

The Prescription of Acute Peritoneal Dialysis in the Neonatal Intensive Care Unit Setting

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Published Date: February 10, 2016

ABSTRACT

Acute Peritoneal Dialysis (**APD**) should be life saving for the infants with metabolic, fluid, electrolyte, and acid-base imbalance due to acute renal failure or toxin accumulation. Although invasive, **APD** can be successfully prescribed, even in the very small neonates. It is a safe, simple, easy to perform and effective therapy in the neonatal period. The complexity of the technique and the invasiveness of the procedure restrict the use of **APD**. Furthermore, **APD** is a modality most often used in the developing world, where the cost and available resources are major issues.

This mode of dialysis does not require highly sophisticated equipment or personnel allowing slow removal of fluid and solutes, while avoiding hemodynamic instability, anticoagulation and problems associated with vascular access. When necessary, **APD** should be performed continuously at bedside. During every session of **APD**, appropriate dialysate volume and dwell-time not to cause volume overload, monitoring fluid, glucose and electrolyte balance are essentials of the **PD** especially in neonates.

Besides life saving, **APD** may have some risks and can be related complications. Special conditions for neonates during implementation include hyperglycemia, hyponatremia, and

hypothermia. **APD** has higher complication and mortality ratios in neonates than adults and young children. Nevertheless, acute **PD** improves outcome, if instituted in the early stage of disease.

Key words: Dialysis; Complication; Indication; Newborn; Peritoneal; Technique

INTRODUCTION

The management of neonates with Acute Renal Failure (**ARF**) may involve Renal Replacement Therapy (**RRT**) [1-3]. Acute dialysis should be life saving for the infants with metabolic, Fluid, electrolyte, acid-base imbalance due to **ARF** or toxin accumulation [4]. The modes of **RRT** instituted even in Very Low Birth Weight (**VLBW**) infants are Peritoneal Dialysis (**PD**), extracorporeal methods including intermittent hemodialysis, hemodiafiltration or hemofiltration (with or without a dialysis circuit) [3]. **PD** was initially used in the 1920s to treat **ARF**, but it was not until 1946 that it was first described to save the life of a patient [5]. However, **PD** for **ARF** has fallen down by newer, technologically advanced treatments such as hemofiltration and hemodialysis recently. The use of hemofiltration by pediatric nephrologists is increasing and preferred [6,7]. As the technical problems associated with vascular access and haemodynamic instability, haemodialysis is difficult in newborn, infants and preschool children (0-5 years age) [4,6-8]. In neonates and small infants, **PD** has become a major modality for the management of **ARF**, because vascular access should be difficult to maintain in other modes of dialysis [1-8].

The removal of toxins, fluid and plasma solutes by passive movement (diffusion through their concentration gradients) across a semi-permeable membrane is defined as dialysis. The process is described as hemodialysis if the membrane is synthetic, **PD** if it is peritoneum [9]. The basic principles, indications, procedures, equipment, complications of dialysis in children and neonates are same as in adults [4]. But, the evaluation, medical management, decision to initiate dialysis therapy, neonatal and dialysis nursing require expertise for the optimal care and successful provision of dialysis. Neonatal intensive care physicians, pediatric surgeons, medical geneticists, and pediatric nephrologists have to be in rapid collaboration to initiate **PD**. High complication and mortality ratios may be responsible for the complexity of technique and invasiveness of procedure. Nevertheless, if initiated early, **PD** might improve outcome [1-4,6-10].

Bidirectional movement of solute and water between the two solutions (blood and dialysate) across a semipermeable membrane is the basic principal of **RRT**. The direction of solute movement is determined by relative concentration of solute on each side of the membrane. The solute moves from the side of greater to lesser concentration. The differences in hydrostatic or osmotic pressure (eg, hemodialysis and PD) determining water and solute movement across membrane mean filtration. The exchange of solute between blood and peritoneal or dialysis fluid refers to diffusion. The phenomenon of solute movement across membrane independent from concentration gradient corresponds convection. The concentration gradient and size of the solute, the permeability and effective surface area of the membrane are the factors controlling solute exchange rate [9,11,12].

