# Successful Peritoneal Dialysis in Large-Weight Subjects: Clinical Features and Comparisons with Normal-Weight Subjects

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*Peritoneal dialysis (PD) obviates the need for temporary vascular access in end-stage renal disease; however, extremely heavy weight has been viewed as a relative contraindication to PD.*

*We performed a cross-sectional review of multiple clinical and laboratory variables for 75 current or past PD patients (vintage > 6 months), comparing dialysis adequacy parameters for those with a large body weight (>100 kg, LWS group) and with a normal body weight (<75 kg, NWS group).*

*In the LWS group (*n *= 17), mean weight was 117.2 ± 15.7 kg, and mean body mass index (BMI) was 37.2 ± 6.3 kg/m$^2$; in the NWS group (*n *= 33), mean weight was 63.2 ± 9.2 kg, and mean BMI was 25.3 ± 4.5 kg/m$^2$. Despite the marked differences in weight and BMI between the groups (both* p *< 0.0001), achieved Kt/V was adequate, although marginally less, in large subjects (1.96 ± 0.29 for the LWS group vs. 2.22 ± 0.47 for the NWS group,* p *= 0.022), and weekly global creatinine clearance was significantly better in the LWS group (92.5 ± 43.5 L/1.73 m$^2$ vs. 62.2 ± 27.5 L/1.73 m$^2$,* p *= 0.016). The total daily exchange volume was approximately 30% higher in the LWS group (12.8 ± 2.5 L vs. 9.9 ± 2.2 L,* p *< 0.0001). Residual creatinine clearance (*p *= 0.224) and residual urine output (*p *= 0.125) were similar and did not seem to influence the results. Compared with their LWS counterparts, members of the NWS group were more likely to have higher iron saturation (*p *= 0.053) and serum ferritin (*p *= 0.004), but lower achieved hemoglobin (*p *= 0.055).*

*Successful PD is feasible in larger-weight individuals; however, given the retrospective nature of the present study, prospective trials are needed to confirm that observation.*

**Key words**
Body mass index, creatinine clearance, dialysis adequacy, end-stage renal disease, obesity, residual renal function

## Introduction

In chronic kidney disease patients reaching end-stage renal disease, the lack of pre-existing arteriovenous access (arteriovenous fistula) is a frequent concern when deciding between modalities of renal dialysis (1,2). Immediate start with hemodialysis (HD) requires placement of a temporary vascular access (3), with the attendant risks of infection, malfunction, and bleeding (4–6); injury to major vessels; pneumothorax; and long-term dependency on vascular catheters (7).

Peritoneal dialysis (PD) obviates the need for placement of a temporary vascular access, but extremely heavy weight or marked obesity has been viewed as a relative contraindication to PD. Large patients on PD would have inherent difficulty in achieving weekly creatinine clearance and urea Kt/V targets considered adequate by the Kidney Disease Outcomes Quality Initiative guidelines, especially when anuric (8,9). Earlier studies describe multiple factors predicting avoidance of PD, including worsening of obesity, high serum triglycerides, inadequate solute clearance, abdominal herniation, catheter infection, and peritonitis (10). However, over recent years, the use of higher exchange volumes and the

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more frequent use of automated PD with a cycler have allowed better clearances to be achieved in obese patients (8). Obesity does not necessarily mean a large body size, and a distinct question is the impact of large body size on PD.

The purpose of the present study was to examine and compare exogenous and endogenous clearances for large-weight subjects [LWS (>100 kg)] and normal-weight subjects [NWS (<75 kg)] managed through our outpatient home dialysis unit. Our hypothesis was that the LWS group could achieve acceptable clearances with current regimens. Given the enormous effect of residual renal function in PD (11), we also examined the contribution of residual renal function to global creatinine clearances in this setting.

## Methods

*Study population*

The Jackson Medical Mall Home Dialysis Unit, located in Jackson, Mississippi, an inner-city area, follows a large cohort of patients dialyzing at home (predominantly using PD). Full details of the cohort have been published elsewhere (12). The present study collected cross-sectional data for current and past patients dialyzing at the Unit between March 1, 2004, and June 30, 2015, if they had been on PD for at least 6 months without major interruption. For the study, we collected demographic, anthropometric, and biochemical data.

