Peritoneal Dialysis: Misperceptions and Reality

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Abstract: Peritoneal dialysis (PD) continues to be underutilized in the United States, even though it is less expensive, provides better quality of life and has better outcomes compared with hemodialysis. The reasons for low utilization of PD are influenced by complex psychosocial and economic factors, lack of physician training, physician bias and inadequate pre–end-stage renal disease care and education to the patients. Providing quality pre–end-stage renal disease education to patients and families and improving education and training of physician in PD, so that they become comfortable with the therapy, are of paramount importance to increase PD growth. Minimizing episodes of PD-related infections and noninfectious complications, preserving peritoneal membrane using more biocompatible solutions and drugs, such as angiotensin-converting enzyme inhibitors and angiotensin receptor blockers, and careful management of volume status can reduce the loss of PD patients to hemodialysis. Timely surgical interventions can prevent the malfunction and loss of PD catheters. Consolidating smaller PD facilities in a given geographical area into a single large PD center can further improve PD outcomes and PD growth. Finally, with the introduction of bundled payment for dialysis services, PD may emerge as a cost-effective therapy and rekindle interest in the dialysis community to consider PD as a better renal replacement therapy option.

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The past 2 decades have witnessed an immense growth of end-stage renal disease (ESRD) population. The 2013 United States Renal Data System (USRDS) report showed more than 50% increase in the prevalent dialysis population between 2000 and 2011.[1] There were 615,899 ESRD patients in 2011, and with an annual growth of 3.2%, the ESRD population is projected to grow to more than 700,000 dialysis patients by 2020.[1] Although ESRD comprises only 1% of the total Medicare population, it consumes 8.1% of the Medicare budget and $34.3 billion in the total Medicare spending.[1] With extensive efforts made to prevent or slow the progression of renal disease, there has been a recent reduction in the overall ESRD incidence.[1] Nevertheless, the incidence of ESRD continues to grow particularly among elderly patients. This increase in the number of ESRD patients has obvious social and economic dimensions that are even more pronounced in the case of older patients.[1,2]

Currently, 3 renal replacement therapy (RRT) options are available for ESRD patients: renal transplantation, hemodialysis (HD) in various forms (in-center HD, home HD, and nocturnal HD), and peritoneal dialysis (PD). Renal transplantation by far is the most cost-efficient RRT modality and provides ESRD patients the highest quality of life (QOL) and the longest life expectancy. However, because of the limited availability of organs and other constraints, the proportion of ESRD patients receiving renal transplants has not changed in the past decade.[1] Thus, the majority of ESRD patients depend on various dialysis modalities to survive. With increasing number of ESRD patients requiring dialysis, an equitable growth of all dialysis modalities would be expected. However, on the contrary, although utilization of HD has progressively increased, there has been a steady decline in PD usage over the past 2 decades, with paltry 7.25% of the total U.S. dialysis patients receiving PD in 2011[1] (Figure 1). In contrast, PD is used much more frequently elsewhere in the world and is the primary mode of dialysis therapy in places such as Mexico and Hong Kong[1] (Figure 2).

Many complex confounding factors influence the crucial selection of the best RRT modality for the individual patient. A thorough understanding of these factors and implementation of appropriate measures are explicitly essential to enhance the growth of a PD in the United States (Table 1).

OVERVIEW OF PD

PD is achieved by instilling a dialysis solution into the peritoneal cavity using a percutaneous abdominal catheter. The efficacy of PD depends on the structural and functional integrity of the peritoneum, which is a thin layer (40 micro m) of membrane lining the peritoneal cavity. It consists of a mesothelial monolayer and an underlying connective tissue interstitium comprising collagen, mucopolysaccharides, blood vessels and lymphatics.[3] In normal circumstances, the closed peritoneal cavity contains 50 to 100 mL of surfactant like phospholipid-rich fluid secreted mainly by mesothelial cells.[4] In PD, water and solutes are exchanged between the capillary blood and the intraperitoneal dialysate across the peritoneum.[3]

PD can be done manually (continuous ambulatory PD [CAPD]) or with automated devices (cyclers) (automated PD [APD]), either continuously (fluid in the abdominal cavity 24 hours a day, ie, continuous cycler-assisted PD) or intermittently only

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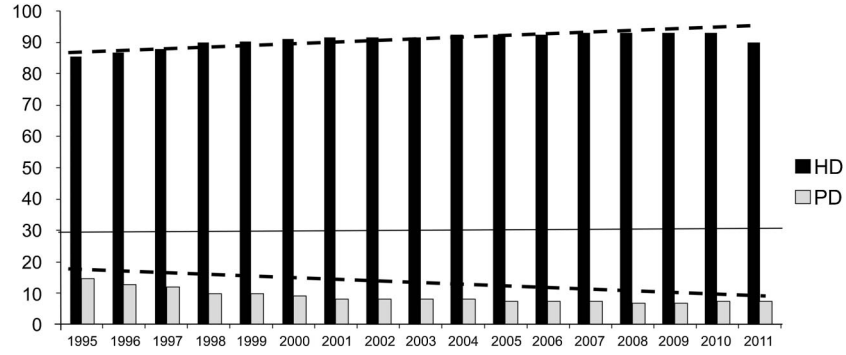

FIGURE 1. Proportion of dialysis patients using peritoneal dialysis in the United States. Based on the United States Renal Data System 2013 annual data report, only 7.2% of dialysis patients used peritoneal dialysis as of 2011.

during the nighttime with dry abdominal cavity during the day (nocturnal intermittent PD). Nocturnal intermittent PD is reserved for patients who still have good residual renal function (RRF).

