Introduction

Hypertension in adults of age 18 years and older is defined as SBP of 140 mm Hg or greater and/or DBP of 90 mm Hg or greater or any level of BP in patients taking antihypertensive medication. Hypertension and CVD remain one of the leading causes of morbidity and mortality in dialysis patients. Identification and treatment of hypertension is a persistent challenge that nephrologists face when managing patients on hemodialysis.²

Blood pressure control is of paramount importance in reducing morbidity and mortality in this high-risk population, although there is no consensus on target BP.² It has previously been shown that 2-week routine BP recordings in the dialysis unit when averaged can give a qualitative estimate of presence or absence of hypertension.² However, the thresholds for these qualitative estimates were such that the individual BP recordings were not helpful in determining any trend in sensitivity or specificity.²,³ Thus, substantial uncertainty exists in making an accurate diagnosis of hypertension in hemodialysis patients.

Ambulatory BP recording is currently considered as gold standard in estimating the BP among patients on dialysis. However, this facility is not easily available, especially in rural health setup and it is not economical as well, apart from being a cumbersome procedure. Therefore, there is a need for an easier and more convenient method to monitor the BP in patients on hemodialysis. Further, ABPM can only be used as a one-time measure to evaluate BP which is not adequate, especially for patients on hemodialysis. Some studies have demonstrated that home BP recordings may be promising in making a more accurate diagnosis of hypertension in hemodialysis patients.⁶However, the studies indicated further evaluation in making a home-based BP measurement a reliable alternative to ABPM. Also, these studies did not explore whether home BP recordings can improve the prediction of hypertension as assessed by ABPM.⁶,⁷

There is paucity on research studies that compare home-based BP monitoring with ambulatory BP recordings as a method of monitoring BP in patients on hemodialysis. Hence, our study was planned to examine the hypothesis that out-of-dialysis unit BP measurement in the form of home-based
measurement of BP is as efficacious and accurate as ABPM in evaluating hypertension among patients on hemodialysis.

**Materials and Methods**

**Place of Study**
The study was conducted in the Department of Medicine in a tertiary care hospital in Mumbai from Jun 2017 to May 2019.

**Study Design**
A prospective, randomized, observational study.

**Sampling Technique and Sample Size**
A consecutive type of nonprobability sampling was followed for selection of study subjects. A total of 52 consecutive patients fulfilling the eligibility criteria were taken up for the study after informed consent.

**Inclusion Criteria**
- Age above 18 years.
- Diagnosed case of CKD on maintenance hemodialysis.
- Completed a minimum period of 1 month on maintenance hemodialysis.

**Exclusion Criteria**
- Age less than 18 years.
- Chronic kidney disease patients who have not completed a period of 1 month on maintenance hemodialysis.
- Hemodynamically unstable patients.

**Methodology**
Blood pressure was measured using standardized BP measuring equipment at home, thrice a day for 3 days in the interdialysis period. Also, all these patients were subjected to 24 hours of ABPM in the interdialysis period. Ambulatory BP monitoring was done using ABPM apparatus—an oscillometric method-based recording device which was secured to the patient’s thorax with a belt provided and tethered around the neck. The first manual recording after the press of start button initiated automatic recordings every 30 minutes during daytime (from 7 am to 10 pm), and every 60 minutes at night (from 10 pm to 7 am). For all patients, ABPM was done for 24 hours in interdialysis period. The apparatus was detached from the patient after 24 hours, and reconnected to the computer for retrieving data. Home-based BP monitoring records are then compared with the one-time ABPM records.

**Statistical Methods of Analysis**
Data were statistically described in terms of mean (±standard deviation), frequencies (number of cases), and percentages when appropriate. Data were tested first for normal distribution by Kolmogorov–Smirnov test. Comparison of quantitative variables between the study groups was done using Student’s t-test for independent samples if normally distributed. Mann–Whitney U test was used for non-normally distributed quantitative data. For comparing categorical data, Chi-square test was performed. Exact test was used instead when the expected frequency is less than 5. Pearson’s correlation coefficient was computed to evaluate the correlation between quantitative variables. A probability value (p-value) less than 0.05 was considered statistically significant. All statistical calculations were done using computer programs Microsoft Excel 2007 (Microsoft Corporation, NY, USA) and SPSS (Statistical Package for the Social Science; SPSS Inc., Chicago, Illinois, USA) version 21.

