7. Technique of insertion of peritoneal dialysis catheter

Date written: February 2003
Final submission: May 2004

Guidelines
(Include recommendations based on level I or II evidence)

There is no technique of insertion of a peritoneal dialysis catheter that has consistently proven to be superior in the prevention of peritonitis. (Level II evidence)

Suggestions for clinical care
(Suggestions are based on level III and IV sources)

- **No recommendation.**

Background

Infectious and mechanical complications continue to be a major problem in the management of patients on peritoneal dialysis (PD). A number of different methods of insertion of the PD catheter have been proposed in an attempt to reduce these complications. These techniques include surgical placement by open dissection, blind percutaneous placement using a Tenckhoff trocar, blind percutaneous placement using a guidewire (Seldinger technique), minitrocar placement using peritoneoscopy (Y-TEC) or laparoscopy, the Moncrief-Popovich technique (the segment of the catheter that is usually brought out through the skin is buried subcutaneously and the entire wound is closed for 4-6 weeks before the distal segment of the catheter is brought out through the skin via a small incision 2 cm distal to the subcutaneous cuff) and the presternal catheter (a modified Swan neck Missouri coil catheter which is composed of 2 silicone rubber tubes that are connected at the time of insertion).

The aim of this guideline was to assess whether any particular surgical technique for the insertion of a PD catheter had a lower incidence of peritonitis. The issue of other complications, including mechanical complications, was not formally addressed.

Search strategy

Databases searched: MeSH terms and text words for PD were combined with MeSH terms and text words for PD catheters and MeSH terms and text words for surgical technique, then combined with MeSH terms and text words for peritonitis. The search was carried out in Medline (1966 – October Week 3 2002). The Cochrane Renal Group Trials Register was also searched for trials not indexed in Medline.

Date of search/es: 12 November 2002.

What is the evidence?

Randomised prospective studies

Ejlersen et al (1990) randomised 37 patients to either a midline incision (21) or a lateral incision (16) and found no statistically significant difference in catheter failure due to peritonitis (midline 1, lateral 3). There was no statistically significant difference in one-year catheter survival (midline 59% vs lateral 51%).

Rubin et al (1990) randomised 85 patients to either a midline or lateral rectus incision, and then to either a straight or spiral intraperitoneal segment, and found no difference in peritonitis or catheter survival.

Tsimoyiannis et al (2000) randomised 50 patients to either open laparotomy (22 midline incisions, 3 paramedian incisions as patients had had previous catheters) or laparoscopic insertion of PD catheter, with fixation into the pelvis and suture closure of the port wounds (in 4 patients, a previous catheter had been inserted by the open technique and removed because of dysfunction). There was no statistically significant difference in peritonitis incidence (laparoscopic 3 patients vs open laparotomy 5 patients) but there were fewer fluid leaks (0 vs 8), less migration of the catheter tip (0 vs 5) and reduced mean operative time (22 minutes vs 29 minutes, $p < 0.001$) in the laparoscopic group.

Gadallah et al (1999) randomised 148 patients to either the surgical (72) or the peritoneoscopic (76) technique for insertion of a double-cuff, curled-end, Swan-neck PD catheter. There were significantly fewer early peritonitis episodes within 2 weeks of catheter placement, in the peritoneoscopic group (9 vs 2, $p = 0.02$). This higher rate of infection in the surgical group was most likely related to a higher exit-site leak in the surgical group (11.1%) compared with the peritoneoscopic group (1.3%). Peritoneoscopically-placed catheters were found to have better survival at 1, 2 and 3 years than those placed surgically (77.5% vs 62.5% $p = 0.02$, 63.0% vs 41.5% $p = 0.01$, 51.3% vs 36.0% $p = 0.04$).