ADVANTAGES OF ACUTE PERITONEAL DIALYSIS

Although invasive, **PD** is a safe, simple, easy to perform and effective therapy even in very small neonates. This mode of dialysis does not require highly sophisticated equipment or personnel [4]. **PD** allows slow removal of fluid and solutes, while avoiding hemodynamic instability, anticoagulation and problems associated with vascular access. It is technically simple and, when necessary, should be performed continuously in the Neonatal Intensive Care Unit (**NICU**) regardless of birth weight [1-10,13].

Compared to other available modalities, **PD** has several advantages in the neonates with **ARF** [1-4,6-8,13]:

- **PD** is easy to perform and widely available technically
- Large amounts of fluid should be removed in hemodynamically unstable patients
- Disequilibrium syndrome is not precipitated, because of the slow rate of solute removal
- Easy and gradual correction of acid-base and electrolyte imbalance may be performed
- **PD** access placement is relatively easy in children and neonates
- Arterial or venous catheter placement and anticoagulation are not required
- The technique is highly biocompatible
- Dosing of dialysate solution is easy

The slow removal of solutes (eg, urea) and fluid depends on the continuous nature of **PD** [13]. Large amounts of fluid should be removed over a prolonged period of time. Therefore, **PD** is preferred mode of **RRT** in hemodynamically unstable patients and neonates. Acute **PD** provides continuous correction of acid-base, electrolyte imbalance and the gradual removal of toxins. The slow removal of uremic toxins may prevent the development of disequilibrium syndrome during acute **PD** [1-4,6-8,13].

THE INDICATIONS TO ACUTE PERITONEAL DIALYSIS IN NEONATES

The indications to initiate **PD** in neonates are as follows [13-15];

1. Anuria-oliguria due to **ARF** (secondary to dehydration, sepsis, perinatal asphyxia or multiple organ dysfunction syndrome)
2. Fluid overload causing heart failure or pulmonary edema
3. Electrolyte abnormalities unresponsive to medical management (hyperkalemia, serum potassium concentration ≥ 8 mEq/L; hyponatremia, serum sodium concentration below ≤ 120 mEq/L; etc...)

4. Severe metabolic acidosis resistant to NaHCO₃ and supportive therapies (Serum bicarbonate concentration ≤ 12 mEq/L)
5. Toxic metabolite accumulation exogenously or due to inborn errors of metabolism (ammonia, citrulline, branched-chain amino acids, etc.).

The American College of Critical Care Medicine Clinical Guidelines for Hemodynamic Support of Neonates and Children with Septic Shock suggested that **RRT** be considered following early goal-directed fluid resuscitation in patients at risk for worsening fluid overload [16].

THE CONTRAINDICATIONS TO ACUTE PERITONEAL DIALYSIS IN NEONATES

The contraindications to PD in neonates are summarized as follows [13-15];

1. Abdominal wall defects such as omphalocele, gastroschisis
2. Diaphragmatic hernia
3. Bladder extrophy
4. Bleeding diathesis
5. Obliterated peritoneal cavity
6. Abdominal malignancy
7. Necrotizing enterocolitis
8. Severe respiratory failure
9. Fecal or fungal peritonitis
10. Abdominal wall cellulitis
11. Recent abdominal surgery

The only relative contraindication to **PD** is recent abdominal surgery. The intrusion of peritoneal cavity and/or placement of multiple abdominal drains are accountable to this contraindication. There may be an increase in the incidence of infection and fluid accumulation with ongoing **PD**, secondary to abdominal drains [13-15].

The presence of abdominal hernia, necrotising enterocolitis or intra abdominal adhesions can make **PD** difficult. Intra abdominal pressure may increase by instilling fluid in the peritoneal cavity. The increased pressure can compromise lung function (by limiting diaphragmatic excursion) and interfere gase exchange [13-15].

ACCESS TO THE PERITONEUM

A small tube or catheter inserted into the abdomen surgically means access to the peritoneum. One difficulty related to **PD** is the introduction of a suitable peritoneal catheter [17].

Peritoneal dialysis was first used for the management of end-stage renal disease in 1959 [18]. In 1968, Henry Tenckhoff developed the indwelling peritoneal catheter, which was placed via an open surgical technique [19]. Subsequently, percutaneous and laparoscopic techniques for placement have been utilized.

