

From Ambulatory Blood Pressure Monitoring
Ed in H. Weber and J. Im. Dräger. Springer Verlag

Reproducibility of ambulatory blood pressure recordings New York

Desmond J. Fitzgerald¹⁾, Kevin O'Malley¹⁾, Eoin T. O'Brien²⁾

1984. pp 71-4

Summary: Reproducibility of ambulatory blood pressure recordings was assessed in 19 untreated hypertensive subjects over a six month period. Ambulatory blood pressure was recorded using a semi-automatic portable blood pressure recorder (Remler M2000) from 900 h until retiring. The mean (\pm SEM) number of days on which recordings were made in each patient was 5.1 ± 0.31 , the period between recordings being 2-6 weeks. Parameters derived from these recordings were the peak, trough and mean of all daily recordings, and the standard deviation and coefficient of variation of these recordings were derived as indices of blood pressure variability. Analysis of variance of the first 3 days of ambulatory blood pressure recordings showed no change in any of these parameters over time. The coefficients of variation within patients of the mean, peak and trough blood pressures were less than 11%. In comparison, the coefficients of variation of the parameters of blood pressure variability were greater than 20%. Analysis of variance of the first three ambulatory recording days (all patients had at least three) showed that the within-patient variance was significantly less than between-patient for the mean, peak and trough systolic and the mean and trough diastolic blood pressures but not for the peak diastolic pressure or parameters of blood pressure variability. In conclusion, ambulatory blood pressure measurements are reproducible. The poor reproducibility of the standard deviation and coefficient of variation negates their usefulness as measures of blood pressure variability.

Introduction

Repeated indirect recordings of blood pressure in hospital have proven reproducible from day to day when hourly averages or the means of recordings for the whole day are compared (1, 2) while measures of blood pressure variability are poorly reproducible (2). However, patients are restricted in hospital, and increasingly portable blood pressure recorders are being used to assess ambulatory blood pressure behavior outside hospital during normal daily activities (3). Ambulatory monitoring can only be considered a practical method of assessing blood pressure behavior if results are reproducible over a prolonged period. Other investigators have examined reproducibility of ambulatory recordings. However, these studies were either in hospital (4) or over 2-3 days within a short period of each other (5, 6, 7). In this study, the reproducibility of non-invasive ambulatory recordings is assessed over a 6 month period in non-hospitalized ambulant patients.

Methods and patients

Ambulatory recordings were performed repeatedly on 19 hypertensive subjects using the Remler M2000 semi-automatic recorder (8) at intervals of 2-6 weeks over a 6 month

¹⁾ The Blood Pressure Clinic Charitable Infirmary Jervis St. Dublin and

²⁾ Dept. of Clinical Pharmacology Royal College of Surgeons in Ireland St. Stephen's Green Dublin.

period. None of the subjects were on drug treatment during the study. The mean age of the study group (7 men, 12 women) was 43.9 ± 2.1 with a range of 29–60 years. Patients attended the hospital in the morning where the recorder was attached. For the remainder of the day patients carried out their normal activities while recording their blood pressure every 30 min. A successful day-recording was defined as one in which 10 or more recordings were decodable. Day-recordings with fewer than 10 decodable individual recordings were not included in the analysis.

Reproducibility of five parameters was assessed; the peak, trough, mean, standard deviation and coefficient of variation of daily ambulatory recordings. The coefficient of variation within subjects was derived for each parameter and compared against that for between subjects. Time-related changes in recording parameters were assessed from the first three successful day-recordings (all patients had at least three) by two-way analysis of variance.

Results

The mean (\pm SEM) number of successful day-recordings over the period of study was 5.1 ± 0.31 (range 3–7). Mean, peak, and trough systolic pressures, and mean and peak diastolic pressures tended to fall between the first (R_1) and third (R_3) days of recording (Table 1). However, these differences were not statistically significant. Over the same period clinic blood pressure for the group as a whole (mean \pm SEM) remained unchanged ($160 \pm 3.9/96.3 \pm 1.7$ Vs $160 \pm 4.1/96.8 \pm 3.2$) although mean clinic pressure at the first clinic visit which occurred 4 weeks before the study began had been slightly higher ($163 \pm 3.5/99 \pm 1.6$).

