ISSN: 2581 – 3633
PubMed - National Library of Medicine - ID: 101745081

International Journal of Medical Science and Advanced Clinical Research (IJMACR)

Available Online at:www.ijmacr.com

Volume – 8, Issue – 1, February - 2025, Page No. : 69 – 75

Incidence and Microbiological spectrum of Peritonitis in Continuous Ambulatory Peritoneal Dialysis Patients: A Retrospective Study

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How to citation this article: Dr. Manjuri Sharma, Dr. Harmeet Singh, Dr. P Doley, Dr. G Pegu, "Incidence and Microbiological spectrum of Peritonitis in Continuous Ambulatory Peritoneal Dialysis Patients: A Retrospective Study", IJMACR- February - 2025, Volume – 8, Issue - 1, P. No. 69 – 75.

Type of Publication: Original Research Article

Conflicts of Interest: Nil

Abstract

Introduction: Peritonitis is a major complication and the leading cause of technique failure in continuous ambulatory peritoneal dialysis (CAPD). While numerous factors influence its incidence, the specific microorganisms isolated largely determine clinical outcomes. This study aimed to assess the incidence rate, microbiological spectrum, and antibiotic sensitivity patterns of peritonitis in CAPD patients at a single tertiary care center.

Methods: We retrospectively analyzed patients who developed peritonitis while on CAPD between 1st January 2022 to 31st december 2023. Peritonitis was defined according to the International Society for Peritoneal Dialysis guidelines. Baseline demographic data, etiologies of chronic kidney disease (CKD), and clinical outcomes were recorded. Dialysate samples underwent standard culture and sensitivity testing

Results: A total of 34 peritonitis episodes occurred in 32 CAPD patients (mean age 52.7 ± 10.0 years; mean CAPD duration 28 ± 6.2 months), corresponding to a peritonitis rate of 0.36 episodes per patient-year. Of these, 26 episodes (76.47%) were culture-positive, with Gram-positive organisms (especially Staphylococcus aureus and coagulase-positive staphylococci) predominating (16/26). Gram-negative isolates included Escherichia coli, Pseudomonas spp., and ESBL-producing Klebsiella pneumoniae.

Conclusion: Staphylococci remained the most common pathogens in CAPD peritonitis, although Gram-negative, fungal, and mycobacterial infections pose significant diagnostic and therapeutic challenges. Prompt detection,

including specialized tests for mycobacteria, along with robust infection control practices and appropriate antibiotic stewardship, are essential to improve CAPD outcomes

Keywords: CAPD, Cloudy Dialysate, Peritonitis, Uremia, White Blood Cell

Introduction

Peritonitis remains the leading cause of technique failure in patients undergoing continuous ambulatory peritoneal dialysis (CAPD).[1] Numerous factors—including age, ethnicity, educational background, environmental conditions, and the type of dialysis system—can influence the incidence of peritonitis, whereas the specific organism responsible largely determines the outcome.[2,3] Many studies have reported a decline in Gram-positive peritonitis alongside a rise in Gram-negative peritonitis.[4] Moreover, the microbiological profile of peritonitis in developing nations (e.g., India) may vary compared to that in developed countries, likely reflecting differences in social, environmental, educational, and economic circumstances, as well as local climate

Material and methods

It was a retrospective study involving patients undergoing CAPD at our center who developed peritonitis over a period of two years (January 1, 2022 to 31st December, 2023). The study was approved by the institutional ethics committee and an informed consent was obtained from the patients before their inclusion in the study. Peritonitis was defined according to the International Society of Peritoneal Dialysis recommendations.[5] PD peritonitis can be diagnosed based on at least two of three criteria: (1) symptoms and signs, such as abdominal pain, cloudy dialysate, and/or fever; (2) white blood cell (White blood cell, WBC) count of $\geq 100 \times 10^6$/L and multinucleated cell rate of $\geq 50\%$ in the dialysate; (3) positive dialysate smear or culture

The inclusion criteria were as follows: (1) patients with > 3 months of experience in maintenance PD for uremia; (2) patients between 18 and 80 years old; (3) patients on regular PD for at least 3 months; The exclusion criteria were as follows: (1) patients without complete clinical and follow-up records or participating in other clinical studies; (2) patients producing bloody PD fluid; (4) patients producing chylous PD fluid; (5) patients with mental disorders and are unable to cooperate during treatment;(8) patients with comorbid severe communicable diseases.

