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Peritoneal Dialysis in Patients with Acute Renal Failure

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Of the two main renal replacement therapies, peritoneal dialysis (PD) was the modality first used for the treatment of patients with acute renal failure (ARF) because of its inherent advantages. Highly trained personnel, expensive and complex apparatus, and systemic anticoagulation were not needed, and so the procedure could be simply and quickly initiated. Further, because of the gradual removal of fluid and solutes, PD results in better hemodynamic stability. Manually or cycler-assisted ("automated") PD has been successfully used in many ARF patients, especially those at risk of bleeding or with hemodynamic instability, and in infants and children with ARF or circulatory failure.

Recently, technological developments in hemodialysis techniques (bicarbonate dialysis, hemofiltration, hemodiafiltration) and the continuous renal replacement therapies (CRRTs), have limited the indications for PD in critically ill patients with ARF. In addition, better knowledge about the connection between early and adequate dialysis dose and improved outcomes has led to a tendency to increase the dialysis dose given to ARF patients, furthering the development of newer techniques.

Although PD has been considered less effective than hemodialysis and CRRTs are in patients with severe acute illness (pulmonary edema, poisoning, extreme catabolysis) and ARF, PD remains an effective therapy that is easily and simply instituted, especially for infants and children with ARF, both within and outside of intensive care settings.

Key words
Acute renal failure, therapy, acute peritoneal dialysis techniques, continuous renal replacement therapies

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Introduction

Acute renal failure (ARF) occurs predominantly in hospital and is seen in as many as 5% of hospitalized patients in all medical settings, with approximately 0.5% of those patients requiring dialysis (1). The onset of ARF occurs more frequently in the intensive care unit (ICU) as the end result of multi-organ failure, which explains the higher mortality rate and increased dialysis requirement in that setting.

Of the two main renal replacement therapies, peritoneal dialysis (PD) was the modality first used for the treatment of ARF (2). The then newly developed technique was quite simple and could be performed at any hospital. The contents of two 1-L glass solution bottles would be instilled into the peritoneal cavity through a temporary access and then allowed to drain back into the original bottles after a 30-minute dwell time. This procedure would be continued until the patient's blood chemistries were normal and repeated as required. The patient's metabolic status would be used to guide the composition of the dialysis solution (Table I), which would be chosen to correct the presumed electrolyte and acid–base imbalances.

This "intermittent PD" (IPD) was widely used in the 1970s because of its inherent advantages:

- The technique can be initiated simply and quickly, because no highly trained personnel nor expensive and complex apparatus are needed.
- Patients with ARF are commonly debilitated, malnourished, or hemodynamically unstable and thus unable to tolerate more intensive measures.
- Systemic anticoagulation is not needed.

However, in severe acute illness (pulmonary edema, poisoning, drug overdose, hyperkalemia, extreme catabolysis), PD was considered less effective than hemodialysis (HD), and so continuous PD techniques (3,4) were developed, sometimes handled by automated cycling machines ("cyclers").

TABLE I Composition of peritoneal dialysis solutions

Sodium (mmol/L)	132–134
Potassium (mmol/L)	0–2
Calcium (mmol/L)	1.25–1.75
Magnesium (mmol/L)	0.25–0.75
Chloride (mmol/L)	95–106
Lactate (mmol/L)	35–40
Glucose (g/dL)	1.5–4.25
pH	5.5

Although acute PD was traditionally delivered using manual exchanges, cyclers now deliver predetermined volumes of solution into the peritoneal cavity and then drain it after a programmed dwell time. Dialysis solutions of varying glucose concentration can be simultaneously attached (usually by the spike-and-port method) to a multipronged cycler manifold (up to 5 – 8 containers of 3 – 5 L each), and the cycler can calculate the ultrafiltration volume. The use of cyclers has greatly reduced the incidence of peritonitis, saved much nursing time, and improved the recordkeeping related to fluid balance.

However, in recent years, the indications for acute PD in critically ill patients have been limited, mainly because of newer HD techniques and the development of continuous renal replacement therapies (CRRTs). The extracorporeal circuit in HD now incorporates several technological advances that have successfully competed with the traditional advantages of PD.

