Noninfectious Complications of Peritoneal Dialysis: Implications for Patient and Technique Survival

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ABSTRACT
Noninfectious complications of peritoneal dialysis (PD) are increasing in relative importance due to success in decreasing the rate of PD peritonitis. Mechanical catheter complications are emerging as an important cause of technique failure at the same time as experience with PD is declining in North America. Noninfectious complications arise from the insertion and maintenance of the PD catheter in the peritoneal cavity, the increase in intraabdominal pressure caused by dialysate, and the metabolic effects of the absorption of glucose and its byproducts (Table 1).

Since the inception of continuous ambulatory peritoneal dialysis (PD) in the 1970s, there has been a concerted and successful effort to reduce the rate of PD peritonitis. This achievement in decreasing infectious complications has not been matched, however, by the management of noninfectious complications of PD. Noninfectious complications arise from the insertion and maintenance of the PD catheter in the peritoneal cavity, the increase in intraabdominal pressure caused by dialysate, and the metabolic effects of the absorption of glucose and its byproducts (Table 1).

Prevention, early recognition, and appropriate management of these complications are important because of associated patient morbidity and technique failure. In particular, there is increasing appreciation that catheter-related problems are a major cause of PD technique failure and that the metabolic effects of the dialysate may augment cardiovascular risk. The overall success in managing these complications is highly dependent on the experience of local home dialysis programs, a fact that makes declining use and loss of training and expertise in PD in North America especially concerning.

Mechanical complications, mainly peritoneal catheter problems, are increasing in relative importance as a cause of technique failure and account for approximately 20% of transfers to hemodialysis (HD). In fact, as many patients fail on PD as a result of catheter problems as for inadequate dialysis or ultrafiltration failure. Unlike PD adequacy, few multicenter, prospective trials have defined optimal catheter practice, although guidelines do exist and practitioners of PD should be familiar with them.

Strategies to prevent early catheter malfunction include appropriate catheter selection, optimal surgical technique, and good postoperative care. Open and frequent communication between the nephrology and surgical teams is important because decisions that are made before and during insertion of the catheter have implications for catheter function. Similarly, in units where the catheters are inserted by radiologists, there should be close collaboration with the nephrologist. Expertise in insertion of PD catheters is an acquired skill, and insertion of catheters by unsupervised trainees is an unacceptable practice.

A number of modifications to PD catheter design have been proposed, but overall the “swan neck” catheter has the lowest rate of drainage failure, whereas the intraperitoneal configuration, straight versus coiled, does not seem to modify this risk. The selection of an appropriate intraperitoneal catheter length along with preoperative exit-site marking is necessary for successful function. The catheter tip should sit deep in the pelvis. Selection of a catheter that is too short will result in poor drainage because the catheter will sit higher in the abdomen where it is vulnerable to interference from the omentum.

Although no one method is universally recommended for insertion of PD catheters, the experience of certain centers with the laparoscopic technique merits special consideration. Crabtree et al. have described advanced laparoscopic management with rectus sheath...
tunneling, prophylactic adhesiolysis, and prophylactic omentopexy (fixing the redundant omentum to the upper abdomen by means of a suture). This group reported a reduction in the rate of catheter flow complications to <1% compared with 12% with standard laparoscopic technique. For patients at higher risk for catheter malfunction as a result of previous complicated abdominal surgery, advanced laparoscopic technique provides the best results in experienced hands. Nephrologists have an important role to play in encouraging surgeons to gain experience with this technique.

Early obstruction to catheter flow and early exit-site leak are common and can be discouraging for the patient. It can negatively cloud their first experience with PD and affect their willingness to persist with the therapy. The clinical expertise of the PD team and the provision of support and education to the patient are important in preventing these early transfers to HD.

Liberal use of laxatives such as lactulose and senna before and during PD training is an underappreciated strategy to promote good catheter function. Constipation is associated with poor catheter performance because fecal impaction can cause catheter migration and external compression of the lumen by bowel. The use of high dosages of laxatives to induce vigorous bowel peristalsis and frequent loose bowel movements are often required to achieve optimum early catheter function, even in the absence of a history or radiographic findings of constipation. Inflow obstruction suggests intraluminal blockage, usually with fibrin or blood, but occasionally may be due to kinking of the catheter. Intraluminal instillation of thrombolitics is helpful if inflow obstruction persists after vigorous flushing and results in a high rate of restoration of flow. Guide-wire manipulation should be considered when poor drainage persists despite an adequate trial of laxative therapy. This treatment is usually reserved for catheters with radiographic evidence of migration, although malfunctioning catheters that are properly positioned in the true pelvis may be entrapped in an adhesion and benefit from guide-wire manipulation. The rate of initial success with fluoroscopic guide-wire manipulation is in the range of 60 to 85%, but the improvement is often short lived and the long-term patency rate is <50% in most series. Laparoscopic salvage of malfunctioning catheters is increasingly popular, with reported success rates of >80%, although rates of recurrent obstruction vary widely.

