

# Dialysis-associated peritonitis in patients with automated peritoneal dialysis vs. Continuous outpatient peritoneal dialysis: A single-center observational study.

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## Abstract

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**Introduction:** People requiring dialysis in Mexico increase between 6–12% annually. Peritoneal dialysis (PD)-related peritonitis is the leading cause of a permanent transition to hemodialysis. Its appearance is associated with prolonged hospitalization, increased morbidity and mortality, higher costs, and increased long-term sequelae of the peritoneal membrane. The study aimed to describe the epidemiology of patients with dialysis-associated peritonitis treated in the emergency department at a referral hospital in Mexico, comparing treatment modalities.

**Methods:** The present observational, analytical, retrospective study was conducted from March 2021 to February 2022 at the General Hospital of Zone and Family Medicine 1 of Pachuca-Hidalgo. The variables were demographic, clinical, and laboratory. Descriptive statistics, proportions, and confidence intervals for a proportion are used. An analysis is presented comparing the two PD modalities.

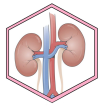
**Results:** 142 confirmed cases are compared to the target statistical population of 1147 patients, with an infection rate of 12.3% (95% CI 10.4%-14.2%). In APD, they were 56/642 (0.0872 cases/patient/year), and in CAPD, they were 86/505 (0.170 c/p/a)  $P < 0.0001$ . The most frequent etiology was *E. coli* (36.28%).

**Conclusion:** Patients in automated peritoneal dialysis programs had a lower prevalence of peritonitis than the continuous ambulatory peritoneal dialysis group.

## Keywords:

**MeSH:** Peritoneal Dialysis; Dialysis; Peritoneal Dialysis, Continuous Ambulatory; Observational Study; Hospitalization; Indicators of Morbidity and Mortality; Ascitic Fluid; Peritonitis.

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Peritoneal dialysis (PD) is Mexico's most common renal function replacement therapy method. It requires a vital training component in patients and caregivers since it does not require direct assistance or supervision from a healthcare provider. Poor adherence to the PD exchange procedure is associated with an increased risk of peritonitis [1]. Training practices have been reported to be highly variable among PD centers, with training time variations from 6 hours to 96 hours [2]. Currently, there is no robust evidence generated from randomized controlled trials (RCTs) or meta-analyses to inform how to best provide training to people receiving peritoneal dialysis. The PDOPPS [3] is a prospective study that follows maintenance PD patients and aims to understand variations in practices and outcomes. Despite examining many training characteristics of the PDOPPS, the present study found no evidence that the risk of peritonitis was associated with when, where how, or how long PD patients should be trained. As such, evidence from this study suggests that training can be provided in any way that is convenient and consistent with available local resources and is individualized to patient needs [4].

It has been suggested that there is a relationship between initial peritoneal dialysis modality and the risk of peritonitis. The most substantial literature on peritoneal dialysis comes from Japan, where high-quality studies have demonstrated that peritonitis is a direct or indirect cause of death in 2–16% of patients [5–7]. Peritonitis can reduce dialytic efficiency by causing peritoneal fibrosis, leading to technique failure.

The incidence of peritonitis has been significantly reduced in recent years due to technological advances, the development of new biocompatible peritoneal dialysis solutions, and the International Society of Peritoneal Dialysis (ISPD) guidelines for preventing and treating peritonitis [4].

Peritonitis is one of the leading causes of PD failure through structural and functional alterations of the peritoneal membrane, which can lead to life-threatening events [8]. Some observational reports have shown a relationship between PD modality and peritonitis; however, it is not a constant observation and does not affect mortality [9]. The results of many studies have shown that patients on APD have a lower or similar incidence of peritonitis than those on CAPD. For example, a randomized control study in the Netherlands revealed that PE peritonitis occurred significantly less frequently in patients with APD than in patients with CAPD (0.51 vs. 0.94 episodes per patient-year, respectively) [3]. A retrospective observational study in the United Kingdom showed that the rate of peritonitis was 1:36.7 patient months for patients treated with DPA and 1:28.8 patient months for patients treated with CAPD, representing an odds ratio of 0.78 in favor of DPA.