Several catheters and techniques have been previously described in neonates, all of require the introduction of a catheter into the peritoneum, either over a trocar (as in adult acute peritoneal dialysis) or over a stylet (as when inserting an intravenous cannula) [20]. The design of catheter, implantation site, and the configuration of system used to perform dialysis determine the effectiveness of **PD** [21].

The **PD** catheter should be implanted at bedside, and strict aseptic conditions must be provided during the whole process of **PD**. The use of local anesthesia is better and safer than general, since the incision to insert catheter into the abdomen is small, and the procedure is actually quick. Acute **PD** with a rigid straight catheter inserted into the peritoneum over a guidewire in the **NICU**, and the head of the catheter pointing up generally preferred in neonates. The caudal direction of exit site of catheters (opening of tunnel through where catheter enters into the peritoneal cavity) lowers the incidence of exit site infections [2,6,22].

The proper direction of catheter is critical in children and infants. In the infants, the place above diaper for a downward facing exit site may not enough, therefore the site is upward facing. The catheters placed in the right lower quadrant in the patients with gastrostomy tubes or vesicostomies, and presternal placement among the infants with diapers, ostomies, and abdominal wall weakness are also described [23-25]. Partial omentectomy or omental tacking to epigastrium or lateral abdominal wall should be beneficial, since omental catheter occlusion is more common in children than adults [2,6,22-25].

The Choice of Dialysis Catheter

PD catheter has to permit bidirectional flow of dialysate without magnificent effort or unessential discomfort. The soft silastic (smooth silicone polymer of methyl-silicate) or plastic **PD** catheters with curled or straight configurations are available. Although, lack of general consensus for ideal dialysis catheter in pediatric and neonatal care, the best practices established in the adult population is the preference. The double cuff, swan neck, and downward exit have successful outcomes [2-10,17,22-25]. In neonates, pig-tail and straight rigid catheters without cuffs have been preferred, due to the suggestion of a need to **PD** for a brief period of time. Various substitutes of catheters have been defined such as suction catheter, 16 F plastic catheter, angiocath, and neonatal chest drain. Most of the catheters have side holes allowing easy exchange of fluid regardless of the catheter position in the peritoneum. A polyester fabric cuff combines to most catheters allowing tissue ingrowth from the skin or preperitoneal fascia, ideally watertight, bacteria-impermeable and preventing introduction of microorganisms along the catheter tract [2-10,17,22-25].

The Equipment

Dialysis catheter, sterile gloves, betadine, dressing pack, syringes, needles, lidocaine, scissor, surgical string (silk), stitch, scalpel, three way cannula, serum physiologic, resuscitation equipment, monitor to demonstrate heart rate and rhythm, pulse oxymetry, blood pressure and respiration, **PD** solution, 2 Port Clamp, 2 manual dialysis tubing, 1 drain bag [2-10].

The Insertion of the Catheter

The common sites of insertion are in the midline below the umbilicus, right or left lower quadrant of the abdomen. During the procedure, the patient must be monitored, and empty urinary bladder is preferred so as not to damage. The placement of the catheter is preferably performed at bedside in the **NICU** by a pediatric surgeon. After choosing appropriate site to introduce the catheter, the skin must be sterilised with betadine, and lidocaine 1% must be injected. The introducing neonatal rigid straight catheter through a mini skin incision (0.5-1 cm) at or below the umbilicus is generally preferred. After positioning the catheter by mini-laparotomy, soft plastic extension of catheter must be taped to the skin, and catheter was connected to a peritoneal dialysis delivery system by a three way cannula. The head of the catheter pointing up is preferred [2-10,17,22-25].

The dialysate fluid has to be connected to an intravenous (iv) fluid administration set and its terminal end has to be connected to one of the ports of three way cannula. The remaining port of the three way cannula has to be connected to a sterile container (i.e. empty iv fluid bottle), usually by an iv set to collect draining fluid from the peritoneum [2-10,17,22-25].

THE COMPONENTS OF ACUTE PERITONEAL DIALYSIS PRESCRIPTION:

The components of standard acute PD prescription are shown as follows [2-6,27]:

1. Length of the dialysis session
2. Dialysate composition
3. Exchange volume
4. Inflow and outflow (drain) time
5. Dwell time
6. Number of exchanges
7. Dialysate additives
8. Monitoring fluid balance

The length of dialysis session: The length of acute **PD** session generally lasts about 48-72 hours and 48-72 exchanges with each session taking approximately one hour. But, **PD** can be continued until the desired effect is obtained. The cause and duration of **AKI**, desired amount of solute and

fluid removal, the risk of infection, particularly with rigid catheters determine the length of the **PD** session [28].

