A model to estimate glucose absorption in peritoneal dialysis: A pilot study

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Abstract

Background: Glucose absorption in peritoneal dialysis (PD) patients may contribute to adverse metabolic effects. Previous studies on glucose absorption were done on continuous ambulatory PD (CAPD) patients, with long dwell time. However, the growing majority of contemporary PD patients perform automated peritoneal dialysis with short dwell time. Moreover, membrane characteristics and dwell time determine small solute transport across the peritoneal membrane.

Methods: In our pilot study, we used data from peritoneal equilibration test (PET) to develop a model to estimate glucose absorption. In six randomly selected PD patients, we calculated actual glucose absorption from directly measuring effluent glucose concentration. We then used R programming language to create non-linear least squared regression model inputting PET data, D2/D0 and D4/D0 to generate exponential decay curve. This model was then utilized to estimate the fraction of glucose remaining in the dialysate at a particular dwell time t (Dt/D0). Daily glucose absorption was calculated by multiplying 1-Dt/D0 with the amount of glucose the patient was exposed to in 24 hours.

Results: We observed the mean glucose absorption (89.7 ± 28.8 g/d) as measured from the effluent very close to our estimate (88.12 ± 28.9 g/d) and the difference between the glucose estimation and actual absorption was not statistically significant (p>0.05). After validating our hypothesis, we randomly selected an independent cohort of 11 ESRD patients on various PD modalities and analyzed the data. We observed that mean daily glucose absorption of 62.7 ± 24.5 g (27.98-110.35 g), much lower than that reported in the literature and depends upon dwell times and membrane characteristics in addition of amount of glucose exposure.

Conclusions: Our model provides a simple tool to estimate glucose absorption and caloric load in contemporary PD patients. Hopefully, accurate estimation of caloric load and incorporating it in the
daily caloric intake of the individual will help to reduce metabolic consequences of hyperglycemia and weight gain and improve overall outcomes of PD.

Introduction:

Peritoneal dialysis (PD) patients are exposed to high concentration of glucose in the dialysate and glucose absorption may contribute to adverse metabolic effects such as hyperglycemia, hyperlipidemia, hyperinsulinemia and obesity. Most studies on glucose absorption have been performed on continuous ambulatory peritoneal dialysis (CAPD) patients with long dwell times (1,2). Grodstein et al (1) studied glucose absorption in seven patients and concluded that glucose absorption is proportional to the amount glucose exposed in peritoneal dialysis fluid. They estimated daily glucose absorption of 100 to 300 g, amounting to approximately to 400-1200 calories per day. Unlike CAPD patients examined in earlier studies, growing majority of contemporary PD patients in the United States perform automated peritoneal dialysis (APD) with short dwell time (3). In 2017, 56% of all PD patients in the United States utilized APD, while 44% patients were on CAPD (3). Moreover, it has now become evident that in addition to amount of glucose exposure, membrane characteristics and dwell time determine small solute transport across the peritoneal membrane (4). Hence, a new method of estimating glucose absorption in contemporary PD patients is needed. In our pilot study, we have used data from peritoneal equilibration test (PET) to develop a simple model to estimate glucose absorption.
**Materials & Methods:**

To develop a model to estimate glucose absorption in PD, we randomly selected 6 stable patients undergoing PD at our center (Table 1). These patients were on various PD modalities: 1 Continuous ambulatory peritoneal dialysis (CAPD), and 5 automated peritoneal dialysis patients (APD). Medical charts were reviewed to retrieve data on their PD prescriptions including the PD schedule, fill volumes, dwell times and the dialysate dextrose concentration used. Additionally, PET data, including D2/D0 and D4/D0 values were obtained. D0 is the dialysate glucose concentration (mg/dl) at the beginning of the PET study and D2 and D4 are dialysate glucose concentrations at 2 hours and 4 hours of the dwell respectively (5). Furthermore, glucose concentration in the pooled 24 hour-dialysate effluent sample was obtained. Actual glucose absorption in a day was determined by calculating the difference between the amount of glucose instilled and that in the pooled 24-hour effluent (see Appendix 1 for an example).

