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Original Article

Frequency of Perforated Appendix in Patients of Acute Appendicitis

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ABSTRACT

Background: Appendiceal perforation remains a significant complication of acute appendicitis, associated with increased morbidity, prolonged hospitalization, and higher healthcare costs. Despite advances in diagnostic modalities, variability in perforation rates persists globally, and limited regional data exist regarding its frequency and risk factors in Pakistan. Objective: To determine the frequency of perforated appendix among patients with acute appendicitis and to identify demographic and clinical factors associated with increased risk of perforation. Methods: A descriptive cross-sectional study was conducted at Lady Reading Hospital, Peshawar, from January to December 2024. A total of 177 patients aged 18–65 years with CT-confirmed acute appendicitis were enrolled through consecutive sampling. Surgical exploration confirmed perforation status. Data on demographics, symptom duration, and residence were collected and analyzed using chi-square tests and odds ratios, with $p < 0.05$ considered statistically significant. Results: Perforated appendicitis was observed in 19 of 177 patients (10.7%). Patients aged 46–65 years demonstrated the highest perforation rate (21.1%, OR 3.36, 95% CI: 0.96–11.74). Symptom duration >48 hours significantly increased perforation risk (24.0%, OR 7.58, 95% CI: 1.45–39.69, $p = 0.001$). Rural residence was associated with higher perforation rates (13.5% vs. 6.1% urban, $p = 0.031$). Gender was not significantly related to perforation ($p = 0.623$). Conclusion: Approximately one in ten acute appendicitis patients experiences perforation, with advanced age, delayed presentation, and rural residence identified as significant risk factors, underscoring the importance of timely diagnosis and intervention to mitigate complications.

Keywords: *Appendicitis*; Perforation; Risk Factors; Delayed Diagnosis; Rural Health; Pakistan.

INTRODUCTION

Acute appendicitis remains one of the most prevalent surgical emergencies worldwide, characterized by inflammation of the vermiform appendix, an embryonic offshoot of the midgut, whose length varies considerably among individuals (1). While the clinical recognition of appendicitis dates to the early nineteenth century, its timely diagnosis remains a challenge, despite advances in diagnostic imaging and laboratory markers (2,3). Classically, appendicitis presents with right lower quadrant pain, anorexia, nausea, and tenderness upon physical examination, yet these features may overlap with other intra-abdominal conditions, contributing to diagnostic uncertainty and delays in treatment (2). Such delays are clinically significant because the natural progression of appendicitis can lead to gangrene and eventual perforation, complicating the clinical course and substantially increasing morbidity and mortality (4,5).

Perforated appendicitis continues to pose a considerable public health concern, as it is associated with higher rates of postoperative intra-abdominal abscesses, prolonged hospitalization, increased need for advanced surgical intervention, and elevated healthcare costs (6,7). Although global efforts to improve early detection have reduced overall perforation rates over past decades, significant heterogeneity persists across populations and healthcare systems (3,8). Several studies have identified advanced age, prolonged symptom duration, and delayed medical presentation as critical risk factors for perforation, with elderly individuals demonstrating heightened vulnerability due to physiological changes such as immunosenescence and atypical symptom presentation that obscure timely diagnosis (9,10). Furthermore, socioeconomic and geographic disparities can exacerbate delays in care, as patients residing in rural regions often face barriers such as limited healthcare infrastructure, greater distances to surgical facilities, and reduced health literacy, all of which contribute to higher rates of complicated appendicitis (11).

Despite substantial research in high-income settings, the epidemiology of perforated appendicitis in developing nations remains less well defined, particularly in Pakistan, where variations in health system accessibility, diagnostic resources, and public health infrastructure may influence both disease presentation and outcomes (12). While a previous study in Khyber Pakhtunkhwa reported an 8% perforation rate among acute appendicitis cases, the determinants contributing to this burden have not been comprehensively explored, leaving critical knowledge gaps regarding risk stratification and preventive strategies (13). Importantly, understanding these risk factors in local

populations is essential to guide timely surgical intervention, reduce postoperative complications, and optimize resource allocation in healthcare settings with constrained diagnostic and surgical capacity. Therefore, this study was conducted to determine the frequency of perforated appendix among patients presenting with acute appendicitis at a tertiary care hospital in Peshawar, Pakistan, and to identify demographic and clinical factors associated with increased risk of perforation. The findings aim to contribute valuable regional data to inform clinical practice and public health strategies to improve outcomes for patients with suspected appendicitis.

