

# Blood Pressure Measurement and Left Ventricular Mass Index in Hemodialysis Patients

## Comparison of Several Methods

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**Introduction.** Systemic arterial hypertension is prevalent in end-stage renal disease and is closely associated with left ventricular hypertrophy (LVH). Blood pressure (BP) behavior is unique in this population, and it is not clear which BP measurement should be used for treatment guidance. We aimed to evaluate the association of several methods of BP measurement with left ventricular mass index (LVMI) as hypertensive end-organ damage.

**Materials and Methods.** Patients on maintenance hemodialysis, 3 or 4 times per week for at least 3 months, were enrolled. We compared the diagnostic value of 6 different methods of BP measurement, including predialysis, postdialysis, interdialysis, and standard BP measurements as well as ambulatory blood pressure monitoring (ABPM) and home blood pressure monitoring, based on LVMI as the gold standard.

**Results.** Twenty patients, including 9 women and 11 men were enrolled. Ten patients (50%) had LVH and the others had normal LVMI (LVMI > 100 g/m<sup>2</sup> for women and > 131 100 g/m<sup>2</sup> for men). Only predialysis and postdialysis systolic BP values were significantly associated with LVMI ( $P = .02$  and  $P = .02$ , respectively).

**Conclusions.** Predialysis and postdialysis systolic BP values maybe reliable for detecting hypertension in hemodialysis patients, although according to previous data, the importance of self and ambulatory BP monitoring could not be overlooked.

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## INTRODUCTION

The cardiovascular complications are an important predictor of survival in hemodialysis patients and are responsible for more than half of mortalities.<sup>1</sup> Hypertensive vascular disease as a common risk factor has the most prominent role in providing cardiovascular disabilities.<sup>1</sup> Despite several studies in the case of blood pressure changes in hemodialysis patients, there is no agreement about the time and method of blood pressure

measurement that have the most association with cardiovascular outcomes.<sup>2-4</sup> The major proportion of studies have suggested that ambulatory blood pressure monitoring (ABPM) is the most valuable method of blood pressure (BP) measurement in hemodialysis patients (as in normal population), although because of difficulty and cost, this method in not feasible or reproducible in practical means.<sup>5</sup>

Furthermore, the recommendation of the Kidney Disease Outcomes Quality Initiative 2005 guideline

for management of blood pressure in hemodialysis patients is still based on predialysis BP.<sup>6</sup> Because the best BP measurement in this population is unclear, we aimed to evaluate the association of several methods including 44-h ABPM with left ventricular mass index (LVMI) as hypertension end organ damage and predictor of cardiovascular disability.

## MATERIAL AND METHODS

We studied 30 patients from 2 centers. The patients with any underlying cause of end-stage renal disease, which have been under hemodialysis 3 or 4 times per week for at least 3 months were enrolled in this study. The exclusion criteria were severe congestive heart disease, severe chronic anemia (hemoglobin < 7 mg/dL), severe hyperparathyroidism (> 600 pg/mL), pregnancy, recent malignancy, ongoing infection, and illicit drug use. In addition, the participants were those with no changes neither in antihypertensive medication nor in dry weight during recent 2 weeks. Ten patients were excluded. In 20 patients, 6 different BP measurement methods were evaluated and compared to left ventricular mass index (LVMI) based on echocardiographic data.

### Blood Pressure Measurements

Six methods for measurement of BP were employed for each patient during a 2-week period, as follows:

**Dialysis unit measurements.** Predialysis and Postdialysis BP levels were measured by a trained nurse at 6 session of hemodialysis. Six to 8 intradialysis BP values were obtained during a session of hemodialysis.

**Standard blood pressure measurement.** This method, applied routinely in clinical practice, was measured by physicians with manual sphygmomanometer. In this method, 3 separate BP values were measured with 5-minute intervals after the patient was relaxed for 15 minutes in sitting position.

**Ambulatory blood pressure monitoring.** Forty-four-hour-ABPM with a Mobil Graft instrument were performed during the interdialysis period (between 2 sessions of dialysis). The instrument measured BP values every 30 minutes and 60 minutes during the day and the night, respectively.

**Home blood pressure monitoring.** Omron and

Watch BP instruments were used for home blood pressure monitoring. The patients themselves or a trained careful member of their family measured the BP values in this method during a week and 3 separate measurements were obtained each day.

### Echocardiography

Two-dimensional echocardiography was performed for each patient at the beginning of study by an echocardiologist. Left ventricular internal diameters at end diastole and end systole, thickness of the interventricular septum, posterior left ventricular wall thickness at end diastole, and ejection fraction were measured. Left ventricular mass index was calculated according to the Devereux and Reichek formula.<sup>7-9</sup> We defined left ventricular hypertrophy (LVH) as an LVMI greater than 131 g/m<sup>2</sup> for men and greater than 100 g/m<sup>2</sup> for women (based on Framingham criteria).<sup>8</sup> Severe LVH was described if LVMI was greater than 140 g/m<sup>2</sup> and 160 g/m<sup>2</sup> for women and men, respectively.<sup>8</sup>

### Statistical Analyses

The correlation between mean values of BPs based on different methods, eg, predialysis systolic BP (pre-SBP) and postdialysis systolic BP (post-SBP), was evaluated by the Pearson correction coefficient. A nonparametric test, the Mann-Whitney U, was used to compare differences between the two independent groups including different BP measurement data between patients with and without LVH. Data were presented as mean ± standard deviation. *P* values less than .05 were considered significant. The SPSS software (Statistical Package for the Social Sciences, version 16.0, SPSS Inc, Chicago, IL, USA) was used for statistical analysis.

