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*Original Article*

# Technical survival of CAPD catheters: comparison between percutaneous and conventional surgical placement techniques

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**Abstract**

**Background.** Percutaneous peritoneal dialysis catheter (PDC) placement is a well-tolerated, rapidly performed bedside procedure that allows a rapid initiation of CAPD. We compared the technical survival of PDCs while comparing the mode of insertion.

**Methods.** We retrospectively reviewed 215 PDCs inserted over a 60-month period in 191 patients on CAPD therapy. Of these, 133 were placed percutaneously by nephrology staff (group P) and 82 were placed using conventional surgical techniques by surgical staff (group S). The total experience accumulated was 4000 patient-months: 2260 patient-months in group P and 1740 patient-months in group S.

**Results.** The incidence of complications in PDCs did not differ between the groups (1 episode/33 patient-months in group P and 1 episode/29 patient-months in group S). Two episodes of early leakage and 9 episodes of late leakage were observed in group P compared with one early leakage and 4 episodes of late leakage in group S. Of the mechanical complications in group P, 8.86% were due to catheter malfunction, including catheter tip migration and obstruction, compared with 12.63% in group S. The incidence of catheter infections was 1 episode/73 patient-months in group P and 1 episode/62 patient-months in group S. Significantly more catheters were removed in group S compared with group P (40% *vs* 16%, $P<0.001$). One-year and 2-year technical survivals were 90% and 82% in group P, and 73% and 60% in group S ($P=0.0032$), respectively.

**Conclusions.** Percutaneous bedside placement of PDCs by nephrologists provides a safe and reliable access for peritoneal dialysis.

**Keywords:** CAPD; methods of insertion; peritoneal dialysis catheters; technical survival

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## Introduction

Continuous ambulatory peritoneal dialysis (CAPD) is an established form of renal replacement therapy for patients with end-stage renal disease (ESRD). The key to successful peritoneal dialysis is permanent and safe access to the peritoneal cavity. Percutaneous peritoneal dialysis catheter (PDC) placement is a well-tolerated, rapidly performed bedside procedure that allows a rapid initiation of CAPD and avoids the necessity for operating room time and the requirement for a large peritoneal incision. Most published studies have reported results from surgically placed PDCs while only a few have evaluated percutaneously placed PDCs. We retrospectively reviewed PDCs inserted by the percutaneous and surgical methods in our institution from April 1994 to April 1999, and compared clinical outcomes up to September 1999, to evaluate the potential difference in the technical survival of these catheters. Furthermore, we compared our results with data from major reports on catheter survival for both surgically and percutaneously placed PDCs with the intent of re-examining the role of the percutaneous placement technique in providing peritoneal access for CAPD.

## Subjects and methods

A total of 215 permanent PDCs was placed into 191 patients with ESRD from April 1994 to April 1999 in our University Hospital-based CAPD centre. Of these, 133 PDCs were placed percutaneously by nephrology staff (group P) and 82 were placed using conventional surgical techniques by surgical staff (group S). Patients with previous abdominal surgery or severe liver disease were not considered for CAPD therapy. The majority of the surgically-placed catheters were placed between 1994 and 1996, and most of the percutaneously-placed catheters were placed from 1996 by nephrology staff. Only patients who refused placement under local anaesthesia were referred to surgery. Patient selection for percutaneous or surgical placement was not randomized, prospective, or controlled.

All catheters were evaluated for mechanical and infectious complications, and the overall technical survival was

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analysed separately in regard to insertion technique. If a patient required catheter replacement, the second catheter was analysed as a separate event. We used double-cuffed Tenckhoff catheters with straight or coiled tips (Quinton Instrument Company, Seattle, WA, USA). Straight catheters were used mostly during the first two years, whereas the majority of PDCs after 1996 had coiled tips.

### *Catheter insertion*

Surgical insertions (placement by dissection) were performed generally by using the paramedian or lateral approach [1]. The ratio specialist/non-specialist was the same in the surgery and nephrology teams and all procedures were performed in the presence of at least one attending physician-specialist.

