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Original Research Article

Factors Associated with Appendicular Perforation in Children Undergoing Surgery for Acute Appendicitis at a Tertiary Care Hospital in Tamil Nadu

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Abstract

Background and aim: Acute appendicitis is one of the most common surgical emergencies in children, and appendicular perforation remains an important complication associated with increased morbidity. Early identification of factors associated with perforation may help in timely diagnosis and prompt management. The present study was undertaken to assess the factors associated with appendicular perforation in children undergoing surgery for acute appendicitis at a tertiary care hospital in Tamil Nadu.

Materials and Methods: This hospital-based cross-sectional study included 130 children diagnosed with acute appendicitis and undergone surgery. The records of the children admitted and treated for acute appendicitis from 2023 to 2025 were taken. The details were collected using a semi-structured questionnaire. The data were entered in MS excel and analysed using SPSS. Appropriate descriptive and inferential statistics were used with $p<0.05$ was considered as statistically significant.

Results: The mean (SD) age of the study participants was 9.7 (1.8) years, and 68.5% were males. Appendicular perforation was observed in 26 (20%) children. Abdominal pain was the most common presenting symptom (92.3%), followed by rebound tenderness (83.8%), right iliac fossa tenderness (81.5%), and fever (66.2%). Male gender was significantly associated with appendicular perforation (24.7% vs 9.8%, $p=0.047$). Among clinical features, fever ($p=0.026$), guarding ($p=0.033$), and rigidity ($p<0.001$) showed significant association with perforation. Raised WBC count ($p<0.001$) and raised neutrophil count ($p<0.001$) were also strongly associated with perforation. Age, vomiting, anorexia, nausea, diarrhoea, delayed presentation, right iliac fossa tenderness, rebound tenderness, and diffuse tenderness were not significantly associated with perforation.

Conclusion: Appendicular perforation was present in one-fifth of children undergoing surgery for acute appendicitis. Male gender, fever, guarding, rigidity, leukocytosis, and neutrophilia were significantly associated with appendicular perforation. Careful clinical assessment supported by basic laboratory parameters may help identify children at higher risk of perforation and facilitate earlier surgical decision-making.

Keywords: Children; Appendicitis; Perforation.

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Introduction

Acute appendicitis is one of the most common surgical emergencies in children and remains a leading cause of acute abdominal pain requiring urgent operative management. Although the diagnosis is often straightforward in older children with classical symptoms, paediatric appendicitis continues to pose a major diagnostic challenge because the presentation may be variable, nonspecific, and easily confused with other common childhood illnesses.

Delayed recognition can result in progression of inflammation to gangrene, perforation, peritonitis, abscess formation, prolonged hospitalization, and increased postoperative morbidity. [1-3] Appendicular perforation is a particularly important complication in the paediatric age group.

Compared with adults, children have a higher risk of perforation, largely because they often present with atypical symptoms, have difficulty localizing or communicating pain, and may initially be treated for alternate diagnoses such as gastroenteritis or nonspecific abdominal pain. Younger children are especially vulnerable, and several studies have shown that the risk of perforation increases as age decreases.

In young children, diffuse abdominal tenderness, fever, vomiting, diarrhoea, and delayed presentation may predominate over the classic pattern of migratory pain and localized right iliac fossa tenderness, thereby contributing to missed or delayed diagnosis. [3-6] The pathophysiology of appendicular perforation reflects progression from luminal obstruction and bacterial overgrowth to vascular compromise, ischemia, necrosis, and eventual rupture.

This progression is time-dependent, and the duration of symptoms before definitive treatment has consistently been identified as a major determinant of perforation. Earlier studies have demonstrated that perforation correlates more strongly with prehospital delay than with in-hospital delay, emphasizing the importance of early suspicion, timely referral, and prompt surgical evaluation. [1,7,8]

Several clinical and laboratory factors have been evaluated as possible predictors of appendicular perforation in children. Fever, generalized or diffuse abdominal tenderness, guarding, rigidity, and longer symptom duration have been associated with complicated disease in different settings. Similarly, inflammatory markers such as leucocytosis, neutrophilia, and elevated C-reactive protein have been reported to correlate with perforation, although no single symptom, sign, or laboratory parameter is sufficiently accurate in isolation to predict perforation with certainty.