The present paper reviews the currently available treatments for patients with ARF, emphasizing the particular indications for, and current experience with, various PD techniques. It also describes the prescription of acute PD for these patients.

Discussion

Techniques of acute PD

Starting in the 1970s, PD was widely used in patients with ARF (5), especially in those with hemodynamic instability or a bleeding risk from severe coagulation abnormalities (6); in infants and children with circulatory failure; and in patients with serious heart failure and a low cardiac index who could not tolerate HD (7,8). This widespread use largely resulted from the nephrologist's or surgeon's ability to institute PD quickly, easily, and safely by insertion of a semi-rigid catheter or a single-cuff Tenckhoff catheter at the bedside using a fluoroscopy table and guidewire direction or a peritoneoscopic technique. Performance of acute PD required only an intact peritoneal cavity (9).

Treatment schedule

Figure 1 shows the three main dialysis schedules typically used:

- Classical IPD uses a cycling device programmed to deliver a predetermined volume of dialysate and to drain the peritoneal cavity at fixed intervals. Short exchanges using volumes of 1 – 2 L and hourly dialysate flows of 2 – 6 L, in sessions of 16 – 20 hours twice or three times weekly, deliver doses of about 40–60 L per session (80 – 180 L/week). This type of PD has been widely used in ARF (10,11).
- Continuous equilibration PD (CEPD), which is similar to, but often more intensive than continuous ambulatory PD (CAPD), provides PD in an inpatient setting (12). The CEPD technique differs from IPD in that it uses relatively long dwell times, with multiple daily exchanges, in which dialysate is instilled and drained continuously every 2 – 6 hours by a cycler or manually, in a low-flow continuous system that maintains stable blood levels of nitrogenous products. Fluid is removed by using solutions of varying dextrose concentration. However, because of the lower dialysate flow rate as compared with IPD, CEPD achieves lower small-solute clearances.
- Tidal PD is designed to optimize solute clearances (13) by leaving a constant "tidal volume" of 0.5 – 1.0 L of dialysate in the peritoneal cavity throughout the dialysis session. This volume represents one half of the initial filling by the cycler of a large (2-L) volume of solution; that volume is rapidly exchanged (4 – 6 minutes dwell time, 20 minutes total exchange time) during a dialysis session that lasts 8 – 10 hours. During that period 26 – 30 L of dialysate are exchanged. The peritoneal cavity is drained completely only at the end of the session.

Indications for acute PD

Peritoneal dialysis proved to be a valuable renal replacement therapy in patients with ARF as well as in non-renal emergency situations (Table II) whose indications are based mainly on the advantages of the PD modality. In fact, PD can easily and adequately meet the treatment goals for ARF patients, maintaining

fluid, electrolyte, and acid–base balances and solute homeostasis. Moreover, PD permits other supportive measures to proceed without limitation until renal function resumes. However, as compared with HD, PD is less effective in severe acute illnesses such as pulmonary edema, poisoning or drug overdose, and extreme catabolysis.

In early studies, patients treated with PD had a lower mortality rate and a higher incidence of renal recovery than did similar patients treated with HD (3,14). However, the small-molecule clearances achieved with PD are commonly lower than those achieved with daily 4-hour HD treatments, because the small-molecule concentrations in peritoneal dialysate reach approximately 30% – 50% of the equivalent serum values after 1 hour of PD and 50% – 80% after a 4-hour dwell (15). Conversely, the clearance of higher molecular weight substances is greater with continuous PD than with HD (16).

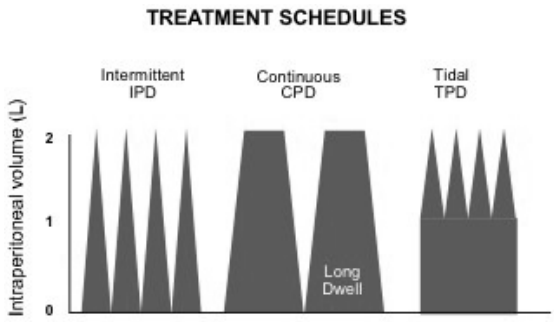

FIGURE 1 Basic mechanisms operating in peritoneal dialysis are shown schematically.

