



Use of the embedded peritoneal dialysis catheter

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ABSTRACT

INTRODUCTION The use of embedded peritoneal dialysis (PD) catheters is purported to offer numerous benefits over standard placement. However, the optimum period of embedment and the effect of prolonged embedment on subsequent catheter function remain unclear.

METHODS This retrospective observational study looked at adult patients undergoing embedded PD catheter insertion in a large tertiary referral centre in the UK. Possible predictors for catheter non-function at externalisation were investigated. These included patient factors (age, sex, diabetic status, body mass index, ethnicity, smoking status, previous surgery, estimated glomerular filtration rate), procedural factors (modality of surgery, concurrent surgical procedure), duration of catheter embedment and catheter damage at externalisation. Outcomes examined comprised proportion of catheters functioning after externalisation, futile placement rate, surgical reintervention rate, infectious complication rate and proportion of externalised catheters lost owing to malfunction.

RESULTS Sixty-six catheters were embedded and two-thirds ($n=47$, 63.6%) were externalised after a median embedment period of 39.4 weeks. Of these, 25 (53.2%) functioned on externalisation. Fourteen (63.6%) of the 22 non-functioning catheters were salvaged. The overall utilisation of PD was 34/47 (72.3%) and the futile placement rate was 12.1%. Over half of the externalised catheters ($n=27$, 57.4%) were lost directly as a result of catheter related complications, with a median survival time of 39.4 weeks. In adjusted analysis, increasing embedment duration was significantly predictive of catheter non-function at externalisation (adjusted odds ratio: 0.957, 95% confidence interval [CI]: 0.929–0.985, $p=0.003$) while subsequent catheter loss was highly dependent on catheter function at externalisation (hazard ratio: 0.258, 95% CI: 0.112–0.594, $p=0.001$).

CONCLUSIONS Prolonged embedment of PD catheters is associated with a significantly higher likelihood of catheter dysfunction following externalisation, which is in turn associated with subsequent catheter loss. We have discontinued the use of this technique in our unit.

KEYWORDS

Catheter – Peritoneal dialysis – Moncrief-Popovich

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More than 500,000 patients with stage 5 chronic kidney disease are treated by peritoneal dialysis (PD) worldwide.¹ However, the number of patients treated by PD in North America and Europe continues to decline. Although some patients have a steady decline in kidney function over time, many others have sudden episodes of acute kidney deterioration, which may lead to unplanned commencement of haemodialysis (HD). As such, patients who may have expressed an initial preference for PD are initiated on HD and once started on HD, few patients change dialysis modality.¹

In order to increase the number of patients treated by PD, some centres have opted for prophylactic insertion of PD catheters, with the external portion of the catheter capped and embedded in the subcutaneous tissue in the anterior abdominal wall so that the catheter can be readily accessed and used in cases of sudden deterioration in kidney function. This concept was originally described by Moncrief *et al*

25 years ago.² By allowing time for the catheter cuffs to become integrated into host tissue and for peritoneal incisions to heal, this technique potentially offers lower infection rates and fewer technical complications (such as leaks), thereby allowing more patients to successfully initiate PD.^{2,5}

Peritonitis and exit site infections are the most common complications of PD, and initial reports of the embedded PD catheter technique suggested lower infection rates.^{5–6} As such, although many PD centres adopted this method, difficulty in predicting the exact timing of when any individual patient needs to start PD has led to centres describing prolonged embedment periods and ‘futile’ placement, whereby embedded catheters are never externalised or used.^{5,7,8} While the majority of centres have reported few technical problems when initiating PD with catheters that had been embedded for protracted periods, this positive experience has not been universal.^{9–12} The aim of this study was therefore to review our experience of embedding PD catheters

with respect to clinical outcomes including futile placement and catheter dysfunction.

Methods

Clinical, laboratory and outcomes data were gathered retrospectively from the medical records of all patients who underwent insertion of an embedded PD catheter at our institution (a large tertiary referral hospital with a catchment area of approximately 1,000,000, and a stage 5 chronic kidney disease patient cohort comprising approximately 750 HD and 200 PD patients) over a five-year period from December 2008 to November 2015. Follow-up data were obtained for each patient until the time of data collation (January 2015) or until cessation of PD (either due to death, transplant or switch to HD).

Patient population/selection and demographics

Patients were referred from the nephrology department to the renal transplantation surgical unit for consideration of embedded PD catheter insertion. Timing of referral was not protocolised but mirrored the same principles for vascular access referral and was based on the rate of decline of estimated glomerular filtration rate (eGFR).^{15,14} The choice of dialysis modality was made in consultation with the patient while the ultimate decision about suitability for PD was based on surgical and anaesthetic considerations. Data on patient sex, age, body mass index (BMI), co-morbidity, and procedural details such as modality of surgery (laparoscopic or open) and concurrent (simultaneous) surgical procedures (eg hernia repair) were abstracted directly while eGFR was calculated using the four-variable Modification of Diet in Renal Disease (MDRD) study formula.¹⁵

Catheter equipment and implantation technique

PD catheter equipment was standardised throughout the study period, and comprised a 65cm long, straight neck, double cuff, coiled Tenckhoff catheter (Kimal, Uxbridge, UK) and the TE-1000 Embedding[®] Tool (Merit Medical, South Jordan, UT, US). Laparoscopic insertion was the default operative modality unless the patient was unfit for general anaesthesia, in which case open insertion under local anaesthesia was performed. All patients received intravenous antibiotics (teicoplanin and gentamicin unless known to be colonised with methicillin resistant *Staphylococcus aureus*, in which case vancomycin was administered) at induction.

Initial entry into the abdominal cavity was achieved either through an open cut-down technique at the umbilicus or in cases where off-centre entry was preferred (eg owing to a previous midline incision), the Endopath XCEL[®] optical trocar system (Ethicon, Somerville, NJ, US) was employed with or without preceding Veress needle puncture at Palmer's point (left upper quadrant). A 5mm disposable port was inserted initially and diagnostic laparoscopy performed with a 5mm 30° laparoscope at an insufflation pressure of 12mmHg. An 8mm disposable bladeless trocar was introduced in either the left or right paramedian position and the tip directed inferocaudally under vision. The 8mm trocar

was advanced into the preperitoneal space and tunnelled further caudally in this plane before being directed inferiorly to breach the peritoneum (separating the point of skin and peritoneal puncture). In cases where significant adhesions were encountered, adhesiolysis was performed laparoscopically before introducing the PD catheter through the 8mm port.

