ORIGINAL RESEARCH

Admission blood pressure indexes and risk of in-hospital death and dependency among acute hemorrhagic stroke patients, Inner Mongolia, China

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Abstract

Purpose: To study the association between blood pressure (BP) SBP, DBP, mean arterial pressure (MAP) and pulse pressure (PP) and clinical outcome in acute hemorrhagic stroke patients in the Chinese population.

Methods: 1,760 hemorrhagic stroke patients admitted to six hospitals from January 1, 2003 to December 31, 2005 were included in the study. BP and other variables were collected within the first 24-hr of admission. Clinical outcomes at discharge were evaluated by neurologists. Multivariate-adjusted odds ratios associated with increment of 1 standard deviation (SD) mmHg in four BP were determined by multiple logistic regression analysis.

Results: The four BP indexes at admission were positively associated with death and SBP, DBP, MAP were associated with dependency. Adjusted odds ratios (95% confident interval) of death associated with increment of 1 SD mmHg were 1.74 (1.44,2.12), 1.39 (1.15,1.69), 1.61 (1.32,1.96) and 1.66 (1.39,1.99) for SBP, DBP, MAP and PP, respectively (all $P < 0.01$), and adjusted odds ratio of dependency associated with increment of 1 SD mmHg was 1.15 (1.03,1.27), 1.21 (1.09,1.34) and 1.19 (1.07,1.32) for SBP, DBP and MAP, respectively (all $P < 0.05$).

Conclusion: Increased SBP, DBP, MAP and PP at admission were all associated with in-hospital mortality, and increased SBP, DBP and MAP were associated with dependency at discharge among hemorrhagic stroke patients.

Stroke is the leading cause of death and long-term disability worldwide.¹ In China, stroke is the third leading cause of death for men and the second for women.² The incidence and proportion of hemorrhagic stroke, especially, is much higher in the Chinese population than in western populations.³

Systolic blood pressure (SBP) and diastolic BP (DBP), two important indexes of BP, were strongly and independently associated with the incidence and mortality of stroke.^{4,5} Pulse pressure (PP), an estimation of the pulsatile component of BP, has been established as a risk factor of stroke by some cohort studies⁶⁻⁹: mean arterial pressure (MAP), reflecting the steady component of BP, was also considered to be

positively related to the risk of stroke.¹⁰ However, the relationship between BP and clinical outcome (i.e., death or disability) among acute stroke patients is less certain.^{11,12} Some observational studies have suggested that elevated BP was associated with poor outcome for acute stroke patients.¹³⁻¹⁶ Several other studies did not find an association between BP and poor outcome.^{17,18}

Despite the fact that stroke is a leading cause of death and that the incidence and proportion of hemorrhagic stroke are higher in China, there are no data on the relationship between BP, SBP, DBP, MAP and PP, and clinical outcome in acute hemorrhagic stroke patients in the Chinese population. In this study, we examined the association between admission SBP, DBP, MAP and PP and clinical outcome, including death and dependency among acute hemorrhagic stroke patients in Inner Mongolia, China.

Subjects and Methods

Participants

The study was approved by Soochow University School of Radiation Medicine and Public Health Ethics Committee. Acute hemorrhagic stroke patients were recruited from 6 hospitals (Tongliao Municipal Hospital, Teaching Hospital of Inner Mongolia University For Nationality, Kezuohou Banner Hospital, Kezuozhong Banner Hospital, Zalute Banner Hospital, and First Hospital of Kerqin District) in Tongliao, a prefecture-level city in eastern Inner Mongolia, China. These are the only hospitals with western medicine facilities in this region and serve a population of 2.04 million, most of whom are of Han or Mongolian ethnicity. All patients with a clinical diagnosis of acute hemorrhagic stroke admitted to the hospitals from January 1, 2003 to December 31, 2005 were potentially eligible for the study. However, only those cases confirmed by computed tomography (CT) scan or magnetic resonance imaging (MRI) were included. All hemorrhagic stroke (intracerebral hemor-

rhage or subarachnoid hemorrhage) were included in this study. A team of investigators including neurologists reviewed the eligibility of study participants. 1760 patients had a CT scan or MRI being confirmed as hemorrhagic stroke and were included in this analysis.