The ultrafiltration rate is maximal at the beginning of a PD exchange when the glucose concentration is at its maximum. As the glucose is absorbed and its concentration is further diluted by the movement of ultrafiltrate into the peritoneal space, an exponential decrease in the ultrafiltration rate follows. Consequently, the intraperitoneal volume peaks at about 120 – 180 minutes of dwell; in the supine position, the transcapillary ultrafiltration induced by a 3.86% glucose solution reaches up to 15 mL/min.

Acute PD in critically ill and hypercatabolic ARF patients

Critically ill patients with ARF who will require dialysis are usually in an unstable hemodynamic state; they also tend to be hypercatabolic. Usually, they require meticulous attention to fluid requirements, acid–base and electrolyte balances, and special needs for hyperalimentation or ultrafiltration in addition to the removal of uremic toxins and maintenance of hemodynamic stability.

For many years in such patients, intermittent HD (IHD) was the standard therapy in ICU and non-ICU settings alike, mainly because of high efficiency (17,18). Often, IHD was prescribed empirically for 3 or 4 hours, 3 or more times weekly, although such management could often provoke hemodynamic instability because of the large shifts in solutes and fluid over a short period.

TABLE II Renal and non-renal indications for acute peritoneal dialysis

Renal indications [acute renal failure (ARF)]	*Non-renal indications (ARF may not be present)*
Oliguria in hemodynamically unstable patients	Refractory congestive cardiac failure
Presence of a bleeding diathesis or hemorrhagic conditions	Life-threatening fluid overload
Difficulty in obtaining blood access	Correction of electrolyte (hyperkalemia) and acid–base disorders (severe acidosis)
Clinical uremic syndrome—uremic pericarditis or encephalopathy	Poisoning [removal of high molecular weight toxins(>10 kD)]
	Acute pancreatitis
	Clinically significant hypothermia and hyperthermia
	Hepatic failure
	Infusion of drugs and nutrients—supportive to allow total parenteral and fluid nutrition

Traditionally, it was held that acute IPD might be inadequate to control azotemia in some hypercatabolic patients (12). Similarly, low efficiency is seen as the major disadvantage of CEPD, because its daily solute clearances are lower than those of daily HD. The CEPD technique cannot control uremia in an acutely ill patient with ARF (19), even though it represents a more natural dialysis system because of the gradual removal of solutes and water through the peritoneum, providing hemodynamic stability. But CEPD has been demonstrated to control azotemia attributable to rhabdomyolytic renal failure (20) and azotemia and hyperkalemia in patients who exhibit pre-dialysis increases in blood urea nitrogen of more than 25 mg/dL daily (21). Indeed, most of the studies that evaluated PD efficiency in hypercatabolic ARF reported satisfactory control of fluid and metabolic derangements (3,6,21–25). However, those studies had major limitations because of a lack of accurate measurement of dialysis adequacy and catabolic status.

Recently, the adequacy of PD in ARF was evaluated in a prospective, randomized crossover trial of 87 hypercatabolic ARF patients (26). That study showed that tidal PD and CEPD were both reasonable options for mild-to-moderate hypercatabolic ARF, even though CEPD fell just short of the adequacy standard. Tidal PD provided better clearances at the same dialysate volume for a lower inpatient cost in ARF; the only limitation to its use in this circumstance was greater protein loss.

In the same year, Phu *et al.* (27) compared acute PD with hemofiltration in 76 adult patients with infection-associated ARF (falciparum malaria or sepsis) who were randomly allocated to one of the two modalities. These authors concluded that hemofiltration was more effective in bringing about a resolution of acidosis and lowering plasma creatinine levels—effects that were accompanied by a marked increase in survival. However, the authors did not employ optimal PD techniques; rigid peritoneal catheters and manual exchanges of a locally prepared solution with an acetate base and a high glucose level were used (28).