The dialysate composition: **PD** solutions contain water, osmotic agents, electrolytes and minerals and are sometimes fortified with different substances. An ideal solution may [29]:

- Have a sustained and a predictable solute clearance with minimal absorption of osmotic agents
- If required, provide deficient electrolytes and nutrients
- Correct acid base problems without interacting with other solutes in the PD fluid
- Be free of and inhibit the growth of pyrogens and microorganisms
- Be free of toxic metals

Be inert to the peritoneum

The composition of commercially available dialysate solutions vary depending on their osmolality, osmotic agent (usually dextrose) and buffer used. **PD** dialysate is available in standard hydrous dextrose concentrations of 1.5, 2.5, and 4.25% with osmolalities of 346, 396, and 485 mOsm/L respectively. The composition of the dialysate can be modified according to the infant's needs. Acetate, lactate, and bicarbonate have been used as buffers to control acidosis. Lactate in the dialysate as a buffer should be avoided in the patients with hepatic dysfunction. Commercially prepared bicarbonate-based solutions may be very rarely necessary in neonates [29,30].

Commercially available solutions contain sodium, magnesium, calcium, and chloride. The standard solution contains 132 meq/L of sodium, 3.5 meq/L calcium, 1.5 meq/L magnesium, 35 meq/L lactate, and 102 meq/L of chloride. The dextrose in **PD** dialysate can provide an extra source of carbohydrate and calories. But, it may also cause hyperglycemia and the requirement of insulin therapy. Dialysate solutions offered to be warmed to the body temperature before infusion to avoid discomfort, hypothermia and improve solute Exchange [29,30]. Frequently used methods to warm the dialysate (with manual systems) include: utilizing bag warmers, placing heating pads around the bags, or if the infant is in an isolette, placing the equipment in the isolette, if no contraindications are noted [1-4,6-8,29,30].

An initial dialysis solution of 1.5% dextrose concentration may be more appropriate in the infants and hemodynamically unstable patients. It is rational to initiate acute PD with 2.5% dialysate solution to achieve better ultrafiltration in children [1-8,10].

The exchange volume: The exchange volume means the amount of dialysate solution instilled into the peritoneal cavity during an exchange. The size of peritoneal cavity, the weight of the infant, presence of pulmonary or another disease, and the degree of uremic toxicity may affect exchange volume [1-8,10].

In the beginning of the **PD**, flushing with low volumes or until the dialysate clear is recommended. The initial exchange volume is recommended to be low (10 mL/kg) in order to reduce abdominal pressure resulting dialysate leakage around the catheter. The volume can be slowly increased to a maximum of 35 to 40 mL/kg [1-8,10].

The inflow time: The time required to instill dialysate into the peritoneal cavity means inflow time. Inflow time usually lasts a short period, approximately 10 - 15 minutes, and minimizing inflow time is a necessity of **PD** [29,30].

The dwell time: The period between the end of inflow time and the beginning of the drain period means dwell time lasting approximately 30 to 90 minutes for acute **PD**. This duration is most advantageous to promote urea and fluid removal owing to the gradients. Dwell time shorter than 30 minutes will usually be not adequate [29,30].

The dwell time can be reduced in case of respiratory compromise. Short dwell time is also necessary in the patients with peritonitis, as glucose gradient wastes more quickly across more permeable peritoneum [29,30].

The outflow time: Outflow time is defined as the time required to drain effluent dialysate from the peritoneal cavity. The gravity controls the drain of dialysate and usually lasts about 20 - 30 minutes. The major determinants of outflow time include followings [29,30]:

- Dialysate volume to be drained
- Outflow resistance resulting from kinks in the catheter, decreased bowel motility, and fibrin in the dialysate
- The height difference between the patient and drainage bag

Keeping outflow time to a minimum by adjusting the height of drainage bag is important, as inflow time. The rate-limiting step of **PD** is outflow period. If the drainage is slow (necessitating 20 to 30 minutes to complete), dwell time may be increased, and the number of exchanges per day may be decreased. This alterations may prevent the lost contact time during slow drainages and diminution of solute removal [29,30].

