20 Complications of Peritoneal Dialysis: Prevention and Management

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Clinical Scenario

A 35 year old male PD patient presents with a 24 h history of nausea, vomiting and generalised abdominal pains. He has end stage kidney disease (ESKD) due to diabetes mellitus, and started dialysing via automated peritoneal dialysis (APD) six months ago. He has not noted any problems with drainage; he says that his bags have remained clear, and he continues to manage ultrafiltration of around 1 L per day, alongside a native urine output of 1 L per day. His most recent PET test, undertaken earlier this month, showed him to be a high average transporter. His PD catheter exit site is clean, and there is no purulent discharge emanating from this. He is currently apyrexial, is able to lie flat, and has no peripheral pitting oedema. His blood pressure was 124/84, and his pulse 64 beats per minute.

Introduction

Peritoneal dialysis (PD) is a vital form of kidney replacement therapy, that—once patients (and their carers), are trained and comfortable with the rigorous hygiene involved in catheter care techniques—enables patients to dialyse safely and independently at home, often with very limited specialist support, for many years. Conversely, PD complications are not uncommon, and can lead to significant morbidity and mortality—particularly in lower middle income countries (LMIC), where the provision of alternative forms of kidney replacement therapy (KRT) is not guaranteed. PD complications can be simply divided into infective (75%) and non-infective causes (25%). Clinicians need to be well-versed in prevention, investigation and management of PD complications. In this chapter, we shall discuss in detail the complications of PD, and their appropriate management pathways and strategies for prevention.

Infective Complications

Apart from catheter malfunction, infections pose the biggest threat to the continuity of PD in an individual, and represent an important barrier to the uptake of PD. Where there may be no alternative forms of KRT in LMIC, this can lead to significant morbidity and mortality [1]. Clinicians must therefore be well-versed in the effective prevention and

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management of infection in PD, and should develop clear protocols in their own units for use by all staff.

Much progress has been made over the last few decades in addressing the prevention and treatment of infections in PD, and in providing sound recommendations for clinical practice. To this end, the International Society for Peritoneal Dialysis (ISPD) has published graded and pragmatic guidelines for clinical use which were recently updated in 2016 (peritonitis) and 2017 (catheter-related infection) [2, 3]. We will focus on many of these recommendation in this chapter, but it is important to note that the local context will determine which problems are prevalent in any specific area and recommendations will need to be adapted accordingly. Patients on PD are also at increased risk for systemic infections such as tuberculosis (TB), and other severe bacterial and viral illnesses, but this chapter will focus on those specific to PD.

It is recommended that each PD unit monitors the incidence of peritonitis as a quality control indicator. While the overall peritonitis rate should be less than 0.5 episodes per year at risk, the rate achieved will depend on local factors, including whether patients have been given a choice in terms of dialysis modality, clinic attendance, and possibly sociodemographic factors and comorbidities such as HIV and diabetes. Lower socioeconomic status has not been consistently shown to associate with peritonitis risk [4, 5].

Prevention of Infection

The key emphasis needs to be placed on adequate training of the patient by experienced staff in terms of hand hygiene, exit site care and exchange technique. Further specific measures have also been shown to be effective:

1. The administration of prophylactic antibiotics (with gram positive cover such as cefazolin or vancomycin) prior to catheter insertion.
2. Daily topical application of mupirocin or gentamicin preparations to the catheter exit site.
3. Adequate catheter immobilisation during daily care.
4. Modern connectology: The use of disconnect systems that utilize a "flush before fill" design and avoidance of manual spike systems.
5. The use of anti-fungal prophylaxis during antibiotic treatment for peritonitis (with nystatin or fluconazole, depending on local resistance and drug interaction concerns).
6. Soaking of the transfer set adapter in 10% povidone iodine solution at transfer set change [6].

Observational data has shown that automated peritoneal dialysis (APD) may be associated with a lower risk of peritonitis, but definitive data is lacking. Other measures that appear to be helpful but lack randomised data include the use of prophylactic antibiotics for touch contamination or accidental disconnection (gram positive cover) and prior to most endoscopic/dental procedures (gram positive and negative cover) and the avoidance of hypokalaemia and constipation to reduce bacterial translocation. Loss of patient motivation and depression are also risk factors for infection and should be actively enquired after during patient interactions.

The ideal exit site should be situated away from the belt line and skin folds and be downward and lateral facing to allow for good drainage. Showering is permissible, as is swimming in the sea or private pools, however baths and communal pools should be avoided, and are associated with pseudomonal infections. Many recommend covering the exit site during swimming with an occlusive dressing such as an stoma bag. Patients should keep their nails trimmed and inspect and clean the exit site at least twice weekly or after every shower, following hand hygiene in a clean environment free of wind and pets. The exit site can be cleansed with soap and water or 2% chlorhexidine or similar antiseptic. After rinsing and drying the exit site well, a small amount of antibacterial ointment can be applied with a cotton bud or gauze and then dressed with gauze and secured with tape. In warm climates, leaving the exit site open has also been shown to be a safe option. Avoidance of excessive movement at the exit site is very important and taping the catheter to the skin about 2 cm away from the exit site should be done. Securing the catheter extension set in a purpose-made fabric belt has proven very useful in assisting immobilisation. There are currently no firm data to recommend one dressing or cleaning solution over any other.

Diagnosis of Infection

Effective treatment involves the rapid recognition of infection in order to preserve PD as a technique. Patients should be taught how to recognise infection at home to facilitate early presentation for assessment. Infections in PD can present as either, or a combination of both catheter-related infection and/or peritonitis:

Catheter-Related Infections

Exit site infections are often associated with poor catheter care and subsequent peritonitis and catheter loss. Scoring systems can be used to assist with the evaluation of the exit site (see Table 20.2). Tunnel infection usually occurs in association with an exit site infection. Signs of inflammation are present along the catheter tunnel tract, although this may be occult, in which case fluid can be demonstrated ultrasonographically around the catheter tract [7]. This distinction is important, due to the higher risk of refractory infection or progression to peritonitis, especially in the presence of *Staphylococcus aureus* infection. Any discharge present should be cultured.