Sample collection

In sterile conditions, a volume of 10 mL dialysate (retained in the abdominal cavity for at least 4 h) was collected and placed in a blood culture bottle for testing using the Bact/ALERT 3D automated microbial detection system.[6] Then, the dialysate in the positive bottle was smeared and seeded on the Columbia blood agar and chocolate blood agar. The quality control bacteria included E. coli, Staphylococcus aureus, and Pseudomonas aeruginosa.[7,8] The drug susceptibility test was conducted according to the method described by the Clinical and Laboratory Standards Institute (CLSI) (2016), using BACTEC™

Results

A total of 34 episodes of peritonitis occurred in 32 patients. The mean age was 52.7 ± 10.0 years, and the mean duration on CAPD was 28 ± 6.2 months. The calculated peritonitis rate was 0.36 episodes per patient-year. Out of 32 CAPD patients, 26 (81.25%) were male and 6 (18.75%) were female. A majority (24) resided in urban areas, while 8 lived in rural regions. Underlying

CKD Etiologies include: Diabetic nephropathy: 10 patients, Hypertensive nephropathy: 6 patients, Chronic tubulointerstitial disease (CTID): 11 patients, Chronic glomerulonephritis (CGN): 5 patients, **Comorbidities**: Diabetes mellitus (any type): 12 patients, Coronary artery disease (CAD): 8 patients, Dilated cardiomyopathy (DCMP): 6 patients Smoking (current or former): 6 patients

Table 1:

Characteristics	Value
Mean Age	52.7 ± 10.0
Gender	- Male: 26 (81.25%) - Female: 6 (18.75%
Residence	- Urban: 24 (75.0%) - Rural: 8 (25.0%)
Mean duration of CAPD (months)	28 ± 6.2
Etiology	- Diabetic nephropathy: 10 - Hypertensive nephropathy: 6 - Chronic tubulointerstitial disease (CTID): 11 - Chronic glomerulonephritis (CGN): 5
Co morbidities	- Diabetes Mellitus (any type): 12 - Coronary artery disease (CAD): 8 - Dilated cardiomyopathy (DCMP): 6 - Smoking (current/former): 6
Peritonitis rate	0.36 episodes per patient-year

1. **Culture-Negative Episodes (n = 8; 23.53%)**

- Among these, extended testing revealed Mycobacterium tuberculosis and Mycobacterium kansasii in 2 cases.
- Therefore, 6 episodes ultimately remained truly culture-negative despite extended diagnostic efforts.

2. **Culture-Positive Episodes (n = 26; 76.47%)**

- **Gram-Positive (n = 16)**
  - Staphylococcus aureus (n = 6)
  - Coagulase-positive staphylococci (n = 9)
  - Enterococcus faecalis (n = 1)
- **Gram-Negative (n = 8)**
  - Escherichia coli (n = 3)
  - Pseudomonas spp. (n = 2)
  - Klebsiella spp. (n = 2)
  - Enterobacter spp. (n = 1)
- **Fungal (n = 2)**
- Candida Albicans

Table 2:

Source / Flora	Organisms	Number of Episodes	% of Total (n=34)
Touch Contamination (Skin Flora)	- Staphylococcus aureus (6) - Coagulase-positive staphylococci (9)	15	41

Enteric flora	- Escherichia coli (3) - Klebsiella spp. (2) - Enterobacter spp. (1) - Enterococcus faecalis (1)	7	20.6
Environmental/Water Source	Pseudomonas spp 2 Mycobacterial 2 Fungal 2	6	17.6
Truly culture negative	No organism found after extended testing (6)	6	17.6

Gram-positive organisms were sensitive to all tested antibiotics, and neither methicillin-resistant Staphylococcus aureus (MRSA) nor vancomycin-resistant Enterococcus (VRE) was isolated. All Gram-negative isolates were sensitive to ciprofloxacin, ceftriaxone, cefotaxime, cefepime, and gentamicin; however, Klebsiella pneumoniae demonstrated resistance to beta-lactams (ESBL-producer) but remained sensitive to imipenem. Two episodes of recurrent peritonitis due to Staphylococcus aureus occurred in two separate CAPD patients. Nasal swabs were obtained from each patient and from the dialysis assistant. Notably, the assistant's nasal swab grew S. aureus with an identical antibiotic sensitivity profile to that isolated from the CAPD dialysate. In terms of outcomes, 29 patients fully recovered, whereas one patient with Mycobacterium kansasii peritonitis died. Catheter removal was required in three patients—two with fungal peritonitis, one with Mycobacterium tuberculosis peritonitis

Discussion

Peritonitis remains a significant cause of morbidity and technique failure among continuous ambulatory peritoneal dialysis (CAPD) patients.[7] In the present study, we observed a total of 34 peritonitis episodes in 32 patients, yielding a peritonitis rate of 0.36 episodes per patient-year, which is comparatively favorable relative to the threshold of 0.5 episodes per patient-year recommended by the International Society for Peritoneal Dialysis (ISPD)[8]

1. Overall Distribution of Organisms

In our cohort, Gram-positive organisms constituted the majority (16 of 26 culture-positive cases), especially Staphylococcus aureus and other coagulase-positive staphylococci. Gram-negative organisms (8 of 26) included Escherichia coli, Pseudomonas spp., Klebsiella spp., and Enterobacter spp. Fungal infections accounted for 2 episodes, while 2 additional cases were mycobacterial (M. tuberculosis, M. kansasii). These proportions align with many single-center and multi-center reports:

- **Li et al. (2016)** in the ISPD Peritonitis Recommendations noted that Gram-positive organisms typically comprise 50–60% (sometimes up to 70%) of CAPD peritonitis episodes, with staphylococci (both S. aureus and coagulase-negative species) being the single largest group 111.
- **Szeto et al. (2018)**, in a multi-center Asian cohort, similarly found that Gram-positive organisms were responsible for ~60% of peritonitis, Gram-negative organisms for ~25%, and fungi for 2–5% 222.[9]

- **Brown et al. (2019)** reported a large North American registry-based study showing Gram-positive infections in ~65% of cases, Gram-negative in ~25%, and fungal <5% 333.[10]

Our findings (i.e., ~61.5% Gram-positive if considering all episodes, 23.5% Gram-negative, 5.9% fungal, and 5.9% mycobacterial) therefore resemble these established global patterns, although the presence of mycobacterial infections is somewhat higher than in many Western cohorts, where it remains <1% .[11]

2. Mycobacterial and Fungal Peritonitis

Mycobacterial peritonitis poses a diagnostic challenge due to its insidious onset and the need for special culture techniques or molecular testing. Mycobacterial peritonitis can be challenging to diagnose using standard culture methods alone. In our study, two cases previously deemed culture-negative were found to be caused by M. tuberculosis and M. kansasii after applying next-generation sequencing (NGS). These findings illustrate the value of advanced molecular techniques in detecting fastidious organisms, particularly in regions where tuberculosis prevalence is higher therefore demonstrating that routine bacterial cultures alone can miss these pathogens. This observation is consistent with studies from regions with higher tuberculosis prevalence, where up to 2–5% of peritonitis cases may be mycobacterial. Fungal peritonitis, although infrequent (2/34 episodes in our series), is reported to account for roughly 2–5% of peritonitis cases in other cohorts.[12] These infections often require prompt catheter removal in addition to antifungal therapy, given their propensity for relapse and higher mortality rates.

3. Gram-Negative and Resistant Organisms

In our analysis, Klebsiella pneumoniae was found to be an ESBL producer but remained sensitive to imipenem, highlighting the emergence of multidrug-resistant organisms in PD-related infections. Increasing rates of ESBL-producing Enterobacteriaceae and carbapenem-resistant Gram-negative bacteria have been reported globally, underscoring the necessity for regular antibiotic susceptibility surveillance and judicious use of broad-spectrum agents.[13] While overall Gram-negative peritonitis comprised ~23.5% of our total episodes, large cohort studies often report similar or slightly higher rates (around 25–35%) for Gram-negative infections.[14,15]

4. Staphylococcal Contamination and Recurrent Peritonitis

Two of our patients experienced recurrent peritonitis with S. aureus, and a nasal swab from the dialysis assistant grew an identical strain. Healthcare personnel as carriers of S. aureus is well-documented; for instance, Virgiriyo et al. (2020) identified staff carriage of S. aureus as a risk factor for recurrent PD peritonitis in 5% of their cohort.[16] This highlights the importance of infection control measures and potential decolonization protocols to mitigate cross-infection between staff and patients.

Clinical Implications

1. **Diagnostic Vigilance**: Culture-negative cases should prompt specialized tests for mycobacteria or fungi, especially in endemic areas or when clinical suspicion remains high.
2. **Infection Control**: Regular screening of staff for S. aureus, and strict hand hygiene and aseptic protocols, can reduce recurrent infections.
3. **Antibiotic Stewardship**: Rapid detection of ESBL-producing Gram-negative organisms and prudent antibiotic selection are critical to prevent the escalation of resistant strains.

4. **Comparative International Data**: Our results largely mirror existing literature from diverse regions, although local variations (e.g., higher prevalence of mycobacterial infections) highlight the influence of regional epidemiology.

Study Limitations

Key limitations include the relatively small sample size and single-center design, which may limit the generalizability of our findings. Additionally, retrospective data (if applicable) can introduce information bias regarding the timing of infection onset and culture collection. Nonetheless, by comparing our microbiological profile to that reported in other series, our study contributes to the broader understanding of CAPD peritonitis patterns, especially regarding the importance of extended investigations for mycobacteria and the role of health personnel in potential cross-contamination.

Conclusion

Our study confirms that staphylococci remain the predominant pathogens in CAPD peritonitis, in line with multiple international and regional studies. However, Gram-negative resistance**,** fungal infections, and mycobacterial peritonitis are increasingly relevant and may require extended diagnostic methods, more aggressive management (including catheter removal), and ongoing surveillance of antibiotic resistance. By adopting a multifaceted approach—emphasizing aseptic technique, staff decolonization protocols where indicated, and careful antibiotic stewardship—we can strive to reduce peritonitis incidence and improve long-term outcomes for CAPD patients.

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