Tohoku J. Exp. Med., 1991, **163**, 119-127

Population Study of Ambulatory Blood Pressure in a Rural Community in Northern Japan

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NAKATSUKA, H., IMAI, Y., ABE, K., NAGAI, K., IKEDA, M., SATO, H., SASAKI, S., MINAMI, N., MUNAKATA, M., SAKUMA, H., HASHIMOTO, J., SEKINO, H., IMAI, K. and YOSHINAGA, K. *A Population Study of Ambulatory Blood Pressure in a Rural Community in Northern Japan.* Tohoku J. Exp. Med., 1991, **163** (2), 119-127 —— A cross sectional survey was performed on ambulatory blood pressure (ABP) in a rural community in northern Japan. ABP was measured in 468 participants (148 men and 320 women, or 27.3% of the ≥20 year-old population in the study region) with a Colin ABPM 630, an ABP monitoring system. ABP was determined every 30 min for 24 hr. All-day average of 24 hr ambulatory systolic, (SBP) and diastolic BP (DBP) in these subjects were 121.5±11.8 and 71.7±8.0 mmHg (mean±S.D.), respectively. Ambulatory SBP and DBP levels increased gradually with an increase in age in both sexes. The age dependent increase in SBP was, however, extremely small in men compared with that in the casual SBP of the ordinary Japanese reported. The minimal age-dependent increase in ambulatory SBP in men reflects a high ambulatory SBP in those below 50 years-old as well as a minimal increase in ambulatory SBP in those over 50. Ambulatory SBPs in women were lower than those in men until they reach the age of 50 years. Ambulatory SBP levels in men and women were similar after their 60's. Ambulatory DBP tended to fall or remain at the same level after 60 years-old. Thus, a greater pulse pressure was observed in elderly subjects. Casual SBP and DBP in the ordinary Japanese were significantly higher than the daytime average ambulatory SBP and DBP in all age groups of both sexes in the population except those in their 20's. The result suggests that ABP has different clinical characteristics and may have a different clinical significance from casual BP. ——

Received December 4, 1990; revision accepted for publication January 21, 1991.

ambulatory blood pressure; aging; casual blood pressure; epidemiology

The development of non-invasive techniques for measuring ambulatory blood pressure (ABP) has made it possible to study blood pressure (BP) as it changes, which offers advantages over the conventional practice of sporadical measurement by a technique with potential inaccuracies (Weber and Drayer 1990). ABP predicts the prognosis of hypertension and the presence of hypertensive cardiovascular complications more accurately than casual BP measurement (Sokolow et al. 1966; Floras et al. 1981; Devereux et al. 1983; Drayer et al. 1983; Perloff et al. 1983; Mann et al. 1985; Parati et al. 1987; White et al. 1989b). However, the use of ABP in clinical practice is hampered by the scarcity of studies reporting reference values in a representative sample. Most of the information concerning normal ABP levels has come from studies of subjects designated as normal by conventional casual BP measurements rather than from the population at large (Pickering et al. 1982; Kennedy et al. 1983; Drayer et al. 1985; DeGaudemaris et al. 1987). Therefore, reliable criteria for differentiating normal from hypertensive values are yet to be established. Theoretically, normalcy and hypertension based on ABP may be defined best through the relationship between BP and the status of underlying hypertensive target organ damage or on the basis of longterm prospective prognosis of hypertension in a population. It is also apparently urgent to know the normalcy of ABP level, since ABP is now widely used in practice. In the present study a cross-sectional survey on ABP was carried out in a rural community in northern Japan, with a view to investigating the distribution of ABP values in various age groups in both sexes. Statistical analysis of data was also performed for tentative evaluation of ABP normalcy.

