Role of in-hospital blood pressure and stroke severity in predicting 3-month functional outcomes after acute ischemic stroke: Experience from a Malaysian tertiary centre

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Abstract

Background & Objective: The optimal inpatient blood pressure (BP) target after acute ischemic stroke (AIS) remains uncertain, particularly in Asian populations. We evaluated whether mean in-hospital BP during the first five days is associated with 3-month functional outcomes, and examined the relative contribution of stroke severity. *Methods:* We included 200 patients from April 2024 to April 2025 who were admitted with Acute Ischemic Stroke (AIS) at a tertiary hospital in Malaysia. Blood pressure was measured every 4 hourly and daily mean BP (days 1–5) was calculated. Functional status at 3 months was presented as either good outcome (mRS 0-2) or poor outcome (mRS 3-6). *Results:* Discharge mRS was the only independent predictor of clinical outcome (OR 0.04; 95% CI 0.01–0.16; p<0.001). *Conclusion:* Mean inpatient BP during first 5 days post-AIS was not independently predictive of 3-month outcome. However, we found that discharge mRS score remained strongest predictor.

Keywords: Acute ischemic stroke, blood pressure, stroke severity, modified Rankin Scale, Malaysia

INTRODUCTION

Stroke remains a leading cause of death and disability worldwide.[1] In Malaysia, stroke ranks third among causes of mortality.[2,3] Hypertension is the most significant modifiable stroke risk factor.[4] In the acute phase both hypotension and hypertension can worsen outcomes due to impaired cerebral autoregulation.[5] Some studies have shown no clinical significance between in hospital BP and clinical outcomes while others have described a U- or J-shaped relationship between BP and prognosis, with increased mortality and disability at either extreme.[6]

Despite multiple studies and meta-analysis, optimum blood pressure management in AIS remains unknown. Permissive HTN (≥220/110 mmHg) is advised in patients who are not treated with reperfusion therapy while SBP ≤180/105mmHg is advised during the peri-reperfusion period for IVT.[7,8,9] Optimal BP targets for EVT remain uncertain despite multiple studies

and meta-analysis.[10-18] At our center, systolic BP is generally lowered between 140–160 mmHg and diastolic between 80–90 mmHg during acute admission. This study therefore aimed to determine whether in-hospital BP levels are associated with 3-month functional outcomes following AIS in Asian population where the data is limited.

METHODS

This prospective single-center cohort study was conducted at Hospital Canselor Tuanku Muhriz (HCTM), Malaysia, from April 2024 to April 2025. Consecutive patients with confirmed acute ischemic stroke (AIS) presenting within 7 days of symptom onset were enrolled. Patients with baseline disability (mRS ≥3), extreme admission BP values, or hospital stays exceeding 7 days were excluded. Demographic and clinical variables, including admission NIHSS, were recorded. Blood pressure was monitored every 4 hours

for up to 5 days to calculate daily mean values. NIHSS and mRS were reassessed at discharge, and functional outcomes at 3 months were obtained during follow-up visits or telephone interviews.

Statistical analysis

Data analysis was performed using IBM SPSS Statistics version 30.0. Categorical variables were presented as frequencies and percentages, and continuous variables as mean ± SD or median (IQR). Group comparisons were conducted using independent t-tests and chi-square tests. Functional outcomes were categorized as good (mRS 0–2) or poor (mRS 3–6). Logistic regression was used to assess associations between blood pressure control and 3-month outcomes, adjusting for potential confounders. A p-value < 0.05 was considered statistically significant.

RESULTS

Among 200 patients analyzed, 163 (81.5%) achieved good 3-month outcomes (mRS 0–2) and 37 (18.5%) had poor outcomes (mRS 3–6). The mean age was 65.0 ± 12.5 years, with a male predominance (60%). Age, sex, and ethnicity did not differ significantly between outcome groups. The prevalence of vascular risk factors including hypertension (79.5%), diabetes mellitus (50.5%), and hyperlipidemia (59%) was similar across groups. Chronic kidney disease (CKD) was more frequent among patients with good outcomes (14.7% vs 0%, p = 0.009). Lipid and glycemic parameters, including mean HbA1c 7.4 ± 2.5%, were comparable between groups.

