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Role of Peritoneal Dialysis in Acute Kidney Injury

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ABSTRACT

Peritoneal dialysis **(PD)** as a modality of dialysis in acute kidney injury **(AKI)** has markedly decreased with time mainly due to fears of its inadequacy. Yet PD has several advantages which could make it a better option in certain situations. Clinical situations where PD may be a preferred mode of initial dialysis and the role of PD in AKI is discussed and guidelines suggested on its use.

Keywords: Peritoneal dialysis; Acute kidney injury; Continuous venovenous hemodiafiltration; Intraabdominal hypertension

INTRODUCTION

Acute Kidney injury **(AKI)** is a common medical problem accounting for around 5% of hospital inpatients [1].Whilemajority of such patients get admitted with AKI(community acquired), several develop AKI following hospitalization (Hospital acquired) [2]. Despite advances in knowledge on the pathogenetic factors responsible for developing AKI and newer modalities of renal replacement therapies, mortality remains high. Recognizing the need for avoiding preventable deaths from AKI,a goal of 0 by 25 was set, aiming to reduce the number of preventable deathsin AKI tozeroby 2025 [3]. Considering the fact that AKI accounts for 1.7 million preventable deaths per year worldwide [3] and most occur indeveloping countries where resources may limit the options of renal replacement therapies [4,5], it may be worthwhile to consider the role of peritoneal dialysisin AKI.

MODALITIES OF DIALYSIS IN AKI

Various modalities of dialysis are available for the management of AKI (Table 1). The choice of dialysis is influenced by several factors like infrastructure, hemodynamic and coagulation status, stage of AKI and associated complications (Table 2).

Table 1: Modalities of dialysis in acute kidney injury.

1. Peritoneal dialysis
a. Stiff catheter/ manual exchanges
b. Tenckhoff catheter/ manual exchanges
c. Tenckhoff catheter/ automated exchanges using cycler
d. Tidal peritoneal dialysis
2. Hemodialysis
a. Conventional(intermittent) hemodialysis
b. Slow low efficiency hemodialysis (SLED)
3. Slow continuous ultrafiltration (SCUF)
4. Continuous arteriovenous hemofiltration (CAVH)
5. Continuous venovenous hemofiltration (CVVH)
6. Continuous arteriovenous hemodialysis (CAVHD)
7. Continuous venovenous hemodialysis (CVVHD)
8. Continuous arteriovenous hemodiafiltration (CAVHDF)
9. Continuous venovenous hemodiafiltration (CVVHDF)

Table 2: Factors influencing choice of Dialytic Modality.

1. Infrastructure Equipment for Dialysis Trained personnel Water treatment plant Electricity
2. Hemodynamic instability
3. Bleeding tendency/Coagulation abnormalities
4. Hypercatabolic state
5. Pulmonary oedema / Hyperkalemia
6. Stage of AKI
7. Difficulty in transporting patient to major Hospital/ Dialysis Room
8. Availability of vascular access
9. Cost

ROLE OF PERITONEAL DIALYSIS

Peritoneal dialysis **(PD)** was the first form of dialysis tried for AKI due to its simplicity [6]. PD has several advantages which could be beneficial in certain situations. The lack of need for a vascular access makes this a better choice in the pediatric population as well as in patients having problems in getting a vascular line. This makes its use feasible even in remote areas and places where doctors trained in placing vascular accesses are not available [7]. Even nursing staff with minimal training can initiate and continue PD. As there is no need for electricity, it could be used in AKI developing in underdeveloped areas and low income countries where reliable electric supply may not be available [8]. As conventional hemodialysis **(HD)** often needs a water treatment facility to treat raw water, PD could be an option if this facility is not available [9]. AKI is a common accompaniment in multiorgan failure. This is especially so in the intensive care units **(ICU)**. It is not uncommon for critically ill patients to be on multiple supports including inotropes and ventilators. Very often, HD machines may not be available in the ICUs, which necessitates transferring the critically ill patients to the dialysis units or shifting the HD machine to the ICU. As PD can be started in the ICUs itself, these can be avoided [10]. Thrombocytopenia, coagulation abnormalities and bleeding from various sites are common when AKI occurs following sepsis and multiorgan failure [11]. Need for anticoagulation during HD adds to the risk. PD offers a significant advantage of not needing anticoagulation. Another clinical situation where PD has benefits is in those with hemodynamic disturbances, where conventional HD is often not tolerated.

