Factors influencing peritoneal catheter survival in continuous ambulatory peritoneal dialysis

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The success of continuous ambulatory peritoneal dialysis (CAPD) is to a great extent determined by the survival of the peritoneal catheter. The aim of this study was to identify technical factors which influence CAPD catheter survival.

A total of 453 CAPD catheters inserted into 310 patients over an 8-year period were analysed. Access to the peritoneum was gained either by an open surgical technique (*n*=290) or by a closed technique using a trocar and introducer (*n*=163).

Data relating to a number of potentially significant risk/benefit factors were analysed using multiple regression analysis (proportional hazards method of Cox). Three factors were found to be independently associated with improved catheter survival. They were: using an open surgical insertion technique, performing a partial omentectomy at the time of catheter insertion and the procedure being performed by a consultant.

Continuous ambulatory peritoneal dialysis (CAPD) was first described in 1976 (*1*) and quickly became an established method of renal replacement therapy (*2*). In Leicester, the CAPD programme started in 1980 and approximately one-half of the dialysis population are currently being treated by this method. The number of new patients accepted annually for dialysis in this unit has far outstripped the number of renal transplant operations for the last 10 years, resulting in an ever-increasing number of patients on dialysis. This has led to saturation of haemodialysis facilities and increasing reliance has therefore been placed upon CAPD.

Although a number of studies have demonstrated that CAPD can provide effective long-term dialysis (*3,4*), it is important to establish ways of optimising CAPD catheter survival. It is known that peritonitis is a major source of CAPD failure (*5–8*), but there may also be important technical factors which determine the life span of CAPD catheters. The aim of this study was to define those technical factors which improve CAPD catheter survival.

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Patients and methods

Data was collected from two sources: the CAPD patient register and the hospital notes. The CAPD register contains extensive prospectively recorded patient and follow-up details. The hospital notes were reviewed retrospectively for further details of the operative technique used. The information obtained was recorded and analysed on the Leicester University mainframe computer.

Between May 1980 and February 1988, 453 CAPD catheters were inserted into 310 patients. Of these patients, 172 (55.5%) were male and 138 were female. The ages of the patients ranged from 15 to 79 years (mean 52.8 years) and approximately 40% were over 60 years

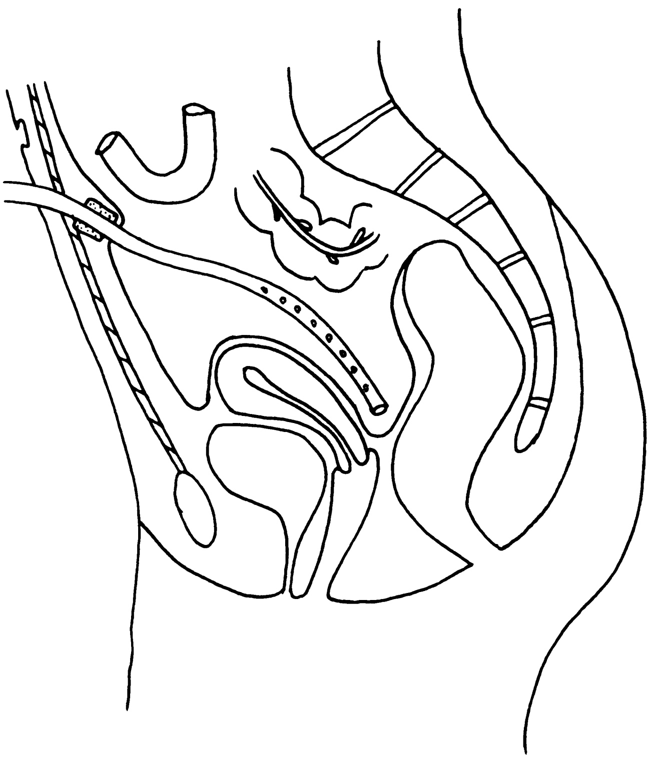


Figure 1. Diagram showing the correct position of the CAPD catheter. The cuff is deep to the rectus sheath but extraperitoneal and the tip of the catheter lies in the pelvis which acts as a sump for the dialysis fluid.

old. CAPD was the primary method of dialysis in the vast majority of patients, only 12% having previously received haemodialysis or a renal transplant. The underlying renal diseases were: vascular disease and hypertension (20%), chronic pyelonephritis (14%), diabetic nephropathy (12%), glomerulonephritis (10%), polycystic kidneys (5%), unknown (18%) and others (21%).