Over time, the indications for PD in critically ill patients became limited for several reasons:

- Extracorporeal methods have undergone technological advances, such as easier percutaneous vessel cannulation, low-dose heparinization in improved circuits that reduce the bleeding risk, and better biomaterials.
- Newer developments in hemodialysis techniques (bicarbonate dialysis with ultrafiltration control, hemofiltration, hemodiafiltration) and CRRTs are achieving better cardiovascular stability.
- Knowledge about the connection between early and adequate dialysis dose and improved outcome is increasing.

But despite all the improvements, the mortality rate in ARF patients remained high, leading to a tendency to increase the dialysis dose given to ARF patients and to develop yet newer techniques.

Since the mid-1990s, the CRRTs—continuous arteriovenous hemofiltration, continuous arteriovenous HD, and hemodiafiltration, and their venovenous analogs—have become the treatments of choice for critically ill patients who require dialysis, even though comparative studies (17,29,30) have not demonstrated any reduction in mortality with CRRT as compared with IHD. Moreover, a trend emerged toward the increased use of the most complicated and most expensive newer dialysis techniques despite the disadvantages of those procedures (complexity, prolonged immobilization, and anticoagulation that increase the risk of bleeding and nosocomial infection). Most recently, the sustained low-efficiency dialysis and extended daily dialysis techniques have become popular. These slower forms of dialysis use conventional dialysis machines with modifications to the blood and dialysate flows, avoiding the need for expensive CRRT machines, costly filters, replacement fluid, and specially trained staff.

A survey of Canadian adult nephrology centers (31) compared the then current (1999 – 2000) approaches to dialysis for ARF in the ICU with the methods used 5 years earlier (1994 – 1995). The survey authors (32) found that the largest increase was in CRRT (26% vs. 9%), with venovenous access predominating (80%). The use of IHD and PD had decreased to 71% from 83% and to 3% from 8% respectively. Interestingly, most of the centers (81%) used manual PD exchanges to treat ARF in the ICU, and the reasons most commonly given for choosing PD over other options were that IHD was hemodynamically unacceptable and that PD did not require anticoagulation.

More recently, the value of acute IPD as an early intervention for decreasing the mortality and morbidity attributable to renal failure was analyzed (33) in 245 patients who had undergone PD in Thanjavur Medical College Hospital because of ARF arising from various causes: snakebite ($n = 108$), acute diarrheal disease ($n = 45$), obstetric renal failure ($n = 15$), and miscellaneous causes ($n = 31$). The authors concluded that PD is a valuable procedure in renal failure patients and that its simplicity permitted interns and postgraduate students to be trained to manage ARF earlier, at a primary care center, thus avoiding the delay caused by referring critically ill patients to nephrologists. The technique saves most of the patients and helps to reduce the mortality attributable to ARF.

Lately, a continuous form of high-dose PD was evaluated in 30 ARF patients, 76% of whom were in the ICU (34). By using a flexible (Tenckhoff) catheter, a cycler, and higher dialysate volumes (36 – 44 L per session) than those commonly used, high-volume PD (HVPD) provided high solute removal, appropriate metabolic and pH control, adequate dialysis dose (Kt/V of 0.65 per session), and fluid removal. The authors concluded that HVPD can be considered an alternative to other forms of renal replacement therapy in ARF.

Acute PD in the pediatric ICU

In the pediatric ICUs at most centers, acute PD has been the renal replacement therapy of choice for decades (33) in part because of its simplicity and safety and the relative ease with which the procedure can be performed in very small patients. The technique has no serious hemodynamic consequences, blood-priming of a hemodialysis circuit is unnecessary, and no vascular access is needed (which is often the limiting factor in the dialysis of small children and infants). Per unit weight, an infant's peritoneal surface area is about twice that of an adult, leading to more-efficient clearance of urea and creatinine. But the rate of glucose absorption is also increased in infants, and to remove large fluid volumes, either higher dextrose concentrations or shorter dwell times must be used. Thus, continuous PD usually achieves adequate urea clearances in small children, except for those with severe hyperkalemia, hyperphosphatemia, or hyperammonemia, who need a more rapid metabolic correction. In infants weighing less than 2500 g, PD remains the renal replacement therapy of choice, and acute PD has been successful even in premature infants weighing less than 1000 g (34).