Table 20.1 Presentations of PD infections

Presentations of PD infections
1. Catheter-related infection (a) Exit site infection—purulent discharge at catheter exit site with or without erythema; confirmed on culture of exit site specimen. Tunnel infection—clinical inflammation or ultrasonographic evidence of fluid collection along the subcutaneous catheter tract.
2. Peritonitis (a) Diagnosed in the presence of *two of the following three*: • Generalised abdominal pain with or without other symptoms. • Cloudy dialysis effluent with a white cell count >100/μL (0.1×10^9/L) and >50% polymorphonuclear (after minimum 2 h dwell). • A positive dialysis effluent culture. (b) For patients on APD, a percentage neutrophils >50% should be considered indicative of peritonitis even if the WCC is <100, due to the short dwell times. Alternatively, a 1 L manual 2 h dwell can be performed in the unit in order to obtain sample for culture. (c) Note the differential diagnosis of cloudy effluent also includes: Chemical peritonitis due to batch contamination or dihydropyridine calcium channel blockers, eosinophilic peritonitis, hemoperitoneum, chylous effluent, pancreatitis, malignancy and specimen after a prolonged period when PD has been interrupted. (d) The presence of a lymphocytic pleocytosis should also prompt investigation for TB peritonitis which is not rare in endemic areas, although it is often initially neutrophilic.

Table 20.2 Exit site scoring system[a]

Parameter	0	1	2
Swelling	No	Exit only (<0.5 cm)	>0.5 cm and/or tunnel
Crust	No	<0.5 cm	>0.5 cm
Redness	No	<0.5 cm	>0.5 cm
Pain	No	Slight	Severe
Drainage	No	Serous	Purulent[b]

Infection should be assumed with a score of 4 or higher
[a]Modified from Schaefer F et al.
[b]Purulent drainage, even by itself, is sufficient to indicate infection. A score of less than 4 may or may not represent infection

Peritonitis

Peritonitis can be catheter-related through touch contamination or through extension of exit site/tunnel infection into the peritoneal space. It can also be secondary to translocation of bacteria from the gut or though transient bacteraemia, either spontaneously, after invasive procedures or following a bowel perforation. Peritonitis should be suspected in the presence of abdominal pain or a cloudy dialysis effluent and should be promptly investigated (Table 20.3). While cloudy dialysate is usually associated with infection, other non-infectious causes should be considered, especially in the absence of abdominal pain (see above). Localised abdominal pain or polymicrobial infection should raise the suspicion for surgical causes such as appendicitis and may warrant specific imaging, surgical assessment and the addition of anaerobic cover.

Table 20.3 Steps in Investigating for PD peritonitis

Steps in investigating for PD peritonitis
• Dialysate fluid should be drained and inspected then sent for an urgent cell count, gram stain and culture prior to initiation of antibiotics. • Culture yields should be >85%, and are increased by placing 5–10 mL directly into aerobic and anaerobic blood culture bottles and through re-suspended sediment culture after centrifuge of a 50 mL aliquot. • It is important to liaise with the local microbiology lab in order to increase diagnostic yields. • The exit site and tunnel should be carefully evaluated for signs of infection and any purulent discharge cultured. • The Gram stain is only predictive of the final organism, or if fungal elements are present. • The presence of gram-negative rods indicates the need for pseudomonal cover if not already in place.

Treatment of Infections

Catheter-Related Infection

Clinical judgement is required to distinguish bacterial colonisation (positive culture without evidence of inflammation) from true infection in order to avoid unnecessary antibiotic prescription and the promotion of antimicrobial resistance. Apart from culturing any exit site discharge, peritonitis should also be ruled out through fluid assessment and culture. Mild exit site infection in the absence of tunnel involvement or peritonitis can initially be managed with intensified local care. The presence of *S. Aureus* or *Pseudomonas* on initial cultures, or a failure to respond to this regimen within 1 week would indicate the need for systemic antibiotics, even if initially mild. Chronic exit site inflammation can lead to the formation of a pyogenic granuloma, which can further become infected. Topical application of silver nitrate is often successful in this context and any associated infection should also be treated.

Concomitant peritonitis or abdominal wall abscess implies deep cuff involvement and mandates catheter removal as well as the use of intraperitoneal antibiotics until catheter removal. In this instance and depending on residual renal function, temporary haemodialysis may be required.

More severe exit site and/or superficial tunnel infection and any febrile patient should be treated with systemic antibiotics along with intensified daily exit site care and careful clinical follow up. The initial empirical antibiotic choice should cover *S. Aureus,* according to local or known sensitivity patterns but cover for *Pseudomonas* should be added where the patient has a history of such an infection. The prescription should be adapted according to culture results as soon as available. Common appropriate initial empiric choices are cloxacillin/flucloxacillin or Clindamycin/Linezolid, depending on local sensitivities. The duration of treatment should be a minimum of 2 weeks and until the exit site looks normal, but 3 weeks for associated tunnel infection or pseudomonas. Where pseudomonas is cultured and is susceptible, an effective treatment consists of combined oral ciprofloxacin with topical ciprofloxacin drops and gauze soaks 4 times per day. The gauze is soaked in a solution made up of 125 ml of vinegar (acetic acid) mixed with 125 ml of sterile (or cooled boiled) water and 1 teaspoon of salt. Resolution of any tunnel infection should be confirmed by the absence of fluid around the catheter on follow-up sonography—persistent fluid around the catheter would indicate refractory infection.

For refractory/relapsing exit site or tunnel infections in the absence of peritonitis, simultaneous catheter removal and replacement under antibiotic cover is recommended [8, 9]. In this instance, low volume PD (or supine APD) can be used initially to avoid the need for temporary HD. However, catheter salvage therapy has been successfully performed by shaving off the external cuff and re-tunnelling the catheter through a new exit site under ongoing antibiotic cover. This technique may be preferable, particularly in resource-constrained areas, and allows continued PD immediately.