The number of exchanges: Although the number of exchanges may vary, it is usually about 24 per day for acute **PD**. The number of exchanges is determined by the amount of fluid and solute removal required. A total of 20-40 cycles can be used or it can be continued till the desired effect is obtained [29,30].

The additives of peritoneal dialysis solution: Drugs should be added to dialysis solution in case of specific conditions. Following sterile technique is crucial when adding additives. Heparin, insulin, and potassium are the commonly used dialysate additives [29,30].

Heparin is occasionally added to dialysate solutions to prevent fibrin clot formation and obstruction of the peritoneal catheter. The recommended dose of heparin is 200 to 500 units

per liter. It is usually added when plugs or strands of fibrin are visible in the drained fluid. In neonates, low dose may be preferred due to the risk of hemorrhage [29,30].

The addition of potassium to dialysate to correct serious hypokalemia is not recommended, because other routes are preferred for potassium supplementation. If the avoidance of hypokalemia is mandatory, addition of potassium to dialysate can be used to keep serum potassium level within the normal range. The potassium chloride can be added to dialysate at a dose of 3 to 4 mmol/L to prevent hypokalemia [29,30].

Medical staff have to maintain complete drainage of effluent dialysate. Because, incomplete drainage can result in progressive accumulation of dialysate in the peritoneal cavity, and lead to respiratory insufficiency and/or abdominal discomfort. The fluid left in the peritoneal cavity during tidal **PD** intentionally is a different issue. It is extremely important to continue outflow until drainage ceases in order to avoid incomplete drainage. But, complete drainage for each exchange is not an obligation. Another option is maintaining the complete drainage to occur after every second or third exchange [29,30].

The peritoneal permeability seems to be in a hyperpermeable state in the infants and neonates. Practical **PD** instructions in neonates have to be balanced between either short dwell times to optimize ultrafiltration or long dwell times to optimize the diffusive process and blood purification according to their needs. In neonates, short dwell times (one hour or less) adapted to ultrafiltration need, and small instilled dialysate volumes (initially 10-20 mL/kg) to avoid increased intra-abdominal pressure the recommendations for **PD**. Hyponatremia, hyperglycemia and hypophosphatemia are age-related particular risks [1-8,10,22-25].

The fluid balance monitoring: The accurate flow records, monitoring intake and output, and documenting net ultrafiltration are essentials of acute **PD**. Blood sugar every 4-6 hourly, serum electrolytes every 6-12 hourly, serum creatinine every 24 hourly, and infant's weight every 12-24 hourly have to be monitored during acute **PD** [1-8,10,22-25].

Each exchange should be noted and the following informations should be recorded:

1. Exchange number
2. Dialysate concentration
3. Volume of exchange
4. Medications added
5. Amount of effluent obtained, if drained
6. Appearance of effluent
7. Tubing change

Effluent dialysate has to be examined for color, clarity and amount. Sterile dialysate effluent

samples can be obtained from the drain bag into a sterile container. Exit site care should be done every day. Dialysis tubing may be changed with each **PD** set up, not to exceed 72 hours. Dialysis tubing changes have to be documented on the Acute **PD** Record [1-8,10,22-25].

THE COMPLICATIONS OF ACUTE PERITONEAL DIALYSIS

Acute **PD** has some risks and may be associated with complications. Although some of these complications might be serious and potentially life-threatening, many of them are preventable (31,32). Most of the problems associated with **PD** related to the catheter. Catheter obstruction, abdominal pain, or malpositioning of the catheter tip may all limit the efficiency of the dialysis. Blockage or poor drainage due to omentum around the catheter can require omentectomy, revision, or replacement of a new catheter [33-36].

The mechanical complications

Most of the mechanical complications related to acute **PD** should reduce dialysis efficiency. These include the followings [31-36]:

Abdominal pain or discomfort

Mild abdominal pain or discomfort is a common symptom and usually in accompaniment to abdominal distention. On the other hand, moderate to severe discomfort might be related to a catheter-related complication or infection and warrants investigation [32-34].

Intra abdominal hemorrhage

Mild bleeding is a frequent finding and generally occurs following catheter placement. However, semirigid and rigid catheters should result in severe intraabdominal hemorrhage [31-36].