This underscores the need for combined clinical assessment supported by basic laboratory parameters and appropriate imaging when required. [3,9-11] Recent evidence-based guidelines continue to emphasize structured clinical assessment, judicious use of imaging, and early risk stratification to improve diagnostic accuracy and reduce complications in acute appendicitis. However, the profile of appendicitis and the relative importance of associated factors may vary across age groups, health-care settings, and referral pathways. Hence, institution-specific data remain relevant, particularly in children undergoing surgery at tertiary care centres. [12,13] In this context, the present study was undertaken to assess the factors associated with appendicular perforation in children undergoing surgery for acute appendicitis at a tertiary care hospital in Tamil Nadu. The study also aimed to describe the demographic profile and clinical presentation of affected children and to estimate the proportion of appendicular perforation in the study population.

Aim: To assess the factors associated with appendicular perforation among children undergoing surgery for acute appendicitis.

Objectives

Primary Objective

1. To determine the factors associated with appendicular perforation among children operated for acute appendicitis.

Secondary Objectives

1. To describe the demographic profile of children undergoing surgery for acute appendicitis.
2. To describe the clinical presentation of children with acute appendicitis.
3. To estimate the proportion of appendicular perforation among children undergoing surgery for acute appendicitis.

Materials and Methods

This was a hospital based cross-sectional study done among children who were diagnosed with acute appendicitis and undergone surgery in the year from 2023 to 2025, in a tertiary care hospital in Tamil Nadu. All the records of children undergone surgery for acute appendicitis during that period was taken and incomplete records were excluded. A total of 130 children with acute appendicitis were included for analysis.

The data was collected using a semi-structured questionnaire. The demographic details, clinical presentation, treatment undergone and outcome were collected.

The variables collected included demographic characteristics such as age and gender; clinical features such as fever, abdominal pain, vomiting, anorexia, nausea, diarrhoea, delayed presentation beyond 48 hours, right iliac fossa tenderness, rebound tenderness, diffuse tenderness, guarding, and rigidity; and laboratory parameters including total leukocyte count and neutrophil count. The primary outcome variable was appendicular perforation, which was categorized as present or absent.

Data were entered in Microsoft Excel and analysed using SPSS statistical software. Categorical variables were expressed as frequency and percentage. Continuous variables were summarized as median and interquartile range (IQR) or as appropriate.

Inferential statistics like Chi square test, Fisher exact test, and Independent t test were used. A p

value of <0.05 was considered statistically significant.

Results

A total of 130 children who underwent surgery for acute appendicitis were included in the study. The mean (SD) age of the participants was 9.7 (1.8) years. Male children constituted more than two-thirds of the study population [89 (68.5%)], while females accounted for 41 (31.5%), indicating a male predominance among the study participants. (Table 1)

Table 1: Demographic details

S. No	Variable	Category	N (%)
1	Age	Mean (SD)	9.7 years (1.8)
2	Gender	Males	89 (68.5%)
		Females	41 (31.5%)

Table 2 summarizes the clinical presentation of children with acute appendicitis. Abdominal pain was the most common presenting symptom, reported in 120 (92.3%) children.

Fever was present in 86 (66.2%) cases, while vomiting, anorexia, nausea, and diarrhoea were noted in 74 (56.9%), 78 (60.0%), 76 (58.5%), and 68 (52.3%) children, respectively. Delayed presentation beyond 48 hours was observed in 64 (49.2%) children. On clinical examination, right iliac fossa tenderness and rebound tenderness were documented in 106 (81.5%) and 109 (83.8%) children, respectively.

Diffuse tenderness, guarding, and rigidity were present in 75 (57.7%), 76 (58.5%), and 27 (20.8%) cases, respectively. Laboratory abnormalities showed raised total leukocyte count in 32 (24.6%) children and neutrophilia in 30 (23.1%).