By TOAST classification, small-vessel occlusion predominated among good outcomes (53.4%, p < 0.001), whereas large-artery atherosclerosis was more common in poor outcomes (73.0%, p < 0.001). Cardioembolic stroke was rare (4.5%, p = 0.673).

Medical therapy alone patients were associated with better outcomes (79.1% vs 56.8%, p = 0.005), while IVT-only group correlated with poorer outcomes (32.4% vs 17.8%, p = 0.046). Stroke severity was the strongest discriminator. Poor-outcome group had significantly higher NIHSS scores at admission (median 12.5 vs 2.0, p < 0.001) and discharge (10.5 vs 1.0, p < 0.001), along with higher discharge mRS values.

Mean blood pressures from day 1 to day 5 as well as blood press ure on arrival were not statistically significant.

Recurrent stroke occurred in only two patients (1.2%).

The multivariate logistic regression analysis demonstrated that discharge mRS was the only independent predictor of 3-month outcomes (OR = 0.04, 95%, p < 0.001).

Across all treatment groups, mean systolic and diastolic BP values were slightly higher among patients with poor outcomes, but none reached statistical significance. Overall, mean in-hospital SBP and DBP showed no significant association with 3-month functional outcomes.

DISCUSSION

This study examined the relationship between in-hospital blood pressure and 3-month functional outcomes in acute ischemic stroke (AIS) patients admitted to a Malaysian tertiary center. The cohort had a mean age of 65 years and was predominantly male.[19] No significant associations were observed between age, sex, or ethnicity and outcomes, suggesting that stroke severity and etiology were stronger determinants of recovery. Previous studies have shown that older age and female sex predicts poorer outcomes after AIS.[20-23] This trend was not seen here, possibly due to a smaller sample and the influence of stroke severity.

Traditional vascular risk factors were not significantly predictive of 3-month outcomes, echoing previous findings that the prognostic effect of comorbidities diminishes once stroke severity is considered. An unexpected finding was the higher prevalence of chronic kidney disease (CKD) among patients with good outcomes, contrary to established evidence associating CKD with poorer outcomes and higher mortality.[24-26] This discrepancy may reflect small sample size and most of the patients being in early stages of CKD.

Stroke subtype, classified by TOAST, showed a significant association with outcomes. Small vessel occlusion was linked to good recovery, whereas large artery atherosclerosis predicted poorer outcomes, consistent with prior evidence showing that lacunar infarcts, typically milder and subcortical, have better functional recovery, while large artery strokes tend to cause greater neurological deficits and worse outcomes.[27-30] Cardioembolic strokes were relatively uncommon in this cohort, but prior studies have established their association with higher mortality and disability.[31-33]

Patients treated with medical therapy alone had significantly higher rates of good outcomes compared with those treated with IVT only, likely reflecting the influence of baseline severity, as