**Duration of Study**
Two years, from June 2017 to May 2019.

**Blinding**
Unblinded study.

**Ethical Issues**
Ethical clearance was obtained from institutional ethical committee.

**Result**
A total of 52 consecutive patients on hemodialysis, fulfilling the eligibility criteria were taken up for the study after informed consent. Blood pressure was measured using a standardized BP measuring equipment at home, thrice a day for 3 days in the interdialysis period. Also, all these patients were subjected to 24 hours of ABPM in the interdialysis period. Home-based BP monitoring records are then compared with the one-time ABPM records.

**Discussion**
In patients with CKD, the diagnosis and management of hypertension rest almost entirely on BP measurements. Various studies have demonstrated that ABPM is superior to clinic-recorded BP in predicting cardiovascular events in patients with hypertension. The superior ability to risk stratify by ABPM has been confirmed in the general population, treated hypertensive patients, untreated hypertensive patients, refractory hypertension, and isolated systolic hypertension in the elderly. However, ABPM is not easily available, especially in rural health setup and it is not economical as well. Though ABPM is proven to be superior to clinic BP measurements, there are studies that demonstrated that home BP recordings may be promising in making a more accurate diagnosis of hypertension in hemodialysis patients. Since the evidence is not robust, still home-based BP measurements are not routinely used to diagnose or predict cardiovascular events in hemodialysis patients. Our study is aimed at establishing the fact that home-based BP measurements are as accurate, if not better than ABPM and can be safely used to diagnose and predict cardiovascular events in patients on hemodialysis.

In our present study, the mean age of the study subjects was 49.56 years with over half of them above 50 years of age (57.7%) (Table 1). Slight male predominance was observed in the study subjects with 55.8% males to 44.2% females. Similar observations were also made by Rahman et al. and Andersen et al. where the mean age of subjects on dialysis was 63.34 and 67.0 years, respectively with male predominance (64 and 96.1%) thereby confirming that our study population did not differ significantly from the representative general population.

In our study, the mean awake, asleep, and average ABPM readings of SBP were 141.69, 139.39, and 141.23 mm Hg, respectively. Mean awake, asleep, and average ABPM readings of DBP were 81.33, 80.04, and 80.67 mm Hg (Table 2). These results are corresponding to the studies conducted by Tonbul et al. and Farmer et al. Similarly, the mean SBP and DBP recorded on home-based measurements were 143.6 and 82.69 mm Hg, respectively, and similar observations were also made by Agarwal, Andersen et al., and Ye et al. The results confirm that there is not much of variation in BP as measured by ABPM and home-based BP measurements among different study population and hence the results of our study can be extrapolated to the target population. Also, our present study shows that there is no statistically significant difference between mean BP readings as observed by ABPM and home-based BP measurements among different age groups (Table 2).

Table 1: Distribution of subjects based on age group

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>No. of patients (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;30</td>
<td>4 (7.7%)</td>
</tr>
<tr>
<td>31–40</td>
<td>12 (23.1%)</td>
</tr>
<tr>
<td>41–50</td>
<td>6 (11.5%)</td>
</tr>
<tr>
<td>51–60</td>
<td>16 (30.8%)</td>
</tr>
<tr>
<td>&gt;60</td>
<td>14 (26.9%)</td>
</tr>
<tr>
<td>Total</td>
<td>52 (100%)</td>
</tr>
</tbody>
</table>
We also observed that all subjects showing mean SBP ≥140 mm Hg as per ABPM, also had home-based readings of above 140 mm Hg while 23 out of 27 patients (85.2%) with mean SBP <140 mm Hg as per ABPM had similar observation by home-based monitoring (Table 3). Overall a good measure of agreement was seen between the two methods (kappa 0.847; p < 0.01). Similarly, all subjects showing mean DBP ≥90 mm Hg as per ABPM had home-based readings of above 90 mm Hg, while 42 out of 44 patients (95.5%) with mean DBP <90 mm Hg as per ABPM had similar observation by home-based monitoring (Table 3). Again, an overall good measure of agreement was seen between the two methods (kappa 0.866; p < 0.01). Studies by Agarwal et al. also showed a similar good measure of agreement.13 They observed that standard deviation of the difference with ABPM was least for home BP. They concluded that home BP monitoring appears to be a better alternative than clinical measurements in dialysis. Our study too reiterates the fact that home-based BP could be an effective replacement to ABPM. In a study of 32 peritoneal dialysis patients by Wang et al., the relationship between home BP monitoring and 24-hour ABPM was evaluated.14 Home BP was taken as the 10-day average of three BP readings obtained in the morning. There was a high correlation between home BP and 24-hour ABPM values (r = 0.54–0.71). In our present study too, an excellent correlation was observed between the home-based and ambulatory BP measurements (r = 0.93; p < 0.01). These data suggest that home BP monitoring may add value to the diagnosis of hypertension in peritoneal dialysis patients. Similar results were also reported in children with CKD and people with type 2 diabetes mellitus.15

