Peritoneal Dialysis

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Clinical Scenario

A 68-year old woman with long-standing diabetes mellitus and stage 4 chronic kidney disease (CKD), followed up at the renal clinic showed gradual deterioration in kidney function over the last few years. In the past 6 months, her kidney function has deteriorated further. She lives with her husband, and carries out her daily activities independently, and also looks after her family. Clinically, she is asymptomatic. On examination, her blood pressure is 150/95, she has a mild pallor over her palmar creases and conjunctiva. Her chest is clear on auscultation, but there is mild bilateral pedal edema. Her blood tests show a blood haemoglobin of 9 g/dL, her serum sodium 142 mmol/L, and potassium 5.4 mmol/L, urea is 37.8 mmol/L, and creatinine 450 μmol/L, her estimated glomerular filtration rate (eGFR) using CKD-EPI equation is 8.1 mL/min/1.73 m^2, her serum bicarbonate is 19 mmol/L, serum albumin is 35 g/L, and adjusted serum calcium is 2.34 mmol/L, and phosphate is 2.10 mmol/L.

How would you counsel the patient about her options for kidney replacement therapy?

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Introduction

Peritoneal dialysis (PD) is one of the main kidney replacement therapies (KRT) that can be carried out at home for patients with end stage kidney disease (ESKD). To carry out PD, patients need to have a catheter placement into peritoneal cavity. Dialysis fluid is instilled into the peritoneal cavity through the catheter and allowed to dwell for 4–6 h. Uraemic retention solutes are removed through the semi-permeable peritoneal membrane by diffusion. Simultaneously, ultrafiltration takes place through the peritoneal membrane, with the dialysis fluid glucose acting as an osmotic agent. The peritoneal membrane characteristics differ among patients and affect peritoneal membrane transport kinetics of fluid and solutes. Peritoneal membrane characteristics may change over time in individual patients due to uremia, diabetes, dialysis procedure, dialysis fluids, drugs, peritoneal infections or inflammation. This chapter aims to give a practical guidance to clinicians delivering PD therapy. The topics include: assessing and preparing kidney failure patients for PD and contraindications to PD. A brief description of the different PD modalities, solutions, prescription, and key principles in delivering high quality goal-directed PD will be given. The chapter will outline assessments of residual kidney function (RKF), indices of dialysis adequacy, peritoneal membrane transport characteristics as well as quality of PD therapy. A

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clinical approach to low clearance and low drain volume in PD will be discussed.

Assessing and Preparing Kidney Failure Patients for PD

The provision of pre-dialysis education and decision aids increase the likelihood of patients choosing home dialysis therapy such as PD. Home dialysis or PD provides patients more freedom and flexibility with their time and improves their sense of well-being. When being told of the need for dialysis, patients very often have difficulties accepting it and are fearful that dialysis initiation might impact their work, personal life, travel and quality of life. Pre-dialysis education provided by a multidisciplinary team of experienced staff plays an essential role in alleviating fear and anxiety of patients, help patients to better understand kidney failure, face and accept dialysis, make their preferred choice of dialysis modality, prepare and cope with life on dialysis better and maintain a feeling of control with their health condition. Generally, patients should be referred to pre-dialysis education at least 4–6 months before dialysis initiation or when their eGFR falls below 15 mL/min/1.73 m. The multidisciplinary team involved in giving pre-dialysis education should include experienced nephrologist, renal nurse, dietitian, physiotherapist, psychologist, and social worker. The program should be designed according to local settings, culture, staff availability and patient load in individual hospitals. Lack of patient preparedness and an urgent start to dialysis are associated with lower survival and higher morbidity.

In assessing patients planning for PD therapy, a careful history should be taken in relation to their co-morbidities, bowel habits, personal hygiene, and prior abdominal surgeries. Patients' general condition, ability to perform PD, family support and home environment need assessment. Assisted PD may be considered in elderly patients or patients with mental or physical disabilities who choose PD.

PD is contraindicated if the peritoneal cavity is obliterated or the membrane is not functional, for example due to peritoneal adhesions or catheter placement is not possible. Obesity may present a challenge but is not a contraindication to PD. Obese patients receiving PD may be at an increased risk of catheter leak, hernias, exit site infection, and peritonitis compared with non-obese patients. A high body mass index may lead to inadequate solute clearance especially with loss of RKF, thus requiring larger dwell volumes. In morbidly obese patient, an extended catheter with a high abdominal or pre-sternal exit site may be used to avoid placement in a skin fold or the pannus region, but this would require considerable operator experience. A history of previous abdominal surgery does not preclude percutaneous PD catheter placement unless extensive adhesions are present or anticipated. Polycystic kidneys may increase intra-abdominal pressure and increase risk of hernias. However, PD has been successfully performed in these patients. Thus, the decision of modality choice in patients with polycystic kidneys need to be individualized, taking into consideration the enlarged kidneys and/or liver size, patients' body build and sense of abdominal fullness with the enlarged kidneys and/or liver. Patients with chronic constipation, diverticular disease and other causes of abnormal colonic distention may be unsuitable candidates for PD. Patients with cirrhosis and ascites are at an increased risk of spontaneous bacterial peritonitis and protein loss, but PD is not contraindicated. PD has been successfully performed in these patients and the PD catheter allows drainage of ascites.

Choice in PD Modality

The choice of PD modality should be personalized, involving a shared decision-making approach between physicians and patients and is the modality that patient chooses after receiving dialysis education and decision support. Patients and caregivers need to be informed of the challenges, considerations, and trade-offs of the dif-

ferent dialysis modalities so that modality selection can be tailored to their individual health and social circumstances.

PD Catheter Placement

PD catheter can be placed by traditional open surgical techniques, laparoscopic implantation, or percutaneous insertion. Percutaneous insertion is preferred because it can be done under local anaesthesia, is less invasive and less costly. Physicians can be easily trained to perform percutaneous PD catheter insertion and this significantly minimizes delays in arranging catheter insertions. Both laparoscopy and open surgery typically require general anaesthesia, are most costly and usually reserved for cases with previous abdominal surgeries. In placing a PD catheter (double cuffed preferred), the catheter coil must be positioned in the most dependent region of the peritoneal space: the posterior low pelvis. Meticulous attention should be placed to the location of the catheter exit site, creation of an inferiorly angled tunnel through the rectus abdominis muscle, and establish a stable position of catheter coil within the pelvic cul-de-sac. Prophylactic antibiotics should be given prior to catheter operation. After catheter placement, a breathable dressing must completely cover the abdominal incision wound and catheter exit site. Both the wound and exit site dressing should be kept dry and intact. Unless the catheter is used immediately as part of an urgent-start program, a minimum 2-week healing time is needed to ensure tissue ingrowth of the catheter cuffs and prevent fluid leaks prior to starting PD.

Urgent Start PD

Urgent start PD is defined as the situation in which PD needs initiation in less than 48 h after presentation to correct life-threatening complications. Non-urgent start refers to those in which dialysis initiation can be delayed more than 48 h after presentation. A planned approach is one in which the modality has been chosen prior to the need for dialysis and there is an access ready for use at the initiation of dialysis. An unplanned start is dialysis initiation when access is not ready for use or requires hospitalization or when dialysis is initiated with a modality that is not the patient's choice.

PD is possible in both planned or unplanned and urgent or nonurgent start. However, patients with hyperkalemia, volume overload, or marked uremia are not good candidates for urgent-start PD.

The major barriers to an urgent-start PD program are lack of operators who can place a PD catheter within the urgent start time frame and limited capacity of the health care facility to support PD for urgent-start patients and nursing manpower to train patients at short notice (Table 19.1). Where technical expertise in PD catheter placement is lacking, this can be addressed by increasing training of nephrologists. In urgent start, PD patients may have limited time to receive required education for an informed decision making on their initial choice of modality. These patients need to be provided with the required education and support to enable transition to their preferred modality when feasible.

Starting PD exchanges shortly after PD catheter placement instead of waiting for 2 weeks period for the cuff ingrowth and abdominal wound healing requires treatment modifications include doing intermittent PD in hospital in

Table 19.1 Institutional infrastructure setup required for urgent-start PD programs

(i) Ability to place a peritoneal catheter immediately within 48 h;
(ii) Staff education regarding use of catheter immediately after placement;
(iii) Administrative support in inpatient and outpatient settings;
(iv) Identification of appropriate candidates for urgent-start PD;
(v) Utilization of protocols in every step of the urgent-start process from patient selection for PD through appropriate post-discharge follow-up.

recumbent position and reducing instillation volume to prevent leaks.

Initiation of PD Therapy for End-Stage Kidney Disease

For patients who choose PD modality, initiation of therapy should be considered when one or more of the following are present:

(i) symptoms or signs attributable to kidney failure (e.g., neurological signs and symptoms attributable to uremia, pericarditis, anorexia, medically resistant acid-base or electrolyte abnormalities, reduced energy level, weight loss with no other potential explanation, intractable pruritus, or bleeding);
(ii) inability to control volume status or blood pressure;
(iii) progressive deterioration in nutritional status refractory to interventions.

