Peritoneal Dialysis International, Vol. 35, pp. 576–585
doi: 10.3747/pdi.2013.00003

0896-8608/15 $3.00 + .00

COMPARISON OF PERCUTANEOUS AND OPEN SURGICAL TECHNIQUES FOR FIRST-TIME PERITONEAL DIALYSIS CATHETER PLACEMENT IN THE UNBREACHED PERITONEUM

Samar Medani,[1] Wael Hussein,[1] Mohamed Shantier,[1] Robert Flynn,[2] Catherine Wall,[1] and George Mellotte[1]

Nephrology,[1] Adelaide & Meath Hospital; and Urology,[2] Adelaide & Meath Hospital, Dublin, Ireland

♦ ***Background:*** **The percutaneous Seldinger method of peritoneal dialysis catheter (PDC) insertion has gained favor over recent years whereas traditionally it was reserved for patients considered not fit for general anesthesia. This blind technique is believed to be less safe, and is hence avoided in patients with previous laparotomy incisions. Reports on the success of this method may therefore be criticized for selection bias. In those with no prior abdominal surgery the optimal method of insertion has not been established.**

♦ ***Methods:*** **We retrospectively reviewed the outcomes of first-time PDC placements comparing the percutaneous (group P) and surgical (group S) insertion techniques in patients without a history of previous abdominal surgery in a single center between January 2003 and June 2010. We assessed catheter survival at 3 and 12 months post-insertion and compared complication rates between the two groups.**

♦ ***Results:*** **A total of 63 percutaneous and 64 surgical catheter insertions were analyzed. No significant difference was noted in catheter survival rates between group P and group S (86.2% vs 80% at 3 months, $p = 0.37$; and 78.3% vs 71.2% at 12 months, $p = 0.42$ respectively). Early and overall peritonitis rates were similar (5% vs 5.3%; $p = 1$, and 3.5 vs 4.9 episodes per 100 patient-months; $p = 0.13$ for group P and group S respectively). There were also no significant differences between the two groups in exit site leaks (15.9% in group P vs 6.3% in group S; $p = 0.15$), poor initial drainage (9.5% in group P vs 10.9% in group S, $p = 0.34$) or secondary drainage failure (7.9% in group P vs 18.8% in group S, $p = 0.09$).**

♦ ***Conclusion:*** **This study illustrates the success and safety of percutaneous PDC insertion compared with the open surgical technique in PD naive patients without a history of prior abdominal surgery. Catheter survival was favorable with percutaneous insertion in this low-risk patient population but larger prospective studies may help to determine whether either method is superior. The percutaneous technique can be recommended as a minimally invasive, cost-effective procedure that facilitates implementing an integrated care model in nephrology practice.**

Perit Dial Int **2015; 35(5):576–585 www.PDIConnect.com**
epub ahead of print: 31 Jul 2014 doi:10.3747/pdi.2013.00003

KEY WORDS: PD catheter; percutaneous insertion; surgical insertion; catheter survival; abdominal surgery.

A successful PD program requires efficiency in peritoneal dialysis catheter (PDC) placement as a key aspect of its development (1). Surgical insertion via minimal laparotomy remains the most common technique of PDC placement (2–4), and in the United States, laparoscopic insertions account for at least a quarter of total PD access procedures (5). However, previous studies have shown encouraging outcomes of percutaneous insertion of PDCs, demonstrating favorable catheter survival and a good safety profile (6–16). There are few specific indications to recommend one technique over the other. The blind percutaneous method is considered less safe in patients who had undergone prior abdominal surgery, but even in patients with an unbreached peritoneum this technique remains less common. The advantages of percutaneous placement of PDCs under local anesthesia include ease of insertion as a bedside intervention and faster recovery. In particular, avoidance of general anesthesia, potentially shorter hospital stays and cost effectiveness are important considerations. Visceral injury, the major concern as a potential complication of this technique, is uncommon. We previously reported a comparative analysis of surgical versus percutaneous insertion of PDCs showing a trend towards better outcomes in the percutaneous group (8). We pointed out that potentially significant bias imposed by avoidance of the percutaneous method in a majority of the patients who had prior abdominal surgery is a major limitation of the study, as pre-existing adhesions in those patients selected for the surgical technique may have affected

Correspondence to: Dr. Samar Medani, C/O Professor George Mellotte, Department of Nephrology, Adelaide & Meath Hospital, Dublin 24, Ireland.
smedani@doctors.org.uk
Received 4 January 2013; accepted 2 March 2014.

catheter function and hence outcomes. We therefore carried out a separate analysis of the subpopulation of patients from our previous study whose catheters were inserted from January 2003 to June 2010 and who had no prior abdominal surgery or PDC insertion to elucidate the effect of eliminating this particular selection bias on the measured outcomes. To our knowledge, no previous study has compared the two implantation techniques, percutaneous and open surgical insertion, exclusively in patients without prior laparotomy or PDC placement.

SUBJECTS AND METHODS

This is a retrospective analysis of all first-time PDC insertions between January 2003 and June 2010 in patients without prior abdominal surgery in our center. We reviewed the medical records of these patients for clinical data and used the hospital's laboratory database to confirm peritonitis episodes. All catheter insertions were carried out using the surgical mini-laparotomy technique or the bedside percutaneous Seldinger method. The selection of patients for either procedure was generally based on the nephrologists' practices and operator availability unless, occasionally, patient choice and/or frailty dictated otherwise. During the study period, one of three nephrologists at our center practiced the percutaneous method of insertion routinely in the majority of his/her eligible patients, a second nephrologist inserted PDCs percutaneously but less frequently (a third of his/her patients who were included in this study), and a third nephrologist referred suitable patients for surgical or percutaneous insertion depending on operator availability and the majority of these had their catheters inserted surgically by urology colleagues.

