Review

The surgical management of peritoneal dialysis catheters

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Peritoneal dialysis is a safe and effective form of renal-replacement therapy. Its use is increasing as the gap widens between the number of patients waiting for renal transplants and the number of available organs. This article reviews the surgical considerations and complications of peritoneal dialysis that may present to general surgeons.

Key words: Continuous ambulatory peritoneal dialysis – Peritoneal dialysis – Renal failure

The increasing discrepancy between the number of patients requiring renal transplantation and the number of available donor organs means a greater number of patients are being treated with peritoneal dialysis. The surgical considerations of peritoneal dialysis have, therefore, assumed increasing importance for medical staff. Maintaining a reliable form of replacement therapy comprises a significant workload for the surgeon and nephrologist. There have been recent reviews of the mechanism of action and associated physiology of peritoneal dialysis² and the different systems that are available for the delivery and maintenance of peritoneal dialysis.³ This article reviews the surgical considerations and complications of peritoneal dialysis that may present to general surgeons.

Management of complications

Bleeding

Blood-stained fluid is a common finding, occurring in up to 30% of patients⁴ for the first few catheter exchanges. The bleeding most often arises from small vessels on the surface of the peritoneum at the point of catheter entry and usually stops within 24 h.

Pain

The first attempts at dialysate infusion can produce discomfort. This is more common with straight Tenckhoff catheters when infusion pressure is greatest. With coiled catheters this is less likely, as dialysate flows through the side perforations. The pain is most often temporary and resolves within a few weeks. Slower infusion rates and incomplete drainage alleviate these short-term symptoms.⁵

Cuff extrusion

The single most important factor for cuff extrusion is the depth at which the subcutaneous cuff is implanted; at least 2 cm below the skin is required. Tension on the extraperitoneal portion of the catheter, such as during bag exchange, can bring a poorly sited subcutaneous cuff to the surface.

Catheter obstruction

This is usually due to outflow obstruction, the causes of which are summarised in Table 2. Obstruction may be extrinsic or related to catheter positioning. Clotted blood may collect in the distal portion of the catheter shortly

Table 1 Contra-indications to peritoneal dialysis

Absolute contra-indications
Encapsulating peritoneal sclerosis
Inflammatory bowel disease
Large unreparable abdominal wall herniae
Relative contra-indications
Severe obesity
Severe peritoneal adhesions
Large herniae of the anterior abdominal wall
Abdominal wall stomas
Chronic obstructive airways disease
Psychosocial factors likely to result in poor compliance
Physical disability
Learning disability

after surgery. This can be effectively treated with peri-catheter infusion of heparin, urokinase or streptokinase.⁶ Extrinsic compression resulting in obstruction can be caused by bladder distension or an impacted sigmoid colon;⁷ although these causes should be ruled out, they are uncommon causes of obstruction compared to omental wrapping (see below). Intra-abdominal adhesions can also obstruct outflow. In vulnerable patients this potential problem can be avoided by laparoscopy and adhesiolysis before catheter insertion. Techniques for re-positioning or catheter replacement are discussed below.

Catheter tip migration

Twardowski⁸ stated that the incidence of catheter migration is 20% but that only 20% of migrated catheters will obstruct. Indeed, some obstructions will resolve spontaneously, but most require intervention to allow re-positioning.⁹ Treatment of tip migration includes stiff wire manipulation,^{10,11} fluoroscopic-guided re-positioning^{12,13} or open surgical re-positioning. Manipulation with a Fogarty catheter inserted into the peritoneal dialysis tube has been shown to be successful in re-positioning a migrated catheter in 70% of cases.¹⁴

Table 2 Causes of catheter obstruction

	Cause	Treatment
Extrinsic	Omental wrap Impacted sigmoid colon Urinary retention	Catheter repositioning Enemas Urethral catheter
	Adhesions	Adhesiolysis
Luminal	Blood clot/fibrin	Catheter flush Heparin in dialysate fluid Urokinase or streptokinase Flush or omentectomy Catheter re-positioning
	Omentum Bowel	
Catheter position	Malposition or kinking	Reposition by open/laparoscopic surgery, or radiologically