Coefficients of variation of blood pressure parameters were less within patients than between patients, with the exception of measures of blood pressure variability (Table 2). Similarly, the two-way analysis of variance of the first three successful ambulatory recordings in all 19 subjects showed that between-patient variance was significantly greater than within-patient variance for systolic peak (F 5.6, $P < 0.05$), trough (F 13.5, $P < 0.001$) and mean pressures (F 16.4, $P < 0.001$) and for diastolic mean (F 11.5, $P < 0.01$) and trough pressures (F 7.4, $P < 0.01$). However, variance of diastolic peak pressure and of the standard deviations and coefficients of variation of systolic and diastolic pressures were not greater between than within patients.

Table 1: Comparison of First Three Remler (R) Ambulatory Blood Pressure Recordings.

	Systolic			Diastolic		
	R_1	R_2	R_3	R_1	R_2	R_3
Mean BP (mmHg)	151.4 ± 3.1	149.7 ± 3.6	148.8 ± 3.7	98.3 ± 2.3	97.7 ± 3.1	95.8 ± 3.0
Peak BP (mmHg)	174.6 ± 3.6	172.3 ± 4.02	170.7 ± 4.1	113.7 ± 2.6	112.9 ± 3.1	108.6 ± 3.6
Trough BP (mmHg)	130.5 ± 3.2	130.9 ± 3.9	128.1 ± 4.2	80.6 ± 4.9	81.2 ± 4.1	81.6 ± 3.2
SD (mmHg)	11.9 ± 0.67	11.8 ± 0.72	12.4 ± 0.63	7.4 ± 0.42	8.1 ± 0.33	7.5 ± 0.52
C V (%)	8.3 ± 0.57	8.5 ± 0.52	8.3 ± 0.5	7.9 ± 0.6	8.8 ± 0.58	7.3 ± 0.38

SD = standard deviation; C V = coefficient of variation

Table 2: Comparison of Coefficients of Variation Between and Within Subjects for Different Parameters of Non-invasive Ambulatory Blood Pressure.

	Systolic		Diastolic	
	Within patients	Between patients**	Within patients	Between patients
Mean BP (%)	4.8* (1.0–12.1)	8.8–10.7**	5.9* (1.4–12.5)	10.2–14.4**
Peak BP (%)	6.4 (2.8–13.2)	9–10.5	6.4 (1.3–13.7)	10.1–11.9
Trough BP (%)	7.9 (3.4–16.8)	10.8–14.3	10.7 (3.8–16.6)	17.2–26.7
SD (%)	21.1 (8.8–38.4)	22.3–26.7	20.1 (6.9–32.5)	17.6–30.7
CV (%)	22.8 (9.4–38.3)	25.6–30.5	21.8 (1.1–35.0)	22–32.9

* Mean within-patient coefficient of variation for all subjects (range).

** Range of between-patient coefficient over the first three ambulatory recordings.

SD = standard deviation; CV = coefficient of variation of all recordings through the day.

Discussion

This study fails to confirm previous findings of a significant fall in ambulatory blood pressure during repeated ambulatory non-invasive blood pressure recordings (4, 6). Conway (4) demonstrated a fall of 18 mmHg and 9 mmHg in mean ambulatory systolic and diastolic pressures respectively between the first and third day of ambulatory recording in hypertensive subjects. However, their patients had been hospitalized for the study so that this change may partly reflect the fall in blood pressure which occurs during hospitalization of hypertensive subjects (9). Kain et al (6) noted a more modest fall between the first and third successive day of ambulatory recording. The fall in systolic pressure which was about 5–6 mmHg occurred largely in the early part of the day. This resembles the fall found between successive recordings in our study. However, the significance of this may have been exaggerated by multiple paired comparisons. Direct ambulatory blood pressure monitoring using the Oxford recording system in 8 patients showed no mean difference in blood pressure levels on two successive days of recording (5) in agreement with the findings of this study.