Data Collection

Baseline data were collected within the first 24-hr of admission by in-person interview with patients or their family members (if patients were not able to communicate). Data on demographic characteristics, lifestyle risk factors, medical history, clinical laboratory tests, and imaging data (CT and MRI) were obtained using a standard questionnaire administered by trained staffs. Cigarette smoking was defined as having smoked at least 1 cigarette per day for 1 year or more. The amount and type of alcohol consumption during the past year was collected. Alcohol consumption was defined as consuming one or more alcoholic drinks per day during the last year. Three BP measurements were taken within 30 min of admission and the participants were in the supine position using a standard mercury sphygmomanometer according to a standard protocol.¹⁹ The first and fifth Korotkoff sounds were recorded as SBP and DBP, respectively. The mean of 3 BP measurements were used in all analyses.

Fasting plasma glucose (FPG) was measured using a modified hexokinase enzymatic method. Total cholesterol, HDL-cholesterol, and triglycerides were analyzed enzymatically on a Beckman Synchron CX5 Delta Clinical System (Beckman Coulter, Inc., Fullerton, CA, USA) using commercial reagents²⁰. LDL-cholesterol levels were calculated by use of the Friedewald equation for the participants who had triglyceride levels <400 mg/dL: $\text{LDL cholesterol} = \text{total cholesterol} - \text{HDL-cholesterol} - \text{triglycerides}/5$ ²¹.

The study outcome included death during hospitalization and dependency at discharge. If a patient died in the hospital, a study staff member recorded the

death on the event form and obtained the death certificate. If a patient survived the acute stroke, the study neurologists conducted a comprehensive clinical evaluation at discharge. Dependency was defined as moderate or severe disability using a Modified Rankin's scale (MRs) ≥ 3 .^{22, 23}

Statistical Analysis

MAP was calculated as $1/3 \text{ SBP} + 2/3 \text{ DBP}$, and PP was calculated as $\text{SBP} - \text{DBP}$. The mean and standard deviation (SD) of continuous variables and proportion of categorical variables at hospital admission were calculated for the patients with MRs < 3 , dependency and death, respectively. Multiple logistic regression analysis was used to examine the association between four BP indexes and clinical outcome (death and dependency) adjusted for age, gender, ethnicity (Mongol vs. Han), alcohol consumption, cigarette smoking, and history of hypertension, history of diabetes, hyperglycaemia, and dyslipidemia. Patients were also divided into male and female groups, association between four BP indexes and clinical outcome was examined in male and female groups, respectively, by using multiple logistic regression analysis. Odds ratio (OR) and

95% confidence interval (95% CI) associated with increment of 1 SD mmHg in four BP indexes were calculated in the analysis. Statistical analysis was conducted using SAS 9.13 statistical software.

Results

Table 1 presents the demographic and clinical characteristics at admission among hemorrhagic stroke patients. Among all subjects, there were 103 patients who died during hospitalization, 576 patients with dependency and 1081 patients with MRs < 3 at discharge. The median durations of hospitalization were 4, 13 and 12 mos for the patients with death, dependency and MRs < 3 , respectively. Patients with dependency were more likely to be older, and have a higher rate of hypertension compared with those MRs < 3 , and patients who died were more likely to have lower rates of Mongolian ethnicity, cigarette smoking, alcohol drinking and a higher rate of hyperglycemia than those with MRs < 3 . The patients who died had lower rates of cigarette smoking, alcohol drinking and hypertension, and a higher rate of hyperglycemia than those with dependency. Patients who died had higher mean values of SBP, DBP, MAP and