MATERIALS AND METHODS

This descriptive cross-sectional study was conducted in the Department of General Surgery at Lady Reading Hospital, Peshawar, Pakistan, over a twelve-month period from 1st January 2024 to 30th December 2024. The study aimed to ascertain the frequency of perforated appendix among patients presenting with acute appendicitis and to evaluate associated demographic and clinical risk factors within a tertiary care context serving both urban and rural populations. Approval for the study protocol was obtained from the hospital's ethical review committee under reference number 822/LRH/MTI, and the research evaluation unit of the College of Physicians and Surgeons Pakistan (CPSP) also endorsed the project. Informed written consent was secured from all participants after a thorough explanation of the study objectives, procedures, potential risks, and benefits, ensuring adherence to the ethical principles of the Declaration of Helsinki (14,15).

Eligible participants included patients aged 18 to 65 years of either gender who presented with clinical suspicion of acute appendicitis and were subsequently diagnosed based on computed tomography (CT) imaging. The operational definition of acute appendicitis for this study included findings of an appendiceal diameter greater than 6 mm, mural thickening exceeding 3 mm, peri-appendiceal fat stranding, and possible presence of an appendicolith on CT imaging, consistent with established radiological criteria (16). Patients were excluded if they had prior abdominal trauma, known renal disease, or conditions that could mimic appendicitis such as Crohn's disease, pelvic inflammatory disease, or other intra-abdominal infections. Recruitment followed a non-probability consecutive sampling technique, wherein all eligible patients presenting to the surgical emergency unit or outpatient clinics during the study period were approached for inclusion. This approach was chosen to ensure feasibility in a busy clinical setting, though it inherently carries potential selection bias (17).

Data collection was standardized and performed under supervision of surgical consultants with a minimum of three years' post-fellowship experience. For each patient, a structured proforma captured demographic details such as age, gender, residence (urban or rural), and socioeconomic status. Socioeconomic status was classified based on monthly household income, with thresholds defined according to national economic indicators distinguishing lower, middle, and upper economic classes (18). Clinical information, including duration of abdominal pain before hospital presentation, was meticulously recorded, with patients categorized into groups based on symptom duration: ≤24 hours, 24–48 hours, or >48 hours. All patients underwent physical examination and were subsequently evaluated using contrast-enhanced CT scans of the abdomen. Surgical exploration during appendectomy was performed either via open or laparoscopic techniques, at the discretion of the operating surgeon. Intraoperative confirmation of perforation was defined by direct visualization of an appendiceal rupture with leakage of intraluminal contents into the peritoneal cavity, adhering to consistent intraoperative criteria to ensure diagnostic accuracy (19).

The calculated sample size of 177 patients was derived using a single population proportion formula, considering an estimated perforated appendicitis prevalence of 8%, with a 4% absolute precision and 95% confidence interval, following recommendations for descriptive studies to ensure adequate statistical power (13,20). Data were entered and analyzed using IBM SPSS Statistics Version 21 (IBM Corp., Armonk, NY). Categorical variables such as gender, residence, socioeconomic status, and perforation status were summarized as frequencies and percentages. Continuous variables, including age and symptom duration, were presented as means with standard deviations after testing for normality of distribution. Stratification was conducted to assess potential effect modifiers, specifically age groups, gender, symptom duration, and residence. Associations between categorical variables and perforation status were examined using the chi-square test, with statistical significance defined as a two-tailed p-value less than 0.05. Where appropriate, odds ratios with 95% confidence intervals were calculated to estimate the strength of associations (21). Missing data were managed through complete-case analysis, excluding records with incomplete critical variables from subgroup analyses to minimize potential bias while maintaining analytical integrity (22). Measures were implemented throughout the study to ensure data reliability, including double data entry verification and periodic audits of recorded data by the research team.

RESULTS

Among 177 patients diagnosed with acute appendicitis, the mean age was 34.2 years (SD ±12.8), with a range spanning from 18 to 65 years. Males accounted for a slight majority, comprising 103 individuals (58.2%), while females represented 74 patients (41.8%). Most patients resided in rural areas, totaling 111 individuals (62.7%), whereas 66 patients (37.3%) were from urban settings. Approximately half the cohort, or 89 patients (50.3%), were classified as belonging to lower socioeconomic status, though socioeconomic subcategories were not significantly analyzed for perforation outcomes due to incomplete stratified data.