For current (prevalent) patients, we recorded data from the most recent 3 months; for past (former) PD patients, we examined their last 3-month period, excluding the final month of PD before modality failure or transfer. The study was reviewed and approved by the University of Mississippi Medical Center Human Research Office (IRB protocol 2014-0073).

*Measurements*

We recorded weight, body mass index (BMI), dialysis adequacy, and multiple clinical and laboratory variables. The anthropometric data and clinical characteristics were recorded at the 1st month of the data collection period. We also recorded data about age, race, sex, current smoking, past medical history, and duration of renal replacement therapy on PD at the time of data collection. Dry weight was the physician-prescribed ideal weight. In terms of past medical history, type 1 and 2 diabetes mellitus were both recorded if documented or if the patient received antidiabetic medications. Smoking was noted if active smoking was recorded on the chart in any form or amount. Information about dialysis modality was recorded (continuous ambulatory vs. cycler-assisted PD), total volume of dialysis exchanges, and adequacy parameters on PD [Kt/V, global creatinine clearance, residual urine output (RUO), and residual creatinine clearance].

General biochemistry data were recorded as the average of the values obtained during the 3-month period examined. Those data included general serum biochemistry (potassium, bicarbonate, calcium, phosphorus); iron saturation; albumin; and hemoglobin. When more than a single value was available for the month, we entered the first value obtained from the monthly biochemical panel evaluation as part of capitated ESRD care provided. Other parameters (parathyroid hormone level, ferritin, iron studies) were available only once during the 3-month period.

Exclusion criteria for the study included home modality other than PD (for example, home HD), dialysis vintage less than 6 months, and age less than 18 years. No additional tests were performed as part of this retrospective study.

*Statistical methods*

Data were collected into Microsoft Excel (Office 2010: Microsoft, Redmond, WA, U.S.A.). Statistical analyses were performed using the IBM SPSS Statistics software application (version 22: IBM, Armonk, NY, U.S.A.). Descriptive data are reported as means ± standard deviation, medians with 25%–75% percentiles, or percentages, as appropriate. We reviewed dialysis adequacy parameters for the LWS group and compared them with parameters for the NWS group. The relationships between the various parameters were examined using the Pearson chi-square or the independent samples t-test.

## Results

Table I shows baseline demographics for the entire cohort. Of the 50 analyzed patients, 17 weighed 100 kg or more, and 33 weighed 75 kg or less. In the LWS group, mean weight was 117.2 ± 15.7 kg and mean BMI was 37.2 ± 6.3 kg/m$^2$; 70.6% were African American, 23.5% were women, and 47.1% had diabetes. Age was 46.6 ± 10 years, with a PD vintage of 21.5 ± 18.2 months.

TABLE I Overall cohort characteristics

| *Characteristic* | *Value* |
|---|---|
| Patients (*n*) | 75 |
| Mean age (years) | 49.2±14.7 |
| Ethnicity [*n* (%) African American] | 73.3 |
| Mean weight (kg) | 83.1±23.5 |
| Mean BMI (kg/m$^2$) | 29.5±6.7 |
| Sex [*n* (%) women] | 57.3 |
| With diabetes (%) | 48 |
| Active smoker (%) | 25.7 |
| PD modality (%) | |
| CAPD | 21.3 |
| APD | 78.7 |
| Mean PD vintage (months) | 28.2±24.3 |

BMI = body mass index; PD = peritoneal dialysis; CAPD = continuous ambulatory peritoneal dialysis; APD = automated peritoneal dialysis.

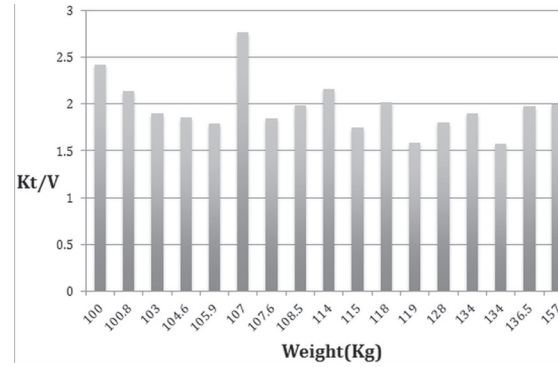


FIGURE 1 Plot of Kt/V by weight in large peritoneal dialysis patients (>100 kg).

