Research Article

Microbiological Profile and Antimicrobial Susceptibility of Perforation Peritonitis in a Tertiary Care Hospital

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Background: Perforation peritonitis is a life-threatening surgical emergency with reported mortality ranging from 17 to 63%. Empirical antibiotic selection remains challenging due to regional variation in microbial flora and emerging antimicrobial resistance. Institution-specific bacteriological data are essential for guiding rational therapy.

Objectives: To study the bacteriological profile and antibiotic sensitivity patterns of peritoneal fluid in patients with perforation peritonitis and to assess whether the anatomical site of perforation influences the bacterial spectrum.

Methods: An observational, cross-sectional, hospital-based study was conducted at a tertiary care teaching hospital in central India from 2024 to 2025. Ninety-six patients undergoing emergency laparotomy for perforation peritonitis were enrolled. Intraoperative peritoneal fluid was subjected to Gram stain, aerobic culture, and antibiotic susceptibility testing by the Kirby–Bauer disc diffusion method (CLSI guidelines).

Results: Male predominance was noted (80.2%). Mean age was 47.46 ± 15.16 years. Gastric (43.8%) and ileal (39.6%) perforations were most common. Culture positivity was 70.8%; *Escherichia coli* was the predominant isolate (34.4%), followed by *Klebsiella pneumoniae* (12.5%) and *Enterococcus* spp. (8.3%). Aminoglycosides (gentamicin 38.5%, tobramycin 35.4%, amikacin 32.3%) and carbapenems (meropenem 29.2%) showed the highest sensitivity. Resistance to third-generation cephalosporins and fluoroquinolones was high. Ileal perforations were significantly associated with bacterial growth and mortality ($p = 0.001$). Overall mortality was 15.6%.

Conclusion: *E. coli* remains the dominant organism in peritoneal infections. High resistance to conventional antibiotics necessitates empirical regimens incorporating aminoglycosides or carbapenems, guided by local antibiogram data. Ileal perforations carry the highest septic burden and mortality risk, warranting aggressive early intervention.

Access this article online

Website: www.cijmr.com

DOI: 10.58999/cijmr.v5i03.488

Keywords: Perforation peritonitis, Bacteriological profile, Antibiotic sensitivity, Peritoneal fluid culture, Antimicrobial resistance, Emergency laparotomy, Multidrug resistance

Introduction

Perforation peritonitis continues to be one of the most frequently encountered surgical emergencies worldwide. Secondary peritonitis, arising most commonly from perforation of a hollow viscus, constitutes the predominant form encountered in surgical practice. Whether originating from a gastric or duodenal ulcer, ileal perforation due to enteric fever or tuberculosis, appendicular perforation, or colonic disease, it carries substantial morbidity and mortality despite advances in surgical technique, critical care, and antimicrobial therapy [1]. Reported mortality rates range between 17 and 63%, reflecting the severity of this condition [2].

The pathophysiology involves contamination of the peritoneal cavity by gastrointestinal contents rich in microorganisms, triggering a cascade of inflammatory mediators leading to systemic inflammatory response syndrome (SIRS), septic shock, and multiorgan dysfunction.[3] These infections are typically polymicrobial, involving both aerobic and anaerobic organisms. Common isolates include *Escherichia coli, Klebsiella pneumoniae, Enterococcus* spp., *Pseudomonas aeruginosa*, and *Staphylococcus aureus*.[4,5]

In recent decades, the emergence of multidrug-resistant organisms (MDROs) has significantly complicated the empirical management of intra-abdominal infections. Resistance to third-generation cephalosporins and fluoroquinolone agents frequently used empirically is

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Submitted: 23/07/2026 Revision: 08/08/2026
Accepted: 25/08/2026 Published: 25/09/2026

How to cite this article: Jain S, Mukhiya SP, Dubey V. Microbiological Profile and Antimicrobial Susceptibility of Perforation Peritonitis in a Tertiary Care Hospital. Central India Journal of Medical Research. 2026; 5(3):110-115.

now widely reported, with carbapenem resistance also increasing among gram-negative bacilli [6,7]. In developing nations, these challenges are compounded by late clinical presentation, limited diagnostic infrastructure, and suboptimal antibiotic stewardship [8].

Because the microbial spectrum and resistance profile vary considerably by geographic region and institution, periodic institution-specific surveillance is essential to update empirical protocols. No universal antibiotic regimen can be applied across all centres. The present study was therefore undertaken to characterize the bacteriological profile and antibiotic sensitivity pattern of peritoneal fluid isolates in patients managed at a tertiary care centre in central India, and to evaluate the influence of anatomical perforation site on microbial yield and clinical outcomes.