Despite the increasing use of new CRRTs in pediatric ICUs to treat children with ARF, PD remains an efficient, useful, and simple method (34–36), especially in small children with difficult vascular access. But in this setting, the acute PD catheter needs careful attention, because catheter-related infections continue to be the most common complication of acute PD in children and infants and the most frequent cause of catheter removal. Harvey *et al.* (37) reported that the acute peritoneal catheter should ideally incorporate these features: easy and prompt bedside insertion, adequate dialysate flow rate, absence of leakage, minimal catheter movement at the exit site, and a low incidence of catheter-related infections.

Traditionally, the catheters that have most commonly been used for acute PD in infants and children are the bedside-placed Cook Teflon non-cuffed rigid acute catheter (Cook Inc., Bloomington, IN) and the surgically placed cuffed silicone Tenckhoff catheter (38), which, when compared with other acute catheters in terms of the incidence of complications and survival rate, has proven to be superior (38,39). Although available evidence supports the superiority of double-cuff catheters and a downward-facing tunnel for preventing peritonitis in children (37), surgical insertion combined with operational exposure may delay early initiation of dialysis or dissuade PD selection in children. Easy and safe bedside placement of a double-cuff peritoneal catheter may therefore lead to favorable outcomes of PD treatment in children and infants with ARF.

Non-renal indications for acute PD

ACUTE PANCREATITIS

Peritoneal lavage has been used in acute pancreatitis on the supposition that bioactive substances presumed to be responsible for the systemic illness that accompanies severe pancreatitis can be removed with the peritoneal effluent (40–42). However a multicenter prospective randomized controlled trial found no difference in mortality or complication rates for patients who received standard supportive therapy with or without hourly 2-L PD exchanges for 3 days (43).

OTHER NON-RENAL INDICATIONS

Peritoneal dialysis may be used as adjunctive treatment in the management of severe hypothermia

because rapid peritoneal exchanges of dialysis solution heated to normal body temperature raise core temperature. Conversely, cold peritoneal solutions have been used to lower core temperature in patients with hyperpyrexia refractory to conventional treatment (44–46). However, whether these maneuvers improve prognosis has not been established.

In patients with fulminant hepatic failure, PD has been used because it avoids the need for anticoagulation, permits the correction of fluid and electrolyte disorders and, in contrast with charcoal hemoperfusion, may reduce the risk of hypoglycemia and hypothermia (40). It has been proposed that PD can remove toxins such as ammonia, methyl mercaptan, bilirubin, and free fatty acids.

In critically ill patients, the peritoneal membrane is also used as a route for uptake of drugs and nutrients such as glucose and amino acids, although in malnourished individuals, such infusions rarely achieve positive nitrogen balance.

Contraindications to acute PD

There are several relative contraindications to acute PD (Table III), such as a recent operation requiring abdominal drainage, peritonitis (fecal or fungal), and known pleuroperitoneal fistula (after cardiothoracic surgery). Abdominal drains increase the incidence of local infection and confound the measurement of fluid in ongoing PD, and the presence of an abdominal hernia or intra-abdominal adhesions might make PD difficult.

The institution of PD may be relatively contraindicated in the presence of abdominal wall cellulitis that may proceed to peritonitis, of severe gastroesophageal reflux disease, of adynamic ileus that may decrease the efficiency of PD, and of a recent (<4 – 6 months) aortic graft that may become infected. Also, in patients with severe respiratory insufficiency, instilling fluid into the peritoneal cavity may increase intra-abdominal pressure and compromise lung function and respiratory exchange.

TABLE III Relative contraindications for acute peritoneal dialysis

Recent abdominal or cardiothoracic surgery
Diaphragmatic peritoneopleural connections
Fecal or fungal peritonitis
Severe respiratory failure
Abdominal wall cellulitis
Severe gastroesophageal reflux disease
Low peritoneal clearances
Life-threatening hyperkalemia
Severe acute pulmonary edema
Extremely high catabolysis

Prescription of acute PD

After insertion of an acute or (preferably) chronic peritoneal catheter, the dialysis prescription must be individualized to the patient's clinical situation. Because the dialysis requirement in an acutely ill patient with unstable hemodynamic signs may change from day to day, a prudent precaution is to write PD orders for only 24 hours at a time. In this setting, a standardized form with complete and clear specifications for the procedure will be of great assistance to the nursing staff responsible for treatment delivery.

