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ORIGINAL RESEARCH

Metabolic Syndrome Predicts Poor Outcome in Acute Ischemic Stroke Patients After Endovascular Thrombectomy

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Background and Aims: The metabolic syndrome (MetS) is believed to contribute to a higher probability of developing cardiovascular diseases. This study aimed to investigate whether MetS could predict the prognosis in ischemic stroke patients after endovascular thrombectomy (EVT).

Methods: Between January 2016 and September 2019, patients treated with EVT due to large vessel occlusions in anterior circulation were prospectively recruited. MetS was defined using the International Diabetes Federation criteria after admission. The primary outcome was a 3-month poor outcome (modified Rankin scale score of 3–6). Secondary outcomes included symptomatic intracranial hemorrhage (sICH) and mortality at 3 months. Multivariable logistic regression models were used to assess the relationship between MetS and clinical outcomes.

Results: A total of 248 patients were enrolled (mean age, 66.7 years; 37.5% female) and 114 (46.0%) met with the MetS criteria. The median National Institutes of Health Stroke Scale score was 15.0. There were 131 (52.8%) patients achieving the poor outcome at 3 months, among which 26 (10.5%) patients developed sICH. The mortality at 3 months was 19.0% (47/248). In multivariable analysis, MetS was significantly correlated to poor outcome (odds ratio [OR], 2.48; 95% confidence interval [CI], 1.29–4.78, $P = 0.014$). The risk for poor outcome was positively associated with the increased number of MetS components (OR 1.78; 95% CI 1.39–2.35, $P = 0.001$). No significant findings were found in the association of MetS with sICH and mortality.

Conclusion: Our data demonstrated that MetS was associated with poor prognosis in acute ischemic patients treated with EVT.

Keywords: metabolic syndrome, ischemic stroke, endovascular thrombectomy, prognosis

Introduction

Stroke has been ranked as the first leading cause of major disability and mortality in China.[1] Endovascular thrombectomy (EVT) has profoundly changed the landscape of acute stroke therapy in large vessel occlusions of the anterior circulation.[2–4] This early identification of the patient's prognosis is of vital importance for further improving the benefit of EVT.

The metabolic syndrome (MetS) is a highly prevalent constellation of vascular risk factors, including insulin resistance, central obesity, elevated blood pressure, and dyslipidemia.[5] The epidemiological investigation demonstrated the prevalence of MetS has reached approximately 60% of the elderly Chinese population and it is

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projected to increase considerably.[6] Moreover, data from the Guangdong Nutrition and Health Survey estimate that a total of 4.0 million residents aged 20 years or above have the MetS in southern China.[7] Inflammatory state and coagulation system activation accompanied by MetS may confer higher risks for ischemic events.[8] Guidelines for the prevention of stroke showed that MetS could predict cardiovascular disease including coronary heart disease and stroke, leading to increased mortality.[9] MetS has been also reported to be associated with functional outcomes,[10,11] and refractoriness to intravenous thrombolysis[12] in acute ischemic stroke patients. To date, there remains a paucity of data from a prospective cohort examining the relationship between MetS and prognosis in ischemic stroke patients treated with EVT. We, therefore, performed this prospective study to investigate whether MetS could predict the functional outcome at 90 days in ischemic stroke patients after EVT treatment.

Methods

Study Design and Participants

We prospective recruited patients with EVT admitted to Mianyang Central Hospital between January 2016 and September 2019. The participants were screened consecutively based on the inclusion criteria: (1) acute ischemic stroke with occlusions of the internal carotid artery (ICA) or middle cerebral artery (MCA) confirmed by computed tomographic angiography, magnetic resonance angiography, or digital subtracted angiography; (2) aged ≥ 18 years; (3) pre-stroke modified Rankin Scale (mRS) score ≤ 2. Patients with severe renal disease and hepatic disease, cardiac insufficiency, tumor, and autoimmune disease were excluded. This study was approved by the ethics committee of Mianyang Central Hospital. The study was conducted under the declaration of Helsinki. Informed consent was obtained from participants or legal representatives. Several ischemic stroke patients admitted to hospital with severe neurological deficits, such as disturbance of consciousness. Therefore, the informed consents were obtained from their legal representatives.

