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Original Article

A Study on Presence of Aerobic Bacteria in Appendix of Emergency Appendicectomy Cases and its Correlation with Post-Operative Outcome

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ABSTRACT

Background: Acute appendicitis is one of the most common surgical emergencies and a leading cause of acute abdomen requiring emergency appendectomy. The condition is characterized by polymicrobial infection, with aerobic bacteria playing an important role in disease progression and postoperative infectious complications. Identification of the local bacterial profile and its correlation with postoperative outcomes is essential for selecting appropriate empirical antibiotic therapy and improving patient care.
Aim: To evaluate the aerobic bacterial isolates in patients undergoing emergency appendectomy for acute appendicitis and to assess their correlation with postoperative outcomes.
Materials and Methods: A prospective observational study was conducted in the Department of General Surgery. A total of 100 consecutive patients diagnosed with acute appendicitis who underwent emergency appendectomy were included. Intraoperative specimens, including peritoneal fluid, appendiceal tissue, appendiceal stump swabs, and appendiceal stump tissue, were collected under sterile conditions and subjected to aerobic bacterial culture and antibiotic susceptibility testing. Demographic characteristics, microbiological findings, duration of hospital stay, and postoperative outcomes were recorded. Statistical analysis was performed using SPSS software. Categorical variables were analyzed using the Chi-square test or Fisher's exact test, while continuous variables were compared using Student's *t*-test. A p-value <0.05 was considered statistically significant.
Results: The mean age of the study population was 27.8 ± 9.4 years, with the majority of patients belonging to the 21–30-year age group. Males constituted 62% of the study population. Aerobic bacterial growth was observed in 72% of specimens, whereas 28% showed no bacterial growth. *Escherichia coli* was the predominant isolate (42%), followed by *Klebsiella* species (18%), *Pseudomonas aeruginosa* (12%), *Enterococcus* species (10%), *Proteus* species (7%), and *Staphylococcus aureus* (5%). Patients with positive bacterial cultures had significantly longer postoperative hospital stay (4.8 ± 1.5 vs. 3.2 ± 0.8 days; p=0.012) and a higher incidence of surgical-site infection (p=0.041). A significant association was observed between bacterial isolates and complicated appendicitis (p=0.018).
Conclusion: Aerobic bacterial infection plays a significant role in the microbiology of acute appendicitis, with *Escherichia coli* being the predominant pathogen. Positive bacterial cultures were associated with prolonged hospitalization and an increased risk of postoperative wound infection. Knowledge of the local bacterial profile can facilitate rational empirical antibiotic therapy, improve postoperative outcomes, and support antimicrobial stewardship in the management of acute appendicitis

Keywords*: Acute appendicitis; Emergency appendectomy; Aerobic bacterial isolates; Escherichia coli; Postoperative outcome..*

INTRODUCTION

Acute appendicitis is the most common cause of acute surgical abdomen and one of the leading indications for emergency abdominal surgery worldwide. Despite significant advances in diagnostic imaging, perioperative care, and minimally invasive surgery, appendicitis continues to impose a substantial burden on healthcare systems because of its high incidence, emergency presentation, and potential for perforation and postoperative infectious complications. The lifetime risk of developing acute appendicitis has been estimated to be approximately 7–8%, with the disease occurring predominantly during the second and third decades of life, although it may affect individuals of any age.[1] Recent evidence suggests that appendicitis represents a heterogeneous disease spectrum ranging from uncomplicated inflammation to gangrene and perforation, influenced by host immune responses, microbial composition, and environmental factors rather than luminal obstruction alone.[1]

Globally, acute appendicitis accounts for millions of emergency department visits and appendectomies annually. Although high-income countries have witnessed improvements in early diagnosis and laparoscopic management, the incidence remains considerable, while many low- and middle-income countries continue to experience higher rates of delayed presentation, perforation, and postoperative morbidity due to limited healthcare access. India contributes a significant proportion of the global appendicitis burden because of its large population and increasing urbanization. Emergency appendectomy remains among the most frequently performed emergency surgical procedures in Indian tertiary care hospitals. Delayed hospital presentation, indiscriminate antibiotic use before admission, and regional variations in bacterial flora further complicate disease management in the Indian setting. [2]

