Relationship between double-cuff *versus* single-cuff peritoneal dialysis catheters and risk of peritonitis

Sharon J. Nessim¹, Joanne M. Bargman² and Sarbjit V. Jassal²

¹Department of Medicine, Division of Nephrology, Jewish General Hospital, Montreal, Quebec, Canada and ²Department of Medicine, Division of Nephrology, Toronto General Hospital—University Health Network, Toronto, Ontario, Canada

**Abstract**

**Background.** Peritonitis among peritoneal dialysis (PD) patients remains an important complication. To date, no catheter type has consistently been shown to reduce peritonitis risk. It has been hypothesized that double-cuff catheters might be superior to single-cuff catheters in preventing peritonitis caused by periluminal entry of organisms.

**Methods.** Using data collected in the multicentre Canadian Baxter Peritonitis Organism Exit-Sites Tunnel Infections (POET) database between 1996 and 2005, the association between number of catheter cuffs and peritonitis was tested. Variables adjusted for in the negative binomial model included age, gender, race, diabetes, renal disease, transfer from haemodialysis, previous renal transplant, PD modality and swan neck *versus* straight catheter.

**Results.** Data were available for 4247 incident patients with a total of 2555 peritonitis episodes, corresponding to a peritonitis rate of 0.364 per dialysis year at risk. After adjustment for covariates, double-cuff catheter use was associated with a trend towards a lower peritonitis rate ratio (RR) 0.90, 95% confidence interval (CI) 0.80–1.01, *P* = 0.08]. This trend was largely due to a decreased *Staphylococcus aureus* peritonitis rate in those with a double-cuff catheter (RR 0.46, 95% CI 0.33–0.64, *P* < 0.001). When stratified by era of PD initiation, the benefit of double-cuff catheters was seen only among those initiating PD before 2001.

**Conclusion.** Use of a double-cuff PD catheter is associated with a reduction in *S. aureus* peritonitis. Loss of the association between cuff number and peritonitis after the year 2000 may relate to changes in exit-site care that reduce the bacterial burden available for periluminal migration.

**Keywords:** catheter; double cuff; peritoneal dialysis; peritonitis; *Staphylococcus aureus*

**Introduction**

The occurrence of peritonitis is an important complication of peritoneal dialysis (PD), accounting for significant morbidity and mortality [1–4]. Entry of organisms into the peritoneal cavity can occur via several mechanisms. The two most common mechanisms include intraluminal entry often resulting from touch contamination at the time of catheter connections, and periluminal entry by migration from the exit site along the catheter tunnel. While intraluminal introduction of organisms at the time of catheter connection was a major concern with the advent of PD, the frequency of peritonitis resulting from this procedure among continuous ambulatory PD (CAPD) patients was dramatically reduced with the widespread adoption of the ‘flush before fill’ technique using a Y connector system [5–8]. In contrast, the biggest advance in the reduction of periluminal entry of organisms has been the introduction of prophylactic antibiotic ointments. Since the predominant organism causing exit-site infection is *Staphylococcus aureus* [9–11], it is not surprising that applying the anti-staphylococcal agent mupirocin to the exit site or nares reduces the risk of *S. aureus* exit-site infection and peritonitis [12,23,29,31,32]. More recently, exit-site gentamicin cream was shown to have similar beneficial effects on PD catheter-related infections [14,15].

As PD technique has evolved, several attempts have been made to design a PD catheter that would reduce peritonitis risk. These have included modifications to the extraperitoneal portion of the catheter (swan neck *versus* straight) and to the number of cuffs. Since the cuff of a PD catheter leads to a fibrotic reaction around it, this fibrosis might protect against migration of organisms along the tunnel of the catheter. It is therefore plausible that two cuffs might be a better barrier to periluminal passage of organisms into the peritoneal cavity than a single cuff. Early observational studies reported lower peritonitis rates with double *versus* single-cuff catheters [20,34]. However, the best study to have tested this hypothesis was a trial by Eklund *et al.* in which 60 patients were randomized to insertion of a single- or double-cuff catheter [16]. While this study showed no difference in the peritonitis rate between the two groups, the number of peritonitis episodes in each group was relatively small such that it was likely underpowered to detect a difference, should one have been pres-
ent. Current guidelines for insertion of PD catheters suffer from a lack of evidence in large population bases, and are therefore unable to put forward a strong evidence-based recommendation for single versus double-cuff catheters [19,26].