Curled double-cuffed Tenckhoff catheters were used for both the surgical and percutaneous techniques. Written consent was obtained and preoperative blood tests performed including a full blood count, coagulation screen and group and save. Piperacillin-tazobactam 4.5 g (or vancomycin in case of penicillin allergy) was administered intravenously one hour prior to the procedure. Patients with a *Staphylococcus*-positive nasal swab result or those for whom a swab result was not available used Mupirocin 2% nasal ointment. Patients were instructed to wash the whole body with Hibiscrub (Chlorhexidine Gluconate 40mg/mL) and to empty their bladder immediately prior to the procedure. A urinary catheter was rarely necessary. Laxatives were used as required to ensure patients had a bowel movement on the day of the procedure.

Surgical insertion was carried out under general anesthesia by a consultant urologist or by trainees under consultant supervision. A 5-cm sub-umbilical midline skin incision was made. After dissection of the subcutaneous layer and incision of the linea alba, the peritoneum was incised to enter the peritoneal cavity. With the aid of an introducer, the Tenckhoff catheter was positioned in the pelvic cavity. A 50-mL heparinised saline solution was flushed into the abdominal cavity to test flow. The inner cuff was fixed to the external surface of the peritoneum by a purse string suture and the catheter was tunneled through the subcutaneous tissue leaving the outer cuff buried 2 cm from the exit site. The linea alba and subcutaneous layer were closed with polyglactin 910 suture and the skin closed with subcutaneous sutures.

Percutaneous insertion was carried out in a dedicated procedure room in the renal ward. The procedure was performed by a consultant nephrologist, or, occasionally, by nephrology trainees under consultant supervision. Oral diazepam 10 mg and dihydrocodeine (DF11) 60 mg were administered as premedication. A 2-cm midline incision, 3 cm below the umbilicus, was made under aseptic conditions after local anesthetic infiltration, followed by blunt dissection of the subcutaneous tissue down to the linea alba and 5 cm to the left to create a subcutaneous tunnel for the catheter. The peritoneum was then punctured with a 16 gauge needle attached to a 10-mL syringe filled with normal saline and advanced firmly with care through the linea alba into the peritoneal cavity in a direction perpendicular to the abdominal wall. Needle position was confirmed with a saline flush. The syringe was then removed and a guide wire passed through the needle directed downwards into the left iliac fossa. The needle was then removed and a peel-away sheath with an introducer was inserted over the guide wire. The guide wire and introducer were removed leaving the peel away sheath in situ. The PDC was straightened using a metal stylet then advanced though the peel away sheath directed caudally and posteriorly. When the PDC was fully inserted as far as the inner cuff would allow the stylet was removed and the peel away sheath was pulled apart. With the aid of a tunneling tool attached to the other end of the Tenckhoff catheter, the extraperitoneal portion of the catheter was then tunneled subcutaneously towards the previously marked exit site, with the external cuff being positioned in the middle of the tunnel. A 0.5 cm incision was made to facilitate the tunneling tool piercing the epidermis at the exit site through which the PDC is pulled out. The midline incision site was sutured with a stitch. The tunneling tool was detached from the end of the Tenckhoff catheter and a titanium adapter and transfer set applied. The peritoneal cavity was flushed with three 500-mL exchanges to ensure catheter patency and then drained out and left dry.

Peritonitis episodes were identified by documented clinical history and confirmed by laboratory data (dialysate white cell count more than 100/mm³ and/or a positive effluent culture). We recorded rates of positive exit swab cultures using the same laboratory database. Primary failure was defined as failure to advance the guide wire or flush the PD catheter immediately after insertion. Poor initial drainage and secondary drainage failure were defined as drainage failure resulting in catheter manipulation, replacement or discontinuation of PD within and after 48 hours of commencing PD exchanges respectively.

Outcomes at 3 and 12 months post catheter insertion and overall complication rates were retrospectively studied and compared. Catheter outcomes are end points of catheter use analyzed at 3 and 12 months post catheter insertion and include patient-related events (death, transplantation, and transfer to hemodialysis (HD) due to ultrafiltration failure, poor clearance or patient choice) as well as transfer to HD due to mechanical or infectious complications of the PDC, catheter replacement or ongoing catheter use. Catheter survival analysis was carried out, censoring for all events leading to discontinuation of PDC use other than mechanical and infectious complications of the catheter. We analyzed complications related to PD following catheter placement until June 2011 or until discontinuation of PD.

STATISTICAL ANALYSIS

Mean and standard deviations or median and interquartile ranges were calculated for continuous parametric and non-parametric data respectively. We reported frequencies for categorical data. For group comparisons, we used the Student *t*-test, Mann-Whitney test, and Chi-square test (Pearson or Fisher's exact test) as appropriate. For rates, we calculated rate ratios with 95% confidence intervals. We used Kaplan-Meier curves to compare catheter survival in the two groups for the first 12 months after catheter insertion. Statistical analysis was carried out using SPSS Statistics Package version 15.0 (SPSS Inc. Chicago, IL, USA).

