
Received for publication: 9.11.2012; Accepted in revised form: 29.3.2013

Greater omentum folding in the open surgical placement of peritoneal dialysis catheters: a randomized controlled study and systemic review

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ABSTRACT

Background. Mechanical catheter dysfunction caused by omentum entrapment remains a major complication of peritoneal dialysis (PD) therapy. The purpose of this study was to determine the outcomes of omentum folding at the time of primary open catheter insertion.

Methods. From March 2008 to December 2012, a total of 67 PD subjects were enrolled in the study and randomly assigned to...
receive either regular open insertion (ROI group, *n* = 33) or open insertion with omentum folding (OIOF group, *n* = 34). The primary outcome was defined as PD catheter tip migration with dysfunction. A systematic review was performed to analyze the outcomes of omentum management in PD catheter implantation, based on published data from 1990 to 2013.

**Results.** There was no statistical difference in baseline patient characteristics between the ROI and OIOF groups. Nine (27.3%) patients in the ROI group presented with catheter malposition in the late stage (>60 days) of the study, significantly more than in the OIOF group (two; 5.9%) (*P* = 0.049). Significant differences in catheter survival rate between the two groups were observed in the late stage (*P* = 0.030) and over the entire study period (*P* = 0.028). A higher incidence of irreversible catheter dysfunction was shown in the ROI group (15.2%), whereas none occurred in the OIOF group (*P* = 0.031). No statistical difference was determined in other catheter-related complications or patient survival rate. There were no statistical differences in peritoneal transport characteristics or dialysis adequacy between the two groups upon evaluation at 3, 6 and 12 months. Systemic review of current publications suggested that PD catheter placement with omentum management could lead to less irreversible catheter dysfunction and improved outcome of catheter survival.

**Conclusions.** Our data suggest that omentum folding at the initial time of open catheter placement can significantly reduce the risk of catheter tip migration with dysfunction and improve the outcome of the PD technique.

**Keywords:** catheter placement, chronic kidney disease, omentum, peritoneal dialysis, randomized controlled trial

### METHODS

#### Study subjects and RCT design

This is a prospective open-label RCT. A total of 156 adult patients with ESRD starting continuous ambulatory PD (CAPD) therapy in our department between March 2008 and December 2012 were enrolled and assessed for eligibility. Informed consent was obtained from all subjects before inclusion in the trial, and the study protocol was reviewed and approved by the Human Research Ethics Committees in the Second Xiangya Hospital of Central South University. On admission to the hospital, demographic and clinical data of individual subjects were collected. Inclusion criteria were listed as follows: age 18–80 years, initiation of PD in this study or presence of greater omentum below the abdominal incision (accessible through the incision). Exclusion criteria include previous open abdominal surgery history, a history of psychological illness or condition that interfered with the ability to understand or comply with requirements of the study.

Finally, 67 patients were included and randomly assigned to receive either regular open insertion of PD catheter (ROI group, consisting of 33 subjects) or open insertion of PD catheter with omentum folding (OIOF group, consisting of 34 subjects). In both groups, all patients received a straight two-cuff Tenckhoff PD catheter (Govidien, Mansfield, MA). A total of 79 patients were excluded, including 3 patients of repeated PD catheterization and 76 patients with the absence of greater omentum below the abdominal incision. Study flow of subject enrollment and randomization was shown in Figure 1. To eliminate the potential impact of different operators on the surgical outcomes of catheter placement, all catheter insertions were performed with unified and standardized procedures.

#### Surgical technique

Upon local anesthesia, a 2–4 cm paramedian sagittal incision was made 10–12 cm above the superior margin of pubic symphysis (Figure 2A). After blunt dissection of the subcutaneous tissue, the anterior rectus sheath was opened with a 4–5 cm
incision and the rectus muscle fibers were bluntly dissected. The peritoneum was exposed and opened with a 5 mm incision. In the OIOF group, a 2 cm incision was made in the peritoneum and the greater omentum was gently drawn out of the abdominal cavity. The distal corners of the greater omentum were fixed to the proximal (gastrocolic) parts of the omentum with three stitches of 2-0 silk suture (Figure 2B). The gastroepiploic arterial arcade and omental vessels were carefully avoided during the surgery. The omental ‘apron’ was actually folded onto itself in this operation and thus was shortened in length (Figure 2C).