Table 2: Clinical presentation

S. No.	Variable	Category	N (%)
1	Fever	Yes	86 (66.2%)
		No	44 (33.8%)
2	Abdominal pain	Yes	120 (92.3%)
		No	10 (7.7%)
3	Vomiting	Yes	74 (56.9%)
		No	56 (43.1%)
4	Anorexia	Yes	78 (60%)
		No	52 (40%)
5	Nausea	Yes	76 (58.5%)
		No	54 (41.5%)
6	Diarrhoea	Yes	68 (52.3%)
		No	62 (47.7%)
7	Delayed presentation (>48 hours)	<48 hours	66 (50.8%)
		>48 hours	64 (49.2%)
8	RIF tenderness	Yes	106 (81.5%)
		No	24 (18.5%)
9	Rebound tenderness	Yes	109 (83.8%)
		No	21 (16.2%)
10	Diffuse tenderness	Yes	75 (57.7%)
		No	55 (42.3%)
11	Guarding	Yes	76 (58.5%)
		No	54 (41.5%)
12	Rigidity	Yes	27 (20.8%)
		No	103 (79.2%)
13	WBC	Raised	32 (24.6%)
		Normal	98 (75.4%)
14	Neutrophils	Raised	30 (23.1%)
		Normal	100 (76.9%)

Figure 1 illustrates the distribution of appendicular perforation in the study population. Of the 130 children included, appendicular perforation was observed in 26 (20%) children, whereas 104 (80%) did not have perforation. Thus, appendicular perforation was observed in one-fifth of children undergoing surgery for acute appendicitis.

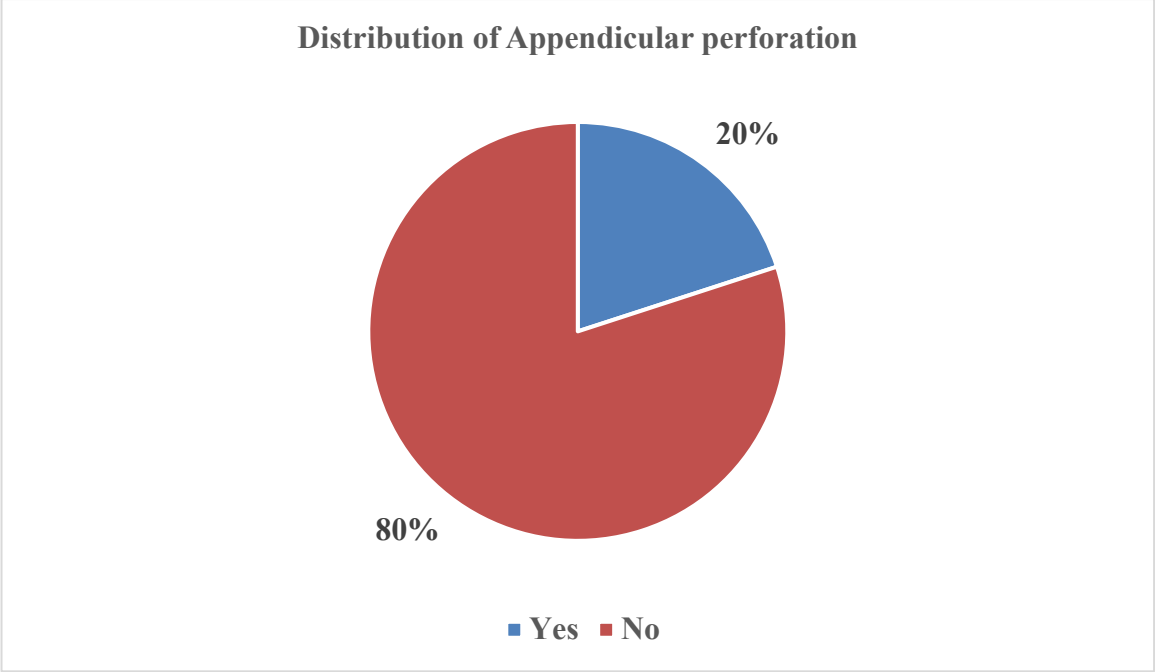

Figure 1: Distribution of Appendicular perforation

Table 3 presents the association between selected demographic, clinical, and laboratory variables and appendicular perforation. The mean age was comparable between children with and without perforation [9.6 (2.0) vs 9.7 (1.7) years; p=0.98]. Male gender was significantly associated with perforation, with 24.7% of males having perforation compared with 9.8% of females (p=0.047). Among clinical features, fever and guarding showed significant associations with perforation (p=0.026 and p=0.033, respectively). Rigidity demonstrated a particularly strong association, as perforation was present in 85.2% of children with rigidity compared to only 2.9% of those without rigidity (p<0.001). Raised WBC count and raised neutrophil count were also strongly associated with appendicular perforation (p<0.001 for both). In contrast, age, abdominal pain, vomiting, anorexia, nausea, diarrhoea, delayed presentation, right iliac fossa tenderness, rebound tenderness, and diffuse tenderness were not significantly associated with perforation.

