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ORIGINAL RESEARCH

Adverse Outcomes Associated With Higher Mean Blood Pressure and Greater Blood Pressure Variability Immediately After Successful Embolectomy in Those With Acute Ischemic Stroke, and the Influence of Pretreatment Collateral Circulation Status

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BACKGROUND: To investigate whether collateral status could modify the associations between post-thrombectomy blood pressure (BP) measures and outcomes.

METHODS AND RESULTS: Patients with anterior-circulation large-vessel-occlusion successfully recanalized in a multicenter endovascular thrombectomy registry were enrolled. Pretreatment collateral status was graded and dichotomized (good/poor) in angiography. Maximum, minimum, and mean systolic BP (SBP) and BP variability (assessed by the SD, coefficient of variation) during the initial 24 hours after endovascular thrombectomy were obtained. The primary outcome was unfavorable 90-day outcome (modified Rankin Scale score 3–6). Secondary outcomes included symptomatic intracranial hemorrhage and 90-day mortality. Adjusted odds ratios (aOR) of BP parameters over the outcomes were obtained in all patients and in patients with good/poor collaterals. Among 596 patients (mean age 66 years; 59.9% males), 302 (50.7%) patients had unfavorable 90-day outcome. In multivariable analyses, higher mean SBP (aOR, 1.59 per 10 mm Hg increment; 95% CI, 1.26–2.02; $P<0.001$), mean SBP >140 mm Hg (versus ≤120 mm Hg; aOR, 4.27; 95% CI, 1.66–10.97; $P=0.002$), and higher SBP SD (aOR, 1.08 per 1-SD increment; 95% CI, 1.01–1.16; $P=0.02$) were respectively associated with unfavorable 90-day outcome in patients with poor collateral but not in those with good collateral. A marginal interaction between SBP coefficient of variation tertiles and collaterals on 90-day functional outcome (P for interaction, 0.09) was observed. A significant interaction between SBP coefficient of variation tertiles and collaterals on 90-day mortality (P for interaction, 0.03) was observed.

CONCLUSIONS: Higher postprocedural BP is associated with 90-day unfavorable outcomes after successful endovascular thrombectomy in patients with poor collateral.

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Key Words: blood pressure ■ blood pressure variability ■ collateral ■ endovascular treatment ■ outcome

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CLINICAL PERSPECTIVE

What Is New?

- In this study enrolling patients with large-vessel-occlusion acute ischemic stroke, a significant association between higher systolic blood pressure within the first 24 hours after successful recanalization and unfavorable 90-day clinical outcome was observed, especially in those with poor pretreatment collateral.

What Are the Clinical Implications?

- For patients with acute ischemic stroke who had successful endovascular treatment, pretreatment collateral status should be considered in postprocedural blood pressure management and future research.

Nonstandard Abbreviations and Acronyms

BPV	blood pressure variability
CV	coefficient of variation
EVT	endovascular treatment
mRS	modified Rankin Scale
RESCUE-RE	A Registration Study for Critical Care of Acute Ischemic Stroke after Recanalization

Endovascular treatment (EVT) has been mainstay treatment for acute ischemic stroke with anterior-circulation large vessel occlusion (LVO) within a therapeutic time window.[1] However, more than half of patients still failed to regain functional independence at 3 months despite successful recanalization.[2] There have been cumulative studies exploring optimal adjuvant periprocedural management strategies in such patients, for example, periprocedural blood pressure (BP) management strategy, which is critical in governing patients' short- and long-term prognosis.

Several observational studies have revealed that increased post-EVT BP levels were associated with unfavorable functional outcome,[3–8] symptomatic intracranial hemorrhage (sICH),[6–9] and mortality.[6–8] Studies also implied that the detrimental effects of higher systolic blood pressure (SBP) might be more prominent in patients who were successfully recanalized.[8,10] Moreover, post-EVT blood pressure variability (BPV), reflecting BP fluctuation, was also associated with unfavorable functional outcome[10–13] or sICH.[14] A recent multicenter cohort study reported that patients with SBP goals <140 mm Hg following successful revascularization with EVT are associated with better clinical outcomes than SBP goals <180 mm Hg.[15] Nevertheless, questions regarding BP management post-EVT remains. Emerging evidence suggested that periprocedural BP management may have to be individualized, taking into consideration other physiological factors such as the collateral status.[16,17] Theoretically,[18] following successful recanalization, patients with good collaterals can meet cerebral perfusion demand without requiring a significant increase in systemic BP. On the other hand, patients with poor collaterals are more likely to use an autoregulatory increase in BP to meet this same demand. Hence, we believe that individualized BP goals, factoring in collateral status, are more likely to be successful in preventing hyper- or hypoperfusion injury. To this end, a recent observational study suggested that patients with poor collateraland higher BP/BPV had worse outcomes.[16] Although it may be interpreted as high BP being detrimental, it is also possible that the higher BP is a marker of persistent perfusion deficits that we should support with permissive hypertension rather than forceful normotension. Thus, it is important to understand the correlation between collaterals and BP to further inform hypothesis-driven intervention trials. Given only a single-center study with clear limitations is available, we aimed to further clarify the role of pretreatment collaterals and postrecanalization BP on outcomes in a large national EVT registry.

METHODS

Data Availability Statement

Data related to this article are available from the corresponding author upon reasonable request.

Study Design

In the current study, patients were screened from RESCUE-RE (A Registration Study for Critical Care of Acute Ischemic Stroke after Recanalization) registry, which is an ongoing, prospective, observational cohort study recruiting adult patients with LVO-acute ischemic stroke undergoing EVT at 18 comprehensive stroke centers across China, to evaluate the functional outcomes of such patients in real-world settings.[19] Management of patients at each participating center was conducted according to local clinical care protocols and latest international/national guidelines,[1] and all patients were admitted to intensive care unit for early postoperation monitoring and management. The study was approved by the medical ethics committee of Beijing Tiantan Hospital, Capital Medical University, and all patients provided written, informed consent to participate in the study.

Participants

Patients in RESCUE-RE were enrolled in the current study with the following inclusion criteria: (1) age >18 years old; (2) acute ischemic stroke with LVO in the anterior circulation proven in cerebral and vascular imaging; (3) successfully recanalized, defined as modified Thrombolysis in Cerebral Infarction score of 2b or 3 after EVT; (4) sufficient BP measures within the first 24 hours after EVT were obtained; (5) pretreatment collateral status assessed in digital subtraction angiography; and (6) patients followed up for 3 months. Patients with insufficient BP data (recorded <24 hours), incomplete digital subtraction angiography images (eg, missing venous-phase images), and lost to follow-up were excluded.

Postprocedural BP Parameters

Postprocedural BP parameters were measured and recorded every 15 minutes for 2 hours, every 30 minutes at 2 to 6 hours, and every 1 hour at 7 to 24 hours after EVT. We used SBP, SD, and coefficient of variation (CV) of SBP as key indexes. Maximum, minimum, and mean SBPs in the first 24 hours after EVT were recorded. SD and CV formulas are as follow:

$$SD = \sqrt{\left(\frac{1}{n-1}\right)\sum_{(i=1)}^{(n)}\left(BP_i - BP_{mean}\right)^2} \quad CV = \frac{SD}{BP_{mean}} \times 100$$

BP records at each participating center were examined and audited by full-time study quality coordinators.

