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Increased blood pressure variability during general anaesthesia is associated with worse outcomes after mechanical thrombectomy: a prospective observational cohort study

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ABSTRACT

Objectives Optimal periprocedural blood pressure (BP) management during mechanical thrombectomy (MT) for acute ischaemic stroke is still controversial. The aim of this study was to investigate the association between intraprocedural BP variability (BPV) and outcomes in patients with large vessel occlusion (LVO) following MT with general anaesthesia.

Design A prospective observational cohort study.

Setting This study was conducted in a single tertiary hospital of Hangzhou in Zhejiang province.

Participants A total of 141 patients with LVO treated with MT were finally included between January 2018 and September 2020.

Main outcome measures Intraprocedural BP was recorded every 5 min throughout the procedure. BPV was measured as SD, coefficient of variation (CV), max-min (RANGE) and successive variation. Haemorrhagic transformation was assessed on 24-hour CT images according to European Cooperative Acute Stroke Study III trial. Poor functional outcome was defined as 90-day modified Rankin Scale score 3–6. Binary logistic regression analysis was used to investigate the association of BPV parameters with the incidence of parenchymal haemorrhage (PH) and poor functional outcome.

Results After controlling for age, female, history of smoking, hypertension and atrial fibrillation, baseline National Institutes of Health Stroke Scale, baseline systolic BP (SBP), baseline Alberta Stroke Program Early CT Score, bridging thrombolysis and times of retrieval attempts, the results demonstrated that intraprocedural SBP_{RANGE} (OR 1.029; 95% CI 1.003 to 1.055; p=0.027), SBP_{SD} (OR 1.135; 95% CI 1.023 to 1.259; p=0.017) and SBP_{CV} (OR 1.189; 95% CI 1.053 to 1.342; p=0.005) were independently associated with poor functional outcome. However, the independent association between intraprocedural BPV and PH at 24 hours has not been established in this study.

Conclusions Increased intraprocedural BPV was more likely to have poor functional outcome in patients with LVO following MT with general anaesthesia. This finding indicates that special precautions should be taken to minimise BP fluctuation during procedure.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ Using a definite protocol, a prospective collection of data and an adequate number of patients assuring statistically powered data.
⇒ The result further expanded the understanding of the association of intraprocedural blood pressure variability with outcomes in patients with large vessel occlusion following mechanical thrombectomy under general anaesthesia.
⇒ The data collection as part of clinical routine leads to the possibility of loss of data in the course of the study.
⇒ This study is limited due to the single-centre data collection.

INTRODUCTION

Mechanical thrombectomy (MT) has been the first-line treatment for patients who had an acute ischaemic stroke (AIS) caused by anterior-circulation large vessel occlusion (LVO).[1] Nevertheless, despite the high success rates, nearly half of patients still failed to achieve functional independence at 3 months.[2–4] Of the prognostic factors, periprocedural blood pressure (BP) management may be a readily modifiable parameter that could be intervened to improve outcomes.[5–7] Unfortunately, the optimal periprocedural BP management for patients with LVO receiving MT still remains uncertain.

Previous observational studies indicated that either extreme lows or highs in BP during periprocedural period are associated with worse outcomes.[8 9] Goyal *et al* found that high maximum systolic BP (SBP) levels following MT are independently associated with poor functional outcome in patients with LVO.[6] Recently, several studies have shown that a drop in BP during MT under

general anaesthesia is related with worse outcome.[10–12] It is suggested that BP fluctuation during MT, reflected by BP variability (BPV), might serve as a surrogate marker of worse outcome. However, most of the previous studies tended to focus on the relationship between postoperative BPV and outcomes. From a pathophysiological point of view, intraprocedural BPV was mostly assessed during MT and before recanalisation occurs, period in which BPV might have a substantial impact on penumbra survival.[13] It is conceivable that, at different stages, the optimal BP management might present slightly different. Furthermore, the optimal BP threshold in the AIS setting may vary greatly, depending on the patient's conditions, such as hypertension, diabetes mellitus, cardiac function, arterial stiffness and infarct volume and so on. In this perspective, BPV might provide better insight into BP physiological consequences of a given patient and assist with periprocedural BP management.