RESULTS

Between January 2003 and June 2010, 151 PDCs were inserted by the surgical technique and 71 catheters (32%) were inserted percutaneouly. Ninety-five catheter insertions in patients with previous abdominal surgery or prior PDC insertion were excluded (87 were surgical and 8 were percutaneous insertions). Thus there were a total of 127 first-time PDC insertions in patients without a history of prior abdominal surgery in our center. Sixty-four of these were inserted using the percutaneous Seldinger technique and 63 were inserted using the conventional surgical method. Baseline characteristics of the two groups are shown in Table 1. There were significantly more patients with polycystic kidney disease in the surgical insertion

TABLE 1
Baseline Characteristics of the Surgical (S) and Percutaneous (P) Peritoneal Dialysis Catheter (PDC) Insertion Groups

Characteristic	Placement technique Surgical	Percutaneous	Total	*P* Value
Catheters (*n*)	64	63	127	
Mean age (years)[a]	49.39 (16.4)	51.06 (16.0)		0.56
Age >70 years [*n* (%)]	8 (12.5)	9 (14.3)	17 (13.4)	0.80
Female gender [*n* (%)]	23 (35.9)	18 (25.9)	41 (32.3)	0.45
Ethnic minority [*n* (%)]	5 (7.8)	2 (3.2)	7 (5.5)	0.44
Diabetic nephropathy [*n* (%)]	11 (17.2)	13 (20.6)	24 (18.9)	0.65
Polycystic kidney disease [*n* (%)]	9 (14.1)	1 (1.6)	10 (7.9)	0.02
Body mass index[a] (BMI)	26.1(4.6)	25.4 (3.7)		0.36
Baseline eGFR[a]	7.9 (3.2)	7.8 (4.1)		0.90
Median duration of follow-up (months)[b]	17.62 (14.5)	15.22 (14.1)		0.35

Body mass index: mean BMI of patients excluding two patients, one in each group, with no available data on heights, and whose weights were less than the average of 74.3 kg and 75.2 kg for the percutaneous and surgical groups respectively; eGFR = estimated Glomerular filtration rate.
[a] Standard deviation in parentheses.
[b] Interquartile ranges (IQR) in parentheses.

group but no significant differences observed in age, gender, diabetic nephropathy causing end-stage kidney disease (ESKD), body mass index (BMI) or baseline estimated glomerular filtration rate (eGFR).

Table 2 shows catheter outcomes assessed at 3 and 12 months following insertion. There were no statistically significant differences between the two groups in rates of drop out to HD, transplantation or death with a functioning catheter. The numbers of catheters remaining in use and those replaced were similar.

Five patients died with a functioning catheter during the first 12 months of follow-up, four of whom had had their catheters inserted percutaneously. Two patients had dilated cardiomyopathy; one was a diabetic who succumbed to an episode of sepsis and clostridium difficile colitis but had no clinical signs of peritonitis, the other suffered sudden out-of-hospital cardiac arrest. The third patient was a diabetic who died following heart surgery for infective endocarditis, and the fourth died suddenly due to pericardial tamponade secondary to aortic dissection which was diagnosed on autopsy. The fifth patient, a diabetic whose PDC was inserted surgically, died with sepsis secondary to unresolved peritonitis despite exchange of the Tenckhoff catheter and had opted not to switch to HD.

Kaplan-Meier analysis of catheter survival at 3 and 12 months post-insertion showed no difference between the surgical and percutaneous groups (Figure 1). At 12 months, the probability of catheter survival was 76% in the surgical group and 83% in the percutaneous group ($p = 0.35$).

Complications related to PDC insertion and PD treatment are summarized in Table 3. There were no statistically significant differences in complication rates between the two insertion groups. Non-significant trends towards more exit-site leaks in group P and more peritonitis and secondary drainage failure in group S were observed. There was also no difference in the incidence of early peritonitis (PD-related peritonitis within 1 month of PDC insertion) between the two groups. No visceral or vascular injuries resulted from PDC placement in either group.

Only 9 patients were switched to HD due to catheter-related infections (Table 4). In most of these patients, the catheter was removed due to resistant or recurrent PD-related peritonitis. Only one catheter was removed due to exit-site/tunnel infection and one catheter was removed due to persistent peritonitis following laparotomy for an incarcerated hernia. Two other catheters were also lost due to incarcerated hernias. One was removed as the patient needed bowel resection with formation of two ileostomies.The other was replaced during repair of a ventral hernia. Another catheter was replaced

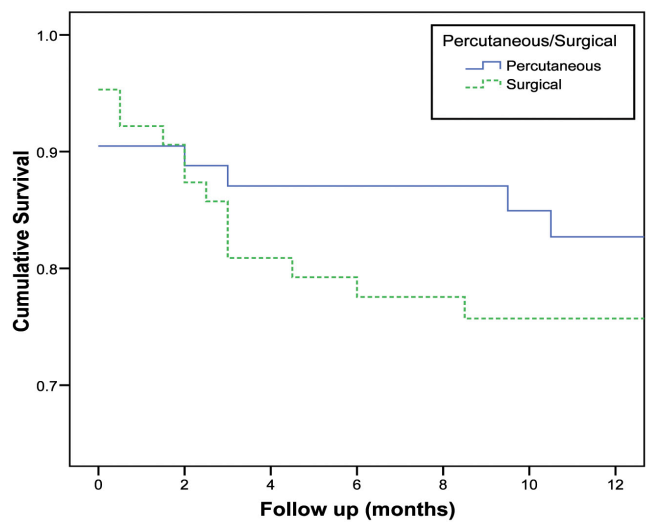

Figure 1 — Kaplan Meier analysis of catheter survival in the surgical (S) and percutaneous (P) groups (censored for non-catheter related complications). P = 0.35.