Method

Study design

The study was carried out in February to October, 1988 in the Uchikawame region, Ohasama, Iwate Prefecture. Ohasama is located 20 km southeast of Morioka, the capital city of Iwate prefecture, and 100 km north of Sendai. The Uchikawame region has a population of 2247 (1104 men and 1143 women) in 465 households. Most of the adult population are engaged in fruit growing, in addition to working in offices and factories in Ohasama and Morioka. Uchikawame is divided into 9 units for health care activities. In November and December 1987, health promotion classes were held by a doctor and/or public health nurses in each unit to inform the people of the significance of ambulatory blood pressure monitoring (ABPM). Among 465 households, 363 (78.1%) attended the classes. Everyone aged 20 years or more was asked to measure their ABP once for 24 hr in the study period. Public health nurses visited all the participants' home in the morning to attach the ABPM devices, and again the next morning to detach them. A total of 468 people (27.3% of the 1716 subjects aged 20 years or more; 148 men and 320 women) participated in the program. As the study was designed to cover a whole population and participants were not selected, approximately 20% of the participants were under several types of medication. The data obtained from these subjects were included in the present analysis.

Device

Nippon Colin ABPM 630 (Nippon Colin, Nagoya), a fully automatic ABPM device, was used in the present study. The device can automatically monitor systolic blood pressure (SBP), diastolic blood pressure (DBP) and heart rate (HR) using the conventional arm-cuff method (Imai et al. 1990). Cuff pressure is provided by a CO_2 cartridge. In hypertensive patients, 50–70 measurements can be made from one cartridge. In the present study the interval between measurements was preset to 30 min. The device measures SBP and DBP by means of the cuff-oscillometric method concurrently with the Korotkoff sound (microphone) method. Since performance of the microphone method was rather poor in the ambulatory condition as compared with that of the cuff-oscillometric method, the data obtained by the latter were employed in the present study. After each reading session, the data from the memory cassette was transferred to a personal computer (NEC PC9800 series; NEC, Tokyo) and the stored data were retrieved and processed to obtain appropriate parameters. The results were stored on a 5 inch floppy disc.

The accuracy and reliability of BP measurements by means of ABPM 630 have been reported previously (White et al. 1989a; Imai et al. 1990), i.e., mean differences between the auscultatory method and the cuff-oscillometric method for SBP and DBP were -1.77 ± 6.07 mmHg and 3.06 ± 6.87 mmHg (mean$\pm$S.D.), respectively (Imai et al. 1990). BP values obtained by the device were well correlated with those by the standard auscultatory method with a regression line of $Y=1.01X-2.37$ ($n=297$, $r=0.92$) for SBP and $Y=0.84X+14.72$ ($n=297$, $r=0.85$) for DBP, in which X is the measure by auscultation and Y by the cuff-oscillometric method (Imai et al. 1990).

Data analysis

The subjects were asked to record the time of going to and leaving bed. The ABP data for each person were discarded unless the monitoring period during waking hours (daytime) was more than 8 hr and that in nighttime (during the time between going to and leaving bed) was more than 4 hr. In the present analysis, the quality of night sleep was disregarded. Artifactual readings during ABPM were defined according to the criteria mentioned previously, i.e. (1) SBP and/or DBP lower than 60 and/or 30 mmHg, respectively, with no similar preceding or subsequent value, (2) SBP and/or DBP higher than 250 and/or 140 mmHg, respectively with no similar preceding or subsequent value, (3) pulse pressure of 10 mmHg or lower etc (Imai et al. 1987). The monitor has a program which distinguishes pressure signals from extraneous sounds or movement and automatically retries a blood pressure measurement when the artifact is too marked to obtain an accurate measurement by either Korotkoff or oscillometric methods. These 'retries' and individual readings that were physiologically not possible or very unlikely were excluded from the analysis.

Average of whole data including both daytime and nighttime BP-values (tentatively called all-day average ABP), daytime (waking period) average and nighttime average of ABP, were calculated for each person. Individual averages of ABP in each period were then grouped by sex and age, and compared with the casual BP for the general Japanese population reported by the Ministry of Health and Welfare, Japan (Ministry of Health and Welfare 1987), which is based on the measurement by auscultation in the sitting position after 5 min resting in 20,000 participants from 7,000 households in 300 areas in Japan. ABP was compared with casual BP in general Japanese population in each age group by Student's *t*-test.

