How Reliable Is Nighttime Blood Pressure Dipping?

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This report examines the reliability of nighttime blood pressure dipping. Twenty-one individuals were studied twice with ambulatory blood pressure monitoring. On one occasion they were studied as outpatients, and on the other as inpatients on a clinical research ward. Blood pressure monitoring revealed the expected dip in blood pressure at nighttime. However, there was little test–retest reliability across the two settings. The test–retest correlations for the dip in blood pressure across the two settings were nonsignificant for systolic, diastolic, and mean arterial blood pressure. Caution is advised before diagnosing dipping or nondipping on the basis of one 24-h ambulatory blood pressure recording. Am J Hypertens 1998;11:606–609

KEY WORDS: **Blood pressure, ambulatory blood pressure monitoring, chronobiology, dipping.**

The advent of noninvasive ambulatory blood pressure monitors (ABPM) has revealed new perspectives on blood pressure (BP) regulation. The bulk of the literature on ABPM has emphasized the usefulness of monitoring across the entire 24-h period of the day or else has reported effects of certain activities during the day, such as employment.[1–3] Early studies on ABPM recognized the potent effect of sleep to decrease BP an average of 10% to 15% in most individuals, a number in agreement with more invasive intraarterial BP monitoring and with sphygmomanometry in sleep laboratories.[4,5]

With further study, however, investigators have observed that some patient groups do not dip their BP during nighttime or have a relatively small dip in BP. A number of studies have reported that blacks are nondippers.[6,7] Other studies have reported that nondippers comprise a diverse group of medical patients such as patients with autonomic neuropathies,[8] diabetes,[9,10] renal failure,[11] and sleep apnea.[12] The mechanism for this nondipping is unknown, but it is believed to be pathologic because it exposes the patient to a higher BP load throughout the 24-h day.

There is no standard definition for the time frame of dipping. Most investigators contrast the daytime BP 6 AM to 10 PM) with the nighttime levels (10 PM to 6 AM); but some investigators favor a more precise definition, timed either according to ''lights out'' for bedtime or for actual time of sleep onset.[13] Dipping is measured with all the common indices of BP (systolic BP [SBP], diastolic BP [DBP], and mean arterial BP [MAP]). Some investigators study dipping as a continuous variable, whereas other investigators define an arbitrary level of presumably pathologic ''nondipping.''

Curiously, few studies have examined the reliability of nocturnal dipping within individuals. On the other hand, there is an extensive literature concerning reliability of 24-h ABPM. The repeated measurements allow an excellent assessment of BP with high test–retest reliability, ~r = 0.82 for SBP and 0.79 for DBP.[14–16] Given the increasing interest in chronobio-

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TABLE 1. SUBJECT CHARACTERISTICS*

Characteristics	Data
No. (M/F)	13/8
Blacks/whites	14/7
Age (mean, SD)	38 (5)
Normotensives/hypertensives	18/3
Screened BP mm Hg	125/76 (15/11)
Outpatient ABPM systolic day/night mm Hg	123/115 (12/15)
Outpatient ABPM diastolic day/night mm Hg	75/68 (9/11)
Outpatient ABPM MAP day/night mm Hg	91/83 (10/12)
Inpatient ABPM systolic day/night mm Hg	123/115 (10/10)
Inpatient ABPM diastolic day/night mm Hg	75/69 (9/8)
Inpatient ABPM MAP day/night mm Hg	91/84 (9/9)
Outpatient systolic dip	9 (8)
Outpatient diastolic dip	8 (8)
Outpatient mean arterial pressure dip	8 (8)
Inpatient systolic dip	9 (6)
Inpatient diastolic dip	7 (5)
Inpatient mean arterial pressure dip	7 (5)

* *Numbers in parentheses are standard deviations.*

logic changes in BP in various illness groups, we wondered whether the BP dipping was a robust phenomenon across multiple occasions and settings.

METHODS

Twenty-one subjects were studied as part of a larger protocol studying sympathetic nervous system and BP regulation. Subjects were located by word of mouth referral or through response to public advertisements. The protocol was approved by the UCSD Human Subjects Committee. All subjects were either normotensives or unmedicated hypertensives whose medications had been tapered for at least 2 weeks before study. Subjects had screening BPs taken on two occasions roughly 1 week apart. After being seated for at least 10 min, patients had their BPs taken three times on both screening occasions, and the average of all these measurements is referred to as our ''screened BP.'' Table 1 provides the subject characteristics.

Patients were studied first as outpatients and then, approximately 2 weeks later, as inpatients on a clinical research ward. The ABPM used was a SpaceLabs (Redmond, WA) model 90207. An appropriately sized cuff was positioned with a Y-connector to establish that BP detected by the monitor agreed within 5 mm Hg with BP detected by standard auscultatory sphygmomanometry. The monitor was programmed to inflate every 15 min during the day and every 30 min during the night. The data were edited using standard artifact software provided by SpaceLabs.

Dipping was calculated as the decrease in BP from daytime level to nighttime level (10 PM to 6 AM). Each subject received a ''dip score'' for SBP, DBP, and MAP. The test–retest agreement was examined with Pearson correlation coefficients. As a further way of examining dipping reliability, Bland-Altman plots were examined.