Initiation of PD therapy should not solely be based on numerical values of eGFR.

PD Modalities

PD can be performed manually or via automated system. Continuous ambulatory peritoneal dialysis (CAPD) is done manually. Automated peritoneal dialysis (APD) includes: continuous cyclic peritoneal dialysis (CCPD), intermittent peritoneal dialysis (IPD), tidal peritoneal dialysis (TPD). Details of the different modalities are outlined in Table 19.2.

Table 19.2 A Summary of Different forms of PD modalities prescription

CAPD	Introduced in 1976 by Popovich and Moncrief and later modified by Oreopoulos as a wearable, portable form of dialysis, not requiring any equipment other than the disposable PD solution bags and a tube connecting the bag to patient's PD catheter to instill PD fluids into patient's peritoneal cavity. Prescription can be modified based on clinical status, sense of well-being, nutrition status, volume and blood pressure control, dietary compliance, biochemical parameters and indices of dialysis adequacy, taking into account patient's work and lifestyle pattern. Prescription can be initiated with 1.5% 2 L × 2 or 3 exchanges and one night time exchange of around 8–10 days, taking into consideration patient's body build, amount of RKF, urine volume and dietary intake. CAPD can maintain a relatively steady physiological state, control volume status and blood pressure in most patients.
APD	Automated PD was introduced in the late 1970s with an aim to achieve higher solute and fluid removal than CAPD and to automate PD with a cycler during patient sleep time.
CCPD	Continuous PD performed using a cycler. Typical prescription includes 3–4 night time exchanges each of 2–3 L, depending on body build, clearance needs and residual kidney function (RKF) and a single long day dwell with 1.5–2 L PD fluid. It allows more flexibility in the number and volume of exchanges carried out during night time, and reduces to a single daytime exchange, allowing patients more free time during the day. CCPD also allows larger volumes to be used in the supine position and minimizes the risk of touch contamination.
IPD	Usually consists of frequent, short cycles performed over 12–24 h per session and peritoneal cavity was drained dry between sessions. Nocturnal IPD (NIPD) is performed nightly and is usually reserved for patients with high peritoneal solute transport and low ultrafiltration. The short cycles of NIPD allow better ultrafiltration than longer cycles of CAPD or CCPD in high transporter. The total PD exchange volume per treatment usually ranges between 8 and 12 L.
PD Plus	PD Plus refers to CCPD with an exchange added to the long day dwell hours. Usually 3 or 4 × 2 L PD exchanges are performed during the night for 8–10 h. The long day dwell is then split into two shorter daytime exchanges performed manually or cycler assisted to improve both clearance and ultrafiltration. It limits daytime exchanges to less than 7 h. It is usually used for patients of larger body build, anuric patients or patients who need more solute clearance.

Table 19.2 (continued)

TPD	It consists of an initial fill usually in the range of 2–2.5 L then a variable dwell and partial drain, usually half of the PD volume, leaving a residual volume in the peritoneal cavity. The cavity is refilled and this will repeat until the last exchange when all PD fluids are drained. There is usually a daytime exchange. The principle purpose of TPD is to enhance clearance of small solutes by reducing the normal loss of dialysis time with inflow and outflow of PD fluid. However, TPD has not been shown to be superior to APD in terms of clearance or ultrafiltration. TPD may be useful for patients with inflow or outflow pain, slow drainage or multiple alarms due to drainage problems. It is more costly and complex to implement.
Assisted PD	It is usually adopted in patients of which a caregiver, helper or nursing staff is required to carry out the PD procedure such as in elderly patients, patients with multi-morbidities who are unable to do the procedure themselves or those in aged home. It can be done either manually by CAPD or using a cycler.
Incremental PD	A strategy by which less than standard full dose PD is prescribed in patients starting PD treatment and the combination of RKF and peritoneal clearance achieved remains sufficient to achieve individual clearance goals. It can be adopted in patients with relatively well preserved RKF. It incurs less workload for patients and their caregivers to do PD, thus enabling them more free time for life participation. It also has the advantage of minimizing patients' exposure to glucose solutions. Incremental PD is more cost-saving for emerging countries.

PD Solutions

Constituents of PD Solutions

Commercially available PD solutions contain sodium (132–135 mmol/L), calcium (1.25–1.75 mmol/L), magnesium (0.5 mmol/L), chloride (95–103.5 mmol/L) and lactate (35–40 mmol/L) and varying concentrations of glucose/dextrose ranging from 1.36%/1.5%, 2.27%/2.5% and 3.86%/4.25%. The overall osmolality was 344–347, 395–398, and 483–486 mOsmol/L, respectively and aimed to facilitate ultrafiltration and removal of water-soluble uremic toxins through the peritoneal membrane while maintaining electrolyte and acid-base balance of PD patients.

Standard glucose solutions are acidic in pH (5.0–5.8) to prevent dextrose caramelization during the sterilization procedure. Lactate concentration varies between 35 to 40 mmol/L. Lactate is rapidly metabolized to bicarbonate in a 1:1 ratio in patients with normal liver function and maintains a high dialysate to plasma lactate concentration gradient required for continued absorption without lactate accumulation in the circulation.

With high lactate, high glucose concentration, high osmolality and high levels of glucose degradation products (GDPs) generated, long term use of these solutions are associated with progressive peritoneal membrane injury, neovascularization, peritoneal sclerosis and fibrosis. The low pH, high osmolarity and high glucose content of these solutions also inhibit phagocytic functions of peritoneal leukocytes and impair host immune defense mechanisms. Some patients may complain of inflow pain with these solutions.

Calcium concentration of these solutions varies between 1.25 and 1.75 mM with 1.75 mM being termed standard calcium and 1.25 mM being termed 'low calcium' but 1.25 mM is the more physiological calcium concentration. Use of 1.75 mM calcium dialysate is associated with more progression in coronary artery calcium score over 24 months than 1.25 mM calcium dialysate in hemodialysis, especially with poor phosphorus control. Furthermore, use of 1.25 mM calcium dialysate showed a significantly lower prevalence of histologically diagnosed low bone turnover than 1.75 mM calcium dialysate group. Although similar study is not available in PD patients, Kidney Disease Improving Global outcomes (KDIGO) 2017 CKD-mineral bone dis-

ease (MBD) guideline and International Society of Peritoneal Dialysis (ISPD) Adult Cardiovascular and Metabolic guideline 2015 suggested the use of 1.25 mM calcium-containing PD solution to avoid positive calcium balance or hypercalcemia.

Types of PD Solutions

Glucose-Based Solutions

The ultrafiltration rate across the peritoneum is directly proportional to the initial glucose osmotic gradient (Table 19.3)

Adverse Effects of Glucose-Based PD Solution

Cumulative glucose absorption through the peritoneum incurs negative effects to the peritoneum and systemically including worsening of insulin resistance, hyperglycemia, accumulation of atherogenic visceral fat, weight gain, dyslipidemia and worsening glycemic control in PD patients with diabetes.

The standard heat sterilization of glucose-based solutions accelerates the generation of GDPs. Glycated local proteins form advanced glycation end-products (AGEs). Both GDPs and AGEs are directly cytotoxic to the peritoneal mesothelial cells and contribute to the long-term bio-incompatibility of glucose-based solutions (Fig. 19.1). They cause mesothelial cell loss, inflammation, submesothelial fibrosis and thick-

Table 19.3 Ultrafiltration volume with different glucose concentrations

Glucose solution concentration	Average ultrafiltration volume (mL)
1.36%/1.5%	100–200
2.27%/2.5%	200–400
3.86%/4.25%	>400