In contrast, three recent observational studies found that peritoneal dialysis modality was not associated with an increased likelihood of developing peritonitis [10]. Different study populations, follow-up times, improvements in CAPD and APD connection systems, and advances in nursing care and dialysis treatment may have led to different results in different studies and may cause bias. The analysis

of these studies does not report on the connection device on the cyclor used. These data should also be interpreted cautiously due to differences in analytical methods. A study in Japan showed that patients started on APD at the start of PD experienced significantly less peritonitis than those started on CAPD in subgroup analyzes of unmatched and matched patients, confirming the robustness of our results [3].

Two hypotheses may explain why APD was associated with a lower incidence of peritonitis than CAPD. First, the number of connections and disconnections required to perform PD may be the most critical determinant of peritonitis rates; DPA requires fewer connections and disconnections than DPCA. Second, APD, mainly nocturnal intermittent PD, involves shorter dialysate dwell times than CAPD, which requires at least 4 to 5 bag changes. Fewer connections and shorter dwell times may reduce the incidence of peritonitis by reducing contact contamination in patients treated with DPA. However, we found an increase in the number and rate of peritonitis-causing gram-positive cocci in patients with CAPD versus patients with APD, but the difference was not statistically significant. Other mechanisms may contribute to the reduced risk of peritonitis in APD [10].

The objective of the present study was to determine the frequency of peritonitis associated with dialysis in patients with automated peritoneal dialysis (APD) vs. continuous ambulatory peritoneal dialysis (CAPD) in a peritoneal dialysis reference center in Mexico.

## Materials and methods

### Study design

The study is an analytical cross-sectional observational study. The source is retrospective.

### Scenery

The study was carried out in the emergency service of the Zona General Hospital and Family Medicine Unit No. 1 Pachuca Hidalgo, Mexico. The study period was from March 1, 2021, to February 28, 2022.

### Participants

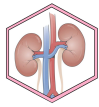
Patients older than or equal to 18 years of age with stage 5d chronic kidney disease on renal function replacement therapy with peritoneal dialysis were included. Cases of pregnant women were excluded.

### Variables

The variables studied were as follows:

- Dependents: presence of peritonitis.
- Moderators: Type of treatment solution, causal agent.
- Independent: type of peritoneal dialysis: Continuous ambulatory peritoneal dialysis (CAPD) and automated peritoneal dialysis (APD).

Descriptive variables: initial treatment, transition to definitive hemodialysis due to loss of peritoneal function, demographic variables such as age, sex, marital status, and education.



### Data sources/measurements

The source was indirect. The information was collected in an electronic database created by the authors from the medical records found in the institution's archive. Biochemical measurements, cultures, and ascitic fluid analysis were part of the regular activity of the institution, which was carried out daily in the control studies and was collected from the institution's laboratory system.

### Biases

To avoid possible interviewer, information, and memory biases, the leading researcher kept the data at all times with a guide and records approved in the research protocol. Observation and selection bias were avoided with the application of participant selection criteria. All clinical and paraclinical variables from the period already mentioned were recorded. Two researchers independently analyzed each record in duplicate, and the variables were recorded in the database once their agreement was verified.

### Study size

The population consisted of patients with peritoneal dialysis as replacement therapy for renal function. The stage 5-d chronic kidney disease rate in Mexico is 1142 ppm [11]. According to the 2020 Population and Housing Census of the National Institute of Statistics and Geography (INEGI), the population of Hidalgo, Mexico, is 3,189,102, which implies 3,641 cases in the region. According to the Mexico global perspective report [11], 59% of patients are in peritoneal dialysis programs, equivalent to 2148 patients as the target population. Approximately half of patients (53%) do not have access to hemodialysis programs, are considered unsuitable for the program, or are undiagnosed, thus limiting the population size to 1,147 cases. To obtain the sample, the prevalence of peritonitis was 0.12 episodes per patient/year. With an expected frequency of 11.9%, a confidence limit of 5%, and a confidence interval of 95%, the sample size was 140 cases. Epi Info™ Version 7.0 was used. (CDC. Atlanta, GA: Centers for Disease Control and Prevention, 2023) for sample calculation.

### Quantitative variables

Descriptive and inferential statistics were used. The results were expressed on a scale of means and standard deviation. Categorical data are presented in proportions.

### Statistical analysis

Noninferential and inferential statistics are used. For the descriptive analysis, measures of central tendency and dispersion were calculated according to the measurement scale of each of the variables. Qualitative variables are presented with absolute numbers and percentages;

quantitative variables are presented with medians and standard deviations.