We then developed an exponential decay model based upon the PET data (D2/D0 and D4/D0) to estimate daily glucose absorption in these patients. A non-linear least squared error model was created in the R programming language. Input data was taken through a user prompt, inquiring upon PD diagnostic glucose absorption proportions at 2 hours and 4 hours (D2/D0 and D4/D0 respectively) based upon their PET studies. The program utilizes least squared residual software and runs through multiple
iterations of fitting an exponential curve, \( y = e^{(a+bx)} \) where \( y \) is the proportion of glucose in the dialysate, \( x \) is the dwell time in minutes that is attached to a variable, \( b \), and a noise (lurking) variable, \( a \), to account for the variance of residuals (6). Once error is minimized, the new, optimized equation is used to return an estimate for the proportion of glucose (Dt/D0) at the requested dwell times of interest \( t \) (Fig.1). The proportion of glucose absorbed at a particular dwell time \( t \) was calculated as 1-Dt/D0. Total amount of glucose absorbed in a day was calculated by multiplying 1-Dt/D0 with the total amount of glucose the patient was exposed to in 24 hours. Patients with multiple dwell times in their daily PD prescriptions (t1, t2, t3, etc) will have corresponding Dt1/D0, Dt2/D0, Dt3/D0 values (See appendix 2, 3 for examples). To investigate the effect of glucose concentration in the dialysate on the rate of glucose absorption, PET was performed in a patient using dialysates with two different concentrations of dextrose (1.5 % and 2.5 %).

Once our model was validated in aforementioned 6 patients, we selected 11 additional ESRD patients undergoing peritoneal dialysis at our center to estimate glucose absorption. Medical records were reviewed to obtain clinical, demographic and laboratory data. PD prescriptions including PD schedules, number of exchanges, fill volumes and dwell times for each exchange, strength of dextrose in each bag and total fill volumes for 24 hours were recorded. PET data was retrieved, and the estimated glucose absorption was calculated using our model as mentioned previously (figure 2).

Statistical methods: Mean and standard deviation of estimated glucose absorbed was calculated in validation and independent cohort. We have also calculated mean and standard deviation of estimated glucose absorption as described by Grodstein in our validation cohort to compare and contrast. Wilcoxon-Rank-Sum Test was used to compare the results obtained by direct measurement of glucose absorption with that estimated by our model (7). In addition, scatter chart was plotted using the values of direct glucose absorption versus those estimated by our model (figure 3).
The study was approved by the institutional review board of the University of Texas Southwestern Medical Center.

Results:

Six patients on various peritoneal dialysis prescriptions were included in our validation study. Demographic and other clinical data is shown in Table 1. We observed that the estimation of glucose with our model (mean 88.12 ± 28.9 g/d) was almost like actual glucose absorption (mean 89.78 ± 28.8 g/d) as measured from effluent (figure 3). The difference between the glucose estimation and actual absorption was not statistically significant (p>0.05). We also estimated glucose absorption based upon linear regression equation \( Y = 11.3 \times - 10.9 \), where \( Y \) is the glucose absorption (g/L) and \( x \), concentration of glucose in the dialysate (g/dL/day), as described by Grodstein, et al(1). In contrast to our model, the equation described by Grodstein, et al grossly overestimated glucose absorption (Mean 140.48 ± 28.8 g/d).

Once our results were validated in 6 patients, we selected 11 additional patients to estimate glucose absorption using our model. Clinical characteristics and demographics of the 11 patients are outlined in table 2. Patients were on PD for a period of one to seven years. Seven patients used dialysate bags with single dextrose concentration while remaining used bags with different dextrose concentrations. Dwell times on the cycler ranged from 80 – 105 minutes, while that on manual exchanges ranged from 3-4 hours. Total daily glucose exposure on an average was 156.9 ± 41.75 g and ranged from 108.8 – 245.29 g. Mean daily glucose absorption was 62.7 ± 24.5 g (range 27.98-110.35 g), as outlined in table 3. The corresponding average daily calories were 223.4 ± 78.1 and ranged from 107.23-312.02 in APD patients. The CAPD patient’s daily caloric load was 424.85. For calories derived from absorption of glucose the value 3.85 kcal/g of anhydrous dextrose absorbed was used (8).
To determine, whether different glucose concentrations in the dialysate affects the rate of glucose absorption, PET was performed in a patient using dialysates with two different dextrose concentrations of 1.5 % and 2.5 %. The data from the two studies was found to be near identical (figure 4).