Peri-catheter leak

Any variable that predisposes to poor wound healing may culminate in peri-catheter leakage (e.g. steroids, obesity, malnutrition). Choice of surgical technique may determine leak rates; they are said to be more common with midline catheter insertion techniques, compared to lateral insertion through the rectus muscle,¹⁵ but this is not the authors' experience. Peri-catheter leakage allows fluid extravasation around the catheter or accumulation in the lower abdominal wall. Leakage rates of 7–24% have been described.¹⁶ Some investigators suggest leak localisation with computed tomography combined with peritoneal contrast⁵ or MR peritoneography.^{17,18} When an early postoperative leak develops, dialysate exchange should be stopped for 2–4 weeks, necessitating a temporary vascular catheter for haemodialysis. Late-onset leaks usually require catheter replacement. Peri-catheter leaks associated with herniation should be treated by catheter removal and hernia repair. Only after allowing for healing (e.g. 2–3 months) should further catheter insertion be attempted.

Herniae

The increased intra-abdominal pressures following infusion of dialysis fluid can enlarge pre-existing herniae, so it is best to repair them prior to catheter insertion, although if necessary, repair can be performed at the time of, or after, insertion.¹⁹

The reported prevalence of *de novo* abdominal herniae in peritoneal dialysis patients lies between 2.5% and 25%.^{20–22} One study showed 32% of all herniae occur at the site of catheter insertion, 18% in the inguinal region, 27% are epigastric or umbilical, and 23% occur at the site of previous incisions.²² Herniation into the thoracic cavity has also been reported.²³ The pressure of dialysate fluid can produce re-canalisation of a patent processus vaginalis, which presents as scrotal or labial oedema,

Table 3 Micro-organisms causing exit site infections.³⁵

Micro-organism	Incidence
<i>Staphylococcus aureus</i>	25–85%
Mixed organisms	16–35%
Gram-negative bacteria	7–14%
<i>Staphylococcus epidermidis</i>	5–14%
<i>Pseudomonas aeruginosa</i>	8–12%
Fungi	1–3%
Negative cultures	7–11%

shortly after full dialysate exchange regimens are commenced.²⁴ Surgical ligation is then necessary,²⁵ with a postoperative regimen of low volume, high frequency dialysate exchanges until healing had occurred²⁶ or temporary conversion to haemodialysis.²¹

The repair of herniae that occur whilst a patient is being treated with dialysis is a controversial area. Ideally, the repair should avoid a breach of the peritoneal membrane. Use of polypropylene prosthetic mesh in incisional hernia repair, attached to the deep fascia of the abdominal aponeurosis without opening the peritoneum, allows immediate use of CAPD.²⁷

Peritoneal dialysis can safely be resumed immediately after inguinal herniorrhaphy.²⁸ Despite this, some surgeons will withhold peritoneal dialysis for a number of weeks after repair, fearing fluid leak or hernia recurrence. Others suggest a modified (high frequency, low volume) exchange regimen²⁹ in the immediate postoperative period.

Exit site and tunnel infections

As lone entities, exit site and tunnel infections pose little risk, but the possibility of developing peritoneal dialysis peritonitis demands careful attention to these infections; peritoneal dialysis peritonitis occurs in roughly 12% of cases of exit site or tunnel infections.^{30,31} A positive culture at the exit site does not necessarily indicate an exit site infection; it merely represents colonisation and is not necessarily an indication for treatment. However, Vychytil *et al.*³² suggested that diabetic or immunosuppressed patients should be treated for a single positive culture indicating exit site

colonisation by (or nasal carriage of) *Staphylococcus aureus*. In all other patients, treatment should be instigated only if there are two or more positive cultures. Rates of exit site infections range between 0.05 to 1.02 episodes per patient per year.^{30,33,34} The common micro-organisms causing exit site infections are summarised in Table 3. *Staph. aureus* is the most common and nasal carriage results in a 4-fold increased risk of developing an exit site infection.³⁵