TABLE 2
Outcomes of Peritoneal Dialysis Catheter (PDC) Insertions in the Surgical (S) and Percutaneous (P) Groups at 3 and 12 Months

	3 Months [*n* (%)]		12 Months [*n* (%)]	
Endpoints of PDC use	Surgical	Percutaneous	Surgical	Percutaneous
Catheter remaining in use	48 (75)	50(79.4)	37 (57.8)	36 (57.1)
PDC replaced	6 (9.4)	6 (9.5)	8 (12.5)	7 (11.1)
Transfer to hemodialysis – Catheter related	6 (9.4)	2 (3.2)	7 (10.9)	3 (4.8)
Transfer to hemodialysis – Patient related	2 (3.1)	2 (3.2)	4 (6.25)	7 (11.1)
Death with a functioning catheter	0	2 (3.2)	1 (1.56)	4 (6.3)
Transplantation	2 (3.1)	1 (1.6)	7 (10.9)	5 (7.9)
Recovery of renal function	0	0	0	1 (1.6)
Total	64	63	64	63

TABLE 3
Complications Following PDC Insertions in the Surgical (S) and Percutaneous (P) Groups

Complication	Placement technique Surgical	 Percutaneous	*P* value
Primary failure [*n* (%)]	0	2 (3.2)	0.15
Poor initial drainage [*n* (%)]	7 (10.9)	6 (9.5)	0.34
Peritonitis[a]	1/20.5	1/28.5	0.13
Early peritonitis[b] [*n* (%)]	3 (5.0)	3 (5.3)	1.00
Tunnel infection [*n* (%)]	1 (1.6)	0	1.00
Hernia [*n* (%)]	5 (8.3)	6 (10.5)	0.80
Exit-site leak [*n* (%)]	4 (6.3)	10 (15.9)	0.15
Scrotal leak [*n* (%)][c]	4 (9.8)	7 (15.6)	0.35
Pleural leak [*n* (%)]	3 (4.7)	1 (1.6)	0.5
Secondary drainage failure [*n* (%)]	12 (18.8)	5 (7.9)	0.09

PDC = peritoneal dialysis catheter; PD = peritoneal dialysis.
[a] PD-related peritonitis episodes per catheter months.
[b] Rates of PD-related peritonitis within one month of PDC insertion.
[c] Percentage of male patients.

TABLE 4
Reasons for Transfer to Hemodialysis

Reason for transfer to hemodialysis	Placement technique Surgical (n=64)	 Percutaneous (n=63)
Catheter-related indications [n (%)]		
Infection	5 (27.8)	4 (23.5)
Leakage	3 (16.7)	1 (5.9)
Blockage	3 (16.7)	0
Non catheter-related indications [n (%)]		
Patient/Carer fatigue	2 (11.1)	5 (29.4)
Poor clearance	4 (22.2)	3 (17.6)
Ultrafiltration failure	1 (5.6)	1 (5.9)
Abdominal surgery	0	3 (17.6)
Total	18	17

due to blockage following repair of an uncomplicated inguinal hernia.

Overall, 12 hernias developed in 10 patients (5 in each group) during the study period. None of these were pericatheter hernias. Therefore they were unrelated to the implantation technique.

Twelve patients in the surgical group experienced secondary drainage failure. Laparoscopic manipulation was attempted in 5 patients and was successful in 3, with only temporary success in a fourth patient who was subsequently switched to HD. In the fifth patient, laparoscopic repositioning failed to restore catheter function and a new PDC was inserted. Four other patients had their PDCs directly replaced. In one patient, catheter function was restored by open surgical repositioning. The remaining 2 patients were switched to HD without attempts for catheter manipulation or replacement; one had concomitant membrane failure with poor ultrafiltration and the other had tunnel infection. In the percutaneous group, 5 patients had secondary catheter dysfunction due to blockage or migration. Laparoscopic salvage was attempted in 3 of these patients. Two resumed PD successfully after a short rest period while the third developed a port-site incisional hernia and postoperative fungal peritonitis resulting in catheter removal. The fourth patient had the PDC removed due to blockage following laparoscopic cholecystectomy. In the fifth patient, a decision was made to remove the catheter and hold PD as the patient had a good urine output and clearance in response to diuretic therapy.

DISCUSSION

This study retrospectively compares percutaneous PDC placement with the open surgical technique in a selected group of patients in whom insertion risk is considered to be low. The study population is a subgroup of our overall PD population in the period specified, namely patients with an unbreached peritoneum (i.e. without a history of abdominal surgery or prior PDC insertion). To our knowledge, no previous studies reported comparisons of the two techniques after eliminating these confounding factors. We previously compared outcomes between the two methods in a more heterogeneous cohort of patients regardless of their surgical history (8). Whether previous abdominal surgery does indeed increase the risk of postoperative catheter related complications regardless of appropriate selection of catheter placement technique remains to be confirmed (17–20). The importance of this analysis is to demonstrate encouraging outcomes of percutaneous PDC placement that are not offset by unmatched patient groups in terms of insertion risk. Techniques allowing direct vision, such as laparoscopic or open surgical insertion, are recommended for more complicated patients including those with a previous laparotomy incision, previous severe or recurrent peritonitis, morbid obesity, distorted anatomy or those with increased risk of bleeding (2,21).

