Selection of the initial dialysis modality is crucial in the treatment of end-stage renal disease (ESRD) patients. Several patient- and physician-related factors play important roles in the decision between peritoneal dialysis (PD) and hemodialysis (HD). Although HD is the most common dialysis modality in the United States, in some studies PD has shown a survival advantage over HD, at least in the first 2 years of dialysis treatment, especially in non-diabetic patients and in young patients with diabetes. Other advantages accrue to early PD use in many patients. An integrated care approach with “healthy start” and PD as the initial renal replacement therapy, followed by timely transfer to HD once complications arise, may improve the long-term survival of ESRD patients.

Key words
Hemodialysis (HD), dialysis modality, integrated care approach

Introduction
Initial selection of renal replacement therapy is controversial because of a lack of conclusive guidelines. Thus worldwide disparity exists in the distribution of dialysis modalities (1). In the United States, 87.3% of end-stage renal disease (ESRD) patients are treated with hemodialysis (HD) and only 12.7% with peritoneal dialysis (PD) (2). In a recent survey of American nephrologists, patient preference followed by quality of life were the two most important modality-determining factors, and PD was considered to be underutilized (2). The discussion that follows presents an evidence-based review of the literature to help in decision-making regarding optimal renal replacement therapy.

Discussion
Survival difference between PD and HD
Several studies have compared the survival difference between HD and PD. Using data from the U.S. Renal Data System (USRDS), Bloembergen et al. (3) studied 170,700 prevalent dialysis patients for the period 1987 – 1989 and noted a 19% increased risk of death with PD in patients with and without diabetes, especially older (>55 years of age) patients. However, the study lacked information on incident patients, dialysis dose, and adequacy, and adjusted only for diabetes as a comorbidity.

Fenton et al. (4) later reviewed 11,970 Canadian incident dialysis patients for the period 1990 – 1994 and noted a 27% lower risk of death for PD patients across all age groups in patients with and without diabetes. Similar results were observed (5,6) in the United States by Vonesh et al. (1987 – 1993) and Collins et al. (1994 – 1996). Vonesh reported gradual improvement in mortality with PD and no statistical difference in survival between PD and HD except in older and female patients with diabetes. Collins observed a lower relative risk of death with PD in all except older patients with diabetes. Moreover, Collins noted a survival advantage over HD in the first 2 years of treatment in nondiabetic patients and in younger patients with diabetes.

A recent prospective cohort study involving 1041 incident dialysis patients showed no difference in the adjusted risk of death between the two dialysis modalities in the first year, but an increased risk for PD in the second year of dialysis (7). However, systematic exclusions favored outcomes in HD (8).

Superior outcome with PD in recent years (9) is probably attributable to better preservation of residual renal function (RRF), individualization of the PD prescription, and improved control of hypertension and fluid status with the use of automated PD and colloid osmotic agents (icodextrin).
Factors influencing dialysis modality selection
Several factors play roles in dialysis modality selection, including patient preference, availability of and distance from an in-center dialysis facility, physician knowledge and experience, pre-ESRD education, time of referral to a nephrologist, survival differences, comorbidities, patient characteristics, and non medical factors such as facility and physician reimbursement, dialysis cost, resource availability, social mores, and cultural habits. Also, as Tables I and II show, PD and HD both have some relative and absolute contraindications.

Patient preference
Patient preference for selecting a modality depends on time to referral, pre-dialysis education, and physician comfort level. However, biased information will likely influence the decision. According to the USRDS wave II data, 68% of patients who chose PD were offered HD, but only 25% of HD patients were offered PD as an option (10,11). However, if patients are educated appropriately, 50% will choose PD (12,13).

Comorbidity
In the CHOICE study, comorbidity was less severe in PD than HD, but selection bias was operative, because healthier patients were selected for PD, and HD was recommended preferentially to patients with moderate or severe comorbidities (14). But Vonesh et al. (15) observed no survival advantage in nondiabetic patients and in younger (<45 years of age) diabetic patients with comorbidity, and PD was associated with increased mortality in older (>45 years of age) diabetic patients regardless of comorbidity.

Residual renal function
The importance of RRF for survival on PD was established by the CANUSA study, in which each weekly 5 L of RRF was associated with 5% reduction in relative risk of death (16). By contributing to both small- and middle-molecule clearances, RRF improves dialysis adequacy, facilitates improved fluid balance, allows for more liberal dietary and fluid intake, and reduces the risk of dialysis-related amyloidosis (9). Residual renal function is probably better maintained in PD patients secondary to positive hemodynamic stability, net lower protein losses, a lower cytokine load, and decreased biologically active substances involved with glomerular sclerosis (1,9). However, whether RRF declines more rapidly in patients on automated PD than in those on continuous ambulatory PD remains controversial (17).