Suggested management strategies for exit site problems and infections are summarised in Table 4. Erythema alone with no discharge should be treated with topical chlorhexidine, mupirocin or hydrogen peroxide. In these circumstances, ultrasonographic examination of the subcutaneous catheter tract can be useful to exclude tunnel infection as this cannot always be ascertained clinically.³⁶ Purulent exit site infections should be swabbed for culture and Gram-stained, in addition to culture of the peritoneal dialysate. In general terms, for Gram-positive micro-organisms a cephalosporin or flucloxacillin is indicated whilst awaiting the results of culture sensitivities. Alternatively, intravenous or peri-catheter vancomycin can be used with careful monitoring of levels. If there is no improvement after 1 week, rifampicin (300 mg twice daily) should be added and if infection persists, the tunnel should be explored and the cuff shaved,³⁷ thus avoiding interruption of dialysis. Alternatively, the catheter can be removed,^{38,39} although some authors advocate partial re-implantation of the catheter, with removal of the infected portion and connection of the remaining section to a new, divided catheter.⁴⁰

For Gram-negative organisms, ciprofloxacin can be used but in our centre peri-catheter gentamycin is preferred. Persistent Gram-negative infections may require catheter removal as persistent infection is almost always due to a deep tunnel infection, with a risk of peritonitis. In the absence of peritonitis, simultaneous catheter insertion can be considered with a contralateral exit site. The usual duration of treatment with oral antibiotics should be a maximum of 14 days, to avoid fungal infection.^{35,41} When they do occur, fungal infections require catheter removal and systemic anti-fungal treatment such as fluconazole.³⁹ It is unlikely that *Pseudomonas* spp. exit site infection will be

Table 4 Treatment of exit-site problems and infections³⁹

Problem	Treatment
Erythema alone no discharge	Topical chlorhexidine, mupirocin, hydrogen peroxide
Over-granulation	Silver nitrate cauterisation
Gram-positive infection	Cephalosporin, flucloxacillin, vancomycin, rifampicin, with catheter removal if persistent
Gram-negative infection	Ciprofloxacin, gentamycin
<i>Pseudomonas</i> spp. infection	Ciprofloxacin + other agent (e.g. tobramycin or cephalosporin)
	Catheter removal
Fungal infection	Catheter removal with systemic antifungals

eradicated by antimicrobial therapy and the catheter needs early removal.³⁸

Peritoneal dialysis peritonitis

Peritonitis is the most significant complication of peritoneal dialysis and is the second commonest cause of mortality in patients undergoing peritoneal dialysis.^{42,43} Incidence ranges between 0.5–1.4 episodes per patient per year,⁴⁴ with about 60% of patients developing peritoneal dialysis peritonitis in the first year.⁴⁵ At least a quarter will culminate in catheter failure. The most common portal of entry for infection is the exit and tunnel site. The first indications of peritonitis are generalised abdominal pain in the presence of a cloudy effluent containing $> 100 \times 10^6$ /l white blood cells (85% polymorphonuclear cells [PMNs]).⁴⁶ Cell counts of $50\text{--}100 \times 10^6$ /l may result in a cloudy effluent⁴⁷ and for this reason the PMN cell percentage may be a more useful indicator of infection.⁴⁸ There have been reports of non-bacterial, non-specific eosinophilic peritonitis in peritoneal dialysis patients.⁴⁹ There is usually an excellent prognosis with resolution within days,⁵⁰ although it can lead to encapsulating sclerosing peritonitis in recurrent cases.⁵¹

The causative organisms in peritoneal dialysis peritonitis are generally different to those causing 'surgical peritonitis'. In the latter case, infections are usually poly-microbial consisting of both anaerobic and aerobic bacteria. In contrast, a single micro-organism, usually a skin-colonising Gram-positive bacteria, is the common cause of peritoneal dialysis peritonitis; *Staph. aureus*, *Staphylococcus epidermidis* and *Streptococcus* spp. account for 60–80% of cases. The categories of micro-organisms commonly cultured in the effluent are presented in Table 3. Coagulase-negative staphylococci make up 30–40% and *Streptococcus* spp. 10–15%. Yeasts, such as *Candida* spp., are the most common cause of fungal peritonitis, entering the peritoneal cavity via the catheter or commonly from the vagina.⁵²