The majority of placements from 1996 to 1997 were performed percutaneously by nephrology staff using similar methods under local anaesthesia. We used blind placement based on the Seldinger technique [2]. All procedures were carried out under strict aseptic conditions, with parenteral sedation and local anaesthesia. Using a 16-gauge lumbar puncture needle, 2 l of dialysis solution was infused into the peritoneal space by puncture at the midline 1–2 cm below the umbilicus, approximately 1 h prior to procedure. All patients received intravenous midazolam and local anaesthesia (1% lignocaine). A 3-cm paramedian incision was made, followed by blunt dissection of the subcutaneous tissue until the fascia of the rectus muscle was reached. The peritoneum was punctured using a 16-gauge needle from the Quinton-catheter placement kit. A Cook peel-away sheath and introducer were inserted over a guide-wire. The guide was introduced only after the previously administered dialysis solution appeared in the needle. The introducer was removed leaving the guide-wire and the peel-away sheath *in situ*. The PDC was advanced through the peel-away sheath over the guide-wire and directed caudally toward the left iliac fossa. The guide-wire was then removed and the peel-away sheath was split. The inner cuff of PDC was secured by suture on the fascia of the rectus muscle. An 8–12-cm subcutaneous tunnel for the PDC was fashioned by using a hand-made specially designed hook-shaped stylet. The end of the catheter was attached to the stylet and the tip of the hook was pushed through the subcutaneous tissue in a latero-caudal direction to the incision. The proximal end of the PDC was pulled through the exit site and positioned so that the inner cuff was located at the peritoneal entry at the fascia of the rectus muscle and the second cuff was more than 3 cm from the exit site. The original incision was then closed and the PDC was flushed with 2 l of heparinized 1.36% dialysis solution to confirm catheter patency and to check for intra-abdominal bleeding. The line was then capped-off unless there was significant blood staining of the effluent. If the latter occurred, hourly cycles were continued until the drained dialysate was clear.

Antibiotic prophylaxis was given with first-generation cephalosporin antibiotics administrated intravenously 2 h prior to the procedure. CAPD was generally instituted 2 weeks after PDC placement. Patient training was performed during this period. Low volume exchanges (up to 250 ml) were periodically performed during training and patients were instructed to avoid constipation.

### *Definition of complications*

We defined mechanical complications as those that were not infectious complications related to the catheter (including peritonitis, exit-site infection and tunnel infection), and those that were neither medical nor psychosocial [3]. Mechanical complications were classified further according to aetiology into the following categories: those related to the insertion procedure, those related to the presence of dialysate in peritoneum, catheter-related malfunction, problems secondary to abdominal events, catheter accidents, and cuff extrusion [3].

Infectious complications related to PDC (later referred to as 'catheter infections') were exit-site infection, tunnel infection and peritonitis. An exit-site infection was defined as pericatheter erythema and/or drainage. Any subsequent exit-site infections were considered to be new infections if patients had not taken antibiotics in the previous 2 weeks, and if the exit site had been examined in the interval and was found to be normal. A peritoneal catheter tunnel infection was defined as erythema, oedema and/or tenderness over the subcutaneous catheter pathway. Cases of simultaneous exit-site and tunnel infections were recorded as a single catheter infection. Peritonitis was considered to be related to catheter infection (exit site and/or tunnel infection) if (1) the two infections occurred simultaneously or (2) peritonitis followed the catheter infection within 2 weeks of antibiotic therapy. Moreover, the organisms cultured from the infections had to be the same, or one or both cultures had to be sterile.

We also distinguished between early complications (occurring within 1 month of commencing PDC) and late complications (occurring more than 1 month after PDC).

### *Removal of catheters*

Only removals related to either mechanical or infectious complications of PDC were included in the analysis of catheter survival. Reasons for PDC removal were intractable peritonitis that did not resolve after 5–10 days of appropriate antibiotic therapy, persistent catheter infection that did not resolve after multiple (at least two) courses of antibiotic therapy, catheter infection associated with peritonitis that did not respond to antibiotic therapy and fungal peritonitis. Catheters removed for other reasons including, transplantation, death unrelated to peritoneal dialysis complications and patient decision, were not included in the analysis for technical survival of PDC but were analysed in the outcome section.