At the beginning of the CAPD programme, Tenckhoff catheters were inserted using a trocar and introducer (the closed technique). The procedure was peformed in the renal dialysis unit theatre under local anaesthetic. From 1984 onwards, peritoneal catheters were placed surgically by an open technique, usually, but not invariably, under a general anaesthetic in the main operating theatres. The peritoneal cavity was opened and the patient was tilted head down allowing the bowel to fall away from the pelvis. Under direct vision, the Tenckhoff catheter was placed into the rectovesical or the rectouterine pouch using either forceps or an introducer fed down the centre of the Tenckhoff catheter (Fig. 1).

In the closed technique of catheter insertion, a midline incision was always used. In contrast, the open surgical technique of catheter placement was performed by one of two different incisions. In the majority ($n = 250$), the skin was opened in the midline and then the peritoneum was entered through a rectus split. A smaller number of catheters ($n = 40$) were inserted by a direct midline incision through the linea alba. In the group of catheters inserted by an open method, a partial omentectomy was performed at the time of operation in 107 cases (37%). Of these omentectomies, 77 were performed by non-consultant staff.

In 22 patients as well as inserting a CAPD catheter, a further operation was performed concomitantly. This was a transplant nephrectomy in three cases and an abdominal hernia repair in 19.

The straight single-cuff Tenckhoff catheter has been used in the vast majority of cases ($n = 432$, or 95%). The other types used were the double-cuff Tenckhoff ($n = 11$), the Toronto Western Hospital type 1 ($n = 9$) and a single-column disc catheter. These alternatives were usually only used when the single-cuff Tenckhoff catheter had failed.

In this series the subcutaneous tunnel was made by two separate methods. In the first a curved Faller stylet was used to create a subcutaneous tunnel passing around and above the umbilicus, and in the second type a straight stylet was used to create a less curved, more direct tunnel. Their use has been decided purely on personal preference, with an approximately even distribution between the two types.

The influence of the following factors on technique survival were studied: age, sex, history of previous CAPD catheter insertion, open or closed insertion technique, the grade of the doctor performing the procedure, previous lower abdominal surgery, type of incision, type of catheter, whether or not an omentectomy was performed, whether or not a concomitant operation was performed and the type of subcutaneous tunnel.

Statistical methods

Survival curves were constructed using the method of Kaplan and Meier *(9)* and compared by the use of the Mantel exponential scores test *(10)*. For the purposes of this study, any of the following events were defined as technique failures: catheter removal for complications; catheter dislocation; cessation of CAPD; transfer to haemodialysis for any other reason. Patients were considered to have stopped CAPD if there was an interruption of 8 weeks or more. Stoppages of less than 8 weeks were considered as temporary interruptions and not as failures. Patients who underwent renal transplantation were considered as lost to follow-up and not as technique failures. Deaths, being unrelated to catheter failure were also treated as lost to follow-up.

The proportional hazards method of Cox *(11)* was used to quantify the observed relationship between each of the factors studied and the risk of catheter failure. By starting with a number of potentially significant risk/benefit factors, a process of stepwise regression can be used to identify those variables that independently and significantly influence CAPD catheter survival. The Cox method combines all significant variables into a best fitting mathematical model in the form of a regression equation, the exponential coefficients of which quantify the observed multiplicative relationship between each variable and the risk of technique failure. Thus, if a variable is assigned an exponential coefficient which is less than one then it is beneficial in terms of technique

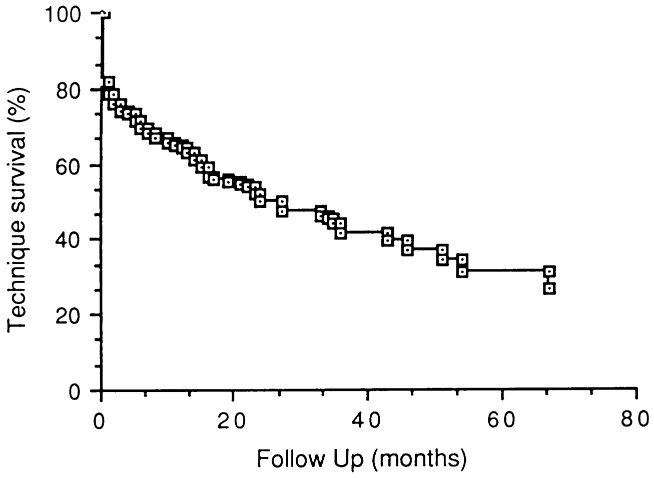


Figure 2. Overall catheter survival (453 CAPD catheters).

survival, and the lower the value, the greater is the observed benefit.

