Neuropsychiatric Disease and Treatment

Dovepress

open access to scientific and medical research

Open Access Full Text Article

ORIGINAL RESEARCH

Fasting Blood-Glucose Level and Clinical Outcome in Anterior Circulation Ischemic Stroke of Different Age Groups After Endovascular Treatment

Lili Yuan*, Yi Sun*, Xianjun Huang, Xiangjun Xu, Junfeng Xu, Youqing Xu, Qian Yang, Yujuan Zhu, Zhiming Zhou

Department of Neurology, The First Affiliated Hospital of Wannan Medical College, Wuhu, Anhui Province, People's Republic of China

*These authors contributed equally to this work

Correspondence: Yujuan Zhu; Zhiming Zhou, Department of Neurology, The First Affiliated Hospital of Wannan Medical College, Wuhu, Anhui Province, 241000, People's Republic of China, Email ajuan3975@163.com; neuro_depar@hotmail.com

Objective: We aimed to analyze the association between fasting blood-glucose (FBG) level and 3-month functional outcome in anterior circulation ischemic stroke in different age groups after endovascular treatment (EVT).

Methods: We retrospectively analyzed the consecutive patients with acute ischemic stroke (AIS) receiving EVT from our department between July 2015 and March 2021. The patients were categorized into the older (≥60 years) and younger (<60 years) groups, and patients in each age group were dichotomized into favorable versus unfavorable outcomes according to the 3-month modified Rankin Scale (mRS) score.

Results: A total of 504 patients (286 males and 218 females) were included in our study. Three hundred ninety-two patients (77.8%) belonged to the group aged ≥60 years, and 112 (22.2%) belonged to the group aged <60 years. At the end of the study, 222 (56.6%) patients developed unfavorable outcomes in the older group and 31 (27.7%) showed unfavorable outcomes in the younger group. FBG level of the younger patients was significantly lower than that of older patients. In the older group, FBG level independently predicted a 3-month clinical unfavorable outcome with an odds ratio of 1.242 (95% confidence interval, 1.096–1.407; p = 0.001). However, the association was not found in the younger group (p = 0.376).

Conclusion: Higher FBG level is an independent risk factor for 3-month unfavorable outcome in the AIS patients aged ≥60 years receiving EVT, but no similar effect was seen in the group aged <60 years.

Keywords: fasting blood-glucose, hyperglycemia, acute ischemic stroke, endovascular treatment, outcome

Introduction

Acute ischemic stroke (AIS) is an important public health concern due to the high mortality and disability rates in China,[1,2] with an increase in the number of younger stroke patients.[3] Endovascular treatment (EVT) is considered to be an effective treatment for emergent large vessel occlusion stroke in the anterior circulation.[4] Previous clinical studies demonstrate that admission and fasting hyperglycemia are associated with poorer functional outcomes in AIS patients receiving EVT.[5–7] The possible mechanisms have been proposed to explain the relationship between hyperglycemia and unfavorable outcomes following ischemic stroke, including impaired blood–brain barrier, disordered cerebral microvasculature, increased inflammatory responses, and aggravated reperfusion injury.[8–11]

Some scholars have proposed that admission blood-glucose is affected by different physiologic statuses, such as feeding or using hypoglycemic agents before stroke.[12] Fasting blood-glucose (FBG) can be more reliable in evaluating glucose metabolism and predicting 90-day outcomes better than admission blood-glucose in patients with AIS. Cao et al's study demonstrates that FBG is a powerful predictor related to the prognosis of AIS treated with intravenous thrombolysis, independent of admission blood-glucose.[12] The MR CLEAN pretrial cohort shows that impaired FBG

Received: 8 December 2021
Accepted: 9 March 2022
Published: 18 March 2022

(>5.5 mmol/L) in the first week of admission is associated with poor functional outcome at discharge after EVT of ischemic stroke.[7] A recent study finds that fasting hyperglycemia on the next day after EVT in patients with AIS is an independent risk factor for unfavorable outcome.[6]

However, previous studies do not group stroke patients according to age to explore the relationship between FBG and the prognosis of AIS undergoing EVT. Age may affect the risk of stroke and glucose metabolism.[13–16] In respect to insulin sensitivity and glucose effectiveness, either a reduction or no change has been reported in healthy subjects with increasing age.[17,18] We wondered whether FBG predicted outcomes of AIS treated with EVT in younger or older patients. Therefore, our study aims to investigate the association between FBG level and clinical outcome in the anterior circulation ischemic stroke of different age groups after EVT.

