Effects of Poststroke Hypertension and Hyperglycemia on Functional Outcomes in Stroke Patients Without History of Hypertension or Diabetes

Lin-Yu Wang,¹ Jie Xu,² Yi-Long Wang,² Xing-Quan Zhao,² Chun-Xue Wang,² Li-Ping Liu,² An-Xin Wang,² Gai-Fen Liu,² Yu-Ming Xu¹ & Yong-Jun Wang²

¹ Department of Neurology, the First Affiliated Hospital of Zheng Zhou University, Henan, China

² Department of Neurology, Beijing Tiantan Hospital, Capital Medical University, Beijing, China

Correspondence

Yong-Jun Wang, Department of Neurology,
Beijing Tiantan Hospital, Capital Medical
University, No.6 Tiantanxili, Chongwen
District, Beijing 100050, China.
Tel.: +86-10-6709-8350;
Fax: +86-10-6701-3383;
E-mail: yongjunwang111@yahoo.com.cn
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The first two authors contributed equally to this work.

Poststroke hypertension (PSHt) occurs in 70–80% of patients with acute ischemic stroke, including 20% of patients without history of hypertension [1]. Meanwhile, poststroke hyperglycemia (PSHg) occurs in 30–40% of patients with acute ischemic stroke, including 20% of patients with normoglycemia [2]. In our routine clinical practice, we have observed that blood pressure and blood glucose often increase together after acute ischemic stroke. In epidemiological studies, PSHt [3,4] and PSHg [5,6] were associated with poor outcomes after stroke; however, very few studies have assessed their joint effects on stroke outcomes. Therefore, the aim of this study was to evaluate the joint effects of PSHt and PSHg on short-term stroke outcomes after acute ischemic stroke in patients with no history of hypertension or diabetes.

Patient data were obtained from the China National Stroke Registry (CNSR), a nationwide, prospective cohort study aimed at identifying vascular risk factors and documenting clinical characteristics, diagnosis, treatments for patients with acute stroke. The detailed protocol of the CNSR has been published elsewhere [7]. Between September 2007 and August 2008, all consecutive patients admitted to 132 urban hospitals across China were recruited. Collection of data for the CNSR was approved by ethics committees at the participating hospitals, and all participants provided written informed consent. In this study, the inclusion criteria were as follows: (1) ≥ 18 years of age; (2) admission for acute ischemic stroke; (3) no history of hypertension or diabetes; and (4) time from onset to admission ≤ 72 h. Acute ischemic stroke was diagnosed according to World Health Organization criteria [8]

and confirmed by brain computed tomography or magnetic resonance imaging. PSHt was defined as SBP ≥ 160 mmHg and/or DBP ≥ 100 mmHg at admission. PSHg was defined as a random blood glucose value ≥ 11.2 mmol/L at admission. If blood glucose was not measured on the day of admission, fasting blood glucose ≥ 7.0 mmol/L the day after hospitalization was used to define PSHg. At 3 months after stroke onset, the outcomes of all patients were assessed by telephone follow-up, including death (or mRS score 6) and dependency (mRS 3–5). All deaths were confirmed by obtaining a copy of the death certificate from the local citizen registry or the attended hospital, or if death was reported at two consecutive follow-up time points.

Logistic regression model was used to calculate odds ratios (ORs) and 95% confidence intervals (CIs) for mortality and dependency among four groups: (1) patients without PSHt or PSHg; (2) patients with PSHt only; (3) patients with PSHg only; and (4) patients with PSHt and PSHg. ORs were adjusted for age, sex, stroke severity at admission, history of stroke, atrial fibrillation, coronary heart disease, smoking status, and complications during hospitalization (pneumonia and gastrointestinal hemorrhage), which were significantly different between four groups in univariate analysis. Interactions of PSHt and PSHg were tested by the chi-square log-likelihood ratio test. Statistical significance was defined as a two-tailed $P < 0.05$ and was performed using SAS 9.1.3 (SAS Institute Inc., Cary, NC, USA).