In view of these considerations, we thus aimed to investigate the relationship between intraprocedural BPV assessed by the mean of RANGE (maximum–minimum), SD, coefficient of variation (CV) and successive variation (SV) and outcomes in patients with LVO undergoing MT and hypothesised that patients with increased BPV were more likely to have worse outcomes.

MATERIALS AND METHODS

Study subjects

Data from consecutive patients who had an AIS with LVO who received MT at our comprehensive stroke centre were prospectively collected as previously described.[14] In the current study, we enrolled patients with anterior-circulation LVO who underwent MT between January 2018 and September 2020. Patients with postprocedural Thrombolysis in Cerebral Infarction (TICI) Scores of 0–2a were also excluded due to the differences in clinical outcomes and BP control between patients with and without recanalisation.

At our centre, the protocol-based practice is to perform MT for patients with CT angiography (CTA)-confirmed LVOs presenting within 6 hours of symptom onset. For the patients presenting 6–16 hours from symptom onset, selection criteria are used according to the DEFUSE-3 trial (Diffusion and Perfusion Imaging Evaluation for Understanding Stroke Evolution).[15] Patients presenting 6–24 hours after symptom onset were included if they met the related criteria described in the DAWN trial (Clinical Mismatch in the Triage of Wake Up and Late Presenting Strokes Undergoing Neurointervention With Trevo).[16] Degree of recanalisation measured by the TICI Score[17] was defined at the end of the procedure. Successful recanalisation was defined as a TICI Score of 2b or 3.[18] Non-contrast CT was routinely performed at 24 hours after MT to evaluate haemorrhage transformation. Patients were enrolled if they had (1) occlusion of internal carotid artery or the M1 or M2 segments of the middle cerebral artery, (2) received MT under general anaesthesia, (3) achieved successful recanalisation after MT, (4) had a follow-up CT scan at 24 hours, (5) had modified Rankin Scale (mRS) score at 90 days.

Clinical data collection

All baseline clinical data were prospectively collected, including demographics (age, sex), baseline National Institutes of Health Stroke Scale (NIHSS) score, baseline Alberta Stroke Program Early CT Score (ASPECTS), baseline SBP and diastolic BP (DBP) levels, pretreatment with intravenous thrombolysis and risk factors such as history of smoking, hypertension, diabetes mellitus, atrial fibrillation and congestive heart failure. Time from onset to recanalisation, general anaesthesia duration; times of retrieval attempts were also recorded.

Anaesthesia protocol and BPV assessment

The anaesthesia protocol at our centre was described in our previously published study.[14] Because general anaesthesia has a more significant inhibitory effect on the circulatory system than conscious sedation,[19 20] and MT under general anaesthesia is a standard procedure at our centre, we excluded patients with conscious sedation in order to reduce study heterogeneity. All BP data from the anaesthesiology reports were prospectively collected during MT in all patients. And continuous arterial BP values were automatically recorded by invasive BP monitoring using an arterial catheter every 5 min throughout the procedure. The observation index in this study was different from that in our previous study as well. In our previous work, we assessed hypotension time, a relatively steady parameter, by calculating the cumulated time of BP drop during MT under different thresholds as described.[14] In the present study, we assessed dynamic BP parameters during MT, which was endowed by BPV and assessed by the mean of RANGE (maximum–minimum), SD, CV and SV, respectively. The maximum (max), minimum (min) and average (mean) of intraprocedural BP values were also calculated, respectively. BPV was represented by four separate measurements: (1) RANGE (maximum–minimum), (2) SD: $\sqrt{\frac{1}{n-1}\sum_{i=1}^{n}\left(\mathrm{BP_i}-\mathrm{BP_{mean}}\right)^2}$, (3) CV: $\left(\frac{\mathrm{SD}}{\mathrm{BP_{mean}}}\right)*100$, (4) SV. SV is calculated as the square root of the average squared difference between two successive BP measurements: $\sqrt{\frac{1}{n-1}\sum_{i=1}^{n-1}\left(\mathrm{BP_{i+1}}-\mathrm{BP_i}\right)^2}$.

