with Hussein *et al*. [19], who reported age as a significant factor (P=0.017). Males were more commonly affected (60%), but gender showed no significant association with abscess development (P=0.897), similar to Hussein *et al*. [19]. Clinical Presentation: Fever (>37.8˚C) was strongly associated with abscess formation (p<0.001), with patients having an 18.2-fold increased risk (OR=18.2, 95% CI=3.65-38.7). This aligns with Tannoury *et al*. [20], highlighting elevated body temperature as a predictor of complicated appendicitis. Diarrhea also showed a significant association (p<0.001), with a 15.17-fold increased risk (OR=15.17, 95% CI=3.05-75.31). Nausea and vomiting, however, were not predictive (P=0.742). Laboratory Findings: Elevated CRP (>70 mg/dl) and WBC count (>15×10³/ml) were significantly associated with abscess formation (p<0.001 and P=0.005, respectively). CRP levels >70 mg/dl carried a 24.2-fold increased risk (OR=24.2, 95% CI=6.68-72.2), while a WBC count >15×10³/ml increased the risk by 8.3 times (OR=8.33, 95% CI=1.95-35.65). These findings are consistent with Gronroos *et al*. [21], who demonstrated elevated CRP and WBC as markers of abscess formation. Bandemia >10% was also a strong predictor (p<0.001), with a 27-fold increased risk (OR=27.0, 95% CI=7.85-59.96), as reported by Talishinskiy *et al*. [22]. Imaging Findings: The presence of an appendicolith was a significant predictor of abscess formation (P=0.009), with an 8.9-fold increased risk (OR=8.9, 95% CI=1.4-56.25), consistent with Aprahamian *et al*. [23]. Appendicular mass size >20 cm² was also associated with abscess formation (p<0.001), with a 9.3-fold increased risk (OR=9.39, 95% CI=2.18-40.53), contrasting Hussein *et al*. [19], who found no significant association (P=0.68). Antibiotic Therapy: Antibiotic combinations targeting gram-negative organisms were most effective in preventing abscess formation. Among patients treated with vancomycin, amikacin, and metronidazole (N=34), nine developed abscesses, while meropenem, amikacin, and metronidazole (N=11) resulted in only one abscess. Cultures from drained abscesses consistently yielded gram-negative organisms, emphasizing the importance of targeted antibiotic regimens [24]. So fever, diarrhea, elevated WBC and CRP levels, bandemia, appendicolith presence, and large appendicular mass size are significant predictors of abscess formation. Effective antibiotic therapy targeting gram-negative organisms is crucial in preventing abscess development and optimizing conservative management outcomes.

Conclusion

High fever (>37.8 °C) and diarrhea significantly increase the risk of abscess formation in children with appendicular mass. Predictive factors include WBC >15×10³/ml, bandemia >10%, CRP >70 mg/dl, mass size >20 cm², and the presence of appendicolith on ultrasound. Effective antibiotics targeting gram-negative organisms and anaerobes are crucial for prevention. Drainage is indicated for abscesses >50 ml with persistent symptoms despite treatment.

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