The primary objective of the present study was to test for an association between use of single- versus double-cuff catheters and peritonitis in a large cohort of PD patients. The secondary objective was to determine whether the relationship between the number of catheter cuffs and peritonitis would vary by organism.

Subjects and methods

Patients

The study included PD patients from 25 centres across Canada for whom data were available through the Peritonitis Organism Exit-Site Tunnel Infections (POET) database (Baxter Healthcare). The data from all Canadian PD centres using the POET clinical monitoring system software were collected as described previously [10]. The database includes prospectively collected data on incident PD patients, as well as data on prevalent patients from as early as 1990 that were retrospectively entered into the database when their centre started using the POET software. For this study, we included only those incident patients in whom data were collected prospectively. The time period for data collection was from 1 January 1996 until 12 September 2005. Information contained within the POET database includes patient demographics, cause of infection, catheter complications and therapy transfers. Approval was obtained from the Research Ethics Board at University Health Network prior to study initiation.

Covariates

Demographic data available for the current study include age, gender, race, cause of end-stage renal disease (ESRD), diabetes status, modality before PD start (new to dialysis, transfer from haemodialysis (HD), failed transplant, other/unknown) and PD modality [CAPD versus automated PD (APD)]. All APD patients used Baxter cyclers. While we do not have data as to when each individual centre switched from spike to luer lock connectology, the luer lock connectology for the Baxter cyclers first became available in Canada in 2003. Cyclers were categorized based on the presence of a double- versus single-cuff and a swan neck versus straight extraperitoneal segment. No data were available on S. aureus nasal carriage or use of prophylactic antibiotic ointments applied to the nares or exit site.

Given that the prospective cohort included patients who initiated PD over a 10-year period, we defined two eras of patients in order to assess for an era effect: an earlier cohort consisting of those who initiated PD between 1996 and 2000, and a more contemporary cohort consisting of those who initiated PD between 2001 and 2005, as previously described [24].

Peritonitis

Relapsing or recurrent peritonitis episodes were excluded. Although there is some controversy as to the definition of a recurrent peritonitis episode, standard International Society of Peritoneal Dialysis (ISPD) definitions were used, with a relapse defined as an episode occurring within 4 weeks of completion of therapy of a prior infection with negative culture or the same organism, and a recurrence defined as an episode occurring within 4 weeks of completion of therapy of a prior infection but with a different organism [26]. Consequently, peritonitis episodes occurring within 60 days of a previous episode were excluded based on the assumption that patients were treated with a maximum of 4 weeks of antibiotic therapy.

Peritonitis organisms

Organisms causing peritonitis were categorized as follows: Gram positive, Gram negative, culture negative and the subsets of coagulase-negative staphylococcus (CNS), S. aureus, Streptococcus species and Pseudomonas species.

Statistical analysis

Continuous variables are reported as mean ± SD, and were compared between patients with single- and double-cuff catheters using the Student’s t-test. Categorical variables are reported as percentages and were compared between groups using the chi-square test. The association between number of cuffs and the peritonitis rate was tested in a univariate negative binomial regression model, as well as in a multivariable negative binomial model that included gender, race, diabetic status, cause of ESRD, modality before PD start, CAPD versus APD and swan neck versus straight catheter type as covariates. A multivariable negative binomial model was also used to study the relationship between organism-specific infection rates and number of catheter cuffs. To assess for an era effect for catheter type, we used a cuff-era interaction term as an initial screening, and when found to be statistically significant, subsequent analyses were performed for each of the two eras. Statistical significance was defined as a P-value of <0.05. All statistical analyses were performed using SAS (version 9.1).

Results

The study sample consisted of 4247 incident PD patients, of whom 1605 had 2555 episodes of peritonitis. The remaining 2642 patients had no peritonitis. Of the 4247 patients, 1201 had single-cuff catheters, and 3046 had double-cuff catheters. There were 25 centres that contributed data for inclusion in the POET database, of which 14 used double-cuff catheters in >90% of patients, and two used single-cuff catheters in >90% of patients. The remaining centres used both single- and double-cuff catheters. All single-cuff catheters had a straight extraperitoneal portion, whereas 44.0% of double-cuff catheters had a swan neck extraperitoneal portion. Demographic characteristics of the patients by catheter cuff number are presented in Table 1.