Table II presents detailed characteristics of the subcohorts, together with PD adequacy variables. In the LWS group, weekly Kt/V (Figure 1) was 1.96 ± 0.29, and weekly creatinine clearance was 92.5 ± 43.5 L/1.73 m$^2$, with a total exchange volume of 12.8 ± 2.5 L. The RUO in this group measured 597 ± 594 mL, and weekly residual creatinine clearance was 43.3 ± 46.4 L/1.73 m$^2$.

The NWS group had a mean weight of 63.2 ± 9.2 kg and a mean BMI of 25.2 ± 4.5 kg/m$^2$ (Table II). Despite the marked and large differences in both weight and BMI (both $p < 0.001$), the difference in achieved Kt/V in the NWS group (2.22 ± 0.47, $p = 0.020$) was less striking; weekly global creatinine clearance was more so (62.2 ± 27.5 L/1.73 m$^2$, $p = 0.004$).

The higher weekly creatinine clearance in the LWS group compared with the NWS group (Figure 2) was not explained by weekly residual creatinine clearance ($p = 0.224$) and RUO ($p = 0.125$), even though nominally higher values were observed in the LWS group. Exchange volumes were approximately 30% greater in the LWS group (12.8 ± 2.5 L vs. 9.9 ± 2.2 L, $p < 0.0001$, Figure 3).

Members of the LWS group were more likely to be men ($p < 0.0001$). No differences were observed in terms of race, diabetes, membrane transport characteristics, or PD modality (cycler-assisted vs. manual exchanges). With respect to the biochemical parameters listed in Table II, iron saturation ($p = 0.53$) and serum ferritin ($p = 0.004$) were more likely to be higher in members of the NWS group than in members of the LWS group, but achieved hemoglobin was lower ($p = 0.048$). No differences were observed in serum albumin, calcium, phosphorus, and parathyroid hormone.

## Discussion and Conclusions

The State of Mississippi has an obesity epidemic that leads our nation (13), but obesity does not necessarily imply a very large body size. The impact of obesity is certainly a well-recognized subject in ESRD. Multiple survival studies (10,14–17) in obese patients on PD have been reported, but only a very few articles report adequacy of solute clearance in obese patients (18,19). Most studies have reported a survival advantage for PD in obese patients (16,20–22). A recent systematic review and meta-analysis of more than 150,000 subjects seemed to confirm at least neutrality for a large BMI with respect to survival, even over the long term (23). The survival advantages in these patients are seen mostly because of better preservation of renal function, hemodynamic stability, higher hemoglobin concentration, and lesser risk of acquiring a blood-borne infection (14,21,24–26). One study from Hong Kong associated large body size with decreased survival, although the exact mechanism remained not well explained (27).

Obese patients might not be offered PD for multiple reasons, including concern about inadequate solute clearance or ultrafiltration, clinician inexperience, and concerns about catheter leaks, exit-site infection, and PD peritonitis. In a national survey, Shibagaki *et al.*

TABLE II Comparison of the characteristics[a] of large- and regular-size subjects