Materials and Methods

Study Design and Setting

This was an observational, cross-sectional, hospital-based study conducted in the Department of General Surgery of a tertiary care teaching hospital in central India, from January 2024 to December 2025. Microbiological processing was performed at the hospital's Department of Microbiology. Institutional Ethics Committee approval was obtained, and all participants provided written informed consent in accordance with the Declaration of Helsinki.

Sample Size and Selection

Sample size was calculated using single-proportion estimation (prevalence 52%, precision 10%, $\alpha = 0.05$), yielding a minimum of 96 patients. All patients presenting with clinical and radiological evidence of perforation peritonitis (free gas under diaphragm on erect X-ray or CT) who underwent emergency laparotomy were enrolled. Exclusion criteria included primary bacterial peritonitis, peritonitis secondary to malignancy or cirrhotic ascites, patients refusing surgical intervention, and post-operative peritonitis unrelated to gastrointestinal perforation.

Surgical Procedure and Specimen Collection

Following standard resuscitation and broad-spectrum empirical antibiotic administration, patients underwent emergency exploratory laparotomy under general anaesthesia.

Exploratory laparotomy was performed under general anaesthesia through a midline abdominal incision after adequate resuscitation and administration of appropriate broad-spectrum antibiotics. On entering the peritoneal cavity, the nature and quantity of intraperitoneal contamination were assessed, followed by systematic exploration to identify the site of perforation. Peritoneal collections and contaminated fluid were evacuated; the site, size, and extent of peritoneal contamination were documented. Approximately 10 mL of peritoneal fluid was aspirated from the region adjacent to the perforation using a sterile syringe under aseptic precautions and transported immediately to the microbiology laboratory. Peritoneal lavage was performed with warm normal saline. The definitive procedure was tailored according to the site and pathology of perforation.

Gastric perforations were generally managed by primary closure with an omental patch, while ileal perforations were treated by primary repair or segmental resection with anastomosis depending on bowel viability and the extent of disease. In selected patients with severe contamination, multiple perforations, unhealthy bowel, haemodynamic instability or poor physiological status, damage-control surgery with resection of the diseased ileal segment and creation of a diverting ileostomy was performed, with restoration of bowel continuity planned after physiological recovery. Appendicular perforations were managed by appendicectomy with evacuation of contamination, whereas colonic perforations were treated by primary repair, resection with anastomosis, or resection with diversion according to the site, bowel viability and severity of contamination.

Microbiological Processing

Peritoneal fluid was subjected to direct gram staining, aerobic culture on standard media (blood agar, MacConkey agar), and antibiotic susceptibility testing by the Kirby–Bauer disc diffusion method, interpreted per Clinical and Laboratory Standards Institute (CLSI) guidelines. Results were categorised as sensitive (S), intermediate (I), or resistant (R). Antibiotic panels were tailored to organism class: a comprehensive beta-lactam, cephalosporin, carbapenem, aminoglycoside, fluoroquinolone, and reserve-drug panel for gram-negative bacilli (GNB), and a glycopeptide, oxazolidinone, and beta-lactam panel for gram-positive cocci (GPC).

Statistical Analysis

Data were entered in Microsoft Excel and analysed using SPSS software. Descriptive statistics (mean ± SD, frequency, percentage) were computed. The Chi-square test was used for categorical comparisons. Multiple logistic regression was applied to identify predictors of adverse outcomes. A *p-value* < 0.05 was considered statistically significant.

Results

Demographic Profile

A total of 96 patients were enrolled. Male patients predominated significantly (77/96; 80.2% *vs.* 19/96; 19.8%). The mean age was 47.46 ± 15.16 years (range: 11–82 years). The 41 to 50-year age group constituted the largest cohort (27 patients; 28.1%), followed by the 51 to 60-year group (21 patients; 21.9%), reflecting a predominantly middle-aged population (Table 1).

Site of Perforation

Gastric perforation was the most common site (42 patients; 43.8%), followed closely by ileal perforation (38 patients; 39.6%). Less frequent sites included appendicular (6; 6.3%), colonic (4; 4.2%), caecal (3; 3.1%), jejuno-ileal (2; 2.1%), and duodenal (1; 1.0%) perforations (Table 2).