Inferential analysis: Study size data were used to calculate prevalence. Statistical association was measured by relative risk, and the divergence measure was performed by chi-square determination. The statistical package used was SPSS 20.0 (IBM Corp. Released 2011. IBM SPSS Statistics for Windows, Version 20.0. Armonk, NY: IBM Corp.).

## Results

### Study participants

The collection of data from patients who had to have a Tenckhoff catheter placed and who developed peritonitis during the study period resulted in 142 patients with peritonitis included in the final analysis; the number of patients who had cultures to determine agent causality was 113, with a percentage of 79.5%.

### General characteristics of the sample

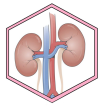
Of the 142 patients, 79 (44%) were women, and 63 (56%) were men (Figure 1). The average age was 51.9 years (Figure 2). When the ages were analyzed according to gender, it was found that the average age of the group of women was  $48.96 \pm 13.57$  years, and that of the men was  $54.59 \pm 14.55$  years. The education of the majority of the sample was secondary (44% of cases) (Figures 3 and 4).

### Peritonitis in peritoneal dialysis

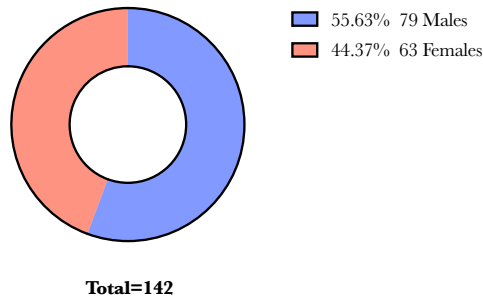
In the automated peritoneal dialysis (APD) modality, there were a total of 56 cases (39%), and in the continuous ambulatory peritoneal dialysis (CAPD) modality, there were 86 cases (61%) (Figure 5). Treatment was in 25 cases (18%) with the PISA brand liquid and in 117 cases (82%) with the Baxter brand (Figure 6). Suppose the population of Hidalgo-Mexico subjected to peritoneal dialysis programs is considered (1147 patients as the target population). In that case, 142 patients represented an infection rate of 12.3%, with a 95% confidence interval of 10.4%–14.2%.

### Causative agent and treatment

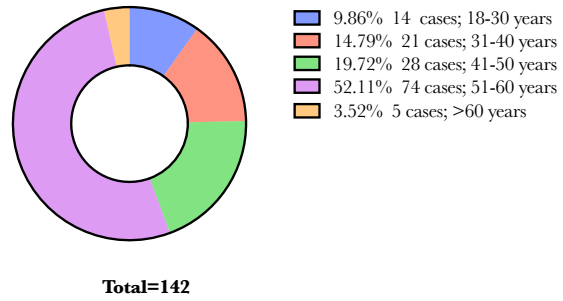
A total of 142 cultured patients were obtained, with 113 positive cases representing 79.5% of the total sample. The causal agent was classified by order of incidence into four categories: *E. coli* with a total of 41 cases and a percentage of 36% and *S. epidermidis* with a total of 22 cases and a percentage of 20%. *S. aureus*, with a percentage of 14 cases, represents 12%, and the rest of the isolated microorganisms represent the remaining 36% of the total cultured patients (Figure 7).



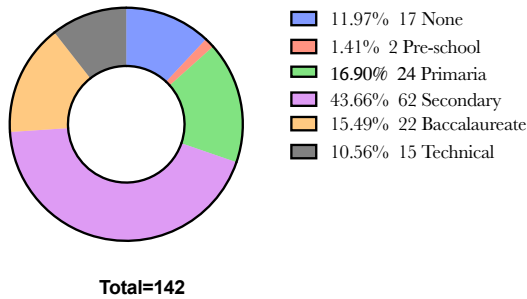
**Figure 1.** Distribution of cases by sex.



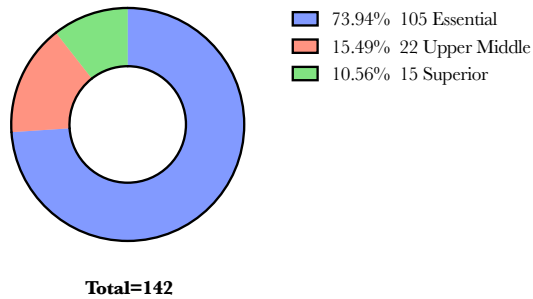
**Figure 2.** Distribution of cases by sex.