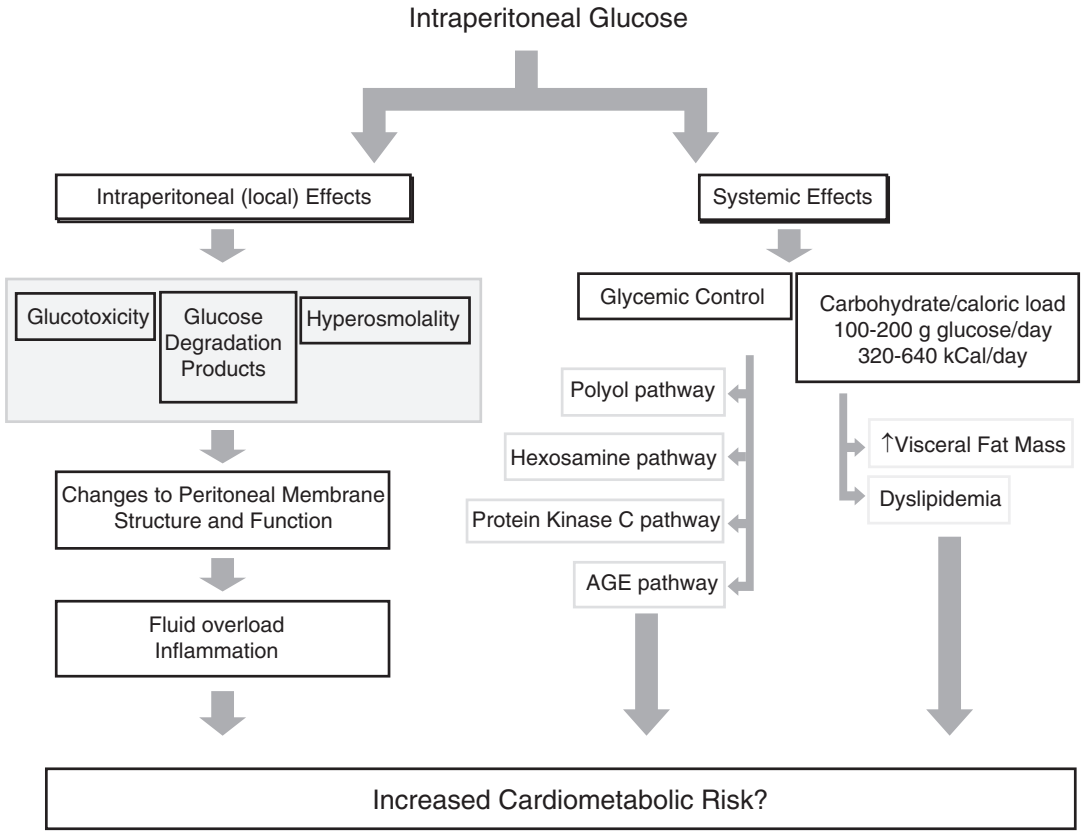


Fig. 19.1 Negative local and systemic impact of peritoneal glucose

ening, calcification, vasculopathy and diabetiform neoangiogenesis, resulting in changes to the peritoneal membrane structure and increased peritoneal solute transport (PSTR) with time on dialysis, requiring use of higher glucose concentration solutions for ultrafiltration. This would eventually lead to peritoneal membrane failure (PMF) over time and increase risk of volume overload. A high PSTR is associated with worse patient survival and a trend towards worse PD technique survival. Thus, a glucose sparing or glucose minimization PD regimen should be adopted in all PD patients as clinical condition and financial situation permit.

Almost two thirds of the PD fluid glucose are absorbed during a 4-h dwell and over 85% in an 8-h dwell with an average PSTR. This translates to an obligatory absorption of 43 g and 73 g of glucose with an 8-h dwell of 2.5% and 4.25% solutions, respectively. Exposure to glucose-based PD solution is associated with more weight gain, truncal fat mass and visceral adiposity increase than use of non-glucose-based PD solutions. Increased abdominal adiposity also contributes to a higher cardiovascular risk in PD patients. High glucose solutions may also add satiety and reduce appetite.

Glucose Polymer Solution or Icodextrin

Icodextrin is a starch-derived, branched, water soluble glucose polymer with an average molecular weight between 13,000 and 19,000 Daltons. Commercially available 7.5% icodextrin solution has a sodium concentration of 133 mmol/L and a lactate concentration of 40 mmol/L and is iso-osmotic (284 mOsmol/L). Icodextrin is not significantly metabolized in the peritoneum and is slowly absorbed into the bloodstream via the lymph vessels, with around 40% being absorbed after a 12 h period and is metabolized into oligosaccharides and maltose by circulating α-amylase (Fig. 19.2). Maltose cannot be metabolized in the circulation of humans as maltase is not in the circulation but is present in the kidney and intracellularly in the body. As icodextrin does not get reabsorbed, it is a superior osmotic agent and has superior ultrafiltration capacity than glucose solution, especially when dwell for long hours.

Icodextrin is a useful salvage therapy in PD patients with refractory fluid overload or ultrafiltration failure and may prolong PD technique survival (Table 19.4). PD patients using icodextrin achieved significantly better daily peritoneal ultrafiltration and had lower incidence of uncon-

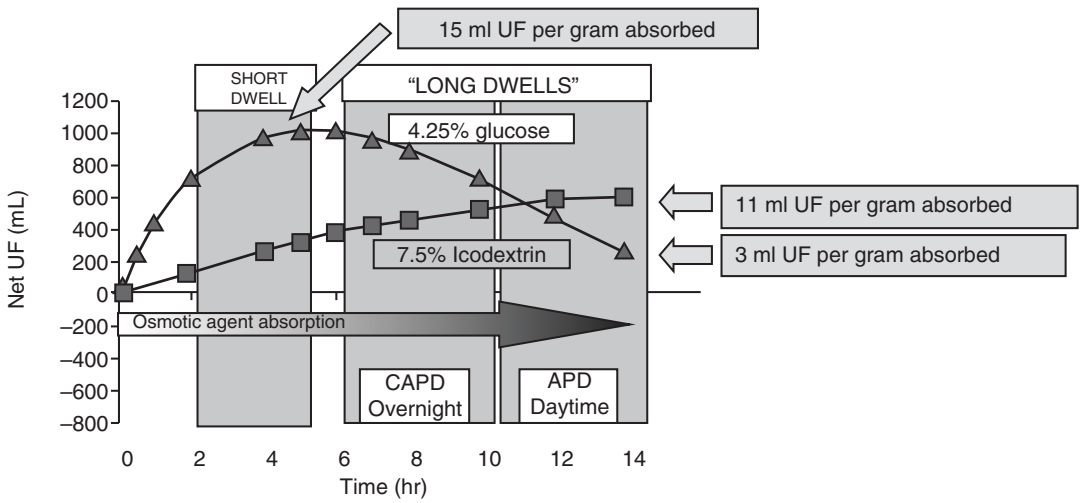


Fig. 19.2 Ultrafiltration profile of Icodextrin

Table 19.4 Current recommendations for icodextrin use

- Icodextrin is recommended to improve ultrafiltration independent of the dialysate to plasma creatinine ratio [ISPD 2020 guideline].
- Icodextrin should be used as the long dwell in high transporter patients with a net peritoneal ultrafiltration <400 mL during a PET with a 3.86% glucose solution [European Best practice working group].
- Once daily icodextrin should be considered as the long-dwell dialysis solution in diabetic peritoneal dialysis patients for better glycemic control (2C) [ISPD 2015 guideline].

trolled fluid overload than standard glucose PD solutions without compromising RKF.

Icodextrin as the long-dwell solution minimizes glucose exposure and absorption, and incurs less metabolic disturbance compared to glucose solutions. Icodextrin improves glucose metabolism, insulin sensitivity and reduces dyslipidemia compared to glucose solutions. It has been shown to reduce insulin requirement, lower fasting glucose, improve glycated hemoglobin, lower serum triglycerides and has fewer adverse events than glucose solution in diabetic PD patients. It also reduces insulin resistance index in non-diabetic PD patients. Icodextrin did not adversely impact on RKF.

Adverse effects of icodextrin may include sterile or chemical peritonitis or skin rash as a result of allergy to starch (around 10%). Sterile peritonitis with icodextrin IS related to contamination of icodextrin by peptidoglycan which is a constituent of bacterial cell walls. Clinically, patients with sterile or chemical peritonitis may remain well despite having cloudy effluent. The differential cell count of PD fluid shows predominantly eosinophilia but not neutrophils. PD effluent usually clears up rapidly on withdrawal of icodextrin.

Icodextrin and its metabolites may interfere with some laboratory analytical methods on plasma glucose measurements. Glucometers that use glucose dehydrogenase-pyrroloquinolinequinone overestimate blood glucose in patients using icodextrin.

Neutral pH Low-GDP Solutions

Epithelial-to-Mesenchymal transition (EMT) of peritoneal mesothelial cells is a hallmark feature in the peritoneum of PD patients and plays a mechanistic role in the initiation of peritoneal fibrosis, leading onto peritoneal membrane function decline and failure.

Bicarbonate is the most physiologic and biocompatible buffer. However, calcium and magnesium precipitate with bicarbonate in alkaline pH. The biocompatible PD solution adopts a dual-chamber dialysate bag in which one chamber contains the bicarbonate buffer of 34 mmol/L and the other contains a solution with calcium and magnesium. The two solutions are mixed together only prior to instillation into patients' abdomen to prevent calcium and magnesium carbonate precipitation. It allows heat sterilization and storage occurring at a lower pH in a separate bag and minimizes generation of GDPs. Some of the low GDP solutions used bicarbonate instead of lactate as buffer. Mixing the contents of the two chambers just before use produces a more physiological solution with a neutral pH of around 7.0.

The use of neutral pH, low GDP solutions was associated with better preserved peritoneal membrane morphology, function, better host immune defense and less systemic inflammation and is effective in ameliorating metabolic acidosis. The Cochrane systemic review of several randomized trials concluded that neutral pH, low GDP solutions was associated with better preservation of RKF and greater urine volumes when used for 12 months or more and also beyond 12 months though less significant. Peritonitis rates did not differ between neutral pH, low GDP solutions and standard glucose solutions. A trend towards lower ultrafiltration volume and lower incidence of inflow pain was observed with neutral pH low GDP solutions compared to standard glucose solutions but not reaching statistical significance. There is no data to show that this solution impacts patients' survival. Table 19.5 lists the current recommendations for use of neutral pH, low GDP solutions.