## RESULTS

The data of 20 patients were analyzed, including 9 women and 11 men, with a mean age of 56.1 ± 15.78 years. Access was brachial in 13 cases and radial in 7. Forty-five percent of the patients were diabetic and 90% had a history of ischemic heart disease. The patients' mean body mass index was 16.83 ± 6.35 kg/m<sup>2</sup>. The mean laboratory values of serum calcium, phosphorus, albumin, and parathyroid hormone, and hemoglobin of the patients are presented in Table 1. The mean LVMI in all of the patients was

**Table 1.** The Mean Laboratory Values

Blood Parameter	Mean (Range)
Calcium, mg/dL	8.65 ± 0.91 (6.7 to 10.0)
Phosphorus, mg/dL	5.86 ± 1.40 (3.3 to 8.0)
Hemoglobin, g/dL	10.65 ± 1.77 (7.3 to 13.8)
Alkaline phosphatase, U/mL	476.35 ± 290.69 (164.0 to 1178.0)
Parathyroid hormone, pg/mL	399.54 ± 339.29 (80.9 to 1203.0)
Albumin, mg/dL	4.14 ± 0.40 (3.3 to 4.8)

119.6 ± 46.2 g/m<sup>2</sup>, but the amount was 129.7 ± 18.48 g/m<sup>2</sup> in the women and 121.08 ± 42.30 g/m<sup>2</sup> in the men. The minimum and maximum LVMI values were 4.35 g/m<sup>2</sup> and 217.83 g/m<sup>2</sup>, respectively.

Ten patients had hypertrophic left ventricle and 10 patients had normal left ventricle. The mean BP values of the patients based on various methods, including systolic, diastolic, and mean BP were extracted (Table 2). Finally, the mean values of BP in patients with and without left ventricular hypertrophy were calculated and analyzed separately. Statistical analysis showed that only pre-SBP and post-SBP had significantly different mean values ( $P = .02$  and  $P = .02$ , respectively). The differences were not significant in other measuring methods.

The mean pre-SBP in the patients with a normal and hypertrophic left ventricle was 129.27 ± 13.78 mm Hg and 149.53 ± 21.6 mm Hg, respectively. These values were 16.59 ± 120.96 mm Hg and

144.23 ± 24.46 mm Hg for the post-SBP, respectively.

If the LVMI value is divided based on the mentioned classification into those with and without LVH, the mean values of BPs based on different methods showed that the direct and positive correlation of pre-SBP and post-SBP was significant within the LVMI groups ( $r = 0.655$  and  $r = 0.566$ ;  $P = .002$  and  $P = .009$ ; respectively). Direct and positive correlations were also observed for predialysis mean arterial BP ( $r = 0.502$ ,  $P = .02$ ), 44-h ABPM ( $r = 0.464$ ,  $P = .06$ ), SBP night ( $r = 0.540$ ,  $P = .01$ ), night mean arterial BP ( $r = 0.500$ ,  $P = .03$ ), and standard SBP ( $r = 0.616$ ,  $P = .004$ ).

After classifying postdialysis BP, the mean values of BP (including systolic, diastolic, and mean arterial BP) had no significant differences based on LVH. However, all the patients with LVH had a generally higher mean BP. The addition of 4 patients with permanent catheter access did not significantly change the results.

An overview of the mean values in patients with and without LVH showed that the mean BP in patients with LVH was lower than that in patients without LVH in postdialysis diastolic BP (post-DBP), intradialysis DBP, home-measured SBP, DBP, and mean arterial BP in the morning, in the evening, and at night. However, as mentioned earlier, these differences were not significant.

