Differential Effects of Peritoneal and Hemodialysis on Central Aortic Pressure

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Abstract

Background: In patients receiving dialysis therapy, cardiovascular diseases is the leading cause of death and there are a close association between mortality and blood pressure. However, there have been few reports discussing the effects of dialysis therapy on central aortic pressure (CAP).

Aim: The purpose of the present study was to examine CAP of patients receiving peritoneal dialysis (PD) and hemodialysis (HD).

Methods: There were 53 PD patients and 52 HD patients in this study. These two groups were comparable in age, and gender. All individuals were examined after resting in the supine position and radial artery pulse waveform was obtained by an automated tonometric system HEM-9000AI (Omeron Healthcare, Kyoto, Japan). SBP2, an index of CAP, is well correlated with CAP when measured simultaneously by a direct catheter method, as well as simultaneous measurement of pulse wave velocity (PWV). Clinical data and lab tests were collected from the electronic medical records.

Results: Systolic (S) BPs were positively correlated with CAP in both groups. The levels of SBP (mm Hg) were similar in both groups (140 ± 23 in PD and 137 ± 21 in HD). However, the levels of CAP in patients with PD (126 ± 27) were lower than in HD patients (137 ± 25 mm Hg) (p<0.01). In contrast, there were no differences in PWV between PD and HD patients.

Conclusion: This study supports the recent call for a prospective examination of CAP as a treatment target in future trials in dialysis patients.

ABBREVIATIONS

CAP: Central Aortic Pressure; SBP: Systolic Blood Pressure; DBP: Diastolic Blood Pressure; CVD: Cardiovascular Disease; PD: Peritoneal Dialysis; HD: Hemodialysis; CAPD: Continuous Ambulatory Peritoneal Dialysis. PWV: Pulse Wave Velocity; CF: Carotid Femoral; BA: Brachial Ankle; ESRD: End-Stage Renal Disease; DM: Diabetes Mellitus; CKD: Chronic Kidney Disease; CCr: Creatinine Clearance

INTRODUCTION

Cardiovascular disease (CVD) represents the major cause of morbidity and mortality in patients with end-stage renal disease (ESRD) [1,2]. Most importantly; several longitudinal studies have demonstrated arterial stiffness in patients with ESRD has strong and independent predictive value for survival [3-5]. Recently; central aortic pressures (CAP) have been shown to be pathophysiologically more relevant than peripheral pressure for the pathogenesis of CVD [6-8]. These advances were attributed to the development of instruments [9,10]. In a systematic review and meta-analysis Vlachopoulos11 concluded that central hemodynamic indexes are independent predictors of future CVD and all-cause mortality. In addition; central pulse pressure has a marginal but not significantly better predictive ability than peripheral pulse pressure. Although few studies of CAP have been conducted in chronic kidney disease (CKD); Cohen and Townsend [12] proposed that CAP can predict the progression of CKD. However; there is a paucity of data discussing a role for CAP in patients undergoing hemodialysis (HD) and peritoneal dialysis (PD). The aim of this study was to examine CAP as well as pulse wave velocity (PWV) in PD and HD patients.
MATERIALS AND METHODS

A total of 53 PD patients and 52 HD patients participated in this study with informed consent. These two groups were comparable in age and gender. All patients were regularly monitored at our center and had started their PD or HD treatment at least 6 months before enrollment. Baseline data were collected regarding patient’s demographic characteristics; laboratory values; PD prescription; methods of HD; and duration on dialysis before enrollment. This study was performed in accordance with the principles of the World Medical Association Declaration of Helsinki and was conducted in the Kidney Disease Center in Saitama Medical University Hospital; Saitama; Japan.