A further 5mm port was introduced on the opposite side of the 8mm port to facilitate introduction of laparoscopic graspers to help direct the catheter tip into the pelvis and to hold it in place while withdrawing the 8mm port. The catheter was positioned with the deep cuff in the preperitoneal space and a subcutaneous tunnel created in a lateral direction using the introducer spike from a standard closed suction drain. The superficial cuff was left in a subcutaneous position approximately 3cm from the exit site of the introducer spike (the primary exit site).

The abdomen was deflated and catheter function tested using a 500ml bag of normal saline. Once adequate catheter inflow and drainage was confirmed, the curved embedding handle and attached titanium plug were used to create a second subcutaneous tunnel through a counterincision (the secondary exit site), which allowed them to traverse in a medial direction and exit via the primary exit site. The PD catheter was flushed with heparinised saline before being attached to the plug/handle device and pulled through the second subcutaneous tunnel. After exiting the secondary exit site, the handle was removed and a titanium cap affixed to the plug, thereby sealing the catheter. The capped catheter was left in the subcutaneous tissue around the secondary exit site.

Wound closure was achieved in layers with a slowly absorbable suture (PDS[®]; Ethicon) for fascia and a rapidly absorbable suture (Vicryl[®]; Ethicon) with tissue adhesive (Dermabond[®], Ethicon) for skin. Open insertion was performed through an infraumbilical minilaparotomy incision (with infiltration of local anaesthetic prior to skin incision)

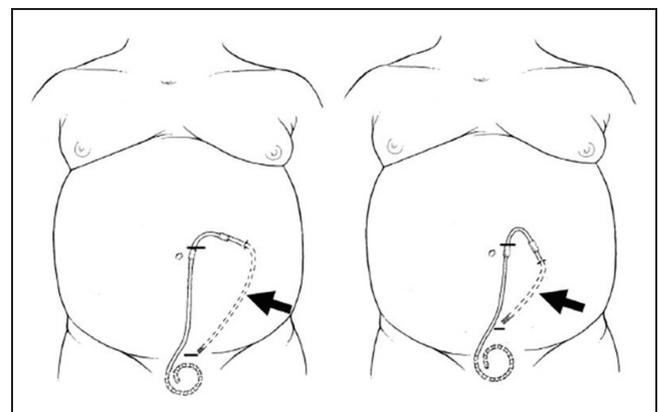


Figure 1 Illustration of site and configuration of embedded catheters. Arrows point to position of embedded portion of catheter. Reprinted from Crabtree and Burchette,⁷ with permission from Elsevier.

and planned subcutaneous routes for the catheter. The tunnelling and embedding processes were otherwise as described for the laparoscopic approach. Figure 1 illustrates the position of catheters after the embedding process.

Plain film abdominal radiography was used to confirm adequate placement of the catheter tip. The standardised care pathway for embedded PD catheter insertion involved a day-case procedure through a specialised renal day ward.

Externalisation process and technique

Patients were referred for externalisation on the basis of deteriorating biochemistry or clinical symptoms (fluid overload or uraemia) and this was performed under local anaesthesia as a day-case procedure in the renal day ward. Prophylactic antibiotics were not administered. A 10mm incision was made at the primary exit site. Blunt dissection was used to free and deliver the catheter into the wound from its subcutaneous position. The plugged end was amputated and a connection set attached (MiniCap Extended Life PD Transfer Set with Twist Clamp; Baxter, Deerfield, IL, US). After flushing with heparinised saline, a trial of irrigation was performed with 500ml of normal saline. Catheters with poor flow were given a bolus of 8mg of tissue plasminogen activator (tPA) (administered as an infusion in 20ml of normal saline over 2 hours) to try to dislodge fibrin deposits.

This was repeated on a second consecutive day in patients whose catheters remained blocked. Patients with catheters that remained obstructed despite two consecutive tPA flushes were booked on to the next available elective operating list for laparoscopic manipulation and salvage of the catheter. Once externalised, mupirocin ointment was applied to the PD catheter exit sites on alternate days.⁴

Outcomes

The primary outcome was the proportion of catheters functioning after externalisation ('primary function', defined as satisfactory catheter flow following externalisation without the need for surgical reintervention). Secondary outcomes were the futile placement rate (defined as the proportion of catheters that were embedded but never externalised), the rate of catheter loss (defined as replacement or removal of the originally embedded catheter for mechanical/structural dysfunction [catheter obstruction, peritoneal leak or abdominal wall herniation] or infectious complications [PD peritonitis or exit site infection]), the surgical reintervention rate, the PD associated peritonitis rate and the exit site infection rate. PD associated peritonitis (referred to as 'peritonitis' in this paper) and exit site infection were defined according to published standards.¹⁶

Ethical approval

The requirement for individual patient consent was waived by the Royal Free Hospital research and development office as this retrospective study complied with National Health Service guidelines for clinical audit and service development.^{17,18} Anonymised data were collected, in keeping with the trust policy, and no patient identifiable data were used.

Statistical analysis

Data were tabulated in Excel® (Microsoft, Redmond, WA, US), and analysed using SPSS® version 20 (IBM, NY, US) and R version 3.1.1 (R Foundation for Statistical Computing, Vienna, Austria). Categorical data were compared using Fisher's exact test and continuous data with the Mann-Whitney U test. Differences with a *p*-value of <0.05 were considered statistically significant.

