A Comparison Study of Glucose Fluctuation During Automated Peritoneal Dialysis and Continuous Ambulatory Peritoneal Dialysis

In recent years, it has become possible to examine an individual’s daily glucose profile with a continuous glucose monitoring system (CGMS). The aim of the present study was to use a CGMS to evaluate the difference in glucose fluctuation between diabetic patients on automated peritoneal dialysis (APD) and those on continuous ambulatory peritoneal dialysis (CAPD).

We retrospectively studied 20 diabetic patients on peritoneal dialysis (16 men, 4 women; mean age: 55 ± 10 years) who used a CGMS a total of 23 times (12 times by APD users, 11 times by CAPD users). The difference in the maximum and minimum blood glucose over 72 hours (ΔBG) and the standard deviation of blood glucose were used as indicators of glucose fluctuation.

Average blood glucose levels as evaluated by CGMS and by glycosylated hemoglobin were not significantly different between the APD and CAPD patients. However, the ΔBG (181 ± 64 mg/dL vs. 238 ± 67 mg/dL, p = 0.02) and the standard deviation of blood glucose (36.3 ± 14.5 mg/dL vs. 49.2 ± 14.1 mg/dL, p = 0.03) were significantly lower in the APD patients than in the CAPD patients.

The present study indicates that, compared with CAPD, APD might reduce glucose fluctuation in diabetic peritoneal dialysis patients.

Key words
Continuous glucose monitoring systems, automated peritoneal dialysis, continuous ambulatory peritoneal dialysis, glucose fluctuation

Introduction
The number of new patients with end-stage renal disease starting dialysis because of diabetes has been increasing in Japan (1). Most dialysis patients with diabetes already have complications of micro- or macroangiopathy (or both) at dialysis initiation. However, even in those patients, strict glucose control will suppress development not only of retinopathy and neuropathy, but also of complications such as macroangiopathy and infection. Hence, strict glycemic control has been reported to improve prognosis in dialysis patients (2,3).

Currently, glycated albumin and glycosylated hemoglobin (HbA1c) are not the most appropriate glycemic control parameters in dialysis patients, because those indicators are influenced by factors such as renal anemia, uremia, erythropoiesis-stimulating agents, and hypoalbuminemia. Recently, a new technology, the continuous glucose monitoring system (CGMS), has permitted a daily glucose profile to be recorded, and a relationship between large glucose fluctuations (as measured by CGMS) and cardiovascular disease has been reported (4,5).

Peritoneal dialysis (PD) patients with diabetes have a unique glucose metabolism derived from their dialysis therapy. In PD patients, use of dialysates containing high glucose concentrations is well known to cause a rise in blood glucose. However, no published study has examined the possible differences in glucose fluctuation between patients on automated PD...
(APD) and on continuous ambulatory PD (CAPD). The present study aimed to use a CGMS to evaluate any difference in glucose fluctuation between APD patients and CAPD patients.

Methods
Our study was approved by the institutional review board of the St. Marianna University School of Medicine. Informed consent was obtained from participating patients according to policy established by our institutional ethics review committee. We retrospectively studied 20 diabetic PD patients (16 men, 4 women; mean age: 55 ± 10 years) who used CGMS a total of 23 times (12 times by APD users, 11 times by CAPD users) at St. Marianna University Hospital and Kawasaki Municipal Hospital between April 2011 and March 2014. Table I shows the characteristics of the study population.

Of the 20 patients, 16 were using insulin for their diabetes; 3 were being treated only with hypoglycemic agents; and 1 was not receiving diabetes treatment. The patients had no acute infections or peritonitis, and no changes in their diet or drug therapy for diabetes were made while they were using the CGMS. The CGMS monitors used in the study were the Minimed Gold (Medtronic, Dublin, Ireland) or the iPro2 (Medtronic). The sensor was inserted subcutaneously into the skin of the patient’s abdomen under local anesthesia. Interstitial glucose levels were recorded every 5 minutes for 72 hours and were sent to a monitor for storage. To calibrate the sensor, the patients used a glucometer to self-monitor their blood glucose by intermittent sampling of capillary blood; CGMS measurements occurred in the hospital. The difference in the maximum and minimum blood glucose over 72 hours (ΔBG) and the standard deviation (SD) of blood glucose were evaluated as indicators of glucose fluctuation. Residual renal function at the time of CGMS monitoring was determined as the mean of the urea and creatinine clearances in accordance with Japanese guidelines (6).

All data analysis was performed using PASW Statistics for Windows (version 17.0J: IBM, Armonk, NY, USA). Values are presented as mean ± SD. Comparisons of the APD and CAPD patients were performed using the chi-square test or the Mann–Whitney U-test. For correlations between continuous variables, a Spearman rank correlation test was used. A p value less than 0.05 was considered statistically significant.

Results
As shown in Table I, serum creatinine was significantly higher in the APD patients than in the CAPD patients. However, no differences in residual renal function and other characteristics were observed between the two groups. In the data obtained during the 23 uses of the CGMS, average blood glucose was 164 ± 35 mg/dL (range: 116 – 247 mg/dL), SD blood glucose was 42 ± 15 mg/dL (range: 23 – 71 mg/dL), and ΔBG was 208 ± 70 mg/dL (range: 119 – 330 mg/dL).