Data Collection

We collected patient's demographic characteristics, traditional risk factors, baseline clinical data, imaging data, and procedure-related characteristics. The baseline stroke severity was assessed by trained neurologists using the National Institutes of Health Stroke Scale (NIHSS).[13] Ischemic stroke subtype was classified based on the trial of ORG 10,172 in Acute Stroke Treatment classification.[14] The Alberta Stroke Program Early Computed Tomography Score (ASPECTS) was used to evaluate the extent of preoperative early cerebral ischemia.[15] The collateral circulation status was evaluated using the American Society of Interventional and Therapeutic Neuroradiology/Society of Interventional Radiology (ASITN/SIR) and defined ASITN/SIR ≥ 2 as a good collateral circulation.[16] Successful vascular recanalization was defined as the modified Thrombolysis in Cerebral Infarction scale 2b/3.[17] Symptomatic intracranial hemorrhage (sICH) was diagnosed according to Heidelberg Bleeding Classification.[18]

Definition of MetS

MetS was defined according to the International Diabetes Federation criteria.[19] Individuals were considered to have MetS if they had central obesity (waist circumference ≥ 90 cm for Asian men or ≥ 80 cm for Asian women) plus any 2 of 4 additional components. These 4 risk components are as follows: (1) triglyceride (TG) ≥ 1.70mmol/L; (2) Decreased HDL-cholesterol < 1.03 mmol/L in male and < 1.29 mmol/L in female (or specific treatment for these lipid abnormalities); (3) elevated blood pressure: systolic blood pressure ≥ 130mmHg, or diastolic blood pressure ≥ 85mmHg, or use for antihypertensive drugs; (4) hyperglycemia: fasting plasma glucose ≥ 5.6mmol/L or previously diagnosed type 2 diabetes.

Clinical Outcomes

The 90-day functional outcomes after stroke were evaluated using mRS by outpatient service, the medical information provided by the rehabilitation hospital, and the telephone interview. The primary outcome was the unfavorable functional outcome (mRS of 3–6). Secondary outcomes included sICH with 72 hours and mortality at 3 months.

Statistical Analysis

Continuous variables were presented as mean (SD, standard deviation) and median (interquartile range) and categorical variables as number (percentage). Differences in baseline characteristics between groups were analyzed using independent sample t-tests, and Mann–Whitney *U*-tests for continuous variables, and the chi-square test or fisher's exact test for categorical variables, as appropriate. Binary logistic regression analysis with 2 models was performed to estimate the risk of 3-month unfavorable