Results

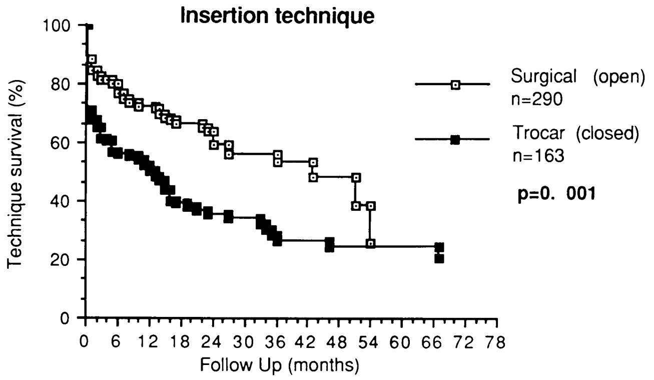
The overall catheter survival for the series was 42% at 3 years and 31% at 5 years (Fig. 2). An analysis of the causes of technique failure is shown in Table I. Fifteen patients (3.3%), were ≤20 years old at the time of catheter insertion, 90 (19.9%) were aged 21 to 40 years, 168 (37.7%) were between 41 and 60 years and 180 (39.7%) were aged 61 years or over. Analysis of these age groups shows that patient age had no significant effect on CAPD catheter survival ($P = 0.65$). A total of 254 CAPD catheters (56%) were inserted into 172 males and 199 catheters (44%) were inserted into 138 female patients. Technique survival was slightly higher in the male group, but the difference was small and did not reach statistical significance ($P = 0.56$).

In this series of catheters, 309 (68%) were first insertions, 108 (24%) were second catheters, 29 (6%) were third catheters and 7 (the remaining 2%) were fourth catheters. Even with up to three previous catheter insertions, the survival of a subsequent catheter was not impaired ($P = 0.14$).

Approximately two-thirds of the catheters were inserted by the open technique and one-third by the closed technique. Technique survival for the open method was 59.48±4.23% (estimate ±SD) at 2 years, which was significantly better than the 2-year survival of 35.65±4.36% for the closed method (Fig. 3). These

Table I. Causes of technique failure

Peritonitis	46 (26.0%)
Loss of correct catheter position	45 (25.4%)
Catheter obstruction by omentum	32 (18.1%)
Fluid leak	26 (14.7%)
Catheter dislocation	16 (9.0%)
Tunnel infection	7 (4.0%)
Incorrect initial placement	5 (2.8%)



Number of patients at risk

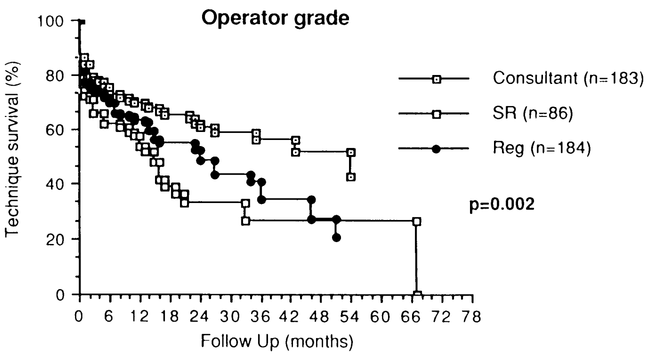
Follow-up (months)	6	12	18	24	30	36	42	48	60
Surgical	184	112	68	44	28	20	13	5	0
Trocar	81	63	37	26	21	15	13	9	7

Figure 3. The influence of insertion technique on catheter survival.

differences are highly significant ($P = 0.0001$). The type of incision used to access the peritoneal cavity in the open surgical technique had no effect on CAPD survival ($P = 0.83$).

