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Bacterial Profile and Sensitivity in Adults Post Appendectomy for Acute Complicated Appendicitis

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Abstract

Background: Acute appendicitis, a significant abdominal surgical emergency, presents diagnostic and management challenges and often results in complications. This study investigated microbial pathogens and antibiotic sensitivity patterns in complicated acute appendicitis to provide essential insights for targeted antimicrobial therapy.

Methods: This retrospective cross-sectional review at Dr. George Mukhari Academic Hospital included 52 culture-positive cases of complicated acute appendicitis diagnosed between October 2021 and October 2022. Demographics, clinical presentations, diagnostic methods, operative procedures, and outcomes were analyzed. Microbial pathogens, antibiotic sensitivity, and resistance patterns were examined.

Results: *Escherichia coli* (*E. coli*) emerged as the predominant organism as a single isolate and mixed with other pathogens at 82.69% (n=43), displaying varying sensitivities to antibiotics. Other cultures included *Streptococcus species*, *Klebsiella species*, and *Pseudomonas*, in descending order. *E. coli* showed sensitivity rates of 97%, 70%, and 60% to gentamycin, cefuroxime, and amoxycillin/clavulanic acid, respectively. Gram-positive organisms, including *Streptococcus* and *Enterococcus* spp., were prevalent, whereas *Pseudomonas aeruginosa* was prominent among gram-negative organisms. Surgical site infection occurred in 21% of the cases, underscoring the importance of appropriate antibiotic treatment. This study identified significant antibiotic resistance, particularly in penicillin's, sulfonamides, cephalosporins, and quinolones.

Conclusion: This study offers crucial insights into the microbial landscape of complicated acute appendicitis and emphasizes the prevalence of antimicrobial resistance. *Escherichia coli* dominated, and antibiotic sensitivity patterns underscored the need for cautious drug usage. These findings contribute to refining treatment protocols and highlight the urgency of ongoing surveillance to combat the rising challenges of antimicrobial resistance in complicated acute appendicitis.

Keywords: Complicated Appendicitis; *Escherichia coli*; Antimicrobial Resistance; Surgical Site Infections; Antibiotic Sensitivity

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Introduction

Acute appendicitis is the predominant abdominal surgical emergency in Acute Care Surgery and spans various specialties. Complications can lead to substantial morbidity and mortality [1]. Predominantly, complications arise due to delayed patients seeking medical attention, diagnostic delays by healthcare practitioners, and impediments to surgical access [2]. A comprehensive understanding of the primary pathogens is imperative for prescribing targeted antimicrobials, ultimately mitigating mortality rates, minimizing morbidity, and shortening hospital stays after appendectomy, irrespective of whether it is open or laparoscopic. Developing protocols that align with contemporary global antimicrobial stewardship practices is crucial for optimal treatment.

Clinical diagnosis of acute appendicitis remains challenging, often necessitating the synthesis of clinical, laboratory, and radiological findings. In certain instances, the diagnosis is definitively made intraoperatively. Enhancing the diagnostic workup involves incorporating clinical scoring systems that integrate physical examination findings with inflammatory markers. Despite the availability of several user-friendly scoring systems, none has achieved widespread acceptance [3-5].

Surgical removal, through either open or laparoscopic procedures, remains the cornerstone of treatment. Current evidence favors laparoscopic appendectomy, demonstrating superior outcomes, including a lower incidence of wound infections, reduced post-intervention morbidity, shorter

hospital stays, and improved quality of life scores, compared to open appendectomy [6,7]. However, in the last two decades, there has been a resurgence of interest in the nonoperative management of uncomplicated acute appendicitis [8,9] through antibiotic therapy. Therefore, insights from this study are pivotal for identifying the target pathogens for effective management.

In the initial management of patients with confirmed complicated acute appendicitis (either clinically or supported by imaging), resuscitation and empiric antimicrobial administration, aligned with surviving sepsis guidelines, precede surgical intervention. At Dr. George Mukhari Academic Hospital (DGMAH), amoxicillin/clavulanic acid (Amoxi/Clav) is the empirical antimicrobial of choice. However, there are instances of noted resistance in patients who do not respond clinically, despite adequate source control.

