Microbiological Profile of Peritoneal Dialysis
Peritonitis and Predictors of Hospitalization

Peritonitis, the major complication of peritoneal dialysis (PD), is associated with high morbidity and mortality. It is a major cause of hospitalization and transfer to hemodialysis. In the present study, we aimed to identify predictors of hospitalization in PD-related peritonitis and to examine its microbiology profile over time in our unit to determine the best therapeutic approach. We studied all peritonitis episodes that occurred in a 6-year period (January 1, 2004, to December 31, 2009), evaluating whether adequate treatment could be delivered on an outpatient basis.

During the study period, 411 patients were on PD, and 229 peritonitis episodes were recorded in 91 patients. Peritonitis were treated according to unit protocol. The average hospital stay was 11.6 ± 6.6 days. We observed an increase of *Streptococcus* (to 19.4% from 7.7%) and a stabilization of coagulase-negative *Staphylococcus*, *S. epidermidis*, and *S. aureus* (from 9.5%, 22.6%, and 3.2% to 7.7%, 30.8%, and 3.8% respectively) peritonitis episodes. The main risk factors for hospitalization were fungal infection, poor 72-hour outcome, inability to perform self-care, and age greater than 80 years. We observed a decline in the incidence of peritonitis, and despite changes in its microbiology profile, no loss of sensitivity to antibiotics used was observed.

**Key words**
Hospitalization, microbiology profile, outcome, peritonitis

**Introduction**
Peritonitis remains the most important complication of peritoneal dialysis (PD) and a common cause of catheter loss and transfer to hemodialysis (HD) (1,2); its incidence is about 0.3 – 0.5 episodes per patient per year (3).

Clinically, peritonitis is easy to diagnose: most patients have abdominal pain and cloudy peritoneal effluent. Other systemic signs and symptoms such as fever, nausea, and vomiting may be present (4). The most important laboratory finding is the presence of more than 100 leukocytes per cubic millimeter of PD effluent, with at least 50% polymorphonuclear cells (5–7). Gram-positive coagulase-negative staphylococci are the most common cause of peritonitis (4), followed by gram-negative organisms. Fungi are an uncommon cause.

To avoid complications, it is important to start empiric antibiotic therapy for peritonitis as soon as possible; treatment is usually administered on an outpatient basis (8). Major causes of hospitalization in PD patients are peritonitis (47.6%) and cardiovascular complications (31.9%) (9). Serum albumin is a strong negative predictor for hospitalization (10), as is creatinine clearance (11). However, since 2000, the need for hospitalization has declined thanks to improved equipment, greater manageability, and ease of administration of intraperitoneal (IP) antibiotics.

The aims of the present study were

- to describe the main driving factors and predictors of admission in patients with PD peritonitis, analyzing clinical course and mortality.
- to evaluate the incidence of peritonitis and to review its microbiology profile over time to determine if changes had occurred during the study period.
- to evaluate whether the empiric antibiotic treatment protocol in use continues to provide coverage against the most frequent micro-organisms.

**Methods**
Our study included all patients on PD who had experienced an episode of peritonitis between 2004...
and 2009. Peritonitis was defined as the presence of abdominal pain, cloudy peritoneal fluid, and leukocytes in excess of 100/mm³ in effluent, with at least 50% polymorphonuclear cells. Treatment success was defined as the disappearance of symptoms and clearing of the effluent after initiation of therapy, with an absence of relapse within 4 weeks after withdrawal of antibiotics. The catheter was removed in fungal peritonitis episodes, after several episodes of recurrent peritonitis, or when the initial outcome of peritonitis was poor in the presence of adequate treatment. Hospitalization was defined as a patient who remained in hospital for at least 12 hours.

**Peritonitis protocol**

When peritonitis was suspected, effluent samples were collected for culture, Gram stain, and cell count and differential. Antibiotic therapy consisted of intravenous vancomycin (1 g on days 1 and 5) to cover gram-positive organisms and IP ceftazidime (1 g daily for 15 days) to cover gram-negative organisms (7,12,13).

In our unit, patients are usually hospitalized if severely affected or if unable to receive treatment on an outpatient basis.

**Statistical analysis**

We recorded age, sex, cause of renal disease, type of PD, time from start of PD to first peritonitis, hospitalization and length of hospital stay per episode, and presentation of peritonitis. We also analyzed cell counts and percentages, cultures, and Gram stain from peritoneal effluent. All data were processed using the SPSS software application (version 12.0: SPSS, Chicago, IL, U.S.A.). Quantitative variables are expressed as mean ± standard deviation. Categorical variables are expressed as percentages.

