The Effect of Age on Blood Pressure and Heart Rate Variability in Hypertension

Margaret Brennan, Eoin O'Brien and Kevin O'Malley

There is confusion in the literature as to the effect of ageing on blood pressure variability. The lack of consistency in reports probably reflects differences in blood pressure measurement techniques and in the choice of statistics used to describe variability. We studied 16 hypertensives (clinical blood pressure >140 /90 mmHg on 3 occasions) over 60 (67 ± 5.5 years) and 16 under 60 years of age (44 ± 8.9 years) using the Remler M 2000 ambulatory system to measure blood pressure and heart rate every 30 min during the awake hours of the day.

Mean ± s.e.m. blood pressure and heart rate for the elderly was 168± 2.5/95 ± 1.0 mmHg and 72 ± 1.5 beats/min, corresponding values for the young being 162 ± 5.3/103 ± 2.1 and 78 ± 2.5. Four statistics of variability were used: standard deviation, coefficient of variation, range and mean hourly change. Differences between old and young were found only for the range of systolic and diastolic blood pressure which was lower in the elderly (52 ± 3.9/32 ± 2.4 versus 67 ± 5.2/46 ± 4.8 mmHg, both $P < 0.05$) and mean hourly change of heart rate ($P < 0.05$). The standard deviation of heart rate was negatively correlated with age ($r = -0.37$; $P < 0.05$).

Only the systolic and diastolic blood pressure ranges were found to differ with age; the more rigorous tests of variability, standard deviation and coefficient of variation, were not changed. These data show that in hypertensives of different age but with roughly comparable blood pressure levels, variability of blood pressure is not consistently related to age. We conclude that clinical decision and assessment of blood pressure behaviour can be made with similar confidence in old and young hypertensives.

Journal of Hypertension 1986, **4** (suppl 6):S269–S272

Keywords: Age, blood pressure, heart rate, hypertension.

Introduction

Although variability of blood pressure is well recognized clinically, large variations on replicate readings or on readings on separate occasions in both normotensives and hypertensive patients may not be widely appreciated [1]. Epidemiologic data show that the level of blood pressure increases with age [2]. Blood pressure variability in studies using ambulatory blood pressure measurement has been shown both to increase with age [3–5] or to be unrelated to age [6–8]. In these studies variability has been expressed by statistics such as standard deviation or coefficient of variation of the mean blood pressure measurement for young and old. However, comparisons between these groups have not produced consistent findings of the relationship between blood pressure variability and age. In this paper we report data obtained by non-invasive ambulatory blood pressure measurement in 16 young and 16 elderly essential hypertensives on no medication. Blood pressure variability is compared between groups using absolute measurements derived from the ambulatory data as well as standard deviation and coefficient of variation.

Methods

Seven hundred and fifty ambulatory blood pressure recordings were done at the Unit from January 1980 to September 1984 using the Remler M-2000 recorder. Referrals were mainly from the outpatient hypertensive clinic. The Remler M-2000 is a portable patient-activated

From the Blood Pressure Clinic, Charitable Infirmary, Jervis Street, Dublin 1, and the Department of Clinical Pharmacology, Royal College of Surgeons in Ireland, Dublin 2.

Sponsorship: This work was supported by the Medical Research Council of Ireland and the Research Committee of the Royal College of Surgeons in Ireland.

Requests for reprints to: Prof.K. O'Malley, The Blood Pressure Clinic, Charitable Infirmary, Jervis Street, Dublin 1, Republic of Ireland.

blood pressure recorder which is both accurate [9] and reliable [10].

All recordings were reviewed. For inclusion, patients had both mean systolic and diastolic values on ambulatory measurements greater than 140/90 mmHg. One hundred and fifty-five recordings were carried out on patients over 60 years of age. One hundred and eighteen patients had taken antihypertensive medication within two weeks prior to the Remler recording and were excluded. Patients with diabetes, alcohol-related disease or secondary hypertension were also excluded. Sixteen patients met the above criteria. Casual clinic blood pressure was recorded with a conventional mercury sphygmomanometer after several minutes of rest with the patient either supine or seated.

The ambulatory recordings of all patients under 60 years of age were reviewed alphabetically. The same criteria were applied. The first 16 eligible young patients were matched with the 16 elderly patients by sex and body mass index. When more than one ambulatory recording was available for a patient the initial recording was used.

Data analysis

In our system, routine statistics on each ambulatory recording include the 12–16 h mean blood pressure and heart rate with standard deviation, standard error and coefficient of variation. Peak and trough systolic and diastolic pressure and heart rate were also available. The range is herein defined as the peak minus the trough ambulatory value for systolic pressure, diastolic pressure and heart rate. The mean hourly change is defined as the sum of the changes in recording measurement for each interval divided by the number of intervals minus one. Paired t-tests were used to compare the elderly and young values for standard deviation, coefficient of variation, range and mean hourly change. Correlation and linear regression of the statistics were performed on age.