Overall, 19 patients (10.7%) were found to have a perforated appendix during surgical exploration, while 158 patients (89.3%) presented with non-perforated appendicitis. Analysis by age group revealed a significant relationship between advancing age and perforation risk ($p = 0.042$). Patients aged 46 to 65 years exhibited the highest perforation rate, with 8 of 38 individuals (21.1%) affected, translating to an odds ratio (OR) of 3.36 (95% CI: 0.96–11.74) compared to the reference group aged 18–30 years, where the perforation rate was 7.4% (5 of 68 patients). The intermediate age group, spanning 31–45 years, demonstrated a perforation rate of 8.5% (6 of 71 patients), with an OR of 1.16 (95% CI: 0.33–4.08) relative to the youngest cohort. Gender did not exhibit a statistically significant association with perforation

status (p = 0.623). Of the 103 male patients, 12 (11.7%) experienced perforation, whereas 7 of 74 females (9.5%) were similarly affected, yielding an OR of 0.79 (95% CI: 0.28–2.24) for females compared to males, suggesting no meaningful difference in risk between sexes.

Table 1. Baseline Characteristics of Study Participants (n = 177)

Characteristic	Total (n = 177)	Perforated (n = 19)	Non-Perforated (n = 158)	p-value	OR (95% CI)
Age, years (mean ± SD)	34.2 ± 12.8	44.7 ± 13.1	33.0 ± 12.3	–	–
Age Group				0.042	
18–30 years	68 (38.4%)	5 (7.4%)	63 (92.6%)		Ref
31–45 years	71 (40.1%)	6 (8.5%)	65 (91.5%)		1.16 (0.33–4.08)
46–65 years	38 (21.5%)	8 (21.1%)	30 (78.9%)		3.36 (0.96–11.74)
Gender				0.623	
Male	103 (58.2%)	12 (11.7%)	91 (88.3%)		Ref
Female	74 (41.8%)	7 (9.5%)	67 (90.5%)		0.79 (0.28–2.24)
Residence				0.031	
Rural	111 (62.7%)	15 (13.5%)	96 (86.5%)		Ref
Urban	66 (37.3%)	4 (6.1%)	62 (93.9%)		0.41 (0.13–1.30)
Socioeconomic Status				–	–
Lower	89 (50.3%)	–	–	–	–
Middle/Upper	88 (49.7%)	–	–	–	–
Duration of Pain				0.001	
≤ 24 hours	50 (28.2%)	2 (4.0%)	48 (96.0%)		Ref
24–48 hours	77 (43.5%)	5 (6.5%)	72 (93.5%)		1.66 (0.30–9.13)
> 48 hours	50 (28.2%)	12 (24.0%)	38 (76.0%)		7.58 (1.45–39.69)

Table 2. Perforation Rates by Duration of Pain

Duration of Pain	Total (n)	Perforated (n)	Perforation Rate (%)	p-value	OR (95% CI)
≤ 24 hours	50	2	4.0%		Ref
24–48 hours	77	5	6.5%		1.66 (0.30–9.13)
> 48 hours	50	12	24.0%	0.001	7.58 (1.45–39.69)

Table 3. Perforation Rates by Age Group and Residence

Age Group	Rural Perforation n (%)	Urban Perforation n (%)
18–30 years	3/48 (6.3%)	2/20 (10.0%)
31–45 years	5/44 (11.4%)	1/27 (3.7%)
46–65 years	7/19 (36.8%)	1/19 (5.3%)

A striking disparity emerged when analyzing symptom duration. Patients who sought medical care after more than 48 hours of pain faced the highest perforation risk, with 12 of 50 individuals (24.0%) affected. This delayed group had an OR of 7.58 (95% CI: 1.45–39.69) for perforation compared to those presenting within 24 hours, where only 2 of 50 patients (4.0%) experienced perforation.