**Results**

**Patient characteristics**

During the study period, 411 patients were on PD (Table I), and 229 episodes of peritonitis (26 in 2004, 29 in 2005, 55 in 2006, 47 in 2007, 41 in 2008, 31 in 2009) occurred in 91 patients, for an incidence of 0.66 per patient per year. The average duration on PD before the first episode was 441.5 ± 618.5 days (range: 1 – 3285 days).

**Diagnosis of peritonitis**

All patients had turbid effluent from the first day, with varying effluent characteristics (Table I). Of the 229 episodes, 202 (88.2%) resulted in a positive culture. Gram-positive micro-organisms were responsible for 148 peritonitis episodes (64.6%), with *Staphylococcus epidermidis* and *Streptococcus* species being the most frequently isolated. Gram-negative organisms, principally *Escherichia coli*, were cultured in only 47 episodes (20.5%). Anaerobic and fungal peritonitis episodes were rare (Table II).

**Microbiology profile during the study period**

Among the gram-positive micro-organisms, only *Streptococcus* rose in frequency during the study...
Peritonitis in PD

was 11 ± 6.6 days (range: 1 – 26 days).

Discussion
Peritonitis remains a major complication of PD. As has been observed in multiple studies (5,7), more than 90% of patients have cloudy fluid (100% of our patients) and many have abdominal pain (67.7%) and hypercellular effluent (>100 cells/mm$^3$, at least 50% neutrophils) at presentation (6,7). Of all episodes of peritonitis in the present study, 88.2% resulted in a positive culture, with gram-positive organisms causing most of the episodes (64.6%) and gram-negative organisms (20.5%), anaerobes, and fungi being isolated less frequently—observations already reflected in other studies (14,15). Only 11.8% of the episodes resulted in a negative culture, a rate lower than that generally reported (8,15) and stable in recent years.

When looking at the various micro-organisms (gram-positive, gram-negative, fungi, and anaerobes), we observed no significant differences in absolute numbers through the years.

In our unit, the incidence of peritonitis was 0.66 per patient per year, which is similar to that reported by other groups (3,15) and close to the incidence period (to 19.4% in 2009 from 7.7% in 2004). Other gram-positive organisms, including coagulase-negative staphylococci, *S. aureus*, and *S. epidermidis*, did not change in frequency. We also observed no differences in the frequencies of gram-negative organisms, with the exception of a decrease in the incidence of *Enterobacter* infections (to 3.2% in 2009 from 11.5% in 2004). We observed no other differences in the organisms isolated.

**Peritonitis evolution**
During the study period, 215 of the 229 peritonitis episodes were treated on an outpatient basis, resulting in complete healing without hospitalization in 202 of the 215 episodes (94%, Table II). In 27 episodes (11.8%), hospitalization was needed: in 14 at the start, and in 13 because of poor outcome with therapy. Among the 14 patients hospitalized upon diagnosis, 2 had fungal peritonitis, 4 could not perform treatment at home, and 8 patients were in a poor clinical state. Of all 27 patients that were hospitalized, 20 (74.1%) completely recovered, and 7 died. The catheter had to be removed in 8 patients (5 with fungal peritonitis, 3 with recurrent infection). The mean hospital stay was 11 ± 6.6 days (range: 1 – 26 days).

<table>
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<th>Variable</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
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</thead>
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<td>67</td>
<td>103</td>
<td>69</td>
<td>57</td>
<td>52</td>
<td>63</td>
</tr>
<tr>
<td>Peritonitis episodes ($n$)</td>
<td>26</td>
<td>29</td>
<td>55</td>
<td>47</td>
<td>41</td>
<td>31</td>
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<td>Incidence (episodes/patient–year)</td>
<td>0.55</td>
<td>0.22</td>
<td>1</td>
<td>0.93</td>
<td>0.9</td>
<td>0.34</td>
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<td>Outpatients (%)</td>
<td>92.3</td>
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<td>96.4</td>
<td>91.5</td>
<td>95.1</td>
<td>90.3</td>
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<tr>
<td>Hospitalization (%)</td>
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<td></td>
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<tr>
<td>On presentation</td>
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<td>3.4</td>
<td>3.6</td>
<td>8.5</td>
<td>4.9</td>
<td>9.7</td>
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<td>3.6</td>
<td>14.5</td>
<td>2.3</td>
<td>2.6</td>
<td>3.6</td>
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<td>100</td>
<td>96.6</td>
<td>96.4</td>
<td>97.9</td>
<td>97.6</td>
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<tr>
<td>Mortality (%)</td>
<td>0</td>
<td>3.4</td>
<td>3.6</td>
<td>2.1</td>
<td>2.4</td>
<td>3.2</td>
</tr>
</tbody>
</table>

