Stroke Risk of Blood Pressure Indices Determined by Home Blood Pressure Measurement

The Ohasama Study

Ryusuke Inoue, MD, PhD; Takayoshi Ohkubo, MD, PhD; Masahiro Kikuya, MD, PhD; Hirohito Metoki, MD, PhD; Kei Asayama, MD, PhD; Atsuhiro Kanno, MD; Taku Obara, PhD; Takuo Hirose, PhD; Azusa Hara, PhD; Haruhisa Hoshi, MD, PhD; Kazuhiito Totsume, MD, PhD; Hiroshi Satoh, MD, PhD; Yoshiaki Kondo, MD, PhD; Yutaka Imai, MD, PhD

Background and Purpose—The purpose of this prospective cohort study was to investigate associations between stroke and blood pressure (BP) indices (systolic BP [SBP], diastolic BP [DBP], mean BP, and pulse pressure [PP]) determined by home BP measurement.

Methods—Associations between stroke and BP indices were examined in a rural Japanese population. Home BP data of 2369 subjects (40% men) ≥35 years of age (mean, 59 years) without a history of stroke were obtained. Associations between stroke and each index were determined using Cox proportional hazards regression and the likelihood ratio (LR) test.

Results—During follow-up (mean, 11.7 years), 238 strokes occurred. The LR test showed that SBP and mean BP were significantly more strongly associated with total and ischemic stroke than DBP and PP (LR χ² ≥9.3, P<0.01 for SBP/mean BP, LR χ² ≥3.8, P=0.05 for DBP/PP). SBP tended to be more strongly associated with total/ ischemic stroke than mean BP (LR χ² =3.8, P=0.05 for SBP, LR χ² ≤0.2, P>0.6 for mean BP). PP tended to be slightly more strongly associated with ischemic stroke than DBP (LR χ² =7.5, P<0.01 for DBP, LR χ² =9.3, P<0.01 for PP), whereas DBP was significantly more strongly associated with hemorrhagic stroke than PP (LR χ² =9.2, P<0.01 for DBP, LR χ² =2.5, P=0.01 for PP).

Conclusion—PP obtained from home BP measurements was weakly associated with stroke, whereas SBP showed the strongest association. Additionally, DBP and PP may be associated with different stroke types. (Stroke. 2009;40:2859-2861.)

Key Words: diastolic blood pressure • home blood pressure measurement • mean blood pressure • pulse pressure • stroke • systolic blood pressure

Recently, pulse pressure (PP) was reported to be associated with coronary heart disease.1,2 However, several studies showed that PP is not strongly associated with stroke when compared with other blood pressure (BP) indices.3,4 These studies were based on casual-screening BP (CBP). Thus, the present study evaluated associations between stroke and systolic BP (SBP), diastolic BP (DBP), mean BP (MBP), and PP obtained from home BP (HBP) measurement, which has been demonstrated to predict cardiovascular diseases more accurately than CBP.5

Methods

The present study is part of a longitudinal observational cohort study of subjects who have been participating in our HBP measurement project in Ohasama, Japan. The socioeconomic and demographic characteristics of Ohasama, the selection procedure of the study populations, the HBP and CBP measurement procedures, and the data collection procedures have been described previously.5–7 The present study population consisted of 2369 individuals (40% men), ≥35 years of age (mean, 59.2 years), without a history of stroke and with ≥3 days of morning HBP and a CBP.6

The subjects were followed from the dates of HBP measurement (approximately 1992) until December 31, 2004. The procedures for diagnosing stroke were described previously.7,8 Cerebral infarction (International Classification of Diseases, 10th Revision code I63) was defined as ischemic stroke, and intracerebral hemorrhage (I61) and subarachnoid hemorrhage (I60) were defined as hemorrhagic stroke. The relative hazard and 95% CI were estimated for a 1-SD difference for each index using Cox proportional hazards regression, adjusted for age, sex, smoking status, use of antihypertensive medica-
Results

During follow-up (mean, 11.7 years), 238 strokes occurred (169 ischemic, 69 hemorrhagic).

All baseline BP indices were significantly higher in subjects who developed stroke than in those who did not (Table 1).

Figure A shows relative hazards for total stroke. Of the HBP indices, SBP and MBP were strongly associated with total stroke followed by DBP. The association between total stroke and PP was relatively weak. Associations between stroke and the CBP indices were generally weak. Table 2 shows the LR $\chi^2$ values when 2 HBP indices were analyzed simultaneously. For SBP and MBP were compared with DBP and PP. The LR $\chi^2$ value of SBP tended to be larger than that of MBP (LR $\chi^2=3.8, P=0.05$). The LR $\chi^2$ value of SBP tended to be larger than that of MBP, although the difference was not significant. The LR $\chi^2$ values of DBP and PP were not significantly different when DBP and PP were compared.