Collateral Assessment

The pretreatment collateral status was evaluated in digital subtraction angiography, using the American Society of Interventional and Therapeutic Neuroradiology / Society of Interventional Radiology collateral flow grading system.[20] This grading system is a 5-point (0–4) scale; grades 0 to 1, 2, and 3 to 4 are usually regarded as poor, moderate, and good collateral respectively for the detailed categories.[21] Patients with grade 2 have rapid collateral flow and better outcomes than patients with grade 0 to 1 (no/slow collateral flow).[22] Considering the potential influence of BP level on outcomes differs in various categorized collaterals, in order to enhance the sensitivity, we defined 0 to 1 as poor and 2 to 4 as good collateral status in the current study. All images were stored in digital imaging and communicated in medicine format and were assessed by two independent neuroradiologists (Dr G.W. and Dr H.X.) blinded to the clinical information. A third neuroradiologist blinded to the clinical information was involved for additional assessment in cases with disagreement.

Outcomes

The primary outcome was unfavorable functional outcome (functional dependence or death) at 90 days, defined by modified Rankin Scale (mRS) score 3 to 6. Secondary outcomes included sICH and 90-day mortality. sICH was defined as any intraparenchymal, subarachnoid, or intraventricular hemorrhage on post-EVT cerebral imaging with ≥4 points increase in National Institutes of Health Stroke Scale score within 7 days after EVT, according to the ECASS (European-Australasian Acute Stroke Study) II criteria.[23] The 90-day outcomes were obtained through clinic or telephone follow-up by trained research assistants blinded to patients' baseline clinical information.

Statistical Analysis

Kappa statistic was used to evaluate the interrater agreement in 5-point collateral status assessment. Baseline demographics of patients in RESCUE-RE who were enrolled in or excluded from this study were compared, as were patients with different collaterals and patients with different SBP/BPV levels. χ^2 tests or Fisher's exact tests were used for univariate analyses of categorical variables; and Student *t* tests or Mann-Whitney *U* tests for continuous variables.

Multivariable logistic regression was used to evaluate the independent associations between post-EVT SBP, BPV parameters (all as continuous variables and some as categorical variables as well) and the outcomes, adjusting for potential confounders including age, National Institutes of Health Stroke Scale score, diabetes mellitus, atrial fibrillation, prior stroke, history of smoking, onset-to-recanalization time, occlusion site, and antihypertensive therapy. Adjusted odds ratios (aOR) and 95% CIs were reported for every 10 mm Hg increment of each SBP parameter and 1-unit increment of SBP BPV, as well as for mean SBP (≤120, 121–140, >140 mm Hg), mean SBP SD and CV (in tertiles) as categorical variables. The analyses were performed in all patients enrolled and then separately in subgroups dichotomized by the collateral status. Interactions of mean SBP, SBP SD, or SBP CV in categories and collateral status over the outcomes were tested by including an interaction term (eg, mean SBP category×collateral status) in the multivariable regression model. All analyses were performed with SAS 9.4 (SAS Institute Inc, Cary, NC). Two-sided $P<0.05$ was considered statistically significant.

RESULTS

From July 2018 to May 2019, 1218 consecutive patients with 90-day follow-up were enrolled in RESCUE-RE study. After excluding 322 patients with posterior-circulation stroke, 176 patients without successful recanalization, 60 patients with insufficient BP data, 6 patients lost to follow-up, and 58 patients with

incomplete digital subtraction angiography images for collateral status assessment, 596 patients were analyzed in the current study (Figure S1). The baseline characteristics of enrolled and excluded patients are displayed in Table S1. The excluded patients seemed to have a lower percentage of middle cerebral artery M1 occlusion, higher percentage of receiving general anesthesia, shorter time from onset to groin or recanalization, and higher post-EVT mean, maximum, and minimum SBP than included patients.

Baseline characteristics were summarized in Table 1. Overall, 329 (55.2%) patients had good and 267 (44.8%) had poor pretreatment collaterals, with good interrater agreement in the assessment between two raters in 596 cases (kappa=0.82; $P<0.001$). A total of 302 (50.7%) patients had an unfavorable functional outcome (mRS score 3–6) at 90 days; 35 (5.8%) patients had sICH, and 79 (13.3%) patients died within 90 days. Baseline characteristics of patients with different functional outcome are shown in Table S2. Details by different SBP levels are shown in Table S3.

SBP Parameters as Continuous Variables and the Primary Outcome

Patients with poor collateral had a higher maximum post-EVT SBP (145.5±20.0 versus 142.1±17.9 mm Hg, $P=0.03$), SBP SD (11.3±4.7 versus 10.5±4.4 mm Hg, $P=0.04$), and SBP CV (9.0±3.4 versus 8.5±3.5 mm Hg, $P=0.04$) than those with good collateral. In addition, patients with poor collateral were more likely to have the highest SBP CV tertile (38.4% versus 29.2%, $P=0.05$, Table 1).

In multivariable logistic regression models with SBP parameters as continuous variables, higher mean SBP (aOR, 1.31 per 10 mm Hg increment; 95% CI, 1.14–1.51; $P<0.001$), maximum SBP (aOR 1.19 per 10 mm Hg increment, 95% CI 1.06–1.32, $P=0.002$), and minimum SBP (aOR, 1.27 per 10 mm Hg increment; 95% CI, 1.10–1.47; $P=0.001$) were all associated with increased risks of unfavorable outcome at 90 days in overall analysis after adjusting for potential confounders (Table 2). In subgroup analyses, such associations remained in those with poor collateral status (mean SBP: aOR, 1.59 per 10 mm Hg increment; 95% CI, 1.26–2.02; $P<0.001$; maximum SBP: aOR, 1.34; 95% CI, 1.13–1.60; $P<0.001$; and minimum SBP: aOR, 1.36; 95% CI, 1.07–1.74; $P=0.01$) but not in those with good collaterals.

Independent association between SBP SD and unfavorable outcome was detected in patients with poor collaterals (aOR, 1.08 per 1 SD increment; 95% CI, 1.01–1.16; $P=0.02$) but not in those with good collaterals or in the overall analysis. A trend but not significant association between SBP CV and unfavorable outcome was found in the group with poor collateral (aOR, 1.07 per 1 CV increment; 95% CI, 0.98–1.18; $P=0.14$) (Table 2).

Mean SBP in Categories and the Outcomes

Proportions of patients with unfavorable outcome increased with higher mean SBP in patients with poor collateral (56.9%, 69.5%, and 80.9%, respectively, with mean SBP ≤120, 121–140, and >140 mm Hg; $P=0.02$). In contrast, the proportions were not different by mean SBP categories in patients with good collateral (35.4%, 39.0%, and 39.5% respectively; $P=0.35$; Table 3). Compared with mean SBP ≤120 mm Hg, mean SBP >140 mm Hg was independently associated with a higher risk of unfavorable outcome in overall analysis (aOR, 2.59; 95% CI, 1.45–4.54; $P=0.001$) and in patients with poor collateral (aOR, 4.27; 95% CI, 1.66–10.97; $P=0.002$) but not in those with good collateral (aOR, 1.55; 95% CI, 0.68–3.52; $P=0.29$; P for interaction=0.41; Table 3). The distributions of 90-day mRS scores by mean SBP categories in those with good and poor collaterals are shown in Figure 1; patients with higher mean SBP had higher 90-day mRS scores in the group with poor collateral ($P=0.02$) but not in the group with good collateral ($P=0.35$). As for secondary outcomes, the highest proportions of sICH (19.2%) and 90-day mortality (25.5%) were detected in patients with poor collateral and mean SBP >140 mm Hg, compared with other patients (Table 3). However, there was no significant, independent association between SBP category and the secondary outcomes in multivariable analyses.