| *Characteristic* | *Patient group* | | p *Value* |
|---|---|---|---|
| | *Large (>100 kg)* | *Regular (<75 kg)* | |
| Patients (*n*) | 17 | 33 | |
| Age (years) | 46.6±10 | 49±17 | 0.547 |
| Ethnicity [*n* (%) African American] | 70.6 | 84.8 | 0.38 |
| Weight (kg) | 117.2±15.7 | 63.2±9.2 | <0.0001 |
| BMI (kg/m$^2$) | 37.2±6.3 | 25.3±4.5 | <0.0001 |
| Sex [*n* (%) women] | 23.5 | 84.8 | <0.001 |
| With diabetes (%) | 47.1 | 54.5 | 0.61 |
| Active smoker (%) | 37.5 | 12.1 | 0.03 |
| PD modality (%): | | | |
| CAPD | 11.8 | 21.2 | 0.41 |
| APD | 88.2 | 78.8 | |
| PD vintage (months) | 21.5±18.2 | 27.1±25.6 | 0.42 |
| Total daily exchange volume (L) | 12.87±2.53 | 9.95±2.29 | <0.001 |
| Transport type (%)[b] | | | |
| High | 0 | 15.4 | 0.36 |
| High average | 71.4 | 53.8 | |
| Low average | 28.6 | 26.9 | |
| Low | 0 | 3.8 | |
| Weekly Kt/V | 1.96±0.29) | 2.22±0.47) | 0.022 |
| Weekly CCr (L/1.73 m$^2$) | 92.5±43.6 | 62.2±27.5 | 0.016 |
| Residual urine output (mL) | | | |
| Mean | 597±594 | 335±467 | 0.125 |
| Median | 450 | 225 | |
| IQR | 0–1000 | 0–400 | |
| Residual weekly CCr (L/1.73 m$^2$) | | | |
| Mean | 43.3±46.4 | 26±46.8 | 0.224 |
| Median | 33.2 | 12 | |
| IQR | 0–85 | 0–32 | |
| Serum albumin (g/L)[c] | 37.5±2.5 | 35.8±11.3 | 0.58 |
| Serum potassium (mmol/L)[c] | 3.9±0.3 | 4.1±0.4 | 0.14 |
| Serum bicarbonate (mmol/L)[c] | 24±2.4 | 25.7±2.9 | 0.03 |
| Corrected calcium (mmol/L)[c] | 2.30±0.18 | 2.30±0.15 | 0.88 |
| Phosphorus (mmol/L)[c] | 1.58±0.23 | 1.62±0.39 | 0.77 |
| Serum iron (mm/L)[c] | 12.8±2.27 | 13.4±4.39 | 0.24 |
| Serum iron saturation (%)[c] | 26.8±4.9 | 50.4±48.9 | 0.053 |
| Ferritin (pmol/L) | 921±422 | 1642±919 | 0.004 |
| Hemoglobin (g/L)[c] | 109±9 | 103±10 | 0.055 |
| Weekly ESA[d] dose (mg) | 107±283 | 42±43 | 0.359 |
| iPTH [mg/mL (normal: 15–65)] | 622±460 | 540±310 | 0.457 |

BMI = body mass index; PD = peritoneal dialysis; CAPD = continuous ambulatory peritoneal dialysis; APD = automated peritoneal dialysis; CCr = creatinine clearance; IQR = interquartile range; ESA = erythropoiesis-stimulating agent; iPTH = intact parathyroid hormone.

[a] Results are expressed as mean and standard deviation for continuous variables, and frequencies and percentages for categorical values. Associations between variables were examined using the independent samples t-test for continuous variables and the Pearson chi-square for categorical variables.

[b] Missing data in 21.3%.

[c] Three-month average.

[d] Darbepoetin or equivalent.

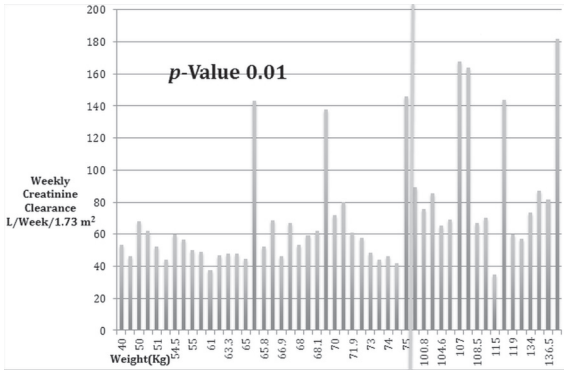


FIGURE 2 Plot of creatinine clearance in large and regular-sized peritoneal dialysis patients. (The full-length bar marks the division between the groups.)