Further analysis of our data showed that amount of glucose absorption depends on the amount of glucose exposure in many patients (ID 7,8,9,10,11) (table 3). However, in some instances, patients with lower glucose exposure (ID 17) had higher glucose absorption compared to patients with higher glucose exposure (ID 16) (Table 3). On the other hand some patients with similar glucose exposure (140.6 ± 4g) and similar membrane characteristics (ID 17 and 7) had different amounts of glucose absorption (110.35 g and 76.85 g respectively) largely due to different dwell times (Table 3). Finally, patients with ID-9 and ID-13 had similar glucose exposure (181.6g) and similar dwell times (90 minutes) but had different glucose absorption (68.29 g vs 53.28 g respectively) due to different membrane transport characteristics. By the same token, lower membrane transport status of our CAPD patient (Case 1, Table 1) likely led to overestimation of glucose absorption by Grodstein’s linear regression equation when compared with estimation by our model.

**Discussion:**

Conventional PD solutions contain glucose as the osmotic agent to provide ultrafiltration. However, various quantity of glucose is absorbed from the dialysate into the bloodstream. While providing a source of energy, glucose absorption can be associated with dire metabolic consequences and attendant adverse cardiovascular outcomes (9). Due to logistic constraints, it is quite cumbersome to directly measure glucose absorption during PD. Concomitantly, limited data is available on estimation of glucose absorption in contemporary PD patients. Grodstein, et al studied peritoneal absorption in 7 CAPD patients with long and fixed dwell time using 1.5% and 4.25% dextrose dialysate solutions and observed
a large quantities of daily glucose absorption (182 ± 61 g) during CAPD (1). They observed a high
correlation between the amount of glucose absorbed and the average concentration of glucose in the
dialysate and predicted that glucose absorption in CAPD patients with long and fixed dwell time solely
depends on one variable, the amount of glucose in the dialysate. However, it is now evident that in
addition to the tonicity of dialysate, glucose absorption depends upon peritoneal membrane transport
characteristics and dwell time (4,10). Heimburger, et al studying diffusion mass transport properties of
the small solutes, including glucose, in 41 CAPD patients (4 exchanges of 2 Liters-6hours dwell) using
conventional dextrose dialysate solutions, showed that glucose absorption during a PD dwell is
exponential and the fractional absorption of glucose in a patient is similar with different tonicity of the
dialysate (4). Similar results were discerned in our study. On performing PET using 2 different dextrose
concentrations (1.5% and 2.5%), the percentage absorption of glucose over time was near identical with
both solutions (Fig. 4). Heimburger and co-workers further observed that on an average, 75% of the
initial intraperitoneal glucose amount is absorbed by the end of 6 hours, with 50% of the absorbed
glucose ensuing in the first 90 minutes. Additionally, they noted that total amount of daily glucose
absorption ranged from 80-220 g in CAPD patients by direct measurement depending upon the
concentration of glucose in the dialysate (4).

In contrast to the aforementioned studies, contemporary patients use night-time cyclers with short and
variable dwell times. Moreover, unlike CAPD patients, many patients on cyclers use dialysate bags with
different tonicities that allow admixture of dialysate solutions with different glucose concentrations.
Hence, a novel method to estimate glucose absorption in contemporary PD patients is needed.