Table 1 Comparison of Baseline Data in Patients with and Without MetS

Variables	All Patients (n = 248)	With MetS (n = 114)	Without MetS (n = 134)	*P* value
Demographic characteristics				
Age, years	66.7 ± 13.0	68.8 ± 13.2	64.9 ± 12.7	0.018
Female, n (%)	93 (37.5)	60 (52.6)	33 (24.6)	0.001
Vascular risk factors, n (%)				
Hypertension	150 (60.5)	71 (62.3)	79 (59.0)	0.285
Diabetes mellitus	64 (25.8)	37 (32.5)	27 (20.1)	0.027
Hyperlipidemia	25 (10.1)	12 (10.5)	13 (9.7)	0.830
Atrial fibrillation	101 (40.7)	44 (38.6)	57 (42.5)	0.396
Coronary heart disease	32 (12.9)	14 (12.3)	18 (13.4)	0.787
Current smoker	81 (32.7)	37 (32.5)	44 (32.8)	0.949
Current drinker	50 (20.2)	19 (16.7)	31 (23.1)	0.207
Family history of stroke	19 (7.7)	11 (9.6)	8 (6.0)	0.278
Medication history				
Antiplatelet drugs	78 (31.5)	37 (32.5)	41 (30.6)	0.753
Statin	67 (27.0)	35 (30.7)	32 (23.9)	0.228
Antihypertensive drugs	79 (31.9)	42 (36.8)	37 (27.6)	0.120
Clinical data				
Waist circumference, cm	86.5 ± 5.4	89.4 ± 4.2	84.0 ± 5.2	0.001
Systolic blood pressure, mmHg	154.8 ± 23.8	164.5 ± 19.5	146.7 ± 24.1	0.001
Diastolic blood pressure, mmHg	79.9 ± 12.9	83.2 ± 14.2	77.1 ± 11.0	0.001
Time from onset to treatment, min	220.5 (177.0, 265.0)	235.0 (176.0, 270.0)	218.0 (199.0, 250.0)	0.653
Time from puncture to recanalization, min	62.5 (43.5, 77.0)	56.0 (43.0, 75.0)	65.0 (45.0, 84.5)	0.153
Baseline NIHSS, score	15.0 (11.0, 20.0)	16.0 (13.0, 20.0)	14.0 (11.0, 18.0)	0.047
Baseline ASPECTS, score	9.0 (9.0, 10.0)	10.0 (9.0, 10.0)	9.0 (9.0, 10.0)	0.241
Prior IVT, n (%)	168 (67.7)	82 (71.9)	86 (64.2)	0.193
Good collateral, n (%)	175 (70.6)	80 (70.2)	95 (70.9)	0.901
Total passes of stent retriever	2.0 (1.0, 2.0)	1.5 (1.0, 2.0)	1.0 (1.0, 2.0)	0.140
Successful recanalization, n (%)	181 (73.0)	84 (73.7)	97 (72.7)	0.819
Vascular occlusion site, n (%)				0.777
ICA	95 (38.3)	46 (40.4)	49 (36.6)	
MCA-M1	138 (55.6)	63 (55.3)	75 (56.0)	
MCA-M2	15 (6.0)	6 (5.3)	9 (6.7)	
Stroke etiology, n (%)				0.031
Atherosclerotic	119 (48.0)	56 (49.1)	63 (47.0)	
Cardioembolic	106 (42.7)	42 (36.8)	64 (47.8)	
Others	23 (9.3)	16 (14.0)	7 (5.2)	
Procedural modes, n (%)				0.699
Stent retriever only	238 (96.0)	110 (96.5)	128 (95.5)	
Stent retriever with implantation of stent	10 (4.0)	4 (3.5)	6 (4.5)	
Clinical outcomes, n (%)				
Poor outcome at 3-months	131 (52.8)	72 (63.2)	59 (44.0)	0.003
Mortality at 3-months	47 (19.0)	25 (21.9)	22 (16.4)	0.270
sICH	26 (10.5)	11 (9.6)	15 (11.2)	0.692
Laboratory data				
Total cholesterol, mmol/L	4.1 ± 1.1	4.1 ± 1.1	4.1 ± 1.0	0.772
Triglyceride, mmol/L	1.6 (1.3, 2.1)	1.7 (1.4, 2.3)	1.5 (1.2, 1.9)	0.004
Low density lipoprotein, mmol/L	3.0 (2.6, 3.5)	3.3 (2.6, 3.7)	2.8 (2.5, 3.4)	0.033

(*Continued*)

Table 1 (Continued).

Variables	All Patients (n = 248)	With MetS (n = 114)	Without MetS (n = 134)	*P* value
High density lipoprotein, mmol/L	1.2 ± 0.2	1.1 ± 0.2	1.2 ± 0.2	0.886
Blood glucose level, mmol/L	8.2 ± 3.1	8.6 ± 3.5	7.8 ± 2.7	0.036
Hs-CRP, mg/L	1.8 (1.3, 2.6)	2.0 (1.2, 3.0)	1.5 (1.2, 2.3)	0.018

Abbreviations: ASPECTS, the Alberta Stroke Program Early Computed Tomography Score; Hs-CRP, hyper-sensitive C-reactive protein; ICA, internal carotid artery; IVT, intravenous thrombolysis; MetS, metabolic syndrome; MCA, middle cerebral artery; NIHSS, National Institute of Health Stroke Scale; sICH, symptomatic intracranial hemorrhage.

outcome by calculating odds ratios (OR) and 95% confidence intervals (CI). Model 1 was adjusted for age and gender. Model 2 included the factors in model 1 as well as variables with $P < 0.1$ in univariate analysis (including atrial fibrillation, onset to treatment time, puncture to recanalization, baseline NIHSS score, baseline ASPECTS, prior IVT, collateral circulation status, total passes of stent retriever, successful recanalization, vascular occlusion site, and Hs-CRP levels). We also used the ordinal logistic regression analysis to estimate an effect of MetS across the entire range of the mRS score. All *P* values were 2 tailed, and a significance level of 0.05 was used. Statistical analysis was performed using SPSS 24.0 (IBM, Chicago, IL, USA).