Covariates associated with the primary outcome in univariate analysis were tested in a multiple logistic regression model at a threshold coefficient *p*-value of <0.15 for inclusion in the model. Collinearity was assessed by examining variance inflation factors (with a threshold of >10 representing significant collinearity) and rerunning regressions as sensitivity analyses with each redundant variable removed in turn. Time to event outcomes was represented using Kaplan-Meier survival curves with appropriate censoring for death, transplantation and transfer to HD for reasons other than catheter related complications. Time from externalisation to catheter loss was modelled using Cox proportional hazards regression with the same criteria for variable selection as for logistic regression modelling. Model adequacy was assessed using Nagelkerke's *R*², the Hosmer-Lemeshow goodness of fit test and receiver operating characteristic curve analysis (with bootstrapping to account for model overfitting).

Results

A total of 66 PD catheters were embedded during the study period with baseline demographics as listed in Table 1. Follow-up data were available for all patients and the median follow-up duration from embedding until cessation of PD was 21 months (interquartile range [IQR]: 10–34 months), equating to a total of 1,676 patient-months. Ten patients (15.2%) died during the follow-up period but none of these deaths were related to either embedding or externalisation of catheters. Figure 2 summarises the outcomes for the 66 embedded PD catheters at the end of the study period.

Nineteen catheters (28.8%) had not been externalised by the end of the period of observation. Eight (12.1%) were regarded as examples of futile placement because patients were either pre-emptively transplanted (6 cases), died (1 case) or switched to HD following native nephrectomy prior to externalisation (1 case) and as a result, none of these catheters were used. Eleven catheters (16.7%) remained embedded at the time of data collation, with a median embedment duration of 131 weeks (IQR: 68–206 weeks).

Of the 47 catheters (71.2%) that were externalised (median embedment: 39.4 weeks, IQR: 20.4–66.4 weeks, *p*<0.0001 vs catheters still embedded), 25 (53.2%) achieved primary function. Twenty-two (88.0%) of these went on to be successfully utilised for PD with a median treatment period of fourteen months (IQR: 6.75–30 months).

Twenty-two (46.8%) of the embedded catheters did not function immediately after externalisation. The primary reason for non-function was catheter malposition (*n*=12), occlusion by fibrin plugs (*n*=6), damage at externalisation (*n*=3)

Table 1 Baseline demographics for study population of 66 patients

Patient characteristic	
Median age in years	63.9 (IQR: 50.7–75.9)
Male sex	40 (60.6%)
Diabetic	25 (37.9%)
Median BMI in kg/m ²	27.2 (IQR: 24.2–31.2)
African race	14 (21.2%)
Smoker	7 (10.6%)
Previous intraperitoneal surgery	22 (33.3%)
Median eGFR at embedment in ml/min/1.73m ²	13.0 (IQR: 11.0–15.3)
Suspected or known cause of renal failure	
Diabetes	20 (30.3%)
Hypertension	13 (19.7%)
Diabetes and hypertension	5 (7.6%)
Polycystic kidney disease	11 (16.7%)
Glomerulonephritis/intrinsic renal disease	8 (12.1%)
Other (eg obstructive uropathy, unknown)	9 (13.6%)
Procedural characteristic	
Laparoscopic procedure*	62 (93.9%)
Concurrent surgical procedure**	6 (9.1%)
BMI = body mass index; eGFR = estimated glomerular filtration rate; IQR = interquartile range	
*Of the 4 non-laparoscopic cases, 3 were open and 1 was laparoscopic converted to open.	
**5 were hernia repair and 1 was adhesiolysis.	

and obstruction of catheter by adhesions ($n=1$). Bedside flushing with tPA was temporarily successful in only two cases (both of which went on to require surgical rescue). Fourteen (63.6%) of the non-functioning catheters underwent successful surgical reintervention following externalisation to establish flow and twelve (85.7%) of these patients went on to establish themselves on PD for a median of 10.5 months (IQR: 6.0–20.8 months). The difference in PD treatment duration was not statistically significant for patients whose catheters functioned primarily versus those whose catheters required surgical rescue ($p=0.279$). In two patients, surgical rescue was technically successful but PD was never commenced (owing to peritonitis with *Enterococcus faecium* in 1 case and insertion of a gastrostomy tube in the other).

Six (12.8%) of the forty-seven catheters were damaged during the process of externalisation. Of these, three (50.0%) remained usable for PD for a period of time (median: 7 months, range: 3–8 months) without requiring repair. However, five (83.3%) of the six catheters eventually required surgical reintervention and replacement (odds

ratio [OR]: 5.20, 95% confidence interval [CI]: 0.31–79.40, $p=0.596$ vs undamaged catheters).

Of the 22 catheters that did not function primarily, 5 (22.7%) were not successfully rescued despite multiple surgical procedures (median: 2 procedures, range: 2–3 procedures) and in three cases (15.6%), rescue was not attempted owing to patient death, transplant and deterioration in comorbidity precluding general anaesthesia.

Thirty (63.8%) of the patients with externalised catheters underwent a total of fifty surgical reinterventions following externalisation during the study period (median: 1 procedure per patient, range: 1–4 procedures), equating to 0.36 reinterventions per patient year. Of the 50 reinterventions, 13 (26.0%) were flushing and repositioning of the catheter (with or without laparoscopic adhesiolysis and/or removal of occluding fibrin plug), 20 (40.0%) were replacement of the original catheter with a new catheter and 17 (34.0%) were removal of the catheter. When considering only the first reintervention ($n=50$), 11 (36.7%), 12 (40.0%) and 7 (23.3%) were repositioning, replacement and removal procedures respectively.

Of the 47 patients with externalised catheters, 18 (38.3%) suffered a total of 32 episodes of peritonitis, equating to 0.25 episodes per patient per year. Seven (14.9%) of the patients suffered ten episodes of exit site infection (0.07 episodes per patient year) and three patients (6.4%) developed peritoneal leak or abdominal wall herniation as a consequence of PD. Twenty-seven (57.4%) of the externalised catheters required replacement or removal during the study period for mechanical dysfunction or infectious complications. Figures 3–5 illustrate censored survival times from externalisation until first surgical reintervention (median: 20.4 weeks), first episode of peritonitis (median: 103.6 weeks) and catheter replacement or loss for dysfunction (median: 39.4 weeks). There was no association between duration of catheter embedment and occurrence of infectious or abdominal wall complications (ie peritonitis, exit site infection and abdominal wall herniation).