SBP BPV in Tertiles and the Outcomes

Patients with higher SBP CV tertile had a higher risk of unfavorable 90-day outcome in those with poor collateral (58.9%, 63.9%, 74.5% in lowest, intermediate, and highest tertiles, respectively; $P=0.01$), whereas the proportions of unfavorable outcome were not different by SBP CV tertiles in patients with good collateral (34.5%, 42.3%, and 34.7%, respectively; $P=0.88$; Table 4). In multivariable analyses, a nearly significant association was found in patients with poor collateral (aOR, 2.03 for highest versus lowest SBP CV tertile; 95% CI, 0.99–4.17; $P=0.05$), which was neutral in patients with good collateral (aOR, 0.77; 95% CI, 0.42–1.44; $P=0.42$). There was a marginal SBP CV tertiles-collateral interaction for the primary outcome (P for interaction=0.09; Table 4). Distributions of 90-day mRS scores by SBP CV tertiles among patients with good or poor collateral status are shown in Figure 2; there was a significant trend of higher 90-day mRS scores with higher SBP CV in patients with poor collateral ($P=0.01$) but not those with good collateral ($P=0.88$). For the secondary outcomes, mortality was higher in patients with SBP CV of the highest (versus lowest) tertile in patients with poor collateral (aOR, 4.00; 95% CI, 1.37–11.72; $P=0.01$)

Table 1. Baseline Characteristics of Patients

Characteristics	Total (n=596)	Good Collateral (ASTIN/SIR Score 2–4, n=329)	Poor Collateral (ASTIN/SIR Score 0–1, n=267)	*P* Value
Age, y, mean±SD	66.1±12.4	65.5±13.0	66.9±11.6	0.26
Male, n (%)	357 (59.9)	197 (59.9)	160 (59.9)	0.95
Risk factors, n (%)				
Hypertension	314 (52.7)	175 (53.2)	139 (52.1)	0.72
Diabetes mellitus	125 (21.0)	58 (17.6)	67 (25.1)	0.03
Previous stroke	104 (17.4)	58 (17.6)	46 (17.2)	0.87
Coronary heart disease	111 (18.6)	59 (17.9)	52 (19.5)	0.63
Atrial fibrillation	138 (23.2)	68 (20.7)	70 (26.2)	0.11
Smoking	185 (31.0)	101 (30.7)	84 (31.5)	0.88
Baseline National Institutes of Health Stroke Scale score, median (IQR)	14 (12–19)	14 (10–19)	15 (12–19)	0.01
Imaging items, n (%)				
Baseline Alberta Stroke Program Early CT score, median (IQR)	8 (7–9)	8 (7–9)	8 (6–9)	0.53
Internal carotid occlusion	172 (28.9)	84 (25.5)	88 (33.0)	0.05
Middle cerebral artery-M1 occlusion	274 (46.0)	146 (44.4)	128 (47.9)	0.39
Stroke etiology, n (%)				0.57
Large-artery atherosclerosis	304 (51.0)	167 (50.8)	137 (51.3)	
Cardioembolic	255 (42.9)	138 (41.9)	117 (43.8)	
Others	37 (6.2)	24 (7.3)	13 (4.9)	
Treatments				
Intravenous thrombolysis, n (%)	212 (35.6)	126 (38.3)	86 (32.2)	0.12
General anesthesia, n (%)	223 (37.4)	115 (35.0)	108 (40.5)	0.17
Onset to groin puncture, min, median (IQR)	340 (250–485)	335 (250–485)	345 (240–490)	0.78
Onset to recanalization, min, median (IQR)	459 (330–599)	450 (332–584)	464 (330–620)	0.63
Modified Thrombolysis in Cerebral Ischemia 3, n (%)	410 (68.8)	227 (69.0)	183 (68.5)	0.90
Antihypertensive, n (%)	322 (54.0)	168 (51.5)	154 (58.3)	0.26
Blood pressure parameters within 24 h after procedure (mm Hg, mean±SD)				
Mean SBP	124.6±14.4	124.0±14.2	125.4±14.7	0.24
Maximum SBP	143.6±18.8	142.1±17.9	145.5±20.0	0.03
Minimum SBP	108.2±14.0	108.5±14.2	107.9±13.8	0.64
SBP SD	10.9±4.6	10.5±4.4	11.3±4.7	0.04
SBP CV	8.9±3.5	8.5±3.5	9.0±3.4	0.04
Categorized mean SBP, n (%)				0.09
≤120 mm Hg	229 (38.4)	127 (38.6)	102 (38.2)	
121–140 mm Hg	282 (47.3)	164 (49.9)	118 (44.2)	
>140 mm Hg	85 (14.3)	38 (11.6)	47 (17.6)	
SBP CV in tertiles*, n (%)				0.05
Lowest tertile	197 (33.3)	119 (36.6)	78 (29.3)	
Intermediate tertile	197 (33.3)	111 (34.2)	86 (32.3)	
Highest tertile	197 (33.3)	95 (29.2)	102 (38.4)	
Symptomatic intracerebral hemorrhage	35 (5.9)	12 (3.7)	23 (8.6)	0.01
Death within 90-d	79 (13.3)	38 (11.6)	41 (15.4)	0.17
90-d mRS score 3–6	302 (50.7)	124 (37.7)	178 (66.7)	<0.001

ASITN/SIR indicates American Society of Interventional and Therapeutic Neuroradiology/Society of Interventional Radiology; CV, coefficient of variation; IQR, interquartile range; mRS, modified Rankin Scale; and SBP, systolic blood pressure.

*Five patients were not enrolled in SBP CV analysis because of measurement numbers ≤10, 1 in mRS score 0 to 2 and 4 in mRS score 3 to 6 group; lowest SBP CV tertile: ≤6.94 mm Hg; intermediate SBP CV tertile: 6.95 to 9.90 mm Hg; highest SBP SD tertile: ≥9.90 mm Hg.

Table 2. Effects of SBP and BPV Parameters on Unfavorable Outcome at 90-Day According to Collateral Status

	Total (n=596)		Good Collateral (n=329)		Poor Collateral (n=267)	
	aOR (95% CI)*	*P* Value	aOR (95% CI)†	*P* Value	aOR (95% CI)†	*P* Value
Mean SBP	1.31 (1.14–1.51)	<0.001	1.14 (0.95–1.38)	0.15	1.59 (1.26–2.02)	<0.001
Maximum SBP	1.19 (1.06–1.32)	0.002	1.08 (0.93–1.25)	0.28	1.34 (1.13–1.60)	<0.001
Minimum SBP	1.27 (1.10–1.47)	0.001	1.20 (0.99–1.45)	0.06	1.36 (1.07–1.74)	0.01
SBP SD	1.02 (0.98–1.06)	0.27	0.98 (0.93–1.04)	0.67	1.08 (1.01–1.16)	0.02
SBP CV	0.99 (0.94–1.06)	0.97	0.96 (0.89–1.03)	0.26	1.07 (0.98–1.18)	0.14

Odds ratio per 10-mm Hg increment for mean, maximum, and minimum SBP, per 1-SD increment for SD, per 1-CV increment for CV. aOR indicates adjusted odds ratio; BPV, blood pressure variability; CV, coefficient of variation; and SBP, systolic blood pressure.

*Adjusted for age, history of diabetes mellitus, prior stroke, atrial fibrillation, smoking, baseline National Institutes of Health Stroke Scale score, occlusion site, onset-to-recanalization time, antihypertensive therapy, and collateral status.