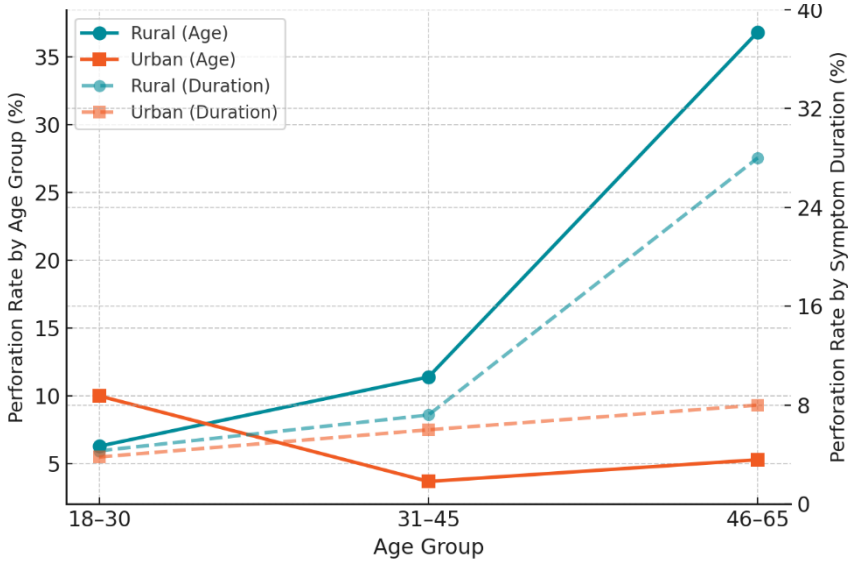

Figure 1 Perforation Rates in Acute Appendicitis by Age, Duration, and Residence

Those presenting between 24 and 48 hours showed an intermediate perforation rate of 6.5% (5 of 77 patients), corresponding to an OR of 1.66 (95% CI: 0.30–9.13), although this increase was not statistically significant. Overall, the association between prolonged symptom duration and perforation was highly significant (p = 0.001). Residence emerged as another significant factor influencing perforation risk

(p = 0.031). Among rural patients, 15 of 111 individuals (13.5%) suffered appendiceal perforation, whereas only 4 of 66 urban patients (6.1%) were similarly affected. The odds of perforation for urban residents were lower, with an OR of 0.41 (95% CI: 0.13–1.30) compared to their rural counterparts. When stratified by both age and residence, the rural elderly subgroup demonstrated the most pronounced perforation risk, with 7 of 19 patients aged 46–65 years (36.8%) from rural areas experiencing perforation, compared to just 1 of 19 (5.3%) urban patients in the same age range. These findings collectively underscore the significant influence of patient age, symptom duration, and geographic residence on the likelihood of appendiceal perforation in acute appendicitis, whereas gender did not exert a significant effect in this cohort.

Figure 1 demonstrates how perforation rates in acute appendicitis increase sharply with advancing age and prolonged symptom duration, with rural patients experiencing consistently higher risks than urban counterparts. In the 46–65 year group, rural patients exhibit a perforation rate of 36.8% compared to just 5.3% in urban peers. Similarly, when symptom duration exceeds 48 hours, rural patients approach a 28% perforation rate, substantially higher than the 8% observed in urban cases. The combined visual trends underscore the compounded clinical vulnerability of elderly and rural populations—particularly those presenting late—highlighting the urgent need for expedited surgical evaluation and targeted public health interventions to reduce diagnostic delays and mitigate adverse outcomes in high-risk groups.

DISCUSSION

The present study determined that perforated appendicitis occurred in 10.7% of patients diagnosed with acute appendicitis, reflecting a moderate prevalence consistent with ranges reported internationally, yet underscoring the persisting clinical burden of delayed diagnosis in resource-limited settings. This perforation rate aligns with prior regional data from Khyber Pakhtunkhwa indicating an 8% prevalence, but falls below higher figures observed elsewhere, such as the 24.3% rate documented by Nouri et al. in their Iranian cohort, and the 17.7% reported in North American studies evaluating complex appendicitis within quality improvement initiatives (13,23,24). Such variability in reported rates underscores substantial heterogeneity across healthcare systems and patient populations, driven by differences in diagnostic capabilities, healthcare-seeking behaviors, and sociodemographic factors.

A salient finding in this study was the significant association between advanced age and appendiceal perforation, with patients aged 46–65 years exhibiting a perforation rate of 21.1%, over threefold higher than the 7.4% observed among those aged 18–30 years. This trend is consistent with prior research highlighting the increased vulnerability of older patients, attributable to age-related physiological changes such as immunosenescence, reduced visceral pain perception, and greater likelihood of atypical presentations that complicate timely diagnosis (9,25). Drake et al. similarly demonstrated that perforation risk rises markedly with age, exceeding 36% in patients over 70 years, emphasizing that even in younger geriatric cohorts, vigilance remains critical to avoid progression to complicated appendicitis (25). These age-associated risks suggest that clinicians should maintain a heightened index of suspicion and potentially lower surgical thresholds in elderly patients presenting with nonspecific abdominal symptoms.