Results

A total of 248 patients (mean age, 66.7 years; 37.5% female) were included with large vessel occlusions in the anterior circulation treated by EVT. Demographics, clinical, and radiological characteristics, as well as clinical outcomes in the study cohort, are summarized in Table 1. Median onset to treatment time was 220.5 minutes. The median NIHSS was 15 (IQR 11–20) at baseline and the median ASPECTS was 10 (IQR 9–10). Vascular occlusion site was as follows: MCA-M1 138 (55.6%), MCA-M2 15 (6.0%) and ICA 95 (38.3%). sICH was diagnosed in 26 patients (10.5%) within 72 hours after EVT treatment. MetS was present in 46.0% of the participants. As compared with subjects without MetS, patients with MetS were more likely to be female and older, and had a higher prevalence of diabetes mellitus and atherosclerotic stroke, and had a higher level of waist circumference, blood pressure, baseline NIHSS score, blood glucose and, Hs-CRP. There were 131 patients (52.8%) who developed an unfavorable functional outcome (mRS 3–6). The overall mortality was 47 (19.0%) at 90 days after EVT. Unfavorable functional outcome was more prevalent in patients with MetS than in patients without it (63.2% versus 44.0%; $P = 0.003$). No significant findings were found in association of MetS with sICH (9.6% versus 11.2%; $P = 0.692$) and mortality (21.9% versus 16.4%; $P = 0.270$) at 3 months.

Comparison of baseline data in patients with and without 3-month poor outcome is showed in Table 2. In univariate analysis, the prevalence of atrial fibrillation in patients with unfavorable outcome was higher (48.1% versus 32.5%; $P = 0.009$). Baseline systolic blood pressure was higher in patients with unfavorable outcome (median 158 versus 150; $P = 0.012$). Patients with 3-month poor outcome had lower baseline ASPECT scores (median, 8.0 versus 9.0; $P = 0.001$) and higher baseline NIHSS scores (median, 16 versus 14; $P = 0.001$). Prior IVT was less prevalent in patients with poor outcome (61.8% versus 74.4%; $P = 0.035$). Unfavorable outcome was associated with longer delay from symptom onset to treatment (median, 240 versus 220 minutes; $P = 0.001$), and longer puncture to recanalization (median, 65 versus 55 minutes; $P = 0.035$). Moreover, unfavorable outcome lowered successful recanalization ratio (54.2% versus 94.0%; $P = 0.001$).

In univariate logistic analysis, MetS (OR, 2.18; 95% CI, 1.31–3.63; $P = 0.003$), increased numbers of MetS components (OR, 1.89; 95% CI, 1.46–2.44, $P = 0.001$), low HDL-C (OR, 3.13; 95% CI, 1.83–5.36; $P = 0.001$), elevated blood pressure (OR, 2.79; 95% CI, 1.48–5.26; $P = 0.002$), and elevated blood glucose (OR, 2.05; 95% CI, 1.04–4.06; $P = 0.038$) were associated with 3-month unfavorable outcome after EVT (Table 3). After controlled for age, gender, atrial fibrillation, onset to treatment time, puncture to recanalization, baseline NIHSS score, baseline ASPECTS, prior IVT, collateral circulation status, total passes of stent retriever, recanalization, vascular occlusion site, and Hs-CRP levels, this associations remained significant.