Results

The mean (± s.e.m.) age of the elderly was 67 ± 5.5 years (range 60–75) and the young were 44 ± 8.9 years (range 21–58). There was no difference in the number of blood pressure measurements per ambulatory recording between groups: for the elderly 21 ± 4.6 and for the young 22 ± 6.3.

The mean clinic blood pressure was 180 ± 3.9/98 ± 1.7 mmHg for the elderly and 168 ± 3.7/104 ± 1.5 mmHg for the young. Mean systolic blood pressure was greater in the elderly ($P < 0.05$) but mean diastolic blood pressure was greater in the young ($P < 0.05$). The mean daily ambulatory measurement was 168 ± 2.5/95 ± 1.0 mmHg for the elderly and 162 ± 5.3/103 ± 2.1 mmHg for the young. The corresponding ambulatory heart rates were 72 ± 1.5 and 78 ± 25. There was no significant difference in ambulatory mean systolic blood pressure or heart rate between elderly and young, but mean diastolic blood pressure was greater in the young. The average difference between clinic and ambulatory blood pressure was 13.3 ± 5.3/4.7 ± 1.6 mmHg in the elderly and 6.5 ± 2.1/−0.3 ± 2.5 in the young. Although both systolic and diastolic pressure fell more, from clinic to ambulatory measurement, in the elderly than in the young this difference did not reach statistical significance.

Four statistics used to describe blood pressure variability, the standard deviation of the ambulatory mean, coefficient of variation of the ambulatory mean, range and mean hourly change in measurement, were compared between elderly and young (Table 1). The range for systolic and diastolic ambulatory blood pressure measurement was significantly greater in the young. Mean hourly change in heart rate was significantly greater in the young.

Table 1. Comparison of variability by age group.

Statistic	Variable	Elderly	Young	*P*
Range	Systolic	52 ± 3.9	67 ± 5.2	< 0.05
	Diastolic	32 ± 2.4	46 ± 4.8	< 0.05
	Heart rate	34 ± 3.3	41 ± 2.6	NS
Mean hourly change	Systolic	13 ± 1.0	13 ± 1.0	NS
	Diastolic	8.4 ± 0.6	7.6 ± 0.5	NS
	Heart rate	6.6 ± 0.6	9.5 ± 1.0	< 0.05
s.d	Systolic	14.7 ± 1.1	13.8 ± 0.8	NS
	Diastolic	8.1 ± 0.5	8.2 ± 0.8	NS
	Heart rate	9.2 ± 0.9	11.4 ± 0.6	NS
CV	Systolic	8.8 ± 0.7	8.6 ± 0.5	NS
	Diastolic	8.7 ± 0.5	8.2 ± 0.9	NS
	Heart rate	10.2 ± 1.0	11.7 ± 0.5	NS

Values are mean ± s.e.m.; s.d., standard deviation; n = 16 in both groups. CV, coefficient of variation.

Linear regression of each statistic of variability on age showed that the only significant correlation was for the standard deviation of heart rate ($r = 0.37$, $P < 0.05$).

Discussion

Variability in blood pressure measurement results both from true variation in arterial pressure and variation due to measurement error [11,12]. Ambulatory blood pressure measurement with the Remler M-2000 provides accurate and reproducible data which eliminate observer-measurement error [9,10]. True variation in blood pressure is related to many factors including physical activity, emotional state, ambient temperature, season, associated medical conditions, body weight and the level of blood pressure [7,8,11]. To make a valid comparison of blood pressure variability between groups both the statistic itself and the characteristics of the groups to be compared must be strictly defined. Our patients all had essential hypertension and were hypertensive by office blood pressure measurement and ambulatory blood pressure measurement. They were closely matched by body-mass index and had no medical conditions known to be associated with altered blood pressure variability. Comparison of standard deviation and coefficient of variation failed to demonstrate a difference in variability between the two groups.

Using standard deviation alone as a measure of variability Rowlands *et al.* [4] and Drayer *et al.* [3] showed increased systolic pressure variability in the elderly. Clement *et al.* [12] also found increased variability with age as measured by the standard deviation. However, this result was lost when the standard deviation relative to mean pressure, as in the coefficient of variation, was used to define variability. In the present study, blood pressure was roughly comparable in the two groups (though ambulatory diastolic pressure was significantly higher in the young group) and paired analysis failed to demonstrate a difference in these indirect statistics of variability.

However, the range of systolic pressure and diastolic pressure was greater in the young than in the elderly, as was the mean hourly change in heart rate. Richardson *et al.* [6] studied a group of hospitalized patients (normotensive and hypertensive) using intra-arterial measurement and found the range in the elderly (47 mmHg) was greater than in the young (36 mmHg). On the other hand, our patients were all hypertensives, were not hospitalized and went about their usual daily activities.

Isolated systolic hypertension may be due to increased cardiac output with a normal vascular resistance in the young, but to decreased arterial compliance in the elderly. Arterial compliance is determined by both the level of arterial pressure and intrinsic arterial distensibility. The latter may be altered in the elderly. As isolated systolic hypertension may represent a distinct entity we felt it appropriate to exclude such patients from the study. Thus, all our patients had combined systolic and diastolic hypertension.