The percutaneous technique has limitations, including restriction as per general consensus to low-risk patients without such history as the above. On the other hand, frail patients and those with co morbidities who are considered high risk from an anesthetic perspective may be selected for percutaneous insertion (22). More recently this has caused less confounding where nephrologists practice the percutaneous method routinely in all suitable patients where a blind technique is not conventionally contraindicated (6). Visceral injury is a concern but is a rare event and was not observed in our study group. Currently, variation in local expertise governs the choice of method of PDC insertion in low-risk patients.

Our data was collected retrospectively but was complete and unambiguous, allowing accurate results concerning complications and outcomes. An exception is that data on clinical signs of exit-site infection were not consistently documented and could not be analyzed. Therefore possible exit-site infections as indicated only by positive exit swab cultures (1 per 9.3 catheter months in the surgical group versus 1 per 15.4 catheter months in the percutaneous group) are probably overrated due to incompleteness of supportive clinical data and re-swabbing in some persistently colonized patients.

Owing to various competing outcomes dictated by the nature of ESKD, survival probability estimates become less reliable as more patients are censored. In addition, removal of catheters due to early catheter-related complications may represent unmeasured confounding with respect to evaluation of long-term outcomes and complications of the PDC. More patients died with a functioning catheter in the percutaneous group during the first 12 months of follow-up although the difference was not statistically significant. These deaths were not due to catheter- or PD-related complications. Thus, the higher rate of death with a functioning catheter in the percutaneous group in the first 12 months may be related to higher comorbidity or increased frailty in this group. The overall rates of death with a functioning catheter during the study period were equivalent in the two groups. Patients were unmatched with respect to diagnosis of polycystic kidney disease (PCKD). However, after excluding patients with PCKD, catheter survival rates at 12 months were 77.8% and 73.9% in group P and S respectively, not significantly different. There were 10 patients with PCKD included in our study, 9 of whom had their PDCs inserted surgically. During the first year of follow-up, 3 of the PCKD patients had their catheters removed due to catheter-related complications. Two of these patients had persistent peritonitis while the third experienced secondary drainage failure. Previous retrospective cohort studies showed that there is no difference in technique survival and peritonitis rates between PCKD patients and other non-diabetic patients receiving PD therapy (23–27). Another observational study revealed that PCKD does not increase the risk of peritonitis compared to all non-PCKD patients on continuous ambulatory peritoneal dialysis (CAPD) (28).

There were no differences between the 2 techniques insofar as using a midline point of insertion and creating a laterally directed tunnel track. In the surgical technique, the inner catheter cuff is sutured to the external surface of the peritoneum while in the percutaneous technique, the cuff is positioned in the subcutaneous tissue external to the fascia. Inserting the catheter through a paramedian location and burial of the inner cuff beneath the anterior rectus sheath have been advocated as measures to reduce leaks, cuff extrusion and catheter migration (5,29–31). In this study, the deeper positioning of the inner cuff secured to the peritoneum when placing catheters surgically may explain the trend of lower rates of exit-site and scrotal leaks in this group. The average time from catheter insertion to use was 6 days and 7.2 days in the percutaneous and surgical groups respectively. We speculated that the trend towards a significant difference in secondary drainage failure between the 2 groups may be related to variations in operator performance, patient compliance with laxative use and susceptibility to adhesions with episodes of peritonitis. Approximately 90% of percutaneous insertions were performed by an experienced nephrologist as opposed to supervised nephrology trainees. Urology trainees, on the other hand, performed more than half of the surgical insertions under supervision. The practice of flushing the PDC with three consecutive 500-mL saline exchanges immediately after percutaneous insertion to test catheter function, as opposed to only a 50-mL flush with the surgical technique, theoretically represents a confounding variable. However, as this is a test of initial catheter function, it does not explain the trend towards more secondary drainage failure in the surgical group.

Excluding the Tenckhoff catheter kit, which was identical in both procedures, the cost of the percutaneous insertion procedure in our center is 650 euros whereas the cost of the surgical implantation technique is approximately 1200 euros, corresponding to theatre cost per hour. In addition, the average cost per bed day in this institution is 806 euros. Although most of the study patients were admitted for variable periods of time to facilitate transplant work-up and inpatient PD education, in recent years we have shifted towards a day case practice for percutaneous insertion, further reducing the cost associated with this technique. The length of hospital stay in this study was also influenced by treatment of comorbid conditions, and provision of community support services where required. The study was single-center based with one operator for the most part performing the percutaneous catheter insertions (80% of percutaneous insertions included in the study). Larger prospective and ideally multicenter studies are needed to demonstrate whether improved outcomes can be achieved with the percutaneous Seldinger technique. It is unlikely that adequately powered randomized trials would be feasible in view of the time needed to recruit suitable patients and the relatively limited number of centers and nephrologists experienced in practicing this technique at present.