The infusion volume—commonly 0.5 L – 2 L—must be adjusted to the size of the patient's peritoneal cavity and to the severity of the uremic syndrome. In children, a fluid volume of 20 – 50 mL/kg is typical, starting with the lower volume; their peritoneal surface area is related more to body surface area than to weight. The exchange time (combined time for inflow, dwell, and drain) most commonly used is 1 hour (inflow 10 minutes, dwell 30 minutes, outflow 20 minutes), which means that, with a 2-L exchange volume, 48 L of fluid will be exchanged daily.

With regard to glucose concentration, 2-L hourly exchanges of a solution with 1.5% glucose usually gives an ultrafiltration rate of 50 – 150 mL/h, which equals 1200 – 3600 mL/24 h; higher glucose concentrations (2.5% – 4.25%) can result in the removal of larger volumes of fluid (200 – 400 mL/h). Occasionally, in patients with pulmonary edema, 2 or 3 consecutive 2-L exchanges (without dwell time) of 4.25% glucose solution may remove approximately 1 L over a 1-hour period. Furthermore, by reducing the dwell time (the time from the end of inflow to the beginning of outflow) to 15 minutes from 30 minutes, the dialysate flow rate can be increased to about 4 L/h (66 mL/min) and thus achieve more efficient dialysis that might be used for short periods in hypercatabolic and hyperkalemic patients.

The length of the session depends on the dose of acute PD that must be delivered. A patient with ARF requires continuous removal of fluids and solutes, especially when oliguric, hypercatabolic, and in need of ongoing nutritional and therapeutic support. In such a case, PD sessions regularly last from 24 hours

to 72 hours with hourly 2-L exchanges, but the PD dose would be considered efficient if it can meet the daily protein and energy requirements of the patient and maintain stable, near-normal fluid and electrolyte homeostasis. In general, depending on the patient's body size and metabolic needs, a dialysis urea clearance of 10 – 30 mL/min (14.4 – 43.2 L daily) may be adequate (6). Dubose *et al.* recommended that adequate dialysis of ARF patients should maintain urea levels at less than 29 mmol/L (47).

The volume of dialysate that will be exchanged daily depends on the exchange volume and treatment time. Thus 48 L of fluid will be consumed daily with peritoneal exchanges of 2 L every hour. To increase solute clearances, it is usually better to increase the exchange volume, maintaining the dwell and diffusion times, rather than to increase the number of exchanges with shorter dwell times, unless the patient has high peritoneal transport characteristics. A fill volume of 2.5 L in an average-sized individual seems to give maximal peritoneal transport; a volume of 3.0 L is suitable in patients with a body surface area greater than 2.0 m^2 (48). Nevertheless an exchange volume of 2.5 L allows almost all patients to reach Kt/V and creatinine clearance targets even if they are anuric.

Because the composition of PD solution is tailored to correct presumed electrolyte and acid–base imbalances, several additives may have to be injected into solution bags. If so, careful sterile technique is required.

Heparin (1000 U/2 L) can be added to the dialysis solution to prevent catheter obstruction by fibrin clots secondary to slight bleeding or irritation of the peritoneum from the newly inserted peritoneal catheter. Potassium chloride (2 – 4 mEq/L) can be added to the dialysis solution when the patient is hypokalemic. Patients with diabetes require additional intraperitoneal doses of regular insulin to cover the glucose absorbed during dialysis: 3 – 4 U/L for 1.5% glucose, 5 – 6 U/L for 2.5%, and 7 – 10 U/L for 4.25%.

Complications of acute PD

In addition to infection and catheter complications, acute PD may be associated with infectious, mechanical, or medical complications of varying severity (49,50).

INFECTIOUS COMPLICATIONS

Peritonitis complicates acute PD in up to 12% of cases, frequently developing within the first 48 hours (51). Because the major source of infection and of subsequent peritonitis is contamination during connection or disconnection of each new exchange, infection is more common with open-drainage systems.