The elderly group had an average fall in blood pressure from clinic to ambulatory measurement of 13.3 ± 5.3/4.7 ± 1.6 mmHg. The young had an average fall of 6.5 ± 2.1/−0.3 ± 2.5 mmHg. Although this difference did not reach statistical significance in our study, a significant difference between these measurements in the elderly has been previously described by Rowlands *et al.* [4], who found a greater fall in systolic and diastolic pressure on ambulatory recordings in elderly hypertensives. Thus comparison of methodology within patients adds an additional complication in the evaluation of variability.

There was significantly less variability in heart rate in the elderly as measured by the mean hourly change in heart rate and there was a significant negative correlation between age and standard deviation of the heart rate but not with the heart rate coefficient of variation. Baroreceptor function in the elderly and heart rate response to changes in arterial blood pressure have been well characterized [5,13]. Age and hypertension may act independently to reduce baroreceptor sensitivity [13,14] and heart rate variability. Mancia *et al.* [5] identified a relationship of borderline significance between decreased baroreceptor sensitivity and increased blood pressure variability, but concluded that it could only account for a small portion of the difference in variability with age they identified using standard deviation and coefficient of variation. In our study the decreased heart rate variability is associated with a decrease in the range of systolic and diastolic blood pressure in the elderly.

In conclusion, we were unable to demonstrate age-related differences in blood pressure variability using rigorous tests (standard deviation or coefficient of variation), yet the range of blood pressure was different in young and elderly. Furthermore, there may well be differences in the blood pressure obtained by ambulatory compared with clinic methods. This difference concerns a method and circumstances of blood pressure measurement that must be taken into account in clinical decision-making as well as research. However, when a single accurate method, in this case ambulatory measurement, is used one cannot demonstrate consistent age effects on blood pressure variability. We conclude that the outcome of studies of variability is influenced by study design and the methods used for blood pressure measurement and statistical expression of variability. Between-method differences may be quite large in the elderly compared to the young but, when the same methods are used in the elderly and young, differences in variability are probably not large.

References

1. Armitage P, Rose GA: The variability of measurements of casual blood pressure. I. A Laboratory Study. Clin Sci 1966, **30**:325–335.
2. Kanel WB, Dawber TR, McGee DL: Perspectives on systolic hypertension. The Framingham Study. Circulation 1980, **61**: 1179–1182.
3. Drayer JIM, Weber MA, De Young JL, Wyle FA: Circadian blood pressure patterns in ambulatory hypertensive patients. Effects of age. Am J Med 1982, **73**:493–499.
4. Rowlands DB, Stallard TJ, Littler WA: Continuous ambulatory monitoring of blood pressure and assessment of cardiovascular reflexes in the elderly hypertensive. J Hypertension 1984, **2**:615–622.
5. Mancia G, Ferrari A, Gregorini L, Parati G, Pomidossi G, Bertinieri G, Grassi G, Zanchetti A: Blood pressure variability in man: its relation to high blood pressure, age and baroreflex sensitivity. Clin Sci 1980, **50**:401s–404s.
6. Richardson DW, Honour AJ, Fanton GW, Stott FH, Pickering GW: Variation in arterial pressure throughout the day and night. Clin Sci 1964, **26**:445–460.
7. Kain HK, Hinman AT, Sokolow M: Arterial blood pressure measurements with a portable recorder in hypertensive patients. Circulation 1964, **30**:882–892.
8. Watson RDS, Stallard TJ, Flinn RM, Littler WA: Factors determining direct arterial pressure and its variability in hypertensive man. Hypertension 1980, **2**:33–41.
9. Fitzgerald DJ, O'Malley K, O'Brien ET: Accuracy of the LSH and Remler M2000 Sphygmomanometers. Clin Sci 1981, **61**: 399s–401s.
10. Fitzgerald DJ, O'Malley K, O'Brien ET: Reproducibility of ambulatory blood pressure recordings. *In* Ambulatory Blood Pressure Recording edited by Weber MA, Drayer JIM. New York: Springer-Verlag 1984, pp 71–74.
11. Brennan PJ, Greenberg G, Miall WE, Thompson CG: Seasonal variation in arterial blood pressure. Br Med J 1982, **285**: 919–923.
12. Clement DL, Mussche MM, Vanhoutte G, Pannier R: Is blood pressure variability related to the activity of the sympathetic system. Clin Sci 1979, **57**:217s–219s.
13. McGarry K, Laher M, Fitzgerald D, Horgan J, O'Brien E, O'Malley K: Baroreceptor function in elderly hypertensives. Hypertension 1983, **5**:763–766.
14. Gribbin B, Pickering TG, Sleight P, Peto R: Effect of age and

high blood pressure on baroreceptor sensitivity in man. Circ Res 1971, **29**:424–431