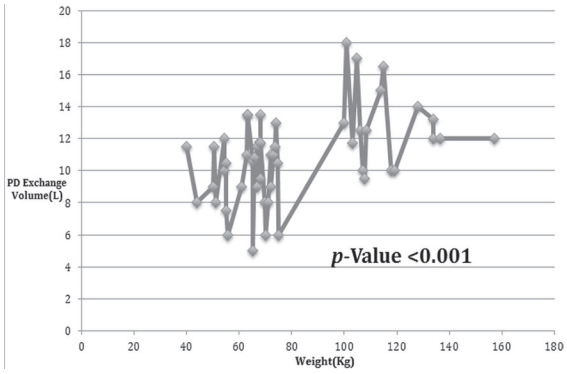


FIGURE 3 Plot of total daily peritoneal dialysis exchange volume (liters) by body weight.

reported that only 28% of patients with a weight greater than 91 kg were recommended for PD, compared with 44% of patients with a weight less than 91 kg (8). In another study of dialysis patients reported by Chaudhary *et al.,* 66% of incident dialysis patients were not presented with the option of PD at the initiation of dialysis or thereafter (30). In the present study, we found better weekly creatinine clearance in the LWS group than in the NWS group—a difference that was not sufficiently explained by RUO or weekly residual creatinine clearance. Overall, members of the LWS group were almost double the size of the NWS group members (63.2 ± 9.2 kg vs. 117.2 ± 15.7 kg), but used only 30% more PD fluid. One potential explanation is that some of the large body size could be attributed to obesity and increased fat mass in general, which is anhydrous (that is, LWS group members had less total body water) and does not participate in the blood urea nitrogen water space (8). Again notably, the overlap between large body size and obesity is not perfect, especially when BMI is used as the benchmark. Bioimpedance technology has the potential for detailing the exact body fat mass and water compartments in ESRD patients (32,33), but remains underutilized (34,35).

Our largest study subject (160 kg in weight) provides an illustrative example for the cohort: he had a short PD vintage of only 7 months; he had a weekly Kt/V of 2 and a weekly creatinine clearance of 182 L, including a weekly residual clearance of 132 L and a daily RUO of 1700 mL. In such subjects, PD is a way of avoiding temporary vascular access placement and a "bridge" toward successful arteriovenous fistula placement or renal transplantation (2,36). But one related concern is the general reluctance of transplant programs to accept subjects with massive obesity, a practice that has been challenged (37,38).

Although small-solute clearance has been thought to be an important predictor of survival in PD (20,39), neither the ADEMEX (40) nor the Hong Kong study showed an improvement in survival when Kt/V urea was raised above the currently recommended 1.7 in the Kidney Disease Outcomes Quality Initiative guidelines, which was easily achieved in almost 90% of our LWS group, even though 9 of 17 patients were anuric. Iron saturation was low in the LWS group, possibly because of upregulation of hepcidin in obesity with a chronic inflammatory state; however, that phenomenon was unlikely to explain a lower serum ferritin in the LWS group. Another explanation of the higher iron in normal-sized subjects is the protocol administration of maintenance and loading doses of intravenous iron in our unit, which does not account for the subject's weight—that is, members of the LWS and NWS groups all received the same dose.

Economics for PD have been very impressive. Per-person, per-year Medicare ESRD costs for HD and PD in 2010 were $87,561 and $66,751 respectively (40,41). Costs for erythropoiesis-stimulating agents are higher for HD patients than for PD patients (17), and higher in black and African American individuals than in white individuals (42). Overall, care costs were $5,885 and $6,334 less per year for PD patients than for HD patients (white, and black or African American respectively), and costs for erythropoiesis-stimulating agents were $2,441 and $1,908 lower

(42). One potential modifier to that statement is the likely cost-saving effect of subcutaneous dosing of recombinant erythropoietin in obese subjects (43). The foregoing differences all provide clear incentives under the bundled payment system to consider the use of PD in all patients, including in very large subjects, in whom the modality might be underutilized. Of all ESRD patients, more than 10 times as many receive HD treatments at a clinic as perform home PD and home HD combined (42). In spite of well-known increasing risks of PD peritonitis with African American race and low socioeconomic and health care literacy status (common in our service area), the incidence of peritonitis in our program is an acceptable 1 in 33 patient–care months.

To conclude, the present study does not support a selective disadvantage of large weight to the successful achievement of PD, especially in new starts with maintained residual renal function, who should be considered for PD. However, prospective trials are needed to confirm the conclusions of our study.

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