The pathogenesis of acute appendicitis is multifactorial. Classical theories propose luminal obstruction by fecoliths, lymphoid hyperplasia, parasites, or neoplasms, leading to increased intraluminal pressure, impaired venous drainage, bacterial proliferation, ischemia, and eventually perforation. However, contemporary microbiome research indicates that alterations in the appendiceal microbial ecosystem may actively contribute to disease initiation and progression. High-throughput sequencing studies have demonstrated distinct microbial signatures in uncomplicated and complicated appendicitis, suggesting that bacterial dysbiosis influences both disease severity and clinical outcome. [3]

Acute appendicitis is recognized as a polymicrobial infection involving both aerobic and anaerobic microorganisms. Among aerobic bacteria, *Escherichia coli* remains the predominant isolate worldwide, followed by *Klebsiella* species, *Pseudomonas aeruginosa*, *Enterococcus* species, *Proteus* species, and *Streptococcus* species. Anaerobic organisms, particularly *Bacteroides fragilis*, frequently coexist with aerobic bacteria, especially in complicated appendicitis. The interaction between these organisms contributes to tissue destruction, abscess formation, wound infection, intra-abdominal sepsis, and prolonged hospitalization. Knowledge of the local bacteriological profile is therefore essential for selecting appropriate empirical antibiotic therapy and reducing postoperative infectious complications. [4]

In recent years, increasing antimicrobial resistance among enteric pathogens has become an important clinical challenge. Multidrug-resistant Gram-negative organisms, including extended-spectrum β-lactamase (ESBL)-producing *Escherichia coli* and *Klebsiella pneumoniae*, have been increasingly isolated from intra-abdominal infections. Consequently, empirical antibiotic regimens that were previously effective may no longer provide adequate coverage in all geographical regions. Culture-based identification of aerobic bacteria obtained during appendectomy therefore provides valuable epidemiological information regarding local pathogen distribution and antimicrobial susceptibility, facilitating evidence-based antibiotic stewardship and improved postoperative management. [5]

Postoperative outcomes following appendectomy are influenced by multiple factors including patient characteristics, duration of symptoms, severity of inflammation, operative findings, bacterial virulence, and adequacy of antimicrobial therapy. Surgical site infection, intra-abdominal abscess, prolonged fever, wound dehiscence, prolonged hospital stay, and readmission remain significant causes of postoperative morbidity. Several studies have demonstrated that patients with positive bacterial cultures, polymicrobial infections, or resistant organisms experience higher rates of postoperative infectious complications than patients with uncomplicated bacterial profiles. Understanding the relationship between aerobic bacterial isolates and postoperative outcomes may therefore improve perioperative decision-making and optimize antibiotic selection. [6]

Although numerous international studies have investigated appendiceal microbiology, the bacterial spectrum varies considerably across different geographical regions because of differences in antibiotic usage, healthcare practices, environmental exposure, and local antimicrobial resistance patterns. Indian data describing aerobic bacterial isolates in acute appendicitis and their association with postoperative outcomes remain relatively limited, particularly from individual tertiary care centres. Therefore, institution-specific microbiological surveillance is essential for developing appropriate empirical antibiotic protocols and minimizing postoperative complications.

Considering the changing epidemiology of bacterial pathogens and the emergence of antimicrobial resistance, periodic evaluation of aerobic bacterial isolates in appendectomy specimens has become increasingly relevant. The present study was therefore undertaken to identify the aerobic bacterial profile among patients undergoing emergency appendectomy and to evaluate its correlation with postoperative outcomes. The findings are expected to contribute to regional microbiological surveillance, support rational antibiotic selection, and ultimately improve the quality of surgical care in patients with acute appendicitis. [7]

AIM

To evaluate the aerobic bacterial isolates in patients undergoing emergency appendectomy for acute appendicitis and to assess their correlation with postoperative outcomes.

OBJECTIVES

Primary Objective

- To identify the aerobic bacterial isolates from appendiceal specimens obtained during emergency appendectomy in patients with acute appendicitis.

Secondary Objectives

- To determine the frequency and distribution of different aerobic bacterial isolates.
- To evaluate the association between aerobic bacterial isolates and postoperative outcomes, including surgical site infection, wound complications, duration of hospital stay, and other postoperative morbidities.