Methods

Subjects

We retrospectively reviewed the consecutive patients with acute anterior circulation stroke patients receiving EVT between July 2015 and March 2021 at our department. The study was approved by the Ethics Committee of the First Affiliated Hospital of Wannan Medical College (201900039). Due to the retrospective nature, patient consent was waived. Patients were included if they met the following criteria: (1) age ≥18 years; (2) modified Rankin Scale (mRS) score before stroke <2; (3) occlusion of the internal carotid artery (ICA) or MCA was confirmed by computed tomographic angiography/magnetic resonance angiography/digital subtraction angiography (DSA); and (4) patients undergoing EVT. The flow chart of the inclusion of the study population is shown in Figure 1.

Clinical Information and Laboratory Assays

The clinical information about demographic data, medical history (hypertension, diabetes mellitus, and atrial fibrillation), the Trial of ORG 10,172 in the Acute Stroke Treatment (TOAST) classification, baseline National Institutes of Health

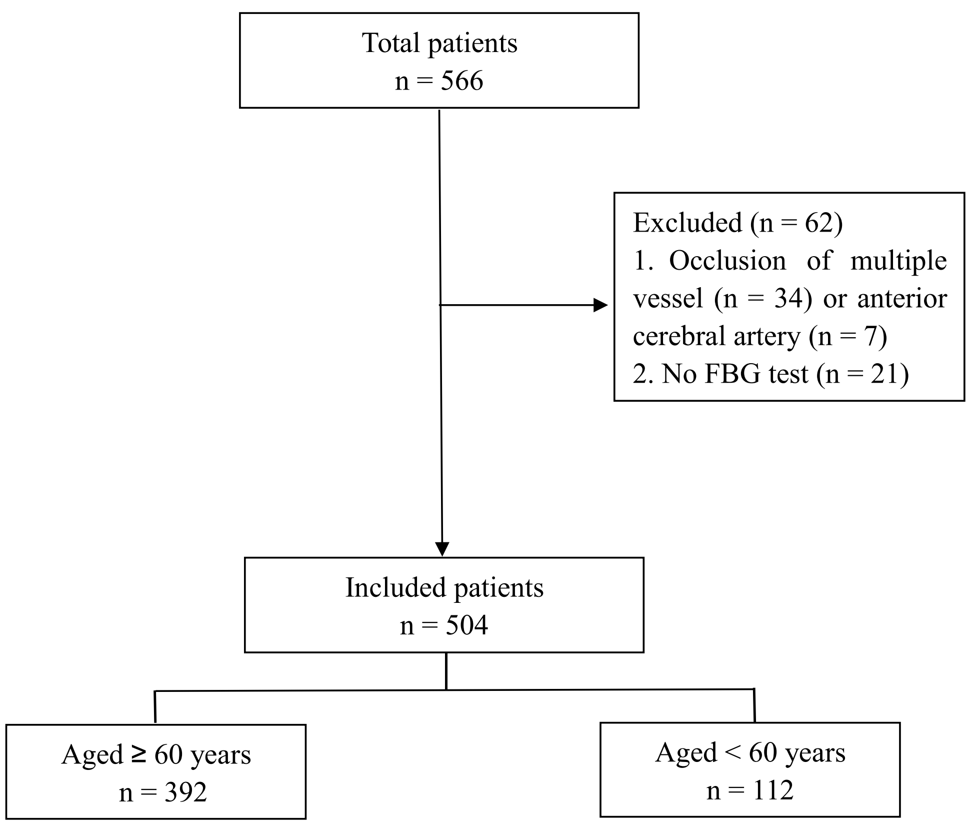

Figure 1 Inclusion flow chart.

