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Research Article

Microbial Spectrum and Resistance Patterns in Peritoneal Fluid of Patients with Hollow Viscus Perforation

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ABSTRACT

Background: Hollow viscus perforation leading to secondary peritonitis is a common abdominal emergency in low- and middle-income countries. The outcome relies heavily on timely surgery and appropriate early antibiotic treatment. However, standard antibiotic regimens may not reflect the local microbial flora and resistance patterns.

Objectives: This study aims to describe the microbial spectrum found in the peritoneal fluid of patients with hollow viscus perforation. It will also analyze the sensitivity and resistance patterns of the bacteria, focusing on the antibiotics commonly used.

Methods: This prospective observational study took place in the Department of General Surgery at Raichur Institute of Medical Sciences (RIMS), Raichur, Karnataka, India, from September 2022 to February 2024. Fifty adults who underwent emergency surgery for hollow viscus perforation were included. Peritoneal fluid was collected during surgery and processed using standard culture methods and automated identification with VITEK-2. Sensitivity to commonly used antibiotics was recorded. Data were analyzed with descriptive statistics and suitable inferential tests.

Results: Most participants were between 21 and 40 years old (43%), and 76% of the cohort were females. Duodenal perforation was the most common site (52%), followed by gastric perforation (28%) and ileal perforation (14%). The overall culture yield was modest; 54% of peritoneal samples showed "no growth." Among the positive cultures, Escherichia coli (20%) was the most prevalent, followed by Klebsiella spp. (14%), Klebsiella pneumoniae (8%), Acinetobacter spp. (2%), and Staphylococcus aureus (2%). Doripenem had the highest sensitivity (46%) among the tested antibiotics, while significant resistance was noted to Tigecycline (40%) and Colistin (42%). Ciprofloxacin (40% sensitive) and Gentamicin (38% sensitive) remained relatively effective. A considerable number of isolates deemed "sensitive" showed intermediate or resistant patterns in culture testing, especially for Piperacillin-Tazobactam and Ticarcillin-Clavulanic acid.

Conclusions: The microbial spectrum of secondary peritonitis following hollow viscus perforation in this setting is mainly influenced by Enterobacteriaceae, particularly E. coli and Klebsiella spp., alongside a high rate of culture-negative samples. Resistance to several broad-spectrum antibiotics, including Tigecycline and Colistin, is concerning. Routine culture of peritoneal fluid and regular review of local antibiograms are crucial for improving empirical antibiotic guidelines and slowing the advancement of antimicrobial resistance.

Keywords: hollow viscus perforation, peritoneal fluid culture, secondary peritonitis, antimicrobial resistance, Enterobacteriaceae, doripenem

INTRODUCTION

Perforation of a hollow viscus that leads to peritonitis is a serious surgical emergency around the world. When gastrointestinal contents leak into the peritoneal cavity, it causes severe inflammation, sepsis, and, if not treated, multiple organ failure. Despite better care before and after surgery, this condition still results in high rates of illness and death, especially in places with limited resources where patients often arrive late and access to intensive care is restricted [1-3].

The causes of this condition vary by region. In many studies from India, duodenal or gastric perforation due to peptic ulcers is the leading cause, followed by ileal perforation from enteric fever or tuberculosis [4-6]. In other areas, conditions like diverticular disease, cancer, and injuries from medical procedures may play a larger role [7]. These variations suggest that the types and amounts of microbes in the peritoneal cavity also differ by location.

Managing hollow viscus perforation relies on two key factors: urgent surgical intervention to control the source and the right antibiotic treatment. Since culture and sensitivity results are not available right away, doctors usually start with broad-spectrum antibiotics. However, rising resistance to antibiotics is diminishing the effectiveness of these standard treatments. The overuse and misuse of extended-spectrum cephalosporins and carbapenems have been linked to the rise of multidrug-resistant Gram-negative bacteria [8-10].

Several studies have highlighted the value of peritoneal fluid cultures in customizing antibiotic therapy for secondary peritonitis [11-13]. Common bacteria found include E. coli, Klebsiella spp., Pseudomonas aeruginosa, Enterococcus spp., and anaerobes like Bacteroides fragilis [14,15]. Local resistance patterns often differ significantly from global guidelines, emphasizing the need for specific monitoring in different regions.