### *Statistical analysis*

Categorical values are presented in tables as number of cases with the percentage of cases given in parentheses. Continuous variables are presented as means ± standard deviation (SD). Chi-square analysis with Yates' correction and, when indicated, Fischer exact tests were used for the analysis of categorical variables. Continuous variables between two groups were analysed by unpaired Student's $t$ tests. PDC-related mechanical and infectious complication rates were calculated as total number of events for all patients in a group divided by total time on CAPD, and are expressed as episodes/patient-months. With the assumption that the number of events follows a Poisson distribution, the rates were compared using two-tailed z tests. Product-limit Kaplan-Meier estimation of technical survival functions was computed for PDCs inserted either percutaneously (group P) or surgically (group S) as well as for all catheters together. Catheter survival was calculated from the day of insertion to the day of removal. Patients were excluded if they had catheter removal due to successful transplantation, transfer to haemodialysis due to inadequate CAPD or death from concurrent disease with functioning catheter. An identical analysis was performed to compare peritonitis-free and catheter infection-free survival between PDCs placed either surgically or percutaneously. The Breslow-Gehan log-rank test was used to compare the survival curves. The null hypothesis was rejected at a two-tailed $P < 0.05$.

## Results

The data from 215 PDCs inserted over a 60-month period in 191 patients on CAPD therapy are presented in Table 1. There were no differences in age, sex, duration of follow-up or number of diabetic patients between the two groups. Straight catheters were used significantly more in group S compared with group P ($P < 0.001$) (Table 1).

The incidence of complications related to PDCs did not differ between the groups (1 episode/33 patient-months in group P, 1 episode/29 patient-months in group S and 1 episode/31 patient-months when analysing all catheters) (Table 2). Mechanical complications accounted for more than 50% of all complications for both groups and when analysing all catheters together. Of all mechanical complications, 47% and 41% were early complications in groups P and S, respectively. Two episodes of early and 9 episodes of late leakage were observed in group P, compared with one early leakage and 4 episodes of late leakage in group S (Table 3). Of mechanical complications in group P, 8.86% were due to catheter malfunction, including catheter tip migration and obstruction, compared with 12.63% in group S (Table 3).

The incidence of catheter infections was 1 episode/73 patient-months in group P and 1 episode/62 patient-months in group S (Table 2). The overall incidence of peritonitis was 1 episode/25 patient-months in group P, 1 episode/17 patient-months in group S, and 1 episode/21 patient-months when analysing all catheters together ($P = 0.01$, Table 4). Peritonitis related to catheter infection accounted for 16% and 14% of all peritonitis episodes in groups P and S, respectively. *Staphylococcus aureus* accounted for the majority of episodes of peritonitis related to catheter infection in both groups. The log-rank analysis revealed that the peritonitis-free period between PDC placement and first peritonitis episode was significantly longer in group P compared with group S (median survival time between PDC placement and first peritonitis episode was 22.7 months and 12.6 months for groups P and S, respectively) ($P = 0.02$). There was no difference in the catheter infection-free period between the two groups.

Significantly more catheters were removed in group S compared with group P (40% *vs* 16%, $P < 0.001$) (Table 5). Catheter infections and intractable and/or fungal peritonitis accounted for 58% of all removed catheters for both groups. The 1-year and 2-year survivals for group P, group S, and all catheters together were 90%, 73%, and 83%, and 82%, 60%, and 72%, respectively. The log-rank analysis of technical survival in regard to insertion technique revealed significantly better survival for percutaneously placed catheters (group P) than for surgically placed PDCs ($P = 0.0032$) (Figure 1). Technical survival of curled PDCs was significantly better than in straight catheters ($\chi^2$ for equivalence of death rates $= 4.73$, $P = 0.029$). There

**Table 1.** Baseline characteristics of CAPD patients and catheters

| | Group P | Group S | *P* value | All catheters |
|---|---|---|---|---|
| Number of catheters | 133 | 82 | | 215 |
| Age (years) | 52 ± 17 | 55 ± 18 | 0.3 | 53 ± 17 |
| Age > 65 years | 40 (30%) | 31 (38%) | | 71 (33%) |
| Male | 74 (56%) | 43 (52%) | 0.75 | 117 (54%) |
| Diabetes | 16 (12%) | 11 (13%) | 0.93 | 27 (13%) |
| Mean duration of follow-up (months)* | 17 ± 12 (1–52) | 21 ± 18 (1–64) | 0.48 | 18 ± 15 (1–64) |
| Cumulative duration of follow-up (patient-months) | 2260 | 1740 | | 4000 |
| Type of catheter | | | | |
| Straight two-cuff | 3 (2%) | 42 (51%)[a] | 0.0001 | 45 (21%) |
| Curled two-cuff | 130 (98%) | 40 (49%) | | 170 (79%) |
| Outcome | | | | |
| Still on CAPD | 89 (67%)[b] | 26 (32%) | 0.0001 | 115 (54%) |
| Death | 23 (17%) | 26 (32%)[c] | 0.02 | 49 (23%) |
| Transplantation | 2 (1%) | 2 (2%) | 0.97 | 4 (2%) |
| Transfer to HD | 6 (5%) | 14 (17%)[d] | 0.0001 | 20 (9%) |
| Catheter replacement | 10 (8%) | 10 (12%)[e] | 0.02 | 20 (9%) |
| Other | 3 (2%) | 4 (5%) | 0.51 | 7 (3%) |