Results

Figs. 1A and 1B demonstrate the average ABP value by decade of age in men and women, respectively, to illustrate the relationship between ABP averages (in

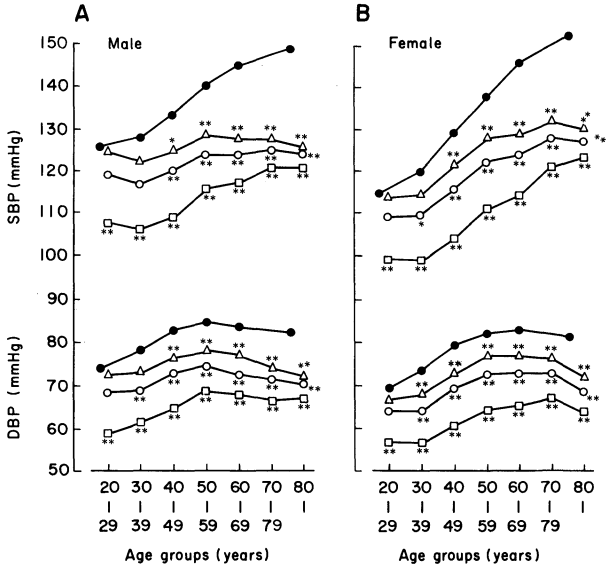

Fig. 1. Daytime, all-day and nighttime average ambulatory blood pressure in each age group of both sexes. The casual average blood pressure values for each generation of both sexes in the Japanese population obtained by reports from the Ministry of Welfare, Japan (1987), are also represented in the figure. ●, casual BP in general Japanese population ; ○, all-day average of ABP ; △, daytime average of ABP ; □, nighttime average of ABP. $*p<0.05$, $**p<0.01$ compared to casual BP in general Japanese population.

TABLE 1. *All-day average of ambulatory blood pressure grouped by decade of age and by sex*

		20≦<30	30≦<40	40≦<50	50≦<60	60≦<70	70≦<80
	n	6	8	14	30	52	33
Men	SBP	118.9±5.9[a]	116.8±8.1	120.0±10.1	123.7±14.1	123.8±11.2	125.1±13.7
		124.6[b]	124.9	130.1	137.8	135.0	138.8
	DBP	68.3±4.3	69.2±4.6	72.9±6.8	74.5±9.4	72.5±11.3	71.6±7.3
		72.6	73.8	79.7	83.9	83.8	78.9
	n	13	26	53	93	77	47
Women	SBP	108.8±5.5	109.2±7.5	115.5±9.3	122.1±12.6	123.7±13.3	127.8±12.4
		114.3	116.7	124.8	134.7	137.0	140.2
	DBP	63.8±4.0	63.8±5.6	68.8±7.0	72.2±7.9	72.5±8.6	72.2±7.5
		67.8	69.4	75.8	80.1	81.1	79.9

[a]Mean±S.D. [b]Mean+S.D.

all-day, daytime, and nighttime, respectively) and the casual BPs for the general Japanese population. Tables 1, 2 and 3, respectively, show ABP values averaged for all-day, daytime and nighttime in each age group. BP values equal to 1 S.D. above the mean are also given in each Table. Ambulatory SBP and DBP increased gradually with age in both sexes, although DBP tended to fall or remain at the same level when men and women were 60 years old. Thus, a greater pulse pressure was observed in elderly subjects. The increment in SBP with age was smaller in men than in women. A minimal age-dependent increase in ambulatory

TABLE 2. *Day-time average of ambulatory blood pressure grouped by decade of age and by sex*