Wire-guided percutaneous placement of an indwelling PDC has been described since 1984–1985 (32–35). To date, there are at least 20 other published reports on bedside percutaneous PDC insertion in the English literature, mostly retrospective cohort studies (6–16,22,36–43). Although some studies compared percutaneous to surgical insertions, only the study by Perakis *et al.* matched patients for previous laparotomy showing no significant difference between the two groups, but there was a trend towards more laparotomy incisions in the surgical insertion cohort (15). Most of the studies that reported results of survival analysis showed favorable survival with the percutaneous technique except the study by Mellotte *et al*. where outcomes were significantly affected by severity of illness of those selected for percutaneous insertion (22). The randomized study by Nielson *et al.* showed poor outcomes using the straight catheter compared to the curled catheter (40). Excluding those two outlying cohorts in whom 1-year catheter survival was only 33–36%, the average survival of catheters inserted using the percutaneous technique in the literature was 80% at 12 months following insertion. Percutaneously inserted catheters also appear to fare well in terms of overall complication rates with some studies showing a reduced peritonitis rate (6,8,15) and other studies showing no significant differences in peritonitis rates between the two insertion groups (7,11). Similarly, no difference in incidence of unresolved drainage failure was seen between the two groups in most studies that compared the 2 techniques (7–9,11,15). Selection bias, previous laparotomy, operator expertise, catheter type (coiled vs straight) and, in the case of peritonitis, other patient-related factors are all potential confounders that may have affected outcomes in these retrospective studies. Dialysate leakage was seen more frequently in the percutaneous insertion groups in some studies (8–10,15,22); other studies showed no difference between the two groups (6,7,11,13). The higher incidence of leakage associated with percutaneous placement may be partly attributed to a shorter break-in period (time from insertion to use of catheter) in the percutaneous insertion groups (8,9,15,22). The majority of exit-site leaks occur early and settle conservatively by holding PD exchanges for a few days (6,10,12,13,15,22,40,43). The reported incidences of bowel or bladder perforation or hemorrhage necessitating operative intervention were typically 0–1.5% in total in any one study (6–13,15,22,40,43).

These studies demonstrate that nephrologists practicing bedside percutaneous PDC insertion can contribute to facilitating timely commencement of PD in selected patients who have no contraindications for a blind Seldinger technique. This is of particular importance in the "crash-lander" ESKD population when PD is appropriate but delays in access to the surgical theatre may represent an impediment to utilization of PD and result in increased central venous catheter use. There is increasing recognition that streamlining PD access provision enhances utilization of this effective cost-efficient dialysis modality (44–48). Similar to data from the UK, about 2/3 of catheter insertions in our PD population were performed using the open surgical technique and the rest were done using the percutaneous technique (2).

As one of the few PD centers in Ireland providing services for a wide geographical area, the average number of PD catheter insertions in our center was 30 per year over the 7-year study period. This allows for development of the inevitably required skills of surgeons, particularly for complex at-risk patients such as those with previous laparotomies or PDC insertion who, on their own, represented 42% of our PD population. However, particularly in centers with lower procedural volumes, concerns regarding the learning curve of surgical operators and impracticality of nephrologists routinely undertaking the role of PD access provision are well founded (5). Training should therefore be focused on dedicated surgical doctors and probably only nephrologists who intend to embark on this interventional procedure as part of their long-term career. In previous studies, although not through direct comparison, best catheter outcomes were seen with laparoscopic insertion compared with reports of other insertion methods: blind percutaneous, fluoroscopically guided insertion and open surgery (5,30). A recent meta-analysis study supported this view (49). Where facilities exist, adoption of the laparoscopic technique may further improve outcomes of surgical PDC placement. It has been estimated that the higher initial costs of laparoscopic PDC insertion are offset by a lower incidence of complications that may necessitate re-positioning, re-implantation or switching patients disheartened by the initial failure directly to HD (5,50). Likewise it has been argued that expanding the candidate pool of patients offered PD by employing the laparoscopic technique in patients not suitable for the blind percutaneous method negates the advantage of avoiding general anesthesia, considering the small proportion of patients in whom a general anesthetic poses conceivable risk due to cardiovascular instability, frailty or other medical comorbidities (5). Therefore, planning for PD access provision should be undertaken within an integrative approach of multidisciplinary involvement where maximizing use and development of local expertise, the pros and cons of different available techniques performed by different specialities, risk-tailored selection of patients and overall healthcare system cost considerations are taken into account.

CONCLUSION

Outcomes of percutaneous and surgical PDC insertions are comparable in first-time PD starters who had no previous abdominal surgery. The results emphasize the success and safety of the percutaneous technique in experienced hands in a low-risk patient population. Variability in operator expertise and inherent patient characteristics may represent hidden confounders. Prospective cohort studies may help to better determine how the different insertion techniques affect outcomes and rates of complications in this subset of PD patients. The cost effectiveness, convenience and favorable catheter survival associated with the percutaneous insertion method make this relatively simple intervention an attractive option for securing peritoneal access in suitable patients.

DISCLOSURES

The authors have no conflicts of interest to declare.

ACKNOWLEDGMENTS

The authors thank Barbara Lambert, senior peritoneal dialysis nurse specialist, the CAPD nurses, the medical records staff and the renal secretaries at the Adelaide & Meath Hospital, Dublin, for their assistance in collecting data for this study.