Table 1: Demographic and clinical characteristics of patients

Variables	Total (N = 200)	Good mRS (N = 163)	Poor mRS (N = 37)	*p-*value
Age, years	65.0 ± 12.5	64.6 ± 12.4	66.5 ± 12.6	0.400*
Sex, n (%)				0.118#
Male	120.0 (60.0)	102.0 (62.6)	18.0 (48.6)	
Female	80.0 (40.0)	61.0 (37.4)	19.0 (51.4)	
Ethnicity, n (%)				0.975#
Malay	100.0 (50.0)	82.0 (50.3)	18.0 (48.6)	
Chinese	80.0 (40.0)	65.0 (39.9)	15.0 (40.5)	
Indian	20.0 (10.0)	16.0 (9.8)	4.0 (10.8)	
Others	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	
Comorbidities, n (%)				
Diabetes mellitus	101.0 (50.5)	81.0 (49.7)	20.0 (54.1)	0.632#
Hypertension	159.0 (79.5)	131.0 (80.4)	28.0 (75.7)	0.523#
Hyperlipidaemia	118.0 (59.0)	99.0 (60.7)	19.0 (51.4)	0.295#
Ischemic heart disease	31.0 (15.5)	26.0 (16.0)	5.0 (13.5)	0.712#
Atrial fibrillation / atrial flutter	14.0 (7.0)	11.0 (6.7)	3.0 (8.1)	0.726#
Chronic kidney disease	24.0 (12.0)	24.0 (14.7)	0.0 (0.0)	**0.009#**
Previous stroke	38.0 (19.0)	30.0 (18.4)	8.0 (21.6)	0.653#
Biochemical parameters				
TC, mmol/L	5.1± 1.5	5.2 ± 1.5	4.9 ± 1.5	0.323*
TG, mmol/L	1.3 (0.8)	1.4 (0.8)	1.2 (0.7)	0.314*
LDL, mmol/L	3.3 ± 1.4	3.4 ± 1.4	3.1 ± 1.4	0.358*
HDL, mmol/L	1.0 (0.3)	1.1 ± 0.3	1.0 (0.3)	0.400*
HbA1C, %	7.4 ± 2.5	7.4 ± 2.5	7.4 ± 2.4	0.963*
TOAST Classification, n (%)				
Small vessel occlusion	95.0 (47.5)	87.0 (53.4)	8.0 (21.6)	**<0.001#**
Large artery atherosclerosis	96.0 (48.0)	69.0 (42.3)	27.0 (73.0)	**<0.001#**
Cardioembolic	9.0 (4.5)	7.0 (4.3)	2.0 (5.4)	0.673#
Unclassified	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	-
Treatment Received				
Medical therapy	150.0 (75.0)	129.0 (79.1)	21.0 (56.8)	**0.005#**
IVT only	41.0 (20.5)	29.0 (17.8)	12.0 (32.4)	**0.046#**
IVT and MT	4.0 (2.0)	2.0 (1.2)	2.0 (5.4)	0.157#
MT only	5.0 (2.5)	3.0 (1.8)	2.0 (5.4)	0.231#
Clinical Characteristics				
NIHSS on arrival	5.1 ± 6.1	2.0 (4.0)	12.5 ± 7.1	**<0.001***
NIHSS on discharge	3.6 ± 5.2	1.0 (3.0)	10.5 ± 7.2	**<0.001***
mRS at discharge	1.1 ± 1.3	0.7 ± 0.9	3.0 (1.0)	**<0.001***
D1 SBP, mmHg	147.2 ± 16.1	146.7 ± 16.6	149.6 ± 14.8	0.321*
D1 DBP, mmHg	82.1 ± 10.5	81.7 ± 10.7	84.0 ± 9.5	0.226*
D2 SBP, mmHg	143.3 ± 16.7	142.3 ± 15.8	147.1 ± 19.8	0.129*
D2 DBP, mmHg	81.0 ± 10.8	80.7 ± 10.9	82.2 ± 10.5	0.480*
D3 SBP, mmHg	140.5 ± 14.8	140.6 ± 14.5	140.2 ± 15.8	0.884*
D3 DBP, mmHg	79.3 ± 10.5	79.0 ± 10.4	80.3 ± 10.7	0.542*
D4 SBP, mmHg	139.3 ± 16.8	138.3 ± 17.9	141.4 ± 14.3	0.451*
D4 DBP, mmHg	81.7 ± 10.6	81.7 ± 10.9	81.8 ± 10.2	0.962*
D5 SBP, mmHg	139.6 ± 16.6	138.8 ± 16.2	140.8 ± 17.3	0.662*

Table 1: (continued)

D5 DBP, mmHg	80.5 ± 10.6	81.3 ± 11.0	79.3 ± 10.1	0.477[*]
Mean SBP, mmHg	143.2 ± 13.2	142.8 ± 13.1	144.8 ± 13.8	0.429[*]
Mean DBP, mmHg	80.9 ± 9.3	80.7 ± 9.4	81.6 ± 8.9	0.614[*]
SBP on arrival , mmHg	156.5 ± 25.2	156.2±24.2	157.9± 29.6	0.36*
DBP on arrival , mmHg	186.7 ± 16.	86.1±16.4	89.2±14.4	0.14*
Recurrent stroke, n (%)	2.0 (1.0)	2.0 (1.2)	0.0 (0.0)	1.000[#]

Continuous values are presented as mean ± standard deviation for normally distributed data and median (interquartile range) for non-normally distributed data. [*]= Independent T-test; [#] =Pearson Chi-square; TC = Total cholesterol; TG = Triglyceride; LDL = Low density lipoprotein; HDL = High density lipoprotein; TOAST= Trial of ORG 10172 in Acute Stroke Treatment; IVT = Intravenous thrombolysis; MT = Mechanical thrombectomy; NIHSS = National Institute of Health Stroke Score; mRS = Modified Rankin Scale; D = Day; SBP = Systolic blood pressure; DBP = Diastolic blood pressure.

patients eligible for IVT usually present with more severe neurological deficits. No significant outcome differences were found among other reperfusion subgroups, likely due to small sample sizes.