Stroke Scale (NIHSS) score, baseline Alberta Stroke Program Early computed tomography (ASPECT) score, perioperative variables (time from stroke onset to puncture [OTP], collateral circulation and recanalization status), and post-stroke functional outcome were collected.

TOAST classification was used to identify subtypes of ischemic stroke based on their etiology. NIHSS and ASPECT scores were used to assess stroke severity and early ischemic change on admission, respectively. Collateral circulation was evaluated according to retrograde contrast opacification of the vessels within the occluded area on delayed DSA images and classified by the criteria as follows: grade 0 (no reconstitution in the occluded area or the collaterals reached less than 1/3 of the occluded area), grade 1 (the collaterals reached less than 2/3 of the occluded area), grade 2 (the collaterals reached more than 2/3 of the occluded area). Poor collateral circulation was defined as grade 0 or 1, and good collateral circulation was defined as grade 2. Recanalization status after EVT was evaluated based on modified Thrombolysis in Cerebral Infarction (mTICI) grading. Unsuccessful recanalization was defined as an mTICI score ranging from 0 to 2a, and successful recanalization was defined as an mTICI score ranging from 2b to 3. The clinical outcome of the patients was determined by the mRS at 3-month after stroke. The mRS score ≤2 was defined as the favorable outcome, and the mRS score ≥3 was defined as the unfavorable outcome.

The blood samples were drawn by nurses on the next day after EVT and overnight fasting, and FBG was examined using the glucose oxidase method in the laboratory department. The normal FBG level was defined as 3.9–6.1mmol/L.

Statistical Analysis

Statistical Package for the Social Sciences (SPSS) version 22.0 was used for all statistical analyses. The patients were categorized into the older (≥60 years) and younger (<60 years) groups, and patients in each age group were dichotomized into favorable (mRS score 0–2) versus unfavorable outcomes (mRS score 3–6) according to the 3-months mRS score. The normally distributed continuous variables were presented as mean ± standard deviation (SD), and the nonnormally distributed continuous variables were presented as median (interquartile range [IQR]). Comparison of variables between groups was done using t-tests, nonparametric tests, Chi-square tests, or Fisher's exact tests as appropriate. Multivariate binary logistic regression was used to calculate Odds Ratios (OR) and the 95% confidence intervals (CI) for the association between unfavorable outcomes and the variables with $p < 0.05$ from the univariate analysis. A receiver operating characteristic curve analysis was performed between FBG and unfavorable outcome in the group aged ≥60 years.

Results

A total of 504 patients (286 males and 218 females) were included in our study. Three hundred and ninety-two patients (77.8%) belonged to the group aged ≥60 years, and 112 (22.2%) belonged to the group aged <60 years. At the end of the study, 222 (56.6%) patients developed unfavorable outcomes in the older group and 31 (27.7%) showed unfavorable outcomes in the younger group. The demographics and clinical characteristics of patients (total and stratified by age group) are summarized in Table 1.

In the younger (<60 years) group, there was a significant difference between the patients with unfavorable and favorable outcome in TOAST classification (large-artery atherosclerosis, 32.3% vs 54.3%; cardioembolic, 41.9% vs 19.8%; undetermined or others, 25.8% vs 25.9%; $p = 0.038$) and occlusion site (ICA, 61.3% vs 30.9%; MCA 38.7% vs 69.1%; $p = 0.003$). The patients with an unfavorable outcome had higher baseline NIHSS score (16.00 [12.00–20.00] vs 13.00 [10.00–16.00], $p = 0.006$), lower baseline ASPECT score (8.00 [7.00–9.00] vs 9.00 [8.00–10.00], $p = 0.001$), higher prevalence of poor collateral circulation (grade 0, 22.6% vs 6.2%; grade 1, 48.4% vs 17.3%; grade 2, 29.0% vs 76.5%; $p < 0.001$), lower rate of successful recanalization (67.7% vs 90.1%; $p = 0.004$) and higher level of FBG (6.06 [5.13–9.02] vs 5.39 [4.83–6.58], $p = 0.016$) compared with those with favorable outcome (Table 2).