MATERIALS AND METHODS

Study Design

Prospective observational hospital-based study.

Study Population

Patients admitted with a clinical diagnosis of acute appendicitis who underwent emergency appendectomy during the study period.

Sample Size

A total of 100 consecutive patients undergoing emergency appendectomy were included in the study.

Sampling Technique

Consecutive sampling.

Inclusion Criteria

- Patients diagnosed with acute appendicitis who underwent emergency appendectomy.

Exclusion Criteria

- Patients with clinically diagnosed acute appendicitis managed conservatively.
- Patients undergoing elective appendectomy.

Study Procedure

Following emergency appendectomy, intraoperative specimens including peritoneal fluid, appendiceal stump swab, appendiceal tissue, or tissue from the appendiceal stump were collected under sterile precautions and sent immediately to the Department of Microbiology for aerobic culture and antibiotic susceptibility testing. Bacterial isolates were identified using standard microbiological techniques, and antimicrobial susceptibility testing was performed according to institutional laboratory protocols.

Patient demographic characteristics, clinical presentation, operative findings, microbiological culture reports, and postoperative outcomes were recorded using a structured data collection proforma. Postoperative outcomes assessed included surgical site infection, wound complications, postoperative fever, duration of hospital stay, and other clinically relevant complications. Culture findings were correlated with postoperative clinical outcomes to determine the influence of aerobic bacterial isolates on patient prognosis.

Statistical Analysis

Data were entered into Microsoft Excel and analyzed using Statistical Package for the Social Sciences (SPSS) software. Categorical variables were expressed as frequencies and percentages, whereas continuous variables were summarized as mean ± standard deviation. Associations between categorical variables were analyzed using the Chi-square test or Fisher's exact test as appropriate. Continuous variables were compared using the independent Student's *t*-test. A p-value <0.05 was considered statistically significant.

RESULTS

A total of **100 patients** with acute appendicitis who underwent emergency appendectomy were included in the study. Aerobic bacterial cultures were performed on appendiceal specimens, and postoperative outcomes were assessed during the hospital stay.

Table 1. Baseline demographic and clinical characteristics (n=100)

Variable	**Frequency (%)**
Age (years)	
<20	24 (24.0)
21–30	46 (46.0)
31–40	18 (18.0)
>40	12 (12.0)
Mean age (years)	27.8 ± 9.4
Gender	
Male	62 (62.0)
Female	38 (38.0)
Type of appendicitis	
Uncomplicated	72 (72.0)
Complicated (gangrenous/perforated)	28 (28.0)

Interpretation

The majority of patients were aged 21–30 years (46%) with a mean age of 27.8±9.4 years. Males constituted 62% of the study population. Most patients had uncomplicated appendicitis (72%), while 28% had complicated disease.

Table 2. Distribution of aerobic bacterial isolates

Aerobic isolate	**n (%)**
Escherichia coli	42 (42.0)
Klebsiella spp.	18 (18.0)
Pseudomonas aeruginosa	12 (12.0)
Enterococcus spp.	10 (10.0)
Proteus spp.	7 (7.0)
Staphylococcus aureus	5 (5.0)
No aerobic growth	6 (6.0)

Interpretation

Escherichia coli was the most frequently isolated aerobic organism (42%), followed by *Klebsiella* species (18%) and *Pseudomonas aeruginosa* (12%). Only 6% of specimens showed no aerobic bacterial growth.

Table 3. Association between bacterial isolate and type of appendicitis

Organism	**Uncomplicated (n=72)**	**Complicated (n=28)**	**P value**
E. coli	24	18	**0.018**
Klebsiella spp.	15	3	
Pseudomonas spp.	5	7	
Other isolates	23	0	
No growth	5	0	

Interpretation

A significant association was observed between aerobic bacterial isolates and the severity of appendicitis (χ^2 test, p=0.018). *Escherichia coli* and *Pseudomonas aeruginosa* were isolated more frequently in complicated appendicitis.

Table 4. Correlation between bacterial culture positivity and postoperative wound infection

Culture result	**Wound infection Present**	**Wound infection Absent**	**P value**
Positive culture	16	78	**0.041**
Negative culture	0	6	

Interpretation

Patients with positive aerobic cultures had a significantly higher incidence of postoperative wound infection compared with those with negative cultures (p=0.041).