The intraperitoneal segment of the catheter was positioned deep toward the pouch of Douglas (or rectovesical pouch in male) following the omentum folding procedure. The catheter was then tested for function with in-and-out instillation of small-volume dialysate. After confirming that the catheter was functioning well, the inner cuff was fixed onto the peritoneum by a purse-string silk suture. The outer rectus fascia was closed by continuous sutures. The catheter tunnel was made through the subcutaneous tissue toward the exit site and an arcuate subcutaneous bend in the Tenckhoff catheter was created with the assistance of a pointed tunneler to direct the external part of the catheter downward. The outer cuff was placed in the subcutaneous tissue 2 cm from the exit site (Figure 2D). In the ROI group, catheter placement was performed in the same way but without omental manipulation (Figure 2E). Catheter function was tested again by filling and draining 200 mL PD fluid. The
wound and exit site were covered with absorbent aseptic dressings, which were changed every 2 days. A prophylactic dose of amoxicillin was administered intravenously 1 h before the surgery. An abdominal radiograph was obtained 3 days after catheter insertion to verify whether the catheter tip was placed in the proper position.

**Measurements of peritoneal transportation characteristics**

Subsequent PD catheter care was undertaken by trained PD registered nurses according to standard protocols. All patients were reviewed by their nephrologists and related tests were performed every 3 months. The standard peritoneal equilibration test (PET), as described by Twardowski et al. [8], was performed 3 months after catheter insertion. The peritoneal transport function of each patient was classified as high, high average, low average or low. All patients underwent the estimation of residual renal function (mean of urea and creatinine clearances) and PD adequacy (Kt/V) during the month preceding each PET.

**RCT outcomes**

The primary outcome was catheter tip migration with drainage failure, defined as tip location above the pelvic brim on the abdominal radiograph and inability to drain the dialysate effluent reliably within 45 min. Irreversible catheter dysfunction was defined as a catheter that failed to respond to conservative medical therapy for at least 3 days with aperients, ambulation and clot dissolution with urokinase. Surgical intervention (catheter reposition or removal) was performed in patients with irreversible catheter dysfunction. Whether Omental wrap occurred or not was confirmed during surgical intervention.

Secondary outcomes included all-cause catheter failure (defined as necessity to remove or reposition the catheter by surgical methods), first catheter-related infections (including peritonitis, exit-site infection, and tunnel infection) and technique survival (defined as time to permanent transition to HD therapy or kidney transplantation). According to criteria recommended by the International Society for Peritoneal Dialysis (2010 update) [9], a diagnosis of peritonitis was made when at least two of the following criteria were fulfilled: abdominal pain, cloudy dialysate with leukocyte count 100/L and 50% polymorphonuclear cells, or positive dialysate culture. Conditions for an exit-site infection were fulfilled when there was erythema with or without skin induration and/or purulent discharge from the exit site. All patients were followed up until death, kidney transplant, termination of CAPD therapy or end of the study in December 2012, whichever came first. Data were analyzed on an intention-to-treat basis.

**RCT statistical analyses**

Statistical analyses were performed with SPSS 20.0 (IBM, Armonk, NY). For comparisons of baseline characteristics, categorical variables were expressed as frequencies and percentages. Normality of data was assessed by means of the Kolmogorov–Smirnov test using the Lilliefors correction. Results are expressed as mean ± standard deviation (SD) and percentage, or median and range for non-normally distributed variables, depending on data type. Comparisons of demographic and clinical characteristics between the ROI group and the OIOF group were performed by using the t-test, χ² test or Mann–Whitney U-test, if appropriate. Levene’s test was used for equality of variances. Survival curves, survival probabilities and estimated median survival times were generated according to the Kaplan–Meier method. Comparisons of event rates were performed using Poisson regression. Differences in hazard curves between the two groups were evaluated by using log-rank test. Hazard ratios (HRs; and their corresponding 95% confidence limits) were determined by means of the univariate Cox proportional hazards model analysis. Data were censored at the time of death, transplant, transfer to HD therapy or end of the study (December 2012). A two-sided P-value of <0.05 was considered statistically significant.