†Adjusted for all confounders mentioned in total except for collateral status.

but not in patients with good collateral (aOR, 0.78; 95% CI, 0.34–1.85; *P*=0.58), with a significant interaction (*P*=0.03). A marginal interaction between SBP CV tertiles and collaterals on sICH (*P* for interaction, 0.07) was found (Table 4). The results about SBP SD tertiles and outcomes were shown in Table S4.

DISCUSSION

Our study corroborated the associations between higher post-EVT BP and worse functional outcomes in those with successful recanalization; more important, in subgroup analysis, the association seemed to be mostly driven by patients with poor collateral. Higher SBP (mean SBP >140 mm Hg) over the initial 24 hours after EVT was more likely to be associated with worse functional outcomes in patients with poor collateral status but not in those with good collateral. However, with no significant interaction detected over the primary outcome, the findings should be interpreted with caution. SBP CV in highest tertiles was significantly associated with 90-day mortality in those with poor collateral.

In the overall analyses, higher post-EVT SBP was associated with unfavorable outcome in patients who were recanalized, in line with previous studies.[4,5,7,8] In the recent DAWN (Diffusion Weighted Imaging or Computerized Tomography Perfusion Assessment With Clinical Mismatch in the Triage of Wake Up and Late Presenting Strokes Undergoing Neurointervention) trial, target SBP <140 mm Hg was suggested within the first 24 hours after successful recanalization.[24] However, whether patients could benefit from aggressive BP management especially with poor collaterals after successful EVT is still unknown. On the other hand, no association was found between SBP levels and sICH in our cohort, which is consistent with the BEST (Blood Pressure after Endovascular Therapy for Ischemic Stroke) cohort study[4] but inconsistent with other previous researches.[6,8,14] Only patients with anterior-circulation stroke were enrolled in our study and the BEST cohort,[4] whereas both patients with anterior- and posterior-circulation stroke were enrolled in other studies.[8,14] Moreover, the mean post-EVT SBP in the current cohort was lower than that in earlier study,[15] reflecting stroke physicians' preference of more aggressive BP control after EVT, especially for those with successful recanalization. This may partially explain the relatively lower proportion of sICH in the current cohort, which was underpowered to detect any significant association between SBP and sICH.

Data regarding the association between post-EVT BP parameters and outcomes in patients with successful recanalization based on collateral status were scarce. The recent ASTER (Contact Aspiration Versus Stent Retriever for Successful Recanalization) trial[25] reported that an intraoperative BP metric (duration of hypotension with periprocedural mean arterial pressure <90 mm Hg) was negatively associated with favorable outcome in patients with poor -collateral rather than in patients with good collateral, indicating the potential impact of collateral status on periprocedure BP management. In our study, a separate question of postprocedure BP rather than procedural BP on prognosis was detected based on collaterals.

In another observational single-center study enrolling 90 patients with anterior-circulation stroke who were recanalized, Chang et al[16] reported higher post-EVT mean SBP and SBP SD in patients with worse outcomes only in poor collaterals (by pial arterial filling score), which is similar to our results. In our cohort, we found a similar correlation between higher post-EVT mean SBP and worse outcomes exclusively in patients with poor collaterals. In addition, our data suggest even a higher minimum and maximum SBP correlates with poor outcomes in this subgroup. Interestingly, we found a trend of higher systolic BPV with poor outcomes as has been previously described, more so in the cohort with poor collateral albeit not statistically significant.

Table 3. Primary and Secondary Outcomes Associated With Categorized Mean SBP by Collateral Status

	Mean SBP			121–140 mm Hg vs ≤120 mm Hg		>140 mm Hg vs ≤120 mm Hg		Test for Interaction
	≤120 mm Hg	121–140 mm Hg	>140 mm Hg	aOR (95% CI)	*P* Value	aOR (95% CI)	*P* Value	
Modified Rankin scale score 3–6 at 90-d*								0.41
Total	103/229 (45.0)	146/282 (51.8)	53/85 (62.4)	1.62 (1.09–2.40)	0.02	2.59 (1.45–4.54)	0.001	
Good collateral	45/127 (35.4)	64/164 (39.0)	15/38 (39.5)	1.63 (0.95–2.81)	0.08	1.55 (0.68–3.52)	0.29	
Poor collateral	58/102 (56.9)	82/118 (69.5)	38/47 (80.9)	1.81 (0.97–3.35)	0.06	4.27 (1.66–10.97)	0.002	
Symptomatic intracerebral hemorrhage†								0.33
Total	14/229 (6.1)	12/282 (4.3)	9/85 (10.6)	0.76 (0.33–1.79)	0.54	2.18 (0.84–5.66)	0.11	
Good collateral	4/127 (3.2)	8/164 (4.9)	0/38 (0)	1.58 (0.44–5.60)	0.48	NA	NA	
Poor collateral	10/102 (9.8)	4/118 (3.4)	9/47 (19.2)	0.37 (0.10–1.34)	0.13	2.56 (0.86–7.64)	0.09	
Mortality‡								0.70
Total	27/229 (11.8)	36/282 (12.8)	16/85 (18.8)	1.12 (0.65–1.91)	0.68	1.63 (0.85–3.14)	0.14	
Good collateral	15/127 (11.8)	19/164 (11.6)	4/38 (10.5)	1.10 (0.52–2.34)	0.80	1.05 (0.33–3.40)	0.93	
Poor collateral	12/102 (11.8)	17/118 (14.4)	12/47 (25.5)	1.05 (0.48–2.29)	0.90	1.91 (0.83–4.36)	0.12	

aOR indicates adjusted odds ratio; NA, not available; NIHSS, National Institutes of Health Stroke Scale; and SBP, systolic blood pressure.

*Adjusted for age, history of diabetes mellitus, prior stroke, atrial fibrillation, smoking, baseline NIHSS score, occlusion site, onset-to-recanalization time, antihypertensive therapy and collateral status in total cohort analysis; and adjusted for all confounders mentioned in total except for collateral status in good and poor collateral cohort analysis.

†Adjusted for age, history of atrial fibrillation, baseline NIHSS score, occlusion site, modified Thrombolysis in Cerebral Ischemia scale score, antihypertensive therapy and collateral status in total cohort analysis, and adjusted for all confounders mentioned in total expect for collateral status in good and poor collateral cohort analysis.

‡Adjusted for age, history of atrial fibrillation, prior stroke; coronary heart disease, baseline NIHSS score, occlusion site, onset-to-recanalization time, antihypertensive therapy and collateral status in total cohort analysis, and adjusted for all confounders mentioned in total expect for collateral status in good and poor collateral cohort analysis.