Peritonitis

Initial Management of Suspected Peritonitis

Send appropriate cultures and cell count, examine the exit site and tunnel carefully and culture any purulent discharge present. Initiate empiric broad-spectrum antibiotics (see Table 20.4) while awaiting culture and it is an option to add heparin 500u/L to the first few exchanges to prevent fibrinous catheter occlusion. Approximately 70%

Table 20.4 Commonly used antibiotics and their dosing (adapted from ISPD 2016 update [2])

DRUG	ONCE DAILY DOSING[a] (per exchange, once dly)	EACH BAG EQUIVALENT (mg/L, unless indicated otherwise)
Vancomycin	20–30 mg/kg every 5–7 days or if level <15	LD 30 mg/kg, MD 1.5 mg/kg/bag
Teicoplanin	15 mg/kg every 5 days	LD400 mg/bag/MD 20 mg/bag
Cefazolin	15–20 mg/kg	LD 500/MD 125
Cloxacillin	ND	LD 500/MD 125
Clindamycin	ND	MD 600 mg/bag
Ampicillin	2 g BD	MD 125
Ceftazidime	3 g stat, then 1–1.5 g/day	LD 500/MD 125
Ceftriaxone	2 g stat, then 1 g/day	ND
Cefipime Ciprofloxacin	1 g ND (can use orally)	LD 500/MD 125 MD 50
Gentamycin	0.6 mg/kg	LD 8/MD 4
Tobramycin	0.6 mg/kg	LD 3 mg/kg/MD 0.3 mg/kg
Amikacin	2 mg/kg	LD 25/MD 12
Cotrimoxazole	960 mg orally BD	
Fluconazole	200 mg	ND
Meropenem	1 g	LD250/MD125
Imipenem/Cilastatin	1 g BD	LD250/MD50

Note: Most antibiotics are stable for at least 5 days when mixed in the bag and stored at room temperature. The exception to this is ampicillin (12 h) where intermittent mixing/dosing required. (At room temperature: Vancomycin is stable 28 days, Gentamycin 14 days, cefazolin 8 days; Ceftazidime 4 days, but 7 days if refrigerated). First line agents are all stable in icodextrin if refrigerated

[a]Once daily dosing requires a dwell of at least 6 h LD = loading dose per litre in first bag, MD = maintanence dose per litre in each bag, ND = No data

of infections are related to gram positive organisms, with the balance being gram negative or other (such as fungal or mycobacterial). Consider whether a surgical cause for peritonitis may be present and manage appropriately. Patients who have systemic sepsis should be admitted and considered for IV antibiotics, although most patients will be able to be treated as outpatients, provided they have ready access to transport back, and their pain is not severe. Ancilliary use of antifungal prophylaxis (nystatin orally or fluconazole 200 mg po alternate days) should be given. Note that a temporary increase in dialysate glucose concentration or use of icodextrin may also be necessary since an increase in membrane transport due to inflammation is common in peritonitis, and may result in fluid overload.

Basic principles of Antibiotic Therapy for Peritonitis:

- Broad spectrum antibiotics to cover both gram positive and gram negative organisms are initiated empirically but narrowed down after positive culture is obtained. The combination of a glycopeptide and ceftazidime has been shown to be superior to other regimens [10]. Glycopeptides cover many inherently penicillin-resistant gram positive organisms and ceftazidime affords pseudomonal in addition to other gram negatives. There are many rational combinations and the choice should be tailored according to local susceptibility data and ecology (Table 20.4).
- Intraperitoneal (IP) antibiotics are superior in efficacy compared to IV, with the exception being in the presence of systemic sepsis. They should be added to the dialysate in a sterile fashion (after 5 min of disinfection of the injection port) by trained personnel.
- Once-daily IP treatment of most antibiotics is possible and has equivalent efficacy to intermittent dosing, provided the dwell is at least 6 h.
- Antibiotics can be added to the same bag but should not be mixed in the same syringe.
- Antibiotics can be mixed in the unit and provided to patients to take home with them. They can be mixed at home, but given the stability of the agents, in-unit mixing is preferable.
- Serum vancomycin levels can be checked after 3–5 days, and a trough concentration of >15 μg/ml should be maintained, although there is no good evidence to support this prac-

tice. Dosing is usually required every 7 days, but every 3–5 days in those with good residual kidney function.
- Aminoglycosides appear largely safe when necessary and do not impact residual kidney function or cause ototoxicity when dosed correctly, daily and for ≤1 week. However, where an alternative non-toxic therapy is unavailable, safe use has been reported over up to 3 weeks.
- Data concerning APD are scant, but strategies for dosing include dosing per bag as for CAPD (preferred strategy), reprogramming the cycler to allow a daily 6-hour dwell, switching to CAPD for the duration of treatment, and intermittent instillation of a 6-hour dwell for glycopeptide dosing [11].

Further Assessment of the Patient Should Occur Within 2–3 Days:
- Most patients improve rapidly within 2–3 days and failure to do so demands re-consideration of the diagnosis, possible further imaging (Chest radiograph/CT Abdomen/ultrasonography of the tunnel), repeat cell count/cultures including TB/fungal cultures and a possible switch in therapy to broaden cover. Failure to respond by day 5 necessitates prompt catheter removal to protect the membrane. A high index of suspicion for TB should also be maintained in endemic areas.
- Dialysate cell count >1090 cells/μL (1.09×10^9/L) on day 3 strongly predicts treatment failure [12].
- For patients that have responded well clinically, antibiotic therapy should be narrowed according to culture results.
- For those patients with a rapid clinical response but negative culture, it is usually safe to continue only gram positive cover provided the cell count has dropped markedly by day 3, since most culture negative episodes are gram positive in origin. An alternative is to continue an oral quinolone antibiotic for 10 days.
- The presence of fungal elements on initial gram stain or subsequent culture demands immediate removal of the catheter and a switch to include antifungal treatment (Table 20.5). Cure rates for fungal peritonitis are less than 10%.
- Early catheter removal is mandatory for all organisms if there is concomitant tunnel infection (or where an exit site organism is the same as peritoneal fluid), with the exception for coagulase negative staphylococcal (CNS) and streptococcal infection that is rapidly responding (Table 20.5).