MECHANICAL COMPLICATIONS

Marked pain on inflow of dialysis solution may be a result of the solution's low pH, its low temperature, the "jet flow" from a straight catheter tip, or distension of the tissue around the catheter. This pain may be relieved by alkalinization of the solution with sodium bicarbonate (5 – 25 mEq/L), by warming the solution, and by choosing a lower infusion rate. Localized outflow pain associated with drainage may indicate that the omentum or other tissues have trapped the catheter.

Visceral perforations of bowel, bladder, or aorta are major complications infrequently associated with nonsurgical insertion of a rigid catheter.

Bloody dialysate, which is frequently seen after catheter insertion, is usually a result of the lysis of peritoneal adhesions from a previous abdominal operation or of peritoneal irritation. The presence of a bleeding tendency predisposes to this complication.

Early dialysate leakage may be seen in the presence of predisposing factors such as age over 60 years, obesity, diabetes mellitus, chronic use of steroids, multiparity, and a previous abdominal operation. Such leakage may be avoided by using lower fill volumes.

Abdominal distension and even respiratory compromise may follow incomplete drainage and progressive accumulation of dialysate in the peritoneal cavity. This complication may be prevented by careful observation to ensure complete emptying during the allowed drainage period.

Abdominal wall and genital edema have been attributed to peritoneal defects at the site of catheter insertion. Abdominal-wall edema should be suspected in cases of a sudden reduction in effluent volume and increased abdominal girth and body weight in the absence of edema elsewhere.

Hydrothorax is a rare complication, and its clinical presentation varies from asymptomatic pleural effusion discovered on routine chest X-ray to life-threatening respiratory failure. This complication has been attributed to the presence of a diaphragmatic defect with pleuroperitoneal communication.

MEDICAL COMPLICATIONS

Fluid, electrolyte, and acid–base disorders can be minimized by close evaluation of changes in the patient's weight and of the total dialysis regimen, with special attention to the frequency of exchanges, osmotic strength of the solution, volume per exchange, and ultrafiltration.

Hypervolemia because of poor ultrafiltration is a possibility, as is hypovolemia and hypotension because of excess water removal. Hypotension is often seen with rapid hypertonic exchanges; when severe, this complication may require temporary discontinuation of dialysis and infusion of intravenous saline. The patient may also require intravenous administration of 5% dextrose in water to correct the hypernatremia that occurs because of excess water removal (sodium sieving) with hypertonic dialysis.

Patients on acute PD may develop an acid–base imbalance in the presence of simultaneous intravenous administration of bicarbonate solution to secure a rapid correction of metabolic acidosis. Paradoxically, this problem leads to acidosis of the cerebrospinal fluid, hyperventilation, and finally alkalosis. Because standard PD solutions contain lactate buffer, patients with hepatic failure or severe lactic acidosis and slow lactate metabolism may present with elevated plasma lactate levels; if so, they will need dialysis solutions containing bicarbonate buffer.

The frequent exchanges used in acute PD may produce hypoalbuminemia; protein losses via the dialysate can be as high as 10 – 20 g in 24 hours and up to twice that amount during episodes of peritonitis. To compensate for dialysate protein losses, oral or intravenous protein supplementation may be required.

Finally, ultrafiltration failure during acute PD is commonly associated with high solute transport and early dissipation of the osmotic gradient (type I ultrafiltration failure: dialysate-to-plasma creatinine greater than 0.8 with glucose dialysate levels less than 500 mg/dL). Ultrafiltration failure is observed more frequently during episodes of peritonitis because of an increased peritoneal membrane permeability that usually abates as the inflammation resolves.

Conclusions

Since the 1970s, either manual or cycler-assisted PD has been widely used in patients with ARF, especially those who are hemodynamically unstable or at risk of bleeding because of severe coagulation abnormalities, in infants and children with ARF, and in patients with circulatory failure.

Although PD is considered less effective than HD and the newer CRRTs in patients with severe acute illness (pulmonary edema, poisoning, extreme catabolysis), PD remains a therapy that is easily, simply, and adequately instituted, especially for infants and children with ARF both within and outside of ICU settings.

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