In the univariate negative binomial regression model, use of a double-cuff catheter was associated with a trend towards a lower peritonitis rate than use of a single-cuff catheter rate ratio (RR) 0.90, 95% confidence interval (CI) 0.82–1.00, P = 0.06. Similar results were obtained in the multivariable negative binomial model (RR 0.90, 95% CI 0.80–1.01, P = 0.08). The extraperitoneal configuration of the catheter (straight versus swan neck) was not significantly associated with peritonitis (RR 1.01, 95% CI 0.91–1.13, P = 0.80), and did not affect the relationship between cuff number and peritonitis. The complete results of the multivariable analysis are presented in Table 2.

In order to further explore the relationship between double- versus single-cuff catheters and peritonitis, we performed additional analyses looking at organism-specific peritonitis rates in patients with one or two cuff catheters. In these multivariable analyses, use of a double-cuff catheter was associated with a significant reduction in the rate of Gram-positive peritonitis (RR 0.80, 95% CI 0.69–0.92, P = 0.002). This was largely accounted for by a reduction in the S. aureus peritonitis rate with double-cuff catheters (RR 0.46, 95% CI 0.33–0.64, P < 0.001). There was a trend towards reduction in the CNS peritonitis rate with double-cuff catheters (RR 0.86, 95% CI 0.71–1.04, P = 0.12). Peritonitis rates for each of the other organism categories did not differ among patients with single- versus
In the present study, the use of a double-cuff catheter was associated with a trend towards a lower peritonitis rate than use of single-cuff catheters. This was mostly accounted for by a 54% reduction in \( S. aureus \) peritonitis. Furthermore, there was an era effect for catheter type such that a reduction in the peritonitis rate with the use of double-cuff catheters was only present among patients initiating PD prior to 2001.

Several PD catheter types have been designed in order to try to reduce peritonitis risk. Modifications to the extraperitoneal segment of the catheter (straight versus swan neck) have not led to reductions in peritonitis \([13,17,18,22,25,28,30]\). The data with regard to double-versus single-cuff catheters are limited. The best study to have addressed this question was a small randomized controlled trial of 60 patients in which double-cuff catheters did not reduce the frequency of peritonitis \([16]\). Since peritonitis is a relatively rare event, and since the use of a double-cuff catheter would only be expected to reduce the rate of peritonitis episodes caused by periluminal entry of organisms, it is clear that a large number of patient-years of follow-up might be required to detect such a difference, should one exist. The importance of this issue is evidenced by the fact that, to date, recommending bodies such as the ISPD have not had sufficient data on which to base firm recommendations as to the optimal catheter type for prevention of peritonitis \([19,26]\).

In this large observational study, the use of double-cuff catheters was associated with a trend towards a lower peritonitis rate than use of single-cuff catheters. This was mostly accounted for by a 54% reduction in \( S. aureus \) peritonitis. Furthermore, there was an era effect for catheter type such that a reduction in the peritonitis rate with the use of double-cuff catheters was only present among patients initiating PD prior to 2001.

Several PD catheter types have been designed in order to try to reduce peritonitis risk. Modifications to the extraperitoneal segment of the catheter (straight versus swan neck) have not led to reductions in peritonitis \([13,17,18,22,25,28,30]\). The data with regard to double-versus single-cuff catheters are limited. The best study to have addressed this question was a small randomized controlled trial of 60 patients in which double-cuff catheters did not reduce the frequency of peritonitis \([16]\). Since peritonitis is a relatively rare event, and since the use of a double-cuff catheter would only be expected to reduce the rate of peritonitis episodes caused by periluminal entry of organisms, it is clear that a large number of patient-years of follow-up might be required to detect such a difference, should one exist. The importance of this issue is evidenced by the fact that, to date, recommending bodies such as the ISPD have not had sufficient data on which to base firm recommendations as to the optimal catheter type for prevention of peritonitis \([19,26]\).
Table 4. Absolute peritonitis rates for several organism categories, stratified by era

<table>
<thead>
<tr>
<th>Organism Category</th>
<th>Overall peritonitis rate</th>
<th>Peritonitis rate by era</th>
</tr>
</thead>
<tbody>
<tr>
<td>All organisms</td>
<td>0.364 (1 in 33 p-m)</td>
<td>0.0414 (1 in 29 p-m)</td>
</tr>
<tr>
<td>Gram positive</td>
<td>0.185 (1 in 65 p-m)</td>
<td>0.216 (1 in 56 p-m)</td>
</tr>
<tr>
<td>Gram negative</td>
<td>0.068 (1 in 178 p-m)</td>
<td>0.073 (1 in 163 p-m)</td>
</tr>
<tr>
<td>Culture negative</td>
<td>0.080 (1 in 150 p-m)</td>
<td>0.083 (1 in 144 p-m)</td>
</tr>
<tr>
<td>CNS</td>
<td>0.095 (1 in 126 p-m)</td>
<td>0.115 (1 in 104 p-m)</td>
</tr>
<tr>
<td>S. aureus</td>
<td>0.027 (1 in 452 p-m)</td>
<td>0.034 (1 in 355 p-m)</td>
</tr>
<tr>
<td>Streptococcus</td>
<td>0.036 (1 in 332 p-m)</td>
<td>0.040 (1 in 299 p-m)</td>
</tr>
</tbody>
</table>