Figure 1 shows the overall distribution of mRS score stratified by patients with and without MetS. The adjusted

Table 2 Comparison of Baseline Data in Patients with and Without 3-Month Poor Outcome

Variables	Unfavorable Outcome (n = 131)	Favorable Outcome (n = 117)	*P* value
Demographic characteristics			
Age, years	66.5 ± 13.6	66.9 ± 12.3	0.792
Female, n (%)	57 (43.5)	36 (30.8)	0.039
Vascular risk factors, n (%)			
Hypertension	80 (61.1)	70 (59.8)	0.842
Diabetes mellitus	38 (29.0)	26 (22.2)	0.233
Hyperlipidemia	11 (8.4)	14 (12.0)	0.351
Atrial fibrillation	63 (48.1)	38 (32.5)	0.009
Coronary heart disease	17 (13.0)	15 (12.8)	0.971
Clinical data			
Waist circumference, cm	86.7 ± 5.2	86.3 ± 5.8	0.545
Systolic blood pressure, mmHg	158.4 ± 23.1	150.8 ± 24.1	0.012
Diastolic blood pressure, mmHg	80.7 ± 12.6	78.9 ± 13.2	0.289
Time from onset to treatment, min	240.0 (215.0, 283.0)	202.0 (176.0, 245.0)	0.001
Time from puncture to recanalization, min	65.0 (48.0, 84.0)	55.0 (43.0, 73.0)	0.001
Baseline NIHSS, score	16.0 (12.0, 20.0)	14.0 (9.0, 17.0)	0.001
Baseline ASPECTS, score	9.0 (8.0, 10.0)	10.0 (9.0, 10.0)	0.001
Prior IVT, n (%)	81 (61.8)	87 (74.4)	0.035
Good collateral, n (%)	65 (49.6)	110 (94.0)	0.001
Total passes of stent retriever	2.0 (1.0, 2.0)	1.0 (1.0, 2.0)	0.004
Successful recanalization, n (%)	71 (54.2)	110 (94.0)	0.001
sICH, n (%)	25 (19.1)	1 (0.9)	0.001
Vascular occlusion site, n (%)			0.036
ICA	59 (45.0)	36 (30.8)	
MCA-M1	67 (51.1)	71 (60.7)	
MCA-M2	5 (3.8)	10 (8.5)	
Stroke etiology, n (%)			0.074
Atherosclerotic	54 (41.2)	65 (55.6)	
Cardioembolic	64 (48.9)	42 (35.9)	
Others	13 (9.9)	10 (8.5)	
Procedural modes, n (%)			0.855
Stent retriever only	126 (96.2)	112 (95.7)	
Stent retriever with implantation of stent	5 (3.8)	5 (4.3)	
MetS	72 (55.0)	42 (35.9)	0.003
Numbers of MetS components	3.0 (3.0, 4.0)	2.0 (2.0, 3.0)	0.001
Elevated waist circumference	71 (54.2)	49 (41.9)	0.053
Elevated triglyceride	59 (45.0)	48 (41.0)	0.524
Decreased high density lipoprotein	68 (51.9)	30 (25.6)	0.001
Elevated blood pressure	113 (86.3)	81 (69.2)	0.001
Elevated blood glucose	115 (87.8)	91 (77.8)	0.036
Laboratory data			
Total cholesterol, mmol/L	4.0 ± 1.1	4.2 ± 1.0	0.318
Triglyceride, mmol/L	1.7 (1.2, 2.2)	1.6 (1.3, 1.9)	0.473
Low density lipoprotein, mmol/L	2.8 (2.5, 3.7)	3.2 (2.6, 3.4)	0.621
High density lipoprotein, mmol/L	1.2 ± 0.2	1.2 ± 0.2	0.158
Blood glucose level, mmol/L	8.3 ± 3.1	8.0 ± 3.2	0.424
Hs-CRP, mg/L	2.1 (1.3, 3.0)	1.6 (1.2, 2.2)	0.014

Abbreviations: ASPECTS, the Alberta Stroke Program Early Computed Tomography Score; Hs-CRP, hyper-sensitive C-reactive protein; ICA, internal carotid artery; IVT, intravenous thrombolysis; MetS, metabolic syndrome; MCA, middle cerebral artery; NIHSS, National Institute of Health Stroke Scale; sICH, symptomatic intracranial hemorrhage.