Danielsson et al (2002) randomised 60 patients to either the subcutaneous buried technique or standard insertion with a Moncrief-Popovich catheter and these were compared to a non-randomised group of 65 patients given a standard Tenckhoff catheter. There was no difference in the number of episodes of peritonitis (MP buried 11, MP not buried 12, Tenckhoff 26) but the cumulative probability of peritonitis at 18 months was greater in the MP not buried group than the MP buried group (MP buried 1/40, MP not buried 1/26, Tenckhoff 1/33 treatment months). There were fewer exit-site infections (ESIs) in the standard Moncrief-Popovich group compared with the standard Tenckhoff group, but no difference in the subcutaneously buried group.

Park et al (1998) randomised 60 patients to either subcutaneous catheter implantation for 6 weeks (I) or insertion by conventional technique (C) with a 6 week break-in period. Subgroups of 15 patients were randomised to the Y connector (IY, CY) or the standard spike (IS, CS). Patients in the subcutaneous Y group had the least peritonitis, (1/14.9 patient months vs 1/8.4 in the conventional Y connector group) and the longest peritonitis-free period in those patients who did not experience peritonitis (120 patient months at 2 years); they also had the least ESI. There was no difference in technique survival at 2 years.

Moncrief and Popovich (1998) randomised 113 patients to either the subcutaneously buried technique (MP) or to the regular catheter insertion and found no difference in peritonitis (0.47 vs 0.41 episodes/year/patient). The ESI were significantly lower in the subcutaneously buried group (0.109 vs 0.284 episodes/year/patient, $p = 0.04$).

Dasgupta et al (2000) randomised 41 patients to the subcutaneously buried Moncrief-Popovich catheter or standard Tenckhoff catheter and found no difference in peritonitis (0.63 vs 0.68) but significantly less ESI (0.1 vs 0.4 episodes/year/patient, $p < 0.05$).

Summary of the evidence

There are two randomised studies comparing the midline with the lateral incision which do not show any significant difference in the incidence of peritonitis. There is one randomised study comparing open surgical with laporoscopic insertion which shows no difference in peritonitis and one study comparing open surgical insertion with peritoneoscopic insertion, which shows a significant reduction in early peritonitis at 2 weeks in the peritoneoscopic group. There are four randomised studies comparing the subcutaneous buried technique with standard catheter insertion. One study shows less peritonitis in the subcutaneous buried group, two studies show no difference and the third study shows no difference in the incidence of peritonitis but the cumulative probability of developing peritonitis at 18 months was lower in the subcutaneous buried group.

Non-randomised studies

Copley et al (1996) reported on their experience with 136 catheters that were placed with a peritoneoscope (135 were double cuff Swan neck curled catheters). They did not report on a peritonitis rate but commented that 16 were removed due to catheter-related infections and 9 because of catheter outflow failure due to migration. The actuarial catheter survival was 62% at 40 months.

Eklund et al (1998) prospectively analysed 108 peritoneoscopically-placed catheters and 43 surgically-placed catheters and found no difference in peritonitis or ESI. There were more mechanical complications in the peritoneoscopic group and the catheter survival was lower than in the surgical group at 1, 2 and 3 years (73% vs 87%, 56% vs 87%, 24% vs 66%, $p < 0.05$)

Draganic et al (1998) retrospectively compared complications and patency for 30 catheters inserted via laparoscopy with 30 inserted with a laparotomy. They found no difference in peritonitis, ESI or catheter survival rates.

Batey et al (2002) compared a technique of mini-laparoscopy-assisted (MLA) placement of dialysis catheters (n = 14) with open placement (n = 12). Postoperative narcotic analgesia, length of hospital stay, operative times, days until cycling, and rates of leakage, infection, and malfunction necessitating removal of catheters were compared. Differences in complications necessitating catheter removal were not significant. Peritonitis was not specifically recorded. The difference in the mean operative times of 41.7 minutes in the MLA group and 55.7 minutes for the open placement group was statistically significant. Postoperatively, the MLA group used less narcotic analgesia, had shorter hospital stays, and returned earlier to usual activities. The incidence of leakage after catheter placement was greater in the open group, although this difference was not statistically significant.