Regular treatment modality in the kidney center in saitama medical university

More than 50% of patients were treated with a standard PD regimen that consisted of three to four daily exchanges of 1.5 or 2 liters of dialysate; while other patients used one to two daily exchanges of dialysate. The strength of the bags was individualized to maintain the desired weight. Dwell times were also individualized to maximize overall ultrafiltration volumes. All subjects consumed between 0.8 and 1.0 g of protein/kg/day and their energy intake exceeded 25 kcal/kg/day. Salt intake was restricted to less than 9 g daily throughout of the study.

HD was carried out using a bicarbonate dialysate and a dialyzer with a polysulfone dialysis membrane.

Patient monitoring

PD patients were followed every month. At clinic visit; serum creatinine; electrolyte concentrations; complete blood count; and other serum chemistries (uric acid; glucose; and liver enzymes) were measured. Indices of the adequacy of dialysis; including weekly Ccr; were calculated using the Adequest computer program; version 2.0 (Baxter Healthcare; Tokyo; Japan) for Windows. Chest radiographs were obtained regularly; and cardiothoracic index was calculated according to established methods.

In HD patients pre- and post-dialysis blood pressures were calculated as the average value of all recordings taken over a one-month period. Three measurements per week (12 per month) were made. When the SBP exceeded 140 mm Hg or the DBP 90 mm Hg; therapy with antihypertensive agents was initiated. In CAPD patients the BP values were obtained by averaging home BP measurements (10-20 measurements per month); and the average was restricted to less than 9 g daily throughout of the study.

PWV was measured using an automatic waveform analyzer (form PWV/ABI; Omron Colin; Co.; Ltd.; Komaki; Japan). The brachium-ankle PWV (baPWV) was calculated from the equation (D1-D2)/T. D1 is the distance between the heart and ankle; D2 is the distance between the heart and brachium; and T is the transit between the right brachial arterial wave and right tibial arterial wave. The distance between the sampling points was automatically calculated from the patient’s height and divided by the time interval for the wave form from each measuring point [11].

All individuals were examined after resting in the supine position for at least 5 minutes and radial artery pulse waveform was recorded by an automated tonometric system HEM-9000AI (Omeron Healthcare; Kyoto; Japan) with patients in a sitting position. The HEM-9000AI algorithm automatically performed online detection of the second peak (late systolic inflection) based on the second maxima of the fourth derivative of the radial pressure wave form to determine the late or second SBP (SBP2); an index of central BP. SBP2 is well correlated with aortic SBP measured simultaneously by direct catheter method. SBP2; an index of CAp; is well correlated with CAP also measured simultaneously by a direct catheter method [12;13]. Two measurements were taken 5 minutes apart; and the average was used for analysis.

These measurements were taken by a single observer; each over a minute and in duplicate.

In PD patients; measurements of PWV and CAP were carried out with full abdomen [14]. In HD patients; measurements were carried out after a midweek HD session.

Statistical analysis

Results are expressed as mean ± standard error of the mean. Statistical analyses used the Student’s t-test for unpaired samples and the Mann–Whitney test for comparison of means. The relationship between two variables was determined by Pearson’s relation coefficient. Statistical significance was set at p < 0.05. The analyses were performed using JMP software; version 9 (JMP; A Business Unit of SAS; NC USA).

RESULTS AND DISCUSSION

Patient characteristics

The demographic features and baseline data of the PD and HD groups are shown in Tables 1; 2 and 3. The mean ages of the subjects were 65.1 ± 8.2 years in PD and 61.5 ± 14.3 years in HD. Males constituted 52% and 58% of the subjects in PD and HD; respectively. The most common causes of ESRD in patients on PD were glomerulonephritis (57%); DM (11%); and hypertension (9%). Others including unknown diseases were 23%. The most common causes of ESRD in patients on HD were glomerulonephritis (57%); DM (11%); and hypertension (9%). Others including unknown diseases were 23%. The most common causes of ESRD in patients on HD—were DM (38%); glomerulonephritis (31%); and hypertension (13%). Others including unknown diseases were 18. There were no differences in age and gender; but differences in the proportion of DM in HD and in PD were significant. The levels of systolic BP (mm
Hg) were similar in both groups (140 + 23 in PD and 137 + 21 in HD). However; the levels of CAP (SBP2) in PD patients was significantly lower than in HD patients (126 ± 27 vs. 137 + 25 mm Hg) (p<0.01). In contrast; baPWV was higher in PD patients than in HD patients but lacked significance. There were no differences in SBP; DBP and pulse pressure between HD and PD patients. No differences in the levels of hemoglobin; calcium and phosphate were seen that might influence hemodynamics of the heart and vessels in PD and HD patients.