Multivariate logistic regression analysis between variables ($p < 0.05$) and 3-month functional outcomes in the younger group is listed in Table 3. FBG was not independently associated with outcome after adjusting Toast classification, occlusion site, baseline NIHSS score, ASPECT score, collateral circulation, and successful recanalization (OR 1.106, 95% CI 0.884–1.384, $p = 0.376$).

In the older (≥60 years) group, the patients with unfavorable outcome were more likely to be older (74.50 [69.00–79.00] vs 72.00 [66.00–76.00], $p < 0.001$) compared with those with favorable outcome. There was a significant

Table 1 The Demographics and Clinical Characteristics by Age Groups

Parameters	All Patients (n = 504)	≥60 Years (n = 392)	<60 Years (n = 112)	p
Age (years)	70.00 (62.00–76.00)	73.00 (67.00–78.00)	53.00 (49.00 –56.00)	< 0.001
Male, n (%)	286 (56.7)	207 (52.8)	79 (70.5)	0.001
Medical history, n (%)				
Hypertension	336 (66.7)	276 (70.4)	60 (53.6)	0.001
Diabetes mellitus	71 (14.1)	59 (15.1)	12 (10.7)	0.245
Atrial fibrillation	269 (53.4)	242 (61.7)	27 (24.1)	< 0.001
TOAST classification, n (%)				< 0.001
Large-artery atherosclerosis	144 (28.6)	90 (23.0)	54 (48.2)	
Cardioembolic	301 (59.7)	272 (69.4)	29 (25.9)	
Undetermined or others	59 (11.7)	30 (7.7)	29 (25.9)	
Occlusion site, n (%)				0.771
ICA	204 (40.5)	160 (40.8)	44 (39.3)	
MCA	300 (59.5)	232 (59.2)	68 (60.7)	
Baseline NIHSS score	14.00 (12.00–18.00)	15.00 (12.00–18.00)	14.00 (11.00–17.00)	0.022
Baseline ASPECT score	8.00 (8.00–10.00)	8.00 (8.00–9.00)	9.00 (8.00–10.00)	0.003
OTP (minutes)	280.00 (223.00–339.75)	280 (223.00–330.00)	276.50 (222.75–388.00)	0.294
Collateral circulation, n (%)				0.009
Grade 0	92 (18.3)	80 (20.4)	12 (10.7)	
Grade 1	153 (30.4)	124 (31.6)	29 (25.9)	
Grade 2	259 (51.4)	188 (48.0)	71 (63.4)	
mTICI, 2b/3, n (%)	407 (80.8)	313 (79.8)	94 (83.9)	0.334
Unfavorable outcome	253 (50.2)	222 (56.6)	31 (27.7)	< 0.001
FBG (mmol/L)	6.08 (5.10–7.92)	6.31 (5.24–8.01)	5.52 (4.88–6.89)	0.002

Note: The values are presented as n (%), and median (interquartile range).
Abbreviations: ASPECT, Alberta Stroke Program Early CT; FBG, fasting blood-glucose; ICA, internal carotid artery; MCA, middle carotid artery; mTICI, modified thrombolysis in cerebral infarction; NIHSS, National Institutes of Health Stroke Scale; OTP, symptoms onset to groin puncture time; TOAST, the Trial of ORG 10172 in Acute Stroke Treatment.

difference between the patients with unfavorable and favorable outcome in TOAST classification (large-artery atherosclerosis, 17.1% vs 30.6%; cardioembolic, 76.1% vs 60.6%; undetermined or others, 6.8% vs 8.8%; p = 0.003) and occlusion site (ICA, 47.3% vs 32.4%; MCA 52.7% vs 67.6%; p = 0.003). History of hypertension (74.8% vs 64.7%, p = 0.030), diabetes mellitus (18.9% vs 10.0%, p = 0.014) and atrial fibrillation (69.4% vs 51.8%, p < 0.001), higher baseline NIHSS score (16.00 [13.00–19.00] vs 13.00 [11.00–16.00], p < 0.001), lower baseline ASPECT score (8.00 [7.00–9.00] vs 9.00 [8.00–10.00], p < 0.001), higher rate of poor collateral circulation (grade 0, 33.3% vs 3.5%; grade 1, 33.8% vs 28.8%; grade 2, 32.9% vs 67.6%; p < 0.001), lower rate of successful recanalization (72.5% vs 89.4%, p < 0.001), higher level of FBG (7.11 [5.81–9.14] vs 5.54 [4.82–6.95], p < 0.001) were significantly associated with more unfavorable outcome (Table 2).