Evaluation of outcomes

Haemorrhagic transformation (HT) was identified on 24-hour CT images according to European Cooperative Acute Stroke Study III trial: haemorrhagic infarction and parenchymal haemorrhage (PH). Haematoma within infarcted tissue, occupying <30%, no substansive mass effect was defined as PH-1 and haematoma occupying >30% or more of the infarcted tissue, with obvious mass effect was defined as PH-2.[21] At 90 days, good outcome was defined as mRS score 0–2, and poor outcome was defined as mRS score 3–6.

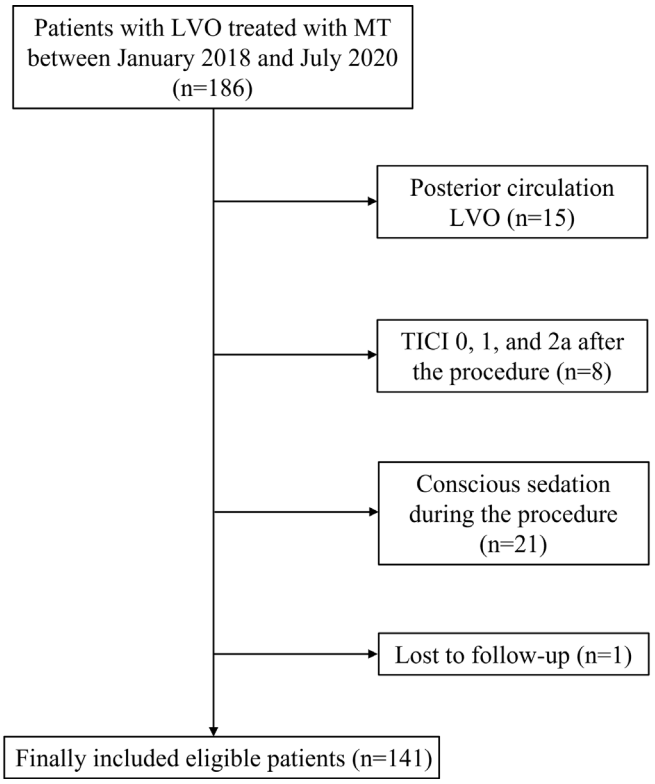

Figure 1 Patients flow chart. LVO, large vessel occlusion; MT, mechanical thrombectomy; TICI, Thrombolysis in Cerebral Infarction.

Statistical analysis

The patients were dichotomised according to PH and functional outcome. Clinical characteristic and imaging profiles were summarised as mean±SD or median (25th–75th percentile) for quantitative variables depending on the normality of the distribution and as frequency (%) for categorical variables. Fisher's exact test was used to compare the dichotomous variables between two groups, whereas an independent sample two-tailed t-test or a Mann-Whitney U test was used for the continuous variables, depending on the normality of the distribution. Associations of each BPV parameters with PH and poor functional outcome were determined using binary logistic regression models adjusted by baseline characteristics with a p value of <0.1 in univariate analyses, respectively. The receiver operating characteristics (ROC) analysis derived optimal cut-off was determined at the maximal Youden's Index. All statistical analyses were performed using SPSS, V.22.0 (IBM, Armonk, New York, USA). A p value <0.05 was considered statistically significance.

RESULTS

As shown in figure 1, a total of 141 patients with anterior-circulation occlusion were included in the final analysis. In total, 45 patients were excluded from the analysis for the following reasons: posteriorcirculation stroke (n=15), conscious sedation (n=21), TICI 0–2a after the procedure (n=8) and lost to follow-up (n=1). Of the included patients, the mean age was 68.1±12.3 years, and 47 (33.3%) were women. The median NIHSS score on admission was 19 (IQR, 14–24), mean time from onset to groin puncture was 382.4±183.2 min, mean time from onset to recanalisation was 462.9±198.8 min and mean procedure duration was 123.5±55.0 min. The median times of retrieval attempts during procedure was 2 (IQR, 1–3). Among them, 34 (24.1%) patients had PH at 24 hours; 81 (57.4%) patients had a poor outcome (mRS score 3–6) at 90 days.

