

# Blood Pressure Measurements in Borderline Hypertension

Rose Anne Kenny, Margaret Brennan, Kevin O'Malley and  
Eoin O'Brien

In 19 patients (mean age 46 years, range 20–54), with borderline hypertension (at least one of three consecutive clinic blood pressure readings  $> 140/90$  and one  $< 140/90$  mmHg), clinic blood pressure was compared with basal (modified Smirk's method), self-recorded and ambulatory 12-h blood pressures (Remler M 2000). Each measurement was made on the same day on three separate occasions at 2-weekly intervals.

For each technique, there was no significant difference in systolic blood pressure (SBP) or diastolic blood pressure (DBP) for the three study days. Clinic SBP ( $159 \pm 13$  mmHg) was higher than basal ( $142 \pm 11$  mmHg,  $P < 0.001$ ), self-recorded ( $148 \pm 13$  mmHg,  $P < 0.01$ ) or ambulatory SBP ( $139 \pm 15$  mmHg,  $P < 0.001$ ) on the first and all subsequent study days. Self-recorded SBP was higher than ambulatory SBP on the first study day ( $P < 0.05$ ) but basal, self-recorded and ambulatory SBP did not differ significantly otherwise. Clinic DBP ( $99 \pm 9$  mmHg) was higher than basal ( $90 \pm 10$  mmHg,  $P < 0.01$ ) and ambulatory DBP ( $88 \pm 10$  mmHg,  $P < 0.001$ ) on the first study day, but did not differ significantly from self-recorded DBP ( $94 \pm 12$  mmHg, NS). Clinic DBP ( $97 \pm 10$  mmHg) was higher than basal ( $91 \pm 9$  mmHg,  $P < 0.001$ ) on study day 2 and on study day 3 ( $97 \pm 14$  mmHg versus  $90 \pm 13$  mmHg,  $P < 0.001$ ).

The blood pressure profile in borderline hypertension obtained by conventional clinic measurement therefore differs significantly from self-recorded measurement and especially from ambulatory and basal measurements which may provide a more representative assessment.

Journal of Hypertension 1987, 5 (suppl 5):S483–S485

**Keywords:** Blood pressure measurements, borderline hypertension.

## Introduction

Blood pressure fluctuates continually over 24-h periods, and it is now accepted that casual measurements may give a false assessment of blood pressure behaviour [1,2]. Diagnosis and management of high blood pressure may be assisted by measurement of blood pressure under basal conditions at home or at work and by ambulatory techniques [3–10]. Moreover, there is evidence now that ambulatory blood pressure is a more accurate predictor of morbidity and mortality than casual blood pressure [11–13]. In borderline hypertension it is particularly important to determine the level of blood pressure accurately, to avoid misdiagnosis, unnecessary treatment and inaccuracy in prognosis.

In the present study, blood pressure in patients with borderline hypertension has been characterized by clinic,

basal, self-recorded and ambulatory blood pressure measurements.

## Patients and methods

We studied 19 patients (nine female, 10 male; mean age 46 years, range 20–54) with borderline hypertension defined as at least one of three clinic blood pressure readings greater than  $140/90$  mmHg and one reading less than  $140/90$  mmHg. Patients with a blood pressure difference between the two arms of 10 mmHg or more were excluded. Antihypertensive medication had been discontinued for the previous 4 weeks. No patients had evidence of cardiovascular end-organ damage. The subjects attended the clinic at 0900 h on three occasions at 2-weekly intervals, and blood pressure was measured

From the Blood Pressure Clinic, The Charitable Infirmary, Jervis Street, Dublin 2, and The Royal College of Surgeons in Ireland, St. Stephen's Green, Dublin 2.

The Royal College of Surgeons Research fund and the Medical Research Council of Ireland are gratefully acknowledged.

Requests for reprints to: Dr Eoin O'Brien, The Charitable Infirmary, Jervis Street, Dublin 2, Ireland.

Sponsorship: Research grants from the Charitable Infirmary Trust,

each time by four methods. Conventional clinic blood pressure was measured by a physician and was followed by basal blood pressure measurement over 30 min; the subject then left the hospital wearing a Remler M2000 with the cuff on the right arm, and instructions to activate the device every 30 min and to measure blood pressure in the left arm every 2 h with a mercury sphygmomanometer. Measurement techniques were not randomized as this would have been possible for only two of the four methods. The present study design is representative of everyday clinical practice.

*Clinic measurements* were carried out by a physician, using a standard mercury sphygmomanometer with the patient seated, after 3-min rest, and the arm supported at heart level; disappearance of Korotkoff sound V was taken as DBP.

*Basal blood pressure* was then recorded according to a modification of Smirk's method [14]. The patient voided if necessary, removed tight clothes, shoes or jewellery and lay recumbent in a quiet, dimly lit room for 10 min, after which blood pressure was recorded with a mercury sphygmomanometer every 5 min for 30 min, with the arm supported at heart level. One physician made all the measurements over the data collection period. The lowest DBP was taken as the basal blood pressure.