Multivariate logistic regression analysis showed that baseline NIHSS score (OR 1.097, 95% CI 1.028–1.172, p = 0.005), ASPECT score (OR 0.761, 95% CI 0.631–0.919, p = 0.004), collateral circulation (grade 0 vs grade 1, OR 0.180, 95% CI 0.068–0.477, p = 0.001; grade 0 vs grade 2, OR 0.116, 95% CI 0.045–0.303, p < 0.001), the rate of successful recanalization (OR 0.430, 95% CI 0.219–0.845, p = 0.014) and FBG (OR 1.242, 95% CI 1.096–1.407, p = 0.001) were independently associated with unfavorable outcome in the group aged ≥60 years (Table 4).

The receiver operating characteristic (ROC) curve of FBG in predicting the 3-months unfavorable outcome of the older group is demonstrated in Figure 2. The optimal cutoff point for FBG to predict the outcome of the older patients with AIS after EVT was 5.680 mmol/L (sensitivity of 79.3% and specificity of 57.6%). The area under the curve (AUC) for the ability of FBG level to predict unfavorable outcomes in the patients with age ≥60 years was 0.719 (95% CI 0.668–0.770, p < 0.001).

Table 2 Comparison of Clinical Characteristics in Those with Favorable versus Unfavorable Outcome of the Different Age Groups

Parameters	Aged ≥60 Years		p	Aged <60 Years		p
	Favorable Outcome (n = 170)	Unfavorable Outcome (n = 222)		Favorable Outcome (n = 81)	Unfavorable Outcome (n = 31)	
Age (years)	72.00 (66.00–76.00)	74.50 (69.00–79.00)	< 0.001	53.00 (49.00–56.50)	53.00 (48.00–56.00)	0.527
Male, n (%)	99 (58.2)	108 (48.6)	0.060	61 (75.3)	18 (58.1)	0.073
Medical history, n (%)						
Hypertension	110 (64.7)	166 (74.8)	0.030	42 (51.9)	18 (58.1)	0.555
Diabetes mellitus	17 (10.0)	42 (18.9)	0.014	9 (11.1)	3 (9.7)	0.826
Atrial fibrillation	88 (51.8)	154 (69.4)	< 0.001	16 (19.8)	11 (35.5)	0.082
TOAST classification, n (%)			0.003			0.038
Large-artery atherosclerosis	52 (30.6)	38 (17.1)		44 (54.3)	10 (32.3)	
Cardioembolic	103 (60.6)	169 (76.1)		16 (19.8)	13 (41.9)	
Undetermined or others	15 (8.8)	15 (6.8)		21 (25.9)	8 (25.8)	
Occlusion site, n (%)			0.003			0.003
ICA	55 (32.4)	105 (47.3)		25 (30.9)	19 (61.3)	
MCA	115 (67.6)	117 (52.7)		56 (69.1)	12 (38.7)	
Baseline NIHSS score	13.00 (11.00–16.00)	16.00 (13.00–19.00)	< 0.001	13.00 (10.00–16.00)	16.00 (12.00–20.00)	0.006
Baseline ASPECT score	9.00 (8.00–10.00)	8.00 (7.00–9.00)	< 0.001	9.00 (8.00–10.00)	8.00 (7.00–9.00)	0.001
OTP (minutes)	300.00 (230.00–330.00)	270.00 (210.00–330.00)	0.458	275.00 (222.50–420.00)	280.00 (222.00–360.00)	0.982
Collateral circulation, n (%)			< 0.001			< 0.001
Grade 0	6 (3.5)	74 (33.3)		5 (6.2)	7 (22.6)	
Grade 1	49 (28.8)	75 (33.8)		14 (17.3)	15 (48.4)	
Grade 2	115 (67.6)	73 (32.9)		62 (76.5)	9 (29.0)	
mTICI, 2b/3, n (%)	152 (89.4)	161 (72.5)	< 0.001	73 (90.1)	21 (67.7)	0.004
FBG (mmol/L)	5.54 (4.82–6.95)	7.11 (5.81–9.14)	< 0.001	5.39 (4.83–6.58)	6.06 (5.13–9.02)	0.016