*Range expressed in parentheses.
[a]Yates-corrected $\chi^2 = 70.56$.
[b]Yates-corrected $\chi^2 = 23.88$. Odds ratio = 2.11 (CI = 1.53–3.01).
[c]Yates-corrected $\chi^2 = 5.20$. Odds ratio = 1.83 (CI = 1.13–2.97).
[d]Yates-corrected $\chi^2 = 16.15$. Odds ratio = 5.54 (CI = 2.36–13.09).
[e]Yates-corrected $\chi^2 = 5.21$. Odds ratio = 2.75 (CI = 1.25–5.89).

**Table 2.** Complications related to PDCs

| | Group P | Group S | *P* value | All catheters |
|---|---|---|---|---|
| Total number of catheter-related | 69 (44%) | 60 (58%)[a] | 0.02 | 129 (49%) |
| complication episodes | 1 episode/33 patient-months | 1 episode/29 patient-months | NS | 1 episode/31 patient-months |
| Mechanical complications | 38 (24%) | 32 (31%) | 0.09 | 70 (27%) |
| | 1 episode/59 patient-months | 1 episode/54 patient-months | NS | 1 episode/57 patient-months |
| Early | 18 (12%) | 13 (13%) | 0.43 | 31 (12%) |
| Late | 20 (13%) | 19 (18%) | 0.09 | 39 (15%) |
| Catheters removed | 9 (7%) | 14 (17%)[b] | 0.008 | 26 (12%) |
| Catheter-related infectious | 31 (20%) | 28 (27%) | 0.07 | 59 (23%) |
| complications | 1 episode/73 patient-months | 1 episode/62 patient-months | NS | 1 episode/68 patient-months |
| Early | 5 (3%) | 2 (2%) | 0.84 | 7 (3%) |
| Late | 26 (17%) | 26 (25%)[c] | 0.04 | 52 (20%) |
| Catheters removed | 4 (3%) | 7 (9%)[d] | 0.04 | 11 (5%) |

[a]Yates-corrected $\chi^2 = 4.74$. Odds ratio = 1.33 (CI = 1.04–1.69).
[b]Yates-corrected $\chi^2 = 6.98$. Odds ratio = 2.98 (CI = 1.39–6.44).
[c]Yates-corrected $\chi^2 = 4.12$. Odds ratio = 1.67 (CI = 1.06–2.61).
[d]Two-sided Fisher's exact test.

**Table 3.** Mechanical complications related to PDCs

| | Group P | Group S | *P* value | All catheters |
|---|---|---|---|---|
| Related to the insertion | 7 (4.43%) | 1 (0.97%) | 0.42 | 8 (3.06%) |
| Wound haematoma | 1 | | | 1 |
| Early dialysate leakage | 2 | 1 | | 3 |
| Pericatheter bleeding | 4 | | | 4 |
| Related to the presence of dialysate | 11 (6.96%) | 6 (5.82%) | 0.96 | 17 (6.51%) |
| Hernias | 2 | 2 | | 4 |
| Late leakage (abdominal wall and genitalia) | 9 | 4 | | 13 |
| Catheter-related malfunction | 14 (8.86%) | 14 (12.63%) | 0.12 | 28 (10.73%) |
| Obstruction | 3 | 3 | | 6 |
| Migration | 11 | 11 | | 22 |
| Intra-abdominal pathology | 1 (0.63%) | 4 (3.88%) | 0.08 | 5 (1.53%) |
| Omental rapping | | 2 | | 2 |
| Diverticulitis | 1 | 2 | | 3 |
| Catheter accidents | 1 (0.63%) | 2 (1.94%) | 0.53 | 3 (1.15%) |
| Punctured lines | 1 | 2 | | 3 |
| Cuff extrusion | 4 (2.54%) | 6 (5.82%) | 0.15 | 10 (3.83%) |

were no differences in technical survival for PDCs in terms of sex or age.