REFERENCES

1. Blake PG. The critical importance of good peritoneal catheter placement. *Perit Dial Int* 2008; 28:111–2.
2. Figueiredo A, Goh BL, Jenkins S, Johnson DW, Mactier R, Ramalakshmi S, *et al*. on behalf of the International Society for Peritoneal Dialysis. Clinical practice guidelines for peritoneal access. *Perit Dial Int* 2010; 30:424–9.
3. Wong L, Liebman S, Wakefield K, Messing S. Training of surgeons in peritoneal dialysis catheter placement in the United States: a national survey. *Clin J Am Soc Nephrol* 2010; 5: 1439–46.
4. Wilkie M, Wild J. Peritoneal dialysis access – results from a UK survey. *Perit Dial Int* 2009; 29:355–7.
5. Crabtree, JH. Who should place peritoneal dialysis catheters? *Perit Dial Int* 2010; 30(2):142–50.
6. Henderson S, Brown E, Levy J. Safety and efficacy of percutaneous insertion of peritoneal dialysis catheters under sedation and local anaesthetic. *Nephrol Dial Transplant* 2009; 24:3499–509.
7. Ozener C, Bihorac A, Akoglu E. Technical survival of CAPD catheters: comparison between percutaneous and conventional surgical placement techniques. *Nephrol Dial Transplant* 2001; 16:1893–9.
8. Medani S, Shantier M, Hussein W, Wall C, Mellotte G. A comparative analysis of percutaneous and open surgical techniques for peritoneal catheter placement. *Perit Dial Int* 2012; 32: 628-35.
9. Swartz R, Messana J, Rocher L, Reynolds J, Starmann B, Lees P. The curled catheter: Dependable device for percutaneous paeritoneal access. *Perit Dial Int* 1990; 10:231–5.
10. Smith SA, Morgan SH, Eastwood JB. Routine percutaneous insertion of permanent peritoneal dialysis catheters on the nephrology ward. *Perit Dial Int* 1994; 14:284–6.

11. Ates K, Erturk S, Karatan O, Duman N, Nergisoglu G, Ayli D, *et al*. A comparison between percutaneous and surgical placement techniques for permanent peritoneal dialysis catheters. *Nephron* 1997; 75:98–9.
12. Euthimiadou A, Thodis E, Passadakis P, Tsalikis D, Kaisas G, Vargemezis V. Nonsurgical implantation of Tenckhoff peritoneal catheters in patients on continuous ambulatory peritoneal dialysis. *Adv Perit Dial* 1999; 15:101–4.
13. Roueff S, Pagniez D, Moranne O, Roumilhac D, Talaszka A, Le Monies De Sagazan H, *et al.* Simplified percutaneous placement of peritoneal dialysis catheters: comparison with surgical placement. *Perit Dial Int* 2002; 22:267–9.
14. Basile C, De Padova F, Parisi A, Montanaro A, Giordano R. Routine insertion of permanent peritoneal dialysis catheters in the nephrology ward. The sliding percutaneous technique. *Minerva Urol Nefrol* 2004; 56:359–65.
15. Perakis KE, Stylianou KG, Kyriazis JP. Long-term complication rates and survival of peritoneal dialysis catheters: the role of percutaneous versus surgical placement. *Semin Dial* 2009; 22: 569–75.
16. Jo YI, Shin SK, Lee JH, Song JO, Park JH. Immediate initiation of CAPD following percutaneous catheter placement without break-in procedure. *Perit Dial Int.* 2007; 27:179–83.
17. Tiong HY, Poh J, Sunderaraj K, Wu YJ, Consigliere DT. Surgical complications of Tenckhoff catheters used in continuous ambulatory peritoneal dialysis. *Singapore Med J* 2006; 47:707–11.
18. Chen SY, Chen TW, Lin SH, Chen CJ, Yu JC, Lin CH. Does previous abdominal surgery increase postoperative complication rates in continuous ambulatory peritoneal dialysis? *Perit Dial Int* 2007; 27:557–9.
19. Crabtree JH, Bourchette RJ. Effect of prior abdominal surgery, peritonitis, and adhesions on catheter function and long-term outcome on peritoneal dialysis. *Am Surg* 2009; 75:140–7.
20. Keshvari A, Fazeli MS, Meysamie A, Seifi S, Taromloo MK. The effects of previous abdominal operations and intraperitoneal adhesions on the outcome of peritoneal dialysis catheters. *Perit Dial Int* 2010; 30:41–5.
21. Dombros N, Dratwa M, Feriani M, Gokal R, Heimburger O, Krediet R, *et al*.; EBPG Expert Group on Peritoneal Dialysis. European best practice guidelines for peritoneal dialysis. 3 Peritoneal access. *Nephrol Dial Transplant* 2005; 20(Suppl 9):ix8–12.
22. Mellotte GJ, Ho CA, Morgan SH, Bending MR, Eisinger AJ. Peritoneal dialysis catheters: a comparison between percutaneous and conventional surgical placement techniques. *Nephrol Dial Transplant* 1993; 8:626–30.
23. Hadimeri H, Johansson AC, Haraldsson B, Nyberg G. CAPD in patients with autosomal polycystic kidney disease. *Perit Dial Int* 1998; 18:429–32.
24. Kumar S, Fan SL, Raftery MJ, Yaqoob MM. Long term outcome of patients with autosomal dominant polycystic kidney diseases receiving peritoneal dialysis. *Kidney Int* 2008 Oct; 74:946–51.
25. Lobbedez T, Touam M, Evans D, Ryckelynck JP, Knebelman B, Verger C. Peritoneal dialysis in polycystic kidney disease patients. Report from the French peritoneal dialysis registry (RDPLF). *Nephrol Dial Transplant* 2011; 26:2332–9.
26. Li L, Szeto CC, Kwan BC, Chow KM, Leung CB, Kam-Tao Li P. Peritoneal dialysis as the first-line renal replacement therapy in patients with autosomal dominant polycystic kidney disease. *Am J Kidney Dis* 2011; 57:903–7.
27. Portoles JM, Tato AM, López-Sánchez P. Peritoneal dialysis for patients with polycystic kidney disease in Spain. *Am J Kidney Dis* 2011; 58:493; author reply 494.
28. Pandya BK, Friede T, Williams JD. A comparison of peritonitis in polycystic and non-polycystic patients on peritoneal dialysis. *Perit Dial Int* 2004; 24:79–81.
29. Crabtree, JH. Selected best demonstrated practices in peritoneal dialysis access. *Kidney Int* 2006; 70:S27–37.
30. Crabtree, JH. Fluoroscopic placement of peritoneal dialysis catheters: a harvest of the low-hanging fruits. *Perit Dial Int* 2008; 28(2):134–7.
31. Gokal R, Alexander S, Ash S, Chen TW, Danielson A, Holmes C, *et al*. Peritoneal catheters and exit-site practices toward optimum peritoneal access: 1998 update. *Perit Dial Int* 1998; 18:11–33.
32. Nakanishi T, Yanase M, Fujii M, Tanaka Y, Orita Y, Abe H. New acute peritoneal dialysis technique: wire-guide insertion and long-term indwelling of peritoneal catheter. *Nephron* 1984; 37:128–132.
33. Gonzalez AR, Goltz GM, Eaton CL, Ratajeski G, Olin JW. The peel away method for insertion of Tenckhoff catheters. *Kidney Int* 1984; 25:256.
34. Perras S, Zappacosta AR, Mattern M. Comparison of two techniques for percutaneous peritoneal dialysis catheter placement. *ANNA J* 1985; 12:307– 10.
35. Updike S, O'Brien M, Petersen W, Zimmerman S. Placement of catheter using pacemaker-like introducer with peelaway sleeve. *Kidney Int* 1985; 27:185.
36. Di Paolo N, Manganelli A, Strappaveccia F, De Mia M, Gaggiotti E. A new technique for insertion of the Tenckhoff peritoneal dialysis catheter. *Nephron* 1985; 40:485–7.
37. Allon M, Soucie M, Macon El. Complications with permanent peritoneal dialysis catheters: experience with 154 percutaneously placed catheters. *Nephron* 1988; 48:8–11.
38. Maher ER, Stevens J, Murphy C, Brown EA. Comparison of two methods of Tenckhoff catheter insertion. *Nephron* 1988; 48:87–8.
39. Zappacosta AR, Perras ST, Closkey GM. Seldinger technique for Tenckhoff catheter placement. *ASAIO Trans* 1991; 37:13–5.
40. Nielsen PK, Hemmingsen C, Friis SU, Ladefoged J, Olgaard K. Comparison of straight and curled Tenckhoff peritoneal dialysis catheters implanted by percutaneous technique: a prospective randomized study. *Perit Dial Int* 1995; 15:18–21.
41. Dequidt C, Vijt D, Veys N, Van Biesen W. Bed-side blind insertion of peritoneal dialysis catheters. *EDTNA ERCA J*