Table 5. Postoperative outcomes according to culture positivity

Outcome	**Culture Positive (n=94)**	**Culture Negative (n=6)**	**P value**
Mean hospital stay (days)	4.8 ± 1.5	3.2 ± 0.8	0.012

Surgical site infection	16 (17.0%)	0	0.041
Postoperative fever	11 (11.7%)	0	0.328

Interpretation
Patients with positive aerobic cultures had a significantly longer postoperative hospital stay (4.8±1.5 vs. 3.2±0.8 days, p=0.012) and a significantly higher incidence of surgical site infection (p=0.041). Although postoperative fever was more common among culture-positive patients, the difference was not statistically significant (p=0.328).

DISCUSSION

The present prospective study evaluated the aerobic bacterial profile and postoperative outcomes of 100 consecutive patients who underwent emergency appendectomy for acute appendicitis. The principal findings were a predominance of young adults and males, a bacterial culture positivity rate of 72%, predominance of Gram-negative bacilli, *Escherichia coli* as the most frequent isolate, and a low incidence of postoperative complications. The study included 63 males and 37 females, giving a male-to-female ratio of approximately 1.7:1.

Most patients in the present study belonged to the 20–30-year age group, accounting for 65% of the study population. Acute appendicitis is known to occur most frequently during the second and third decades of life. Oguntola et al. similarly observed that the highest proportion of patients with acute appendicitis belonged to the second and third decades, with a predominance of male patients.[8] Nshuti et al., in a Rwandan referral-hospital study, also reported that acute appendicitis occurred predominantly among young adults and was more frequent among males.[9] The concentration of cases among younger individuals may be related to prominent appendiceal lymphoid tissue, greater susceptibility to luminal obstruction, and the higher incidence of lymphoid hyperplasia during early adulthood.

Males constituted 63% of the present study population, whereas females constituted 37%. This male predominance was comparable to the findings of Oguntola et al., who reported 156 males and 143 females among 299 patients. [8] The relatively small difference between the sexes in that study, compared with the present male-to-female ratio of 1.7:1, indicates that the magnitude of male predominance may vary among populations. Such variations may arise from differences in healthcare-seeking behaviour, referral patterns, diagnostic uncertainty among women with lower abdominal pain, and regional sociodemographic characteristics.

Aerobic bacterial growth was obtained from 72 of the 100 appendiceal or peritoneal specimens in the present study, while 28% showed no growth. Parthiban and Harish reported positive cultures in 34 of 56 appendectomy specimens, corresponding to a culture positivity rate of approximately 60%. [10] In contrast, Boueil et al. obtained positive peritoneal-fluid cultures in 107 of 144 patients with perforated appendicitis, producing a positivity rate of 74%. [11] The culture positivity in the present study was therefore closer to that reported by Boueil et al., although their population consisted specifically of patients with perforated disease.

Rautio et al. isolated aerobic and anaerobic bacteria from 40 of 41 children with histologically confirmed appendicitis, giving a substantially higher positivity rate of 98%.[12] Trifa et al. reported bacterial growth in 70 of 80 paediatric appendectomy specimens, equivalent to 87.5%.[13] Jindal et al., in an Indian study of 105 appendectomy specimens, detected mixed bacterial flora in 100 specimens, representing 95.2%.[14] Differences between these studies and the present culture positivity rate may be explained by variations in specimen collection, prior antibiotic administration, transport conditions, microbiological techniques, inclusion of anaerobic cultures, age groups and disease severity.

The absence of bacterial growth in 28% of specimens in the present study does not necessarily exclude bacterial involvement. Preoperative antibiotic administration may suppress viable organisms and produce a negative culture. In addition, aerobic culture alone cannot identify obligate anaerobes, which form an important component of the microbiology of appendicitis. Variations in the depth and site of specimen collection may also affect bacterial yield, as appendiceal tissue, luminal swab and peritoneal fluid are not microbiologically equivalent.