Swartz et al (1990) compared 213 curled catheters that were placed percutaneously (P 134) or surgically (S 79) between January 1985 and December 1998 and found no difference in the incidence of peritonitis (P 0.93 ± 0.13 vs S1.05 ± 0.19 episodes per patient-year). There was no difference in catheter survival between the two groups at 1, 2 or 3 yrs (88%, 71% and 61%, respectively). There were more early dialysate leaks with the percutaneous group (21.6% vs 10.1%, $p < 0.05$).

Ozener et al (2001) reported on 133 percutaneous catheters that were inserted by the nephrology staff using the Seldinger technique, and compared the outcomes with 82 surgical controls. They found that there was less peritonitis in the percutaneous group (1/25 vs 1/17 patient months, $p = 0.01$) and a longer time between catheter placement and first episode of peritonitis (22.7 vs 12.6 months, $p = 0.02$). There was no difference in the catheter infection-free period. The one- and two-year catheter survival was significantly better in the percutaneous group than surgical group (90% and 82% vs 73% and 60%, respectively; $p = 0.0032$).

Roueff et al (2002) compared 57 patients who underwent percutaneous placement of the PD catheter with a trocar Seldinger technique (April 1996 to March 1999) with 47 historical controls who had surgically-inserted catheters (April 1993 to March 1996). In the period April 1996 to March 1999 there were 28 patients who could not have a percutaneous procedure due to obesity, previous laparotomy, polycystic kidney disease or hernia. There was no difference in the peritonitis rate at 60 days but late peritonitis after 60 days was lower in the percutaneous group (1/16.4 vs 1/11.7 patient months). The one-year catheter survival was higher in the percutaneous group (75% vs 71%).

In his series of patients given percutaneous insertion of PD catheters, Savader et al (2000) reported catheter survival rates at 6, 12 and 24 months of 89%, 81%, and 81%, respectively. Surgically-implanted catheter survival rates were reported to be 50% to 88% at 12 months and 41% to 60% at 24 months. Peritonitis rates were not specifically reported.

Warady et al (1996) reported lower peritonitis rates with a downward-directed exit site in a number of North American paediatric centres.

Golper et al (1996) in the Network 9 Study, which involved 1,930 North American patients through 1991 and 1992, reported that directing the subcutaneous portion of the catheter downward reduced the risk of peritonitis associated with exit-site and/or tunnel infection by 38% compared with a horizontally-directed tunnel. The upward directed catheter had an increase of peritonitis of 50% compared with the horizontally-directed tunnel. The direction of the catheter did not affect the incidence of peritonitis not associated with ESI or tunnel infections.

Moncrief et al (1993) reported results from 74 patients who had their catheter inserted with the subcutaneously buried technique for 4-6 weeks and then externalised. They documented a peritonitis rate of 1/28.7 patient months compared with historical controls with a rate of 1/9 patient months, (ESI 1/12.6 patient months). Twelve patients had to have the catheter removed and nine of these were free from bacterial biofilm growth on the catheter segment between the two cuffs (the other three had ESI). Moncrief and Popovich (1994) using the disconnect system and the subcutaneous buried technique reported a peritonitis rate of 1/32 patient months.

There are several other non-randomised retrospective studies showing reduced peritonitis with the MP subcutaneous buried compared with historical controls with Tenckhoff or Swan neck catheters – Han et al (1992) (74 patients vs 133 historical controls), Caruso et al (1997), Prischl et al (1997), but there are also studies showing no difference in peritonitis – de Alvaro et al (1994) (25 MP catheter vs 29 conventional, 1/21.3 vs 1/32.5 patient months) and Ahlmen et al (2001), and one study with increased peritonitis in the buried group – Esson et al (2000).