## Discussion

The present report suggests that percutaneous insertion of PDCs performed by a nephrology team is a dependable peritoneal access technique and compares favourably with surgical techniques in terms of catheter-related mechanical and infectious complications. Peritoneal dialysis catheter survival depends on several factors, including the mode of insertion, catheter design, and location of the exit site. Although percutaneous insertion has been reported to be a safe method for peritoneal access [2–6], it has not been widely accepted in the nephrology community because of the high incidence of leaks and early mechanical complications, and the potential risk of bowel perforation since the technique is a 'blind' procedure without direct visualization of the peritoneum [7–9]. There have been several reports concerning complications and survival for surgically inserted PDCs [7–16], whereas only a few have considered percutaneously inserted PDCs [2–6,17–19]. To our knowledge, the present report is one of the largest, single-centre studies comparing the performance of PDCs inserted electively, either surgically or percutaneously, for patients with ESRD. A similar report by Mellote *et al.* [18] had a disadvantage in that the group with percutaneously inserted catheters comprised mostly severely ill patients with acute renal failure and had a high mortality.

The principal major complication of percutaneous placement as a 'blind' technique is the risk of inadvertent puncture of the abdominal viscera. However, the very low (0–1.3%) frequency of perforation reported in previous percutaneous studies argues against the magnitude of this complication [2–4,6]. In our study, we had no episode of bowel perforation despite the

**Table 4.** Characteristics of catheter infections and all peritonitis episodes

| | Group P | Group S | *P* value | All catheters |
|---|---|---|---|---|
| Number of catheter infection episodes | | | | |
| None | 113 (85%) | 63 (76%) | 0.15 | 176 (82%) |
| 1 episode | 14 (11%) | 13 (16%) | 0.30 | 27 (12%) |
| 2 episodes | 3 (2%) | 3 (4%) | 0.66 | 6 (3%) |
| 3+ episodes | 3 (2%) | 3 (4%) | 0.66 | 6 (3%) |
| Exit-site infection[a] | 9 (5.7%) | 6 (5.8%) | 0.77 | 15 (5.7%) |
| Tunnel infection[b] | 7 (4.4%) | 10 (9.7%) | 0.06 | 17 (6.5%) |
| Peritonitis related to catheter infection[c] | 15 (9.5%) | 12 (11.6%) | 0.33 | 27 (10.3%) |
| Total number of peritonitis episodes[d] | 90 | 100 | | 190 |
| | 1 episode/25 patient-months | 1 episode/17 patient-months | 0.01 (z = 2.56) | 1 episode/21 patient-months |
| Number of peritonitis episodes | | | | |
| No peritonitis | 80 (60%) | 33 (40%)[e] | 0.007 | 113 |
| 1 episode | 29 (22%) | 22 (27%) | 0.11 | 51 |
| 2 episodes | 15 (11%) | 12 (15%) | 0.72 | 27 |
| 3+ episodes | 9 (7%) | 15 (18%)[f] | 0.004 | 24 |
| Organism characteristics[g] | | | | |
| One Gram-positive[h] | 45 | 38 | | 41 |
| One Gram-negative[i] | 14 | 14 | | 14 |
| Gram-positive + Gram-negative | 1 | 2 | | 2 |
| Multiple Gram-negative | | 1 | | <1 |
| Fungus | 2 | 6 | | 4 |
| Gram-negative + fungus | 1 | | | <1 |
| Gram-positive + fungus | | 3 | | 2 |
| TBC | 1 | 1 | | 1 |
| Culture-negative | 36 | 35 | | 35 |