In this context, the current study was conducted at a tertiary-care teaching hospital in South India. It aims to identify the types of microbes present in the peritoneal fluid of patients with hollow viscus perforation and to outline the resistance patterns of these strains, especially concerning commonly used antibiotics. The goal is to provide data that can shape local antibiotic policies and promote responsible use of antimicrobial agents.

MATERIALS AND METHODS

Study design and setting

This was a hospital-based prospective observational study conducted in the Department of General Surgery at Raichur Institute of Medical Sciences (RIMS), Raichur, Karnataka, India. The study lasted for 18 months, from September 2022 to February 2024.

Study population

All consecutive adult patients (age 18 years and older) who came to the emergency surgical services with symptoms suggestive of hollow viscus perforation, such as acute abdominal pain, guarding, rigidity, fever, and radiological evidence of pneumoperitoneum or free intraperitoneal fluid, and who underwent emergency laparotomy were included.

Inclusion criteria

1. Age 18 years and older
2. Intra-operative confirmation of hollow viscus perforation
3. Stable enough to undergo surgery
4. Provision of informed written consent by the patient or an attendant

Exclusion criteria

1. Age under 18 years
2. Primary peritonitis (such as spontaneous bacterial peritonitis)
3. Peritonitis caused by penetrating abdominal trauma
4. Patients previously treated elsewhere with documented culture-directed antibiotic therapy and discharged, now presenting as re-admissions
5. Patients deemed unfit for surgery due to severe shock or other health conditions

Sample size

A total of 50 eligible patients who met the inclusion criteria during the study period were enrolled.

Clinical evaluation and peri-operative management

All patients underwent a detailed history and physical examination upon admission. Baseline investigations included complete blood counts, renal function tests, random blood glucose, and relevant imaging, such as erect X-ray of the abdomen and contrast-enhanced CT in selected cases. Standard resuscitative measures, including fluid resuscitation, nasogastric decompression, urinary catheterization, and pain relief, were implemented. Empirical broad-spectrum antibiotic therapy with Piperacillin-Tazobactam 4.5 g IV every 8 hours was started before surgery, following institutional protocol.

All patients underwent emergency laparotomy through a midline incision. The site and cause of perforation, degree of contamination, and any related pathology were noted. Appropriate surgical procedures, such as omental patch repair, segmental resection and anastomosis, or exteriorization, were performed based on intra-operative findings.

Peritoneal fluid sampling and microbiological processing

Immediately after entering the peritoneal cavity and before suction or lavage, approximately 5-10 mL of peritoneal fluid was taken from the area of highest contamination using a sterile syringe. The sample was sent to the microbiology lab within 30 minutes. If there was any expected delay, the sample was refrigerated for no more than two hours.

Cultures were performed using standard methods on blood agar, MacConkey agar, brain heart infusion agar, and thioglycollate broth. Plates were incubated aerobically and anaerobically as needed. Organisms were identified and tested for antibiotic susceptibility using the automated VITEK-2 system according to CLSI guidelines.

Antibiotics tested included Ticarcillin-Clavulanic acid, Piperacillin-Tazobactam, Ceftazidime, .
Cefoperazone-Sulbactam, Cefepime, Doripenem, Imipenem, Meropenem, Ciprofloxacin, Gentamicin, Amikacin, Tigecycline, Colistin, Vancomycin, Clindamycin, Minocycline, and Oxacillin. Results were categorized as sensitive (S), intermediate (I), or resistant (R).

Outcome measures

The primary outcome measures were:

• Distribution of organisms isolated from peritoneal fluid

• Sensitivity and resistance patterns of isolates to the panel of antibiotics

Secondary outcomes included the correlation between empirical and culture-based sensitivity and descriptive post-operative outcomes, such as complications, length of stay, and mortality.

Statistical analysis

Data were entered into an electronic spreadsheet and analyzed using standard statistical software (SPSS). Categorical variables were expressed as frequencies and percentages. Proportions were compared using the Chi-square or Fisher's exact test as appropriate. A p-value less than 0.05 was considered statistically significant.