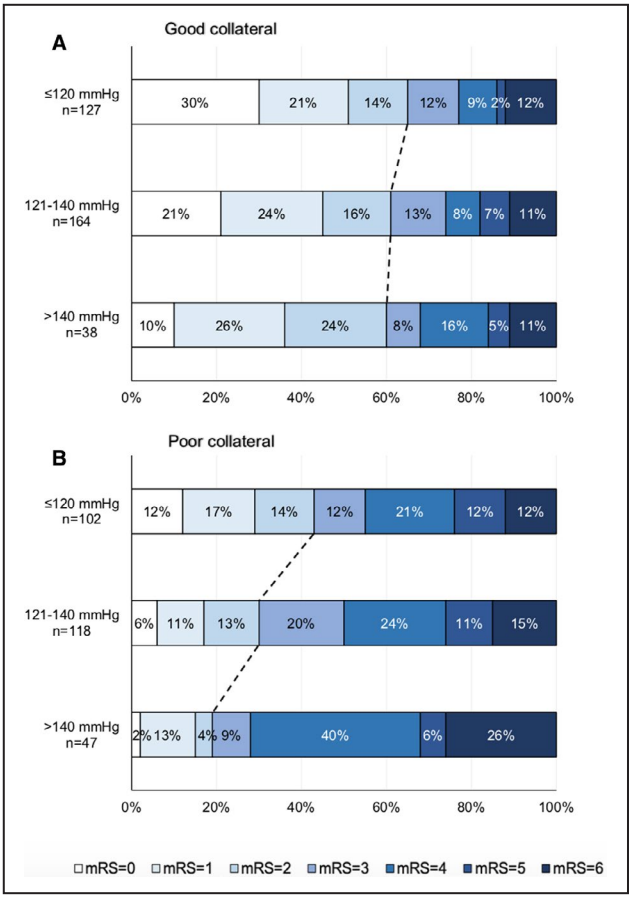

Figure 1. Distribution of mRS score at 90-d by systolic blood pressure categories.
A, Good collateral status (*P* for χ^2 tests is 0.35). **B**, Poor collateral status (*P* for χ^2 tests is 0.02). mRS indicates modified Rankin Scale.

The exact mechanism underlying the different associations of high SBP levels with outcomes upon collateral status is unclear. Impaired cerebral autoregulation may be one explanation. Cerebral autoregulation is usually impaired after ischemic stroke, especially with chronic hypertension and uncontrolled high BP.[26] On the other hand, good collaterals could preserve more brain tissue from ischemic damage, leading to final smaller infarct size and growth and subsequent better clinical outcome.[27,28] The post EVT BP levels might be a synthesized result of premorbid BP control and stress responses during acute phase.[29] Therefore, patients with higher post-EVT SBP might be an indication for those of more severe stroke or larger infarction volume, especially in patients with poor collateral. Such inference needs to be verified in future studies.

BPV is another important predictor of outcome after EVT. SD of BP represents the spread of BP measurements around the mean. CV of BP eliminates the influence of mean. Both are the most commonly used and classical indexes to quantify BPV.[12] During the acute stage of stroke, cerebral autoregulation is impaired and blood flow becomes dependent of systemic BP. Thus, fluctuations in BP may be detrimental for ischemic territories.[18] Increased short-term SBP BPV has been reported to be associated with unfavorite outcome in acute ischemic stroke.[30] In our study, high SBP CV tertile was particularly associated with mortality in patients with poor collateral. There are possible explanations behind this. First, in our study, we found higher sICH among patients with highest SBP CV tertile, especially in the group with poor collateral (shown in Table 4), which might be one reason, because sICH was highly associated with unfavorable outcome. Besides, increased BPV is correlated with larger infarct growth,[31] and patients with poor collateral were more likely to have larger final infarct volume,[27] which can lead to worse functional outcomes. Future investigations to further reveal the mechanisms are needed.

This is, to our best knowledge, the multicenter cohort study to investigate the impact of post-EVT BP/BPV on outcomes among patients with acute ischemic stroke-LVO with successful recanalization based on collateral status. We used the dichotomized BP parameters and systematic evaluation of collaterals on conventional angiography and provided important data on the relationship with functional outcomes commonly encountered in acute stroke, in the era of EVT. Individualized BP management strategies might be implemented upon collaterals. However, the study also had several limitations. First, there was no standardized BP management protocol across centers in this study, similar to other observational studies,[4,8,15] which is inevitable given uncertainties in specific BP control targets in such patients. Second, although the antihypertensive treatment was adjusted in the multivariable analysis, we did not investigate the influence of antihypertensive medications or dosages on BP or BPV in this study. Third, we did not measure more detailed imaging variables, such as final infarct volume, which may be a confounder to the results. We therefore adjusted baseline National Institutes of Health Stroke Scale score in multivariable analyses, which reflects the stroke severity and is closely linked with the infarct volume.[2] Fourth, recruitment bias might occur as a portion of patients were excluded for incomplete data. Furthermore, the proportions of LVO etiologies are different between Chinese and western population,[32] along with other differences in patients' characteristics; therefore, the generalizability of current findings needs to be validated in western populations.

CONCLUSIONS

Among patients with LVO-acute ischemic stroke who had successful recanalization, higher post-EVT SBP was associated with worse functional outcomes, especially

Table 4. Primary and Secondary Outcomes Associated With Tertiles of SBP CV by Collateral Status

	SBP CV			Intermediate vs Lowest Tertile		Highest vs Lowest Tertile		Test for Interaction
	Lowest Tertile	Intermediate Tertile	Highest Tertile	aOR (95% CI)	*P* Value	aOR (95% CI)	*P* Value	
Modified Rankin Scale score 3–6 at 90-d*								0.09
Total	87/197 (44.2)	102/197 (51.8)	109/197 (55.3)	1.16 (0.75–1.80)	0.32	1.25 (0.81–1.94)	0.50	
Good collateral	41/119 (34.5)	47/111 (42.3)	33/95 (34.7)	1.19 (0.66–2.14)	0.55	0.77 (0.42–1.44)	0.42	
Poor collateral	46/78 (58.9)	55/86 (63.9)	76/102 (74.5)	1.13 (0.55–2.31)	0.73	2.03 (0.99–4.17)	0.05	
Symptomatic intracerebral hemorrhage †								0.07
Total	10/197 (5.1)	10/197 (5.1)	14/197 (7.1)	0.87 (0.34–2.26)	0.77	1.28 (0.53–3.10)	0.58	
Good collateral	7/119 (5.9)	3/111 (2.7)	2/95 (2.1)	0.36 (0.08–1.53)	0.16	0.26 (0.05–1.35)	0.11	
Poor collateral	3/78 (3.9)	7/86 (8.1)	12/102 (11.8)	2.16 (0.50–9.29)	0.30	3.75 (0.96–14.70)	0.06	
Mortality‡								0.03
Total	17/197 (8.6)	25/197 (12.7)	37/197 (18.8)	1.15 (0.59–2.22)	0.68	1.64 (0.89–3.02)	0.11	
Good collateral	13/119 (10.9)	14/111 (12.6)	11/95 (11.6)	0.91 (0.40–2.04)	0.83	0.78 (0.34–1.85)	0.58	
Poor collateral	4/78 (5.1)	11/86 (12.8)	26/102 (25.5)	1.61 (0.50–5.23)	0.43	4.00 (1.37–11.72)	0.01	

aOR indicates adjusted odds ratio; CV, coefficient of variation; NIHSS, National Institutes of Health Stroke Scale; and SBP, systolic blood pressure.

*Adjusted for age, history of diabetes mellitus, prior stroke, atrial fibrillation, smoking, baseline NIHSS score, occlusion site, onset-to-recanalization time, antihypertensive therapy and collateral status in total cohort analysis; and adjusted for all confounders mentioned in total except for collateral status in good and poor collateral cohort analysis.

†Adjusted for age, history of atrial fibrillation, baseline NIHSS score, occlusion site, Modified Thrombolysis in Cerebral Ischemia scale score, antihypertensive therapy and collateral status in total cohort analysis, and adjusted for all confounders mentioned in total expect for collateral status in good and poor collateral cohort analysis.

‡Adjusted for age, history of atrial fibrillation, prior stroke; coronary heart disease, baseline NIHSS score, occlusion site, onset-to-recanalization time, antihypertensive therapy and collateral status in total cohort analysis, and adjusted for all confounders mentioned in total expect for collateral status in good and poor collateral cohort analysis.