Examination of the dialysate bags for the absence of biliary or faecal contamination will help with the diagnosis. Dialysate samples for microbiological examination should preferably be taken from the first cloudy bag, providing culture with antibiotic sensitivities. However, cultures can be negative in up to 48% of patients even with clinical signs of peritoneal dialysis peritonitis.⁵³ In the non-surgical, peritoneal dialysis, peritonitic patient, clinical signs are usually mild. Along with abdominal pain, the signs include pyrexia (35–65%), nausea and vomiting (30%) and diarrhoea (10%);⁵³ bowel sounds are often present. Routine investigations include abdominal and chest radiographs to check for the catheter position and air under the diaphragm, although a pneumoperitoneum is not necessarily attributable to

gastrointestinal perforation in patients with peritoneal dialysis.⁵⁴

Management of peritoneal dialysis peritonitis

Early surgical assessment and regular review is necessary for distinguishing peritoneal dialysis peritonitis from a surgical cause. Antibiotics and peritoneal flushes form the mainstay of treatment. In mild cases, patients do not require hospital admission unless they are systemically unwell. Since dialysate cultures are not available in the first instance, antibiotic cover should be broad spectrum. Blood cultures are rarely of value in mild cases.⁵³ Management of so-called 'sterile peritonitis', where no micro-organisms are cultured, is a controversial area. It may represent inadequate sampling, or may be a result of indiscriminate use of antibiotics.⁴⁶

Where antimicrobial therapy is required, the authors' preference is to administer intraperitoneal gentamycin (10 mg/2 l bag q.d.s.) and vancomycin (50 mg/2 l q.d.s.) for up to 10 days. In cases of recurrent peritonitis, it is prudent to use a urokinase flush on the 5th and 7th day of antibiotic cover⁵⁵ as the focus of infection may have been walled off by protective fibrin deposits.

Intraperitoneal *Pseudomonas* spp. infection is difficult to treat.⁵⁶ Patients should receive gentamycin 15 mg added to each 2-l dialysis bag, in combination with oral ciprofloxacin 750 mg twice daily; however, as with exit site infections, the catheter will almost always need removal.

Mycobacterium spp. infections can be a problem in at-risk cohorts, but all patients with ESRF are generally at risk because of impairment of cell-mediated immunity. Diagnosis can be difficult but should be suspected in the presence of persistently elevated mononuclear cell counts combined with negative cultures. Acid-fast bacilli smears of the dialysate fluid may be negative in 90% of cases but formal cultures are likely to be positive in the majority.⁵⁷ Treatment consists of long-term antituberculous drugs; a suggested regimen is isoniazid, rifampicin, pyrazinamide and ofloxacin for 9–15 months.⁵⁸ Catheter removal is usually undertaken,^{57,59} although it is not considered necessary for cure. Mortality attributable to tubercular peritonitis is approximately 15%, and much of this may be due to treatment delay.⁶⁰

Fungal infection complicating peritoneal dialysis needs a different approach, as some antifungal treatments such as amphotericin and ketoconazole cannot be administered directly into the peritoneal cavity. *Candida* spp. has a tendency to adhere to the catheter making eradication difficult.⁶¹ Recommended treatment is flucytosine 1 g orally, and intraperitoneal fluconazole 150 mg daily. If there is no improvement within 48–72 h, the catheter should be removed and antifungal treatment continued. Fungal peritonitis has a mortality of up to 15%.⁴³

Encapsulating peritoneal sclerosis

Encapsulating peritoneal sclerosis is a relatively rare, but potentially life-threatening, complication of peritoneal dialysis. Reported prevalence rates are 2.6–3.5 cases per 1000 peritoneal dialysis patient years.^{62,63} Patients present with abdominal pain, a decline in net ultrafiltration, ascites, blood-stained effluent or bowel obstruction.⁶⁴ Reported mortality rates range between 43–75%.^{65–67} Recurrent episodes of peritonitis result in loss of the mesothelial layer of the peritoneal cavity causing extensive fibrinogenesis, hyalinisation, loculated ascites and eventual encapsulation of the peritoneal cavity. Radiological contrast studies demonstrate delayed transit or intestinal obstruction.⁶⁸ Abdominal ultrasonography may demonstrate loculated ascites containing echogenic fibrin strands. Calcification may also be present and the bowel wall will be thickened⁶⁹ with tethering of the small bowel.⁷⁰ Computed tomography demonstrates these features in greater detail.⁷¹

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