Yet, with time, use of PD has diminished [12], especially in the developed countries, mainly due to concerns about lower efficacy of PD with faster clearance of solute and fluids offered by the subsequent development of HD. This has been shown by calculating solute clearance using the formula KT/V where K is the Urea clearance, T the time on dialysis and V is the volume of distribution. However, PD can be used for prolonged periods and thus clearance can be increased. Conventional HD done for 4 hours every alternate day gives approximately 12 hours of HD per week. Assuming a KT/V of 1 for every 4 hours of HD, this would work out to a weekly KT/V of around four. Use of PD with 2litre exchanges every 2 hours can provide a similar weekly KT/V [13]. Thus patients with azotemia can be maintained on PD which gives a slow but prolonged correction. However, patients with life threatening pulmonary edema or hyperkalemia may need HD as the preferred dialysis modality. Septic patients with AKI are often hypercatabolic, making PD seem less ideal. This is especially true if dialysis is started at later stages of AKI where the blood urea and serum creatinine are high. There are however reports that it is possible to do PD even in hypercatabolic patients with some modifications like using a flexible catheter with a cycler [14]. Modifying the dialysis prescription by adding Tidal Peritoneal dialysis where the entire PD fluid is not drained could be another modification to increase efficiency [15].

In hemodynamically unstable patients, conventional HD may not be feasible. Alterations like slow continuous ultrafiltration **(SCUF)** could be tried when fluid overload is the major concern. Continuous arteriovenous hemofiltration **(CAVH)** or pump assisted continuous venovenous hemofiltration **(CVVH)** with replacement fluid may increase the urea clearance marginally by convective clearance. An additional solute removal by dialysis can be obtained by continuous arteriovenous dialysis **(CAVHD)** or continuous venvenous dialysis **(CVVHD)** Adding replacement fluid to this could combine solute and fluid removal and may be preferred in AKI occurring in the critically ill, hemodynamically unstable patient [11]. When falciparum malaria was the major cause of infection associated AKI, PD with a stiff PD catheter, an open drainage system, and manual exchanges of 2 L with 30 minute dwell time was found to be inferior to CVVHDF with regard to resolution of acidosis and renal failure and mortality was high [16]. This suggested that PD is unsuitable in this setting. However, it is possible that Falciparum malaria infection might have blocked the peritoneal capillaries resulting in inefficient PD which might account for the poor outcome in this study. Another drawback suggested in this study was the use of a stiff peritoneal dialysis catheter with manual exchanges [8]. Use of high volume PD using a Tenckhoff catheter and possible use of cycler performing automated exchanges was suggested as a modification to improve the outcome of PD in such situations [17]. In an open prospective randomised study of 50 patients with acute kidney injury **(AKI)** done in our centre, where the causes of AKI were predominantly sepsis and acute tubular necrosis, there was no significant difference in the composite outcome between PD and CVVHDF. The use of PD in AKI has thus seen a resurgence in recent times [18].

PD has also been compared to daily HD in those with severe ischemic or nephrotoxic acute tubular necrosis. Similar metabolic control, patient outcome and renal recovery were observed with a flexible (Tenckhoff) catheter using an automated cycler delivering 2 litre exchanges with 30-50 min dwell [19].

As metabolic acidosis is often associated with AKI, it is important that PD should tackle this problem. Use of PD fluid containing bicarbonate could correct metabolic acidosis by diffusion. However, lactate based PD fluid is more commonly available and is cheaper. Lactate gets converted in the liver to eventually yield bicarbonate. PD fluid containing lactate can also correct acidosis, though it takes time and the liver should be functioning normally. We have shown correction of metabolic acidosis with lactate based PD fluid [20]. Lactate based PD and replacement fluids are however preferably avoided in those with hepatic dysfunction.

Initial reports suggested that high dose ultrafiltation rates of around 35ml/kg/hour may be beneficial in sepsis associated renal failure due to removal of inflammatory cytokines [21]. It was hence felt that CAVHDF or CVVHDF would be better than PD in such patients as ultrafiltration rates for PD are significantly lower [10]. This has however not been substantiated in subsequent studies with standard ultrafiltration rates of 20 ml/kg/hour being equally effective [22]. Even in sepsis, ultrafiltration rates of 20ml/kg/hour are not inferior [23]. Such ultrafiltration rates can be obtained by PD fluids using hypertonic solutions.