Associations of BP parameters and outcomes

As shown in table 1, patients with PH were had a higher proportion of atrial fibrillation (70.6% vs 44.9%, p=0.008), higher baseline NIHSS score (22 vs 17, p=0.001), lower baseline ASPECTS (8 vs 9, p=0.001) and underwent more retrieval attempts (2 vs 1, p=0.011), compared with those without PH. Moreover, intraprocedural SBP_{RANGE} (57.2 vs 49.2 mm Hg, p=0.046) was higher in patients with PH. After controlling for age, history of atrial fibrillation, congestive heart failure, baseline NIHSS, baseline ASPECTS and times of retrieval attempts, the results indicated that SBP_{RANGE} (OR 1.008; 95% CI 0.986 to 1.031; p=0.489) was not independently associated with PH (table 2).

The associations of each BP parameter with PH were determined using binary logistic regression models adjusted for age, history of atrial fibrillation, congestive heart failure, baseline NIHSS, baseline ASPECTS and times of retrieval attempts. The associations of each BP parameter with poor functional outcome were determined using binary logistic regression models adjusted for age, female, history of smoking, hypertension and atrial fibrillation, baseline NIHSS, baseline SBP, baseline ASPECTS, bridging thrombolysis and times of retrieval attempts.

Patients with poor outcome were older (70.7 vs 64.1 years, p=0.002), had a higher proportion of women (39.5% vs 25.0%, p=0.039), hypertension (76.5% vs 58.3%, p=0.040) and atrial fibrillation (61.7% vs 36.7%, p=0.009), a lower proportion of smoking (16.0% vs 28.3%, p=0.032) and bridging thrombolysis (18.5% vs 36.7%, p=0.014), higher baseline NIHSS score (21 vs 16, p<0.001) and baseline SBP (157.8 vs 144.3 mm Hg, p<0.001), lower baseline ASPECTS (8 vs 10, p<0.001) and underwent more retrieval attempts (2 vs 1, p=0.006) than those with good outcome. In addition, intraprocedural SBP_{RANGE} (57.0 vs 42.2 mm Hg, p<0.001), SBP_{SD} (14.8 vs 11.3 mm Hg, p=0.009), SBP_{CV} (12.1 vs 9.0 mm Hg, p<0.001) were higher, SBP_{min} was lower (100.2 vs 111.4 mm Hg, p<0.001) in patients with poor outcome. Binary logistic regression indicated that intraprocedural SBP_{RANGE} (OR 1.029; 95% CI 1.003 to 1.055; p=0.027), SBP_{SD} (OR 1.135; 95% CI 1.023 to 1.259; p=0.017), SBP_{CV} (OR 1.189; 95% CI 1.053 to 1.342; p=0.005) and SBP_{min} (OR 0.949; 95% CI 0.920 to 0.979; p=0.001) were independently associated with poor outcome after adjusting for age, female, history of smoking, hypertension and