RESULTS

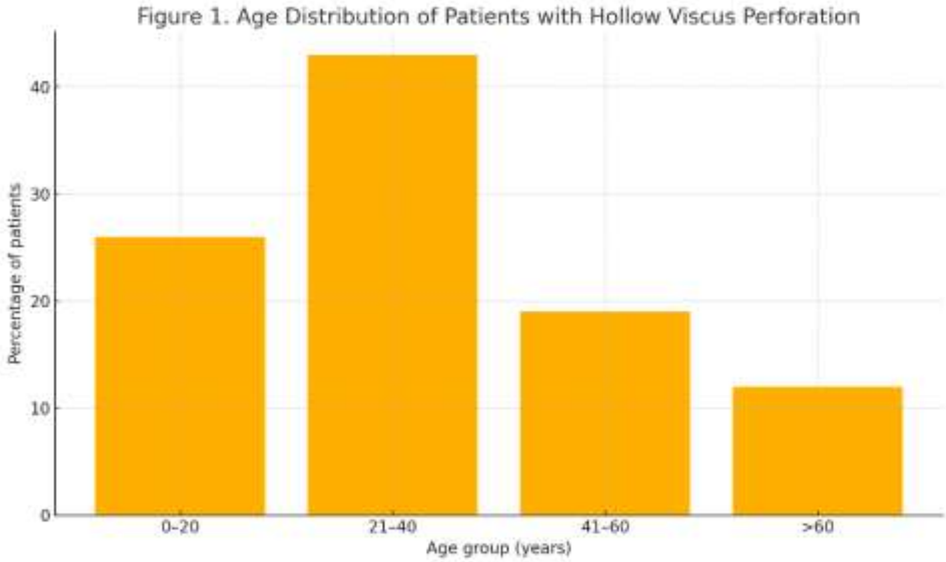
Demographic profile

The study enrolled 50 patients with hollow viscus perforation. The mean age was in the early fourth decade, with a wide range from young adults to elderly. The largest age group was 21–40 years (43%), followed by 0–20 years (26%), 41–60 years (19%) and >60 years (12%)

Table 1. Age distribution of study participants (n = 50)

Age group (years)	Frequency	Percentage (%)
0–20	13	26.0
21–40	22	43.0
41–60	9	19.0
>60	6	12.0
Total	50	100.0

Figure 1. Age distribution of patients with hollow viscus perforation



Females represented a larger proportion of the sample (38; 76%) compared to males (12; 24%), yielding a male-to-female ratio of approximately 1:3 .

Table 2. Sex distribution of study participants (n = 50)

Sex	Frequency	Percentage (%)
Male	12	24.0
Female	38	76.0
Total	50	100.0

Anatomical site and type of perforation

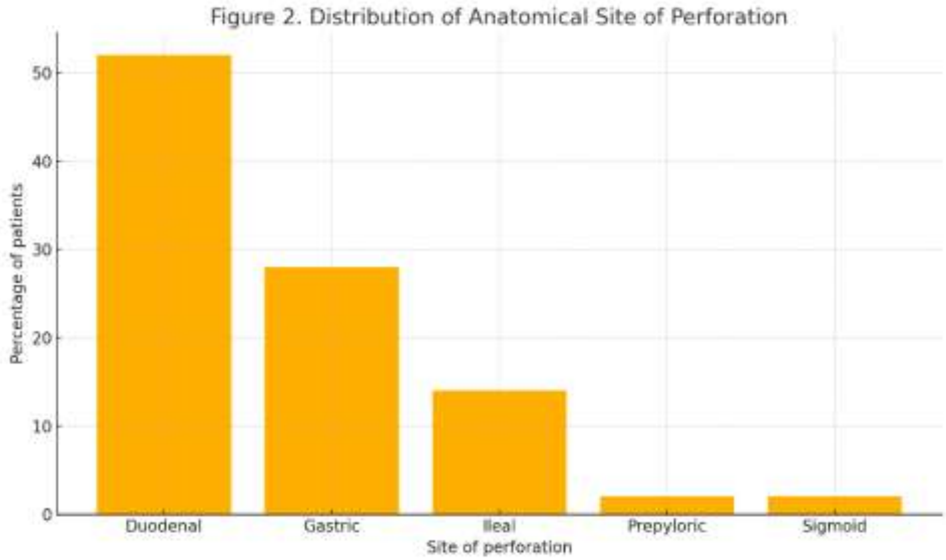
Duodenal ulcer perforation constituted the most frequent diagnosis, seen in over half of the patients (52%). Gastric perforations accounted for 28%, while ileal perforations contributed 14%. Less common sites included pre-pyloric gastric and sigmoid colon perforations (2% each) .