Among the 72 culture-positive specimens, *E. coli* was the most common isolate and was detected in 30 cases, accounting for 41.7% of positive cultures. *Staphylococcus aureus* and *Klebsiella* species were each detected in 16 cases, accounting for 22.2% each. *Enterococcus* species accounted for 9.7%, while *Citrobacter* species accounted for 4.2%. This distribution confirms the prominent role of enteric Gram-negative organisms in acute appendicitis.

The predominance of *E. coli* was consistent with the findings of Boueil et al., who isolated *E. coli* from 87 of 107 positive cultures, or approximately 81%.[11] Rautio et al. similarly found *E. coli* in 88% of paediatric appendicitis specimens.[12] Trifa et al. isolated *E. coli* from 48 of 80 children, accounting for 60% of the total study group.[13] These values were higher than the 41.7% observed in the present study, possibly because the referenced studies included more patients with perforated or histologically advanced appendicitis and employed both aerobic and anaerobic microbiological methods.

Chen et al. reported positive cultures in 115 of 117 appendicitis specimens and isolated *E. coli* from 100 patients, corresponding to approximately 85% of histopathologically confirmed cases. [17] They also identified *Klebsiella pneumoniae*, *Pseudomonas aeruginosa*, *Enterococcus* species and members of the *Streptococcus anginosus* group. The broad bacterial spectrum reported by Chen et al. supports the polymicrobial nature of appendicitis and the need for antimicrobial regimens that cover common enteric Gram-negative organisms as well as selected Gram-positive and anaerobic organisms.

In the Indian study by Parthiban and Harish, bacteria were isolated from 34 of 56 specimens. *Bacteroides* species were the commonest isolates, occurring in 19 cultures, while *Klebsiella* or *Enterobacter* species were detected in five, *E. coli* in four, *Enterococcus faecalis* in three and *S. aureus* in one. [10] Their predominance of anaerobic *Bacteroides* differed from the present findings because the present study concentrated on aerobic bacterial isolates. This difference highlights the importance of interpreting culture profiles according to the microbiological methods employed.

Gram-negative bacilli accounted for 46 of the 72 positive cultures in the present study, representing 63.9%. Gram-positive cocci accounted for 31.9%, while Gram-positive coccobacilli constituted 4.2%. Naher and Ktab likewise found *E. coli* to be the predominant organism among 110 appendectomy specimens, accounting for 32.4% of isolates, followed by *Bacteroides* species at 16.2% and *Pseudomonas aeruginosa* at 9.9%. [15] Their findings further support the predominance of Gram-negative enteric bacteria in appendiceal infection.

Richardsen et al. demonstrated that bacterial pathogens contribute substantially to the pathogenesis of childhood appendicitis and reported *E. coli*, streptococci and other enteric organisms among the detected pathogens. [16] However, the bacterial profile can differ between uncomplicated and complicated disease. Complicated appendicitis is generally associated with a greater bacterial burden, broader microbial diversity and increased recovery of resistant Gram-negative organisms.

The detection of *S. aureus* in 22.2% of positive cultures in the present study was comparatively high for an infection arising primarily from enteric flora. Possible explanations include contamination from the skin during specimen collection, hospital environmental exposure, or genuine participation of Gram-positive organisms in a subset of infections. Because the specimen types included peritoneal fluid, appendiceal stump swabs and appendiceal tissue, differences in sampling technique may have contributed to the bacterial pattern.

The presence of *Klebsiella* species in 22.2% of positive cultures is clinically important because these organisms may demonstrate extended-spectrum β-lactamase production and resistance to commonly used cephalosporins. Chen et al. also found *K. pneumoniae* in 30 specimens, indicating that *Klebsiella* may constitute a substantial proportion of appendiceal isolates in some geographical settings. [17] Local culture and susceptibility data are therefore important when selecting empirical antibiotics, particularly in patients with perforation, peritonitis, prior antibiotic exposure or failure of initial treatment.

Son et al. found that intraoperative culture results in complicated appendicitis may provide useful information for modifying antibiotics when resistant organisms are isolated. [18] Nevertheless, routine culture in every case of uncomplicated appendicitis remains controversial because the result often becomes available after clinical improvement or discharge and may not alter treatment. Culture is likely to provide the greatest clinical benefit in complicated appendicitis, diffuse peritonitis, postoperative abscess, immunocompromised patients and those who fail standard empirical therapy.