In Figure 1(A and B); representative wave forms obtained from HD and PD patients are shown. Compared with the wave forms of Fig1A in HD patients; there was a dip between the forward and the backward pressure waves in PD patients.

### Table 1: Demographic characteristics of study participants.

<table>
<thead>
<tr>
<th></th>
<th>PD</th>
<th>HD</th>
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</thead>
<tbody>
<tr>
<td>Number of patients</td>
<td>53</td>
<td>52</td>
</tr>
<tr>
<td>Age (years)</td>
<td>65.1 ± 8.2</td>
<td>61.5 ± 14.3</td>
</tr>
<tr>
<td>Sex (M/F)</td>
<td>21/32</td>
<td>20/32</td>
</tr>
<tr>
<td>Primary underlying disease</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diabetes Mellitus</td>
<td>6</td>
<td>20</td>
</tr>
<tr>
<td>Glomerulonephritis</td>
<td>30</td>
<td>16</td>
</tr>
<tr>
<td>Hypertension</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>Others</td>
<td>12</td>
<td>9</td>
</tr>
<tr>
<td>Duration of dialysis (months)</td>
<td>48.0±33.5</td>
<td>54.2±30.2</td>
</tr>
</tbody>
</table>

*PD; peritoneal dialysis, HD; hemodialysis

### Table 2: Hemodynamic characteristics of study participants.

<table>
<thead>
<tr>
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<th>HD</th>
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<tbody>
<tr>
<td>SBP (mm Hg)</td>
<td>140±23</td>
<td>137±21</td>
</tr>
<tr>
<td>DBP (mm Hg)</td>
<td>78±20</td>
<td>77±13</td>
</tr>
<tr>
<td>PP (mm Hg)</td>
<td>66±19</td>
<td>57±16</td>
</tr>
<tr>
<td>PWV (cm/sec)</td>
<td>1800±350</td>
<td>1710±490</td>
</tr>
<tr>
<td>SBP2 (mm Hg)</td>
<td>126±27</td>
<td>137±25*</td>
</tr>
</tbody>
</table>

SBP; systolic blood pressure. DBP; diastolic blood pressure. PP; pulse pressure
PWV; pulse wave velocity. SBP2; as representative of central aortic pressure
PD, peritoneal dialysis; HD, hemodialysis

*P<0.01 ; compared with SBP2 of PD patients

### Table 3: Biochemical characteristics of study participants.

<table>
<thead>
<tr>
<th></th>
<th>PD</th>
<th>HD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Creatinine (ng/dL)</td>
<td>11.0±3.2</td>
<td>12.2±2.7</td>
</tr>
<tr>
<td>Blood urea nitrogen (mg/dL)</td>
<td>59.5±16.9</td>
<td>67.2±7.5</td>
</tr>
<tr>
<td>Uric acid (mg/dL)</td>
<td>6.8±1.3</td>
<td>5.4±1.7</td>
</tr>
<tr>
<td>Calcium (mg/dL)</td>
<td>8.9±0.8</td>
<td>9.1±0.9</td>
</tr>
<tr>
<td>Phosphate (mg/dL)</td>
<td>5.2±1.4</td>
<td>5.5±1.6</td>
</tr>
<tr>
<td>Albumin (g/dL)</td>
<td>3.8±0.9</td>
<td>4.1±1.1</td>
</tr>
<tr>
<td>Hemoglobin (g/dL)</td>
<td>10.8±1.2</td>
<td>10.5±1.2</td>
</tr>
</tbody>
</table>