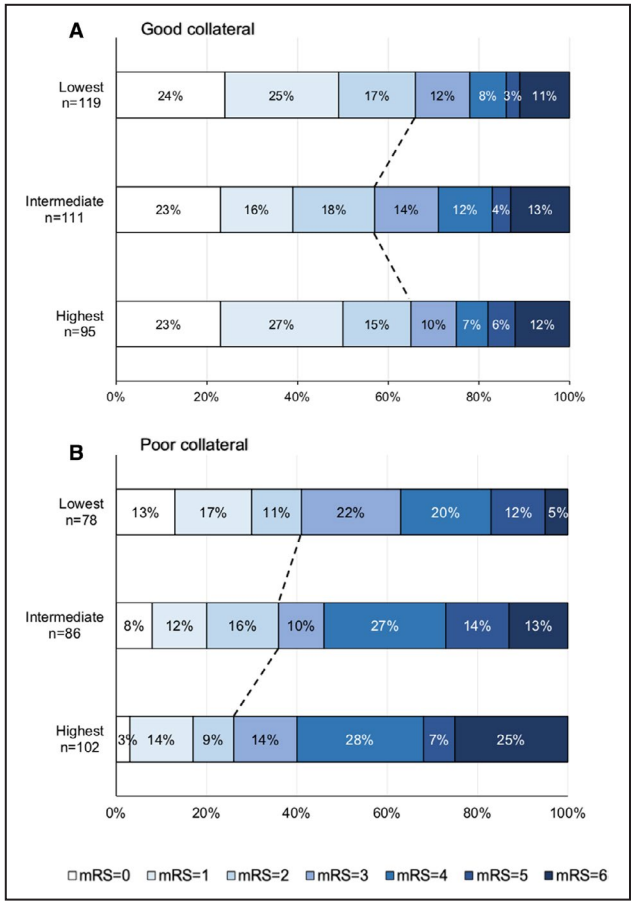

Figure 2. Distribution of mRS score at 90-d by systolic blood pressure CV tertiles.
A, Good collateral status (*P* for χ^2 tests is 0.88). **B**, Poor collateral status (*P* for χ^2 tests is 0.01). CV indicates coefficient of variation; and mRS, modified Rankin Scale.

in those with poor collaterals but not in those with good collaterals. Our observational study brings a new insight that pretreatment collaterals might be considered in post-EVT BP management and future research.

ARTICLE INFORMATION

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Disclosures

None.

Supplementary Material

Tables S1–S4
Figure S1

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SUPPLEMENTAL MATERIAL

Table S1. Baseline characteristics between enrolled and excluded patients.

Characteristics	Enrolled (n=596)	Excluded (n=124)	P value
Age, y, mean ± SD	66.1±12.4	64.3±21.7	0.13
Male, n (%)	357 (59.9)	72 (58.1)	0.69
Risk factors n (%)			
Hypertension	314 (52.7)	70 (56.4)	0.47
Diabetes mellitus	125 (21.0)	29 (23.4)	0.56
Previous stroke	104 (17.4)	17 (13.7)	0.30
Coronary heart disease	111 (18.6)	27 (21.8)	0.42
Atrial fibrillation	138 (23.2)	24 (19.4)	0.36
Smoking	185 (31.0)	36 (29.0)	0.64
Baseline NIHSS, median (IQR)	14 (12-19)	14 (12-18)	0.62
Imaging items, n (%)			
Baseline ASPECTS, median (IQR)	8 (7-9)	8 (7-9)	0.44
ICA occlusion	172 (28.9)	30 (24.2)	0.29
MCA-M1 occlusion	274 (46.0)	32 (25.8)	<0.001
ASITN/SIR collateral grading*			0.14
0	42 (7.1)	2 (3.0)	
1	225 (37.8)	21 (31.8)	
2	235 (39.4)	26 (39.4)	
3	76 (12.8)	12 (18.2)	
4	18 (3.0)	5 (7.6)	
Stroke etiology, n (%)			0.11
Large-artery atherosclerosis	304 (51.0)	72 (59.5)	
Cardioembolic	255 (42.9)	47 (38.8)	
Others	37 (6.2)	2 (1.7)	
Treatments			
IVT, n (%)	212 (35.6)	24 (19.4)	0.005
General anesthesia, n (%)	223 (37.4)	77 (62.1)	<0.001
Onset to groin puncture, min, median (IQR)	340 (250-485)	287 (230-379)	<0.001

Onset to recanalization, min, median (IQR)	459 (330-599)	419 (306-512)	0.002
mTICI 3, n (%)	410 (68.8)	93 (75.0)	0.17
Anti-hypertensive, n (%)	322 (54.0)	74 (60.2)	0.34
Blood pressure parameters within 24 hours after procedure (mmHg, mean ± SD) †			
Mean SBP	124.6±14.4	132.0±13.4	<0.001
Maximum SBP	143.6±18.8	151.7±12.4	0.002
Minimum SBP	108.2±14.0	114.4±13.3	0.003
SBP SD	10.9±4.6	11.5±7.3	0.89
SBP CV	8.7±3.7	8.7±5.5	0.87
mRS 3-6 at 90 days‡	302 (50.7)	59 (50.0)	0.97

SD indicates standard deviation; IQR, interquartile range; NIHSS, National Institutes of Health Stroke Scale; IQR, interquartile range; ASPECTS, Alberta Stroke Program Early CT Score; ICA, Internal carotid; MCA, middle cerebral artery; ASITN/SIR, American Society of Interventional and Therapeutic Neuroradiology/Society of Interventional Radiology; IVT, intravenous thrombolysis; mTICI, modified Thrombolysis in Cerebral Ischemia; SBP, systolic blood pressure; CV, coefficient of variation; mRS, modified Rankin Scale.

* N=66 in excluded patients.

† N=64 in excluded patients.

‡ N=118 in excluded patients

Table S2. Baseline characteristics of patients.

Characteristics	Total (n=596)	mRS 0-2 (n=294)	mRS 3-6 (n=302)	P value
Age, y, mean ± SD	66.1±12.4	63.9±12.8	68.3±11.7	<0.001
Male, n (%)	357 (59.9)	172 (58.5)	185 (61.3)	0.46
Risk factors n (%)				
Hypertension	314 (52.7)	150 (51.0)	164 (54.3)	0.42
Diabetes mellitus	125 (21.0)	47 (16.0)	78 (25.8)	0.003
Previous stroke	104 (17.4)	41 (13.9)	63 (20.9)	0.03
Coronary heart disease	111 (18.6)	47 (16.0)	64 (21.2)	0.10
Atrial fibrillation	138 (23.2)	53 (18.0)	85 (28.1)	0.003
Smoking	185 (31.0)	102 (34.7)	83 (27.5)	0.05
Baseline NIHSS, median (IQR)	14 (12-19)	14 (10-18)	16 (13-21)	<0.001
Imaging items, n (%)				
Baseline ASPECTS, median (IQR)	8 (7-9)	8 (7-9)	8 (6-9)	0.006
ICA occlusion	172 (28.9)	73 (24.8)	99 (32.8)	0.03
MCA-M1 occlusion	274 (46.0)	148 (50.3)	126 (41.7)	0.04
ASITN/SIR collateral grading				<0.001
0	42 (7.1)	8 (2.7)	34 (11.3)	
1	225 (37.8)	81 (27.6)	144 (47.7)	
2	235 (39.4)	135 (45.9)	100 (33.1)	
3	76 (12.8)	57 (19.4)	19 (6.3)	
4	18 (3.0)	13 (4.4)	5 (1.7)	
Dichotomized ASITN/SIR collateral grading				<0.001
Poor collateral (0-1)	267 (44.8)	89 (30.3)	178 (58.9)	
Good collateral (2-4)	329 (55.2)	205 (69.7)	124 (41.1)	
Stroke etiology, n (%)				0.24
Large-artery atherosclerosis	304 (51.0)	158 (53.7)	146 (48.3)	
Cardioembolic	255 (42.9)	116 (39.5)	139 (46.0)	
Others	37 (6.2)	20 (6.8)	17 (5.6)	