In our pilot study, we developed an exponential decay model using PET data to estimate glucose
absorption in PD patients. It accurately estimated glucose absorption, in contrast to the model used by
Grodstein, et al that predictably overestimated the glucose absorption in our patients, who mainly used
cyclers with short and variable dwell times. While, in concurrence with Grodstein, et al several patients
showed correlation between glucose absorption and the amount of glucose in the dialysate, there were
instances when patients with higher glucose exposure actually had lower glucose absorption despite
similar dwell times, likely due to difference in membrane transport characteristics (1) (Table 3). Likewise,
we also observed the reverse situation when some patients with lower glucose exposure than others
had higher glucose absorption, mainly due either to longer dwell times or difference in membrane
transport characteristics (Table 3). Overall, the daily amount of glucose absorption and the consequent
caloric load was much lower in our patients compared to that observed in earlier studies, which were
done in CAPD patients (1,4,11,12). Lower glucose absorption in contemporary PD patients using cycler
is likely because of lower dwell times and avoidance of 4.25% dextrose dialysate solutions.

Our study provides a simple tool to estimate glucose absorption and caloric load in contemporary PD
patients and takes into consideration factors including membrane transport characteristics, dwell time
and glucose exposure, that play an important role in glucose absorption. While direct measurement of
the glucose from the effluent is the most accurate way to measure glucose absorption, this method is
cumbersome and has logistical constraints. Glucose is not routinely measured in the effluent during the
quarterly KT/V estimations, and requires a separate order set. Moreover, patients may use dialysate
bags with different tonicities on their daily PD schedules. Additionally, patients on APD often connect
dialysate bags of different tonicity in variable orders to the cyclers on day-to-day basis. Hence, direct
measurement of effluent glucose will require multiple collections of the effluents reflecting
corresponding combinations and sequences of bags used. Our model obviates such need and is able to
estimate glucose absorption in all ensuing settings. Our study is limited in its small size. We plan to
extend the study to include our entire cohort of more than 150 patients. In addition we plan to develop
web-based and smart phone applications for easy use by the physicians, advanced practice providers,
dietitians and eventually by patients. Hopefully, accurate estimation of caloric load and incorporating it
in the daily caloric intake of the individual will help to reduce metabolic consequences of hyperglycemia, hyperlipidemia and weight gain (13,14) and improve overall outcomes of PD.

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**Author Contributions:**

SK Kotla: Conceptualization; Data curation; Formal analysis; Funding acquisition; Methodology; Writing - original draft; Writing - review and editing

A Saxena: Methodology; Software

R Saxena: Conceptualization; Formal analysis; Funding acquisition; Methodology; Writing - original draft
References:


Table 1: Glucose absorption in six patients on peritoneal dialysis with actual glucose absorption as measured from effluent depicted in green font. Estimated glucose absorption using our model depicted in orange font and that of Grodsteins depicted in blue font.