RESULTS

Table 1 provides the average nighttime dip in BP as assessed in the ambulatory outpatient setting and in the research ward setting. In both instances, BP decreased significantly at nighttime. In general 24-h BP was slightly lower in inpatients, but the nighttime dip in BP was comparable in outpatients and inpatients.

There was poor correlation of the degree of dipping across the two settings. The test–retest correlations were all nonsignificant (SBP, $r = 0.03$ $P = .91$; DBP; $r = -0.12$, $P = .60$; MAP, $r = -0.15$, $P = .51$). In contrast, there was limited test–retest agreement for daytime BP but excellent test–retest reliability for nighttime BP across the two settings (daytime: SBP, $r = 0.50$ $P < .025$; DBP, $r = 0.36$ $P < .11$; MAP, $r = 0.39$ $P < .08$; nighttime: SBP, $r = 0.79$ $P < .001$; DBP, $r = 0.84$ $P < .001$; MAP, $r = 0.82$ $P < .001$). Figure 1 graphically portrays the problems in test–retest agreement using Bland-Altman plots of SBP dipping; points outside the bracketing lines indicate disagreement in dip scores $>$ 5 mm Hg across the two testing occasions. Similar plots were obtained concerning DBP and MAP (data not shown).

DISCUSSION

We found poor test–retest reliability of nocturnal BP dipping. It is possible that dipping or nondipping might be more reliably measured in patients with particular illnesses such as diabetes or renal failure; it may well be the case that such individuals reliably do not dip their BPs at night. Instead we studied a mix of normotensive controls and unmedicated patients with mild hypertension to define the parameters of BP dip reliability in a more normal group of individuals. Nine of 21 patients (43%) had systolic dip scores differing by $>$5 mm Hg across the two testing occasions.

Our study is limited by the small sample size. However, we doubt that sample size accounts for our findings for a number of reasons. First, the P values for the three BP measures were never even close to significant; the most significant value was $P = .51$. Second, the amount of variance explained by these correlations was small; only 0.1% to 2% of the variance was accounted for by the correlations. If in fact we are committing a type II error that would be corrected by a larger sample size, we estimate that we would need to

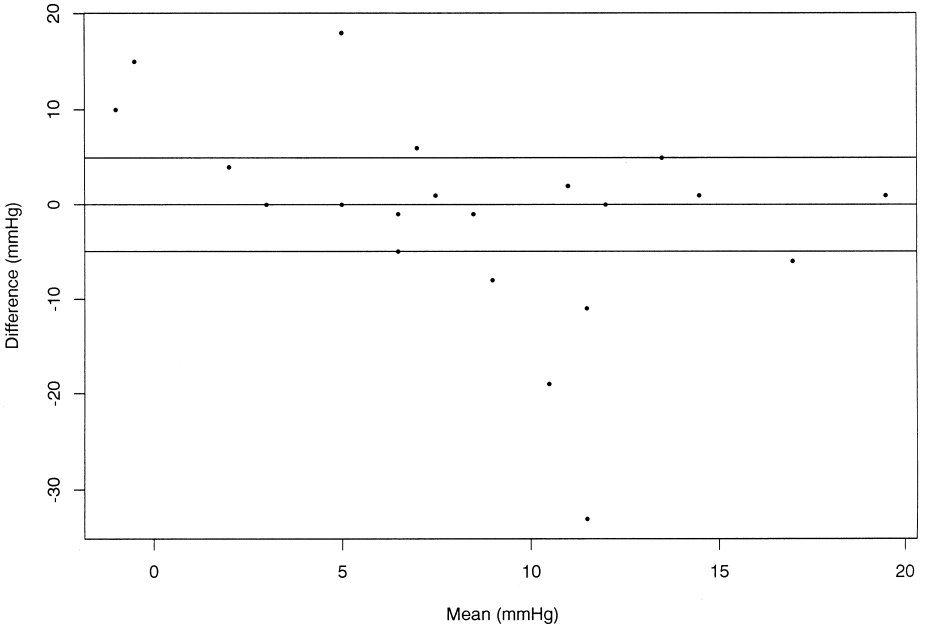

FIGURE 1. *Bland-Altman plot of systolic blood pressure dipping (mm Hg) on two occasions. The lines bracket those points demonstrating agreement in dip scores within 5 mm Hg across the two testing occasions.*

study many more individuals to be able to perceive a significant association between inpatient and outpatient assessments of dipping (~ 120 individuals for MAP, ~ 3000 for SBP, and ~ 190 for DBP). Such large sample size requirements suggest to us that the reliability of the dipping diagnosis is clinically questionable. Third, we observed excellent test–retest correlation of nighttime ABPM values across the two environments, even with our small sample size. The daytime test–retest measures in the ambulatory environment and on the research ward were weak for MAP and DBP, but were significant for SBP. For comparison, recall that the dipping measure had poor reliability for virtually every measure of BP—SBP, DBP, and MAP.

We intentionally assessed dipping in two different environments. It is possible that there would be better dipping reliability if patients were assessed both times in the same environment. However, the entire literature on the pathologic state of nocturnal nondipping treats this phenomenon like a trait and assumes that one can in fact characterize an individual's habitual nocturnal dipping with one 24-h ABPM. Our data suggest that such an assumption needs rethinking.

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