Table 19.5 Current recommendation for Neutral pH, low GDP solutions

- Neutral pH, low GDP solutions is recommended for better preservation of RKF if used for 12 months or more [ISPD 2015 and 2020 guidelines].

Amino Acid Solutions

The 1.1% amino acid solution contains 87 mmol/L of amino acids, 61% of which is essential amino acids. The nitrogen absorbed from a single daily dwell of 1.1% amino acid solution is sufficient to offset the daily losses of amino acids and protein from the peritoneum which may mount up to 3–4 g of amino acids and 4–15 g of proteins per day even in stable condition. This amount may increase further with peritonitis. Usually, around 72–82% of amino acids are absorbed in a single daily dwell and this may amount up to 18grams a day, thus providing a good source of protein supplement without adding phosphorus load. It provides an ultrafiltration volume comparable to that achieved with 1.36% glucose solutions. The peak plasma amino acid concentration is usually achieved around an hour.

Compared to glucose solution alone, combined amino acids and glucose PD solutions have been shown to improve protein kinetics and whole body protein synthesis. 1.1% amino acids solution has confirmed safety. Potential adverse effects include nausea and anorexia. Some patients may develop mild metabolic acidosis. This may be ameliorated by adjusting to using a bicarbonate-based solution in the other exchanges. The overall clinical benefit of 1.1% amino acid solution on nutrition status has remained equivocal. It may be reserved as a glucose-sparing solution and for use in subjects at risk or exhibit features of PEW syndrome.

PD Prescription in Terms of Choice of PD Modality, PD Solutions and Doses

For years, PD prescription has been focused on small solute clearance and urea clearance (Kt/V) has been used as a target in defining dialysis adequacy. The Peritoneal Dialysis Outcome Practice Pattern (PDOPPS) showed a lot of variations in PD prescription in terms of modalities, types of PD solutions and PD regimens around the world. Indeed, the modality of PD should be individualized according to the patients' need, peritoneal transporter characteristics and RKF (Table 19.6).

Table 19.6 Factors affecting clinical outcomes of PD patients

Factors	Impact
Age	Impaired physical function Impaired cognitive function, dementia / delirium Protein energy wasting Falls, frailty
Multi-morbidity	Symptoms Polypharmacy Impaired physical function Impaired cognitive function Protein energy wasting
Dialysis-related	Symptoms Infections Polypharmacy Volume status—volume overload or depletion Protein energy wasting Burden of dialysis
Psycho-social	Depression Anxiety Financial stress Social support

Key Principles in PD Care Delivery

The ISPD 2020 guideline recommended that PD prescription should be 'goal-directed' and should involve shared decision-making in establishing a personalized realistic care goal that maintains quality of life for the person doing PD as much as possible, enables them to meet their life goals, minimize symptoms and treatment burden while ensuring the delivery of high-quality care. Patient reported outcomes are crucial measures of the effectiveness of patient centered care. Patients should have the opportunity to report them and to receive the required symptom evaluation and management in order to improve the care they received.

Patients doing PD should be educated and given choice as far as is possible concerning the

PD prescription they receive. Patients doing PD should be educated about their condition and be informed about their prognosis and be given the opportunity to define their goals of care. PD can be prescribed in a variety of ways and should take into account local resources, person's wishes regarding lifestyle and the family's/caregivers' wishes if they are providing assistance (Fig. 19.3). PD infection, cardiovascular disease, mortality, PD failure and life participation were ranked the top core outcome domains in the Standardized Outcomes in Nephrology (SONG) initiative by all stakeholders (Table 19.7).

The following assessments should be included to ensure high-quality PD care.

(a) Patient reported outcome measures assess how a person doing PD is experiencing life and his/her feeling of well-being. It should take into consideration the person's symptoms, impact of the PD regimen on the person's life, mental health and social circumstances.

According to the ISPD 2020 guideline, patient's perception of their health-related quality of life (HRQOL) should be assessed routinely. This should take into account assessment of patient's symptoms, experience, patient reported outcome measures (PROMS), impact of the dialysis treatment regimen, and the psychosocial status of the patient. Treatment should be adjusted and modified based on patients' HRQOL, including symptom management, adjustments in dialysis treatment regimens, and clearly defining the goals of care.

Table 19.7 Domains to be addressed in patients receiving PD

Cognitive dysfunction	Uremic pruritus
Family and marital discord	Anorexia, nausea
Depression	Restless legs
Anxiety	Satisfaction with dialysis treatment regimen
Fatigue	Impact of the treatment regimen on their life
Lethargy	Satisfaction with care provided
Physical functioning	Caregiver burden
Sexual dysfunction	Abdominal discomfort, anorexia appetite, nausea, vomiting
Symptoms of neuropathy	Additional physical symptoms
Sleep disturbances	

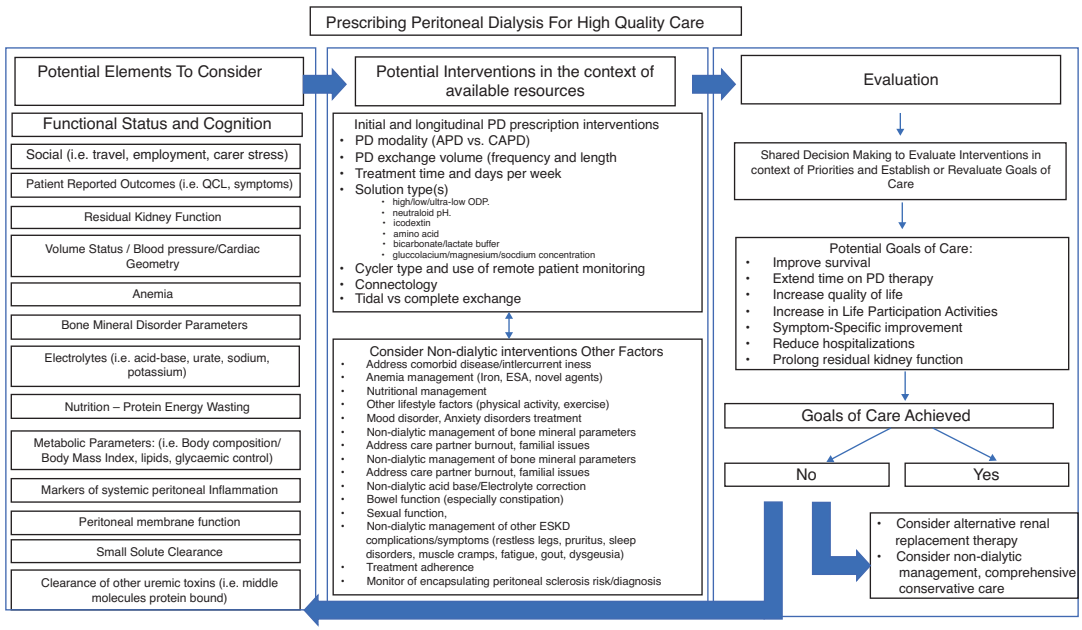


Fig. 19.3 Prescribing high quality PD

(b) Volume status is an important part of PD delivery. Urine output and fluid removed by PD both contribute to euvolemia. Regular assessment of volume status, including blood pressure and clinical examination, should be part of routine PD care.

(c) Nutrition status should be assessed regularly through evaluation of the patient's appetite, clinical examination, body weight measurements and blood tests (potassium, bicarbonate, phosphate, albumin). Dietary intake of potassium, phosphate, sodium, protein, carbohydrate and fat may need to be assessed and adjusted as well.

Various nutritional indices including body weight changes, appetite, subjective global assessment (SGA), serum albumin, handgrip strength may be used.

Hypokalemia is associated with poor nutritional status and adverse outcomes including peritonitis. Hypoalbuminemia is more common in PD than hemodialysis and is associated with PEW and peritoneal protein losses (Table 19.8). Hyperphosphatemia is multifactorial and associated with adverse outcomes in PD. Factors to consider include patients' dietary intake, compliance to phosphate binders, RKF and PD prescription.

Table 19.8 International Society of Renal Nutrition and Metabolism Consensus Criteria to diagnose protein-energy wasting (PEW)

Dietary intake
Unintentional low dietary energy intake <25 kcal/kg/day for at least 2 months
Unintentional low dietary protein intake <0.8 g/kg/day for at least 2 months
Body mass
Body mass index <23 kg/m^2
Unintentional weight loss over time: 5% over 3 month or 10% over 6 month
Total body fat <10%
Muscle mass
Muscle wasting: Reduced muscle mass 5% over 3 m or 10% over 6 month
Reduced mid-arm muscle circumfrence area >10% in relation to 50th percentile of reference population
Creatinine appearance
Serum biochemical parameters
Serum albumen <38 g/L (bromcresol green method)
Serum prealbumin (transthyretin) <300 mg/L
Serum cholesterol <100 mg/L

The diagnosis of PEW is made based on the presence of three out of the four characteristics listed in the table above. Unintentional weight loss should lead one to consider the presence of PEW. Loss of 5% of non-edematous weight within 3 months or an unintentional loss of 10% of non-edematous weight over the past 6 months is an indicator of PEW, independent of weight-for-height measures. Loss of body fat and muscle mass are considered as important criteria for diagnosing PEW. Inflammatory markers such as C-reactive protein are usually elevated in the setting of PEW.