Leakage

Frequent occurrence of leakage around **PD** catheter is easily managed by reducing exchange volume. In some cases, cessation of **PD** may be necessary [31-36].

Inadequate drainage

The technical problems related to catheter, inadequate height difference between the patient and drainage bag, fibrin deposition or blood clots around the catheter, intraperitoneal adhesions, catheter migration or omental trapping may result in inadequate drainage. In most situations, improving drainage can be managed by catheter repositioning or flushing saline. The manipulation of catheter, omentectomy, revision, or inserting a new catheter may occasionally be necessary [33-37].

Bowel perforation

Bowel perforations may very rarely occur, particularly with the placement of semirigid and rigid acute **PD** catheters. The bloody peritoneal effluent, intraabdominal hemorrhage, and rarely

shock may develop. Bowel/fecal material in the effluent dialysate may be observed. The cessation of acute **PD**, removal of the catheter, and intravenous antibiotics have to be implemented. The bowel repair may be necessary [38-39].

The infectious complications

Infection of the skin exit site or the peritoneum (peritonitis) is potentially serious and not uncommon problem requiring prompt attention. While these infectious problems can usually be treated effectively with antibiotics, the catheter removal has to be necessary in order to completely eradicate the infection in neonates [40,41].

The most common infectious complications is peritonitis and it may be serious and fatal. A puncture site abscess may occur very rarely due to the bedside placement of acute **PD** catheters, especially if the sterile technique is not provided with meticulous attention. Maintaining sterile precautions during the **PD** catheter placement and preventing contamination during exchanges can reduce the incidence of peritonitis importantly [40-42].

Wound infection

Wound infection is uncommon and often can be treated with antibiotics. If the infection is deeper and results in purulan collection, drainage may be needed [43].

Peritonitis

Peritonitis may occur more frequently in children and neonates and may be associated with significant mortality. Although, higher peritonitis rates have been reported in children than in adults before 2000s, more recent reports show similar rates. Peritonitis remains one of the most important limitations to the delivery of acute **PD**. The contamination of the peritoneum, from endogenous or exogenous sources, is responsible for most peritonitis episodes. Peritonitis can be suspected if the infant has clinical symptoms of sepsis, abdominal tenderness or discomfort, dystention, changes in skin color, or the dialysate is not clear and the bag is cloudy. A sample of peritoneal fluid has to be obtained for Gram stain, culture, and White Blood Cells (**WBC**) count with differential. The Gram stain is often unrevealing, but cultures are positive in over 90%. About 90% also have above **WBC**100/mm³, usually neutrophils (lymphocytes with fungal peritonitis) [40-45].

Negative cultures and **WBC** counts under 100/mm³ do not exclude peritonitis. If peritonitis is suspected based on clinical or laboratory criteria, the treatment is immediately indicated before culture results are available. Gram-positive bacteria are the most common cause of peritonitis, but Gram-negative bacteria may also be the etiologic agent. The rate of culture-negative peritonitis reported to be 20-22% [46,47].

Although suspicion of peritonitis, other causes may be distinguished culture-positive infectious peritonitis, infectious peritonitis with sterile cultures, chemical peritonitis, hemoperitoneum,

chylous effluent (rare), specimen taken from “dry” abdomen. Clinical suspicion of peritonitis should be followed rapidly by microbiological examination and empirical treatment. Microbiological confirmation allows for subsequent treatment based on sensitivities. Other interventions such as catheter removal may be appropriate in selected patients [48,49].

Peritoneal fluid studies may be falsely negative due to previous antibiotic use, infection limited to the catheter exit site or tunnel, or sampling of too little fluid. If any microorganism is cultured in blood or dialysate, appropriate antibiotic therapy according to the resistance profile has to be started and continued at least 14 days [46-49].

Peritonitis may be prevented by adequate exit-site care, sterile technique, preventing contamination during exchanges and techniques to minimize early contamination of the exit site. A key development is the publication of the Consensus Guidelines for the Treatment of Peritonitis in Pediatric Patients Receiving Peritoneal Dialysis by an international committee of physicians and nurses under the auspices of the International Society of Peritoneal Dialysis. These guidelines include recommendations for empiric antibiotic therapy, treatment of gram-positive, gram-negative, and fungal peritonitis as well as indications for catheter removal and replacement [49-53].