TABLE 1. Baseline characteristics of patients with acute hemorrhagic stroke

	MRs<3 (n=1081)	Dependency (n=576)	Death (n=103)	<i>P</i> Dependency vs. MRs<3	<i>P</i> Death vs. MRs<3	<i>P</i> Death vs. Dependency
Age, mean (SD)	55.41(11.85)	57.07(11.23)	55.42(12.17)	0.006	0.993	0.175
Male, No. (%)	637(58.9)	349(60.6)	64(62.1)	0.511	0.527	0.767
Mongolian ethnicity, No. (%)	299(27.7)	157(27.3)	17(16.5)	0.491	0.034	0.068
Cigarette smoking, No. (%)	214(19.8)	132(22.9)	12(11.7)	0.137	0.044	0.010
Alcohol drinking No. (%)	230(21.3)	139(24.1)	13(12.6)	0.183	0.038	0.010
History of hypertension, No. (%)	602(55.7)	370(64.2)	48(46.6)	0.001	0.077	0.001
History of diabetes, No. (%)	24(2.2)	12(2.1)	2(1.9)	0.856	1.000	1.000
Dyslipidemia *, No. (%)	235(63.9)	145(68.7)	6(75.0)	0.236	0.781	1.000
Hyperglycaemia †, No. (%)	420(53.7)	231(54.2)	41(80.4)	0.863	<0.001	<0.001
Systolic BP, mean (SD)	169.40(34.92)	174.28(31.42)	192.13(40.86)	0.004	<0.001	<0.001
Diastolic BP, mean (SD)	102.35(19.18)	105.68(18.82)	110.61(23.42)	0.001	0.001	0.045
MAP, mean (SD)	124.70(22.96)	128.55(21.57)	137.78 (26.61)	0.001	<0.001	0.001
PP, mean (SD)	67.05(23.70)	68.60(21.21)	81.51(31.05)	0.175	<0.001	<0.001

* Total cholesterol ≥ 200 mg/dl or LDL-cholesterol ≥ 130 mg/dl or HDL-cholesterol < 40 mg/dl or triglyceride ≥ 150 mg/dl; † Fasting plasma glucose ≥ 6.1

TABLE 2. OR and 95% CI of clinical outcomes associated with increment of 1 SD mmHg for four BP indexes among patients with acute hemorrhagic stroke

		unadjusted		Adjusted †	
		OR (95%CI)	P	OR (95%CI)	P
Death	SBP	1.77(1.47, 2.15)	<0.001	1.74(1.44,2.11)	<0.001
	DBP	1.42(1.17, 1.72)	<0.001	1.39(1.15,1.69)	0.001
	MAP	1.64(1.35, 1.99)	<0.001	1.61(1.32,1.96)	<0.001
	PP	1.67(1.40,1.98)	<0.001	1.66(1.39,1.99)	<0.001
Dependency	SBP	1.16(1.05,1.29)	0.005	1.15(1.03,1.27)	0.012
	DBP	1.19(1.08,1.32)	0.001	1.21(1.09,1.34)	<0.001
	MAP	1.19(1.07,1.32)	0.001	1.19(1.07,1.32)	0.001
	PP	1.07(0.97,1.19)	0.107	1.05 (0.94,1.16)	0.421

† Adjusted for age, sex, ethnicity (Mongol vs.Han), alcohol consumption, cigarette smoking, and history of hypertension, history of diabetes, hyperglycemia, and dyslipidemia

PP (all $P<0.05$) than patients with dependency and MRs<3. Patients with dependency had higher means of SBP, DBP and MAP (all $P<0.05$) than patients with MRs<3. There were no differences in sex, diabetes, or dyslipidemia between patients with dependency and MRs<3, death and MRs<3, death and dependency, respectively.

Table 2 presents the ORs and 95% CIs of death and dependency associated with increment of 1 SD mmHg in four BP indices. All four indexes were associated with the risk of death, corresponding ORs for SBP, DBP, MAP after adjustment for covariates (all $P<0.01$). SBP, DBP and MAP were also associated with the risk of dependency (all $P<0.05$), but PP was not after adjusted for covariates.

The ORs (95% CIs) of death and dependency associated with increments of 1 SD mmHg for four BP indices by sex are presented in table 3. In both male and female groups, death was associated with the SBP, DBP, MAP and PP after adjustment for covariates (all $P<0.05$). Dependency was only associated with DBP after adjustment for covariates in males, but associated with all four BP indices adjusted for covariates in females (all $P<0.05$).

Discussion

We found that both deceased and dependent patients had higher admission SBP, DBP, MAP and PP levels than those with MRs<3, and that patients who died

TABLE 3. OR and 95% CI of clinical outcomes associated with increment of 1 SD mmHg for four BP indexes among patients with acute hemorrhagic stroke by gender