Table 3: Factors associated with appendicular perforation

S. No	Variable	Category	Appendicular perforation		p value
			Yes	No	
1	Age (in years)	Mean (SD)	9.6 (2.0)	9.7 (1.7)	0.98 (I)
2	Gender	Male	22 (24.7%)	67 (75.3%)	0.047* (C)
		Female	4 (9.8%)	37 (90.2%)	
3	Fever	Yes	22 (25.6%)	64 (74.4%)	0.026* (C)
		No	4 (9.1%)	40 (90.9%)	
4	Abdominal pain	Yes	23 (19.2%)	97 (80.8%)	0.411 (F)
		No	3 (30%)	7 (70%)	
5	Vomiting	Yes	11 (14.9%)	63 (85.1%)	0.092 (C)
		No	15 (26.8%)	41 (73.2%)	
6	Anorexia	Yes	12 (15.4%)	66 (84.6%)	0.107 (C)
		No	14 (26.9%)	38 (73.1%)	
7	Nausea	Yes	15 (19.7%)	61 (80.3%)	0.92 (C)
		No	11 (20.4%)	43 (79.6%)	
8	Diarrhoea	Yes	13 (19.1%)	55 (80.9%)	0.55 (C)
		No	13 (21%)	49 (79%)	
9	Delayed presentation (>48 hours)	<48 hours	8 (12.5%)	56 (87.5%)	0.30 (C)
		>48 hours	18 (27.3%)	48 (72.7%)	
10	RIF tenderness	Yes	18 (17%)	88 (83%)	0.09 (F)
		No	8 (33.3%)	16 (66.7%)	
11	Rebound tenderness	Yes	19 (17.4%)	90 (82.6%)	0.13 (F)

		No	7 (33.3%)	14 (66.7%)	
12	Diffuse tenderness	Yes	19 (25.3%)	56 (74.7%)	0.07 (C)
		No	7 (12.7%)	48 (87.3%)	
13	Guarding	Yes	20 (26.3%)	56 (73.7%)	0.033* (C)
		No	6 (11.1%)	48 (88.9%)	
14	Rigidity	Yes	23 (85.2%)	4 (14.8%)	<0.001* (C)
		No	3 (2.9%)	100 (97.1%)	
15	WBC	Raised	19 (59.4%)	13 (40.6%)	<0.001* (C)
		Normal	7 (7.1%)	91 (92.9%)	
16	Neutrophils	Raised	18 (60%)	12 (40%)	<0.001* (C)
		Normal	8 (8%)	92 (92%)	
*p <0.05 – Statistically significant. I – Independent t test, C – Chi square test, F – Fisher exact test.					

Discussion

In the present study, appendicular perforation was observed in 20% of children undergoing surgery for acute appendicitis. Male children constituted 68.5% of the study population, and the mean age was 9.7 ± 1.8 years. The overall perforation proportion in this study is lower than the pooled pre-COVID estimate of 28.5% reported in a systematic review and meta-analysis, but it still falls within the broad range described in paediatric literature, where perforation is frequently reported in approximately one-fourth to one-third of cases and may vary widely depending on age, referral patterns, and diagnostic delay. [3,14,15]

A clear male predominance was observed in the study population, and male gender was significantly associated with appendicular perforation. This finding is in agreement with previous studies that have reported a higher frequency of perforation among boys. A retrospective study found perforated appendicitis in 18% of boys versus 10% of girls, while another emergency department–based cohort identified male sex as an independent predictor of perforation. The reason for this difference is not fully understood, but the consistency of this observation across studies suggests that sex-related variation in disease severity or health-seeking behaviour may play a role. [16-18]

The common presenting features in the present study were abdominal pain, rebound tenderness, right iliac fossa tenderness, fever, anorexia, nausea, and vomiting, guarding, and diffuse tenderness. However, among these variables, fever, guarding, and rigidity showed statistically significant association with appendicular perforation. This is clinically plausible because perforation reflects progression to complicated appendicitis with greater inflammatory response and peritoneal irritation. Previous studies have similarly noted that febrile children and those with peritoneal signs such as generalized tenderness, guarding, and rigidity are more likely to have perforated appendicitis. The particularly strong association of rigidity with perforation in the present study supports its importance as a red-flag examination finding in children presenting with suspected acute appendicitis. [3,15,17]