The baseline characteristics of overall study population, and according to presence or absence of PSHt and/or PSHg, are

Table 1 Baseline characteristics according to PSht and PSHg status

Variables	Group 1		Group 2		Group 3		Group 4		P-value*
	All patients (n = 3079)	PSHT- /PSHG- (n = 1777)	PSHT+/PSHG- (n = 751)	PSHT+/PSHG+ (n = 342)	PSHT- /PSHG+ (n = 209)	PSHT+/PSHG+ (n = 209)			
Female	1063 (34.5%)	608 (34.2%)	237 (31.6%)	80 (38.3%)	67.0 (55.0–75.0)	80 (38.3%)	0.02		
Age, median (IQR), y	65.0 (54.0–75.0)	64.0 (53.0–74.0)	66.0 (55.0–75.0)	67.0 (55.0–75.0)	67.0 (55.0–75.0)	67.0 (55.0–75.0)	0.001		
History of stroke	689 (22.4%)	439 (24.7%)	140 (18.6%)	35 (16.8%)	75 (21.9%)	35 (16.8%)	0.002		
History of CHD	278 (9.0%)	155 (8.7%)	58 (7.7%)	15 (7.2%)	50 (14.6%)	15 (7.2%)	0.001		
History of AF	396 (12.9%)	216 (12.2%)	80 (10.7%)	33 (15.8%)	67 (19.6%)	33 (15.8%)	0.001		
History of smoking	1320 (42.9%)	757 (42.6%)	353 (47.0%)	73 (34.9%)	137 (40.1%)	73 (34.9%)	0.008		
History of drinking	347 (11.3%)	188 (10.6%)	102 (13.6%)	26 (12.4%)	31 (9.1%)	26 (12.4%)	0.08		
Prestroke dependency (mRS score: 3–5)	181 (5.9%)	120 (6.8%)	32 (4.3%)	10 (4.8%)	19 (5.6%)	10 (4.8%)	0.09		
NIHSS scores at admission									
0–4	1397 (55.0%)	829 (56.8%)	355 (58.0%)	76 (44.4%)	137 (45.8%)	76 (44.4%)	<0.0001		
5–1	823 (32.4%)	472 (32.3%)	196 (32.0%)	55 (32.2%)	100 (33.4%)	55 (32.2%)			
≥ 15	322 (12.7%)	159 (10.9%)	61 (10.0%)	40 (23.4%)	62 (20.7%)	40 (23.4%)			
Complications during hospital									
Pneumonia	364 (11.8%)	193 (10.8%)	66 (8.8%)	40 (19.1%)	65 (19.0%)	40 (19.1%)	<0.0001		
UTI	112 (3.6%)	55 (3.1%)	29 (3.9%)	10 (4.8%)	18 (5.3%)	10 (4.8%)	0.17		
GI hemorrhage	75 (2.4%)	33 (1.9%)	10 (1.3%)	12 (5.7%)	20 (5.9%)	12 (5.7%)	<0.0001		
SBP at admission, median (IQR), mmHg	143.0 (130.0–160.0)	135.0 (120.0–146.0)	167.0 (160.0–180.0)	170.0 (160.0–180.0)	134.0 (120.0–142.0)	170.0 (160.0–180.0)	<0.0001		
DBP at admission, median (IQR), mmHg	85.0 (79.0–92.0)	80.0 (74.0–89.0)	85.0 (79.0–92.0)	100.0 (90.0–105.0)	80.0 (70.0–88.0)	100.0 (90.0–105.0)	<0.0001		
Blood glucose at admission, median (IQR), mmol/L	6.0 (5.3–6.7)	5.8 (5.1–6.3)	5.8 (5.1–6.4)	8.3 (7.7–10.1)	8.2 (7.5–9.4)	8.3 (7.7–10.1)	<0.0001		
Treated with antihypertensives during hospital	350 (11.4%)	—	267 (35.6%)	83 (39.7%)	—	83 (39.7%)	—		
Treated with antidiabetics during hospital	111 (3.6%)	—	—	51 (24.4%)	60 (17.5%)	51 (24.4%)	—		

PSht, poststroke hypertension; PSHg, poststroke hyperglycemia; PSht-/PSHg-, patients without PSht or PSHg; PSht+/PSHg-, patients with PSht only; PSht-/PSHg+, patients with PSHg only; PSht+/PSHg+, patients with PSht and PSHg; IQR, interquartile range; SBP, systolic blood pressure; DBP, diastolic blood pressure; AF, atrial fibrillation; CHD, coronary heart disease; mRS, modified Rankin Scale; NIHSS, National Institutes of Health Stroke Scale; UTI, urinary tract infection; GI, gastrointestinal. *P value for comparison between four groups.