Table 2 compares the demographic differences between patients with catheters that achieved primary function and those that did not. Diabetes ($p=0.042$) and prolonged embedment duration ($p<0.0001$) were both statistically associated with catheter primary non-function at externalisation. Multivariate modelling ($R^2=0.450$; Hosmer–Lemeshow test, $p=0.431$; bootstrapped area under the receiver operating characteristic curve [AUC]: 0.839) showed that embedment duration remained significantly predictive ($p=0.005$) after controlling for diabetic status: a one-week increase in embedment duration conferred a 4.3% decrease in the adjusted odds of catheter primary function (adjusted OR: 0.96, 95% CI: 0.93–0.99). Following externalisation, patients with non-functioning catheters were significantly more likely than those with primarily functioning catheters to undergo surgical reintervention (unadjusted OR: 8.06, 95% CI: 1.61–45.66, $p=0.005$) although the odds of catheter loss were not significantly different (unadjusted OR: 2.39, 95% CI: 0.85–14.06, $p=0.076$).

Risk factors for catheter loss were similarly tested in univariate analysis and showed no statistically significant

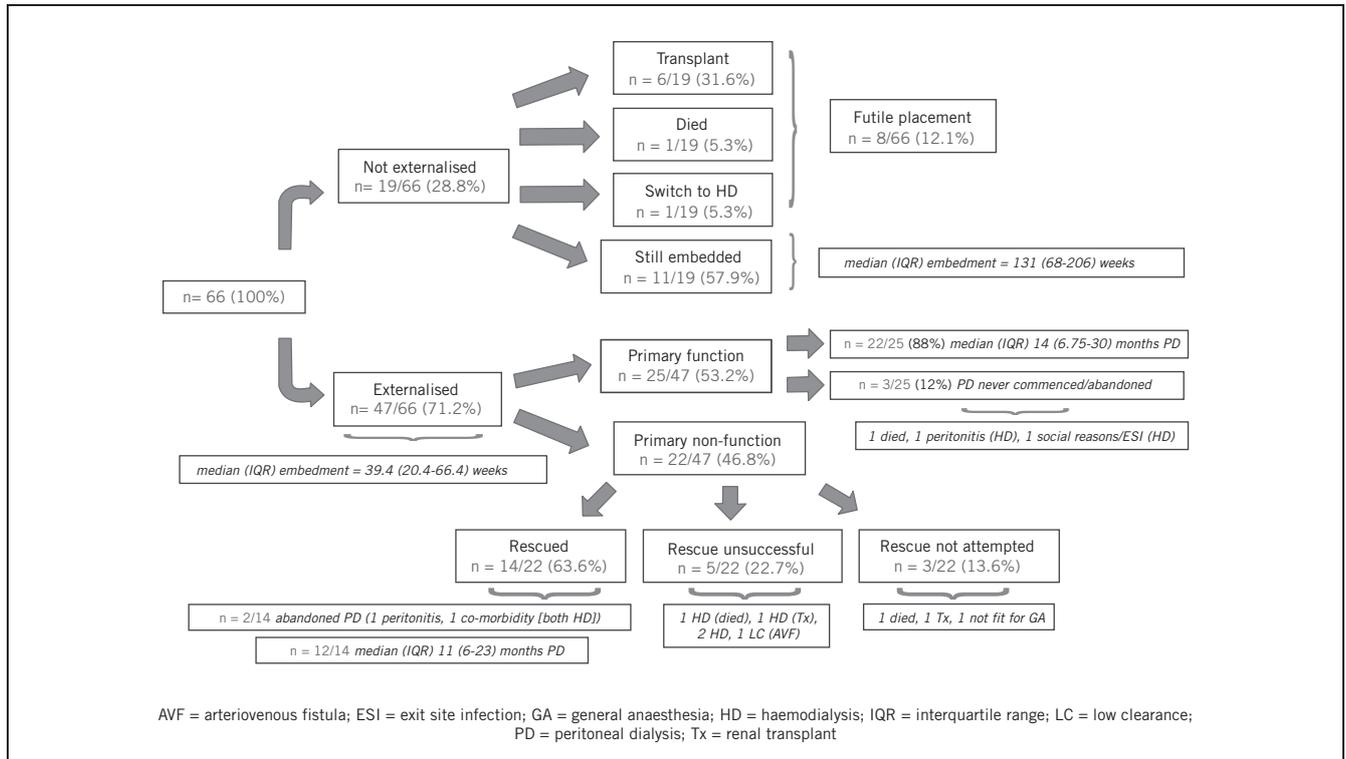


Figure 2 Outcomes for 66 embedded PD catheters at end of study period

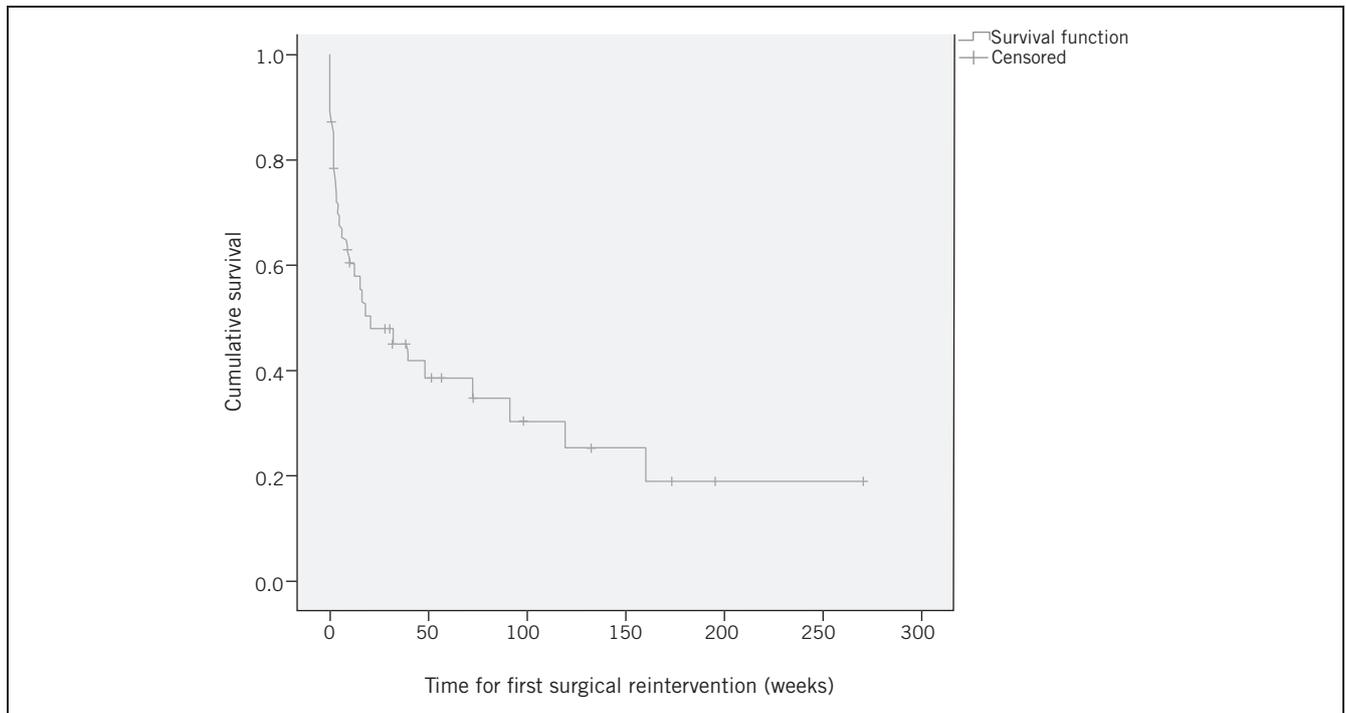


Figure 3 Kaplan-Meier survival curve for time to first surgical reintervention

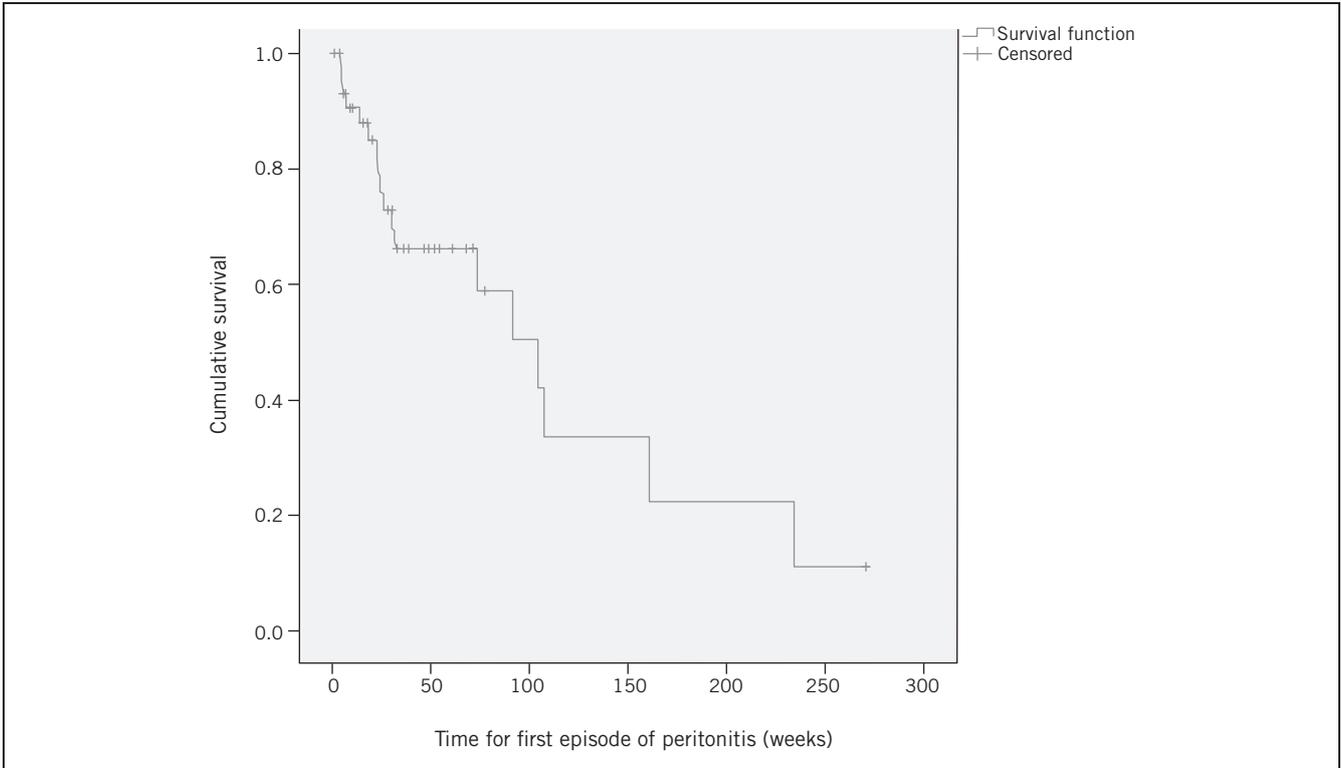


Figure 4 Kaplan-Meier survival curve for time to first episode of peritonitis

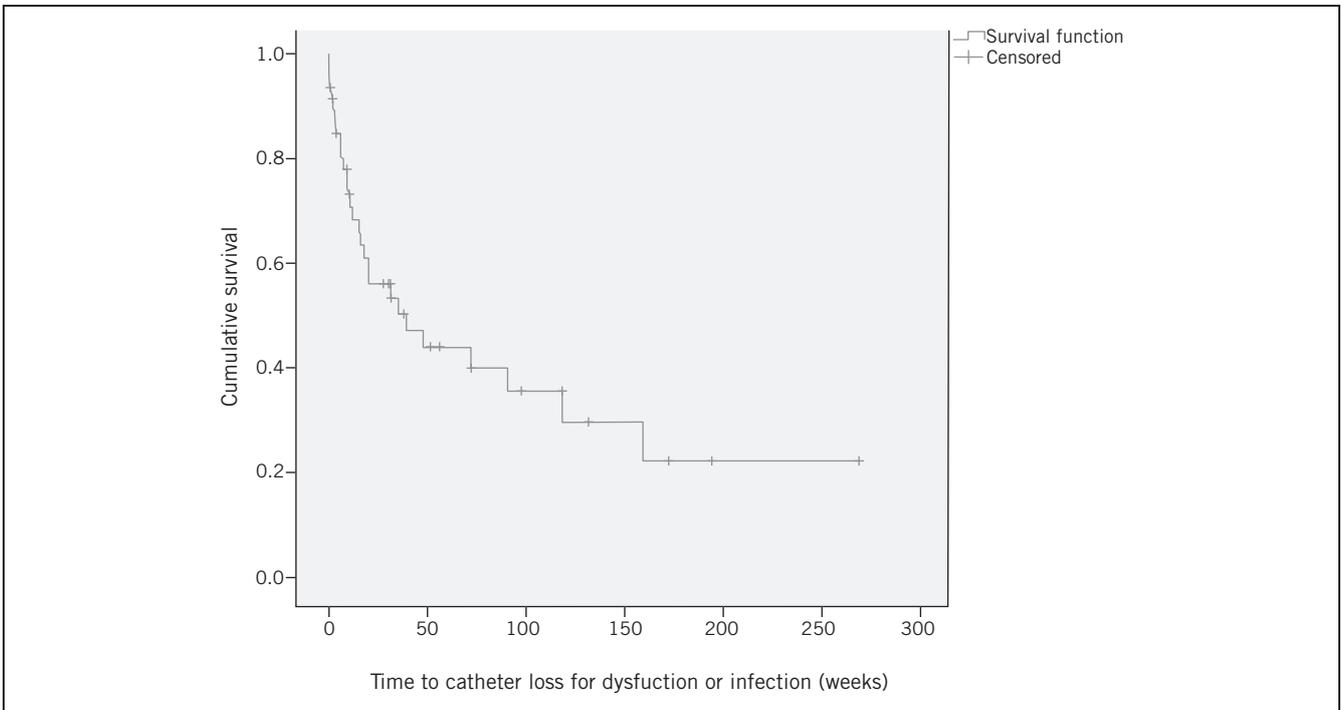