A variety of silastic and polyurethane catheters are available for PD access. The catheter can be placed laparoscopically, percutaneously or by open surgical technique.[5] A double-cuff catheter with an arcuate subcutaneous tunnel and a caudad-oriented exit is recommended. It is best to wait at least 2 weeks before starting PD to assure good healing and to prevent dialysate leaks.[5,6] However, if needed, PD can be initiated almost immediately after the placement of PD catheter (PDC).

Conventional PD fluids consist of aqueous solutions of electrolytes similar to the plasma, a bicarbonate precursor (usually lactate) as a buffer and an osmotic agent, glucose for ultrafiltration (UF).[7] Various concentrations of dextrose (1.5%, 2.5% and 4.25%) are used to produce fluids of different osmolality. Glucose is widely accepted as an osmotic agent for PD because it is inexpensive and is considered relatively safe. However, because of its small size, it is rapidly absorbed into the blood with progressive loss of the osmotic gradient and long-term metabolic consequences related to glucose load in some patients. Furthermore, long-term exposure of the peritoneum to contemporary PD fluids provokes the activation of various inflammatory, fibrogenic and angiogenic cytokines, interplay of which may lead to progressive peritoneal fibrosis, vasculopathy and neoangiogenesis.[8] As a result, peritoneal membrane failure may ensue in some patients with long-term PD.[8] Three novel, more biocompatible PD solutions have been recently introduced for clinical use with a goal to minimize peritoneal toxicity and prevent treatment failure.[8] Of these, 2 solutions are nonglucose based. They include icodextrin-based solution (a large glucose polymer with a molecular weight of 16 KD) and amino acid–based solution that contains a mix of various essential and nonessential amino acids instead of glucose as osmotic agent. The third solution is a glucose-based solution that contains bicarbonate (instead of lactate in conventional PD solution) as the buffer with physiologic pH. Several recent studies have shown that the use of these novel PD solutions is associated with improvement in peritoneal membrane integrity and prolongation of PD technique survival.[8–12] Of these solutions, only icodextrin is approved by the Food and Drug Administration (FDA) for clinical use in the United States.

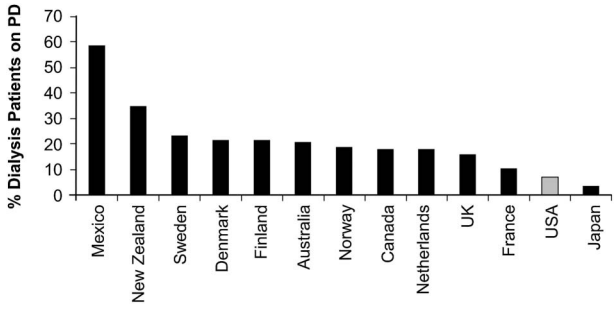

FIGURE 2. Utilization of peritoneal dialysis in various countries. Compared with the United States, many countries use peritoneal dialysis (PD) much more frequently. In countries such as Mexico and Hong Kong, PD is the primary mode of dialysis therapy.

BASIC PHYSIOLOGY OF PD

In PD, 2 major mechanisms, diffusion and convection (UF), are involved in fluid and solute transport across the peritoneum.[13] The 3-pore model of peritoneal transport assumes that capillary endothelium is the major barrier to solute and water transport, which ensues through a system of pores. These pores can be classified into 3 broad categories, ultrasmall, small and large pores.[14–16] The abundant small pores (radius, 40–60 Å) are the tortuous intercellular clefts between the endothelial cells. The ultrasmall pores (radius, 3–5 Å), also present in

TABLE 1. Causes of underutilization of peritoneal dialysis in the United States

Reduced enrollment of CKD patients to PD
Inadequate physician education during residency/fellowship training
Physician bias/lack of enthusiasm
Inadequate pre-ESRD patient education
Lack of infrastructure to sustain PD program
Financial disincentive
Center effect
Increased loss/technique failure
PD-related infections
Ultrafiltration/membrane failure
Mechanical complications of catheter
Inadequate dialysis
Small center size
Psychosocial reasons
Lack of family support
Patient burnout
Relocation
Difficulty in transportation

CKD, chronic kidney disease; PD, peritoneal dialysis; ESRD, end-stage renal disease.