Ability to detect hypertension is an important measure of the diagnostic method adopted. Hence, in our study, we adopted the novel idea of knowing the ability of home-based BP measurement to detect hypertension among patients on hemodialysis. While 25 out of 52 (48.1%) subjects showed a systolic hypertensive record on ABPM, 29 out of 52 (55.8%) were detected to have systolic hypertensive record by home-based BP (Table 4). Similarly, while 8 out of 52 (15.4%) subjects showed a diastolic hypertensive record on ABPM, 9 out of 52 (19.2%) had a similar outcome by home-based BP (Table 4). The ability to detect hypertension by home-based BP measurement is the novelty of our study. Our study showed that home-based BP records can reliably detect hypertension when compared to the ABPM.

**REFERENCES**


**Table 2:** Mean SBP and DBP as measured by home-based and ambulatory BP measurement

<table>
<thead>
<tr>
<th>Variables</th>
<th>Group</th>
<th>Mean (mm Hg)</th>
<th>SE</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>SBP</td>
<td>Ambulatory BP</td>
<td>141.23</td>
<td>2.46</td>
<td>0.493</td>
</tr>
<tr>
<td></td>
<td>Home-based BP</td>
<td>143.60</td>
<td>2.49</td>
<td></td>
</tr>
<tr>
<td>DBP</td>
<td>Ambulatory BP</td>
<td>80.67</td>
<td>1.45</td>
<td>0.329</td>
</tr>
<tr>
<td></td>
<td>Home-based BP</td>
<td>82.69</td>
<td>1.43</td>
<td></td>
</tr>
</tbody>
</table>

**Table 3:** Comparison of SBP and DBP as measured at home to ambulatory BP measurements

<table>
<thead>
<tr>
<th>SBP ≤140/DBP &lt;90 (number)</th>
<th>SBP &gt;140/DBP ≥90 (number)</th>
<th>Total (number)</th>
<th>Kappa</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>23/42</td>
<td>0/0</td>
<td>23/42</td>
<td>0.847</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>04/02</td>
<td>25/08</td>
<td>29/08</td>
<td>0.866</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>27/44</td>
<td>25/08</td>
<td>52/52</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table 4:** Distribution of hypertensive and nonhypertensive records as measured by ambulatory and home-based BP measurements

<table>
<thead>
<tr>
<th>SBP (mm Hg)</th>
<th>Ambulatory BP, n (%)</th>
<th>Home-based BP, n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥140</td>
<td>25 (48.1)</td>
<td>29 (55.8)</td>
</tr>
<tr>
<td>&lt;140</td>
<td>27 (51.9)</td>
<td>23 (44.2)</td>
</tr>
<tr>
<td>DBP (mm Hg)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥90</td>
<td>08 (15.4)</td>
<td>10 (19.2)</td>
</tr>
<tr>
<td>&lt;90</td>
<td>44 (84.6)</td>
<td>42 (80.8)</td>
</tr>
</tbody>
</table>

**CONCLUSION**

Home-based BP monitoring is a simple, easily available, and inexpensive tool that correlates well with ABPM, the present gold standard. Our study shows that there is no significant difference between BP readings as observed by ABPM and home-based BP monitoring. Also, home-based BP monitoring can detect hypertension as effectively as ABPM among patients on hemodialysis. Hence, home-based BP monitoring can replace ABPM, especially in patients of hemodialysis. Also, measuring home BP may lead to more active participation in health care by patients and enhance their quality of life.