Twardowski et al (1996) reported on a 4-year experience of 24 Swan neck presternal catheters which were inserted for obesity (9 patients, 4 with BMI > 40 kg/m^2), ostomies (3), suprapubic catheter (1), previous problems with abdominal catheters (20), desire to use a bathtub (5), need to use a whirlpool (1), need to wear an elastic waistband (1) and body image (2). The outcomes were compared with 47 patients with abdominal Swan neck catheters. No difference in peritonitis episodes (presternal 12 vs abdominal 13), peritonitis rate (presternal 0.47 vs abdominal 0.33 episodes/year) or catheters removed due to recurrent or refractory peritonitis (presternal 2 vs abdominal 0 and presternal 1 vs abdominal 0, respectively). There was also no difference in ESI or tunnel infections. However, the use of antibiotics to treat ESIs was significantly greater in the abdominal group. There was no difference in the 2-year catheter survival.

Twardowski (2002) reviewed the literature on Swan neck presternal peritoneal catheters including 150 at his centre and commented on the decreased risk of peritonitis, ESI and tunnel infections. The two-year survival probability of the catheter was 0.95 and the only cause for failure was recurrent or refractory peritonitis.

What do the other guidelines say?

Kidney Disease Outcomes Quality Initiative: No recommendations.

British Renal Association 2002: No specific recommendations in the adult section apart from supporting the ISPD guidelines, 1998. In the paediatric section, a recommendation that the insertion of the peritoneal catheter should be performed by an appropriately trained surgeon and that the downward exit site has an advantage.

Canadian Society of Nephrology: No recommendations.

European Dialysis and Transplant Association-European Renal Association: Catheters should preferably be implanted operatively or by laparoscopy. No implantation technique has definitely been shown to be superior to others. (Level A).

International Society for Peritoneal Dialysis 1998:
1. The implantation must be performed by a competent and experienced operator, in a planned manner. The procedure must be regarded as an important surgical intervention demanding care and attention to detail equal to any other surgical procedure.
2. Peritoneal entry should be lateral (deep cuff in or below the rectus musculature), or paramedian (deep cuff at the medial edge of the rectus muscle), to give good deep-cuff fixation and minimize herniation and fluid leaks. Other entry sites (midline through the linea alba) are used with trocar insertions.
3. The deep cuff should be placed in the musculature of the anterior abdominal wall or in the preperitoneal space. Good results have also been obtained with the cuff placed within the posterior rectus fascia. The deep cuff should never be placed within the peritoneal cavity. After proper positioning of the catheter tip, the peritoneum is closed tightly around the catheter below the level of the deep cuff using a purse-string suture.
4. The subcutaneous cuff should be located near the skin surface and at a distance of at least 2 cm from the exit site. Care should also be taken to avoid mechanically stressing the cuff material.
5. Check for catheter patency. The catheter should be tested to ensure that there is adequate inflow and outflow without leakage. Techniques to accomplish this include infusing 1 L of peritoneal fluid over 5 minutes and allowing an equal time for drainage, or injecting 60 mL of 0.9% saline and observing if 30-40 mL is easily aspirated.
6. The exit site should be facing downwards or be directed laterally. Upward-directed exit sites should, in general, be avoided.
7. The intra-abdominal portion of the catheter should be placed between the visceral and parietal peritoneum toward the pouch of Douglas and should not be placed within loops of bowel or directly in omental tissue. This maneuver has been shown to be facilitated by the use of a bent stylet (Stegmayr et al 1993) or any device that will add rigidity to the catheter.

Implementation and audit

All renal units should maintain data on PD catheter types and all PD-related problems including exit-site infections, tunnel infections, peritonitis, catheter malfunction rates and catheter survival times. This data should be submitted to the ANZDATA registry.

Suggestions for future research

No recommendation.

References

Ahlmen J, Eriksson C, Dahl I. Subcutaneous implantation of catheters for peritoneal dialysis. Nephrol Dial Transplant 2001; 30: 87-91.

Batey CA, Crane JJ, Jenkins MA et al. Mini-laparoscopy-assisted placement of Tenckhoff catheters: an improved technique to facilitate peritoneal dialysis. J Endourol 2002; 16(9): 681-84.

Caruso DM, Grey DL, Kohr JM et al. Reduction of infectious complications and costs using temporary subcutaneous implantation of PD catheters. Adv Perit Dial 1997; 13: 183-89.