Bacteriological studies of acute appendicitis in Africa [10], particularly in South Africa, are limited. Earlier studies, both within and outside the continent, have predominantly reported polymicrobial infections, with *Escherichia coli* (*E. coli*) emerging as the most frequently isolated organism, exhibiting diverse resistance patterns across studies. Notably, data on the resistance patterns specific to DGMAH are scarce, and the choice of antibiotics relies on studies conducted in disparate geographical areas. This study aimed to bridge this gap by providing comprehensive insights into the bacteriology and antibacterial sensitivity of appendectomy specimens in adults with acute complicated appendicitis at DGMAH.

Subjects and Methods

Study design and setting

This retrospective cross-sectional quantitative review focused on adult patients (>18 years) diagnosed with complicated acute appendicitis who underwent operative procedures (open or laparoscopic) at Dr. George Mukhari Academic Hospital (DGMAH). The study period spanned from October 2021 to October 2022, covering a one-year period. This study was conducted under the Department of General Surgery at DGMAH, a facility with a total bed capacity of 1,650, inclusive of a dedicated Intensive Care Unit and functioning theaters. The patients were referred from feeder clinics around Ga–Rankuwa, Soshanguve, and affiliated referral hospitals (Brits District Hospital, Jubilee District Hospital, and Odi District Hospital).

Participants and materials

The study population consisted of the medical records of all patients (18 years and older) diagnosed with complicated acute appendicitis who underwent operative procedures at DGMAH from October 2021 to October 2022. A total of 102 patients were diagnosed with complicated acute appendicitis; 52 were included for analysis; however, 50 were excluded because the procedure was not performed (26), specimens were rejected by the lab (5), and there was no growth (19).

Inclusion criteria

- Adults (18 years and older).
- With a clinical diagnosis of complicated/perforated acute appendicitis which was confirmed by clinical, radiological, or intra-operative means.
- Underwent laparoscopic or open appendectomy.
- Intra-abdominal specimen collected and sent for MC&S.

Exclusion criteria

- Patients with incomplete information.
- Insufficient medical history.
- Incomplete operating notes.
- Lack of information on MC&S sample collection in patients' files.

Data collection

A self-developed data collection sheet encompassing patient demographic details, clinical presentations, diagnostic confirmation methods, time intervals to surgery, type of operative procedure, intraoperative findings, pathogen isolation, postoperative complications, relook procedures, and total hospital stay was utilized. Data were extracted from the theater book and patient files at the DGMAH. The laboratory reference number of the collected samples was verified using the National Health Laboratory Services (NHLS) database.

Data analysis

Statistical analysis was performed using Stata SE, release 18.0 and included descriptive statistics for demographic characteristics and presenting signs and symptoms. Categorical variables were expressed as frequency counts and percentages, while continuous variables (e.g., age, duration of illness) were presented as mean, standard deviation, median, interquartile range, minimum, and maximum values. Presenting signs and symptoms, including frequency distributions and summary statistics, were subjected to thorough descriptive analysis. Clinical details, such as the duration of illness and time interval to surgery, were analyzed using descriptive statistics, including mean, median, standard deviation, and interquartile range. Operative procedures, such as the type of procedure (laparoscopic or open), are presented with frequency distributions and percentages. Intraoperative findings were subjected to thorough analysis using appropriate statistical tests such as chi-square or t-tests. Analysis of microbiological data involved presenting the isolated pathogens with their corresponding frequencies and percentages. Antibiotic sensitivities of isolated pathogens and their response to antibiotics are presented as frequencies and percentages.

Results

A total of 102 patient files were initially reviewed, which met the inclusion criteria for Complicated Acute Appendicitis (CAA) over the study period. However, 50 files were excluded for various reasons, leaving 52 culture-positive CAA patients as the principal cohort for the analysis (Figure 1).

The majority of the participants were male (73.08%), as depicted in Figure 2. The median age at presentation was 33.5 (41.5-23) years, ranging from 18 to 72 years.

Vomiting was the most prevalent symptom (n=35), followed by Right Iliac Fossa (RIF) tenderness (n=30), RIF pain (n=27), and generalized abdominal pain (n=22). Obturator sign was the least frequently observed (n=1) (Figure 3).