Specific Organisms and Their Treatment

In general, the narrowest spectrum antibiotic available should be used to limit the development of resistance. Some specific recommendations can be made regarding certain organisms (Table 20.6):

Final Assessment of the Patient:
- The duration of therapy should be 3 weeks, but 2 weeks in CNS/streptococcal infection with a rapid response.
- After catheter removal, treatment should continue for 10–14 days.
- Each peritonitis episode should be interrogated and patients should be re-trained regarding hygiene and aseptic technique plus touch contamination protocols.
- The transfer set should be changed once fluid clears.

Table 20.5 Indications for PD catheter removal

Catheter removal is considered necessary for:
1. Refractory peritonitis (failure to resolve by day 5).
2. Fungal peritonitis
3. Relapsing peritonitis (peritonitis with same organism ≤4 weeks after successful treatment)
4. Refractory exit site or tunnel infection.

Note: For relapsing peritonitis due to non-virulent organisms or in the presence of persistent exit site/tunnel infection with resolved peritonitis, simultaneous removal and replacement of the catheter can be safely performed after 2–3 week's treatment, sometimes avoiding HD. However, for refractory peritonitis, a new catheter should only be placed a minimum of two weeks after full resolution of peritonitis. Successful return to peritoneal dialysis after catheter removal for infection is successful in a large number of patients, but should be carefully considered in those with repeated infections (peritonitis with a different organism ≥4 weeks after successful treatment) or after fungal peritonitis

Table 20.6 Specific recommendations for management of PD peritonitis due to isolated organisms

Organism	Management
Coagulase negative Staphylococci (CNS)	• Where methicillin sensitive, continuous instead of daily treatment with first generation cephalosporins is preferred.
Staphylococcus aureus	• High risk for catheter removal. • Where methicillin sensitive, first generation cephalosporins are preferred. • A nasal swab for *S. aureus* should be performed, and where positive, eradication measures should be attempted.
Pseudomonas	• High risk for catheter removal. • Two antibiotics with different mechanisms of action should be used (also for *Stenotrophomonas*): *Oral ciprofloxacin can be combined successfully, but must be dosed apart from phosphate binders, as these can bind ciprofloxacin in the gut, and markedly reduce its absorption.* • Consider extending treatment to 28 days in some cases.
Enterococcus species	• Vancomycin is the preferred agent where sensitive.
Other *enterobacteriaceae*	• Due regard should be given to increasing antibiotic resistance and the use of two agents should be considered for those organisms with inducible beta lactamase inhibition. • Consultation with microbiologists is recommended where possible.
Tuberculosis	• There is a neutrophilic effluent in 75% of cases. Standard anti-TB therapy is used, and catheter removal is often not necessary. • Some patients may develop a protein-losing state via their dialysate, which may necessitate a transfer to HD.

Prognosis

Most patients recover rapidly, but the risk of requiring catheter removal is approximately 20%. The overall mortality rate is approximately 5% but is highest for those with fungal, gram negative, *S. aureus* or TB infections. While the reasons are poorly understood, a recent episode of peritonitis is also associated with an increased odds of all-cause death for the next few months, but especially in the first 30 days. Other possible consequences of peritonitis include the formation of infected intra-abdominal collections, fibrous adhesions and encapsulating peritoneal sclerosis.

Non-Infective Complications

Approximately 25% of cases of technique failure in PD occurs as a result of some form of mechanical complication. These can involve the catheter itself with poor drainage or alternatively the boundaries of the peritoneal space leading to hernias or leaks. The vast majority of these complications can be dealt with and patients can return to PD shortly thereafter. This section will address these issues and how to prevent and manage them.

PD Catheter Obstruction

There are several possible causes of PD catheter flow complications, as listed in Table 20.7.

Table 20.7 Causes of PD catheter obstruction & Specific treatments

Cause of PD catheter obstruction	Treatment
Catheter obstruction due to fibrin	Intraluminal tissue plasminogen activator (tPA)
Catheter migration out of the pelvis	Guidewire manipulation of PD catheter
Catheter entrapment in the omentum	Laparoscopic replacement and omentopexy
Severe constipation	Oral bowel preparation solution

As the PD fluid drains into the true pelvis in the upright position, a catheter sited there is much more likely to drain effectively and to near completion. If the catheter has moved out of the pelvis it often (but not universally) leads to poor drainage. The migration of the catheter may be because of significant constipation with the loaded sigmoid colon moving the catheter into the upper abdomen and this is by far the most common cause. It is easily diagnosed with a plain abdominal x-ray which shows both the catheter migration as well as the faecal loading. The catheter may also migrate when the omentum wraps around the catheter and with traction pulls it out of the pelvis. Omental wrapping cannot be distinguished from other causes of migration without the use of laparoscopy. Catheters may also become blocked with fibrin. This usually leads to problems with both drainage into and out of the abdomen, but occasionally a ball valve effect may be seen and only inflow drainage occurs. In this situation, the abdominal x-ray usually shows the catheter in the correct position. Some rarer causes of obstruction are reported in the literature, such as obstruction due to fallopian tubes, appendices and other mobile structures in the abdomen. It is also relatively common for patients with significant peritonitis or following surgery to develop adhesions, and these can obliterate the pelvis or create pockets where fluid collects and drains slowly. All of the above need to be diagnosed at laparoscopy or laparotomy.