Table 3. Distribution of hollow viscus perforation by diagnosis (n = 50)

Diagnosis	Frequency	Percentage (%)
Duodenal perforation	26	52.0
Gastric perforation	14	28.0
Ileal perforation	7	14.0
Pre-pyloric gastric perforation	1	2.0

Sigmoid colon perforation	**1**	**2.0**
Total	**50**	**100.0**

Figure 2. Distribution of anatomical site of perforation



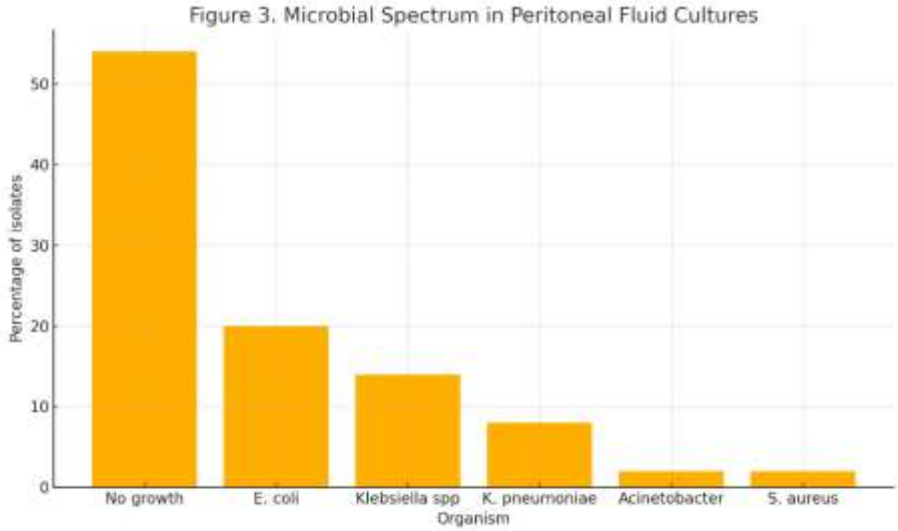
Microbial spectrum in peritoneal fluid

Out of 50 peritoneal fluid samples, 27 (54%) showed no bacterial growth, while 23 (46%) were culture-positive. Among positive cultures, *E. coli* was the most prevalent organism (20% of all samples), followed by *Klebsiella* spp. (14%), *K. pneumoniae* (8%), *Acinetobacter* spp. (2%) and *S. aureus* (2%) .

Table 4. Bacterial profile of peritoneal fluid cultures (n = 50)

Organism	Frequency	Percentage (%)
No growth	**27**	**54.0**
Escherichia coli	**10**	**20.0**
***Klebsiella* spp.**	**7**	**14.0**
Klebsiella pneumoniae	**4**	**8.0**
***Acinetobacter* spp.**	**1**	**2.0**
Staphylococcus aureus	**1**	**2.0**
Total	**50**	**100.0**

Figure 3. Microbial spectrum in peritoneal fluid cultures



The predominance of Enterobacteriaceae, particularly *E. coli* and *Klebsiella* species, is consistent with their role as common gut commensals and frequent culprits in secondary peritonitis.

Antibiotic sensitivity and resistance patterns

The detailed antibiotic sensitivity and resistance profiles, summarised from Table 6 of the thesis, are presented in Table 5 .

Table 5. Antibiotic sensitivity and resistance patterns in bacterial isolates (n = 50)

Antibiotic	Intermediate n (%)	Resistant n (%)	Sensitive n (%)
Ticarcillin–Clavulanic acid	**21 (42.0)**	**15 (30.0)**	**14 (28.0)**
Piperacillin–Tazobactam	**20 (40.0)**	**17 (34.0)**	**13 (26.0)**
Ceftazidime	**17 (34.0)**	**14 (28.0)**	**19 (38.0)**
Cefoperazone–Sulbactam	**18 (36.0)**	**16 (32.0)**	**16 (32.0)**
Cefepime	**18 (36.0)**	**14 (28.0)**	**18 (36.0)**
Doripenem	**16 (32.0)**	**11 (22.0)**	**23 (46.0)**
Imipenem * *(partially shown)*	**16 (32.0)**	**20 (40.0)**	**14 (28.0)**
Tigecycline*	–	**20 (40.0)**	–
Colistin*	–	**21 (42.0)**	–
Ciprofloxacin*	–	–	**20 (40.0)**

Gentamicin*	–	–	**19 (38.0)**

*Percentages for Tigecycline, Colistin, Ciprofloxacin and Gentamicin derived from summary data .