Patients presented with a median duration of illness of 4 (6-3) days. The minimum and maximum illness durations were 1 and 21 days, respectively. Few patients presented within 24 h of symptom onset.

Diagnosis confirmation was primarily clinical (51.92%), followed

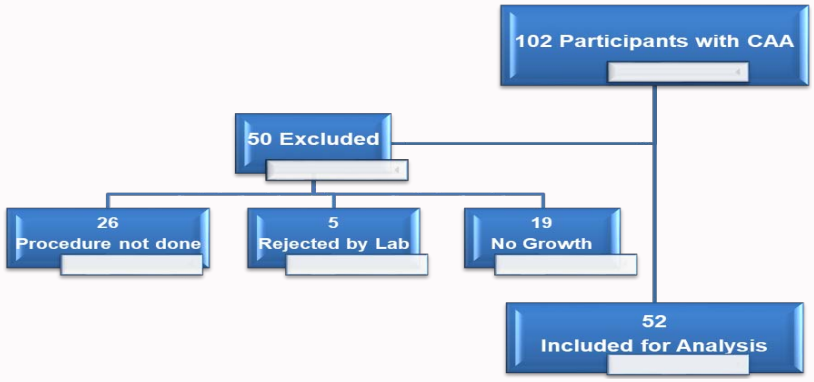

Figure 1: Breakdown of participants with CAA enrolled in the study.

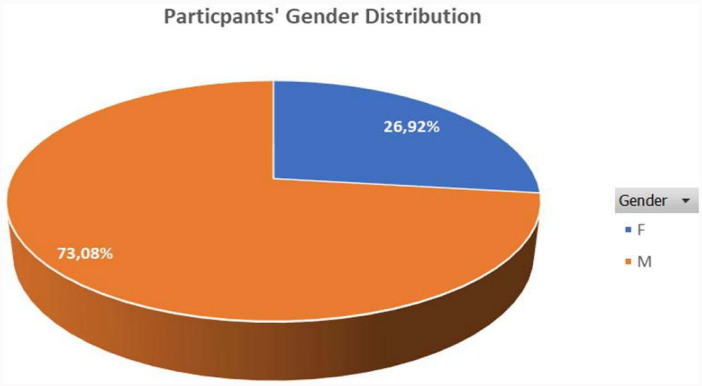

Figure 2: Distribution of participants by gender.

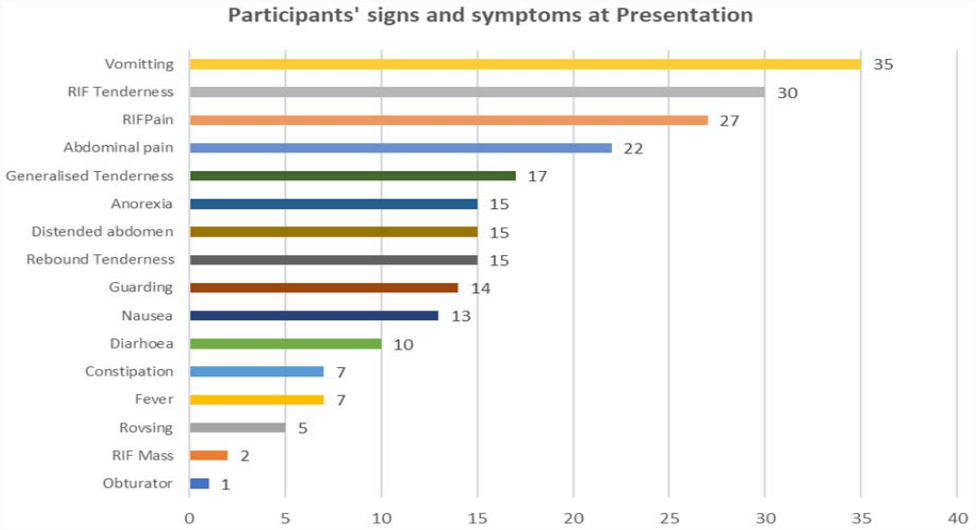

Figure 3: Signs and symptoms of participants at presentations.

by imaging (30.77%), with the least being confirmed intraoperatively (17.31%) (Figure 4). The most commonly used imaging modality was CT.