Copley JB, Lindberg JS, Back SN et al. Peritoneoscopic placement of Swan neck peritoneal dialysis catheters. Perit Dial Int 1996;16 (Suppl 1): S330-S332.

Danielsson A, Blohme, L, Tranaeus A et al. A prospective randomized study of the effect of a subcutaneously "buried" peritoneal dialysis catheter technique versus standard technique on the incidence of peritonitis and exit-site infection. Perit Dial Int 2002; 22(2): 211-19.

Dasgupta MK, Perry D, Fox S. Exit site infection, but not peritonitis, is reduced by the use of Moncrief-Popovich catheters in comparison to Tenckhoff catheters. J Am Soc Nephrol 2000; 11: 205A (abstract).

De Alvaro F, Selgas R, Baja MA et al. Moncrief's technique for peritoneal catheter placement: experience of a CAPD unit. Adv Perit Dial 1994; 10: 199-202.

Draganic B, James A, Booth M et al. Comparative experience of a simple technique for laparoscopic chronic ambulatory peritoneal dialysis catheter placement. Aust N Z J Surg 1998; 68(10): 735-39.

Ejlersen E, Steven K, Lokkegaard H. Paramedian versus midline incision for the insertion of permanent peritoneal dialysis catheters. A randomized clinical trial. Scand J Urol Nephrol 1990; 24(2): 151-54.

Eklund B, Groop PH, Halme L et al. Peritoneal dialysis access: a comparison of peritoneoscopic and surgical insertion techniques. Scand J Urol Nephrol 1998; 32(6): 405-08.

Esson ML, Quinn MJ, Hudson ET al. Subcutaneously tunnelled peritoneal dialysis catheters with delayed externalization: long-term follow-up. Adv Perit Dial 2000; 16: 123-28.

Gadallah MF, Pervez A, el-Shahawy MA et al. Peritoneoscopic versus surgical placement of peritoneal dialysis catheters: a prospective randomized study on outcome. Am J Kidney Dis 1999; 33(1): 118-22.

Golper TA, Brier ME, Bunke M et al. Risk factors for peritonitis in long-term peritoneal dialysis: the Network 9 peritonitis and catheter survival studies. Am J Kidney Dis 1996; 28(3): 428-36.

Han DC, Cha HK, So IN et al. Subcutaneously implanted catheters reduce the incidence of peritonitis during CAPD by eliminating infection by periluminal route. Adv Perit Dial 1992; 8: 298-301.

Moncrief JW, Popovich RP, Dasgupta M et al. Reduction in peritonitis incidence in continuous ambulatory peritoneal dialysis with a new catheter and implantation technique. Perit Dial Int 1993; 13 (Suppl 2): S329-S331.

Moncrief JW, Popovich RP. Moncrief-Popovich catheter: implantation technique and clinical results. Perit Dial Int 1994; 14 (Suppl 3): S56-S58.

Moncrief JW, Popovich RP. Presentation at the XVIII Annual CAPD Conference, Nashville, TH, USA. February 24, 1998.

Ozener C, Bihorac A, Akoglu E. Technical survival of CAPD catheters: comparison between percutaneous and conventional surgical placement techniques. Nephrol Dial Transplant 2001; 16(9): 1893-99.

Park MS, Yim AS, Chung SH et al. Effect of prolonged subcutaneous implantation of peritoneal catheter on peritonitis rate during CAPD: a prospective randomized study. Blood Purif 1998; 16(3): 171-78.

Prischl FC, Wallner M, Kaltschmann H et al. Initial subcutaneous embedding of the peritoneal dialysis catheter – a critical appraisal of this new implantation technique. Nephrol Dial Transplant 1997; 12(8): 1661-67.

Roueff S, Pagniez D, Moranne O et al. Simplified percutaneous placement of peritoneal dialysis catheters: comparison with surgical placement. Perit Dial Int 2002; 22(2): 267-69.

Rubin J, Didlake R, Raju S et al. A prospective randomized evaluation of chronic peritoneal catheters. Insertion site and intraperitoneal segment. ASAIO Trans 1990; 36(3): M497-M500.