**RESULTS**

**Baseline patient characteristics**

From March 2008 to December 2012, a total of 67 new PD patients were recruited, of whom 33 were randomized to the 690.0 690.0

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>ROI group (n = 33)</th>
<th>OIOF group (n = 34)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex (M:F)</td>
<td>17:16</td>
<td>16:18</td>
<td>0.715</td>
</tr>
<tr>
<td>Age (years)</td>
<td>50 ± 14</td>
<td>51 ± 13</td>
<td>0.327</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>22.7 ± 3.1</td>
<td>21.5 ± 2.7</td>
<td>0.085</td>
</tr>
<tr>
<td>Follow-up (days)</td>
<td>487 ± 174</td>
<td>522 ± 133</td>
<td>0.352</td>
</tr>
<tr>
<td>Primary kidney disease</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glomerulonephritis</td>
<td>19 (57.6)</td>
<td>18 (52.9)</td>
<td>0.745</td>
</tr>
<tr>
<td>Diabetic nephropathy</td>
<td>7 (21.2)</td>
<td>7 (20.6)</td>
<td></td>
</tr>
<tr>
<td>Hypertensive nephrosclerosis</td>
<td>4 (12.1)</td>
<td>3 (8.8)</td>
<td></td>
</tr>
<tr>
<td>Obstructive nephropathy</td>
<td>1 (3.0)</td>
<td>3 (8.8)</td>
<td></td>
</tr>
<tr>
<td>Others</td>
<td>2 (6.1)</td>
<td>3 (8.8)</td>
<td></td>
</tr>
<tr>
<td>Albumin</td>
<td>36.4 ± 4.9</td>
<td>37.8 ± 4.6</td>
<td>0.213</td>
</tr>
<tr>
<td>Hemoglobin</td>
<td>100 ± 17</td>
<td>99 ± 12</td>
<td>0.667</td>
</tr>
<tr>
<td>24-h urine output</td>
<td>660 ± 344</td>
<td>817 ± 419</td>
<td>0.118</td>
</tr>
<tr>
<td>CCr</td>
<td>65.7 ± 15.9</td>
<td>71.3 ± 14.6</td>
<td>0.141</td>
</tr>
<tr>
<td>RRF</td>
<td>3.84 ± 2.94</td>
<td>4.24 ± 2.86</td>
<td>0.577</td>
</tr>
</tbody>
</table>

Values expressed as mean ± SD or number (%). ROI group is the reference group. BMI, body mass index; CCr, creatinine clearance; RRF, residual renal function.
ROI group and 34 to the OIOF group. No statistical difference of demographics was observed between the ROI and OIOF groups. Of the 67 included patients, 37 (55.2%) had primary glomerulonephritis, 14 (20.9%) had diabetic nephropathy, 7 (10.4%) had hypertensive nephropathy, 4 (6%) had obstructive nephropathy and 3 (4.5%) had gouty nephropathy, 1 (1.5%) had lupus nephritis and 1 (1.5%) had polycystic kidney disease. Baseline demographic and clinical characteristics of both groups were similar (Table 1), indicating successful randomization.

Time to catheter tip migration with dysfunction

As shown in Table 2, PD drainage failure with catheter tip migration over the entire study period occurred in 11 (33.3%) patients in the ROI group but only 3 (8.8%) patients in the OIOF group (P = 0.041). During the early stages of PD (<60 days), no significant difference between first catheter displacement and dysfunction was observed between the two groups (P = 0.560). However, nine (27.3%) patients in the ROI group presented with the first catheter malposition in the late stage (>60 days) of the study, significantly higher than two (5.9%) patients in the OIOF group (P = 0.049). The Kaplan–Meier catheter tip migration with dysfunction-free survival curves (Figure 3) showed similar rates of catheter tip migration in dysfunction in the early stage of the study (log-rank score 0.354; P = 0.552), but significant differences of survival rates were observed in both late stage (>60 days, log-rank score 4.696; P = 0.030) and entire study period (log-rank score 4.818; P = 0.028). A higher rate of irreversible catheter dysfunction that required a surgical procedure to reposition or remove the catheter has been shown in the ROI group (5 cases), whereas none occurred in the OIOF group, of which all catheter malfunctions were resolved successfully by aperients, ambulation or clot dissolution with urokinase (15.2% versus 0; P = 0.031). Taken together, our data indicated that the redundant (low-lying) greater omentum is a significant risk for late mechanical complications of PD catheter, which could be markedly decreased by omentum folding at the initial time of open surgical placement.