Laparoscopy was the most commonly performed procedure. Most patients who underwent laparotomy were offered laparoscopy as the first approach and then converted to laparotomy. A few patients underwent straight laparotomy due to the severity of their condition and inability to tolerate laparoscopy and the median duration to operation was 8.5 (22-5) hours (range: 2-72 hours). According to the Gomes et al. classification, most patients presented with grade 5 appendicitis, followed by Grade 4B. Grade 3A was the lowest grade observed, with no patients presenting with grades less than 3A (Figure 5).

The outcomes included a total relook rate of 19.2% and complication rate of 32.69%. Surgical site infection was the most common complication followed by abdominal collection.

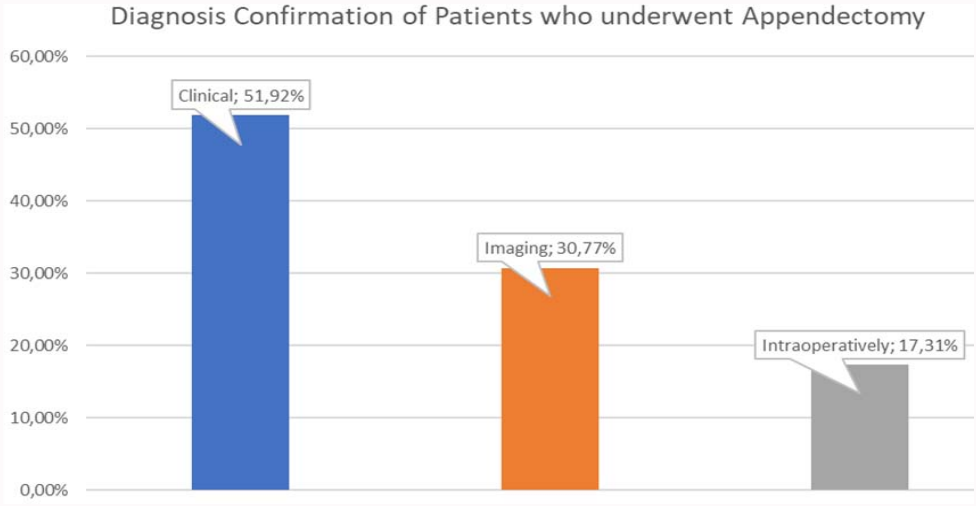

Figure 4: Diagnosis confirmation of patients who underwent appendectomy.

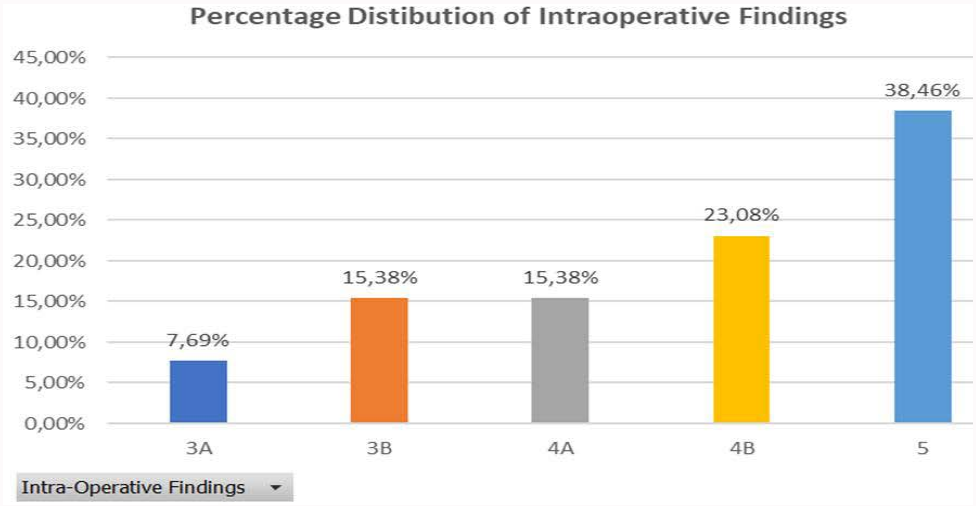

Figure 5: Intraoperative findings.

Complications were most frequent between days 3 and 10 post-procedure. The median length of hospital stay was 6 days (range: 10-35 days) (Table 1).