Table 5. Association between the number of catheter cuffs and peritonitis rate by era of PD initiation

<table>
<thead>
<tr>
<th>Rate ratio (per decade increase in age)</th>
<th>95% CI</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall (n = 4247 patients)</td>
<td>0.90</td>
<td>0.80–1.02</td>
</tr>
<tr>
<td>1996–2000 (n = 1494 patients)</td>
<td>0.82</td>
<td>0.71–0.96</td>
</tr>
<tr>
<td>2001–2005 (n = 2753 patients)</td>
<td>1.04</td>
<td>0.90–1.21</td>
</tr>
</tbody>
</table>

large reduction in peritonitis caused by the organism most likely to enter the peritoneal cavity via migration along the catheter tunnel supports the hypothesis that double-cuff catheters provide an added barrier to periluminal movement of organisms into the peritoneal cavity. It is noteworthy that there was a trend towards a reduction in CNS peritonitis with double-cuff catheters that did not reach statistical significance. While CNS can cause peritonitis by periluminal migration of organisms, it is also the most frequent organism-causing peritonitis by touch contamination. As a result, it is not surprising that use of double-cuff catheters did not have a major impact on the CNS peritonitis rate.

We identified an interaction between the era in which a patient initiated PD and the catheter type, such that double-cuff catheters were associated with a reduction in the overall peritonitis rate among those who initiated PD between 1996 and 2000, but not among those who initiated PD between 2001 and 2005. We hypothesize that the widespread adoption of prophylactic exit-site and intranasal ointments in the more contemporary era may have reduced exit-site colonization and infection sufficiently that it obviated the need for protection offered by the second catheter cuff. In other words, it is possible that the benefit of a double cuff is particularly important among patients who have not received prophylactic ointments that are known to reduce S. aureus colonization and infection. Given that compliance with prophylactic ointments is variable [27], having the added protection of a double-cuff catheter may be advantageous, especially among diabetic and immunosuppressed patients in whom the risk of S. aureus catheter infection is higher [33].

Our study has several limitations. As with most large datasets, the data have not been validated against patient charts. As a result, we have adjusted only for those variables that were most likely to have complete and accurate data entry. An important limitation is the lack of data on prophylactic ointment regimens used at the various centres. As a result, we can only speculate that the loss of an association between double- versus single-cuff catheters and peritonitis among patients initiating dialysis after the year 2000 is due the widespread adoption of prophylactic exit-site and intranasal ointment strategies. We also did not have access to data on S. aureus nasal carriage, which is known to be associated with a higher risk of subsequent S. aureus exit-site infection and peritonitis [12,21]. Finally, of major importance, since some of the centres used either single- or double-cuff catheter almost exclusively, we cannot rule out a centre effect. While we adjusted for several variables that may have differed across centres, we could not adjust for other potentially important variables such as differential use of prophylactic ointments across sites.

In conclusion, in this large observational cohort study, use of a double- versus single-cuff catheter was associated with a trend towards a lower peritonitis rate. This was accounted for by a 54% reduction in peritonitis caused by S. aureus. The loss of the association between cuff number and peritonitis among patients initiating PD after the year 2000 may relate to changes in exit-site care that reduce the bacterial burden available for periluminal migration into the peritoneal cavity.

Acknowledgements. S.J.N. is the recipient of a Kidney Foundation of Canada Research Fellowship award. The authors would like to thank Dr. Rosane Nisenbaum for statistical support, as well as nursing and administrative staff involved in data entry and maintenance of the POET database.

Conflict of interest statement. S.J.N. and J.M.B. have received speaker honoraria from Baxter Healthcare. S.V.J. has held an investigator-driven grant from OrthoBiotec, has received speaker and consulting fees from Amgen Canada and OrthoBiotec and has received speaker fees from Pfizer within the last 5 years. The results presented in this paper have not been published previously in whole or part, except in abstract format.

References


Received for publication: 14.8.09; Accepted in revised form: 4.1.10