This study also demonstrated a strong association of raised WBC count and raised neutrophil count with appendicular perforation. Children with perforation had markedly higher proportions of leucocytosis and neutrophilia than those without perforation. This finding is consistent with the literature, which identifies leucocytosis as one of the most frequently cited laboratory markers associated with perforation. Studies have shown that elevated WBC count, neutrophilia, and other inflammatory markers can support the identification of complicated appendicitis, although none of them are diagnostic in isolation. Therefore, in routine clinical practice, these laboratory findings should be interpreted together with history and physical examination rather than as stand-alone indicators. [3,15,19]

In contrast, age was not significantly associated with appendicular perforation in the present study. This differs from previous studies showing that younger children, particularly those below 5 years of age, have a substantially higher risk of perforation because of atypical presentation, difficulty in communication, and delayed recognition. The absence of such an association in the present study may be due to the relatively narrow age distribution of the sample, with most children clustered around later childhood rather than the very young age groups where the risk of perforation is known to rise sharply. [3,20,21]

Although delayed presentation beyond 48 hours showed a higher proportion of perforation in absolute terms, the association was not statistically significant in this study. This finding contrasts with previous study showing that perforation correlates strongly with increasing duration of symptoms and is influenced more by prehospital delay than by in-hospital delay. The lack of statistical significance in the present study may be related to the modest sample size, the use of a single time cutoff and referral-related variation in disease severity at presentation. Thus, the present findings should not

be interpreted as evidence that delay is unimportant; rather, they indicate that this relationship could not be demonstrated conclusively in this study. [7,20]

Other symptoms and signs such as vomiting, anorexia, nausea, diarrhoea, right iliac fossa tenderness, rebound tenderness, and diffuse tenderness were not significantly associated with perforation in this study. This is not unexpected, since many of these features are common in both uncomplicated and complicated appendicitis and often lack sufficient specificity when considered individually. Current literature emphasizes that no single symptom or sign can reliably distinguish perforated from non-perforated appendicitis in children; instead, risk stratification improves when clinical examination, laboratory parameters, and imaging are interpreted together. [1,13]

Overall, the present study indicates that in children undergoing surgery for acute appendicitis, appendicular perforation is not uncommon and is more likely in those presenting with male sex, fever, guarding, rigidity, leucocytosis, and neutrophilia. These findings are clinically relevant because they identify simple bedside and basic laboratory parameters that may help clinician's suspect complicated appendicitis earlier and prioritize prompt surgical assessment. However, since the analysis was based on univariate comparisons, these variables should be interpreted as associated factors rather than confirmed independent predictors. [3,17]

Strengths: This study has several strengths. It addresses an important paediatric surgical problem in a tertiary care setting and provides institution-specific data from Tamil Nadu, where local evidence on appendicular perforation in children is limited. The study also evaluated a combination of demographic, clinical, and basic laboratory variables that are readily available in routine practice, thereby improving the practical applicability of the findings. In addition, the study outcome was based on surgically managed cases, which reduces diagnostic uncertainty in comparison with purely clinical cohorts.

Limitations: The study has certain limitations. First, it appears to be a single centre hospital-based study, which may limit generalizability to other settings. Second, the sample size, particularly the number of children with perforation, may have limited the ability to detect significant associations for some variables such as delayed presentation and diffuse tenderness.

Conclusion

In this study, appendicular perforation was present in one-fifth of children undergoing surgery for acute appendicitis. Male gender, fever, guarding, rigidity, raised total leukocyte count, and neutrophilia were significantly associated with perforation, whereas age, delayed presentation beyond 48 hours, and other individual symptoms and signs were not significantly associated. These findings suggest that careful assessment of peritoneal signs together with basic inflammatory markers can help identify children at higher risk of complicated appendicitis and facilitate earlier surgical decision-making.

Recommendations

Children presenting with suspected acute appendicitis should be assessed promptly, with particular attention to fever, guarding, rigidity, leucocytosis, and neutrophilia, as these features may indicate a higher likelihood of perforation. Basic laboratory tests should be interpreted alongside clinical findings rather than in isolation. At the institutional level, protocols for early paediatric surgical evaluation and timely referral may help reduce progression to perforation. Future studies with larger sample sizes are needed to identify independent predictors and to develop locally relevant risk stratification models for paediatric appendicular perforation.

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