(d) Removal of uremic solutes may be estimated using Kt/Vurea and/or creatinine clearance. Both are measures of small solute clearance.

Residual Kidney Function

RKF is an important parameter in predicting clinical outcomes of PD patients and its contribution is stronger than PD clearance. Having a better preserved RKF is associated with better small solutes and middle molecule uremic retention solutes clearance, better extracellular volume control, less inflammation, better control of CKD-bone mineral disease, better nutrition status and less resting hypercatabolism, thus contributing to overall better survival and cardiovascular outcomes and better quality of life (Fig. 19.4). PD patients with faster decline in RKF or urine volume were associated with worse patient survival and technique survival. It is therefore imperative to measure urine volume or RKF regularly in PD patients (Table 19.9).

Preserving Residual Kidney Function in PD Patients

It is generally recognized that avoid overdehydration and hypotensive episodes as well as avoid nephrotoxins and iodinated contrast use may be important. Diuretics increases urine volume and sodium excretion and minimizes use of hypertonic PD glucose solutions but did not preserve RKF.

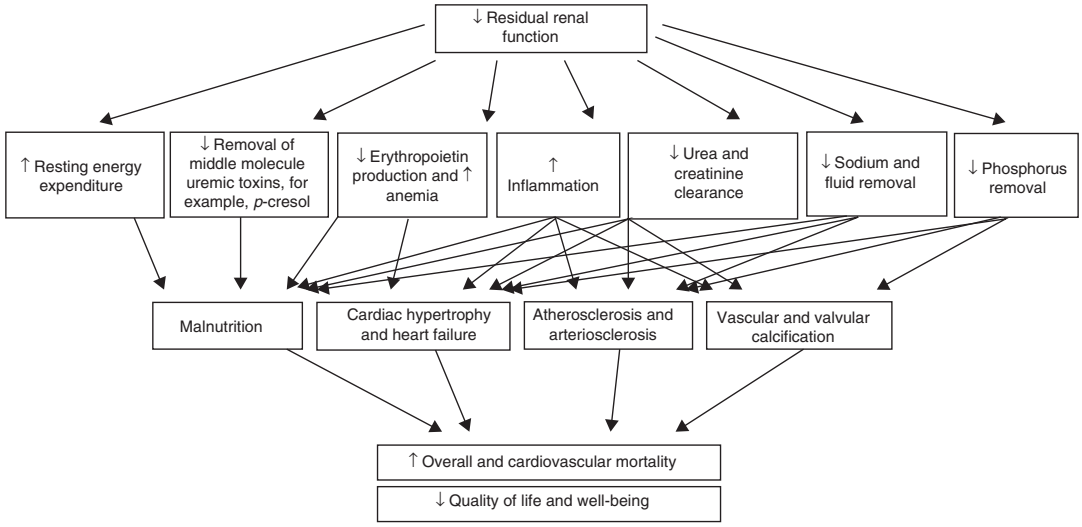


Fig. 19.4 Importance of RKF

Table 19.9 Recommendations on RKF

• RKF should be monitored at least once every 6 months in PD patients with urine output
• Management should focus on preserving RKF as long as possible in PD patients.

Neutral pH, low GDP biocompatible PD solution was associated with better preserved RKF and greater urine volumes for use greater than 12 months. The ISPD Adult Cardiovascular and Metabolic Guidelines recommended that neutral pH, low GDP solutions should be considered for better preservation of RKF if used for 12 months or more (2B). On the other hand, glucose polymer or icodextrin solution has no significant effect on RKF in PD patients (Fig. 19.5).

Two very small trials suggested better preservation of RKF with angiotensin converting enzyme inhibitors or angiotensin receptor blockers. A small trial suggested benefit of ketoacid supplemented low protein diet in preserving RKF in PD patients. Two small single-arm pilot studies suggested that oral N-acetylcysteine 1200 mg twice daily for 2–4 weeks may be useful in increasing urine volume and residual GFR. These preliminary findings need further confirmation in adequately powered RCTs. There is no conclusive evidence to suggest the modality of PD, namely APD versus continuous form of PD may influence the rate of decline in RKF differentially.

Assessment of RKF

Residual glomerular filtration rate (GFR) is estimated by averaging 24-hour urine urea and creatinine clearance and is normalized to body surface area. Unmodified urine creatinine clearance substantially overestimates the true GFR due to tubular secretion of creatinine while renal urea clearance underestimates GFR. At a minimum, urine volume should be measured and tracked regularly.

Assessment of Indices of Dialysis Adequacy

'Dialysis adequacy' is used to denote small solute clearance, namely urea clearance normalized to total body water (Kt/V) and creatinine clearance, normalized to body surface area (CrCl) (150) in PD patients. Both are comprised of two components, namely clearance from RKF and clearance from PD. Kt/V and CrCl are estimated from the urea and creatinine output from the

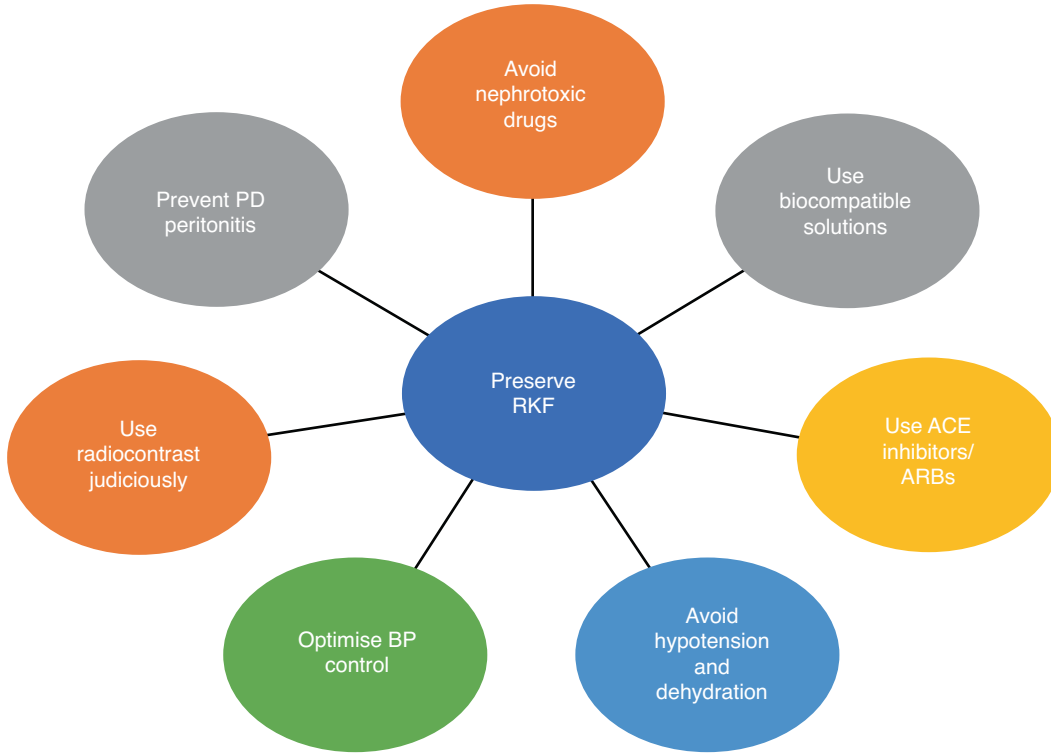


Fig. 19.5 Potential therapeutic strategies that may preserve RKF

drained effluent and urine collected during a simultaneous 24 h period together with a blood sample collected for serum urea and creatinine. Both Kt/V and CrCl values are conventionally expressed as weekly. In APD, the effluent volumes involved may be larger. APD patients are usually trained to record or measure total effluent volumes at home using the machine reading and bring back a representative aliquot of the dialysate to clinic for measurement of urea and creatinine concentrations.

In CAPD, serum urea and creatinine may not fluctuate much during the day and the timing of blood sampling for urea and creatinine may not be as critical. In APD, however, serum urea and creatinine may vary 10% or more from a trough value after stopping PD in the morning to peak levels before patient resumes PD in the evening. Thus, in patients receiving APD with no day dwell, serum samples should be collected approximately half way between the hours with no day dwell.

Estimation of Normalized Protein Nitrogen Appearance (nPNA)

nPNA, a surrogate of dietary protein intake can be estimated using the Randerson formula. However, the equation assumes that the patient is metabolically stable and urea generation, excretion and other nitrogen losses are proportional and in equilibrium to the amount of protein intake. These formulas are derived using the same variables as Kt/V (Table 19.10).