Note: The values are presented as n (%), and median (interquartile range).
Abbreviations: ASPECT, Alberta Stroke Program Early CT; FBG, fasting blood-glucose; ICA, internal carotid artery; MCA, middle carotid artery; mTICI, modified thrombolysis in cerebral infarction; NIHSS, National Institutes of Health Stroke Scale; OTP, symptoms onset to groin puncture time; TOAST, the Trial of ORG 10172 in Acute Stroke Treatment.

https://doi.org/10.2147/NDT.S351725
DovePress

Table 3 Multivariate Logistic Regression for 90-Day Unfavorable Outcome in the Group Aged <60 Years

Parameters	Unfavorable Outcome		
	OR	95% CI	p
TOAST classification			
Large-artery atherosclerosis (reference)			
Cardioembolic	4.284	1.025–17.906	0.046
Undetermined or others	1.860	0.422–8.206	0.412
Occlusion site, n (%)			
ICA (reference)			
MCA	0.269	0.883	0.030
Baseline NIHSS score	1.050	0.920–1.199	0.469
Baseline ASPECT score	0.631	0.426–0.935	0.022
Collateral circulation			
Grade 0 (reference)			
Grade 1	1.004	0.173–5.833	0.997
Grade 2	0.157	0.026–0.970	0.046
mTICI, 2b/3	0.202	0.052–0.777	0.020
FBG (mmol/L)	1.106	0.884–1.384	0.376

Abbreviations: ASPECT, Alberta Stroke Program Early CT; CI, confidence interval; FBG, fasting blood-glucose; ICA, internal carotid artery; MCA, middle carotid artery; mTICI, modified thrombolysis in cerebral infarction; NIHSS, National Institutes of Health Stroke Scale; OR, odds ratio; TOAST, the Trial of ORG 10172 in Acute Stroke Treatment.

Table 4 Multivariate Logistic Regression for 90-Day Unfavorable Outcome in the Group Aged ≥60 Years

Parameters	Unfavorable Outcome		
	OR	95% CI	p
Age	1.031	0.991–1.073	0.126
Hypertension	1.057	0.614–1.818	0.842
Diabetes mellitus	1.262	0.567–2.809	0.569
Atrial fibrillation	1.212	0.563–2.608	0.623
TOAST classification			
Large-artery atherosclerosis (reference)			
Cardioembolic	1.265	0.537–2.980	0.591
Undetermined or others	1.681	0.602–2.691	0.322
Occlusion site, n (%)			
ICA (reference)			
MCA	0.651	0.384–1.105	0.112
Baseline NIHSS score	1.097	1.028–1.172	0.005
Baseline ASPECT score	0.761	0.631–0.919	0.004
Collateral circulation			
Grade 0 (reference)			
Grade 1	0.180	0.068–0.477	0.001
Grade 2	0.116	0.045–0.303	< 0.001
mTICI, 2b/3	0.430	0.219–0.845	0.014
FBG (mmol/L)	1.242	1.096–1.407	0.001

Abbreviations: ASPECT, Alberta Stroke Program Early CT; CI, confidence interval; FBG, fasting blood-glucose; ICA, internal carotid artery; MCA, middle carotid artery; mTICI, modified thrombolysis in cerebral infarction; NIHSS, National Institutes of Health Stroke Scale; OR, odds ratio; TOAST, the Trial of ORG 10172 in Acute Stroke Treatment.