![Table I](image)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>APD</th>
<th>CAPD</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patients (n)</td>
<td>12</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>Mean age (years)</td>
<td>55±10</td>
<td>62±8</td>
<td>0.05</td>
</tr>
<tr>
<td>Mean body mass index (kg/m²)</td>
<td>23.8±3.4</td>
<td>23.1±3.2</td>
<td>0.60</td>
</tr>
<tr>
<td>Sex (n)</td>
<td></td>
<td></td>
<td>0.16</td>
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<tr>
<td>Men</td>
<td>11</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Women</td>
<td>1</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Type of diabetes (n)</td>
<td></td>
<td></td>
<td>1.00</td>
</tr>
<tr>
<td>Type 1</td>
<td>2</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Type 2</td>
<td>10</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Duration of PD (months)</td>
<td>12±3</td>
<td>11±8</td>
<td>0.23</td>
</tr>
<tr>
<td>Daily calorie intake (kcal)</td>
<td>1783±133</td>
<td>1727±100</td>
<td>0.30</td>
</tr>
<tr>
<td>Serum creatinine (mg/dL)</td>
<td>10.6±3.2</td>
<td>7.7±1.3</td>
<td>0.01</td>
</tr>
<tr>
<td>Weekly RRF (L/1.73 m²)</td>
<td>42.2±20.5</td>
<td>44.6±21.5</td>
<td>0.83</td>
</tr>
<tr>
<td>D/P creatinine</td>
<td>0.70±0.15</td>
<td>0.60±0.11</td>
<td>0.09</td>
</tr>
<tr>
<td>Users of icodextrin (n)</td>
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<td>4</td>
<td>0.16</td>
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<tr>
<td>Hemoglobin (g/dL)</td>
<td>9.9±1.2</td>
<td>10.3±0.87</td>
<td>0.21</td>
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<tr>
<td>HbA1c (%)</td>
<td>5.6±0.6</td>
<td>5.9±0.9</td>
<td>0.50</td>
</tr>
<tr>
<td>Albumin (g/dL)</td>
<td>3.5±0.5</td>
<td>3.6±0.5</td>
<td>0.62</td>
</tr>
</tbody>
</table>

APD = automated peritoneal dialysis; CAPD = continuous ambulatory peritoneal dialysis; PD = peritoneal dialysis; RRF = residual renal function; D/P = dialysate-to-plasma ratio.
Glucose Fluctuation in PD

different between the APD and CAPD patients, the SD blood glucose was significantly lower in the APD patients than in the CAPD patients [36.3 ± 14.5 mg/dL vs. 49.2 ± 14.1 mg/dL, \( p = 0.03 \), Figure 1(A)]. Furthermore, the ABG was also significantly lower in the APD patients than in the CAPD patients [181 ± 64 mg/dL vs. 238 ± 67 mg/dL, \( p = 0.02 \), Figure 1(B)].

**Discussion**

Over a full 72-hour period, hyperglycemia was observed for one third of the time, despite acceptable values of HbA1c. In contrast, hypoglycemia was almost never seen. Lee *et al.* (7) reported that average blood glucose was significantly correlated with HbA1c in PD patients. On the other hand, we observed no correlation between average blood glucose and HbA1c in our study.

Several studies have used a CGMS to evaluate glucose fluctuation in diabetic PD patients (7–10). Moreover, Skubala *et al.* (11) used a CGMS to report glucose fluctuations in nondiabetic PD patients. However, no publication has reported differences in glucose fluctuation according to PD modality. Our study is the first to evaluate differences in glucose fluctuation between APD and CAPD patients, and it indicates that glucose fluctuation is higher in CAPD than in APD patients. The causative mechanism is hypothesized to be a synergistic effect of dietary intake and exposure to high glucose dialysate in the CAPD patients.

Glucose absorption from the peritoneum contributes to hyperglycemia and peritoneal permeability. Mori *et al.* (10) reported that glucose fluctuation is significantly correlated with peritoneal permeability as represented by the dialysate-to-plasma ratio of creatinine (SD: \( r = 0.71, p = 0.03 \)) and that glucose fluctuation is greater in APD than in CAPD patients. However, no correlation between the dialysate-to-plasma ratio of creatinine and glucose fluctuation was observed in the present study (ΔBG: \( r = 0.05, p = 0.82 \); SD: \( r = -0.08, p = 0.72 \)).

Various factors can affect glucose fluctuation in diabetic PD patients. In particular, the dialysate glucose concentration, the number of daily exchanges, and the dwell times have a large effect on blood glucose. In a recent randomized controlled trial, Li *et al.* (12) reported that a low-glucose dialysis regimen was associated with improved metabolic indices such as Hba1c, serum triglycerides, very-low-density lipoprotein, and apolipoprotein B.

The present study has several limitations. First, it is a retrospective observational study, and the number of subjects is very small. Second, the PD regimens (type of PD solution, dwell time, and dwell volume) and diabetes treatment used by the participants in each group differed. In evaluating glucose fluctuation by PD modality, it might be necessary to examine glucose fluctuation during the use of APD and CAPD in the same patients. Further investigations involving a larger number of patients and using a prospective observational design are needed to validate our hypothesis.

**Conclusions**

The present study indicates that, compared with CAPD, APD might reduce glucose fluctuation in diabetic PD patients, and that CGMS is useful for glucose monitoring in PD patients.

**Disclosures**

The authors declare that they have no conflicts of interest.

**References**


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