Doripenem showed the best overall activity with 46% of isolates being sensitive, whereas Ticarcillin–Clavulanic acid and Piperacillin–Tazobactam had relatively low sensitive fractions and high intermediate categories. Alarmingly, 40% and 42% of isolates were resistant to Tigecycline and Colistin, respectively. Fluoroquinolone (Ciprofloxacin) and aminoglycoside (Gentamicin) retained moderate activity.

Concordance between empirical and culture-based sensitivity

Although all patients initially received Piperacillin–Tazobactam empirically, culture results revealed a sizeable mismatch between assumed empirical sensitivity and actual susceptibility. Among isolates initially considered sensitive to Piperacillin–Tazobactam, 26.5% were intermediate and 8.2% were resistant on culture testing . Similar discrepancies were observed for several other antibiotics.

Advanced analyses in the thesis (one-sample proportion tests, logistic regression, McNemar's test) suggested that multiple agents, including Ticarcillin–Clavulanic acid, Piperacillin–Tazobactam, Ceftazidime, Cefepime, Imipenem, Tigecycline and Clindamycin, achieved sensitivity rates significantly lower than hypothesised optimal values, pointing to a gap between empirical expectations and reality .

DISCUSSION

The present prospective study provides comprehensive information on the microbial spectrum and resistance patterns of the peritoneal fluid among patients with hollow viscus perforation at a tertiary centre in South India. Several key findings corroborate as well as diverge from previous literature.

Demographic and etiological profile

This predominance of patients in the 21–40-year age group is in conformity with the reports of Indian studies, which state that the majority of emergency surgical admissions comprise young and middle-aged adults [4,5,16]. While most published series report male predominance in cases of perforative peritonitis [4,6,17], the present series found a predominance of female patients as high as 76%. Variations might be due to referral bias, different health-seeking behaviour, or random variation related to the small sample size.

Duodenal perforation was the most frequent cause of peritonitis (52%), followed by gastric and ileal perforations. Several studies from India and other developing countries also report gastroduodenal perforation as the leading etiology, though absolute proportions vary [4,6,18–20]. For instance, Singh et al. noted gastroduodenal perforations in about 61% of their surgical peritonitis cohort, closely followed by ileal perforations [18]. Das et al. reported duodenal perforation as the predominant site in 60% of patients [19]. This consistency underscores the continuing burden of peptic ulcer disease, NSAID use, and helicobacter-associated pathology in the region [3,19].

Microbial spectrum

More than half of peritoneal fluid samples (54%) did not yield growth in culture despite overt peritoneal contamination noted at surgery. Such high proportions of culture-negative peritonitis have been reported elsewhere and are often attributed to prior antibiotic administration, challenging conditions during sampling, fastidious organisms and laboratory limitations [11,13,21]. In this institution, a majority of the patients had already received some form of broad-spectrum antibiotics before their specimens arrived at the microbiology laboratory; thus, this could have lowered the culture yield.

Among positive cultures in the current study, E. coli and Klebsiella spp. combined accounted for the majority of isolates, consistent with numerous series where Enterobacteriaceae dominate the peritoneal flora in secondary peritonitis [14,15,18–20]. Das et al. and Singh et al. each reported E. coli as the most common isolate, followed by species of Klebsiella, with overall trends similar to the current study [18,19]. Less common pathogens such as Acinetobacter and S.

aureus were also encountered in this cohort, reflecting their emerging role in nosocomial and healthcare-associated infections.

The predominance of Gram-negative bacilli has important therapeutic implications, since these organisms often harbour ESBLs and other resistance mechanisms that limit the utility of conventional cephalosporins and penicillins.

Resistance patterns and comparison with other studies

The overall picture of the antimicrobial susceptibility profile is complex. Doripenem showed the highest sensitivity at 46%, indicating that carbapenems retain significant yet incomplete activity against local Enterobacteriaceae. Similar high sensitivity to carbapenems has been reported by Brook et al. in intra-abdominal infections, although there is increasing concern globally about rising resistance to them [14,22]. Singh et al. and others also reported good susceptibility of E. coli isolates to Imipenem and Meropenem, often in areas with increasing ESBL prevalence [18,23].