Figure 5 Kaplan-Meier survival curve for time to catheter loss for dysfunction or infection

Characteristic	Primary function (n=25)	Primary non-function (n=22)	Univariate analysis (p-value)*	Multivariate logistic regression (p-value)
Median age in years	56.8 (IQR: 42.2–71.3)	62.1 (IQR: 51.3–73.0)	0.572	–
Male sex	15 (60.0%)	17 (77.3%)	0.230	–
Diabetic	7 (28.0%)	13 (59.1%)	0.042	0.060
Median BMI in kg/m ²	25.2 (IQR: 22.4–28.3)	27.2 (IQR: 24.3–30.1)	0.153	–
African race	5 (20.0%)	3 (13.6%)	0.706	–
Smoker	3 (12.0%)	3 (13.6%)	0.999	–
Previous intraperitoneal surgery	8 (32.0%)	6 (27.3%)	0.760	–
Median eGFR at embedment in ml/min/1.73m ²	13.0 (IQR: 10.5–15.5)	12.5 (IQR: 11.0–14.0)	0.966	–
Laparoscopic procedure	24 (96.0%)	21 (95.5%)	0.999	–
Concurrent surgical procedure at embedment	3 (12.0%)	1 (4.5%)	0.611	–
Median eGFR at externalisation in ml/min/1.73m ²	9.0 (IQR: 6.0–12.0)	8.0 (IQR: 6.0–10.0)	0.563	–
Median embedment duration in weeks	25.1 (IQR: 7.7–42.5)	63.9 (IQR: 35.0–92.8)	<0.0001	0.003
Catheter damage at externalisation	4 (16.0%)	2 (9.1%)	0.670	–
<i>Outcomes following externalisation</i>				
Surgical reintervention	11 (44.0%)	19 (86.4%)	0.005	
Exit site infection	5 (20.0%)	2 (9.1%)	0.423	
PD peritonitis	11 (44.0%)	7 (31.8%)	0.549	
Catheter loss	11 (44.0%)	16 (72.7%)	0.076	

BMI = body mass index; eGFR = estimated glomerular filtration rate; IQR = interquartile range; PD = peritoneal dialysis
 *Fisher's exact test for categorical variables, Mann-Whitney U test for continuous variables