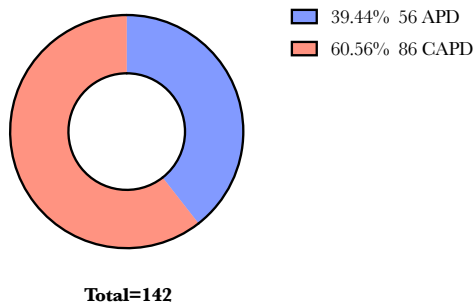
**Figure 3.** Education of the study group.



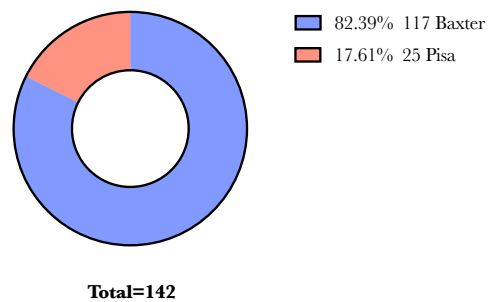
**Figure 4.** Schooling by categories.



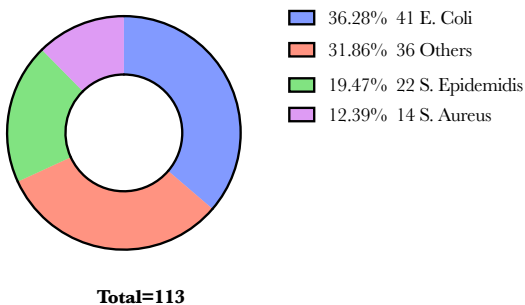
**Figure 5.** Peritonitis associated with the type of dialysis.



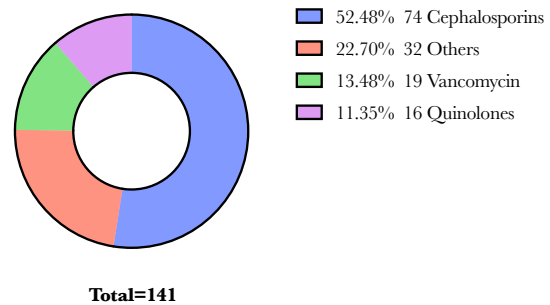
**Figure 6.** Brand names of the replacement fluid.

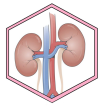


**Figure 7.** Causative agent of peritonitis.



**Figure 9.** Initial treatment of peritonitis.





The initial treatment was compiled, which is divided into antibiotic groups that were classified into four groups with cephalosporins, which consist of ceftazidime, ceftriaxone, and cefixime with a total of 74 cases that represent a percentage of 53%, quinolones such as levofloxacin, ofloxacin and ciprofloxacin with a total of 16 cases with a percentage of 11%, vancomycin as a single group with a total of 19 cases and a percentage of 13%, and others within which a variety of groups of antibiotics are included such as aminoglycoside and penicillins. antipseudomonas, such as tigecycline-tazobactam, carbapenems, and chloramphenicol, as well as antifungals, such as itraconazole and amphotericin B, with a total of 32 cases that represent a percentage of 23% (Figure 8).

**Table 1.** Prevalence of infections in patients in peritoneal dialysis programs.

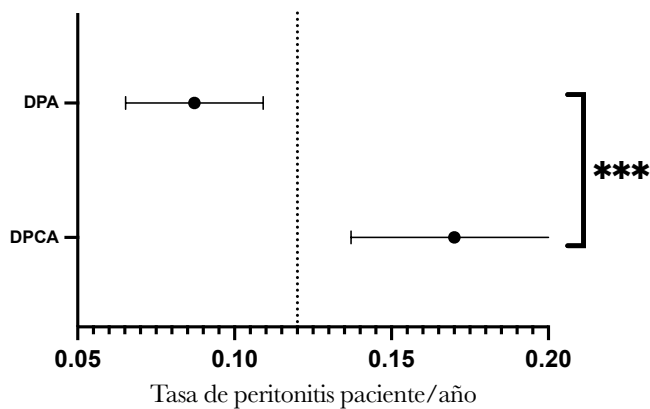
	DPCA n=505	DPA n= 642	$\chi^2$	Q
Peritonitis	86 (17.0%)	56 (8.72%)	17.98	<0.0001
Peritonitis rate/pte/year	0.170 (95% CI 0.1371-0.2029)	0.0872 (95%CI0.0653-0.1091)		

CAPD: continuous ambulatory peritoneal dialysis. APD: automated peritoneal dialysis.