It is clear that catheter problems are an important cause of technique failure. Although technique failure is not associated with increased patient mortality, it does result in conversion to the more costly and, in many cases, less convenient modality of HD, which has its own access problems. The metabolic complications of PD rarely lead to technique failure but have the potential to worsen cardiovascular risk. Patients already at risk, such as the elderly and those with diabetes, pre-existing cardiovascular disease, or congestive heart failure, may have increased mortality when treated with PD compared with HD.9 The metabolic effect of the dialysate is a possible link to explain this observation.

Traditional PD solutions are unphysiologic as a result of the low pH, high lactate concentration, and high concentration of glucose and glucose degradation products. There is a substantial glucose load with traditional solutions, and plasma insulin levels rise with intraperitoneal glucose loading in a dosage-dependent manner.10 Recently it was reported that new-onset diabetes, a consequence of insulin resistance, may be higher among new PD patients than previously thought.11 In this study by Szeto et al., 27% of 252 nondiabetic patients starting PD had elevated levels of fasting glucose after 1 month of therapy. Those who developed elevated levels of fasting glucose had significantly higher baseline comorbidity scores, were older, more inflamed and, not surprising, had decreased actuarial survival.

The hyperglycemia and hyperinsulinemia induced by hypertonic dialysate may also result in adverse short-term hemodynamic changes. The use of 3.86% (4.25%) dextrose dialysate acutely raises BP and cardiac output in the absence of acute changes in left ventricular diameter, suggesting that hyperglycemia and hyperinsulinemia, rather than the high rate of ultrafiltration, are responsible for the altered hemodynamics.10 The use of 1.36% (1.5%) dextrose dialysate does not acutely raise BP or insulin levels, so it is not clear how relevant these findings are for the majority of PD patients who do not routinely use 4.25% exchanges.

Leptin is a hormone released by adipose tissue and is linked to an increased risk for cardiovascular events in the general population.12 Plasma leptin levels are increased in chronic renal failure but are more elevated among patients who are treated with PD compared with HD, and increase with time on PD.13 In vitro secretion of leptin is directly stimulated by exposure of adipocytes to dialysate containing 1.36% glucose via activation of the hexosamine biosynthetic pathway.14 Leptin secretion depends on ambient concentrations of glucose and is stimulated at levels similar to what omental adipocytes experience in vivo. These findings suggest that exposure to high levels of peritoneal glucose may be responsible for the hyperleptinemia seen in patients using PD.

Glucose-sparing solutions that contain

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**Table 1. Common noninfectious complications of PD**

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catheter related</td>
<td>perioperative (perforation of viscus or hemorrhage)</td>
</tr>
<tr>
<td></td>
<td>obstruction to flow</td>
</tr>
<tr>
<td></td>
<td>leakage (exit site or concealed)</td>
</tr>
<tr>
<td></td>
<td>pain (on infusion or drainage)</td>
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<tr>
<td>Related to increased intra-abdominal pressure</td>
<td></td>
</tr>
<tr>
<td></td>
<td>hemia</td>
</tr>
<tr>
<td></td>
<td>pleural leak (hydrothorax)</td>
</tr>
<tr>
<td></td>
<td>back pain</td>
</tr>
<tr>
<td>Metabolic</td>
<td>hyperglycemia</td>
</tr>
<tr>
<td></td>
<td>hypertriglyceridemia</td>
</tr>
<tr>
<td></td>
<td>hyperinsulinemia</td>
</tr>
<tr>
<td></td>
<td>hyperleptinemia</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>hemoperitoneum</td>
</tr>
<tr>
<td></td>
<td>encapsulating peritoneal sclerosis</td>
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</tbody>
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Icodextrin or amino acids represent a strategy for avoiding the metabolic effects of glucose and its byproducts. The conversion of nondiabetic PD patients to icodextrin reduces plasma insulin, indices of insulin resistance, and plasma leptin levels. Icodextrin is variably associated with improved control of BP and it is unclear whether this is due solely to improved ultrafiltration or whether the improved hormonal milieu is also important. There are no long-term studies showing benefit with glucose-sparing solutions for hard cardiovascular end points, so the link between peritoneal glucose loading and cardiovascular disease remains speculative but intriguing.

In conclusion, two noninfectious complications are emerging as the greatest challenge for PD practitioners. The technique failure associated with catheter complications needs to be addressed at both an educational level and the individual program level using a continuous quality improvement approach. One-year catheter survival of >80% and primary nonfunction rates of <10% are acceptable and can be achieved with optimal practices. Glucose-induced metabolic complications may have far-reaching consequences but merit further research with trials adequately powered for hard cardiovascular end points before glucose-sparing strategies can be broadly recommended.

**DISCLOSURES**
None.

**REFERENCES**