Technique survival
Technique survival is lower with PD than with HD (9). Only 50% of patients remain on PD 3 – 5 years after dialysis initiation as compared with 60% – 75% of patients initiated on HD (9,17). Similarly, fewer than 10% of patients remain on PD after 7 years, as compared with 40% – 50% patients who continue on HD (9,17).

Table 1: Indications for peritoneal dialysis (PD)

<table>
<thead>
<tr>
<th>Indication</th>
<th>PD strong choice</th>
<th>PD preferred</th>
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<tbody>
<tr>
<td>Age</td>
<td>0–5 Years</td>
<td>6–16 Years</td>
</tr>
<tr>
<td>Medical</td>
<td>Difficult vascular access</td>
<td>Cardiovascular disease</td>
</tr>
<tr>
<td></td>
<td>Refractory CHF</td>
<td>Hypertension</td>
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<tr>
<td></td>
<td>Prosthetic valvular disease</td>
<td>Chronic disease:</td>
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<td></td>
<td>Problems on HD</td>
<td>Bleeding problems,</td>
</tr>
<tr>
<td></td>
<td>Distance from in-center facility</td>
<td>HIV,</td>
</tr>
<tr>
<td></td>
<td>Strong patient preference</td>
<td>hepatitis B or C</td>
</tr>
<tr>
<td></td>
<td>Strong need for autonomy</td>
<td>Transplant candidate</td>
</tr>
<tr>
<td></td>
<td>Need for independence</td>
<td>Transfusion problem</td>
</tr>
<tr>
<td>Psychosocial</td>
<td>—</td>
<td>Active life</td>
</tr>
<tr>
<td></td>
<td>Variable schedule</td>
<td>Variable schedule</td>
</tr>
<tr>
<td></td>
<td>Need for frequent travel</td>
<td>Need for frequent travel</td>
</tr>
<tr>
<td></td>
<td>Flexible diet</td>
<td>Flexible diet</td>
</tr>
</tbody>
</table>

CHF = congestive heart failure; HD = hemodialysis.
Causes of technique failure on PD include recurrent peritonitis, ultrafiltration (UF) failure, patient or family fatigue or burn out, and severe malnutrition and cachexia (9,17). With the recent reductions in the incidence of peritonitis and better management of UF failure with the use of automated PD and icodextrin, improved technique survival with PD can be hoped for.

**CARDIOVASCULAR DISEASE**

Although PD is, in general, considered advantageous in patients with cardiovascular diseases because of minimal variation in intravascular volume, reduction in cardiovascular stress, and avoidance of peaks and troughs in uremic toxins (9), PD may be detrimental in some patients because of an increased incidence of hypertension and overhydration—features commonly observed in hypervolemic PD patients with the loss of RRF after about 2 years (1). Moreover, elevated serum glucose levels and unfavorable lipid profiles may cause accelerated atherogenesis.

**CONGESTIVE HEART FAILURE**

In congestive heart failure (CHF), PD is advantageous over HD because of arrhythmia prevention, volume stability, and blood pressure control (9). However, in a study involving 107,922 incident dialysis patients, Stack et al. (18) observed a higher adjusted mortality in patients with CHF on PD as compared with similar patients on HD. This study has been criticized for lack of prospective data on RRF, delivered dialysis dose and adequacy, anemia management, nutritional indices, and other cardiac risk factors.

**CORONARY ARTERY DISEASE**

In patients with coronary artery disease (CAD), adjusted mortality was higher for both diabetic and non-diabetic patients on PD, but was equal to HD in nondiabetic patients without CAD (19). It was postulated that HD provides better clearance of atherogenic toxins. However, in a prospective study of 4060 dialysis patients, Locatelli and colleagues observed no difference in the development of cardiovascular disease and in overall survival between PD and HD (20).

Vigorous management of conventional and uremia-related cardiovascular risk factors (malnutrition, inflammation, and atherosclerosis) are required in ESRD patients regardless of the dialysis modality.

**LIPID PROFILE**

A more atherogenic lipoprotein profile—high cholesterol, high triglycerides, low low-density lipoprotein (LDL) cholesterol and low high-density lipoprotein cholesterol—is associated with PD (1.9). However, use of icodextrin may produce a decline in total cholesterol.
and LDL after 6 months (9). A lower cardiovascular mortality was observed in nondiabetic PD patients (9).