Kidney Disease Outcome Quality Initiative (KDOQI) 2020 recommended a dietary protein intake of 1.0–1.2 g /kg body weight for metabolically stable PD patients to maintain a stable nutritional status. A daily energy intake of 25–35 kcal/kg ideal body weight per day (including energy derived from peritoneal glucose absorption) based on age, gender, level of physical activity, body composition, weight status goals, CKD stage, and concurrent illness or presence of inflammation to maintain normal nutritional sta-

Table 19.10 Summary of various equations

nPNA by Randerson	10.76[a](UNA/1.44 + 1.46) and UNA is in g/day
Residual GFR	Average of (24 h urine urea clearance + creatinine clearance in mL/min)
Total Kt/V	Summation of PD Kt/V and renal Kt/V
PD KT/V	[(24 h PD volume in L)[a](24 h PD fluid urea concentration in mmol/L)/Plasma urea concentration in mmol/L] and normalized by V
Renal Kt/V	[(24 h urine volume in L)[a](24 h urine urea concentration in mmol/L)/Plasma urea concentration in mmol/L] and normalized by V
Total CrCl	Summation of PD CrCl and renal CrCl
PD CrCl	[(24 h PD volume in L)[a](24 h PD fluid creatinine concentration in umol/L)/Plasma creatinine concentration in umol/L] and normalized by BSA
Renal CrCl	[(24 h urine volume in L)[a](average of 24 h urine urea and creatinine concentration in umol/L)/Plasma creatinine concentration in umol/L] and normalized by BSA
V	2.447 + (0.3362 × BW in kg) + (0.1074 × BH in cm) − (0.09516 × age in years) for male −2.097 + (0.2466 × BW in kg) + (0.1069 × BH in cm) for female
BSA	0.007184 × BW in kg $^{0.425}$ × BH in cm $^{0.725}$

UNA Urea nitrogen appearance, *V* Total body water estimated by Watson method, *BSA* Body surface area, *BW* Body weight, *BH* Body height

[a]These equations assumed a steady state, where urea nitrogen output equals to urea generation. The Randerson equation assumed the average daily dialysate protein loss is 7.3 g per day. In PD patients with substantial protein losses in dialysate or urine, these losses must be added to the equation in calculating nPNA

tus is recommended for metabolically stable PD patients.

Peritoneal Equilibration Test (PET)

It is a simple bedside test that assesses the diffusive transport capacity of urea, creatinine and other solutes and ultrafiltration across the semipermeable membrane. It involves doing a 4 h dwell with a 2 L bag of 2.5% PD solution during which the ratio of dialysate to plasma creatinine concentration at 4 hour and the ratio of dialysate glucose concentration at 4 h to 0 h are estimated together with ultrafiltration volume at 4 h. The peritoneal transport characteristics are defined accordingly (Fig. 19.6).

Generally, urea clearance is much less affected by peritoneal transport characteristics than CrCl in CAPD as over 90% of Kt/V and equilibration occurs with the long dwell hours of CAPD, regardless of peritoneal transport characteristics. Peritoneal membrane transport characteristics is an important consideration in PD modality (APD versus CAPD) and regimen prescription as creatinine clearance may show two to three times difference between low and high transporters even after a 4–6 h dwell. In APD, dwell time is usually shorter than CAPD except for the long day dwell. In anuric PD patients, there could be problems in achieving optimal clearance targets, depending on the peritoneal membrane transport characteristics.

Is There a Target for Small Solute Clearance?

Two large prospective RCTs did not observe any significant benefit on overall survival of PD patients by increasing peritoneal small solute clearance. In the Adequacy of PD in MEXico (ADEMEX) study, increasing weekly Kt/V from 1.62 to 2.13 (or weekly CrCl from 46.1 to 56.9 L/wk. per 1.73 m^2) had no significant effect on mortality risk in PD patients. In the randomized trial from Hong Kong of which PD patients were randomized to Kt/V targets of 1.7–2.0 and >2.0. no significant difference was observed in the overall survival between the group reaching Kt/V target of 1.7–2.0 and the group reaching Kt/V >2.0. There is no data to support benefit of further increasing total weekly Kt/V beyond 2.0 or total CrCl of over 60 L/week per 1.73 m^2.

The 2 trials raised important questions about previous focus on achieving small solute clearance targets in PD care delivery. In the 2020 ISPD guideline, high quality goal-directed PD should aim to achieve and maintain clinical euvolemia and blood pressure while taking RKF and its preservation into consideration, as well maintain good

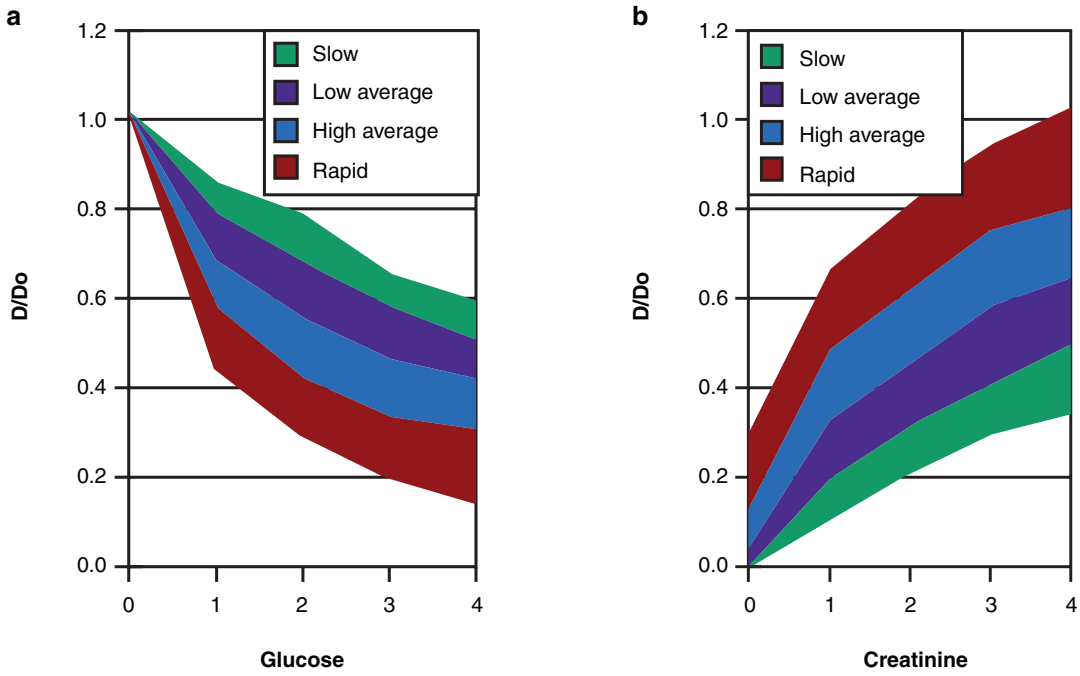


Fig. 19.6 Peritoneal equilibration test

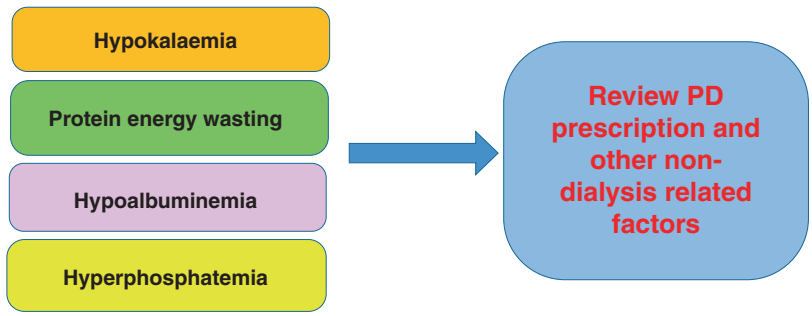


Fig. 19.7 Factors to be reviewed in patients who remain symptomatic despite achieving a Kt/V >1.7

nutrition status, perceived well-being and quality of life of PD patients so for their life participation and not for the role purpose of reaching an arbitrary numerical clearance target.

Patients who remain symptomatic despite a Kt/V >1.7 should have other dialysis and non-dialysis related factors reviewed as possible contributing factors. In emerging countries, every effort should be made to conform to the same principles in PD prescription, taking into account resources limitation (Fig. 19.7).

There was weak evidence to suggest that anuric PD patients should have a weekly Kt/V of at least 1.7. In the NECOSAD (Netherlands Cooperative Study on the Adequacy of Dialysis) observational Study, peritoneal Kt/V <1.5 and CrCl <40 L/week per 1.73 m^2 were associated with higher mortality (175).

In elderly patients who are frail or have a poor prognosis, there may be a quality of life benefit from a modified dialysis prescription to minimize treatment burden (Table 19.11).

Table 19.11 Evaluations in PD patients with a low Kt/V or CrCl result

1. Are there incomplete or missed collection of 24 h urine and dialysate?
2. Any non-adherence to the dialysis prescription or missed cycles?
3. Any clinical and other biochemical evidence of inadequate dialysis?
4. Are the dialysis prescription, namely the number of cycles and the concentration of PD solutions optimal for the patient?
5. Are actual dwell times differ from that prescribed?
6. Any recent loss in residual urine volume and RKF?
7. Any incomplete drain
8. Any hypercatabolic conditions?