		20≦<30	30≦<40	40≦<50	50≦<60	60≦<70	70≦<80
	n	6	8	14	30	52	33
Men	SBP	124.9±7.3[a]	122.7±8.9	125.6±11.9	129.1±14.3	128.1±12.6	128.0±15.8
		132.2[b]	131.6	137.5	143.4	140.7	143.8
	DBP	73.1±5.5	73.4±5.4	77.0±7.7	78.6±9.1	77.5±7.6	74.9±8.5
		78.6	78.8	84.7	87.7	85.1	83.4
	n	13	26	53	93	79	47
Women	SBP	113.6±6.3	115.1±11.2	121.9±9.9	128.1±13.8	129.4±13.3	132.5±14.4
		119.9	126.3	131.8	141.9	142.7	146.9
	DBP	67.3±4.7	67.7±6.2	73.2±7.4	76.7±8.8	76.8±8.6	76.1±8.8
		72.0	73.9	80.6	85.5	85.4	84.9

[a]Mean±S.D. [b]Mean+S.D.

TABLE 3. *Night-time average of ambulatory blood pressure grouped by decade of age and by sex*

		20≦<30	30≦<40	40≦<50	50≦<60	60≦<70	70≦<80
	n	6	8	14	30	52	33
Men	SBP	107.7±5.9[a]	106.4±7.9	109.2±7.0	116.0±16.3	117.3±12.5	121.2±15.1
		113.6[b]	114.3	116.2	132.3	129.8	136.3
	DBP	59.2±3.2	61.8±4.1	65.2±5.2	69.1±10.6	68.7±6.9	67.6±8.4
		62.4	65.9	70.4	79.7	75.6	76.0
	n	13	26	53	93	77	47
Women	SBP	99.1±4.5	99.0±7.4	104.0±9.5	111.0±13.7	113.7±13.3	121.0±13.7
		103.6	106.4	113.5	124.7	127.0	134.7
	DBP	56.4±3.7	56.3±5.6	60.6±6.8	64.2±7.9	64.9±8.0	66.5±7.8
		60.1	61.9	67.4	72.1	72.9	74.3

[a]Mean±S.D. [b]Mean+S.D.

SBP in men reflects a high ambulatory SBP in those below 50 years old as well as minimal increase in ambulatory SBP in those over 50. Ambulatory SBP levels in men and women were similar when they were 60 or more year-old. The difference of daytime and nighttime average of ABP is estimated as the amplitude of the nocturnal fall in BP. As shown in Fig. 1A, the difference between daytime and nighttime SBP was smaller at higher ages in men, and also in women although less evident.

As shown in Figs. 1A and 1B, casual BP in the general Japanese population increased with age. Casual BP is similar to the daytime average of ABP in young groups aged below 30, but higher in the remaining age groups. The differences between casual SBP in the general Japanese population and systolic ABP became greater with the increase in age. As demonstrated by larger standard deviations in accordance with age (Tables 1, 2 and 3), ambulatory SBP values as well as DBP were distributed more widely with an increase in age both in men and women.

Discussion

Most of the information concerning normal ABP level with 24 hr monitoring has come from studies of subjects designated as normal by conventional casual BP measurements (Pickering et al. 1982; Kennedy et al. 1983; Drayer et al. 1985; DeGaudemaris et al. 1987). Although such data offer tentative criteria for definition of hypertension by ABP, it has not yet been possible to establish reliable criteria to distinguish normal pressures from hypertensive ones. The distribution of ABP values in both sexes at different ages are clearly demonstrated in the present study. Although a statistical definition of BP levels is descriptive for diagnostic and therapeutic purpose, it is informative to know where the ABP values of individual subjects stand in the distribution of ABP values in a reference population.

We reported here in detail a distribution of ABP value on the 468 subjects above 20 years old in a rural community in northern Japan. All-day averages of ambulatory SBP and DBP for all participants were 121.5 ± 11.8 mmHg and 71.1 ± 8.0 mmHg, respectively. These data are proportionate to those reported by Drayer et al. in 34 healthy men aged 20 to 43 years old (122/76 mmHg) (Drayer et al. 1985), those by Pickering et al. (1982) in 25 normotensive volunteers aged 26 to 43 years old (114/77 mmHg) (Pickering et al. 1982) or those by Kennedy et al. (1983) in 72 normotensive men between 15 and 69 years old (116/72 mmHg). DeGaudemaris et al. (1987) recruited 200 normotensive male and female workers aged 20 to 59 years old and reported their mean daytime average ABP as 118/73 mmHg. Although these values are similar to those reported in the present study, they were not comparable, since ours were obtained from a population study which included hypertensive subjects as well as normotensive subjects. Furthermore, in the present study about half of the participants were either 60 years old

or more.