Empiric treatment should be adapted to microbial resistance patterns of a given facility. But typical recommendations are for initial treatment with drugs active against gram-positive organisms (eg, either vancomycin or a 1st-generation cephalosporin (iv), plus antibiotics active against gram-negative organisms (such as a 3rd-generation cephalosporin, eg, ceftazidime or an aminoglycoside, eg, gentamicin (iv). The doses are adjusted, if the patient has **ARF** [49-53].

The most cases with peritonitis recover by prompt antibiotic therapy. If peritonitis does not respond to antibiotics within 5 days, or occurs with recurrence of the same microorganism or fungi, the dialysis catheter has to be removed [52,54].

The pulmonary complications

Atelectasis and pneumonia: Secondary to increased intraabdominal pressure during acute **PD**, atelectasis and pneumonia may develop. The increased intraabdominal pressure leads to inadequate lung expansion and formation of plugs due to stasis of secretions [31,33].

Pleural effusion

The shift of intra abdominal fluid into the thoracic cavity and hydrothorax can occur via a diaphragmatic defect or lymphatics. A right sided effusion is most commonly observed form of fluid shift. Lowering exchange volumes to decrease intraabdominal pressure and performing acute **PD** in a supine position may resolve the problem in most situations. Pleurodesis is rarely required [31,33].

Aspiration

Increased intraperitoneal pressure predisposes the infant to gastroesophageal reflux and increases the risk of aspiration [31,33].

The cardiovascular complications

Hypovolemia

Reduced tissue perfusion may develop due to excessive ultrafiltration or decreased venous return (because of increased intraabdominal pressure and diaphragmatic elevation) [31,33,55].

Cardiac arrhythmias

Cardiac arrhythmias may develop during acute **PD** and usually secondary to electrolyte and metabolic disturbances, or diaphragmatic elevation [31,33,55,56].

The metabolic complications

Metabolic complications are not rare and often preventable complications of acute **PD** [31,33,35-37,55].

Hyperglycemia

The high glucose concentration of **PD** fluid may cause hyperglycemia [57].

Hypoglycemia

Hypoglycemia usually occurs following the cessation of **PD**.

Hypernatremia

The repeated use of hypertonic exchanges may cause disproportionate loss of free water in dialysate and may cause hypernatremia. The free water moves down through the aquaporin 1 water channels in the peritoneal capillaries, that are activated by glucose-generated tonicity of the dialysate. Sodium will diffuse down from blood to dialysate through the small intercellular “pores.” If the exchange lasts short in duration, there may be inadequate time for sodium diffusion. The best approach to correct hypernatremia is lengthening the duration of exchanges to induce diffusion and/or using less hypertonic dialysate. The dialysates containing lower sodium concentration are not available [11,12,58].

Hypokalemia

As standard PD solutions do not contain potassium, hypokalemia may develop in the advanced stage of acute **PD** [11,12,29].

Protein losses

Mild protein losses can occur by dialysate and should be exacerbated by aggressive ultrafiltration and infection [59].

THE DISCONTINUATION OF PERITONEAL DIALYSIS

The factors determining to discontinue acute **PD** are not well reported than the factors determining initiation. Currently, no guidelines or strategies have been published regarding the approach to cessation of **PD**. The decision to discontinue acute **PD** are based on multiple factors such as urine output, hemodynamic stability, respiratory, nutritional and volume status, and changes in underlying disease and overall prognosis [1-4,6-8].

THE OUTCOMES RELATED TO THE PERITONEAL DIALYSIS

Despite advances in the management of the neonates in the **NICU**, mortality, morbidity and complication ratios related to **PD** are generally reported to be higher in neonates than older children and adults. Morbidity and mortality in newborns performed **PD** are related to the infant's underlying diagnosis and clinical condition [60-64].

The factors increasing the ratio of mortality in the infants include followings [60-71]:

- Underlying disease [60-66].
- Hypotension at the onset of **RRT** [67-69].
- Use of inotropic agents anytime during the course of **RRT** [66-69].
- Degree of fluid overload present on initiation of **RRT** [70,71].

Most studies have shown that the mortality and the incidence of renal recovery with acute **PD** was at least comparable to hemodialysis [69-71]. The outcome of neonates introduced **PD** should be followed-up prospectively with multidisciplinary approach to monitor long-term neurodevelopmental outcome [71].

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