Table 2 Rates of death and dependency according to the presence or absence of PSht or PSHg.

Outcome at 3 months	All patients	Group 1 PSht–/PSHg–	Group 2 PSht+/PSHg–	Group 3 PSht–/PSHg+	Group 4 PSht+/PSHg+
n	3079	1777	751	342	209
Death	295 (9.6%)	142 (7.9%)	56 (7.5%)	59 (17.3%)	38 (18.2%)
n	2784	1635	695	283	171
Dependency	695 (25.0%)	380 (23.2%)	168 (24.2%)	87 (30.7%)	60 (35.1%)

PSht, poststroke hypertension; PSHg, poststroke hyperglycemia; PSht–/PSHg–, patients without PSht or PSHg; PSht+/PSHg–, patients with PSht only; PSht–/PSHg+, patients with PSHg only; PSht+/PSHg+, patients with PSht and PSHg.

presented in Table 1. Of the 3079 patients included in this study, 295 (9.6%) died within 3 months of the index stroke. Of 2784 patients who were alive at 3 months, 695 (25.0%) were considered dependent (mRS 3–5). The rates of death and dependency among the four groups of patients according to the presence or absence of PSht and/or PSHg are listed in Table 2. Analyses of interaction terms in regression models showed no significant interactions between PSht and PSHg in terms of mortality and dependence, indicating that PSht and PSHg had operated independently on the risk of death or dependence after acute ischemic stroke. After adjusting for potential confounding factors, adjusted ORs were 0.96 (95% CI: 0.65–1.43), 2.10 (1.41–3.13), and 2.13 (1.30–3.48) for death; and 1.09 (0.83–1.41), 1.04 (0.73–1.48), and 1.51 (0.97–2.34) for dependency among patients with PSht only, with PSHg only, and with both PSht and PSHg, respectively, compared with patients without PSht or PSHg.

This study showed that the risk of stroke death was highest among patients with both PSHg and PSht. PSHg was independently associated with the risk of death, but not dependency at 3 months after stroke in patients with or without PSht. By

contrast, PSht was not significantly associated with the risk of death or dependency after stratification for PSHg.

There are several limitations in our study. It is possible that some patients had asymptomatic or undiagnosed diabetes or hypertension, because self-report was used to record the history of these diseases. Therefore, we performed a sensitivity analysis excluding those who were discharged with a diagnosis of diabetes or hypertension to focus on those who indeed had transient elevation of blood pressure and/or serum glucose. And the analysis showed no significant difference between these two population. Next, by including those admitted relatively late (between 24 and 72 h after stroke onset), the transient increase in blood pressure and glucose might have already been over at the time of measurement. However, sensitivity analyses showed no significant differences when stratifying by the measured time (within 24 vs. 72 h).

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References

- Willmot M, Leonardi-Bee J, Bath PM. High blood pressure in acute stroke and subsequent outcome: A systematic review. *Hypertension* 2004; **43**:18–24.
- Luitse MJ, Biessels GJ, Rutten GE, Kappelle LJ. Diabetes, hyperglycaemia, and acute ischemic stroke. *Lancet Neurol* 2012; **11**:261–271.
- Tikhonoff V, Zhang H, Richart T, Staessen JA. Blood pressure as a prognostic factor after acute stroke. *Lancet Neurol* 2009; **8**:938–948.
- Osaki Y, Matsubayashi K, Yamasaki M, et al. Post-stroke hypertension correlates with neurologic recovery in patients with acute ischemic stroke. *Hypertens Res* 1998; **21**:169–173.
- Yong M, Kaste M. Dynamic of hyperglycemia as a predictor of stroke outcome in the ECASS-II trial. *Stroke* 2008; **39**:2749–2755.
- Gray CS, Hildreth AJ, Sandercock PA, et al. Glucose-potassium-insulin infusions in the management of post-stroke hyperglycaemia: The UK Glucose Insulin in Stroke Trial (GIST-UK). *Lancet Neurol* 2007; **6**:397–406.
- Wang Y, Cui L, Ji X, et al. The China National Stroke Registry for patients with acute cerebrovascular events: Design, rationale, and baseline patient characteristics. *Int J Stroke* 2011; **6**:355–361.
- Stroke – 1989. Recommendations on stroke prevention, diagnosis, and therapy. Report of the WHO Task Force on Stroke and other Cerebrovascular Disorders. *Stroke* 1989; **20**: 1407–1431.