In contrast, notable resistance to Tigecycline (40%) and Colistin (42%) in our isolates are striking. These agents often represent last-resort drugs for multidrug-resistant Gram-negative infection. Reports of resistance to Tigecycline and Colistin in intra-abdominal sepsis have been increasing, particularly from centres with heavy usage, raising alarms for antimicrobial stewardship [10,24].

Against Enterobacteriaceae, ciprofloxacin was 40% sensitive and gentamicin 38% sensitive, retaining moderate efficacy. Several Indian studies have reported a declining yet sometimes acceptable sensitivity of Enterobacteriaceae against fluoroquinolones and aminoglycosides [18,20,23]. Variability makes it imperative that each hospital monitors its own susceptibility profile rather than extrapolating from other regions.

A particularly important observation was the discrepancy between empirical and culture-based sensitivity. Piperacillin–Tazobactam, used as the standard empirical agent at this centre, showed relatively modest sensitivity (26%), with many isolates showing intermediate or resistant patterns on culture testing. Analytical models in the thesis such as proportion tests and logistic regression further demonstrated that several widely used antibiotics—including Piperacillin–Tazobactam, Ticarcillin–Clavulanic acid, Ceftazidime and Cefepime—performed below hypothesised sensitivity benchmarks [13]. Similar mismatches between empirical choices and actual susceptibility have been reported in international guidelines for complicated intra-abdominal infections [11,12].

Taken together, these findings highlight the risks of relying on empirical regimens based on outdated data without periodic reevaluation. If empirical therapy is repeatedly discordant with local resistance patterns, patients will be at risk of prolonged sepsis, increased incidence of organ failure, extended hospital stay and increased mortality [9,11,22].

Clinical and policy implications

From a clinical standpoint, several practical considerations are suggested by the results of this study:

1. Culture-directed therapy is essential.

Although not perfect, peritoneal fluid cultures provide invaluable guidance regarding how to tailor antibiotics beyond the initial empirical phase. Even with a moderate culture yield, identification of resistant organisms may trigger important escalations or de-escalations.

2. Empirical protocols need to be updated.

The relatively low susceptibility to Piperacillin–Tazobactam noted locally suggests that empirical regimens may need revision. A combination approach which includes a carbapenem or an aminoglycoside may be justified in patients with high risk of multidrug-resistant infections, balancing efficacy with stewardship principles [11,22].

3. Antimicrobial stewardship

High resistance to last-line drugs, such as Tigecycline and Colistin, indicates potential overuse or misuse. Therefore, institutional antimicrobial stewardship programmes-including restriction policies, audit-and-feedback systems, and prescriber education-are vital for the resistance trends to be slowed down [8–10,24].

4. Public health and surveillance

Local antibiograms should be prepared at least annually for major infection syndromes such as secondary peritonitis. Linking these data into regional or national surveillance networks could facilitate wider policy decision-making and guideline development. Strengths and limitations Strengths of the study include its prospective design, uniform sampling protocol, and use of automated VITEK-2 for the identification of organisms and sensitivity testing. The main focus on concordance between empirical therapy and culture-based sensitivity provides clinically relevant information. However, several limitations need to be recognised: the sample size of 50 patients is modest, which may limit generalisability and statistical power; the study was conducted at a single institution, and patterns may differ across regions or levels of healthcare. Further, anaerobic cultures and fungal isolates (other than Candida) were not comprehensively quantified in some of these studies, which may underestimate their contribution in secondary peritonitis. Finally, the study did not include detailed clinical outcome modelling-such as survival analysis-to rigorously link microbial patterns with morbidity and mortality.

CONCLUSION

This prospective series of hollow viscus perforation demonstrated that most of the peritoneal fluid cultures were either negative or yielded Enterobacteriaceae, mainly represented by E. coli and Klebsiella species. Doripenem had the highest sensitivity in the antibiotics tested above, and there was a worrying level of resistance to Tigecycline and Colistin. Empirical Piperacillin–Tazobactam did not adequately match culture sensitivity patterns consistently, showing a mismatch between standard empirical therapy and local resistance trends.

These findings highlight the importance of routine peritoneal fluid culture, regular review of local antibiograms, and dynamic revision of empirical antibiotic protocols. This requires robust antimicrobial stewardship to preserve the remaining effective agents and improve the outcomes for patients with secondary peritonitis related to hollow viscus perforation.

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