Prevention of PD Catheter Obstruction

In recently published ISPD access guidelines, practical methods to ensure optimal PD access and reduced complications are discussed (Table 20.8) [13]. These guidelines analyse methods of insertion of catheters, as well as some techniques to prevent complications. Although there is no evidence of superiority of different methods of insertion of PD catheters in the hands of a skilled operator, if the laparoscopic route is chosen, then advanced laparoscopic techniques such as musculofascial tunnelling, omentectomy, omentopexy and tip suturing have been shown in a large meta-analysis to lead to better long term outcomes, with fewer mechanical complications.

As constipation is by far the most common reason for catheter migration, maintenance of a regular bowel habit through the regular use of laxatives in PD patients is recommended to prevent catheter migration.

Table 20.8 Advanced laparoscopic techniques to prevent PD catheter blockage

Laparoscopic technique	Description
Musculofascial tunnelling	• Involves the formation of a tunnel along the posterior rectus sheath in a caudal direction prior to the catheter entering the peritoneal space. • Keeps the catheter directed into the pelvis, and if migration occurs will allow it to return to its original position through its elastic memory.
Omentectomy	• Was used historically, and can be performed via either laparotomy or laparoscopic approaches. • Removal of a large proportion of the omentum prevents it reaching into the pelvis and entrapping the catheter: Unfortunately, the omentum is a highly vascular structure, and extreme care needs to be taken to ensure haemostasis as post-operative bleeding results in both fibrin occlusion of the catheter, as well as formation of adhesions.
Omentopexy	• Is preferred over omentectomy. • Involves suturing the end of the omentum to either the mesocolon or a point on the anterior abdominal wall in one of the upper quadrants. Only needs to be performed when the omentum is long enough to reach the level of the pelvic brim, and can be confirmed at the time of surgery.

Table 20.8 (continued)

Laparoscopic technique	Description
Tip suturing	• Is a controversial technique, as it can be argued that having a foreign object may be a nidus for infection, and if the catheter is immobilised too tightly it may result in rectal or vaginal pain. • Significantly reduces the incidence of catheter migration. • Various techniques have been described from a propylene loop of suture protruding from the lower third of the anterior abdominal wall into the abdominal cavity through which the catheter travels, to a loop on the dome of the bladder, directing the catheter into the retrovesical space: Both of these techniques allow easy removal of the catheter if necessary, since the catheter slides through the loop unimpeded. Alternatively, the catheter can be fixed using sutures to the pelvic sidewall.

Note: These techniques cannot be performed if the catheter is inserted percutaneously, however it should be noted that although these methods reduce mechanical complications, many studies show percutaneously inserted catheters have patency in excess of 80% at one year despite this, and therefore if using this approach the above laparoscopic techniques can be performed later if a catheter does become problematic

Obstruction of the catheter due to fibrin can be prevented by the addition of heparin 500-1000iu/l to the PD solution when PD fluid is bloodstained or has significant amounts of fibrin present.

Management of PD Catheter Obstruction

Catheter migration with constipation: This is diagnosed by plain abdominal x-ray showing faecal loading with or without migration of the catheter. In the vast majority of cases, this can be remedied with a single dose of a solution used for bowel preparation for colonoscopy (e.g. sodium picosulphate or macrogol). The patient takes the preparation and waits until the bowel has emptied significantly before performing the next dialysis exchange.

Catheter migration without constipation: Occasionally the catheter will not move into the pelvis of its own accord. This could be due to omental wrapping in which case it is unlikely to move without surgical intervention, however it may simply be that it is in the incorrect position and a much less invasive method may be used to manipulate the catheter to get it into position. This involves fluoroscopy, and use of a flexible guidewire. There are numerous published techniques, ranging from a stiff wire bent into a 270° arc, to various guidewires and angiography catheters, which are advanced under fluoroscopic guidance in order to manipulate the tip of the catheter back into the pelvis. The most commonly used method uses a relatively stiff angiography guidewire with a flexible or j-shaped tip, which is advanced through the catheter and beyond. As the wire is advanced through the tip, it presses against the abdominal side wall and the catheter is pushed downward into the pelvis. Results from most of the published studies show a technique success rate of approximately 80%, however publication bias may overestimate the success rate achieved in clinical practice. It is a very low risk, minimally invasive procedure though, and if facilities exist, may prevent the need for surgery and should be considered [14, 15].

It is imperative that the technique is performed in a sterile manner, and a dose of intraperitoneal antibiotic is administered as per the unit protocol for catheter contamination episodes, in order to prevent PD peritonitis.

Should the above not prove successful, then repositioning of the catheter should be performed surgically. It is preferable to reposition using laparoscopy, as it allows for the above advanced techniques to prevent further complications, but also allows direct visualisation of the catheter, division of adhesions, and placement of the catheter back in the pelvis under direct vision. Finally, the smaller incisions associated with laparoscopy

than for open laparotomy may facilitate a return to PD immediately, provided that the laparoscopic port sites are sutured internally.

Laparoscopy is not available in many centres due to a lack of expertise, and expensive consumable devices. In this situation, the catheter can be replaced by performing a mini-laparotomy, or alternatively, the catheter can be replaced at the bedside. This latter technique involves dissection and freeing of the deep cuff under local anaesthesia. The catheter is slowly withdrawn until the first side hole is visualised. Using a peel-away sheath PD catheter insertion kit, the guidewire is fed through the side-hole into the abdomen. The catheter can then be completely withdrawn, leaving the guidewire with the distal tip in the peritoneal cavity. The catheter can be freed of any fibrin, and then is replaced in the abdomen using the peel-away sheath percutaneous technique, over the guidewire.

Catheter obstruction secondary to fibrin deposition: It is common for fibrin to be found in the PD effluent, and this can cause occlusion of the lumen and side-holes. This can cause both uni- and bi-directional flow obstruction. Under sterile conditions, the catheter can be flushed vigorously with saline or PD solution, using a 20 ml syringe. Avoid aspirating rapidly, as it is possible to entrap mobile structures, such as omental folds in the tip of the catheter. Gentle aspiration may alternatively result in removal of the responsible fibrin plug, and restore PD fluid flow. If this is unsuccessful, then the catheter may be locked with a thrombolytic solution. The most commonly recommended is tissue plasminogen Activator (tPA), which is made up to a 1 mg/mL solution and 8 mls (in an adult Tenckhoff catheter) is slowly injected and left for 1 h, then aspirated. This will usually result in restoration of flow if fibrin is the cause of the obstruction.