It is apparent that BP goes up increasingly with age. Most cross sectional studies in USA indicate that casual SBP increases with age in most populations until the men reach the seventies and women the eighties (Whelton 1985; Gutzwiller et al. 1990). On the other hand, the DBP ceases to increase around the age of 50-60 years old and even falls a little (Whelton 1985; Gutzwiller et al. 1990). As mentioned above, such age- and sex-dependent characteristics of casual BP levels in cross sectional surveys is confirmed also in the general Japanese population (Ministry of Health and Welfare 1987), which suggests that BP levels should be defined on the basis of an age- and sex-specific standard.

Age- and sex- dependent characteristics of ABP levels in the present study are essentially similar to those of casual BP levels in the cross sectional surveys as mentioned above. However, the age-dependent increase in ambulatory SBP levels was surprisingly small in the male population. This reflects a high ambulatory SBP levels in those under 50 years old as well as the minimal increase in ambulatory SBP levels in those over 50 years old. Both casual SBP and DBP levels in the general Japanese population were higher than the daytime average of ambulatory SBP and DBP levels in each age group of Ohasama residents except those in their 20's. The difference between casual and ambulatory SBPs increased with the increase in age. As a result casual SBP levels in the general Japanese population were extremely high when compared with ambulatory SBP levels in elderly subjects of Ohasama residents.

It is unlikely that rural Ohasama population had any distinctive BP tendency: Ohasama is a well developed town: per capita earning in north-east Japan where it is located is equivalent to about US$10,000; the climate of the region and nutritional status of this particular population are not different from the other areas in northern Japan. It is also unlikely that the difference of casual and ambulatory SBPs reflected any difference in BP measurement methods. It has been reported that SBP readings obtained by the Colin ABPM 630 system are higher than those by the auscultatory method (Imai et al. 1990). Nevertheless, the daytime average of ambulatory SBP in the Ohasama population over 70 years old was lower than the casual SBP in the general Japanese population by about 20 mmHg. The daytime ABP may include BP values raised by physical and mental activities. Furthermore, the difference in the casual SBP and daytime average of ambulatory SBP was minimal at least in their 20's, indicating that the difference is not general in all subjects. Therefore, it is unlikely that the time of measurement or circumstances of BP measurement per se is responsible for this considerable difference in casual and daytime average ambulatory SBP. It has been reported that BP in the elderly is labile (Floras and Sleight 1982). Therefore, it seems that casual SBP in elderly subjects reflects the highest BP level in each person or reflects the enhanced BP response to circumstances where casual BP is measured.

It is apparent that casual BP can predict the morbidity of hypertensive complications and the resulting mortality and it is well known that the treatment of hypertension based on the casual BP dramatically reduced morbidity and mortality from cerebrovascular complications. However, since ABP levels differ extremely from casual BP levels in adult and elderly subjects, ABP may predict different types of hypertensive complications from those indicated by casual BP, suggesting a different clinical significance of ABP and casual BP.

Acknowledgments

This study was supported by a Grant-in-Aid for Scientific Research from the Ministry of Education, Science and Culture of Japan (63570373 and 63870025), Research Grant for Cardiovascular Disease from the Ministry of Health and Welfare of Japan (63 C-6), from Mitsui Life Social Welfare Foundation, from The Miyagi Prefecture Kidney Association and from Gonryo Medical Foundation. We are grateful to OMRON (Kyoto, Japan) and Nippon Colin (Nagoya, Japan) for their generous support.

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