Symptom duration emerged as the strongest predictor of perforation in this study, with patients who presented after more than 48 hours demonstrating a perforation rate of 24.0%, significantly exceeding the 4.0% observed in those evaluated within the first 24 hours of pain onset. The odds ratio of 7.58 for late presenters underscores the steep escalation in risk associated with diagnostic delays, consistent with earlier findings that prolonged inflammation facilitates transmural necrosis and rupture of the appendiceal wall (26). However, it is notable that some studies, such as Nouri et al., reported paradoxically lower perforation rates in patients undergoing surgery beyond 48 hours, suggesting that the disease trajectory may be nonlinear in certain individuals, possibly due to spontaneous resolution or early rupture before medical attention (23). Nonetheless, the present findings reinforce the necessity of prompt surgical assessment and highlight the critical window within the first 48 hours to mitigate complications.

Geographic residence was another significant determinant of perforation, as rural patients experienced higher rates (13.5%) compared to their urban counterparts (6.1%). This disparity echoes concerns raised in prior studies about inequities in healthcare access and delayed presentation in rural populations, where barriers such as transportation difficulties, limited diagnostic resources, and socioeconomic constraints hinder timely surgical intervention (27). Rural patients, particularly in the older age group, demonstrated the most pronounced perforation risk, with a rate of 36.8% among those aged 46–65 years, suggesting an additive effect of age and residence on outcomes. Livingston et al. previously documented that structural gaps between urban and rural healthcare systems contribute significantly to the higher incidence of complicated appendicitis and its associated morbidity (28). Addressing these disparities requires targeted public health strategies, including education on early symptom recognition, improved referral networks, and potentially deploying mobile diagnostic services to remote communities.

Interestingly, gender did not exhibit a statistically significant association with perforation in this cohort, with rates of 11.7% in males and 9.5% in females. This finding contrasts with some literature suggesting a male predominance in perforated appendicitis, such as Nouri et al., who reported males accounting for over 70% of perforated cases (23). The absence of significant gender differences in the present study may reflect sociocultural factors in healthcare-seeking behavior or could indicate regional variability in disease biology or access patterns. Kollias et al. emphasized that while overall appendicitis incidence can differ between sexes, perforation risk does not consistently correlate with gender, underscoring the importance of evaluating risk factors independently rather than assuming uniform demographic trends (29).

Although this study provides valuable regional data, several limitations must be acknowledged. The single-center design may limit generalizability to other settings within Pakistan or beyond, where healthcare infrastructure and patient demographics may differ. The reliance on non-probability consecutive sampling introduces potential selection bias, and although stratification was performed, the

relatively small sample size of certain subgroups, particularly older urban patients, constrains the precision of some estimates. Furthermore, socioeconomic status was recorded but not analyzed in detail regarding perforation risk, leaving gaps in understanding potential financial barriers to timely care. Another limitation is the lack of multivariate analysis, which could have better elucidated independent predictors of perforation by adjusting for potential confounders such as comorbidities, laboratory markers like hyperbilirubinemia, and imaging characteristics previously shown to be predictive of complicated appendicitis (30,31).

Future research should aim for multicenter, prospective designs with larger cohorts to validate these findings and develop robust risk prediction models that integrate clinical, radiological, and laboratory parameters. Studies incorporating advanced imaging criteria, biomarkers such as C-reactive protein and bilirubin levels, and exploring genetic predispositions could further refine diagnostic accuracy and risk stratification for perforation. Additionally, public health interventions should focus on improving healthcare accessibility and patient education in rural areas to facilitate earlier presentation and reduce the burden of complicated appendicitis. This study highlights that appendiceal perforation remains a significant complication among patients with acute appendicitis, with advanced age, delayed symptom duration, and rural residence emerging as key risk factors. These findings underscore the urgency of prompt surgical evaluation, particularly in high-risk populations, and call for concerted efforts to address healthcare disparities that contribute to delayed diagnosis and adverse outcomes in acute appendicitis management.

CONCLUSION

This study demonstrates that perforated appendicitis occurs in approximately one in ten patients presenting with acute appendicitis, with significant variation linked to patient age, duration of symptoms prior to hospital presentation, and rural residency. Patients aged 46–65 years, those presenting after more than 48 hours of pain onset, and individuals from rural areas face markedly higher risks of perforation, underscoring the importance of prompt diagnosis and surgical intervention. These findings emphasize the need for heightened clinical vigilance, particularly among elderly and rural populations, and highlight critical areas for public health initiatives aimed at reducing diagnostic delays and improving outcomes in acute appendicitis management. Future research should explore comprehensive predictive models and targeted strategies to mitigate disparities and enhance timely care for patients at elevated risk of perforation.

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