**Micro-organisms**

| Negative culture [$n$ (%)]    | 2 (7.7) | 6 (20.7) | 4 (7.3) | 6 (12.8) | 7 (17.1) | 2 (6.5) |
| Gram positive [$n$ (%)]       | 17 (65.4) | 19 (65.5) | 34 (61.8) | 28 (59.6) | 29 (70.7) | 21 (67.7) |
| Coagulase-negative staphylococci | 2 (7.7) | 0 (0) | 2 (3.6) | 1 (2.1) | 0 (0) | 2 (6.5) |
| *S. aureus*                   | 1 (3.8) | 4 (13.8) | 1 (1.8) | 2 (4.3) | 3 (7.3) | 1 (3.2) |
| *S. epidermidis*              | 8 (30.8) | 9 (31) | 12 (21.8) | 11 (23.4) | 7 (17.1) | 8 (25.8) |
| *Streptococcus*               | 2 (7.7) | 3 (10.3) | 10 (18.2) | 7 (14.9) | 10 (24.4) | 6 (19.4) |
| Other                         | 4 (15.4) | 3 (10.3) | 9 (16.4) | 7 (14.9) | 9 (22) | 4 (12.9) |
| Gram negative [$n$ (%)]       | 7 (26.9) | 4 (13.8) | 13 (23.6) | 11 (23.4) | 5 (12.2) | 7 (22.6) |
| *Escherichia coli*            | 2 (7.7) | 3 (10.3) | 7 (12.7) | 1 (2.1) | 2 (4.9) | 3 (9.7) |
| *Enterobacter* species        | 3 (11.5) | 0 (0) | 1 (1.8) | 3 (6.4) | 1 (2.4) | 1 (3.2) |
| Other                         | 2 (7.7) | 1 (3.4) | 5 (9.1) | 7 (14.9) | 2 (4.9) | 3 (9.7) |
| *Candida* species [$n$ (%)]   | 0 (0) | 0 (0) | 3 (5.5) | 1 (2.1) | 0 (0) | 1 (3.2) |
| Anaerobes [$n$ (%)]           | 0 (0) | 0 (0) | 1 (1.8) | 1 (2.1) | 0 (0) | 0 (0) |
considered to be the quality standard by the Spanish Society of Nephrology and the International Society for Peritoneal Dialysis. Moreover, that incidence has remained stable through the years (0.55 per patient per year in 2004; 0.34 per patient per year in 2009).

At 96.9%, the rate of peritonitis resolution was high [a bit higher than the 80% – 85% rates reported by other groups (16)], and a low proportion of patients needed hospitalization to achieve healing. The catheter removal rate was 3.5%, lower than the approximately 10% – 15% rates reported in other studies (16).

The deaths related to peritonitis episodes as reported in our study are similar to those previously described (16). The average hospital stay in our patients was similar to that reported by Lecame and colleagues (17). However, it must be borne in mind that we basically admitted to hospital all patients with a poor outcome after adequate initial antibiotic treatment and those who felt sick, had fever, had fungal peritonitis, or were unable to perform treatment at home.

Age is associated with immune system dysfunction (18) and with greater morbidity and mortality from common infections (19). That fact was evident in the present study, with elderly patients requiring hospitalization the most frequently; those patients also had more morbidity and more inability to adequately perform self-treatment.

The most recent guidelines from the International Society for Peritoneal Dialysis recommend regular reviews and monitoring of infection rates, causative organisms, and antibiotic sensitivities so that changes that could affect the effectiveness of the antibiotics used in each unit are noticed quickly.

**Conclusions**

Our experience suggests that home treatment for peritonitis is a good option, because most episodes resolve favorably. However, the evolution of peritonitis should be closely monitored so that unfavorable evolution is diagnosed as soon as possible. A change in the antibiotic regimen or sometimes catheter removal might be necessary for complete healing. Although most peritonitis episodes resolve satisfactorily, some patients can die.

In our series, the main predictors of hospitalization were fungal infection, poor initial response to adequate therapy, inability to perform self-care at home, and age greater than 80 years. The incidence of peritonitis remained stable during the study period, as did the organisms cultured, with the exception of a small increase in *Streptococcus* infections and a decrease in *Enterobacter* infections. Those changes have not been associated with a loss of sensitivity by the most common organisms to antibiotics used by protocol as empiric therapy at our center. We suggest that every PD team study the local microbiology profile so as to individually adapt antibiotic therapy.

**Disclosures**

The authors declare that no financial conflict of interest exists.

**References**

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