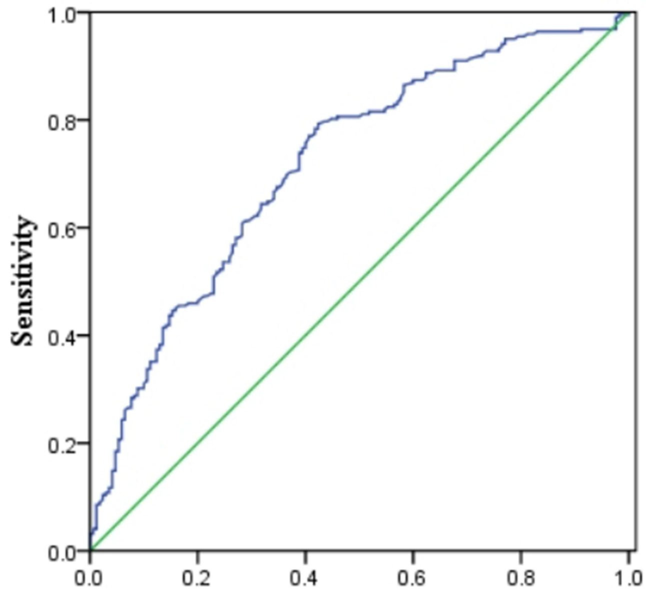

Figure 2 Receiver-operating characteristic (ROC) curve showed predictive fasting blood-glucose for unfavorable outcome in the group aged ≥ 60 years.

Discussion

So far, only a few studies have explored the role of impaired FBG after EVT.[6,7] This is the first study to investigate the association of FBG level with clinical outcome in anterior circulation AIS of different age groups after EVT. We found that higher FBG level increased the risk of unfavorable outcomes independently of established risk factors, such as collateral circulation, successful recanalization, NIHSS, and ASPECT score on admission in the patients with age ≥60 years, but this association was not detected in the group aged <60 years. FBG level of the younger patients was significantly lower than that of older patients. However, a history of diabetes mellitus did not predict unfavorable outcomes in younger or older patients.

Previous studies revealed an association between blood glucose levels and the prognosis of ischemic stroke.[19–23] A study of intravenous thrombolysis showed FBG was a powerful predictor associated with the 90-day outcome of AIS independent of diabetes mellitus history.[12] The pretrial cohort of the Multicenter Randomized Clinical trial of Endovascular Treatment for Acute Ischemic Stroke in the Netherlands (MR CLEAN) found that impaired fasting glucose (IFG) defined as fasting glucose >5.5 mmol/L in the first week after EVT was associated with unfavorable outcomes at discharge.[7] Recent research of Wnuk and his colleagues revealed that fasting hyperglycemia (fasting glycemia >5.5 mmol/L) on the next day after EVT in AIS patients was an independent risk factor for poorer functional outcome.[6] The results of the above studies were similar to those of the older group in our study. However, in the previous literature, all AIS patients were considered as a whole and were not analyzed by age group. The age of the patient was found to be an important factor affecting the prognosis of stroke. Therefore, our study attempted to stratify with age and explore the relationship between FBG level and functional outcome of AIS receiving EVT.

There was some evidence that glucose tolerance deteriorates with age,[13,15,16,18] but other data showed that glucose-stimulated insulin secretion did not significantly alter with age.[17,24] Our study indicated no difference between the older (≥60 years) and younger (<60 years) groups in terms of diabetes mellitus history, but the FBG level of the older patients was significantly higher than that of younger patients. Interestingly, increased FBG level may predict an unfavorable outcome in the older patients after EVT, but no similar effect was seen in the younger patients. We speculated that the result is due to the different characteristics of AIS in different age groups.[3] There was a significant difference in TOAST classification between the older and younger groups. Younger patients had a higher proportion of stroke of undetermined and of other determined etiology, and previous results were generally consistent with our data.[25–27] The older group had more patients with unfavorable outcomes, and higher prevalence of hypertension and atrial fibrillation, higher NIHSS scores, lower rate of collateral circulation and ASPECT scores than the younger group. AIS in the young population accounted for a small proportion of total AIS, and we also considered that the size of younger patients in our study was limited to identifying the association between FBG and prognosis of stroke after EVT in this subgroup, therefore larger studies of younger patients with AIS are needed.