associations although BMI, peritonitis and catheter primary function all had *p*-values of <0.15 (Table 3). Surgical reintervention was excluded as a variable because catheter removal was (by definition) a surgical procedure. Time to catheter loss was modelled using Cox proportional hazards regression ($R^2=0.213$, bootstrapped AUC: 0.702) and this showed that the adjusted risk for catheter loss at any given timepoint was 74% less (adjusted hazard ratio [HR]: 0.26, 95% CI: 0.11–0.59, *p*=0.001) for catheters that functioned primarily following externalisation than for those that did not (after controlling for BMI and peritonitis) (Table 3, Fig 6).

Discussion

In contrast to many centres publishing positive reports extolling the advantages of the embedded PD catheter technique and asserting that the duration of embedment does not adversely affect catheter function,^{8–11} our study found that the duration of PD catheter embedment adversely affected catheter function immediately following externalisation (4.3% increased odds of non-function for each week increase in embedment) and that catheter non-function subsequently carried a 26% increased risk of catheter loss. Our finding that

embedment duration confers an increased risk of catheter malfunction is supported by the observation from a single centre retrospective study, which reported an increased rate of catheter loss when embedment duration exceeded 19 weeks.¹² Insertion of a catheter into the peritoneal cavity is likely to promote an inflammatory response to the foreign body, and obesity, diabetes and chronic renal failure are recognised promoters of systemic inflammation.^{7,19,20}