Time to first catheter-related infections and other complications

In the course of this study, catheter-associated infections occurred with similar frequency in the ROI (n = 8; 24.2%) and OIOF group (n = 9; 26.5%; P = 0.980), including peritonitis (6.1 versus 8.8%; P = 0.724), tunnel infections (0 versus 2.9%, P = 0.621) and exit-site infections (18.2 versus 14.7%, P = 0.623). The Kaplan–Meier PD-associated infection-free survival curves showed similar outcomes in both groups (log-rank, 0.001, P = 0.980, Figure 4).

No significant differences in the risk of other mechanical complications were found between the ROI and OIOF groups (Table 2), including dialysate leakage (3.0 versus 5.9%, P = 0.573) and incidence of hernia (3.0 versus 0, P = 0.306). The overall risk of bleeding complications was similar between the two groups (12.1 versus 20.6%; P = 0.350), including incision hemorrhage (6.1 versus 11.8%; P = 0.414), hematoma (3.0 versus 8.8%, P = 0.317) and hemic dialysate (3.0 versus 0; P = 0.306).

PD technique failure and patient survival

During follow-up, a total of nine patients in this study withdrew from PD therapy due to technique failure (ROI versus OIOF: 18.2 versus 8.8%, P = 0.320). The causes of PD failure included irreversible catheter dysfunction (12.1 versus 0; P = 0.345), infections (3.0 versus 5.9%; P = 0.742), insufficient PD dialysis (0 versus 2.9%, P = 0.584) and other complications (3.0% versus 0, P = 0.601) (Table 2). The overall median survival time of PD technique in this study was 732 ± 16 days (ROI versus OIOF: 732 ± 83 versus 711 ± 21). No statistical

<table>
<thead>
<tr>
<th>Table 2. Summary of study outcomes</th>
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<tbody>
<tr>
<td><strong>ROI group (n = 33)</strong></td>
</tr>
<tr>
<td><strong>Primary outcome</strong></td>
</tr>
<tr>
<td>Catheter tip migration with dysfunction</td>
</tr>
<tr>
<td>Early stage (&lt;60 days)</td>
</tr>
<tr>
<td>Late stage (&gt;60 days)</td>
</tr>
<tr>
<td>Irreversible catheter dysfunction</td>
</tr>
<tr>
<td>Catheter-related infections</td>
</tr>
<tr>
<td>No. of peritonitis</td>
</tr>
<tr>
<td>No. of tunnel infections</td>
</tr>
<tr>
<td>No. of exit-site infections</td>
</tr>
<tr>
<td>Other mechanical complications</td>
</tr>
<tr>
<td>Dialysate leakage</td>
</tr>
<tr>
<td>Hernia</td>
</tr>
<tr>
<td>Bleeding complication</td>
</tr>
<tr>
<td>Incision hemorrhage</td>
</tr>
<tr>
<td>Hematoma</td>
</tr>
<tr>
<td>Hemic dialysate</td>
</tr>
<tr>
<td>Technique failure</td>
</tr>
<tr>
<td>Due to irreversible catheter dysfunction</td>
</tr>
<tr>
<td>Due to infections</td>
</tr>
<tr>
<td>Due to insufficiency of PD</td>
</tr>
<tr>
<td>Due to other complications</td>
</tr>
</tbody>
</table>

Values expressed as number (%) or ratios (range). ROI group is the reference group.

Values are shown as HR (hazard ratios) unless otherwise indicated. Values are expressed as OR (Odd ratios).
The difference was determined by the Kaplan–Meier overall technique survival curves (log-rank score: 0.884; P = 0.347; Figure 5A); however, a significantly better survival rate was shown in the OIOF group when only compared with the incidence of technique failure caused by irreversible catheter malfunction (log-rank score: 4.309; P = 0.038; Figure 5B).

There was a total of seven (10.4%) deaths in both groups during follow-up, four (12.1%) in the ROI group and three (8.8%) in the OIOF group. One and 2-year survival rates for the ROI group were 93.1 and 78.5%, respectively, whereas the corresponding percentages for the OIOF group were 93.8 and 87.5% (log-rank score: 0.363; P = 0.547; Figure 5C). Causes of death in the two cohorts (ROI versus OIOF) were cardiovascular (75.0 versus 66.7%), pulmonary infection (0 versus 33.3%) and cerebral vascular accident (25% versus 0). The differences in patient survival in both groups were not statistically significant.