Hernia and Leak

Hernias and leaks occur in approximately 15% of patients on PD, and appear to be more prevalent than the general population due to the increased abdominal pressure associated with PD solutions, which makes defects in the abdominal wall more apparent. Other factors such as malnutrition, polycystic kidney disease and surgery for catheter placement also increase the risk. They may become apparent initially, with initiation of dialysis or after many years. Hernias are defects in the abdominal with an intact peritoneum, whereas a leak is a defect where the peritoneal membrane has been disrupted. The latter can commonly occur after an episode of peritonitis or surgery, and with rest may resolve, however hernias almost always need to be repaired.

Hernias

The most common sites for hernias in PD patients are inguinal, umbilical and paraumbilical. Other hernias occurring less commonly are femoral, diaphragmatic and Spigelian, along with recto/vaginocoeles. The usual presentation is a sudden swelling over the affected area, however there are reports of patients presenting with recurrent peritonitis associated with intermittent subacute obstruction of bowel.

If it is uncertain as to whether there is a hernia or not, then further imaging may be helpful. The simplest is CT peritoneography (Fig. 20.1). Magnetic resonance imaging (MRI) may also be used, with the PD solution acting as the contrast media (Gadolinium is usually avoided due to the risk of nephrogenic systemic fibrosis and possible peritoneal fibrosis). This technique may be more helpful for diagnosing a leak as discussed later [16].

Hernia Prevention and Management

Prior to insertion of a PD catheter, all patients should have all potential hernia sites inspected; if a hernia is present, this needs to be repaired at the time of surgery to place the PD catheter.

If a hernia is diagnosed at a later point, it is usually advisable for the hernia to be repaired, but occasionally if it is small, not increasing in size, and has a wide neck, it can be left in patients who have a limited life expectancy. In other patients, due to the likelihood of significant worsening, it should be repaired. Inguinal hernias can often be repaired using an extraperitoneal approach which will allow early reinstatement of

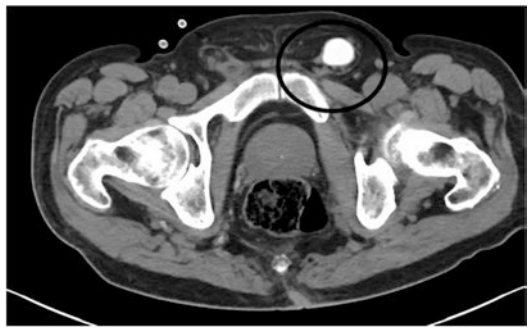

Fig. 20.1 CT Peritoneogram demonstrating an inguinal hernia in a patient who presented with recurrent peritonitis of unknown cause. *Notes: 2 mL/kg of intravenous contrast is injected into a 2 L dialysate bag and instilled into the abdomen. The patient is asked to perform manoeuvres, which increase the intra-abdominal pressure, such as coughing, bending and squatting. 30 min after installation, a standard CT scan of the abdomen is performed, then the fluid is drained out*

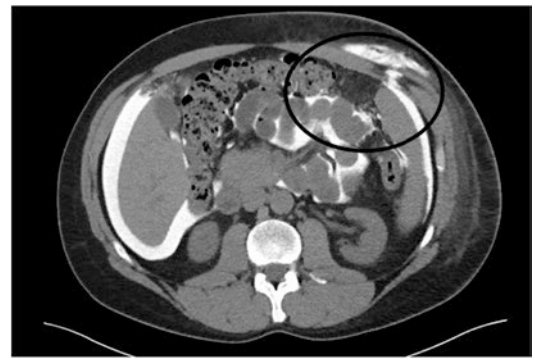

Fig. 20.2 CT peritoneogram demonstrating an extraperitoneal leak into the subcutaneous tissues of the left anterior abdominal wall

PD (see below), however umbilical and paraumbilical hernias usually require a procedure which breaches the peritoneum, and requires a period of rest from PD.

Repair of hernias almost always require the use of a synthetic mesh to prevent recurrence. There is debate as to whether this should be placed intra- or extra-peritoneally. Intraperitoneal mesh has the risk of being infected if the patient develops peritonitis in the 2–4 weeks following repair, however there is little evidence of this occurring in the literature. Until further evidence comes to light, if there is the surgical expertise available, the extraperitoneal approach should be considered.

Although there is little evidence as to the optimal timing for reinitiating PD, if the patient can delay dialysis then 4 weeks is recommended, however if the peritoneum is not breached then 10 days is the minimum before resumption of ambulatory PD. If the patient is on automated PD (APD), a low volume fill program (1–1.5 L) may be used, with a dry abdomen when ambulating, in order to allow an immediate return to PD, without the need for bridging HD.

A patent processus vaginalis is where there is a potential connection between the abdominal cavity and the scrotum. This often presents as a unilateral or bilateral scrotal swelling, and must be distinguished from a leak as discussed below. When this is noted unilaterally, there is a significant risk of a contralateral leak, such that a bilateral repair should be performed.

Leaks

Leaks may occur at any point where there is a defect in the peritoneal membrane, with the most common sites being along the PD catheter tunnel and trans-diaphragmatic, however numerous other potential sites may occur, including pericardial, transvaginal and retroperitoneal. Figure 20.2 shows a leak in the left flank, which would occur after heavy exercise. Identification of a leak may be more difficult than a hernia, as it may be subtle. Features which should alert one to a leak is poor ultrafiltration in the early phase after starting PD, abdominal wall oedema, with a peau d'orange appearance, genital oedema, and in the case of a transdiaphragmatic leak, shortness of breath. Hydrothorax and transdiaphragmatic leaks will be discussed separately.