Escherichia coli was the most commonly isolated bacterium, followed by *Streptococcus* spp., *Klebsiella pneumoniae*, and *Pseudomonas aeruginosa*. Uncommon organisms include *Morganella morganii*, *Enterococcus species*, and Methicillin-resistant *Staphylococcus aureus*. Yeast and anaerobes were not isolated (Figure 6).

Amoxicillin/Clavulanic acid (Amoxi/Clav) demonstrated notable antimicrobial sensitivity, exhibiting complete sensitivity (100%) to *Klebsiella pneumoniae* (KLEPP) and 60% sensitivity to *Escherichia coli* (*E. coli*). Resistance to Amoxi/Clav was observed in 13.95% of *E. coli* strains, while complete resistance was noted in *Enterobacter cloacae* and *Morganella morganii* (MOGM). Ampicillin/amoxicillin (Ampi/Amoxi) displayed varying sensitivity to certain *E. coli* strains, but a majority exhibited high resistance levels, reaching up to 55%. However, Ampi/Amoxi demonstrated notable sensitivity in *Enterococcus faecalis*, *Pseudomonas aeruginosa* (PSEAE), and all *Streptococcus species*. Gentamicin displayed significant sensitivity across various organisms, including *E. coli* (97.6%), *E. cloacae* (100%), KLEPP (100%), PSEAE (100%), and Strep Group C (100%). Gentamicin resistance was minimal, observed in only 2.3% of *E. coli* specimens and 100% of MOGM specimens. Cefuroxime exhibited good sensitivity against *E. coli* (69.76%), *Proteus mirabilis* (100%), and partial sensitivity (50%) in KLEPP, with complete resistance in MOGM. Piperacillin/tazobactam demonstrated noteworthy sensitivity (83.3%) in resistant *E. coli* strains, including *E. cloaca* and PSEAE at 100%.

Carbapenems (Meropenem, Imipenem, and Ertapenem) displayed complete sensitivity (100%) against resistant *E. coli* strains, including *P. mirabilis*, *E. cloaca*, KLEPP, PSEAE, and Strep Group C, with the exception of imipenem, which exhibited resistance to

Table 1: Outcomes of patient's post-procedure.

Outcomes	n (%)
Relook	10 (19.20%)
SSI	11 (21.00%)
Abdominal Collections	6 (11.53%)
LOS, *Median Days (IQR)*	6 (10–35)

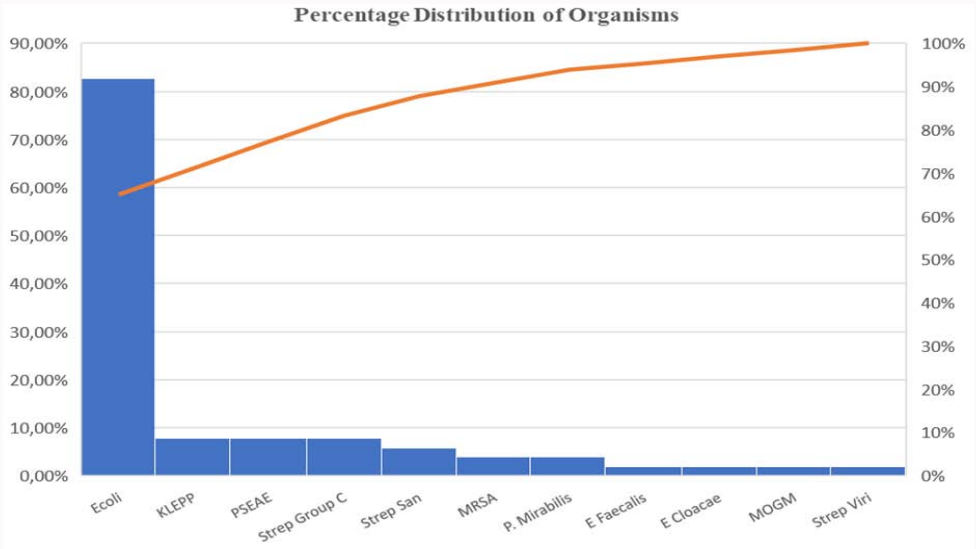

Figure 6: Percentage distribution of organisms.