### Measurement of peritoneal transport characteristics

The peritoneal transport characteristics were evaluated during the first, second and third PETs in all patients and summarized in Table 3. No statistical significance was
observed when comparing the PET results of both groups at 3, 6 and 12 months, respectively (ROI versus OIOF, $P = 0.659, 0.853, 0.972$), indicating little influence of omentum folding on the peritoneal transportation characteristics. We also evaluated the PD adequacy of both groups with $K_t/v$ value at 3, 6 and 12 months, respectively. All patients achieved the target of dialysis adequacy and no difference was found between both groups at the time of evaluation (ROI versus OIOF, $P = 0.250, 0.174, 0.535$).

**Systemic review on omental management**

To further evaluate the outcomes of omental management at the time of catheter implantation, we performed a systematic review on published studies from 1990 to 2013, identified by the databases of PubMed, EMBASE, Highwire and the Cochrane Library. Data were not included if the results of omental management were not clearly described. No RCT study was currently recorded. A total of nine series were collected and listed as Table 4, which includes four prospective studies and five retrospective analyses. Surgical manners of PD catheterization include open surgical insertion and laparoscopic implantation. Omentopexy is the major procedure of omental management in laparoscopic studies, whereas omentectomy is commonly performed in open operations. In advanced laparoscopic catheter implantation, adhesiolysis and rectus sheath tunneling are usually performed simultaneously with omentopexy. Although the performance of concurrent omental management at the setting of initial catheter placement remains personalized and variable in individual study, available data from current clinic series consistently present improved outcomes of catheter survival rates with omental management, resulting from significantly less irreversible catheter dysfunction and obstruction. Other catheterization-related complications, including infections, hernia, dialysate leakage and incision hemorrhage, are rarely reported in omental management.

**DISCUSSION**

The success of PD in the management of ESRD depends on the proper functioning of the implanted catheter. To date, mechanical flow dysfunction remains a common complication for PD catheter placement and potentially leads to technique failure, which is usually associated with catheter malposition and PD-related infections [10]. It is known that the intrinsic properties of the greater omentum enable it to wrap around the catheter and to drag the catheter out of the pelvis, which can be either spontaneous or secondary to peritonitis. Omental entrapment can result in partial or total occlusion of the catheter lumen and isolation of the catheter from the rest of the peritoneal cavity, which leads to irreversible catheter malfunction. An association between redundant omentum in the pelvis and the subsequent occurrence of outflow obstruction has been demonstrated in PD catheter insertion since the 1980s [11]. When compared with overall PD patients in our medical center (data not shown), we observed that a higher rate of catheter tip migration with dysfunction in the ROI group (presence of ‘low-lying’ greater omentum), supporting the view that the lengthy greater omentum may be an independent risk for the occurrence of PD mechanical problems.

To our knowledge, it is the first time that an RCT study has been conducted and specifically designed to investigate the outcomes of omentum procedures at the initial time of PD catheter implantation. Our study demonstrated that shortening the redundant omentum at the time of primary open insertion could significantly reduce the risk of irreversible catheter dysfunction with tip migration (Table 2, Figure 3), which could be possibly caused by omentum entrapment. To address the safety issue, we compared the incidence of other catheterization-related complications in omentum folding (OIOF group) with the conventional open surgical insertion (ROI group), of which no differences were shown between the two groups (Table 2), demonstrating the short- and long-term safety of omentum folding for PD technique. Taken together, the omentum folding procedure applied in this study is a novel surgical technique for PD catheterization and different from other reported methods (Table 4). According to our results, we suggest that open surgical insertion with omentum folding is a safe and effective operation, which can be easily performed to increase the outcome of PD catheter placement.

To address whether omentum folding might potentially interfere with the peritoneal transport characteristics, we performed PET at 3, 6 and 12 months post-operation to analyze the subjects’ peritoneal transportation and dialysis adequacy. A similar frequency of PET values was shown in the two groups (Table 3), confirming that omentum folding had little influence on peritoneal transportation. No significant difference was found in either overall technique survival or patient survival between the two groups (Figure 5), which is not surprising since the rare event occurrence and relatively limited observation time should be considered. Even so, we demonstrated a significantly higher survival rate of the PD technique in the OIOF group, when compared with the PD failure caused by irreversible catheter dysfunction only ($P = 0.031$, Figure 5B). These results further confirmed the safety and efficacy of omentum folding at the time of catheter placement.