If there is poor ultrafiltration due to leakage into the soft tissues, this can be identified by performing a peritoneal equilibration test (PET) which should be discordant with the clinical picture. If a patient has ultrafiltration failure (<200 mL with a 2.5% glucose solution) but is a low, low average or even high average transporter, one should consider a leak and proceed to imaging. There are 3 modalities which are helpful: the first is nuclear scintigraphy, where 2 mCi of Technetium radionuclide is added to a 2 L PD

bag. This may identify a leak, but does not give good definition. CT or MR peritoneography, as discussed earlier, may offer better definition and demonstration of the site of the leak, and where a repair is needed (Fig. 20.2).

Most leaks may resolve if PD is withheld for a period of 2 weeks, allowing the peritoneum to seal itself. If following this rest period, the leak recurs, then it will usually require surgical repair.

Hydrothorax

Hydrothorax occurs due to leakage through a defect in the peritoneum and diaphragm. This may be a congenital defect, or alternatively a rupture of a pleural bleb. The usual presentation is an asymptomatic pleural effusion on chest radiograph (CXR), however it may cause shortness of breath and in extremely rare cases, tension hydrothorax. As with other PD leaks, there is frequently associated poor ultrafiltration, and the patient may present with oedema and signs of fluid overload. It may therefore be difficult to distinguish between a pleural effusion secondary to a leak and one due to fluid overload, or right ventricular failure on clinical grounds. A confident diagnosis may be made by measuring the glucose in the fluid aspirated from the pleural space is >40 mmol/L or >3 mmol/L above that of the serum. CT/MR Peritoneography or scintigraphy may also be helpful in diagnosing a leak, and the former may even demonstrate the exact position which can be sutured thoracoscopically.

Management of Hydrothorax

This is determined by whether the leak occurred following an episode of peritonitis or not. If so, then following a period of 2 weeks' rest, the healed mesothelium may prevent further leakage. If it occurs at the start of PD, it is unlikely to resolve spontaneously. The options are then to perform a thoracoscopic surgical repair, or more commonly pleurodesis. This will usually result in a good functional outcome, and very seldom recurs.

Encapsulating Peritoneal Sclerosis (EPS)

Encapsulating peritoneal sclerosis is a condition that occurs in 1–2.5% of patients on PD, can have dire consequences for the patient, and requires early identification. Significant thickening of the peritoneal membrane results in adhesion of bowel loops, and cocooning of the bowel, resulting in bowel obstruction (Table 20.9). There is often associated ascites associated with this, especially in patients who have transferred to haemodialysis or had a kidney transplant.

The most common clinical features are vomiting and abdominal pain, with rarer symptoms being ascites, blood stained dialysate and an abdominal mass.

The cause remains uncertain, with numerous theories under investigation. One prevalent theory is that there is a predisposition to membrane thickening such as increased time on PD, or an as yet unidentified genetic cause, following which a second insult leads to excessive peritoneal membrane fibrosis: this could be an environmental toxin, or infection. Underlying this theory is a strong association with time on dialysis, with more than 90% of cases presenting after 3 years on PD. Although it was initially considered important, there is no clear link between number of peritonitis episodes and the development of EPS. Many studies have demonstrated a disconnect between ultrafiltration failure (UFF) and peritoneal transporter status: normally, patients with UFF are high transporters, whereas this is not necessarily the case in EPS, presumably due to the fibrotic thickening disrupting the usual performance of the membrane in the PET test. This is important, as many studies have shown that patients continuing PD for 3 years or more after the development of ultrafiltration failure are at exceptionally high risk of EPS.

Table 20.9 Clinical and Radiological features of Encapsulating Peritoneal Sclerosis (EPS)

Clinical presentation	Radiological findings on CT
• Typically after >3 years on PD • Vomiting • Abdominal pain • Ascites • Blood stained dialysate • Abdominal mass	• Thickened bowel loops and peritoneum • Diffuse peritoneal membrane calcification • Loculated ascites

The diagnosis of EPS is usually made with radiological imaging, on the background of the appropriate clinical picture. The gold standard diagnostic test is CT imaging, demonstrating features of thickened bowel loops and peritoneum, diffuse calcification of the membrane, and loculated ascites. None of these features is diagnostic. Normally in the supine patient, bowel loops tend to "float" on the ascites, and are in contact with the anterior abdominal wall. In patients with EPS, the bowel loops are often posterior to the ascites which collects anterior to them. Ultrasound can be used to look for bowel wall thickening, but is very operator dependant, and therefore less reliable for making the diagnosis.

The optimal therapy for EPS remains uncertain. If patients are young, with a reasonable prognosis, then a transfer to haemodialysis is recommended. Small case series have suggested some benefit with the use of tamoxifen, corticosteroids and other immunosuppressants. No randomised controlled trials have been done to determine the best treatment, and publication bias makes it difficult to determine the best option. Also, as EPS has different phases from early inflammatory phase to late fibrotic phase, it may be important to target different therapies at different stages. Once the patient has developed symptoms of bowel obstruction, surgical intervention may be necessary. It is recommended that this be undertaken in a centre experienced with performing peritonectomy, where a multidisciplinary approach to parenteral nutrition, and a combination of peritonectomy and plication of the intestine can be performed. EPS has a high mortality, and malnutrition is thought to play a key role in this, hence the need for aggressively treating this prior to surgery.

Conclusions

Returning to our 35 year old PD patient, who presented in the initial clinical scenario with nausea, vomiting and generalised abdominal pain: with good drainage of his PD fluid, preserved ultrafiltration, and physical signs consistent with euvolaemia, we may consider catheter obstruction, a hernia or fluid leak all less likely causes of his presentation. Further, the fact that he is a relatively new starter on APD makes EPS improbable. The absence of a purulent discharge from around his catheter is only part reassuring—from the perspective of helping to exclude an exit site infection. However, as in 75% of cases, the most likely cause of his presentation remains PD-associated infection, and we must therefore pay careful attention to excluding PD peritonitis, for which shorter dwell times associated with APD may explain his clear bags: sending an urgent PD fluid cell count, gram stain and culture prior to initiation of antibiotics is essential, as per the local PD peritonitis protocol, ensuring at least a 6 h dwell time, and with a view to revising antibiotics according to the results of the gram stain and culture.