These proinflammatory changes may be responsible for the clinical findings of omental wrapping of the intraperitoneal catheter tip and occlusion of the lumen with long fibrin casts associated with prolonged embedment (Fig 7).¹² In our experience, such casts proved resistant to chemical lysis with tissue plasminogen activator and to mechanical removal. Although the external portion of the PD catheter is 'locked' with heparinised saline, the distal tip lying in the peritoneal cavity is open and it has therefore been postulated that the same changes that result in leakage of catheter lock solutions from central venous catheters (eg fluid column pressure, lock solution density, and variations in intracavity pressure with posture and obesity) may potentially apply to PD catheters.^{7,21–25} Nevertheless, despite these observations, other retrospective series have failed to report any

Table 3 Analysis of variables associated with catheter loss for mechanical dysfunction or infectious complications

Characteristic	Catheter survival (n=20)	Catheter loss (n=27)	Univariate analysis (p-value)*	Cox proportional hazards regression**
Median age in years	55.1 (IQR: 40.6–69.6)	61.8 (IQR: 50.8–72.9)	0.245	–
Male sex	13 (65.0%)	19 (70.4%)	0.758	–
Diabetic	9 (45.0%)	11 (40.7%)	0.999	–
Median BMI in kg/m ²	25.2 (IQR: 22.8–27.5)	28.0 (IQR: 25.2–30.9)	0.087	HR: 1.02, 95% CI: 0.94–1.11, p=0.589
African race	5 (25.0%)	3 (11.1%)	0.258	–
Smoker	3 (15.0%)	3 (11.1%)	0.999	–
Previous intraperitoneal surgery	5 (25.0%)	9 (33.3%)	0.748	–
Median eGFR at embedment in ml/min/1.73m ²	13.0 (IQR: 10.5–15.5)	12.0 (IQR: 10.0–14.0)	0.913	–
Laparoscopic procedure	18 (90.0%)	27 (100%)	0.176	–
Concurrent surgical procedure at embedment	2 (10.0%)	2 (7.4%)	0.999	–
Median eGFR at externalisation in ml/min/1.73m ²	8.0 (IQR: 5.0–11.0)	9.0 (IQR: 7.5–10.5)	0.854	–
Median embedment duration in weeks	38.5 (IQR: 15.8–61.3)	46.6 (IQR: 17.1–76.1)	0.389	–
Catheter damage at externalisation	2 (10.0%)	4 (14.8%)	0.999	–
<i>Outcomes following externalisation</i>				
Exit site infection	1 (5.0%)	6 (22.2%)	0.213	–
PD peritonitis	5 (25.0%)	13 (48.1%)	0.137	HR: 0.90, 95% CI: 0.40–2.02, p=0.795
Catheter primary function	14 (70.0%)	11 (40.7%)	0.076	HR: 0.26, 95% CI: 0.11–0.59, p=0.001

BMI = body mass index; CI = confidence interval; eGFR = estimated glomerular filtration rate; HR = hazard ratio; IQR = interquartile range; PD = peritoneal dialysis
 *Fisher's exact test for categorical variables, Mann–Whitney U test for continuous variables
 **For time from externalisation until catheter loss

statistically significant associations between the duration of catheter embedment and catheter malfunction.^{8–11}

Catheter non-function immediately after externalisation was associated with eightfold increased odds of surgical reintervention as our experience with bedside flushing of the catheter with thrombolytic agents was generally unsatisfactory owing to the organised nature of the occlusive fibrin casts encountered. It is worth mentioning, however, that once catheters had been salvaged surgically, the subsequent duration of PD treatment was similar to that for primarily functioning catheters and this may explain why neither embedment duration nor primary non-function individually predicted subsequent catheter loss.

Compared with other published studies (Table 4), our futile placement rate (12.1%) and overall surgical rescue rate (63.6%) were similar, particularly considering our

median embedment duration was among the longest.^{5,7–15} Conversely, our rate of catheter damage at externalisation was high (12.8%) and this can be ascribed in part to the difficulty associated with performing a bedside surgical procedure under local anaesthesia in a relatively obese patient cohort. It is feasible that this outcome could be improved with the use of imaging adjuncts such as bedside ultrasonography to definitively map the location of the buried segment before attempting dissection although it is noteworthy that damage at externalisation was not associated with subsequent increased risk of catheter loss.

Purported initially to be effective in reducing exit site infections and subsequent peritonitis rates, this was not substantiated in meta-analysis of randomised trials comparing embedded catheters with standard placement.²⁴ Our peritonitis rate of 38.3% is comparable with the rates reported in