[a] *Staphylococcus aureus* accounted for 33% and 10% of all episodes in groups S and P, respectively. 67% and 89% of all episodes were culture-negative in groups S and P, respectively.
[b] *Staphylococcus aureus* accounted for 30% and 28% of all episodes in groups S and P, respectively. 60% and 43% of all episodes were culture-negative in groups S and P, respectively.
[c] *Staphylococcus aureus* accounted for 50% and 80% of all episodes in groups S and P, respectively. 33% and 7% of all episodes were culture-negative in groups S and P, respectively.
[d] All peritonitis episodes, including peritonitis episodes related to catheter infections were analysed.
[e] Yates-corrected $\chi^2 = 7.28$. Odds ratio = 0.45 (CI = 0.25–0.78).
[f] Yates-corrected $\chi^2 = 8.24$. Odds ratio = 4.04 (CI = 1.61–10.14).
[g] Percentage of all episodes.
[h] *Staphylococcus epidermidis*-like organisms accounted for 13% and 38% of the Gram-positives in groups S and P; *S. aureus*, 68% and 47%; *Enterococcus*, 5% and 10%, respectively.
[i] *Pseudomonus* accounted for 57% and 14% of the Gram-negative peritonitis episodes in groups S and P, respectively.

**Table 5.** Indications for the removal of PDCs

| | Group P | Group S | *P* value | All catheters |
|---|---|---|---|---|
| Infectious reasons | 12 (9%) | 19 (23%)[a] | 0.002 | 31 (14%) |
| Catheter-related infections | 4 (3%) | 7 (8%) | | 11 (5%) |
| Intractable peritonitis/fungal peritonitis | 8 (6%) | 12 (15%) | | 20 (9%) |
| Mechanical reasons | 9 (7%) | 14 (17%)[b] | 0.008 | 23 (11%) |
| Total | 21 (16%) | 33 (40%)[c] | 0.0001 | 54 (25%) |

[a] Yates-corrected $\chi^2 = 9.51$. Odds ratio = 2.88 (CI = 1.55–5.53).
[b] Yates-corrected $\chi^2 = 6.98$. Odds ratio = 2.98 (CI = 1.39–6.44).
[c] Yates-corrected $\chi^2 = 14.85$. Odds ratio = 2.55 (CI = 1.60–4.08).

large number of PDCs placed in the percutaneous group. The risk of viscus perforation or incorrect placement might be reduced by the installation of dialysis solution prior to needle insertion and by avoiding forceful insertion, as has been reported previously [3] and was supported by the present results. In addition, the avoidance of trocar or stylet use in our percutaneous technique might have aided in avoiding this complication.

Although mechanical complications are still the major cause of catheter removal in both surgical and percutaneous techniques, there was no significant difference in the rate of mechanical complications related to catheter insertion between the two groups. Delaying catheter use for 10–14 days after placement, using low initial exchanges, and avoiding frequent dressing of the exit site and incision following catheter placement may explain the remarkably low incidence of wound

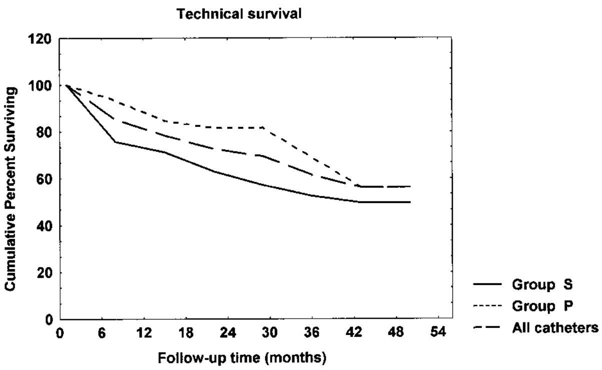


**Fig. 1.** Technical survival for PDCs in regard to placement technique. Group P, percutaneously placed PDCs; Group S, PDCs placed by surgical technique; All catheters, all PDCs regardless of insertion technique. $\chi^2$ for equivalence of death rates = 8.7, $P = 0.0032$.

infection and early leakage observed in the group of percutaneously placed catheters. These observations have been noted by others [3,20]. Early leakage was present in only 0.7% of percutaneously inserted catheters in our study. Among percutaneously placed PDCs, early leakage has varied from 2.6% to 22% [3,6,18,19]. Moreiras *et al.* [3] reported that 15.3% of their mechanical complications were related to the insertion and 6% to early leakage. In the study of Smith *et al.* [4], the most common early complication was leakage (13%) and bleeding that rapidly resolved with repeated exchanges (2/31 catheters). Allon *et al.* [6] reported that 19 of 154 percutaneously placed catheters had early complications, and early leakage was observed in 2.6%. Swartz *et al.* [19] reported early leakage to be as high as 21.6%. Reports of leakage from surgical studies vary between 0.9% and 8.6% [7,8,11,13]. A low incidence of leakage in our percutaneous group was probably due to the lateral placement of the inner cuff and good fixation in the rectus muscle using a paramedian incision, as was described by others [9,12,14]. In addition, we avoided using any forceful action during catheter insertion.