Overall, consultants performed 40% of catheter insertions, senior registrars inserted 19% and registrars 41%. The overall survival curves show that catheters introduced by consultants had the highest technique survival (60.55±4.54% at 2 years), followed by the registrar group (48.26±5.18% at 2 years) and the senior registrar group (32.69±6.74% at 2 years). The differences between consultant-inserted catheters and those inserted by more junior members of staff were shown to be statistically significant ($P = 0.002$) (Fig. 4).

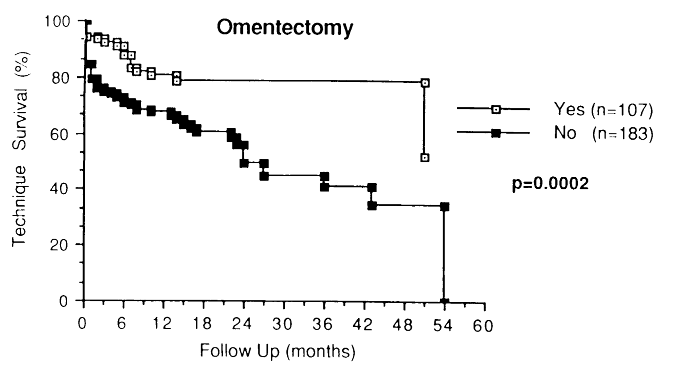
Technique survival at 2 years was 78.35±4.56% in the omentectomy group and 49.57±5.6% in the group of 187 catheter insertions where the omentum was not excised (Fig. 5). These differences are highly significant statistically ($P = 0.0002$). Heavy blood staining of the dialysis fluid occurred in one patient following omentectomy and the abdomen was re-explored. The omentum was found to be bleeding at a point where a ligature had slipped off.



Number of patients at risk

Follow-up (months)	6	12	18	24	30	36	42	48	54
Consultant	106	76	53	37	25	18	13	7	2
SR	45	29	18	6	4	3	3	2	1
Registrar	109	65	42	32	25	14	10	4	1

Figure 4. The influence of operator grade on catheter survival. The P value refers to the difference between consultants and all non-consultant grades (SR + Reg) taken as a single group.



Number of patients at risk

Follow-up (months)	6	12	18	24	30	36	42	48	54
Omentectomy	82	47	38	18	12	7	4	3	0
No omentectomy	103	77	56	35	26	12	7	2	1

Figure 5. The influence of omentectomy on catheter survival.

Previous lower abdominal surgery had only been performed in 7% of patients; mostly an appendicectomy. There was no difference in catheter survival between those who had undergone previous lower abdominal surgery and those who had not ($P = 0.51$). The small numbers of catheters, other than the single-cuff Tenckhoff, make it impossible to construct meaningful survival curves in relation to catheter type and technique survival. Analysis also shows that performing a concomitant operation with CAPD catheter insertion does not appear to be an adverse factor ($P = 0.53$), but again the numbers involved are very small.

The survival data show that the curved tunnel seems to be associated with improved technique survival (70.51±3.38% at 2 years) when compared with the straighter tunnel (59.61±3.35%) ($P = 0.002$).

Multiple regression analysis

The simple, single-variable analyses thus suggested that there were four factors which significantly influenced the survival of a CAPD catheter. However, it was possible that these factors were not independent of one another; for example, the apparent benefit of a curved tunnel might have arisen because curved tunnels were mainly used by consultants. In order to address this problem, a multiple regression approach (the proportional hazards method of Cox *(11)*) was used and it was shown that only three variables had an independent influence upon the prospects of catheter survival. All three variables were beneficial in their influence:

1 A partial omentectomy at the time of catheter insertion—risk multiplication factor (RMF) = 0.36 (95% confidence limits = 0.22–0.06).
2 A consultant performing the procedure—RMF = 0.60 (0.43–0.82).
3 An open insertion technique—RMF = 0.74 (0.54–1.02).

It would appear that, in itself, a curved tunnel confers no additional benefit ($P = 0.21$). The Cox model was appropriately investigated and shown to provide a mathematically valid description of the data.