Ensuring an adequate dose is thought to be important in assessing the dialysis adequacy. It is suggested that a standard weekly KT/V of 2.1 should be the minimum target to be achieved in AKI. This can be achieved by PD also, despite lesser efficiency than HD [24]. Clearance of middle molecules may be even better for PD than conventional HD and its role in management of sepsis associated AKI needs further study.

Use of a flexible biocompatible Tenchkoff catheter has advantages as it can be used for prolonged periods with less chances of obstruction and faster flow [13,14]. Its insertion however needs more expertise and training than a stiff PD catheter. This can be done using a peel away sheath, Trocar, peritoneoscope or surgical insertion. If one anticipates a shorter duration of PD as when being used as a bridge to hemodialysis or till the patient becomes hemodynamically stable, a stiff catheter may suffice. A cycler may be used in the ICU which may increase the efficiency, decrease risk of peritonitis as well as save on nursing time [18].

PD carries a risk of peritonitis and is considered to be a reason for its decline [3]. However, using the flush before fill technique has decreased the risk of peritonitis [10]. Utilising flexible catheters with transfer sets and automated cyclers can further decrease this risk. This often needs the use of commercial CAPD bags which can increase the cost. When conventional PD fluid manufactured locally was used, the cost was only a third of the cost of CVVHDF [10]. The main justification of using CAPD bags over conventional PD bags made from polyvinylchloride **(PVC)** by local hospital pharmacies has been the fear that plasticizers like diethylhexylpthalate can damage the peritoneal membrane in the long run [25]. However in AKI, this concern is minimal as only short term dialysis is required. Use of locally made sterile PD fluid bags with a flexible catheter may achieve a better uremic correction at a lower cost in developing countries.

Other situations where PD may be preferable is in AKI associated with intraabdominal hypertension **(IAH).** When the intraabdominal pressure is >15 mmHg, there is a risk of AKI as it can reduce the kidney perfusion [26]. In such patients, judicious use of PD following partial drainage can reduce IAH. Raised IAH can contribute to AKI in some cases of acute pancreatitis [27]. We have reported better outcome with PD compared to HD in IAH following acute pancreatitis [28].

To conclude, PD appears to be a viable mode of dialysis in selected cases of AKI. It has advantages in critically ill patients with AKI in the ICU as it requires minimally trained staff and infrastructure (Table 3). Due to lesser fluid shifts, it may need less intensive monitoring than CVVHDF. Yet it has some disadvantages like less efficiency compared to HD and CVVHDF (Table4).

Table 3: Advantages of Peritoneal Dialysis.

1. Minimum infrastructure: Equipment, Trained Personnel, electricity, water treatment
2. Cheap
3. Anticoagulation not required
4. Shifting critically ill patients to hemodialysis centres can be avoided
5. Can be done even in primary health centres and hoapitals without dialysis facilities
6. May be used as a bridge to hemodialysis/ continuous venovenous hemodiafiltration if needed
7. Vascular access not needed

Table 4: Disadvantages of Peritoneal Dialysis.

1. Cannot be done following abdominal surgery where peritoneum is opened
2. Risk of Peritonitis
3. Mechanical complications: obstruction causing poor inflow or outflow/blood stained effluent
4. Less efficient clearance of Urea / Creatinine
5. Not ideal in pulmonary oedema

The following guidelines may help in deciding which patients are best suited for PD:

1. PD may be best suited in early stages of renal failure when the urine output starts to decrease and blood urea and serum creatinine are marginally elevated. It is also effective in correcting metabolic acidosis. This may often suffice as the sole form of CRRT, but may need shifting to other forms of dialysis later. Using a flexible Tenckhoff catheter with or without a cycler could be considered when the duration of dialysis is likely to be prolonged.

2. PD may not be ideal if patients are in significant fluid overload where a more rapid removal of fluid is needed. This should also be less preferred when the patient is hypercatabolic with significantly raised blood urea and serum creatinine. This situation often arises when nephrologists are consulted from other departments fairly late. PD may be less preferred in life threatening hyperkalemia.

3. Shifting patients to conventional hemodialysis or CVVHDF could be considered if correction of metabolic parameters is delayed or as soon as patients are hemodynamically stable, initially with a lower pump speed if needed. This will reduce the overall cost, mortality and is less taxing when limited personnel are available.

4. PD has advantages in underdeveloped and economically backward countries with limited resources and can be considered as a first form of dialysis.

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