<table>
<thead>
<tr>
<th>Patient ID</th>
<th>Age (Years)</th>
<th>Sex</th>
<th>Race</th>
<th>PD RX</th>
<th>Bag 1 Dxtrose%</th>
<th>Bag 2 Dxtrose%</th>
<th>Fill volume in Liters</th>
<th>Initial glucose amount in grams</th>
<th>Final Glucose concentration in effluent (mg/dl)</th>
<th>Effluent Volume (ml)</th>
<th>Glucose absorption based on direct glucose measurement in the effluent (grams)</th>
<th>Glucose absorption based on our model (grams)</th>
<th>Glucose absorption based on Grodsteins equation $Y = 11.3x - 10.9$ (grams)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>65</td>
<td>F</td>
<td>AA</td>
<td>CAPD 4 X 2.5 L</td>
<td>2.5</td>
<td>2.5</td>
<td>10</td>
<td>227</td>
<td>690</td>
<td>11600</td>
<td>146.9</td>
<td>136.2</td>
<td>171.1</td>
</tr>
<tr>
<td>2</td>
<td>44</td>
<td>M</td>
<td>C</td>
<td>NIPD 4 X 2.5 L</td>
<td>2.5</td>
<td>2.5</td>
<td>10</td>
<td>227</td>
<td>1167</td>
<td>12341</td>
<td>84.32</td>
<td>88.53</td>
<td>181.3</td>
</tr>
<tr>
<td>3</td>
<td>41</td>
<td>F</td>
<td>AA</td>
<td>NIPD 3 X 2L</td>
<td>2.5</td>
<td>2.5</td>
<td>6</td>
<td>136.2</td>
<td>1134</td>
<td>6877</td>
<td>59.08</td>
<td>54.48</td>
<td>99.6</td>
</tr>
<tr>
<td>4</td>
<td>86</td>
<td>M</td>
<td>C</td>
<td>CCPD 4 X 2.5L, LF 2.5L</td>
<td>2.5</td>
<td>1.5 #BAG 3 1.5</td>
<td>12.5</td>
<td>224.6</td>
<td>937</td>
<td>13837</td>
<td>95.29</td>
<td>88.55</td>
<td>114.6</td>
</tr>
<tr>
<td>5</td>
<td>67</td>
<td>M</td>
<td>A</td>
<td>NIPD 3 X 2.5L</td>
<td>2.5</td>
<td>2.5</td>
<td>7.5</td>
<td>170.25</td>
<td>1181</td>
<td>9129</td>
<td>62.7</td>
<td>62.9</td>
<td>133.7</td>
</tr>
<tr>
<td>6</td>
<td>86</td>
<td>F</td>
<td>C</td>
<td>NIPD 4 X 2.30L</td>
<td>2.5</td>
<td>2.5</td>
<td>9.20</td>
<td>208.84</td>
<td>1235</td>
<td>9767</td>
<td>91.29</td>
<td>98.1</td>
<td>142.59</td>
</tr>
</tbody>
</table>
F = Female, M = Male, AA = Afro-American, C = Caucasian, A = Asian, PD Rx = Peritoneal dialysis prescription, CCPD = Continuous cycler peritoneal dialysis, CAPD = Continuous ambulatory peritoneal dialysis, NIPD = Nocturnal intermittent peritoneal dialysis, MDE = Mid-Day exchange, LF = Last fill.
### Table 2: Patient characteristics

**Patient characteristics at PD initiation:**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>54±24.0</td>
</tr>
<tr>
<td>Sex Male/Females</td>
<td>7/4</td>
</tr>
<tr>
<td>Ethnicity</td>
<td></td>
</tr>
<tr>
<td>African American</td>
<td>6 (54.55%)</td>
</tr>
<tr>
<td>Hispanic</td>
<td>5 (45.45%)</td>
</tr>
<tr>
<td>Cause of Renal Failure</td>
<td></td>
</tr>
<tr>
<td>Diabetes and Hypertension</td>
<td>5 (45.45%)</td>
</tr>
<tr>
<td>Hypertension</td>
<td>4 (36.36%)</td>
</tr>
<tr>
<td>Sickle cell Disease</td>
<td>1 (9.09%)</td>
</tr>
<tr>
<td>Lupus</td>
<td>1 (9.09%)</td>
</tr>
<tr>
<td>Years on Peritoneal Dialysis</td>
<td>1 – 7 years</td>
</tr>
<tr>
<td>PD Prescription:</td>
<td></td>
</tr>
<tr>
<td>NIPD</td>
<td>6 (54.55%)</td>
</tr>
<tr>
<td>CCPD</td>
<td>4 (36.36%)</td>
</tr>
<tr>
<td>CAPD</td>
<td>1 (9.09%)</td>
</tr>
</tbody>
</table>

NIPD: Nocturnal intermittent peritoneal dialysis.
CCPD: Continuous cycler-assisted peritoneal dialysis.
CAPD: Continuous ambulatory peritoneal dialysis.
Table 3: Estimation of glucose absorption in the independent cohort of 11 peritoneal dialysis patients:

<table>
<thead>
<tr>
<th>Patient ID</th>
<th>D2/D0</th>
<th>D4/D0</th>
<th>t 1 Hours:minutes</th>
<th>Dt1/D0</th>
<th>t 2 Hours</th>
<th>Dt2/D0</th>
<th>t 3 Hours</th>
<th>Dt3/D0</th>
<th>t 4 Hours</th>
<th>Dt4/D0</th>
<th>PD RX</th>
<th>Bag 1 Dxtrose%</th>
<th>Bag 2 Dxtrose%</th>
<th>MDE</th>
<th>Glucose exposure (grams)</th>
<th>Glucose absorbed (grams)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>0.46</td>
<td>0.14</td>
<td>1:45</td>
<td>0.47438</td>
<td>3:00</td>
<td>0.27706</td>
<td>0.47438</td>
<td>3:00</td>
<td>0.27706</td>
<td>0.47438</td>
<td>CCPD 4 x 2L, LF 2</td>
<td>1.5%</td>
<td>1.5%</td>
<td>136</td>
<td>76.85</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>0.57</td>
<td>0.43</td>
<td>1:30</td>
<td>0.6958</td>
<td></td>
<td></td>
<td>0.6958</td>
<td></td>
<td></td>
<td></td>
<td>NIPD 4 x 2L</td>
<td>1.5%</td>
<td>1.5%</td>
<td>108.8</td>
<td>33.1</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>0.51</td>
<td>0.31</td>
<td>1:30</td>
<td>0.62394</td>
<td></td>
<td></td>
<td>0.62394</td>
<td></td>
<td></td>
<td></td>
<td>NIPD 4 x 2L</td>
<td>2.5%</td>
<td>2.5%</td>
<td>181.6</td>
<td>68.29</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>0.58</td>
<td>0.43</td>
<td>1:45</td>
<td>0.66088</td>
<td></td>
<td></td>
<td>0.66088</td>
<td></td>
<td></td>
<td></td>
<td>NIPD 4 x 2L</td>
<td>1.5%</td>
<td>1.5%</td>
<td>119.68</td>
<td>40.59</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>0.43</td>
<td>0.28</td>
<td>1:20</td>
<td>0.6086</td>
<td></td>
<td></td>
<td>0.6086</td>
<td></td>
<td></td>
<td></td>
<td>NIPD 4 x 2.5 L</td>
<td>1.5%</td>
<td>2.5%</td>
<td>172.4</td>
<td>67.47</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>0.54</td>
<td>0.37</td>
<td>1:25</td>
<td>0.67588</td>
<td></td>
<td></td>
<td>0.67588</td>
<td></td>
<td></td>
<td></td>
<td>NIPD 4 x 2.5 L</td>
<td>2.5%</td>
<td>1.5%</td>
<td>190.6</td>
<td>61.78</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>0.56</td>
<td>0.47</td>
<td>1:30</td>
<td>0.7066</td>
<td></td>
<td></td>
<td>0.7066</td>
<td></td>
<td></td>
<td></td>
<td>NIPD 4 x 2L</td>
<td>2.5%</td>
<td>2.5%</td>
<td>181.6</td>
<td>53.28</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>0.68</td>
<td>0.51</td>
<td>1:40</td>
<td>0.74286</td>
<td></td>
<td></td>
<td>0.74286</td>
<td></td>
<td></td>
<td></td>
<td>NIPD 4 x 2L</td>
<td>1.5%</td>
<td>1.5%</td>
<td>108.8</td>
<td>27.98</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>0.57</td>
<td>0.39</td>
<td>1:40</td>
<td>0.6531</td>
<td>3:00</td>
<td>0.468</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>CCPD 4 x 2L, MDE 2L</td>
<td>1.5%</td>
<td>1.5%</td>
<td>136</td>
<td>52.21</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>0.51</td>
<td>0.35</td>
<td>1:35</td>
<td>0.6429</td>
<td>3:00</td>
<td>0.4149</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>CCPD 5 x 2.2L, LF 2.2 L</td>
<td>1.5%</td>
<td>2.5%</td>
<td>245.29</td>
<td>98.89</td>
<td></td>
</tr>
<tr>
<td>ID</td>
<td>D2/D0</td>
<td>D4/D0</td>
<td>Dt1/D0</td>
<td>Dt2/D0</td>
<td>Dt3/D0</td>
<td>Dt4/D0</td>
<td>PD Rx</td>
<td>CCPD</td>
<td>NIPD</td>
<td>MDE</td>
<td>LF</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
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<tr>
<td>17</td>
<td>0.42</td>
<td>0.24</td>
<td>4:00</td>
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<td>4:00</td>
<td>0.24</td>
<td>4:00</td>
<td>0.24</td>
<td>4:00</td>
<td>CAPD 5 x2L</td>
<td>2.5%</td>
<td>145.2</td>
<td>110.35</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

