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EDITORIAL

How Should the Diurnal Changes of Blood Pressure Be Expressed?

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"What I tell you three times is true."—Lewis Carroll, *The Hunting of the Snark*

In this issue of the *Journal* three papers discuss the same topic and come to similar conclusions,[1–3] an unusual occurrence in medical science. At issue is the most appropriate method for quantifying the diurnal changes of blood pressure. It has been known for many years that blood pressure decreases during the night, usually by 10% to 20%. Some years ago O'Brien et al suggested that people could be classified as "dippers" or "nondippers" according to the degree to which their blood pressure falls during sleep.[4] While the majority of people would be classified as dippers (usually defined as a nocturnal decrease of 10% or more), there are a variety of clinical situations associated with a diminished nocturnal fall of blood pressure. Nondipping may be seen in healthy normotensive individuals, but is more commonly seen in hypertensives. A potentially interesting observation is the finding that blacks tend to be nondippers more commonly than whites, but this difference is probably environmental rather than genetic, since it is not seen in all populations.[5] Nondipping has also been reported to be associated with several forms of secondary hypertension, including preeclampsia, chronic renal disease, some types of adrenocortical hypertension, such as Cushing's disease, and pheochromocytoma.[6] Several cross-sectional studies have shown that target organ damage may be more pronounced in nondippers than in dippers.[7–9] One study has reported that women who are nondippers are at greater risk of cardiovascular morbidity than women who are dippers.[10] No difference was observed in the men.

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The subject is thus of clinical importance, but there has been up to now no consensus as to how "day" and "night" blood pressures should be defined. As Dr. Filho reports in his paper, as many as twelve different time schedules have been used by different authors.[3] In 1990 the Scientific Committee of an International Conference on Ambulatory Blood Pressure Monitoring recommended standardization of data analysis and proposed using 7 AM to 10 PM for the day and 10 PM to 7 AM for the night.[11] Physiologically this makes little sense, because people go to bed and get up at different times, and it is clearly established that what determines the diurnal rhythm of blood pressure is the cycle of activity and rest rather than an internal biological clock. If the 24-h blood pressure profiles of a number of individuals are averaged, the aggregate curve looks sinusoidal, which led some authors to suggest that the blood pressure starts to rise in the small hours of the morning, before the time of awaking.[12] If, however, the profiles are normalized to the time of waking rather than to the time of day there is an abrupt increase at the time of waking,[13] and another increase on getting up.[14]

All three studies reported in this issue compared the consequences of expressing the day-night differences of blood pressure either by a fixed time of day (which was different in all three) or by the patients' reported times of going to sleep and waking up. Filho et al concluded that the fixed time methods overestimated the level of blood pressure during sleep, and hence underestimated the day-night differences.[3] The other two papers focused on the classification of dippers, and both found that the fixed time methods tended to give a higher prevalence of dippers than the diary method, although in the case of Rosansky these differences were relatively small.[1] Gatska used two fixed time methods of classification, a "wide" method, which simply divided the 24 h into two periods, and a "narrow" method, which used more re-

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stricted windows of time and omitted the transition periods between wakefulness and sleep.[2] In their four groups of subjects, the diary method classified all the normotensive and borderline hypertensive subjects as dippers, while the "wide" method misclassified 31% and 20%, respectively; not surprisingly, the "narrow" method misclassified only 4% and 20%. These results are consistent with Filho's.

It is clear that no single mechanism accounts for the individual differences in the extent of dipping. There is a tendency to regard it as a measure of the fall of blood pressure occurring with sleep, which is the rationale underlying the three papers in this issue, but it should also be recognized that the increases occurring during the day are of equal importance. If the sleeping pressure was used as the basal level, we might refer to peakers rather than dippers. Not surprisingly, the day-night differences are smaller in subjects who stay in bed for 24 h than in those who are ambulatory during the day.[15] We have found that demographic factors, such as smoking and habitual alcohol intake, also influence the difference, but whether the effect is primarily on the daytime or nighttime pressure is not resolved.[16]

There has been some dispute as to whether the diurnal rhythm of blood pressure should be regarded as an intrinsic circadian or sinusoidal rhythm, in which case expressing the changes as a simple day-night difference would be inappropriate. The alternative explanation, that the changes are a function of the cycle of rest and activity is supported by the bulk of the evidence, and an analysis comparing a square wave model with a sinusoidal model of 24-h blood pressure found that the former gave a better fit to the data.[17] This same analysis, which used 20 min averages of blood pressure readings made from continuous intraarterial recording, also found that the distribution of blood pressure over 24 h was bimodal, which implies that a square wave model is appropriate. The transitions between the high and low pressure periods were determined empirically, and showed a surprisingly large range, being from 7:40 to 12:40 PM for the nocturnal decrease, and from 5:40 to 9:40 AM for the morning increase. Whether these changes coincided with the transitions between sleep and wakefulness was not determined.

Ambulatory monitoring of blood pressure is gradually becoming accepted as a valuable clinical tool, and the assessment of the diurnal changes of blood pressure is one of the unique features that it can provide. The interpretation of such changes will be greatly facilitated if there are standard criteria, and it is clear from the three papers presented in this issue that the most meaningful method for defining night and day is by using the patients' reports of sleeping and waking times.

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