Parathyroid hormone, serum calcium, and serum

**Table 2.** Means Blood Pressure Measured by Different Methods by Left Ventricular Mass Index\*

Parameter	Normal Left Ventricle	Left Ventricular Hypertrophy	P
Predialysis SBP	129.26 ± 13.77	149.53 ± 21.60	.02
Predialysis DBP	74.26 ± 9.05	75.06 ± 12.96	.85
Predialysis MAP	92.60 ± 9.13	99.89 ± 12.27	.17
Postdialysis SBP	120.85 ± 16.59	144.42 ± 24.46	.02
Postdialysis DBP	73.71 ± 11.71	72.07 ± 11.96	.80
Postdialysis MAP	89.44 ± 12.00	96.17 ± 12.99	.32
Intradialysis SBP	117.03 ± 40.73	142.13 ± 21.37	.09
Intradialysis DBP	73.87 ± 12.31	68.80 ± 12.29	.44
Intradialysis MAP	91.60 ± 13.19	93.28 ± 13.23	.68
44-hours SBP (ABPM)	132.30 ± 14.84	143.70 ± 18.68	.14
44-hours DBP (ABPM)	78.60 ± 10.98	80.90 ± 10.80	.44
44-hours MAP (ABPM)	103.20 ± 11.84	109.80 ± 12.36	.28
Home measured SBP	136.01 ± 14.66	115.25 ± 63.61	.97
Home measured DBP	76.92 ± 8.52	57.32 ± 32.37	.14
Home measured MAP	96.58 ± 8.70	76.63 ± 41.82	.39
Standard SBP	136.03 ± 15.47	150.49 ± 21.78	.10
Standard DBP	76.49 ± 10.69	71.43 ± 13.16	.53
Standard MAP	96.35 ± 10.91	97.58 ± 13.06	.58

\*SBP indicates systolic blood pressure; DBP, diastolic blood pressure; MAP, mean arterial blood pressure; and ABPM, ambulatory blood pressure monitoring.

phosphorus values were not significantly different among the patients, but the calcium value in the patients with LVH was significantly lower than that in the patients without LVH. Although the value of LVMI (the used quantitative mean) did not have a linear correlation with parathyroid hormone and phosphorus values, it had a negative linear correlation with serum calcium values as expected ( $r = 0.58$ ,  $P = .008$ ).

In all methods of assessing the mean values of BP based on the access type, the mean BP of the patients with radial access was higher than that of those with brachial access.

## DISCUSSION

This is the first study that compared 6 methods of BP measurement in hemodialysis. The study aimed to evaluate the association of LVMI and BP levels; LVMI was used as an indicator of long-standing BP. Left ventricular hypertrophy does not specifically determine BP and many other reasons may be involved in the development of LVH. According to Agarwal and colleagues, none of the blood pressure measurement methods was efficient in identifying LVH,<sup>10</sup> and the level of BP, regardless of the measurement technique, could not indicate LVH by itself.<sup>11</sup> However, LVMI is the only marker for identifying hypertension with the least controversy.

The best criteria to measure left ventricular mass is not specified yet. The prevalence of LVH in this study was 50% (56% in women and 45.5% in men) which was not consistent with previous studies, it was 74% in a large-scale study including 433 patients,<sup>12</sup> and 68% in a study by Agarwal and colleagues with 140 patients.<sup>10</sup>

There is still uncertainties about when to measure left ventricular mass. Previous studies have used different times to measure it. Some believe that the measurement of left ventricular mass immediately after dialysis shows it less than the actual measurements and some believe the contrary. Hence, no particular time was considered for echocardiography in this study. On the other hand, according to some studies, echocardiography estimates the left ventricular mass more than expected compared to magnetic resonance imaging. However, because of the harmful effects of magnetic resonance imaging and computed tomography scanning, especially

in this population, like all previous studies, we used echocardiography for this purpose.

Most studies in this area consider ABPM the best method to determine BP in patients with end-stage renal disease, like the general population, and therefore, it is the best predictor of cardiovascular morbidity. This tacit agreement is contrary to the guidelines, where hypertension definition in hemodialysis patients is still based on predialysis measurements. Meanwhile, the results of this study confirmed that.

According to our study, only SBP before and after dialysis were significantly correlated with LVH. This study was somehow similar to a study by Agarwal and coworkers, indicating that DBP was not useful in LVH diagnosis regardless of the BP measurement technique.<sup>13</sup>

When LVH is classified into mild and severe groups, this association is also observed in many measurement methods in addition to predialysis and postdialysis SBP, including SBP in continuous ABPM, interdialysis SBP.

In a study with 164 patients, the association of hypertension and severe LVH in all patients was higher than that in patients with mild LVH or no LVH. The group with severe LVH had clearly higher BP.<sup>8</sup> While the mean blood pressure in 44-h ABPM was similar to manual BP measurement in that study, a gradual increase in BP was observed during the days between the two sessions of dialysis.<sup>8</sup> This was not observed in our study and there was no difference in BP between the dialysis day and the day after that, although all patients with LVH had higher BP.

The present study also evaluated the mean pulse pressure in patients, which was significantly different in the severe LVH group and not in the groups with mild or no LVH. This variable was not assessed in previous studies.

In this study, 88.3% of patients were nondipper, which had a relatively high prevalence rate compared to previous studies (73% in a study with 93 patients, and 70% in another study with 80 patients). The present study found no relationship between LVMI and nondippers. However, this analysis was not reliable due to the small sample size in the dippers group.

## CONCLUSIONS

The results showed that BP measurements before

and after dialysis, which is the base of hypertension treatment in dialysis patients according to the guidelines, has a significant correlation with LVH. Although many studies consider continuous ABPM reliable, BP measurement before and after dialysis in a dialysis unit is still gold standard in terms of feasibility and reliability.

### CONFLICT OF INTEREST

None declared.

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