Table 1 Comparison of characteristics between patients with different outcomes

	PH			mRS>2		
	Yes (n=34)	No (n=107)	P value	Yes (n=81)	No (n=60)	P value
Age (years), mean±SD	67.1±12.4	71.2±11.3	0.095	70.7±11.5	64.1±12.4	0.002*
Female, n (%)	14 (41.2)	33 (30.8)	0.265	32 (39.5)	15 (25.0)	0.039*
Comorbid conditions						
Smoking, n (%)	5 (14.7)	25 (23.4)	0.343	13 (16.0)	17 (28.3)	0.032*
Hypertension, n (%)	20 (58.8)	77 (72.0)	0.150	62 (76.5)	35 (58.3)	0.040*
Diabetes mellitus, n (%)	6 (17.6)	22 (20.6)	0.711	14 (17.2)	14 (23.3)	0.214
Atrial fibrillation, n (%)	24 (70.6)	48 (44.9)	0.008*	50 (61.7)	22 (36.7)	0.009*
Congestive heart failure, n (%)	16 (47.1)	33 (30.8)	0.084	30 (37.0)	19 (31.7)	0.374
Clinical variables						
Baseline NIHSS, median (IQR)	22 (18–27)	17 (13–23)	0.001*	21 (17–26)	16 (12–19)	<0.001*
Baseline SBP (mm Hg), mean±SD	150.7±16.7	152.9±24.0	0.623	157.8±21.4	144.3±21.7	<0.001*
Baseline DBP (mm Hg), mean±SD	88.7±15.7	88.5±15.2	0.926	89.2±16.6	87.5±12.2	0.137
Baseline ASPECTS, median (IQR)	8 (7–9)	9 (8–10)	0.001*	8 (7–10)	10 (9–10)	<0.001*
Bridging thrombolysis, n (%)	8 (23.5)	29 (27.1)	0.680	15 (18.5)	21 (36.7)	0.014*
Intraprocedural management						
Onset to reperfusion time (min), mean±SD	478.6±167.8	457.8±208.1	0.597	474.0±197.2	446.0±201.8	0.415
Onset to groin puncture time (min), mean±SD	383.8±145.3	381.9±194.2	0.951	386.3±177.1	376.3±193.5	0.753
Procedure duration (min), mean±SD	134.1±56.1	120.1±54.4	0.197	129.6±57.2	114.3±50.5	0.105
Times of retrieval attempts, median (IQR)	2 (1–4)	1 (1–3)	0.011*	2 (1–3)	1 (1–2)	0.006*
Vasopressor use, n (%)	19 (55.9)	55 (51.4)	0.649	42 (51.8)	33 (53.3)	0.834
BP parameters during the procedure (mm Hg), mean±SD						
SBP_{mean}	123.9±13.4	125.2±17.3	0.678	124.1±15.7	126.1±22.5	0.489
SBP_{max}	158.3±18.9	155.2±22.5	0.470	157.3±21.1	154.0±22.5	0.378
SBP_{min}	100.8±14.2	105.9±17.8	0.131	100.2±14.9	111.4±17.9	<0.001*
SBP_{RANGE}	57.2±19.7	49.2±20.5	0.046*	57.0±20.3	42.2±17.5	<0.001*
SBP_{SD}	14.1±4.3	13.2±5.3	0.345	14.8±5.1	11.3±4.2	0.009*
SBP_{SV}	11.3±3.3	11.4±5.0	0.931	11.6±4.9	10.9±4.2	0.410
SBP_{CV}	11.5±3.7	10.6±4.3	0.260	12.1±4.2	9.0±3.4	<0.001*
DBP_{mean}	70.0±11.7	70.0±9.3	0.997	69.6±9.2	70.7±10.9	0.506
DBP_{max}	89.8±14.0	89.7±12.8	0.953	90.4±12.9	88.7±13.3	0.456
DBP_{min}	55.4±10.3	57.3±9.9	0.339	56.6±9.0	57.3±11.5	0.686
DBP_{RANGE}	34.4±13.2	32.3±12.9	0.431	33.8±12.8	31.4±13.1	0.286
DBP_{SD}	8.6±2.5	8.2±3.1	0.422	8.4±2.9	8.0±3.0	0.375
DBP_{SV}	8.2±3.2	7.6±3.6	0.399	7.7±3.4	7.7±3.6	0.953
DBP_{CV}	12.7±4.2	11.8±4.6	0.342	12.3±4.2	11.7±4.8	0.429

*P value indicates statistical significance.
ASPECTS, Alberta Stroke Program Early CT Score; BP, blood pressure; CV, coefficient of variation; DBP, diastolic blood pressure; mRS, modified Rankin Scale score; NIHSS, National Institutes of Health Stroke Scale; PH, parenchymal haemorrhage; SBP, systolic blood pressure; SV, successive variation.

atrial fibrillation, baseline NIHSS, baseline SBP, baseline ASPECTS, bridging thrombolysis and times of retrieval attempts (table 2). Associations of intraprocedural BPV parameters with poor outcome are shown in figure 2.