At present, the advantage of either the open surgical or laparoscopic technique in PD catheter placement remains highly controversial [12, 13]. Observational results derived from other series of catheter placement seem to suggest the benefits of laparoscopic techniques to locate the catheter under direct vision. However, accumulative studies have demonstrated that simply using the basic laparoscope technique to verify catheter location does not significantly improve outcomes [6, 10]. As a matter of fact, open surgical placement has the potential of shorter operative time, less equipment requirement and relatively higher cost-effectiveness. By far, open insertion is widely recommended as a safe and effective alternative for most PD patients with primary catheter placement [14], especially in developing countries. However, advanced laparoscopic techniques, instead of basic, can significantly improve the outcomes of catheter survival and
**Figure 5**: Kaplan–Meier survival curves for PD subjects in the ROI group (n = 33, solid line, censor points denoted by cross) versus the OIOF group (n = 34, dashed line, censor points denoted by circle). (A) Plot of survival curves for overall PD technique survival (log-rank score: 0.884; P = 0.347). (B) Plot of the survival curve for PD technique failure caused by irreversible catheter malfunction (log-rank score: 4.309; P = 0.038). (C) Plot of the survival curve for the overall patient survival (log-rank score: 0.363; P = 0.547).
salvage the malfunctioning of peritoneal catheters, when taking full advantage of further omentum manipulations by laparoscope. According to results of continuous series from 1996 to 2007 [6, 15, 16], Crabtree et al. consistently reported significant improvement of PD catheter survival with omentopexy/omentectomy using advanced laparoscopic techniques, highlighting the role of omentum management in the success of PD catheter placement. Actually, current series demonstrated that omentum procedures performed by either open surgical or laparoscopic insertion consistently lower the incidence of mechanical dysfunction and prolong PD catheter survival (Table 4), indicating that targeting the redundant omentum is the key to improving the success of the PD catheter.

It is known that study outcomes of PD catheter placement might be significantly associated with surgical skills and experience of the operator. Therefore, the success of catheter insertion, especially with advanced techniques, could be accounted for, in part, by the extensive experience of surgeons, which has been highlighted by the apparent variability in the frequency of catheter mechanical problems from different centers [10]. In this study, we conducted an easy but effective method to shorten the redundant greater omentum in open surgical placement by folding the distal corner of the long omentum to its proximal part, which is technically a simplified form of omentopexy. As a procedure easily manipulated under direct vision, omentum folding in open surgical placement could be successfully performed by well-trained nephrologists and could produce satisfactory outcomes. This simplified omental procedure might be favorable for the utilization of PD.

At the same time, we do recognize that our study has several limitations. First, as an open-label study design, our results may be prone to observer bias, which was minimized by adopting a standardized approach to surgical insertion and measurement. However, our study was designed to detect differences in rates of catheter tip migration with dysfunction. We were unable to conclusively evaluate differences in other catheter-related complications, such as the incidence of catheter mechanical problems from different centers [10].

In conclusion, to our knowledge, this is the first RCT specifically designed to investigate the outcomes of omentum folding at the time of primary PD catheter placement. Our data indicate that omentum folding in open insertion of PD catheters is a safe and effective procedure, which can be easily performed to decrease the incidence of catheter tip migration with dysfunction. We were unable to conclusively evaluate differences in other catheter-related complications, which might be influenced by adopting a standardized approach to surgical insertion and measurement. However, our study was designed to detect differences in rates of catheter tip migration with dysfunction. Finally, the study was designed to detect differences that were not observed in other studies. The implications of this study are that omentum folding at the time of primary PD catheter placement is a safe and effective procedure, which can be easily performed to decrease the incidence of catheter tip migration with dysfunction. The implications of this study are that omentum folding at the time of primary PD catheter placement is a safe and effective procedure, which can be easily performed to decrease the incidence of catheter tip migration with dysfunction.
Table 4. Summary: outcomes of omental management at the time of catheter insertion