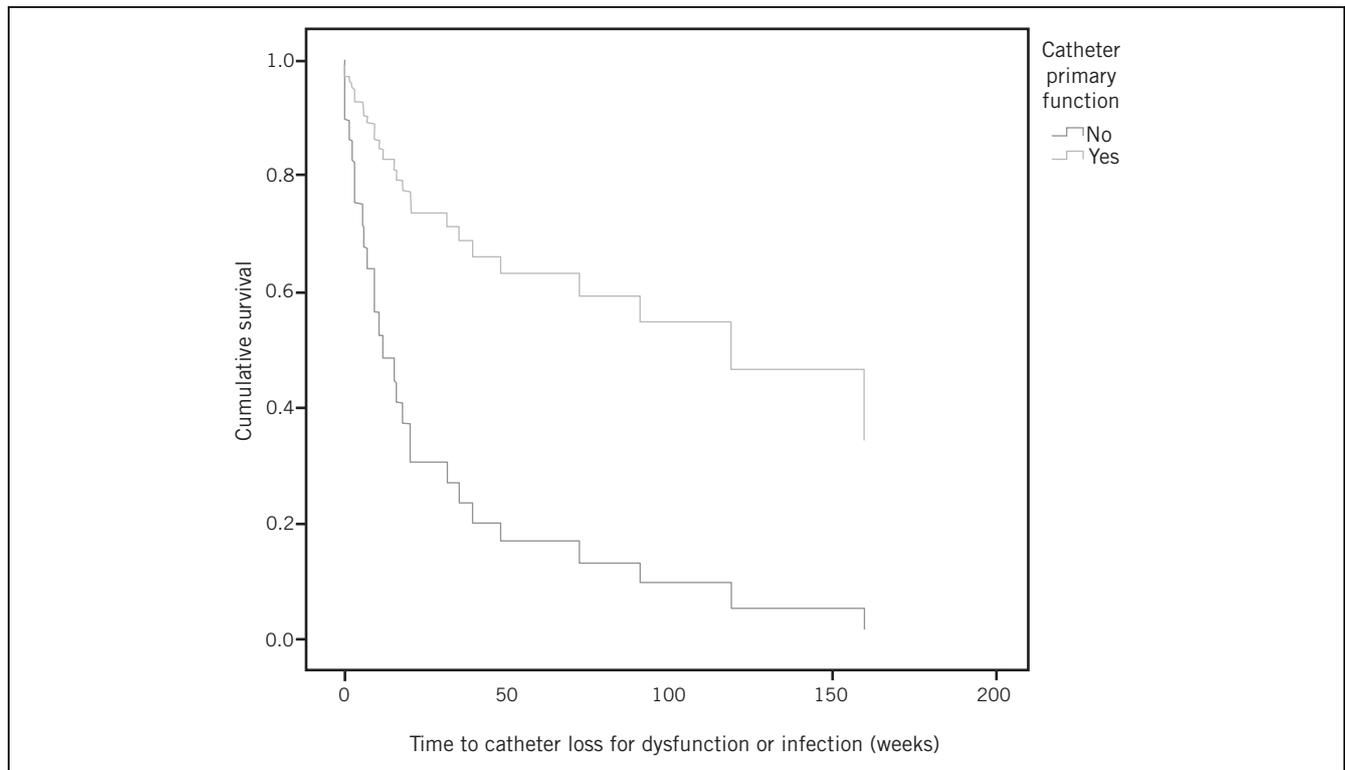


Figure 6 Adjusted Kaplan–Meier survival curves from Cox proportional hazards regression stratified by catheter primary function status



Figure 7 Occlusive fibrin cast removed from embedded peritoneal dialysis catheter

other large series.^{5–5,12} After adjusting for other factors, including catheter primary function, peritonitis did not confer any significantly increased risk of catheter loss.

Nevertheless, our overall experience of the embedded PD catheter technique has not been as positive as earlier reports,^{5,7–9,11–15} with a utility of only 72.3%. Furthermore, in our opinion, the advantage of the technique in allowing placement prior to established renal failure is outweighed by the fact that following externalisation, 64% of our patients needed surgical salvage procedures under general anaesthesia. Given this, our policy towards embedding PD catheters was reappraised and this technique has now been discontinued.

Clearly, efforts to minimise embedment duration are of great importance and could contribute to increasing the utility of the technique by reducing futile placement rates.¹⁵ The difficulty remains in accurately predicting when patients should initiate dialysis as recent trials do not suggest any advantage for an early start (provided that patients remain otherwise healthy).²⁵ In the UK, patients with chronic kidney disease may be listed for transplantation prior to initiation of dialysis. For this reason, UK centres may have a higher futile catheter placement rate than those in other countries. Additionally, the supposed benefits of embedding PD catheters can be questioned owing to increasing evidence that low volume PD can be safely commenced more or less immediately after insertion with few complications.²⁶

‘Urgent start’ PD programmes have been described in both inpatient and outpatient settings although it is recognised that such programmes require significant infrastructural reorganisation encompassing patient education, staff

Table 4 Summary of outcomes of retrospective studies of embedded peritoneal dialysis catheter placement

Study	Number of embedded catheters analysed	Utilisation rate	Primary function rate	Rescue rate	Damage rate	Futile placement rate	Catheters still embedded at end of study period	Median embedment duration in weeks
Sloand, 2001 ⁸	12	12/12 (100%)	8/12 (66.7%)	4/4 (100%)	0/12 (0%)	0/12 (0%)	0/12 (0%)	39.9 (mean)
McCormick, 2006 ³	304	248/266 (93.2%)	226/266 (85.0%)	23/41 (56.1%)	Unclear	32/304 (10.5%)	21/304 (6.9%)	13.1
Junejo, 2008 ¹¹	30	18/18 (100%)	17/18 (94.4%)	2/2 (100%)	1/18 (5.6%)	2/30 (6.7%)	10/30 (33.3%)	15.7 (mean)
Brown, 2008 ¹²	435	331/349 (94.8%)	297/349 (85.1%)	16/34 (47.1%)	Not stated	38/435 (8.7%)	50/435 (11.5%)	11.6
Brum, 2010 ¹⁰	180	Unclear	169/180 (93.9%)	Not stated	2/180 (1.1%)	Unclear	Unclear	7.9
Elhassan, 2011 ⁹	122	121/122 (99.2%)	109/122 (89.3%)	12/13 (93.3%)	0/122 (0%)	0/122 (0%)	0/122 (0%)	5.8
Crabtree, 2013/2014 ^{7,13}	107	83/84 (98.8%)	72/84 (85.7%)	11/12 (91.6%)	2/84 (2.3%)	23/107 (21.5%)	14/107 (13.1%)	40.7
Present study	66	34/47 (72.3%)	25/47 (53.2%)	14/22 (63.6%)	6/47 (12.8%)	8/66 (12.1%)	11/66 (16.7%)	39.4

training, adequate equipment and facilities.²⁷ Given the difficulties in accurately predicting deterioration in renal function, it is perhaps unsurprising that these programmes, which seek to react rapidly to identified cases of deterioration, might be preferable to strategies that subject patients to pre-emptive surgical procedures.

Study limitations

Limitations of this study include the absence of data from a direct comparator cohort in the form of non-embedded PD catheters. Furthermore, this single centre, retrospective analysis is potentially subject to reporting bias. However, complete follow-up data were obtained, and the PD catheter and connection equipment was standardised during the study period; this is a factor that has been identified as a confounder in other series.^{7,28}

Conclusions

Prolonged embedment of PD catheters is associated with a significantly higher likelihood of catheter dysfunction following externalisation, which is in turn associated with subsequent catheter loss. Optimal use of this technique may be achieved by minimising embedment duration but larger studies are needed to try to delineate the ideal period of embedment. Our experience with PD catheter embedment was not successful and we have discontinued use of the technique.

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