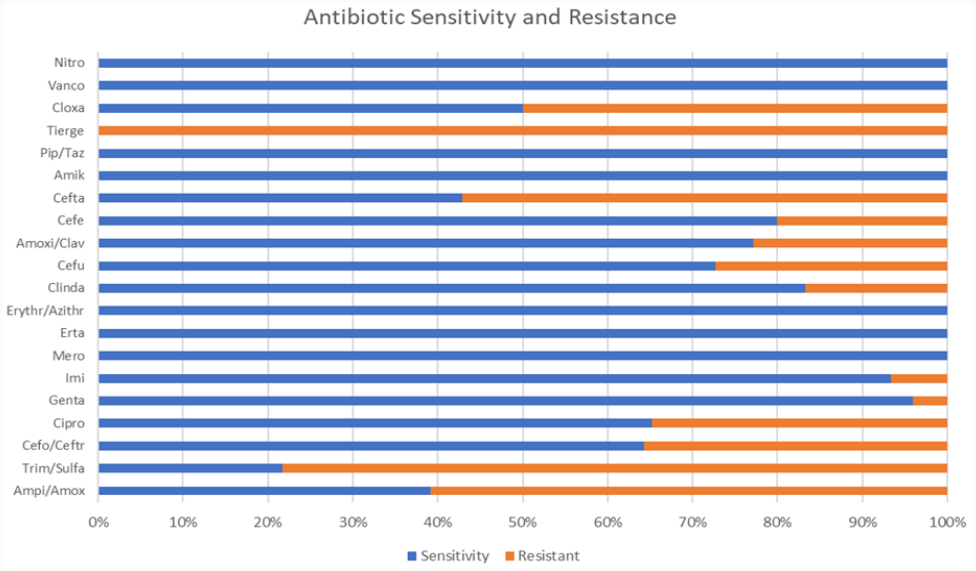

Figure 7: Antibiotic sensitivity and resistance.

MOGM. Amikacin exhibited complete sensitivity (100%) for MOGM and KLEPP. A multidrug-resistant specimen (*E. coli*, *P. mirabilis*, and PSEAE) displayed resistance to tigecycline. Certain antibacterial drugs showed minimal sensitivity and significant resistance, including penicillin's (Amox/Ampi), sulfonamides (Trimeth/Sulfa), cephalosporins (Cefo/Ceftri, Cefepime, Ceftaz), and quinolone (Cipro) (Figure 7).

Discussion

In this study, we scrutinized the microbiological profiles and antibiotic susceptibilities of pathogens isolated from patients with complicated acute appendicitis. Our analysis focused on 52 culture-positive complicated acute appendicitis specimens, revealing a positive culture rate of 52%, which is notably higher than that reported in many studies [13,16,17]. This elevated rate may be attributed to the substantial prevalence of complicated acute appendicitis cases in our cohort [12,13,17]. The sex distribution was skewed towards males, in contrast to previous African studies [10,11,14,15]. The median age at presentation was 33.5 years, indicating the occurrence of complicated acute appendicitis across a wide age range.

Escherichia coli emerged as the most frequently isolated bacteria, either independently or in conjunction with other pathogens, aligning with established trends in the appendicitis literature [10,12-14,16-18]. Notably, *E. coli* exhibits varying sensitivities to different antibiotics. For instance, it displayed high sensitivity to gentamicin (97%), moderate sensitivity to cefuroxime (69.76%), and low sensitivity to amoxicillin/clavulanic acid (60%). Third-generation cephalosporin ceftriaxone exhibited suboptimal sensitivity compared with its second-generation counterpart. Our findings caution against the empirical use of quinolones because of their diminished sensitivity in our study.

Gram-positive organisms, particularly *Streptococcus* and *Enterococcus* species, constitute the second most commonly isolated

group [13,17]. Piperacillin/tazobactam and ampicillin/amoxicillin demonstrated good sensitivity. *Pseudomonas aeruginosa* (PSEAE) is the predominant gram-negative organism, although its prevalence is lower than that reported in previous studies [13,14]. The surgical site infection rate in our study was 21%, underscoring the importance of appropriate antibiotic treatment despite the prevalent use of minimally invasive surgery.