		Death				Dependency			
		unadjusted		adjusted †		unadjusted		adjusted †	
		OR(95%CI)	P value	OR(95%CI)	P value	OR(95%CI)	P value	OR(95%CI)	P value
Male	SBP	1.69(1.32,2.15)	<0.001	1.65(1.29,2.10)	<0.001	1.07(0.93,1.22)	0.348	1.05(0.92,1.20)	0.466
	DBP	1.40(1.10,1.79)	0.006	1.36(1.07,1.74)	0.012	1.14(1.00,1.30)	0.057	1.16(1.01,1.33)	0.036
	MAP	1.58(1.24,2.02)	<0.001	1.54(1.20,1.97)	0.001	1.11(0.97,1.27)	0.123	1.11(0.97,1.27)	0.123
	PP	1.58(1.26,1.98)	<0.001	1.58(1.25,1.98)	<0.001	0.99(0.86,1.13)	0.839	0.95(0.83,1.09)	0.502
Female	SBP	1.91 (1.40,2.61)	<0.001	1.88(1.38,2.56)	<0.001	1.31(1.11,1.55)	0.002	1.29(1.09,1.54)	0.003
	DBP	1.43(1.05,1.94)	0.024	1.44(1.05,1.97)	0.023	1.27(1.08,1.50)	0.004	1.27(1.08,1.51)	0.004
	MAP	1.73(1.26,2.38)	0.001	1.73(1.25,2.38)	0.001	1.31(1.11,1.55)	0.001	1.31(1.10,1.55)	0.002
	PP	1.81(1.37,2.41)	<0.001	1.79(1.35,2.37)	<0.001	1.22(1.03,1.44)	0.022	1.19(1.00,1.42)	0.046

† Adjusted for age, ethnicity (Mongol vs.Han), alcohol consumption, cigarette smoking, and history of hypertension, history of diabetes, hyperglycaemia and dyslipidemia.

also had higher levels of four BP indices at admission than those with dependency. Our study also showed associations between elevated SBP, DBP, MAP and PP and death or elevated SBP, DBP, MAP and dependency among hemorrhagic stroke patients. These findings indicated that all four BP indices were related to poor outcome during hospitalization among acute hemorrhagic stroke patients.

Some^{14,24-26}, but not all²⁷⁻²⁹ previous studies found that elevated BP was associated with increased case-fatality rate among acute hemorrhagic stroke patients. A systematic review including 32 observational studies on BP and outcome suggested that the combined outcome of death and dependency was associated with increased SBP (OR, 2.69) and DBP (OR, 4.68) in patients with intracerebral hemorrhage.²⁶ A J-shaped association between BP and case-fatality rate was reported among 1097 patients with hemorrhagic stroke.²⁵ Our study supported the observation that elevated BP was associated with increased case-fatality rate among acute hemorrhagic stroke patients.

It is well known that BP is usually characterized by its pulsatile and steady components. In addition to SBP and DBP, the two main components, our study also included PP and MAP in analyzing the relationship between BP and clinical outcome among hemorrhagic stroke patients. Like SBP and DBP, MAP and PP were also associated with death during hospitalization and MAP was associated with dependency at discharge among hemorrhagic stroke patients. There are some studies about the relationship between MAP or PP and mortality of stroke among the general population, but the findings are not consistent.³⁰⁻³³ There are also some reports about an association between MAP and PP and clinical outcome of acute hemorrhagic stroke. For example, Fogelholm²⁴ reported an increased 28-day case-fatality rate associated with higher admission MAP in 282 patients with acute intracerebral hemorrhage: the increased mortality was especially striking in the highest quartile of MAP levels (145mmHg). Dandapani¹⁴ showed that the case-fatality rate was higher among 34 acute hemorrhagic

stroke patients with an admission MAP >145mmHg than in 53 patients with an admission MAP <145mmHg. Tuhim and colleagues³⁴ found that elevated PP was related to a poor outcome in 30 days after onset of hemorrhagic stroke. In Vemmos's study³⁵, increased PP values during the first hours after stroke (including ischemic and hemorrhagic stroke) were independently associated with higher 1-year mortality: no effect was observed between MAP and late outcome. However, these studies could not conclude that BP index was more powerful for predicting death and dependency after onset of hemorrhagic stroke.

In summary, our study found that increased SBP, DBP, MAP and PP were associated with death during hospitalization and that increased SBP, DBP, MAP were associated with dependency at discharge among patients with acute hemorrhagic stroke. However, this study could not determine which BP index was more powerful for predicting death and dependency after onset of hemorrhagic stroke. This suggests that lowering BP may be necessary for acute hemorrhagic stroke patients with hypertension.

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