Evaluation of Patients with Low Delivered Urea/Creatinine Clearance Values

General Principles in Adjusting PD Prescription

If dialysis dose is confirmed inadequate, dialysis dose may be increased by increasing the instilling volume as tolerated, thereby maximizing mass transfer and dwell time or by increasing the number of daily PD exchanges while maximizing the dwell time. For example, for PD patients who are prescribed three daily exchanges of 2 L × 1.5% and have a low Kt/V because of loss of RKF, one may increase the dialysis dose by either increasing to four exchanges daily of 2 L × 1.5% or by increasing the volume per exchange to 2.3–2.5 L × 1.5% as required and as tolerated. If there is a need to increase ultrafiltration volume as well, then one may consider replacing 1.5% with 2.5% solution.

Ultrafiltration and Volume Control as a Treatment Target

Generally, a net ultrafiltration >200 mL from a standard 4-hour dwell of 2.27%/2.5% glucose/dextrose or > 400 ml from a standard 4-h dwell of 3.86%/4.25% glucose/dextrose solution is regarded as sufficient ultrafiltration. Values below this indicate relative ultrafiltration failure (UFF). Symptoms of UFF may not manifest overtly until RKF has declined significantly or completely lost.

Ultrafiltration is an important parameter for assessing adequacy of dialysis, and ultrafiltration has been shown to be associated with survival in anuric APD patients; low ultrafiltration volume below 750 ml per day was associated with a higher mortality (176). However, a numerical target for daily ultrafiltration volume was not recommended as the overall volume status depends also on the residual urine volume as well as salt and fluid intake of patients and there may be substantial intra-individual variation.

The ISPD guideline 2020 as well as the ISPD Cardiovascular and Metabolic guidelines 2015 emphasized the importance of maintaining euvolemia as one of the key treatment goals in PD. Attention should be paid to both urine volumes and PD ultrafiltration volumes.

Sodium and fluid removal are important predictors for survival in PD patients. Fluid overload is a highly prevalent complication in PD patients. The estimated prevalence of fluid overload using bioimpedance spectroscopy, was at least over 50% in PD patients and was even higher in anuric patients. Patients with fluid overload is associated with increased risk of mortality.

Many factors contribute to fluid overload in PD patients, one of which is low drain volume or ultrafiltration (Table 19.12). It is essential to take a thorough history and physical examination (Fig. 19.8 and Table 19.13).

High Transporters

Patients who are high transporters equilibrate very quickly and have excellent diffusive transport capacity. However, a major clinical problem encountered by high transporters is suboptimal ultrafiltration, low drain volume and inadequate solute clearance as the osmotic gradient for glucose dissipates relatively quickly. High transporters would be more suited to do

short dwell times as in APD or NIPD using standard glucose solution and then a long day dwell using icodextrin.

Some patients may start as high transporters but some may gradually become high transporters over time on PD. A high peritoneal transport status is associated with an increased mortality. Proposed mechanisms for increased mortality observed in high transporters include fluid overload, chronic inflammation, increased peritoneal protein loss and increased risk of PEW.

Table 19.12 Factors contributing to fluid overload in PD patients

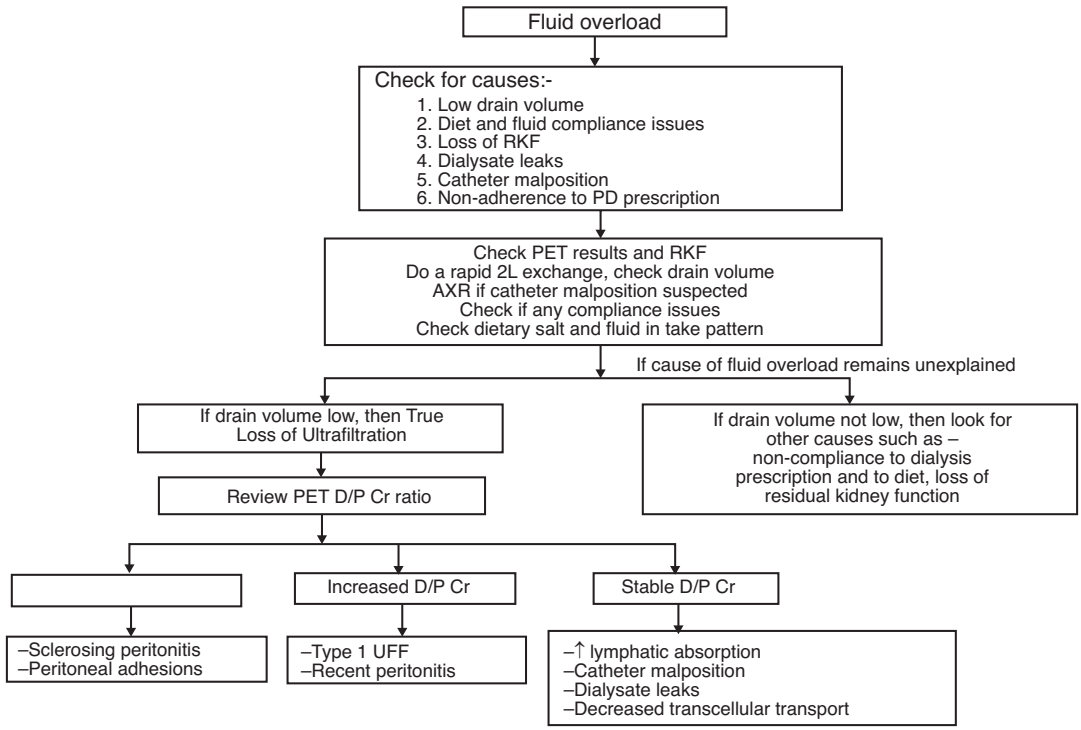
Patient related factors
• Adherence to dietary salt and fluid intake
• Compliance to PD regimen
• Loss of residual kidney function
• Blood glucose control
• Health literacy
• Heart disease and heart failure
• Inflammation
• Protein-energy wasting syndrome
Dialysis related factors
• Mechanical factors eg. catheter function, leaks, hernias, fibrin
• Low ultrafiltration due to
– high peritoneal solute transport
– peritoneal membrane failure
– constipation
– encapsulating peritoneal sclerosis

Low Transporters

Low transporters ultrafiltrate well but equilibrate slowly. Low transporters may do best with longer day dwells such as CAPD with a single overnight exchange or CCPD with fewer overnight exchanges.

Acute Peritoneal Membrane Dysfunction

Patients with acute peritonitis may develop acute reduction in drain volume and increased peritoneal solute transport. as a result of an increased effective surface are and an increased vascular



D/P Dialysate to plasma, *UFF* ultrafiltration failure, *PET* peritoneal equilibration test, *RKF* residual kidney function

Fig. 19.8 Approach to patients with fluid overload

Table 19.13 Clinical evaluation in patient with low drain volume

If drain volume is low, review:
(i) any mechanical issues that may explain low drain volume
(ii) any constipation
(iii) is outflow position related
(iv) catheter position
(v) Any fibrin clots that may obstruct outflow
(vi) Any omental wrap
(vii) Peritoneal membrane transport characteristics
(viii) Any features to suggest peritoneal adhesions or encapsulating peritoneal sclerosis

permeability. Short term adjustment of PD prescription may be needed to improve ultrafiltration.

Ultrafiltration Failure (UFF)

Conventionally, UFF is defined as having a net ultrafiltration volume below 400mls with a standard 2 L 3.86% glucose solution during a 4 h exchange.

There are 3 types of UFF. Type I UFF is the commonest and is partly attributed to long-standing glucose exposure of the peritoneal membrane. Peritoneal membrane showed submesothelial fibrosis, vasculopathic changes and neovascularization. The neovascularization increases the effective peritoneal surface area, leading to more rapid PSTR. The process is thought to be mediated by vascular endothelial growth factor (VEGF) through induction of nitric oxide. Clinically, the osmotic gradient for glucose dissipates rapidly before adequate ultrafiltration has occurred due to very high PSTR. It usually has a more gradual onset and increases with time on PD. In some cases, temporary cessation of PD or resting the peritoneal membrane may allow re-mesothelialization and may transiently improve ultrafiltration capacity (216). However, in some cases, encapsulating peritoneal sclerosis (EPS) may develop after switching to hemodialysis.

The cumulative incidence of UFF was estimated to be 2.6% after 1 year on PD, rising to 9.5% after 2 years and to 30.9% after 6 years. Peritonitis may partly influence the time course of small solute and solute-free water transport. Patients with previous peritonitis showed an earlier and more pronounced increase in the mass transfer area coefficient for creatinine and glucose and a decrease in solute-free water transport and ultrafiltration rate compared to patients with no peritonitis. In long-term peritonitis-free PD patients, small solute transport decreased, while ultrafiltration increased.

Type II UFF occurs as a result of loss of peritoneal surface area, resulting in decrease in peritoneal transport of small solutes and water. This is less common and usually occurs in the context of peritoneal adhesions secondary to severe peritonitis or after surgical complications that substantially reduces peritoneal surface area and transport capacity for both solutes and water. Type II UFF may be a manifestation of encapsulating EPS although in early stages of EPS, a high rather than a low peritoneal transport is usually seen. EPS can be diagnosed by contrast CT abdomen.