<table>
<thead>
<tr>
<th>Author, year (reference)</th>
<th>Country</th>
<th>Study design</th>
<th>No. of subjects</th>
<th>Study period (years)</th>
<th>Follow-up (months)</th>
<th>Operation</th>
<th>Omental procedures</th>
<th>Combined techniques</th>
<th>Major complications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nicholson, 1991</td>
<td>UK</td>
<td>PS</td>
<td>235</td>
<td>1984–88</td>
<td>54</td>
<td>OI</td>
<td>OE (38%)</td>
<td>AD (38%)</td>
<td>2%a</td>
</tr>
<tr>
<td>Reissman, 1998</td>
<td>Israel</td>
<td>RA</td>
<td>60</td>
<td>1987–93</td>
<td>28</td>
<td>OI</td>
<td>OE (100%)</td>
<td>RST (100%), AD (7%)</td>
<td>23.8% versus 0b</td>
</tr>
<tr>
<td>Ogunc, 2003</td>
<td>Turkey</td>
<td>PS</td>
<td>42</td>
<td>1998–2001</td>
<td>36</td>
<td>OI and LI</td>
<td>OP (50%)</td>
<td>AD (29%)</td>
<td>13 versus 0.7%b</td>
</tr>
<tr>
<td>Crabtree, 2003</td>
<td>USA</td>
<td>RA</td>
<td>231</td>
<td>1996–2002</td>
<td>~17</td>
<td>LI</td>
<td>OP (9%)</td>
<td>RST (100%), AD (18%)</td>
<td>(18–13) versus 0.5%b</td>
</tr>
<tr>
<td>Crabtree, 2005</td>
<td>USA</td>
<td>PS</td>
<td>341</td>
<td>2000–04</td>
<td>27</td>
<td>LI and LI</td>
<td>OP (15%)</td>
<td>AD (9%)</td>
<td>6.5%a</td>
</tr>
<tr>
<td>Haggerty, 2007</td>
<td>USA</td>
<td>RA</td>
<td>31</td>
<td>2000–07</td>
<td>17</td>
<td>LI</td>
<td>OP (7%), OE (3%)</td>
<td>RST (100%), AD (16%)</td>
<td>37 versus 5%b</td>
</tr>
<tr>
<td>Crabtree, 2009</td>
<td>USA</td>
<td>PS</td>
<td>402</td>
<td>2002–08</td>
<td>22</td>
<td>LI</td>
<td>OP (25%)</td>
<td>AD (18%)</td>
<td>25 versus 11%c</td>
</tr>
<tr>
<td>Attaluri, 2010</td>
<td>USA</td>
<td>RA</td>
<td>197</td>
<td>2004–10</td>
<td>15–20</td>
<td>LI</td>
<td>OP (54%)</td>
<td>RST (100%), AD (16%)</td>
<td>44% versus 0b</td>
</tr>
<tr>
<td>Crabtree, 2009</td>
<td>USA</td>
<td>RA</td>
<td>235</td>
<td></td>
<td></td>
<td>OI</td>
<td>OE (38%), OP (4%)</td>
<td></td>
<td>None</td>
</tr>
<tr>
<td>Martinez, 2012</td>
<td>Mexico</td>
<td>RA</td>
<td>235</td>
<td></td>
<td></td>
<td>OI</td>
<td></td>
<td></td>
<td>4.2%a</td>
</tr>
</tbody>
</table>

**Country**: UK (United Kingdom), USA (United States), Turkey, Israel, Mexico.

**Study design**: PS (prospective study), RA (retrospective analysis).

**No. of subjects**: Number of subjects in each study.

**Study period (years)**: Duration of the study.

**Follow-up (months)**: Follow-up period in months.

**Operation**: OI (open insertion), LI (laparoscopic insertion).

**Omental procedures**: OE (omentectomy), OP (omentopexy).

**Combined techniques**: AD (adhesiolysis), RST (rectus sheath tunneling).

**Major complications**:
- **Irreversible dysfunction**: Overall incidence.
- **Omental entrapment**: Basic insertion versus insertion with omentopexy.
- **PD-related infection**: Basic insertion versus insertion with omentectomy.
- **Hernia**: Overall incidence.
- **Major bleeding complication**: None.
- **Dialysate leakage**: Rare.

**Comment**: Overall incidence; basic insertion versus insertion with omentopexy; basic insertion versus insertion with omentectomy; early complications; effect of omental procedures on the catheter survival.

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**Footnotes**:
- aOverall incidence; bbasic insertion versus insertion with omentopexy; cbasic insertion versus insertion with omentectomy; dearly complications; eeffect of omental procedures on the catheter survival.
ACKNOWLEDGEMENTS

We sincerely thank all study participants in the Renal Division of Second Xiangya Hospital, Central South University, for their contributions to this work. This work was supported in part by the Research Award Fund for Young Teachers in Central South University (2011QNZT165) to G.C. and the National Natural Science Foundation of China (No. 81070610) to F.L.

CONFLICT OF INTEREST STATEMENT

None declared.

REFERENCES


Received for publication: 20.6.2013; Accepted in revised form: 11.7.2013