2003; 29:137–9.

42. Liberek T, Chmielewski M, Lichodziejewska-Niemierko M, Renke M, Zadrozny D, Rutkowski B. Survival and function of Tenckhoff peritoneal dialysis catheter after surgical or percutaneous placement: one centre experience. *Int J Artif Organs* 2003; 26:174–5.
43. Banli O, Altun H, Oztemel A. Early start of CAPD with the Seldinger technique. *Perit Dial Int* 2005; 25:556–9.
44. Gadallah MF, Ramdeen G,Torres-Rivera C, Ibrahim ME, Myrick S, Andrews G, *et al*. Changing the trend: a prospective study on factors contributing to the growth rate of peritoneal dialysis programs. *Adv Perit Dial* 2001; 17:122–6.
45. Asif A, Byers P, Gadalean F, Roth D. Peritoneal dialysis underutilization: the impact of an interventional nephrology peritoneal dialysis access program. *Semin Dial* 2003; 16:266–71.
46. Asif A, Pflederer TA, Vieira CF, Diego J, Roth D, Agarwal A. Does catheter insertion by nephrologists improve peritoneal dialysis utilization? A multicenter analysis. *Semin Dial* 2005; 18:157–60.
47. Goh BL, Ganeshadeva YM, Chew SE, Dalimi MS. Does peritoneal dialysis catheter insertion by interventional nephrologists enhance peritoneal dialysis penetration? *Semin Dial* 2008; 21:561–6.
48. Li PK and Chow KM. Importance of peritoneal dialysis catheter insertion by nephrologists: practice makes perfect. *Nephrol Dial Transplant* 2009; 24:3274–6.
49. Hagen SM, Lafranca JA, Steyerberg EW, IJzermans JN, Dor FJ. Laparoscopic versus open peritoneal dialysis catheter insertion: a meta-analysis. *PloS one* 2013; 8(2):e56351.
50. Davis WT, Dageforde LA, Moore DE. Laparoscopic *versus* open peritoneal dialysis catheter insertion cost analysis. *J Surg Res* 2014; Mar;187(1):182–8.