Savader SJ, Geschwind JF, Lund GB et al. Percutaneous radiologic placement of peritoneal dialysis catheters: long-term results. J Vasc Interv Radiol 2000; 11: 965-70.

Stegmayr BG, Hedberg B, Norrgard O. Stylet with a curved tip to facilitate introduction of new Tenckhoff catheters and reposition of displaced ones. Surgical technique. Eur J Surg 1993; 159(9): 495-97.

Swartz R, Messana J, Rocher L et al. The curled catheter: dependable device for percutaneous peritoneal access. Perit Dial Int 1990; 10(3): 231-35.

Tsimoyiannis EC, Siakas P, Glantzounis G et al. Laparoscopic placement of the Tenckhoff catheter for peritoneal dialysis. Surg Laparosc Endosc Percutan Tech 2000; 10(4): 218-21.

Twardowski ZJ, Prowant BF, Pickett B et al. Four-year experience with swan neck presternal peritoneal dialysis catheter. Am J Kidney Dis 1996; 27(1): 99-105.

Twardowski ZJ. Presternal peritoneal catheter. Adv Ren Replace Ther 2002; 9(2): 125-32.

Warady BA, Sullivan EK, Alexander SR. Lessons from the peritoneal dialysis patient database: a report of the North American Pediatric Renal Transplant Cooperative Study. Kidney Int Suppl 1996; 53: S68-S71.

Appendix

Table 1 Characteristics of randomised controlled trial evidence

Study ID (author, year)	N	Study Design	Setting	Participants	Intervention (experimental group)	Intervention (control group)	Follow up (months)	Comments
Danielsson et al 2002	60	Randomised controlled trial	University, multicentre	ESRD patients undergoing catheter placement for PD, judged as not in need of PD for at least 6 weeks; 28% diabetic	Subcutaneous burying and rest of PD catheter	Standard insertion with rest but no subcutaneous burying of PD catheter	24	None
Dasgupta et al 2000	41	Randomised controlled trial	University	Patients undergoing catheter placement for PD; proportion of diabetic patients not available	Tehckhoff (straight) catheter	Subcutaneously buried Moncrief-Popovich (curled) catheter	NA	Abstract
Ejlersen et al 1990	37	Randomised controlled trial	University	ESRD patients requiring insertion of PD catheter; proportion of diabetic patients not available; 48.6% had history of intra-abdominal surgery or prior peritoneal catheter	Midline insertion of PD catheter	Lateral insertion of PD catheter	12	None
Gadallah et al 1999	148	Randomised controlled trial	University	Patients undergoing catheter placement for CAPD; 36% diabetic	Laparoscopic insertion of PD catheter	Standard laparotomy insertion of PD catheter	36	None

Study ID (author, year)	N	Study Design	Setting	Participants	Intervention (experimental group)	Intervention (control group)	Follow up (months)	Comments
Moncrief and Popovich 1998	113	Randomised controlled trial	University	Patients undergoing catheter placement for PD; proportion of diabetic patients not available	Subcutaneous burying and rest of PD catheter	Standard insertion with rest but no subcutaneous burying of PD catheter	NA	Abstract
Park et al 1998	60	Randomised controlled trial	University	Patients undergoing catheter placement for CAPD; 43% diabetic	Subcutaneous burying and rest of PD catheter	Standard insertion with rest but no subcutaneous burying of PD catheter	24	None
Rubin et al 1990*	83	Randomised controlled trial	University	ESRD patients requiring insertion of PD catheter; 24% diabetic	Straight catheter midline insertion	Either spiral catheter midline insertion or straight catheter lateral insertion or spiral catheter lateral insertion	NA†	None
Tsimoyiannis et al 2000	50	Randomised controlled trial	Teaching hospital	Patients undergoing catheter placement for CAPD; proportion of diabetic patients not available	Laparoscopic insertion of PD catheter	Standard laparotomy insertion of PD catheter	24	None