**Peritonitis rate patient/year**

Statistical differences were found between the prevalence rate of peritonitis/patient/year concerning the DPA modality, being lower than in CAPD for the national rate of 0.12 cases/patient-year (Table 1 and Figure 9).

**Figura 9.** Gráfico de medias de tasa de peritonitis.



**Discussion**

Patients in peritoneal dialysis programs in Mexico have a peritonitis rate of approximately 0.11 episodes per patient per year. This incidence is similar to the global incidence, which is approximately 0.12 episodes per patient per year. If the population of Hidalgo-Mexico subjected to peritoneal dialysis programs is considered (1147 patients as the target population), 142 patients represent an infection rate of

12.3%, with a 95% confidence interval of 10.4%. 14.2%. In this distribution, compared with national statistics, according to a report from the global perspective of dialysis in Mexico, 35,255 patients are on peritoneal dialysis. Of these, 15,536 were on continuous ambulatory peritoneal dialysis (44.1%), and 19,719 (55.9%) were on automated peritoneal dialysis. The average age of dialysis patients in Mexico is 65 years. Fifty-three percent of patients were men, and 47% were women. The majority of dialysis patients in Mexico are located in Mexico City (7,190 patients), followed by Jalisco (2,164 patients), Nuevo León (1,868 patients) and Puebla (1,398 patients) [11].

Regarding the specific technique of peritoneal dialysis, according to the data from the global perspective of dialysis in Mexico and extrapolating these data to the population of Hidalgo, 505 patients had CAPD, and 642 patients had APD. There were differences between the two modalities for the presence of peritonitis. Although the study has some limitations since it is a cross-sectional and retrospective study, this observational evidence is consistent with other studies carried out worldwide, possibly due to variations in regional practices [12].

The primary microbiological isolation in the present study comprises gram-negative bacilli, *E. coli*, gram-positive cocci, *S. aureus*, and *S. epidermidis*. Our institution's initial empirical antimicrobial scheme, ceftazidime and vancomycin, is justified as *S. aureus*, *S. epidermis*, and enterobacteria are the main etiological agents involved.

The percentage of positive isolation in peritoneal fluid cultures in our institution is adequate (79.5%) compared to that described in international consensus, both by standard technique in blood culture bottles (80%) and by significant aliquot technique (95%), the latter not being carried out in our institution.

Future studies should address longitudinal follow-up to measure mortality and annual rates starting in the second year.

**Conclusion**

Patients in automated peritoneal dialysis programs had a lower peritonitis prevalence than the continuous ambulatory peritoneal dialysis group.

**Abbreviations**

APD: automated peritoneal dialysis.  
CAPD: Continuous ambulatory peritoneal dialysis.

**Supplementary information**

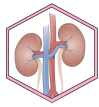
Supplementary materials have not been declared.

**Acknowledgments**

Does not apply.

**Author contributions**

Eduardo Domínguez Fierro: Data curation, Formal analysis, Funding acquisition, Research, Project administration, Resources, Software, Writing – original draft.  
Estrella Elizabeth Pasten López: Conceptualization, Supervision, Validation, Visualization, Methodology, Writing: review and editing.



Néstor Mejía Miranda: Supervision, Validation, Visualization, Methodology, Writing: review and editing.

All the authors have read and approved the final version of the manuscript.

### Financing

Studies and laboratory tests constituted the regular activity of the Emergency Department of the General Hospital of Zone No. 1 Pachuca Hidalgo. They did not constitute a cost for public service patients. None of the authors received funding for the present study. The authors paid the administrative expenses of the research.

### Availability of data or materials

The data sets generated and analyzed during the current study are not publicly available due to participant confidentiality.

## Statements

### Ethics committee approval and consent to participate

The Bioethics Commission of the Faculty of Medical Sciences of the National Autonomous University of Mexico approved the research project before carrying out the study.

All data obtained during the implementation of this project were authorized for use by the teaching and research coordination of the Hospital General De Zona No. 1. Pachuca Hgo. The handling of the data collected was always confidential, using codes instead of names.

### Consent for publication

Not required for studies that do not publish patient photographs, tomography scans, or X-ray studies.

### Conflicts of interest

The authors report having no conflicts of interest.

### Author information

Not declared.

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