Treatments				
IVT, n (%)	212 (35.6)	110 (37.4)	102 (33.8)	0.35
General anesthesia, n (%)	223 (37.4)	77 (26.2)	146 (48.3)	<0.001
Onset to groin puncture, min, median (IQR)	340 (250-485)	325 (238-485)	355 (265-485)	0.18
Onset to recanalization, min, median (IQR)	459 (330-599)	426 (309-579)	480 (367-625)	0.004
mTICI 3, n (%)	410 (68.8)	211 (71.8)	199 (65.9)	0.12
Anti-hypertensive, n (%)	322 (54.0)	140 (47.6)	182 (60.3)	0.008
Blood pressure parameters within 24 hours after procedure (mmHg, mean ± SD)				
Mean SBP	124.6±14.4	122.7±14.4	126.4±14.2	0.002
Maximum SBP	143.6±18.8	141.0±18.4	146.2±18.6	0.002
Minimum SBP	108.2±14.0	107.1±14.0	109.4±13.9	0.04
SBP SD	10.9±4.6	10.4±4.4	11.3±4.7	0.01
SBP CV	8.9±3.5	8.7±3.5	9.1±3.5	0.09
Categorized mean SBP, n (%)				0.02
≤120mmHg	229 (38.4)	126 (42.8)	103 (34.1)	
121-140mmHg	282 (47.3)	136 (46.3)	146 (48.3)	
>140mmHg	85 (14.3)	32 (10.9)	53 (17.6)	
SBP CV in tertiles *, n (%)				0.07
Lowest tertile	197 (33.3)	110 (37.5)	87 (29.2)	
Intermediate tertile	197 (33.3)	95 (32.4)	102 (34.2)	
Highest tertile	197 (33.3)	88 (30.0)	109 (36.6)	

mRS indicates modified Rankin Scale; SD, standard deviation; NIHSS, National Institutes of Health Stroke Scale; ASPECTS, Alberta Stroke Program Early CT Score; IQR, interquartile range; ICA, Internal carotid; MCA, middle cerebral artery; ASITN/SIR, American Society of Interventional and Therapeutic Neuroradiology/Society of Interventional Radiology; IVT, intravenous thrombolysis; mTICI, modified Thrombolysis in Cerebral Ischemia; SBP, systolic blood pressure; CV, coefficient of variation.

*: 5 patients were not enrolled in SBP SD analysis due to measurement numbers ≤10, 1 in mRS 0-2 and 4 in mRS 3-6 group; Lowest SBP CV tertile: ≤ 6.94mmHg; Intermediate SBP CV tertile: 6.95-9.90mmHg; Highest SBP SD tertile: ≥9.90mmHg.

Table S3. Baseline demographics according to collateral status and mean SBP categories.

Characteristics	Good collateral (n=329)				Poor collateral (n=267)			
	≤120mmHg (n=127)	121-140mmHg (n=164)	>140mmHg (n=38)	P value	≤120mmHg (n=102)	121-140mmHg (n=118)	>140mmHg (n=47)	P value
Age, y, mean ± SD	64.9±13.9	65.8±13.0	65.8±9.9	0.86	66.6±11.0	67.2±12.5	67.2±10.7	0.92
Male, n (%)	70 (55.1)	97 (59.2)	30 (79.0)	0.03	53 (52.0)	77 (65.3)	30 (63.8)	0.13
Risk factors, n (%)								
Hypertension	54 (42.5)	91 (55.5)	30 (79.0)	<0.001	41 (40.2)	61 (51.7)	37 (78.7)	<0.001
Diabetes mellitus	22 (17.3)	26 (15.9)	10 (26.3)	0.31	20 (19.6)	29 (24.6)	18 (38.3)	0.05
Prior stroke	19 (15.0)	29 (17.7)	10 (26.3)	0.29	15 (14.7)	17 (14.4)	14 (29.8)	0.04
Coronary heart disease	23 (18.1)	33 (20.1)	3 (7.9)	0.21	24 (23.5)	17 (14.4)	11 (23.4)	0.18
Atrial fibrillation	29 (22.8)	34 (20.7)	5 (13.2)	0.43	24 (23.5)	32 (27.1)	14 (29.8)	0.69
Smoking	36 (28.3)	52 (31.7)	13 (34.2)	0.78	25 (24.5)	43 (36.4)	16 (34.0)	0.15
Baseline NIHSS, median (IQR)	16 (10-20)	14 (11-18)	14 (11-18)	0.32	15 (12-21)	16 (13-19)	15 (12-18)	0.52
Location of occlusion, n (%)								
ICA	42 (33.1)	34 (20.7)	8 (21.1)	0.05	37 (36.3)	36 (30.5)	15 (31.9)	0.65
MCA-M1	63 (49.6)	68 (41.5)	15 (39.5)	0.31	51 (50.0)	56 (47.5)	21 (44.7)	0.83

IVT n (%)	42 (33.1)	68 (41.5)	16 (42.1)	0.30	37 (36.3)	34 (28.8)	15 (31.9)	0.50
Stroke etiology, n (%)				<0.001				0.09
Large-artery atherosclerosis	51 (40.2)	84 (51.2)	32 (84.2)		41 (40.2)	67 (56.8)	29 (61.7)	
Cardioembolic	63 (49.6)	69 (42.1)	6 (15.8)		54 (52.9)	46 (39.0)	17 (36.2)	
Others	13 (10.2)	11 (6.7)	0 (0)		7 (6.9)	5 (4.2)	1 (2.1)	
Procedural variables, n (%) or median (IQR)								
Conscious sedation	94 (74.0)	99 (60.4)	21 (55.3)	0.02	75 (73.5)	65 (55.1)	19 (40.4)	<0.001
Onset to groin puncture, min	390 (280-536)	310 (243-434)	366 (260-535)	0.005	322 (225-515)	342 (260-450)	365 (301-501)	0.36
Onset to recanalization, min	504 (355-637)	419 (314-532)	474 (384-704)	0.005	439 (309-630)	465 (329-599)	474 (410-599)	0.40
mTICI 3	90 (70.9)	113 (68.9)	24 (63.2)	0.67	71 (69.6)	84 (71.2)	28 (59.6)	0.33
Blood pressure variables, mmHg, mean ± SD								
Mean SBP	110.4±7.9	128.8±5.0	149.1±8.9	<0.001	111.2±6.3	128.2±5.2	148.9±7.6	<0.001
Maximum SBP	127.6±13.5	147.7±11.0	166.7±14.8	<0.001	128.9±10.6	148.9±12.3	172.7±13.9	<0.001
Minimum SBP	96.4±7.7	112.2±7.7	132.9±11.8	<0.001	97.0±6.6	109.9±8.9	126.8±12.9	<0.001
SBP SD	9.9±4.3	11.0±4.4	10.8±4.4	0.03	9.6±3.2	11.7±4.9	14.3±5.3	<0.001
SBP CV	8.92±3.81	8.50±3.43	7.19±2.81	0.03	8.68±2.91	9.09±3.81	9.63±3.53	0.19
mRS 3-6 at 90-d, n (%)	45 (35.4)	64 (39.0)	15 (39.5)	0.35	58 (56.9)	82 (69.5)	38 (80.9)	0.02

SBP indicates systolic blood pressure; SD, standard deviation; NIHSS, National Institutes of Health Stroke Scale; IQR, interquartile range; ICA, Internal carotid; MCA, middle cerebral artery; IVT, intravenous thrombolysis; mTICI, modified Thrombolysis in Cerebral Ischemia; CV, coefficient of variation; mRS, modified Rankin Scale.