ID = Patient ID, D2/D0 = Ratio of glucose concentration in the dialysate at 2 hours to that at time 0, D4/D0 = Ratio of glucose concentration in the dialysate at 4 hours to that at time 0, Dt1/D0 = Ratio of glucose concentration in the dialysate at dwell time t1 to that at time 0, Dt2/D0 = Ratio of glucose concentration in the dialysate at dwell time t2 to that at time 0, Dt3/D0 = Ratio of glucose concentration in the dialysate at dwell time t3 to that at time 0, Dt4/D0 = Ratio of glucose concentration in the dialysate at dwell time t4 to that at time 0, PD Rx = Peritoneal dialysis prescription, CCPD = Continuous cycler peritoneal dialysis, CAPD = Continuous ambulatory peritoneal dialysis, NIPD = Nocturnal intermittent peritoneal dialysis, MDE = Mid-Day exchange, LF = Last fill.
**Figure 1:** Patient on CCPD with 5 exchanges of 2.2 L and LF of 2.2 L. using 1.5% & 2.5% dextrose dialysates. Estimation of proportion of glucose absorption (1-Dt1/D0 and 1-Dt2/D0) at dwell times t1 (95 minutes) and t2 (180 minutes). D2/D0 and D4/D0 are 0.51 and 0.35 respectively (Red dots). The D2/D0 and D4/D0 values are obtained from the peritoneal equilibration test.

CCPD = Continuous cycler peritoneal dialysis, Dt1/D0 = Ratio of glucose concentration in the dialysate at dwell time t1 to that at time 0, Dt2/D0 = Ratio of glucose concentration in the dialysate at dwell time t2 to that at time 0. D2/D0 = Ratio of glucose concentration in the dialysate at 2 hours to that at time 0, D4/D0 = Ratio of glucose concentration in the dialysate at 4 hours to that at time 0, LF = Last Fill
Figure 2: An algorithm showing how to calculate glucose absorption from PD fluid

1. Calculate the amount of glucose exposed on the cycler and day exchanges if any.
2. Know the average dwell time for cycler exchanges t1 and day exchanges t2, t3, etc.
3. Analyze the PET Data for D2/D0 and D4/D0.
4. Develop decay curve for D2/D0 and D4/D0.
5. Calculate amount of glucose remaining at t1, t2, t3, etc as Dt1/D0, Dt2/D0, Dt3/D0 by developing a non-linear least squared error model using R programming.
6. Calculate glucose absorbed as 1 – Dt1/D0, 1 – Dt2/D0, etc.
7. Calculate the total amount of glucose absorbed as Amount exposed x (1-Dt/D0).
**Figure 3:** Scatter graph of measured (actual) glucose absorption (g/day) from the effluent (X-axis) and the estimated glucose absorption utilizing our model. All points lie close to the line of equality suggesting an excellent agreement between the two measures.
**Figure 4:** Peritoneal equilibration test was performed in a patient using two different dextrose concentrations of 1.5 % and 2.5 % dextrose. Glucose absorption rate is independent of glucose concentration in the dialysate.

\[ \frac{D2}{D0} = \text{Ratio of glucose concentration in the dialysate at 2 hours to that at time 0}, \quad \frac{D4}{D0} = \text{Ratio of glucose concentration in the dialysate at 4 hours to that at time 0}. \]