Discussion

The large proportion of elderly patients in this series reflects the liberal acceptance policy of the Leicester renal unit, where patients are not excluded from the renal replacement programme on the grounds of age alone. Age was shown, as in other studies *(12)*, to have no significant effect on catheter survival, thus supporting the unit policy. A number of patients had multiple catheter insertions because of either a previous catheter failure or the need to return to dialysis following a failed transplant. The group is variable with some patients having several catheters inserted over a short period of time because of early complications, ie catheter obstruction or leakage, whereas other patients had a number of catheter insertions separated by several years. The number of patients requiring multiple catheter insertions over a period of years is increasing and it is interesting to note that previous catheter insertion was not shown to be an adverse factor in CAPD technique survival. Indeed, there was a trend towards better survival of catheters where there had been a previous catheter insertion. This may reflect the fact that failed catheters were usually replaced by more senior staff using the open surgical method and both these factors were shown to be associated with better technique survival.

In his original description, Tenckhoff placed his catheters by a blind trocar technique *(13)*. When using this method there was a high incidence of leaking or malpositioned catheters and now all catheters are placed by an open surgical technique which is in effect a minilaparotomy. This provides excellent access and facilitates correct positioning of the catheter. The tip of the catheter can be fed into the pelvis under direct vision and this is certainly more reliable than the closed technique and is potentially safer. It is also easier to produce a fluid seal at the exit from the peritoneal cavity by the open method.

In an attempt to combine the advantages of direct visualisation with a relatively atraumatic technique, a peritoneoscopic method of placing Tenckhoff catheters has been described *(14)*. A small diameter endoscope is used to inspect the peritoneal cavity and to place an expandable plastic catheter guide, down which the Tenckhoff catheter is introduced into a suitable position. This procedure can be performed through a small incision under local anaesthetic and initial studies have indicated a low failure rate *(15,16)*. The view of the peritoneum obtained is, nevertheless, limited, and there remains a risk of accidental perforation of the bowel. An open surgical method is therefore safer, and although general anaesthesia is preferable in most patients it is possible to perform a minilaparotomy under local anaesthetic.

Several different methods have been used to insert CAPD catheters in our series and these have been largely dependent upon the personal preference of the individual operator. The single-cuffed Tenckhoff catheter has been used in most of our patients, but the positioning of the Dacron® cuff has varied according to the type of incision used. The theoretical advantage of placing the cuff deep to the rectus muscle is that this provides a buttress of muscular tissue around and in front of the catheter and its cuff. It has been suggested that this technique reduces complications and so prolongs the effective life of the catheter *(17)*. There was, however, no observed advantage of this incision over the midline type. The two types of subcutaneous tunnel used in this series were not greatly different and again as there was no demonstrable advantage of one over the other, the matter remains one for personal choice.

In patients who have undergone previous lower abdominal surgery, there is always the risk that adhesions may have formed and that these will preclude peritoneal dialysis by obliterating the peritoneal cavity. Only a trial dissection will establish the extent of this problem. The open method has always been used in such patients and it is unusual for adhesions to be so extensive that CAPD is not possible.

It is quite common for patients requiring insertion of a CAPD catheter to have a concomitant inguinal or other abdominal hernia. Repairing the hernia as a separate procedure prior to CAPD insertion commits the patient to two anaesthetics and delays the start of peritoneal dialysis whilst the peritoneum heals. Therefore, hernia repair and CAPD catheter insertion were performed synchronously in a number of patients. In this situation there is a potential danger of fluid leakage through the hernia repair site which could lead to failure of either the hernia repair or the CAPD or both. In 19 cases of combined hernia repair and CAPD catheter insertion, CAPD was started in the immediate postoperative period and no complications occurred.

Complications caused by the omentum were common in this series of CAPD catheter insertions. Because of its intrinsic properties, omentum has a tendency to wrap around a CAPD catheter in an attempt to isolate it from the peritoneal cavity. This leads to catheter obstruction and/or loss of position of the catheter tip (catheter flip). One simple option in trying to avoid omentum-related problems is to perform a partial omentectomy at the time of catheter insertion. In this series, the indication for omentectomy varied: one surgeon always performed omentectomy if the omentum was visible on entering the peritoneal cavity, but did not look for the omentum if it did not present itself. Other surgeons had a more selective policy, performing partial omentectomy only if the omentum was large and/or situated in the pelvis. Although partial omentectomy is relatively straightforward, it is not without complications, as instanced by the single episode of intraperitoneal bleeding in this series. This data suggests that omentectomy significantly improves CAPD catheter survival, but a controlled trial would be needed for definite confirmation of this finding.

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