Stroke severity, measured by NIHSS, demonstrated a strong relationship with outcome. Patients in the poor outcome group had markedly higher NIHSS scores at both admission and discharge (p < 0.001). This aligns with multiple studies confirming NIHSS as a robust predictor of mortality and functional independence.[34-37] Interestingly, in the present study, logistic regression revealed that discharge mRS remained the only independent predictor of 3-month outcome. This may be explained by collinearity between NIHSS and mRS, as both assess stroke severity and disability. The mRS, however, captures the patient's functional independence, making it a more comprehensive predictor of long-term outcome.[38]

Mean in-hospital BP was not significantly associated with 3-month outcomes, consistent with evidence that short-term BP levels are poor prognostic markers. Instead, BP variability and mean arterial pressure (MAP) appear to have greater prognostic value. Higher variability is associated with poor outcomes while some studies also shown a U-shaped relationship between mean BP and outcomes supporting a moderate BP control .[39,40] These findings advocate balanced BP management during acute ischemic stroke.

This study's strengths include prospective real-world data collection, standardized 4-hourly BP monitoring and uniform 3-month mRS outcome assessment. Limitations include the single-center design and modest sample size, which may limit generalizability. Larger multicenter studies in diverse Asian cohorts are needed to validate our findings.

In conclusion, this study found no independent association between in-hospital blood pressure control and 3-month functional outcomes after acute ischemic stroke. Stroke severity at admission and discharge remained the strongest predictors of recovery, while small vessel occlusion was linked to better outcomes and large artery atherosclerosis to poorer prognosis. These results highlight the need for individualized management strategies focusing on stroke subtype and severity to optimize recovery.

Table 2: Multivariate logistic regression analysis of the variables to the functional outcome

Variables	OR	95% CI	*p*-value
Chronic kidney disease	0.00	0.00, 0.00	0.998
Small vessel occlusion	1.82	0.30,11.18	0.518
Large artery atherosclerosis	0.58	0.11, 3.05	0.519
Medical therapy	2.55	0.60, 10.86	0.207
IVT only	1.42	0.31, 6.44	0.648
NIHSS on arrival	0.94	0.82, 1.08	0.375
NIHSS on discharge	1.02	0.87, 1.19	0.841
mRS at discharge	0.04	0.01, 0.16	<0.001

OR = Odd's ratio; CI = Confidence interval; IVT = Intravenous thrombolysis; NIHSS = National Institute of Health Stroke Score; mRS = Modified Rankin Scale;

Table 3: Multivariate analysis of blood pressure control with functional outcome

Treatment received	Good mRS	Poor mRS	*p*-value
Medical therapy only			
Mean SBP	144.0 ± 13.1	146.6 ± 14.9	0.408[*]
Mean DBP	81.1 ± 9.8	81.4 ± 8.5	0.886[*]
IVT only			
Mean SBP	140.0 ± 13.3	141.8 ± 13.3	0.71[*]
Mean DBP	80.9 ± 9.1	83.6 ± 8.8	0.39[*]
IVT and MT			
Mean SBP	126.3 ± 5.8	132.3 ± 10.3	0.548[*]
Mean DBP	64.5 ± 0.4	69.6 ± 4.8	0.274[*]
MT only			
Mean SBP	125.7 ± 10.2	140.4 ± 6.2	0.174[*]
Mean DBP	79.8 ± 2.0	85.2 ± 3.7	0.116[*]

[*] = Independent T-test; mRS = Modified Rankin Scale; IVT = Intravenous thrombolysis; MT = Mechanical thrombectomy; SBP = Systolic blood pressure; DBP = Diastolic blood pressure.

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