In conclusion, infectious and non-infectious complications of PD are common: Through rigorous patient training and ensuring familiarity amongst clinicians of local protocols, we can facilitate timely and pro-active investigation and management of PD complications, and in the majority of cases, allow patients to return to PD for long term dialysis.

Questions

1. Which of the following are most important in a patient presenting with cloudy effluent?
   A. Peritoneal fluid culture and cell count
   B. Exit site inspection and pus swab if inflamed
   C. Start on intraperitoneal antibiotics with both gram positive and gram negative cover
   D. Discussion on the possible causes for peritonitis and consider retraining the patient
   E. All of the above

Answer: E.

PD peritonitis is usually simply a coagulase negative staphylococcal infection which is easily treated, however if appropriate investigation of the cause and rapid initiation

of antibiotics to cover gram negative organisms is not performed then there is a higher chance of catheter loss in those with other causes.

2. The ISPD guidelines recommend a culture negative rate of <20% for peritonitis. Which methods can be used to increase this yield?
   A. Centrifuge 50mls of fluid, resuspend the pellet and culture
   B. Inoculate blood culture bottles with 10mls of PD fluid
   C. Ensure fluid samples are collected before antibiotics are added to the bag
   D. Discuss with local microbiology lab the importance of the primary samples
   E. All of the above

Answer: E.

Discsussion with local microbiologists can be extremely helpful as peritoneal fluid specimens are often not regarded as particularly important in the lab and may not be given appropriate consideration. Understanding of the value of centrifugation and use of blood culture bottles to increase yield and peritonitis outcomes are essential.

3. Exit site infections should be managed with:
   A. Warm compresses with a towel soaked in boiling water
   B. Increased exit site care if mild
   C. Shaving of the cuff and retunneling
   D. Antibiotics appropriate to cultures for 2 weeks
   E. B and D

Answer E.

Exit site infections may be very mild and immobilisation of the catheter and increased exit site care can resolve it. If there is a purulent discharge or pain though then appropriate antibiotics are necessary and should be continued for 2 weeks

4. Which of the following is incorrect?
   A. Peritonitis which does not resolve by day 5 is called refractory peritonitis
   B. If PD effluent has not cleared by day 5 the catheter should be removed to preserve the membrane for future use
   C. Fungal peritonitis can be safely treated with fluconazole but if not cleared by day 5 then the catheter should be removed
   D. A PD effluent cell count >1000 on day 3 is predictive of failure to clear by day 5
   E. In relapsing (same organism within 4 weeks) peritonitis simultaneous removal and replacement of the PD catheter after 2 weeks antbiotics is feasible

Answer: C.

Fungal peritonitis carries a very high treatment failure rate and a 25% mortality. Although there are case reports of successful treatment with antifungals but this is not recommended.

5. A patient presents with a case of PD peritonitis secondary to pseudomonas aeriginosa, the following are the most appropriate treatment options:
   A. Remove the PD catheter immediately
   B. Continue ceftazidime/gentamicin for 2 weeks
   C. Treat with 2 anti-pseudomonal antibiotics for 3 weeks
   D. Shave the cuff on the catheter as it is the most likely source.

Answer: C.

Gram negative peritonitis requires 2 agents to improve treatment success. Although an exit site infection and peritonitis with pseudomonas with likely require tube removal it is not necessary unless refractory peritonitis or recurrent peritonitis occur.

6. A patient who has poor ultrafiltration, with a PET test result showing slow average transporter status should be considered to have a mechanical complication until proven otherwise.
   A. True
   B. False

Answer: A.

Patients with poor ultrafiltration especially early in the course of PD and not associated with hyperglycaemia are likely to have a mechanical complication, most especially a leak and CT peritoneography should be considered.

7. A patient presents with a right sided pleural effusion. Which of the following are not likely to assist in the diagnosis of a leak:
   A. Pleural aspiration showing a fluid:serum gradient >3 mmol/L

B. Echocardiogram to exclude right heart failure
C. Pleural biopsy
D. Nuclear scintigraphy
E. MRI of the thorax

Answer: C.

All of the investigations are helpful in distinguishing between a pleural effusion due to fluid overload and a leak except c. A pleural biopsy may be necessary in the case of an exudative effusion but hydrothorax is always a transudate.

8. Encapsulating peritoneal sclerosis (EPS) is a rare complication of PD associated with thickening and cocooning of the peritoneal membrane. The following are options for therapy except:
   A. Tamoxifen
   B. Peritonectomy
   C. Prednisone
   D. Intraperitoneal antibiotics
   E. Sirolimus

Answer: D.

Although all of the above are treatment options, there is no consensus on the optimal treatment regimen and randomised trials are needed, however given the paucity of cases it is unlikely this will be achievable.

9. Rapid of inflow of fluid and poor drainage thereof is likely to be secondary to:
   A. Catheter migration out of the pelvis
   B. Constipation and faecal loading
   C. Omental wrapping of the catheter
   D. Fibrin
   E. All of the above

Answer: E.

Poor drainage may be due to any of these causes however the most common and easily treatable is faecal loading and should be aggressively treated.

10. Polycystic kidney disease patients should not be treated with PD due to the high risk of hernia and lack of space in the abdomen?
    A. True
    B. False

Answer: B.

PKD patients often do well on PD and although those with massively enlarged kidneys may find large fill volumes uncomfortable, it is not a contraindication to therapy. Hernias are more common in these patients, and should be sought and repaired pro-actively, before or at the time of PD catheter placement.

Test your learning and check your understanding of this book's contents: use the "Springer Nature Flashcards" app to access questions using https://sn.pub/cz9Cok. To use the app, please follow the instructions in Chap. 1.

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