A New Index to Predict the Incidence of Cerebral Infarction

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Hypertension is a major risk factor for cerebral infarction (CI). Measures of blood pressure, including diastolic blood pressure (DBP), systolic blood pressure (SBP), and pulse pressure (PP), as well as heart rate (HR) have been associated with target organ damage, especially CI [1–5]. Relative contribution of these measures to the CI risk, however, remains controversial [6,7]. The purpose of the present study is to devise a compound index that includes these factors to predict CI risk.

Briefly, this retrospective study included 1661 elderly (>60 years of age) male patients. The impact of DBP, SBP, PP, and HR on the risk of CI was examined. All patients visited the Geriatrics Department of Xin Hua Hospital for atherosclerosis-related diseases. Patients with various acute diseases and advanced stage of malignancy or valvular heart diseases were excluded. All patients underwent 24-h arterial blood pressure monitoring (ABPM).

The 24-h ABPM data were used to generate BP index (e.g., average SBP, DBP, and HR). PP was defined as $P = SBP - DBP$. The dynamic level (DL) of blood pressure was defined as:

$$DL = \frac{S \times HR^x}{D^y}.$$

The 1661 patients were divided into 19 subgroups based on BP indices that included DL. Each BP index average value with in-

cidence of CI represents a datum. A total of 19 data points were generated. These 19 data points reflect the trend of CI incidence from the 1661 patients, followed a pattern of normal distribution. This “smooth distribution curve” is typically used to reflect the variation trend for a set of data as described previously [8]. The standard error, σ , between the incidence of CI F_i and the

Table 1 Demographic and clinical characteristics of subjects at index blood pressure according to subsequent CI status

	No CI	CI
Number	920	607
Age (years)	79 ± 6	81 ± 5***
SBPmean (mmHg)	130 ± 17	133 ± 18***
SBPmax (mmHg)	161 ± 22	165 ± 23**
SBPmin (mmHg)	101 ± 16	104 ± 17**
DBPmean (mmHg)	71 ± 9	72 ± 9*
DBPmax (mmHg)	92 ± 12	93 ± 13*
DBPmin (mmHg)	53 ± 8	53 ± 8*
PPmean (mmHg)	58 ± 13	61 ± 14***
PPmax (mmHg)	81 ± 17	84 ± 18***
PPmin (mmHg)	37 ± 11	39 ± 13**

* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$.

corresponding value in "smooth curve" f_i , is defined as¹⁹:

$$\sigma = \sqrt{\frac{\sum_{i=1}^{19} (F_i - f_i)^2}{19}}.$$

The x and y value for DL are determined by minimization process of σ value. For the current study, x and y were 0.2 and 0.8, respectively. Thus, DL was calculated as

$$DL = \frac{S \times HR^{0.2}}{D^{0.8}}.$$

All variables were analyzed using a two-tailed Student's t -test with the SPSS 16 statistical package (SPSS Inc., Chicago, IL, USA). A comparison of the traditional BP indices, e.g., SBP, PP, DBP, and HR, between the CI and non-CI groups showed that all measures except HR is correlated to CI risk (Table 1). For comparison, we examined the correlation of traditional blood pressure indices and DL with incidence of CI. DL had the strongest correlation with the incidence of CI (Table 2).

The newly devised index DL describes the overall effects of the blood pressure by including all three directly measured indices (SBP, DBP, and HR). An increase of DL corresponded to high risk of CI in our study. This finding is consistent with other studies that demonstrated that an increase in SBP leads to increased inci-

Table 2 The correlation between different BP index and the incidence of CI

	SBPmean	DBPmean	PPmean	HRmean	DLmean
P	0.02	0.77	0.001	0.62	<0.0001
r	0.66	-0.07	0.68	0.12	0.85
σ	0.042	0.054	0.049	0.056	0.015

dence for CI [9]. This is reflected by $DL \propto S$; PP is an independent risk factor for cardio-cerebral-vascular diseases. This is reflected by $DL \propto S/D^{0.8}$; the increase of heart rate is closely related to cardio-vascular events. This is reflected by $DL \propto HR^{0.2}$; in classical cases of Rourke and Frohlich [10], the condition of the patients worsened when blood pressure was reduced from 188/124 to 142/64 mmHg. This is reflected by the 28% increase of DL value.

The incidence of CI is affected by multiple factors rather than by any single factor. The DL value provides a good reference in properly lowering SBP and DPB to prevent the incidence of CI. The current study recruited only elderly male patients with arteriosclerotic diseases. As such, the applicability of this model in other patient populations remains to be investigated.

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