The incidence of late leakage among our surgically and percutaneously placed catheters was low compared to the incidence of late leakage in the literature, which ranges from 6.6 to 24% [3,7,8,19].

Catheter-related malfunction causing drainage failure may arise following obstruction of the catheter or migration of the catheter tip from the pelvis into the upper abdomen. The incidence of catheter-related malfunction in the literature varies from 0.9% to 17% for surgical [7–16] and 4% to 21% for percutaneous studies [2–6,17–19]. Although it has been argued that surgical catheter placement is preferable to percutaneous placement because of the direct visualization during positioning [21], several studies have shown that there is no advantage for surgical placement in regard to catheter-related malfunction [6,22]. Our data support this view, since we found no significant difference in the incidence of catheter-related malfunction between percutaneously and surgically placed catheters (8.86% in group P *vs* 12.63% in group S). In accord with Moreiras *et al.* [3], the practice of leaving a low volume of dialysis solution with heparin after catheter insertion and the periodic performance of low volume exchanges during the first two weeks after insertion (up to 250 ml), together with strict instructions to avoid constipation may explain this low incidence. However, the low incidence of catheter-related malfunction in group P may be explained in part by the almost uniform use of curled catheters in this group. Several studies have reported a higher incidence of catheter tip migration and catheter-related malfunction with straight Tenckhoff catheters compared with curled PDCs [5,6], although Akyol *et al.* [23] were unable to demonstrate any advantage of curled PDCs over the straight type in their prospective, randomized, double-blind study.

Very few reports discuss details related to the incidence of infectious complications in PDCs. Infectious complications have been reported repeatedly as the major reason for catheter removal for both surgically and percutaneously placed catheters [11,16,19]. In our experience, there was no difference in the rate of catheter infections between percutaneously and surgically inserted PDCs (1/73 patient-months *vs* 1/62 patient-months in groups P and S, respectively). On the other hand, the overall incidence of peritonitis was significantly lower in group P compared with group S (1/25 *vs* 1/17, respectively). Significantly fewer PDCs were removed following infections in the percutaneous group (9% and 23% in groups P and S, respectively). Catheter infection-related peritonitis accounted for 16% of all peritonitis episodes in the percutaneous group, which is similar to the incidence in the Network 9-study [11].

We believe that this difference is due to several factors. The majority of the PDCs in the surgical group were placed before 1996, and it is well known that catheters tend to survive better over time [19]. The use of prophylactic antibiotics before catheter insertion and a downward-directed tunnel are additional factors that may explain the lower incidence of infectious complications as reported in the Network 9-study [11]. In our opinion, the use of education and rigorous training on the proper performance of exchanges employed in our institution is another important factor that reduced the infection rate. In addition, the percentage of ESRD patients beginning renal replacement therapy with CAPD is about 50% in our institution. The large number of new patients contributes to the high number of annually placed PDCs, subsequently increasing the experience of our nephrology team, which we believe is another crucial factor determining the technical survival of catheters.

The technical survival of 90% at 1-year for percutaneously placed PDCs was significantly better than in the surgical group (82% at 1-year). It is comparable to most of the recent reports on survival for both surgical and percutaneous methods [7–19]. On the other hand, technical survival for curled catheters was significantly better than for straight catheters. Since the majority of catheters were straight in the surgical group, these two factors might be additive in determining the technical survival of surgically placed PDCs. It is difficult to assess the importance of each of these parameters for technical survival of PDCs based solely on the results of this study. The retrospective nature of our study as well as the fact that a majority of surgical catheters were placed before 1996 should preclude any conclusions about the superiority of the percutaneous insertion technique. However, we believe that this large study of percutaneously placed PDCs clearly demonstrates that, in the hands of experienced nephrologists and CAPD nurses, with proper education and training of CAPD patients, the percutaneous technique is a reliable, safe, and cost-effective method for the placement of PDCs.

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