*Ambulatory blood pressure* was recorded with a Remler M2000 recorder [15] after determination of the basal blood pressure; the microphone and cuff was placed on the right arm, and after two sample readings to ensure satisfactory recordings, the patient left hospital with instructions to take readings every 30 min for 12 h.

*Self-recorded measurements* were made by the patient, using a mercury sphygmomanometer with a standard cuff (12 x 22 cm) and a separate stethoscope. The subjects were trained for 20 min and accuracy was subsequently assessed by a physician using a dual-headed stethoscope; after a week of practice, by measuring blood pressure twice daily, the accuracy was reassessed. If the difference between the means of two consecutive systolic and diastolic recordings was less than or equal to 5 mmHg, no further instruction was given. On the study days, self-recorded pressures were measured at 2-h intervals in the left arm, the Remler recordings being taken first when both measurements coincided.

### Statistical analyses

Within-patient and between-patient mean SBP and DBP

were compared for each technique, using Student's paired and unpaired t-tests. Variability in the blood pressure measured by ambulatory recordings between weeks was assessed by paired t-tests for standard deviation, coefficient of variation and range.

## Results

For each technique, there was no significant difference in the blood pressure measurements for the three study days (Table 1).

Clinic SBP was significantly higher than basal (study days 1 and 2,  $P < 0.001$ ; study day 3,  $P < 0.01$ ), self-recorded (study days 1 and 2,  $P < 0.01$ ) and ambulatory pressures ( $P < 0.001$ ) on all three study days, apart from self-recorded pressures on study day 3 (NS). Self-recorded pressures were higher than ambulatory on study day 1 ( $P < 0.05$ ), but otherwise the recordings did not vary significantly between basal, self-recorded and ambulatory SBP for study days 1, 2 and 3.

Clinic DBP was higher than the readings by other techniques on study day 1 (basal and ambulatory,  $P < 0.001$ ; self-recorded  $P < 0.05$ ) and higher than basal for study days 2 and 3 ( $P < 0.001$ ).

Blood pressure variability (s.d., % coefficient of variation and range) during Remler 12-h ambulatory sessions did not vary significantly between study days (Table 1).

## Discussion

The biggest discrepancy between ambulatory, self-recorded and clinic readings appears to be in patients with borderline hypertension – precisely the subjects for whom there is the greatest therapeutic dilemma [6,16,17]. Self-recorded blood pressure, a technique which has been shown to be accurate in the management of hypertensive patients [6,18,19] and which is lower than clinic blood pressure, has been recommended as a more representative assessment of blood pressure behaviour in borderline hypertension. However, the results of our study show that basal and ambulatory recordings are lower than self-recorded and clinic measurements, and as ambulatory measurement is a more accurate predictor of morbidity [11,13,20], it may be a more accurate assessment of blood pressure behaviour.

Clinic SBP was consistently higher than basal, ambulatory or self-recorded SBP, but self-recorded SBP was higher than ambulatory on the study day 1 and only fell to levels near basal and ambulatory measurements on

**Table 1.** Blood pressure measurements (mmHg) during each recording period for four different techniques.

	Clinic		Basal		Self-recorded		Ambulatory		CV (%)	Range
	SBP	DBP	SBP	DBP	SBP	DBP	SBP	DBP		
Study day 1	159 ± 13	99 ± 9	142 ± 11	90 ± 10	148 ± 13	94 ± 12	139 ± 15	88 ± 10	11	47
Study day 2	156 ± 10	97 ± 10	142 ± 10	91 ± 9	148 ± 13	94 ± 13	142 ± 14	92 ± 9	10	42
Study day 3	153 ± 15	97 ± 14	137 ± 10	90 ± 13	144 ± 15	94 ± 13	136 ± 16	90 ± 9	11	50
	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

SBP, systolic blood pressure; DBP, diastolic blood pressure; NS, statistical significance between recording intervals for each technique. CV, coefficient of variation

study days 2 and 3. A similar pattern was apparent on the study day 1 for DBP, but clinic DBP only differed significantly from basal pressure thereafter.

Mancia *et al.* [21] have shown that the alerting reaction which characterizes blood pressure measured by the doctor does not abate with repeated visits for blood pressure measurement over a short term, but that longer visits rather than repeated visits may give lower blood pressure recordings. Our results confirm that repeated measurements at 2-weekly intervals were reproducible irrespective of the measurement technique used, and this was consistent for both SBP and DBP. Repeated measurements over this time showed no regression to the mean. Repeated recordings of basal blood pressure over 30 min were more representative of ambulatory recordings than clinic measurements and self-recorded measurements.

In borderline hypertension, conventional clinic measurement gives levels of blood pressure that are higher than basal or ambulatory measurements, with self-recorded measurements falling between the two. If we can accept that ambulatory monitoring is more representative of true blood pressure behaviour and therefore a more accurate measurement for diagnosis and prognosis, ambulatory or basal recordings assess blood pressure behaviour more accurately in borderline hypertensives.

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