Of greater importance than a mean change in blood pressure is the variability of parameters used to describe ambulatory blood pressure behavior. Van Maele and Clements (7) compared Remler ambulatory blood pressure recordings made on two separate days and found that of the measured parameters, including mean blood pressure, only the variance of daily recordings was reproducible. This was determined for each patient from the ratio of the variances of the recordings for each day. However, with a mean of 24 recordings in a day, within-patient variance would have to change by 50% before a significant difference could be shown between two days of recordings in a single patient. The present study showed that the mean of daily systolic and diastolic recordings were highly reproducible in most subjects. Furthermore, peak and trough blood pressure recordings were also reasonably reproducible in comparison with the between-subject variability of these

parameters. However, indices of blood pressure variability, the standard deviation and coefficient of variation, were poorly reproducible in all but a few patients for both systolic and diastolic blood pressure when compared with between-patient variability. Similar results have been shown for repeated recordings of blood pressure in hospitalized patients using an automatic blood pressure recorder (2). The differences in variability between subjects or between days in the same subject may represent within-patient variation only. Thus, in drug studies the variation in these parameters within subjects must be considered before an effect, or more importantly the lack of an effect, is attributed to a drug. In conclusion, the peak, trough and mean blood pressure recorded using the Remler ambulatory blood pressure recorder are reproducible over a period of several months whereas indices of blood pressure variability derived from such recordings are not.

Acknowledgement

We acknowledge gratefully grants from the Royal College of Surgeons in Ireland and Ciba Laboratories.

References

1. Athanassiadas D, Draper GJ, Hanow AJ, Cranston WI: Variability of automatic blood pressure measurements over 24-hour periods. *Clin Sci* 36: 147-156 (1969).
2. Weber MA, Drayer JM, Wyle FA: Consistency of the 24-hr. blood pressure profile (abst.). *Clin Res* 30: 24A (1982).
3. Horan MJ, Padgett NE, Kennedy III: Ambulatory blood pressure monitorings: recent advances and clinical applications. *Am Heart J* 101: 844-847 (1981).
4. Conway N, Rubenstein D, Ervanwel R, Gibbons D: Measurement of blood pressure using a portable recorder operated by the patient. *Cardiovasc Res* 4: 537-544 (1970).
5. Mann S, Millar-Craig MW, Balasubramanian U, Cashman PMM, Raftery EB: Ambulant blood pressure: reproducibility and the assessment of interventions. *Clin Sci* 59: 497-500 (1980).
6. Kain H, Hinman AT, Sokolow M: Arterial blood pressure measurements with a portable recorder in hypertensive patients I. Variability and correlation with 'casual' pressures. *Circulation* 30: 882-892 (1964).
7. Van Maele GO, Clements DL: Reproducibility of blood pressure measurements obtained with semi-continuous recording devices. ISAM, 1981. Proceedings of the Fourth International Symposium on Ambulatory Blood Pressure Monitoring and the Second Gent Workshop in Blood Pressure Variability. Ed. Stott, FD, Raftery EB, Clement DL, Wright SL: 589-595 Academic Press (London, 1982).
8. Fitzgerald DJ, O'Callaghan WG, O'Malley K, O'Brien ET: Accuracy and reliability of two indirect ambulatory blood pressure recorders: Remler M2000 and Cardiodyne Sphygmolog. *Br Heart J* 48: 572-579 (1982).
9. Hossman V, FitzGerald GA, Dollery CT: The influence of hospitalization and placebo therapy on blood pressure and sympathetic function in essential hypertension. *Hypertension* 3: 113-118 (1981).

Address for correspondence:

Dr. Eoin T. O'Brien
The Blood Pressure Clinic
Charitable Infirmary
Jervis Street
Dublin 2