PD; peritoneal dialysis; HD; hemodialysis

### DISCUSSION

This study provides a new insight into the central hemodynamics of patients on dialysis. CAP correlated with systolic BP measure at the peripheral site. A completely different wave form between PD and HD was noted. Central wave form of PD patients showed two peaks instead of the one peak usually observed in HD patients. In addition; CAP (SBP2) of HD patients was 10 mm Hg higher than in those of PD patients. Accumulated data have shown that CAP increased significantly with age [15]. However; in our dialyzed populations; no correlations between age and CAP were found. In patients on dialysis therapy; age distribution is more scattered and the influence of age on hemodynamics is not easily determined; because in addition to age; duration of dialysis therapy; the underlying disease; and the level of blood pressure were widely scattered.

In the present study baPWV were not significantly different between PD and HD patients.

The results of studies comparing PWV between PD and HD patients were inconsistent. PWV was the same [16-18]; lower [19,
Correlation between SBP and SBP2 in patients on PD

Figure 2 Correlations between: (a) SBP2 and SBP; (b) SBP and PWV; (c) PWV and SBP2; (d) SBP2 and SBP; (e) SBP and PWV; and (f) PWV and SBP2. (a;b;c) for PD; and (d;e;f) for HD patients.

20) or higher [14] in CAPD patients compared with HD patients [21].

In Japan; measurements of PWV are generally carried out between the brachial and tibial arteries; instead of between the carotid and femoral arteries. The differences between the two measurements have been discussed elsewhere [22]. Briefly; baPWV reflects the compliance of medium-size arteries and is essentially a marker of aortic stiffness. On the other hand; carotid femoral (cf ) PWV is the gold standard for the assessment of arterial stiffness. Until now; baPWV is shown to be an independent risk factor for death in patients on HD [23].
In contrast to PWV; SBP2 as representative of CAP; was lower in patients on PD than in HD when SBP was at the same level; indicating that backward component of CAP is attenuated in PD patients.

Arterial stiffness is prevalent in both HD and PD patients [24-26]. The impact of dialysis modality on arterial function is not clear. Although some cross-sectional studies reported that PD patients have stiffer arteries [14,16]; no longitudinal study has been undertaken in this field. The difference in hemodynamic measures between patients on PD and HD is not easily explained because the exposures to therapy (both dialysis duration and some medications) are not the same.

Our study has several limitations resulting from a small number of patients. Because only a small group of HD patients from a large HD population was recruited for the study; selection bias cannot be excluded. Secondly; the study groups differed significantly with respect to duration of dialysis therapy; which was longer in HD patients. The duration of dialysis therapy is considered as one of the factors influencing arterial stiffness in HD patients [20]; but did not change in PD patients [20,27]. Thus; it can be speculated that arterial stiffness would be higher in HD patients when PD and HD patients with the same duration of dialysis therapy were compared.

Another limitation of our study is that PWV measurements in HD patients were performed before a midweek HD session; In a recent study; in which PWV measurements were performed in 3 consecutive HD sessions and inter dialysis periods during a week-long period; cyclic changes in PWV values have been observed [28].

The selection of modality may be due to a variety of factors. Without serial vascular function measurements (which; however; are not practical) we cannot separate the impact of dialysis from disease duration and other exposures. In this study; all patients had some degree of preexisting confounders for vascular disease; i.e.; diabetes; dyslipidemia and hypertension; reflecting the selection of dialysis modality.

CONCLUSION

In spite of several studies that examined the role of PWV in PD patients; very few studies measured CAP in dialysis patients. Therefore this study sheds new light on hemodynamic changes in patients on PD. Moreover; this study supports the recent call for a prospective examination of the use of CAP as a treatment target in dialysis patients; because CVD was found more frequently in HD than PD patients in our previous data [29].

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