Microbiological Profile

Bacterial growth was detected in 68 of 96 peritoneal fluid samples (70.8%), while 28 samples (29.2%) showed no growth. Among culture-positive isolates, Gram-negative organisms predominated. *E. coli* was the most common isolate (33; 34.4%), followed by *Klebsiella pneumoniae* (12; 12.5%), *Enterococcus* spp. (8; 8.3%), *Acinetobacter baumannii, Pseudomonas* spp., and *Staphylococcus aureus* (4 each; 4.2%), with rare isolates of *Enterobacter cloacae* complex, *Citrobacter freundii*, and *Morganella morganii* (1 each; 1.0%) (Table 3).

The association between site of perforation and bacterial growth was statistically significant ($p = 0.001$). Ileal perforations accounted for the highest proportion of culture-positive cases (48.5%), while gastric perforations showed the highest proportion of culture-negative results (82.1%), consistent with the comparatively lower bacterial load of the proximal gastrointestinal tract.

Antibiotic Sensitivity Pattern

Overall antibiotic sensitivity results are presented in Table 4. Aminoglycosides demonstrated the highest sensitivity: gentamicin (38.5%), tobramycin (35.4%), and amikacin (32.3%). Among carbapenems, meropenem showed sensitivity in 29.2% of cases, doripenem in 25.0%, imipenem in 21.9%, and ertapenem in 20.8%. Colistin retained sensitivity in 30.2%, and tigecycline in 19.8%, underscoring their roles as reserve agents.

Conventional first-line antibiotics performed poorly. Third-generation cephalosporins (ceftriaxone, cefotaxime) showed sensitivity in only 7.3% each. Fluoroquinolones were similarly ineffective (ciprofloxacin 7.3%; levofloxacin 9.4%). Beta-lactams including ampicillin and narrow-spectrum cephalosporins demonstrated minimal activity.

Antibiogram of Isolates

Among gram-positive isolates, *Enterococcus* spp. (n = 8) showed high sensitivity to gentamicin (87.5%) and complete sensitivity to vancomycin and linezolid (100%). *Staphylococcus aureus* (n = 4) was uniformly sensitive to linezolid, amikacin, tetracycline, doxycycline, and

Table 1: Demographic characteristics of study participants (n = 96)

Parameter	*Category/Value*	*Frequency (%)*
Sex	Male	77 (80.2%)
	Female	19 (19.8%)
Mean age (± SD)	47.46 ± 15.16 years	Range: 11–82 years
Peak age group	41–50 years	27 (28.1%)
Mean hospital stay (± SD)	9.22 ± 5.21 days	Range: 0–32 days
Mortality	15 deaths	15.6%

Table 2: Site of perforation and mortality outcome

Site of perforation	*Frequency*	*Percentage*	*Deaths (n)*	*Survivors (n)*
Gastric	42	43.8%	0	42
Ileal	38	39.6%	13	25
Appendicular	6	6.3%	0	6
Colonic	4	4.2%	2	2
Caecal	3	3.1%	0	3
Jejuno-ileal	2	2.1%	0	2
Duodenal	1	1.0%	0	1
Total	96	100%	15	81

Association between site of perforation and mortality: p = 0.001 (Chi-square test)

Table 3: Distribution of isolated organisms (n = 96)

No growth	28	29.2
Escherichia coli	33	34.4
Klebsiella pneumoniae	12	12.5
Enterococcus spp.	8	8.3
Acinetobacter baumannii	4	4.2
Pseudomonas spp.	4	4.2
Staphylococcus aureus	4	4.2
Enterobacter cloacae complex	1	1.0
Citrobacter freundii	1	1.0
Morganella morganii	1	1.0
Total	96	100.0

Table 4: Antibiotic sensitivity pattern in the study population (Selected Agents)

Antibiotic	*Sensitive (n)*	*Sensitivity (%)*
Gentamicin	37	38.5
Chloramphenicol	37	38.5
Tobramycin	34	35.4
Amikacin	31	32.3
Colistin	29	30.2
Meropenem	28	29.2
Doripenem	24	25.0
Imipenem	21	21.9
Tigecycline	19	19.8
Piperacillin-tazobactam	18	18.8
Linezolid	13	13.5
Levofloxacin	9	9.4
Ceftriaxone	7	7.3
Ciprofloxacin	7	7.3
Ampicillin	6	6.3

chloramphenicol (100%), with cefoxitin sensitivity suggesting predominantly methicillin-sensitive strains (MSSA). Both organisms demonstrated complete resistance to cephalosporins and carbapenems, consistent with their known intrinsic resistance profiles (Table 5).