The ROC curves of SBP_{RANGE}, SBP_{SD} and SBP_{CV} in predicting poor functional outcome are shown in figure 3, and the areas under the curve (AUCs) were 0.713, 0.697 and 0.712, respectively. The optimal cut-offs in predicting

Table 2 Binary logistic regression analysis for the occurrence of parenchymal haemorrhage and poor functional outcome

	PH			mRS>2		
	OR	95% CI	P value	OR	95% CI	P value
SBP_{mean}	1.000	0.971 to 1.029	0982	0.983	0.954 to 1.013	0.267
SBP_{max}	1.007	0.986 to 1.029	0.509	0.992	0.968 to 1.016	0.504
SBP_{min}	0.999	0.971 to 1.027	0.919	**0.949**	**0.920 to 0.979**	**0.001**
SBP_{RANGE}	1.008	0.986 to 1.031	0.489	**1.029**	**1.003 to 1.055**	**0.027**
SBP_{SD}	1.007	0.920 to 1.103	0.881	**1.135**	**1.023 to 1.259**	**0.017**
SBP_{SV}	0.998	0.911 to 1.094	0.969	1.024	0.929 to 1.129	0.631
SBP_{CV}	1.036	0.932 to 1.151	0.512	**1.189**	**1.053 to 1.342**	**0.005**
DBP_{mean}	1.005	0.958 to 1.054	0.843	0.991	0.945 to 1.038	0.693
DBP_{max}	0.991	0.958 to 1.026	0.616	1.001	0.968 to 1.036	0.934
DBP_{min}	0.986	0.941 to 1.033	0.550	0.991	0.945 to 1.039	0.708
DBP_{RANGE}	0.999	0.965 to 1.034	0.957	1.006	0.972 to 1.042	0.720
DBP_{SD}	1.026	0.883 to 1.193	0.737	1.024	0.886 to 1.184	0.744
DBP_{SV}	1.039	0.920 to 1.174	0.534	1.012	0.897 to 1.140	0.854
DBP_{CV}	1.032	0.933 to 1.140	0.543	1.011	0.920 to 1.111	0.820

Bold type indicates statistical significance.
CV, coefficient of variation; DBP, diastolic blood pressure; mRS, modified Rankin Scale score; PH, parenchymal haemorrhage; SBP, systolic blood pressure; SV, successive variation.

poor functional outcome were 52.5, 16 and 11.4 mm Hg for SBP_{RANGE}, SBP_{SD} and SBP_{CV}. The diagnostic parameters including AUCs, sensitivity, specificity at the maximal Youden's Index of SBP_{RANGE}, SBP_{SD}, SBP_{CV} and SBP_{min} are shown in table 3.

Patient and public involvement

Patient and public involvement in the development of the research question, in outcome measures and in the design of this study could not be planned. Results will be disseminated through patient's association.

DISCUSSION

In the present study, we found that patients with LVO following MT with general anaesthesia with increased intraprocedural BPV, assessed by $SBP_{RANGE,}$ SBP_{SD} and SBP_{CV}, were more likely to have poor functional outcome. However, our results failed to demonstrate a consistent association between intraprocedural BPV and PH at 24 hours.

Currently, a growing body of evidence has supported that BP is a critical prognosis factor in patients who had an AIS.[13 22] BPV, reflecting the extent of BP fluctuations, has been regarded as a novel risk factor for worse outcome, brain oedema and HT after stroke.[23–26] Previous studies suggested that increased BPV was associated with worse outcome in patients who had an AIS treated with recombinant tissue plasminogen activator (rt-PA).[23 26–28] Moreover, the finding that increased postprocedural BPV was associated with worse outcome has also been reported in studies of patients treated with MT.[29 30] Recently, Pikija *et al* found that higher in-procedure SBP/MAP (mean artery pressure) was associated with a better 3-month functional outcome in patients with anterior-circulation