Type III UFF occurs when lymphatic reabsorption of fluid from the peritoneal cavity is large enough to reduce ultrafiltration. It is a diagnosis by exclusion since peritoneal lymphatic flow is not measured in most PD centers (Table 19.14).

To evaluate UFF, a modified PET using 3.86% glucose solution is preferred over 2.5% dextrose solution to maximize osmotic drive (227). During the PET, the D/P sodium curve typically shows an initial fall due to high ultrafiltration rate. Ultrafiltration is low in sodium concentration initially due to sodium sieving. Dialysate sodium concentration reduces, resulting in a fall in the D/P sodium ratio. With the cessation of ultrafiltration later in the dwell, dialysate sodium gradually equilibrates with that of plasma, and D/P sodium ratio gradually returns back to baseline. Absence of the initial fall in D/P sodium ratio is a

Table 19.14 Summary of Characteristics in the 3 types of UFF

Types	Characteristics
I	Patients classically on PD for years, presented with a low drain volume, PET showed a high D/P creatinine ratio. Attributed to long exposure of peritoneal membrane to glucose solutions, leading to submesothelial fibrosis, vasculopathic changes and neovascularization of the peritoneum and an increase in the effective peritoneal surface area.
II	Patients classically presented with a low drain volume and PET showed a low D/P creatinine ratio. Decrease in peritoneal transport of small solutes and water due to loss of peritoneal surface area. Characterized by a decrease in the osmotic conductance to glucose and an attenuation of sodium sieving. Usually occurs in the context of peritoneal adhesions secondary to severe peritonitis, encapsulating peritonitis or after surgical complications.
III	Occurs when there is high lymphatic reabsorption of fluid from the peritoneal cavity that reduces ultrafiltration.

feature of UFF and typically seen in the early phase of EPS.

Current treatment for UFF is lacking. For Type 1 UFF, a period of peritoneal rest may transiently improve ultrafiltration capacity. For type II and III, permanent switch to hemodialysis is required.

Practice Points

- Pre-dialysis education involving a multidisciplinary team help patients to better understand kidney failure, accept dialysis, make their preferred choice of dialysis modality and maintain a feeling of control with their health condition. Pre-dialysis education has also been shown to facilitate patients choosing home peritoneal dialysis as the modality.
- In assessing patients suitability for PD therapy, it is important to assess patients' medical history, comorbidities, bowel habits, personal hygiene and prior abdominal surgeries as well as general condition, ability to perform PD, family support and home environment.
- PD is contraindicated if the peritoneal cavity is obliterated or membrane not functional due to peritoneal adhesions.
- Choice of PD modality should be personalized involving a shared decision-making approach between physicians and patients after patients are educated on the different modalities.
- PD is possible in both planned and unplanned and urgent or nonurgent start. In urgent start PD, patients have limited time to receive education for an informed decision making, these patients need to be provided the required education and support to enable transition to their preferred modality where feasible.
- For patients who chose PD modality, Initiation of therapy should be considered in the presence of symptoms or signs attributable to kidney failure, inability to control volume status or blood pressure and progressive deterioration in nutrition status due to uremic symptoms.
- In prescribing PD solutions, icodextrin is recommended to improve ultrafiltration independent of the dialysate to plasma creatinine ratio by the 2020 International Society of Peritoneal Dialysis (ISPD) Guideline.
- Neutral pH, low glucose degradation products solutions is recommended for better preservation of residual kidney function if used for 12 months or more according to the ISPD 2020 and 2015 guidelines.

- PD prescription should be 'goal-directed' and should involve shared decision-making in establishing a personalized realistic care goal that maintains quality of life for the person doing PD as much as possible, enables them to meet their life goals, minimize symptoms and treatment burden while ensuring the delivery of high quality care.
- In order to ensure high quality PD care, the following assessments should be included: (1) Patient reported outcome measures, (2) volume status, (3) nutrition status, (4) uremic solutes removal.
- Preserving residual kidney function (RKF) is an important treatment strategy in PD patients as having better preserved RKF is predictive of better clinical outcomes. RKF should be monitored at least once every 6 months in PD patients with urine output. Management should focus on preserving it as long as possible.
- Patients who remain symptomatic despite a Kt/V > 1.7 should have other dialysis and non-dialysis related factors reviewed as possible contributing factors. This include hypokalemia, protein energy wasting, hypoalbuminemia and hyperphosphatemia.
- Maintaining euvolemia is one of the key treatment goals in PD patients and attention should be paid to both urine volumes, PD ultrafiltration volumes as well as salt and fluid intake pattern of patients.
- Patients with low drain volume should evaluate any mechanical issues, constipation, whether drain is position-related, catheter position, any fibrin clots that may obstruct outflow, any omental wrap, peritoneal membrane function and any features to suggest peritoneal adhesions or encapsulating peritoneal sclerosis.

Conclusions

For the 68 year old lady discussed in the clinical case, peritoneal dialysis offers the advantages of being able to undergo kidney replacement therapy at home, while enjoying her family life, maintaining her residual kidney function, fewer dietary restrictions, a more gradual correction of her metabolic acidosis, whilst avoiding the complications, inconvenience and costs associated with in-centre haemodialysis. She will nevertheless require close monitoring of her peritoneal dialysis adequacy and ultrafiltration, and preparation for transplantation.

Questions

1. A 36-year-old man with end stage kidney failure due focal segmental glomerulosclerosis, on peritoneal dialysis for six years presented with shortness of breath and leg swelling. He used 15 L of glucose based peritoneal dialysis fluid with an osmolality of 395 mosmol/L for nighttime daily dialysis for the last few months. His ultrafiltration was 300 mL per day. He produced very little urine. On examination his blood pressure was 160/80 mmHg pulse 90 beats per min respiratory rate 20 breaths per minute, with leg oedema. His respiratory system exam revealed bibasilar crackles.

   What is most likely cause of his fluid retention?

   A. Increased plasma hydrostatic pressure
   B. Decreased plasma hydrostatic pressure
   C. Heart failure with preserved ejection fraction
   D. Low plasma osmotic pressure
   E. Lack of osmosis across the peritoneal membrane

Answer E Increased glucose concentration is associated with damage and fibrosis of the peritoneal membrane

2. A 55-year-old end stage kidney failure patient on peritoneal dialysis presented with recurrent abdominal pain fever and cloudy peritoneal effluent. She was treated for staphylococcal peritonitis a month before. On exam she had blood pressure of 130/84 mmHg, pulse 84 beats per minute, temperature 36 degrees Celsius. Her abdomen was soft and non-tender. Her peritoneal fluid showed 600 white cells per ml and culture grew Candida albicans.

   What is the next best step management?

   A. Start intraperitoneal vancomycin and intravenous gentamicin
   B. Start oral fluconazole
   C. Start intravenous amphotericin
   D. Start oral fluconazole and remove peritoneal dialysis catheter
   E. Start intravenous cefuroxime

Answer D Fungal infection is an indication for catheter removal, difficult to eradicate

3. A 56-year-old woman with known liver cirrhosis and ascites due to autoimmune hepatitis and ESKD due to IgA nephropathy was referred to advanced CKD clinic. Her eGFR was 15 ml/min. Physical examination showed ascites. She opted to have peritoneal dialysis for her ESKD.

   What is true about peritoneal dialysis in patients with liver cirrhosis?

   A. Associated with increased risk of peritonitis
   B. Associated with increased risk of peritoneal leak
   C. Increased risk of encapsulating peritonitis
   D. Does not help the drainage of ascites
   E. Peritoneal dialysis as a therapy for ESKD is contraindicated

Answer A PD in Cirrhosis patients can be done, helps drain the ascites but increases risk of infection

4. A 55 year-old man with IgA nephropathy presented in the advanced CKD clinic with an eGFR of 10 mL/min/1.73 m2, haemoglobin 102 g/L and leg oedema. He was slim and without any history of diabetes, hypertension or heart disease. He was prepared for a peritoneal catheter placement as PD was his modality of choice. What measures help and uncomplicated start of dialysis.

   A. Erythropoietin therapy before catheter placement
   B. Iron therapy before catheter placement
   C. Prophylactic antibiotic at catheter placement
   D. A surgical catheter placement as opposed to medical catheter placement
   E. Prophylactic anticoagulation

Answer C Prophylactic antibiotic is beneficial to prevent infections

5. A 56-year-old female with polycystic presented with tiredness and eGFR of 10 mL/min/1.73 m^2. She opted for peritoneal dialysis.

   What is not an indication to start dialysis?

   A. An eGFR of 10 mL/min/1.73 m^2
   B. Symptoms of nausea, vomiting and anorexia
   C. Fluid overload not responding to diuretic therapy
   D. Recurrent hyperkalaemia
   E. Weight loss and poor nutritional status

Answer A all but an absolute eGFR are indications for starting dialysis

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.

Further Reading

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