Table 3 OR and 95% CI Between MetS and 3-Month Poor Outcome in Patients After Endovascular Thrombectomy

	Crude Model	*P* value	Model 1	*P* value	Model 2	*P* value
Variables						
MetS	2.18 (1.31–3.63)	0.003	2.04 (1.19–3.49)	0.009	2.48 (1.29–4.78)	0.014
Numbers of MetS components	1.89 (1.46–2.44)	0.001	1.89 (1.42–2.50)	0.001	1.72 (1.34–2.38)	0.001
Elevated waist circumference	1.64 (0.99–2.72)	0.067	0.99 (0.97–1.02)	0.445	1.85 (0.94–3.62)	0.069
Elevated triglyceride	1.18 (0.71–1.95)	0.524	1.20 (0.72–2.01)	0.488	1.21 (0.76–1.93)	0.379
Decreased high density lipoprotein	3.13 (1.83–5.36)	0.001	3.26 (1.72–6.17)	0.001	3.75 (1.79–6.94)	0.001
Elevated blood pressure	2.79 (1.48–5.26)	0.002	2.73 (1.43–5.21)	0.002	4.55 (1.69–9.22)	0.001
Elevated blood glucose	2.05 (1.04–4.06)	0.038	2.01 (1.01–4.03)	0.046	3.04 (1.12–7.77)	0.028

Notes: Crude model did not adjust for any variables; Model 1 adjusted for age and sex; Model 2 adjusted for age, sex, atrial fibrillation, onset to treatment time, puncture to recanalization, baseline National Institute of Health Stroke Scale score, baseline the Alberta Stroke Program Early Computed Tomography Score, prior intravenous thrombolysis, collateral circulation status, total passes of stent retriever, successful recanalization, vascular occlusion site, stroke etiology, and hyper-sensitive C-reactive protein levels.

Abbreviations: CI, confidence interval; MetS, metabolic syndrome; OR, odds ratio.

odds ratio of ordinal logistic regression analysis illustrated that patients with MetS have increased mRS scores (OR, 1.82; 95% CI, 1.16–2.82; $P = 0.009$).

Discussion

In this prospective study, we observed that MetS occurred in 46.0% of patients. MetS was associated with an increased risk of unfavorable functional outcome at 90 days in ischemic stroke treated with EVT. No significant findings were found in the association of MetS with sICH and mortality at 3 months.

MetS is a growing public health problem worldwide. Findings from the third National Health and Nutrition Examination Survey reported the prevalence of MetS was approximately 40% in adults in the United States.[20] A longitudinal study performing in China showed that the 5-year cumulative incidence of MetS was 10.8% in 2007 to 2012.[21] Most researches on MetS with cardiovascular disease have been restricted to stroke prevention rather than prognosis. Our study extended the current knowledge about the detrimental effect of MetS in ischemic stroke as it unveiled a significant association between MetS and poor prognosis in EVT patients. The mechanisms underlying the detrimental effect of MetS on the stroke prognosis after EVT are not well defined, but several explanations may account for this phenomenon. MetS has been reported to be associated with a proinflammatory state, platelet activation, impairments in endogenous fibrinolytic capacity, and endothelial dysfunction, all of which may amplify neuron damage,