While gentamicin exhibited significant sensitivity across various organisms, resistance was observed in 2.3% of *E. coli* specimens and 100% of *Morganella morganii* (MOGM) specimens. Notably, concerns persist regarding the nephrotoxicity and ototoxicity associated with aminoglycoside antibiotics. In our study, cefuroxime outperformed ceftriaxone, and certain antibacterial drugs, including penicillin's, sulfonamides, cephalosporins, cefepime, ceftazidime, and quinolones, showed minimal sensitivity and substantial resistance.

Patients who underwent appendectomy, whether laparoscopic or open, received antimicrobial therapy, emphasizing the importance of appropriate empirical therapy in complicated acute appendicitis [18]. In the face of escalating antimicrobial resistance, continuous collection of intra-abdominal specimens remains crucial. However, anaerobic cultures were not used in our study, necessitating further research to explore their potential roles.

Our study had some limitations, including its retrospective nature and relatively small sample size due to exclusion. Limited data were collected from a single institution, potentially impacting generalizability. External factors such as the COVID-19 pandemic altered the study's original prospective design.

Limitations

Inherent limitations include the retrospective design and the reduced sample size. However, this study remains broadly representative of appendectomy patients at our institution. Single-institution data collection may affect generalizability, but the broad catchment area of our hospital mitigates this concern. Unforeseen circumstances, notably the COVID-19 pandemic, have prompted a shift to a retrospective time horizon.

Recommendations

In light of the outcomes of our study, we propose several recommendations for optimizing clinical practice. First, the continuous collection of microbiological specimens is advocated to bolster ongoing surveillance efforts. Ensuring meticulous specimen labeling and accurate aspiration of pus for microscopy, culture, and sensitivity studies are imperative. Amoxicillin/clavulanic acid is a judicious empiric choice given its favorable sensitivity profile and minimal resistance. Consideration of the inclusion of gentamicin in high-risk groups with intact renal function is recommended. Timely and regular follow-up of microscopy, culture, and sensitivity results is essential to facilitate prompt treatment adjustments. Discouragement of sustained sensitivity testing for penicillin's and sulfonamides owing to the observed high resistance is recommended. The insights gained from this study can contribute to the formulation of an antibiogram, fostering effective antimicrobial stewardship practices within DGMAH and its affiliated institutions. Additionally, future research endeavors should focus on prospective, multicenter studies with larger sample sizes to inform comprehensive South African guidelines, comparative analyses of sensitivity patterns between initial appendicectomy and relooked patients, investigations into age-specific sensitivity and resistance patterns, exploration of factors influencing patient delays in appendicitis presentation, and strategies for timely intervention.

Conclusion

In conclusion, this study aimed to analyze the microbial pathogens and their antibiotic sensitivity patterns in cases of complicated acute appendicitis at Dr. George Mukhari Academic Hospital (DGMAH). This study successfully identified *Escherichia coli* as the predominant isolated organism in patients with complicated appendicitis, deviating from previous research findings that often-included anaerobic bacteria, such as *Bacteroides fragilis*. This study revealed the prevalence of antimicrobial resistance to commonly prescribed drugs. This underscores the critical need for heightened antimicrobial surveillance and implementation of cautious drug usage practices. The findings of this study provide valuable insights into the microbial landscape of complicated appendicitis, paving the way for enhanced treatment strategies, and emphasizing the urgency of ongoing surveillance efforts to combat the rising challenge of antimicrobial resistance. This study provides a foundation for future research endeavors aimed at refining treatment protocols and advancing our understanding of the microbial dynamics in complicated acute appendicitis.

Future Studies

Future research initiatives are encouraged to advance the understanding of complicated acute appendicitis and enhance clinical strategies. A prospective, multicenter study with an expanded sample size should be undertaken to inform the development of comprehensive South African guidelines, considering the diverse patient population. Further investigations comparing antimicrobial sensitivity and resistance patterns in both initial appendicectomy and relooked patients would provide valuable insights into the dynamics of treatment response over time. Exploring age-specific variations in sensitivity and resistance patterns is necessary to tailor therapeutic approaches to different demographic groups. Additionally, delving into the underlying reasons for patient delays in appendicitis presentation and formulating effective strategies to mitigate such delays would contribute to improving the overall patient outcomes and healthcare practices.

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