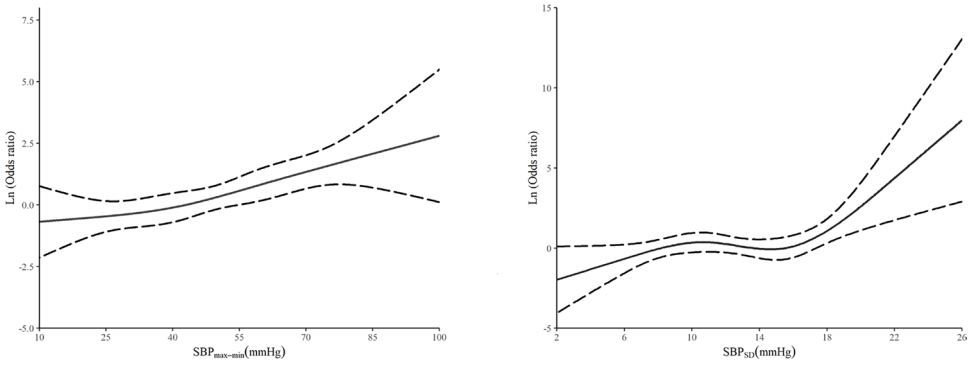

Figure 2 Spline plots of different parameters of intraprocedural BP variability, measured as SBP_{RANGE}/SBP_{SD}, and adjusted OR. The area between the two dashed lines indicates the 95% CI. BP, blood pressure; SBP, systolic BP.

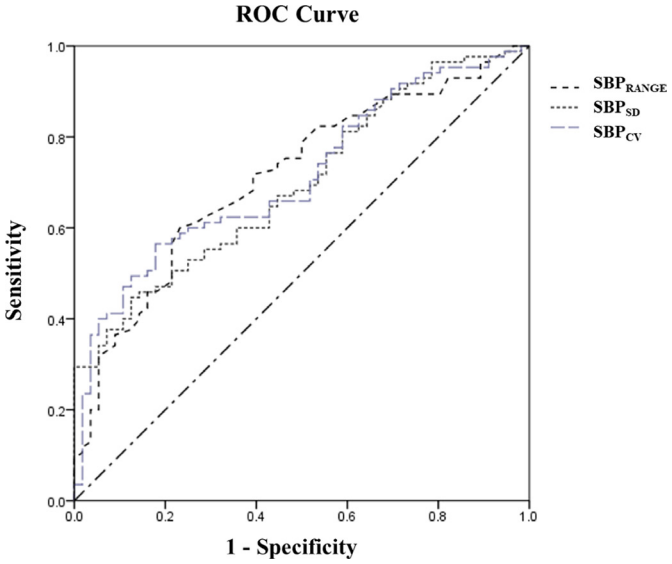

Figure 3 ROC curves of intraprocedural SBP_{RANGE} and SBP_{SD} to predict poor functional outcome. ROC, receiver operating characteristics; SBP, systolic blood pressure.

stroke treated with MT.[31] In the current study, we found that increased intraprocedural BPV, as measured by SBP_{RANGE}, SBP_{SD} and SBP_{CV} was also related to worse outcome at 90 days. Our study differs significantly from previous studies in that we focused on intraprocedural BPV as our observation index. Given that the large vessel is occluded most of the time during the procedure. The BP fluctuations caused by general anaesthesia in the setting of LVO might have a negatively impact on the survival of ischaemic brain tissue, resulting worse outcome. Our result provided further insight into the association of BPV with outcomes in patients with LVO following MT. Interestingly, we found that intraprocedural SBP_{SV} was not evidently associated with worse functional outcome, which was inconsistent with previous study. The SV refers to the square root of the average of squared difference between successive values, implying how the observed value fluctuated in a sequential manner.[32] Therefore, compared with other BPV parameters, such as SD and CV, the SV may better reflect BP changes in a successive order. The BP values were recorded every 5 min during the procedure in the study. A high frequency of intraprocedural BP monitoring could result in a relatively small difference between two consecutively recorded BP values due to the frequent intraprocedural monitoring.