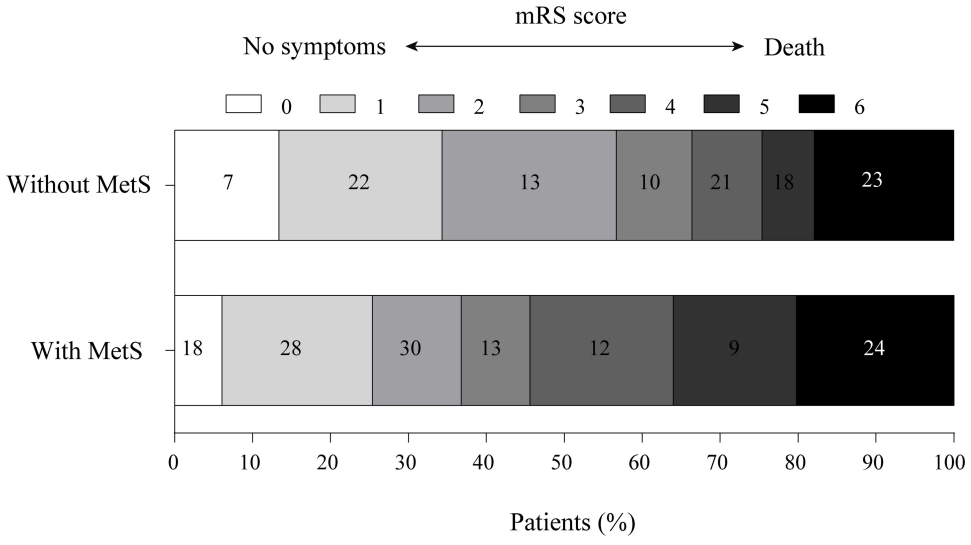

Figure 1 Distribution of modified Rankin Scale (mRS) score at 90 days in patients with and without metabolic syndrome (MetS). There was a significant difference in the overall distribution of mRS score by ordinal regression analysis (adjusted odds ratio, 1.82; 95% confidence interval, 1.16–2.82, $P = 0.009$). Odds ratio was adjusted for the same variables in model 2 in Table 3

hamper arterial recanalization and induce vascular re-occlusion of EVT treatment.[8,22] The mortality ratio in this study was slightly higher in patients with MetS than those without it (21.9% versus 16.4%). However, the difference did not reach statistical significance (P = 0.270). Atherosclerosis may challenge the passage of the retriever devices to the targeting lesions. Repeated thrombectomy may cause intima injury and may be related to a higher risk for sICH.[23] As MetS have been implicated in the pathophysiology of atherosclerosis,[24] we, therefore, hypothesized that the MetS might be associated with sICH. However, we also did not find a significant association between MetS and sICH rates. This discrepancy probably was due to the small sample size. Further studies with large sample size are needed to assess this association.

Obesity, defining based on either waist circumference or body mass index, is a fundamental component of MetS. The role of obesity in the prognosis of stroke has been questioned of debate. A post hoc analysis of the MR CLEAN trial demonstrated that a shift toward a better functional outcome with higher body mass index, and mortality was inversely related to body mass index;[25] while some other studies showed no significant favorable effect, or negative effect of obesity on outcome after recanalization treatment.[26,27] Similarly, our present study did not find a significant association between increased waist circumference and clinical outcomes after EVT. This discrepancy might be due to the differences in study populations and study methods, especially in the definition of obesity. On the other hand, our data confirmed the adverse effect of hyperglycemia on functional outcome in stroke patients after revascularization therapy. It can cause intracellular acidosis and mitochondrial dysfunction and enhance the generation of reactive oxygen species and extracellular glutamate, which might induce the exaggeration of neuronal damage and disruption of blood-brain barrier.[28–30] These results highlighted the need for further randomized controlled trials to determine whether the modulation of blood glucose within an appropriate range could improve functional outcomes in ischemic stroke treated with EVT.

The present study has some limitations. First, the study was performed in one stroke center with 248 patients treated with EVT, which limited the generalizability of our results to other populations. Second, the definition of MetS varies among different studies.[10–12] However, the definition in our study has been widely used in the Asian population. Third, stress hyperglycemia occurs in a relatively high proportion of acute stroke patients. Therefore, it is possible that the blood glucose used for defining MetS in the present study does not accurately reflect pre-stroke metabolic status. Finally, some potential confounders were not available in this study, such as non-HDL cholesterol, blood pressure variability, and chronic kidney disease. Our results should be cautiously interpreted and replicated in a larger series of patients. Despite these limitations, the strengths of our study include using standardized research methods, prospective design, and recruiting a homogeneous population of EVT patients, all of which makes this group appropriate for examining the relationship between MetS and clinical outcomes. The present study is the first attempt to detect the effects of MetS and its components on the prognosis of patients with EVT. Importantly, as a practical consequence of this observation, the diagnosis of MetS may allow a prior identification of a subgroup of patients who are candidates for a more or less postprocedural intensive management.

In conclusion, our study showed that MetS is associated with an increased risk of poor outcome at 90 days in patients with acute ischemic stroke due to large vessel occlusion of the anterior circulation and treated with EVT. Further studies with large patient groups and other populations are needed to investigate this effect comprehensively. Potential pathophysiological mechanisms and therapeutic considerations also remain to be determined.

Data Sharing Statement

The data that support the findings of this study are available on request from the corresponding author.

Disclosure

The authors report no funding and no conflicts of interest for this work.

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