Figure B shows the relative hazards for ischemic stroke. The association between ischemic stroke and SBP was the strongest followed by MBP. Associations between ischemic stroke and DBP and PP were relatively weak. As shown in Table 2, the LR $\chi^2$ value of SBP tended to be larger than that of MBP when SBP was compared with MBP, but there were no significant differences. The LR $\chi^2$ values of SBP and MBP were significantly stronger than those of DBP and PP when SBP and MBP were compared with DBP and PP. The LR $\chi^2$ values of DBP and PP were not significantly different when DBP and PP were compared, although that of PP tended to be larger than that of DBP.

Figure C shows the relative hazards for hemorrhagic stroke. SBP, DBP, and MBP were similarly associated with hemorrhagic stroke, and PP was not significantly associated. No significant differences were observed when the LR $\chi^2$ values of SBP, DBP, and MBP were compared; these values were also significantly larger than that of PP (Table 2). These

tion, and history of heart disease, diabetes mellitus, or hypercholesterolemia. The likelihood ratio (LR) $\chi^2$ value was used as a measure of the improvement of goodness of fit between the model containing a single BP index (and confounding factors) and the model containing 2 indices. A significant LR $\chi^2$ indicates that the index represents a significantly stronger association with stroke.9

Table 1. Baseline BP Values and Age for All Subjects, for Those Who Developed Stroke, and for Those Who Did Not Develop Stroke

<table>
<thead>
<tr>
<th>Variables</th>
<th>Overall</th>
<th>Did Not Develop</th>
<th>Developed</th>
<th>Ischemic</th>
<th>Hemorrhagic</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>2369</td>
<td>2131</td>
<td>238</td>
<td>169</td>
<td>69</td>
</tr>
<tr>
<td>Age</td>
<td>59.2±12.1</td>
<td>58.4±12.1</td>
<td>66.2±9.7*</td>
<td>67.0±9.4</td>
<td>64.3±10.3</td>
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<tr>
<td>Home BP</td>
<td></td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>SBP</td>
<td>124.2±15.1</td>
<td>123.0±14.6</td>
<td>134.4±15.6*</td>
<td>134.9±14.9</td>
<td>133.0±17.5</td>
</tr>
<tr>
<td>DBP</td>
<td>74.5±9.9</td>
<td>74.1±9.8</td>
<td>78.9±10.4*</td>
<td>78.8±10.6</td>
<td>79.1±9.9</td>
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<tr>
<td>MBP</td>
<td>91.1±10.9</td>
<td>90.4±10.7</td>
<td>97.4±11.3*</td>
<td>97.5±11.2</td>
<td>97.1±11.7</td>
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<tr>
<td>PP</td>
<td>49.6±9.9</td>
<td>49.0±9.6</td>
<td>55.5±10.8*</td>
<td>56.1±10.3</td>
<td>53.9±12.0</td>
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<td>CBP</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td>SBP</td>
<td>130.9±18.0</td>
<td>130.1±17.9</td>
<td>138.3±17.2*</td>
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<tr>
<td>DBP</td>
<td>74.4±11.3</td>
<td>74.1±11.3</td>
<td>77.1±10.5*</td>
<td>77.0±10.4</td>
<td>77.3±10.9</td>
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<tr>
<td>MBP</td>
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<td>92.8±12.3</td>
<td>97.5±11.3*</td>
<td>97.5±11.1</td>
<td>97.4±11.9</td>
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<tr>
<td>PP</td>
<td>56.5±13.4</td>
<td>56.0±13.2</td>
<td>61.2±14.3*</td>
<td>61.6±14.6</td>
<td>60.2±13.8</td>
</tr>
</tbody>
</table>

Note: Data are presented as mean±SD. Hemorrhagic stroke included intracerebral hemorrhage and subarachnoid hemorrhage.

*P<0.001.

Figure. Relative hazards (RHs) and 95% CIs of BP indices for stroke risk. Boxes represent RHs. Horizontal lines represent 95% CIs. (A), Total stroke; (B) ischemic stroke; (C) hemorrhagic stroke.
results did not change for the analysis of intracerebral hemorrhage alone.

**Discussion**

Recent studies using CBP and ambulatory BP, which investigated associations between stroke and BP indices, showed that PP was not very strongly associated with stroke. In the present study using HBP, like in these previous studies, PP was not strongly associated with stroke. LR tests showed that SBP and MBP were significantly more strongly associated with total or ischemic stroke than DBP and PP. SBP, MBP, and DBP were all significantly more strongly associated with hemorrhagic stroke than PP. Thus, PP may not be important for predicting stroke. However, PP tended to be slightly more strongly associated with ischemic stroke than DBP, suggesting that different BP indices are specifically associated with different stroke types.

SBP tended to be more strongly associated with total and ischemic stroke than MBP, although the differences were not significant. Considering that MBP has to be calculated from DBP, suggesting that different BP indices are specifically associated with different stroke types.

In conclusion, PP obtained from HBP measurements was a risk-stratification system for the Japanese population based on blood pressure levels: the Ohasama study. Circulation. 1999;100:354–360.


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