PROVIDING ADEQUATE DIALYSIS TO OBSESE ESRD PATIENTS

OBESITY

Providing adequate dialysis to obese ESRD patients is a challenge. Stack et al. reported a survival advantage for HD in diabetic (BMI > 23.5 kg/m²) and non-diabetic (BMI > 30 kg/m²) patients (21). On the other hand, PD was associated with a 47% increased mortality (21).

Higher BMI does not necessarily require a corresponding increase in dialysis dose because body water volume is not proportionately increased; fat tissue does not carry water as muscle tissue does (22). In this patient population, PD is still a viable option if larger exchange volumes of 2.5 – 3 L with APD and 1 – 2 daytime exchanges are used. The advent of icodextrin may further improve outcome in this unique population.

ANEMIA

Higher hemoglobin is maintained in PD perhaps because of better clearance of uremic toxins that inhibit hemoglobin synthesis and erythropoietin production, increased efficacy of erythropoietin, effective erythropoiesis, and higher red cell survival (1). On the other hand, HD contributes to mechanical damage to red blood cells and blood loss (1).

TRANSPLANTATION

The likelihood of transplantation increases by a factor of 1.39 with PD as compared with HD (23). In a French multicenter study, transplantation was more common with PD than with HD as a pre-transplant dialysis modality (24). However, the results were not significant when adjusted for center factor, suggesting center bias, because PD patients were more likely to be registered in centers with the shortest waiting time.

In another study, pre-transplant PD patients had a lower risk of graft failure and increased recipient survival (25). Moreover, the incidence of acute renal failure and delayed graft function was reported to be lower with PD as the pre-transplant dialysis modality (26). Thus, PD as a dialysis modality was a predictor of early graft function independent of fluid-balance parameters and cold ischemia time.

Evidence therefore supports PD as a better pre-transplant dialysis modality.

PREGNANCY

According to the registry of pregnancy in dialysis patients, the likelihood of conception is lower on PD than on HD, suggesting that the presence of intraperitoneal hypertonic dialysate interferes with the transport of ova to the fallopian tubes in PD patients (27). However, infant survival and degree of prematurity were not statistically different between the two dialysis modalities. Although infant survival on dialysis is approximately 42%, survival exceeds 73% if conception occurs before the onset of renal replacement therapy (28). After conception, there is no preferred dialysis modality (27).

Longer and intensive dialysis is indicated in pregnant ESRD patients. A trend toward better survival is seen with more than 20 hours per week of HD (27) and with a Kt/V of 2.2 – 2.6 in pregnant PD patients, however definitive data are scarce (28).

Successful pregnancies on PD with aggressive dialysis using APD with increased volumes (12.8 – 14.4 L) have been reported. Exchange volumes as high as 20 – 22 L can be found in the literature (28); however, pregnant PD patients are usually switched to HD during the last trimester when the fetus and the expanded uterus occupy much of the available intra-abdominal space.

COST

In general, PD is more cost-effective and hence more economical than HD across all age groups. Shih et al. (29) reported that the annual Medicare expenditure per patient starting renal replacement therapy was $56,807 with PD and $68,253 with HD (p < 0.001). Annual expenditure was also low for a switch to HD from PD after the first year. Thus overall, PD had a 23% – 27% lower annual Medicare expenditure (29).

Integrated care approach

Based on the survival advantages with PD in some patients (especially in the first 2 years of dialysis), the better quality of life, the cost savings, and the fact that a switch to HD is feasible when necessary, a PD-first integrated care approach had been proposed to ensure optimum care of ESRD patients (1,9,11,17). This approach involves early nephrology referral, opportunity for full chronic kidney disease education, and choice of PD as the initial modality. It preserves vascular access and RRF, and provides early and good control of anemia and blood pressure (17). A timely
transfer to HD before the onset of complications is imperative to minimize the increased mortality associated with late transfers (17).

A recent comparison between PD, HD, and integrated care demonstrated that 5-year survival was significantly higher for the integrated care group than for the PD group and was comparable to the 5-year survival for the HD group. These promising results suggest the importance of timely transfer (30), but need to be confirmed in large prospective trials.

Conclusions
We can conclude that, although patient preference plays an important role in selection of initial dialysis modality, most patients are not educated about PD benefits. For many patients, PD is preferable in early treatment, given the better quality of life, the better psychosocial adaptation, the higher levels of subjective wellbeing, the sparing of vascular access, and the better preservation of RRF. Peritoneal dialysis is especially effective for transplant candidates. Used in an integrated PD–HD program, PD can be followed by a timely transfer to HD once complications arise.

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