Among gram-negative isolates, *E. coli* showed the highest sensitivity to chloramphenicol (63.6%) and gentamicin (54.5%), with moderate meropenem sensitivity (48.5%), suggesting emerging carbapenem resistance. *K. pneumoniae* demonstrated broadly similar patterns, with chloramphenicol (75%) and meropenem (41.7%) being relatively more active. *Acinetobacter baumannii* exhibited extensive drug resistance, with meaningful sensitivity limited to doxycycline (75%) and tigecycline (50%). *Pseudomonas* spp. retained sensitivity to meropenem (100%) and gentamicin (75%).

Discussion

Demographic profile

The strong male predominance in our cohort (80.2%) aligns with widely reported epidemiological patterns. Studies by Offobo *et al*. (69.5%)[9], Neupane *et al*.[10], and Kumar *et al*. (66%)[11] documented comparable male-to-female ratios, attributing this disparity to lifestyle-related risk factors including smoking, alcohol use, dietary habits, and the higher prevalence of peptic ulcer disease among males. The mean age of 47.46 years is consistent with the findings of Meshram *et al*. (41–60-year peak)[12] and Kumar *et al*.[11], reflecting that perforation peritonitis predominantly affects the economically productive middle-aged population in developing countries.

Site of perforation

Gastric (43.8%) and ileal (39.6%) perforations together accounted for over 83% of cases. This distribution differs from studies in which duodenal perforation predominated (Ranjan *et al*.: 58.2% [13]; Neupane *et al*.: 88.3% [10]), reflecting the higher prevalence of Helicobacter pylori–related peptic ulcer disease or NSAID use in those settings. Our findings more closely resemble those of Deolekar *et al*. [14] and Pimoli *et al*. [15], who observed ileal perforation as a major contributor, attributed to infectious etiologies such as enteric fever (*Salmonella typhi*) and intestinal tuberculosis — diseases endemic in this region. The higher proportion of gastric perforations in our series likely reflects local patterns of peptic ulcer disease and NSAID consumption.

Table 5: Antibiogram of major isolates (Selected Antibiotics)

Antibiotic	*E. coli (%)*	*K. pneumo. (%)*	*A. baumannii (%)*	*Pseudo. (%)*	*Entero-coccus (%)*	*S. aureus (%)*
Meropenem	48.5	41.7	25	100	0	0
Gentamicin	54.5	33.3	25	75	87.5	75
Chloramphenicol	63.6	75	25	0	0	100
Colistin	—	—	—	—	0	0
Tigecycline	33.3	25	50	0	12.5	0
Doxycycline	30.3	8.3	75	0	0	100
Linezolid	3	0	0	0	100	100
Vancomycin	3	0	0	0	100	—
Ceftriaxone	0	0	0	0	0	0
Ciprofloxacin	0	0	0	0	0	25
Ampicillin	0	0	0	0	50	50

— = not tested/not applicable.

Microbiological profile

Culture positivity was 70.8%, with *E. coli* emerging as the dominant isolate (34.4%). This is consistent with the established understanding of enteric Gram-negative organisms as the principal pathogens in secondary peritonitis. Bharathi *et al*. similarly reported *E. coli* in 53.4% of isolates [16]; Bazhar *et al*. documented *E. coli* in 44%,[17] and a 2025 Chinese multicentre study described Gram-negative bacteria in 72% of isolates, primarily *E. coli*, *Pseudomonas*, and *Klebsiella* [18]. The 29.2% culture-negative rate in our series likely reflects prior empirical antibiotic administration before specimen collection, a limitation common to intraoperative studies. The absence of routine anaerobic culture may also underestimate the true polymicrobial burden.

The significant association between site of perforation and culture positivity (p = 0.001) supports the well-established gradient of microbial density along the gastrointestinal tract. The proximal stomach harbours relatively sparse flora under normal pH, explaining the higher culture-negative rate (82.1%) in gastric perforations. Conversely, the distal ileum — with its dense gram-negative and anaerobic populations generated positive cultures in 87.9% of ileal perforation cases.