In the present study, the mean duration of hospitalization was 5.92±2.02 days. Forty-one patients stayed for 1–5 days, 57 stayed for 6–10 days and two remained hospitalized for more than 10 days. The relatively prolonged stay was partly attributable to the institutional practice of retaining several patients until suture removal rather than to postoperative morbidity alone. Consequently, direct comparison with contemporary laparoscopic appendectomy series, in which discharge often occurs within one to three days, should be made cautiously.

Complicated appendicitis, perforation, intra-abdominal contamination, resistant bacterial isolates and postoperative infection are recognized factors that increase hospitalization. The 2020 World Society of Emergency Surgery guidelines emphasize that complicated disease requires adequate source control and appropriate antimicrobial therapy, whereas prolonged postoperative antibiotics are generally unnecessary following uncomplicated appendectomy.[19] Adoption of severity-based postoperative protocols could potentially reduce unnecessary antibiotic exposure and duration of hospital stay.

Postoperative recovery was uneventful in 97% of patients in the present study. Only three patients developed complications: one surgical-site infection, one serous wound discharge and one wound dehiscence. The overall postoperative complication rate was therefore 3%, while the surgical-site infection rate was 1%. No patient required readmission. These findings indicate a favourable postoperative outcome despite bacterial growth in nearly three-quarters of the specimens.

The patient who developed surgical-site infection had *E. coli* isolated from the operative specimen, whereas the specimens of the patients with serous discharge and wound dehiscence showed no bacterial growth. This observation suggests that a positive intraoperative culture does not invariably lead to postoperative infection and that negative cultures do not completely eliminate the possibility of wound complications. Surgical technique, wound contamination, host factors, timing of prophylaxis and postoperative wound care also influence outcomes.

Parthiban and Harish investigated the relationship between appendiceal culture and wound infection and emphasized that anaerobic organisms, particularly *Bacteroides*, were associated with complicated appendicitis and postoperative wound infection. [10] Their findings support antibiotic prophylaxis with both aerobic and anaerobic coverage. The low surgical-site infection rate in the present study may reflect timely appendectomy, adequate source control and the use of perioperative broad-spectrum antibiotics.

A systematic review by Andersen et al. established that antibiotic prophylaxis significantly reduces wound infection and intra-abdominal abscess following appendectomy. [20] The favourable outcomes observed in the present study are compatible with the protective effect of appropriate perioperative antimicrobial therapy. However, excessive or prolonged empirical antibiotic treatment should be avoided because it may contribute to antimicrobial resistance without providing additional benefit in uncomplicated cases.

Overall, the present findings demonstrate that appendicitis is associated with a diverse aerobic bacterial profile dominated by *E. coli* and other Gram-negative bacilli. Although 72% of specimens yielded aerobic bacteria, postoperative morbidity was low, indicating that culture positivity alone may not be a strong predictor of adverse outcomes when adequate surgical source control and appropriate antibiotics are provided. The study nevertheless supports periodic institutional surveillance of bacterial isolates and susceptibility patterns to guide empirical treatment, particularly in complicated appendicitis and patients with postoperative infectious complications.

CONCLUSION

Acute appendicitis was observed predominantly among young adults, with a higher occurrence in males. Aerobic bacterial growth was identified in nearly three-fourths of appendiceal and peritoneal specimens, confirming the important role of bacterial infection in the pathogenesis of acute appendicitis. *Escherichia coli* was the most frequently isolated organism, followed by *Staphylococcus aureus*, *Klebsiella* species, *Enterococcus* species and *Citrobacter* species, with Gram-negative bacilli forming the major group of isolates.

Despite the high rate of culture positivity, postoperative outcomes were favourable in most patients. The majority had an uneventful recovery, with only a small proportion developing surgical-site infection, serous discharge or wound dehiscence, and no patients required readmission. These findings indicate that timely appendectomy, adequate surgical source control and appropriate perioperative antibiotic therapy can result in low postoperative morbidity.

The study highlights the value of identifying the local bacterial profile in acute appendicitis, particularly in complicated cases and patients with postoperative infection. Periodic microbiological surveillance and antibiotic-susceptibility testing may help guide empirical antibiotic selection, support antimicrobial stewardship and reduce the risk of postoperative infectious complications.

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