Table S4. Primary and secondary outcomes associated with tertiles of SBP SD by collateral status.

	SBP SD			Intermediate vs lowest tertile		Highest vs lowest tertile		Test for interaction
	Lowest tertile	Intermediate tertile	Highest tertile	aOR (95% CI)	P value	aOR (95% CI)	P value	
mRS 3-6 at 90-d *								0.25
Total	85/197 (43.2)	99/197 (50.3)	114/197 (57.9)	1.24 (0.80-1.92)	0.34	1.57 (1.00-2.45)	0.04	
Good collateral	40/117 (34.2)	45/113 (39.8)	36/95 (37.9)	1.31 (0.72-2.37)	0.38	1.08 (0.58-1.87)	0.79	
Poor collateral	45/80 (56.3)	54/84 (64.3)	78/102 (76.5)	1.30 (0.63-2.66)	0.47	2.41 (1.17-4.99)	0.01	
sICH †								0.31
Total	8/197 (4.1)	13/197 (6.6)	13/197 (6.6)	1.48 (0.58-3.79)	0.41	1.57 (0.59-4.15)	0.36	
Good collateral	4/117 (3.4)	6/113 (5.3)	2/95 (2.1)	1.45 (0.38-5.48)	0.59	0.53 (0.09-3.18)	0.49	
Poor collateral	4/80 (5.0)	7/84 (8.3)	11/102 (10.8)	1.60 (0.42-6.14)	0.49	2.70 (0.73-9.85)	0.14	
Mortality ‡								0.25
Total	16/197 (8.1)	25/197 (12.7)	38/197 (19.3)	1.36 (0.69-2.67)	0.36	1.83 (0.97-3.44)	0.06	
Good collateral	11/117 (9.4)	15/113 (13.3)	12/95 (12.6)	1.30 (0.55-3.09)	0.55	1.19 (0.48-2.84)	0.73	
Poor collateral	5/80 (6.3)	10/84 (11.9)	26/102 (25.5)	1.47 (0.50-4.33)	0.49	2.84 (1.05-7.68)	0.04	

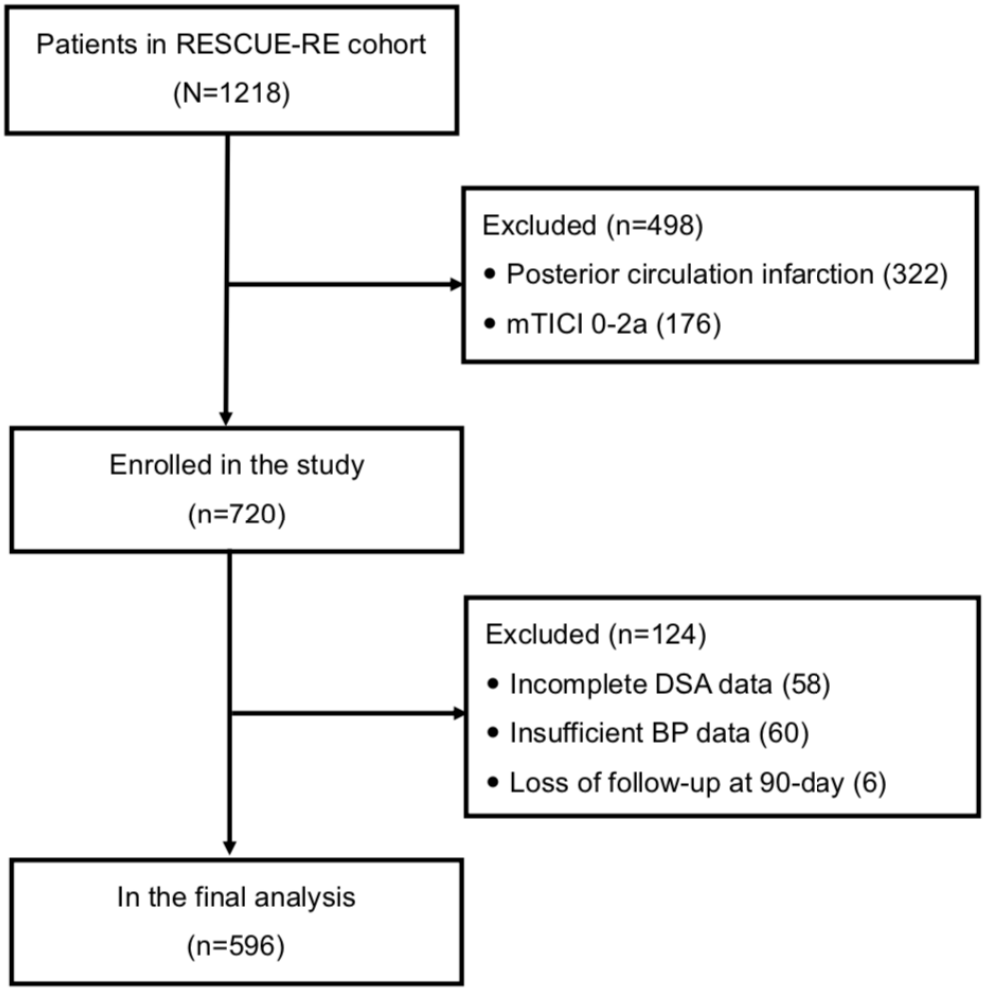
SBP indicates systolic blood pressure; SD, standard deviation; aOR, adjusted odds ratio; CI, confidence interval; mRS, modified Rankin Scale; sICH, symptomatic intracerebral hemorrhage; NIHSS, National Institutes of Health Stroke Scale; mTICI, modified Thrombolysis in Cerebral Ischemia.

*: Adjusted for age, history of diabetes mellitus, prior stroke, atrial fibrillation, smoking, baseline NIHSS, occlusion site, onset-to-recanalization time, antihypertensive therapy and collateral status in total cohort analysis; and adjusted for all confounders mentioned in total except for collateral status in good and poor collateral cohort analysis

†: Adjusted for age, history of atrial fibrillation, baseline NIHSS, occlusion site, mTICI scale, antihypertensive therapy and collateral status in total cohort analysis, and adjusted for all confounders mentioned in total expect for collateral status in good and poor collateral cohort analysis

‡: Adjusted for age, history of atrial fibrillation, prior stroke; coronary heart disease, baseline NIHSS, occlusion site, onset-to-recanalization time, antihypertensive therapy and collateral status in total cohort analysis, and adjusted for all confounders mentioned in total expect for collateral status in good and poor collateral cohort analysis

Figure S1. Flowchart of the study.



RESCUE-RE, A registration study for Critical Care of Acute Ischemic Stroke after Recanalization cohort; mTICI, modified Thrombolysis in Cerebral Ischemia; DSA, digital subtraction angiograph; BP, blood pressure.