To data, the pathophysiology between intraprocedural BPV and outcome of patients who had an AIS following MT has not yet been fully elucidated, but a commonly accepted hypothesis holds that cerebral autoregulation is impaired in patients with LVO, increased BPV may lead to instability of cerebral perfusion due to the impairment in cerebral autoregulation. Accordingly, BP fluctuation may directly worsen the extent of injury to the ischaemic penumbra, leading to the growth of the infarct core, and hence worse functional outcome.[27 28] Another possible explanation might be that higher BPV may contribute to a greater disruption of blood brain barrier (BBB) and lead to exacerbation of reperfusion injury.[13] Previous research suggested that higher BPV might increase the permeability of the BBB and the risk of haemorrhage transformation.[33] Kim *et al* found that increased BPV during the first 24 hours following successful recanalisation was correlated with symptomatic intracerebral haemorrhage in patients with LVO treated with MT.[34] Contrary to the previous study, the independent association between intraprocedural BPV and PH after 24 hours has not been established in this study. The differences in the definition of HT, population cohorts and BPV parameters may partially explain such discrepancy. Another explanation might be that, in patients with LVO and subsequent successful recanalisation after MT, successfully reperfused brain tissue was at high risk of HT due to the direct exposure of the vulnerable oligemic brain tissue to postprocedural BP fluctuations,[35 36] whereas during the procedure the large vessel was occluded most of time, making fluctuations in BP more detrimental to the ischaemic penumbra.

Notably, our study also found that patients with a lower intraprocedural SBP_{min} were prone to have poor functional outcome. BP elevation is a common phenomenon in patients who had an AIS, especially in patients with LVO. Theoretically, this phenomenon may act as a compensatory reaction of the organism to persistent vessel occlusion in the AIS phase, in order to maintain cerebral blood flow in the ischaemic penumbra and to minimise the ischaemic damage.[28 37] Consequently, there is concern that BP lowering may compromise the pressure-dependent cerebral perfusion in the ischaemic penumbra and exacerbate brain injury.[38] These findings emphasise that caution must be applied before aggressively lowering elevated BP as intraprocedural drops in BP are likely predisposed to poor functional outcome. In

Table 3 Predictive value of BP parameters for poor functional outcome

	AUC	95% CI	P value	Cut-off value	Sensitivity	Specificity
SBP_{RANGE}	0.713	0.628 to 0.798	<0.001	52.5 mm Hg	0.600	0.768
SBP_{SD}	0.697	0.611 to 0.782	<0.001	16 mm Hg	0.447	0.875
SBP_{CV}	0.712	0.628 to 0.797	<0.001	11.4 mm Hg	0.565	0.821
SBP_{min}	0.301	0.211 to 0.391	<0.001	101.5 mm Hg	0.388	0.232

AUC, area under the curve; BP, blood pressure; CV, coefficient of variation; SBP, systolic blood pressure.

addition, in this study, patients with LVO seems to benefit from controlling intraprocedural SBP extreme lowing above approximately 100 mm Hg during the procedure.

Interestingly, we found that there was no statistically significance of onset to groin puncture time between poor outcome and good outcome group (386.3 vs 376.3 mm Hg, p=0.753). Similarly, no significant difference was also found between PH and non-PH groups (383.8 vs 381.9 mm Hg, p=0.951). This result contradicted the previous views of common sense, namely the longer the time from onset to recanalisation, the worse the outcome. A possible explanation might be that since most of our patients in this study had a long delay between onset and hospitalisation, and multimodal CT assessment was used as advanced imaging techniques to select patients with brain tissue was still salvageable. Screening of patients for MT is largely determined by a tissue clock rather than a time clock. Therefore, the effect of time on prognosis, to some extent, is weakened.

Limitations include the study being conducted in a single centre and with a relatively small sample. Second, due to heterogeneous inclusion criteria of patients, there is a possibility of selection bias. Third, the mechanism of deleterious effects of intraprocedural BPV on patients with LVO could be largely different between anterior and posterior circulation strokes. Therefore, the generalisability of current findings needs to be validated in patients with posterior circulation strokes. Fourth, vasopressors were administered in approximately 50% of the patients during the procedure. We did not explore the impact of vasopressors on BP or BPV in this study, which might have affected the results. Finally, the causality between increased intraprocedural BPV and poor functional outcome cannot be assumed from our results since this is an observational study. Increased BPV might be reactive to early infarct enlargement or poor collateral status, which are worthy of further investigation.

CONCLUSION

Increased intraprocedural BPV was more likely to have poor functional outcome in patients with LVO following MT with general anaesthesia. This finding indicates that special precautions should be taken to minimise BP fluctuation during procedure and the therapeutic effects of modulating intraprocedural BPV should be investigated.

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