Antibiotic Sensitivity and Resistance

The high resistance to third-generation cephalosporins (ceftriaxone, cefotaxime: 7.3% each) and fluoroquinolones (ciprofloxacin 7.3%; levofloxacin 9.4%) is a major concern, limiting the utility of these widely used empirical agents. This trend is increasingly reported globally and in India. Bazhar *et al*. documented rising *E. coli* resistance to ampicillin and amoxicillin–clavulanate[17]; Pimoli *et al*. reported reduced cephalosporin sensitivity[15]; and Deolekar *et al*. specifically noted high ESBL prevalence among *E. coli* and *K. pneumoniae* isolates.[14]

Aminoglycosides (gentamicin 38.5%, amikacin 32.3%) retained comparatively better activity, consistent with the observations of Singh *et al*.[19] and Bharathi *et al*.[16] Meropenem sensitivity was 48.5% for *E. coli* and 41.7% for *K. pneumoniae*, which, while significantly lower than historical rates, still confirms the role of carbapenems in managing severe intra-abdominal infections. However, the reduced sensitivity compared with earlier publications signals an emerging and concerning trend toward carbapenem resistance, also reported by Kumar *et al*. [11].

Acinetobacter baumannii exhibited near-pan-drug resistance, with meaningful sensitivity limited to doxycycline (75%) and tigecycline (50%), consistent with global ESKAPE pathogen data. Pseudomonas spp. retained better susceptibility to meropenem (100%) and gentamicin (75%), highlighting the importance of anti-pseudomonal coverage in patients with risk factors such as immunosuppression or prolonged hospitalisation.

For gram-positive organisms, linezolid demonstrated uniform sensitivity (100% in both *Enterococcus* spp. and *Staphylococcus aureus*), reaffirming its role as a reliable empirical choice for gram-positive intra-abdominal infections. Vancomycin retained excellent activity against *Enterococcus* (100%), although it was not tested against *Staphylococcus aureus* in this study. The predominantly MSSA profile of *S. aureus* (evidenced by cefoxitin sensitivity 75%) suggests that oxacillin-based regimens may still be considered, though resistance profiling should be confirmed before their use.

Mortality and Clinical Implications

Overall mortality was 15.6%, falling within the 17 to 63% range reported in the literature. Critically, 86.7% of deaths occurred in patients with ileal perforations (p = 0.001), attributable to severe faecal peritoneal contamination, higher organism virulence, delayed presentation, and rapid progression to septic shock and multiorgan dysfunction. This finding is corroborated by Garg *et al*., who identified delayed presentation and preoperative hypotension as key mortality predictors [20], and by Chahal *et al*. (11.4% mortality, predominantly in ileal perforation) [1].

These data carry direct clinical implications: (1) empirical antibiotic regimens should provide adequate Gram-negative coverage and should not rely solely on cephalosporins or fluoroquinolones; (2) aminoglycosides combined with a carbapenem or piperacillin–tazobactam represent more rational empirical choices in this institution; (3) patients with ileal perforation warrant aggressive resuscitation, early theatre access, and close ICU-level postoperative monitoring; and (4) intraoperative peritoneal fluid culture is mandatory and antibiotic therapy should be de-escalated or adjusted within 48 to 72 hours according to culture and sensitivity results.

Limitations

This study has several limitations. It was conducted at a single tertiary care centre, which may limit generalisability. The sample size of 96 patients constrained subgroup analyses, particularly for rare perforation sites and organisms. Only aerobic cultures were performed; the absence of routine anaerobic culture likely underestimates the true polymicrobial burden. A significant proportion

of culture-negative results may reflect prior empirical antibiotic exposure before specimen collection. Long-term follow-up data, severity scoring, and nutritional status were not systematically captured. Future studies should employ larger multicentre designs incorporating anaerobic culture, molecular resistance profiling, and comprehensive prognostic assessment.

Conclusion

Perforation peritonitis remains a serious surgical emergency predominantly affecting middle-aged males. Gastric and ileal perforations are the dominant etiological sites in this central Indian cohort. *Escherichia coli* is the principal pathogen, followed by *Klebsiella pneumoniae* and *Enterococcus* spp. Conventional empirical antibiotics — third-generation cephalosporins and fluoroquinolones — are no longer reliable, with resistance rates exceeding 90%. Aminoglycosides and carbapenems retain comparatively higher efficacy and should anchor empirical regimens, while linezolid and vancomycin are the agents of choice for gram-positive infections. Ileal perforations carry significantly higher bacterial load, septic burden, and mortality, mandating aggressive early intervention. Routine intraoperative culture with antibiotic stewardship guided by local antibiogram data is essential to optimise outcomes and curtail the emergence of multidrug-resistant organisms.

Ethical Approval

Obtained from the Institutional Ethics Committee of the study institution. All procedures comply with the Declaration of Helsinki.

Informed Consent

Written informed consent was obtained from all participants or their legal guardians.

Conflict of Interest

The authors declare no conflicts of interest.

Funding

This study received no external funding.

Data Availability

Data are available from the corresponding author on reasonable request.

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