* Trial with 4 arms

† NA = not available

Table 2 Quality of randomised trials

Study ID (author, year)	Method of allocation concealment	Blinding			Intention-to-treat analysis	Loss to follow up (%)
		(participants)	(investigators)	(outcome assessors)		
Danielsson et al 2002	Unclear	No	No	No	Unclear	0.0
Dasgupta et al 2000	Unclear	No	No	No	NA	NA
Ejlersen et al 1990	Unclear	No	No	No	Yes	0.0
Gadallah et al 1999	Inadequate	No	No	No	No	3.4%
Moncrief and Popovich 1998	NA*	NA	NA	NA	NA	NA
Park et al 1998	Unclear	No	No	No	No	1.6
Rubin et al 1990	Unclear	No	No	No	No	Unclear
Tsimoyiannis et al 2000	Unclear	No	No	No	No	10.0

* NA = not available

Table 3 Results for dichotomous outcomes

Study ID (author, year)	**Outcomes**	**Intervention group (number of patients with events/number of patients exposed)**	**Control group (number of patients with events/number of patients not exposed)**	**Relative risk (RR) [95% CI]**	**Risk difference (RD) [95% CI]**
Danielsson et al 2002	Peritonitis rate*	11/475	12/1133	2.19 (0.97 to 4.92)	0.01 (0.00 to 0.03)
	Exit-site/tunnel infection rate*	5/475	5/1133	2.39 (0.69 to 8.20)	0.01 (0.00 to 0.02)
	Technique failure	1/30	3/30	0.33 (0.04 to 3.03)	-0.07 (-0.19 to 0.06)
	All-cause mortality	6/30	5/30	1.20 (0.41 to 3.51)	0.03 (-0.16 to 0.23)
Dasgupta et al 2000	NA	NA	NA	NA	NA
Ejlersen et al 1990	Peritonitis	1/21	3/16	0.25 (0.03 to 2.22)	-0.14 (-0.35 to 0.07)
	Exit-site/tunnel infection	1/21	0/16	2.32 (0.10 to 53.42)	-0.05 (-0.08 to 0.18)
	All-cause mortality	5/21	0/16	8.50 (0.50 to 143.32)	0.24 (0.04 to 0.44)
Gadallah et al 1999	Peritonitis	11/76	16/72	0.65 (0.32 to 1.31)	-0.08 (-0.20 to 0.05)
	Technique failure	19/58	32/58	0.59 (0.38 to 0.92)	-0.22 (-0.40 to -0.05)
	All-cause mortality	9/76	9/72	0.95 (0.40 to 2.25)	-0.01 (-0.11 to 0.10)
Moncrief and Popovich 1998	NA[†]	NA	NA	NA	NA
Park et al 1998	Peritonitis rate*	37/493	45/410	0.68 (0.45 to 1.04)	-0.03 (-0.07 to 0.00)
	Exit-site/tunnel infection rate*	39/493	43/419	0.75 (0.50 to 1.14)	-0.03 (-0.06 to 0.01)
	All-cause mortality	3/30	5/29	0.58 (0.15 to 2.21)	-0.07 (-0.25 to 0.10)
Rubin et al 1990	Peritonitis[‡]	10/48	10/35	0.73 (0.34 to 1.56)	-0.08 (-0.27 to 0.11)
	Exit-site/tunnel infection[‡]	2/48	4/35	0.36 (0.07 to 1.88)	-0.07 (-0.19 to 0.05)
	Catheter removal/replacement[‡]	14/48	18/35	0.57 (0.33 to 0.98)	-0.22 (-0.43 to -0.01)
Tsimoyiannis et al 2000	Peritonitis	3/20	5/25	0.75 (0.20 to 2.77)	-0.05 (-0.27 to 0.17)
	Catheter removal/replacement	1/20	3/25	0.42 (0.05 to 3.71)	-0.07 (-0.23 to 0.09)
	Technique failure	1/20	3/25	0.42 (0.05 to 3.71)	-0.07 (-0.23 to 0.09)

* Given as episodes/total patient months on PD [†] NA = not available [‡] for midline vs lateral insertion