Moreover, the association of FBG after EVT with unfavorable outcomes in the group aged ≥60 years was independent of the history of diabetes. FBG may reflect the interaction of hormones involved in the stress response with concomitant insulin resistance in the case of acute diseases. Previous studies have confirmed that hyperglycemia may lead to increased oxidative stress, inflammatory response, and endothelial dysfunction, resulting in reperfusion injury to the brain tissue.[28–32] Our result suggested that strict blood glucose management might be required in the AIS patients aged ≥ 60 years receiving EVT.

Inevitably, our study has some limitations. First, our study was limited by monocentric design, and the number of patients receiving EVT was insufficient to allow more detailed age groups. Second, we only measured FBG on the next day after admission and did not dynamically monitor FBG during hospitalization. Finally, we did not take into consideration the influence of hypoglycemic drugs used after ischemic stroke.

Conclusions

Our study found that a higher FBG level is an independent risk factor for 3-month unfavorable outcome in the patients aged ≥60 years receiving EVT, but no similar effect was seen in the group aged <60 years. In the future study, we will explore whether appropriate glucose management after EVT benefits older AIS patients.

Data Sharing Statement

The data used to support the findings of this study are available upon reasonable request.

Ethical Approval

Our study was carried out in compliance with the Declaration of Helsinki and approved by the ethics committee of the First Affiliated Hospital of Wannan Medical College (NO. 201900039). Due to the retrospective nature, patient consent was waived. All individual information was strictly kept confidential and anonymous in the manuscript.

Funding

This work was supported by grants from the Research Project of the First Affiliated Hospital of Wannan Medical College (Grant no. YR202012), the Scientific Research Foundation of Wannan Medical College (Grant no. WK2019F20), and the Teaching Research Foundation of Wannan Medical College (Grant no. 2020jyxm79). The funding sources had no role in the design, collection, analysis, or interpretation of data and in writing the manuscript.

Disclosure

The authors declare no conflicts of interest in this work nor regarding the publication of this article.

References

1. Chao BH, Yan F, Hua Y, et al. Stroke prevention and control system in China: CSPPC-Stroke Program. *Int J Stroke*. 2021;16:265–272. doi:10.1177/1747493020913557
2. Tu WJ, Chao BH, Ma L, et al. Case-fatality, disability and recurrence rates after first-ever stroke: a study from bigdata observatory platform for stroke of China. *Brain Res Bull*. 2021;175:130–135. doi:10.1016/j.brainresbull.2021.07.020
3. Hathidara MY, Saini V, Malik AM. Stroke in the young: a global update. *Curr Neurol Neurosci Rep*. 2019;19:91. doi:10.1007/s11910-019-1004-1
4. Powers WJ, Rabinstein AA, Ackerson T, et al. Guidelines for the early management of patients with acute ischemic stroke: 2019 update to the 2018 guidelines for the early management of acute ischemic stroke: a guideline for healthcare professionals From the American Heart Association/American Stroke Association. *Stroke*. 2019;50:e344–e418. doi:10.1161/STR.0000000000000211
5. Lu GD, Ren ZQ, Zhang JX, et al. Effects of diabetes mellitus and admission glucose in patients receiving mechanical thrombectomy: a systematic review and meta-analysis. *Neurocrit Care*. 2018;29:426–434. doi:10.1007/s12028-018-0562-4
6. Wnuk M, Popiela T, Drabik L, et al. Fasting hyperglycemia and long-term outcome in patients with acute ischemic stroke treated with mechanical thrombectomy. *J Stroke Cerebrovasc Dis*. 2020;29:104774. doi:10.1016/j.jstrokecerebrovasdis.2020.104774
7. Osei E, den Hertog HM, Berkhemer OA, et al. Increased admission and fasting glucose are associated with unfavorable short-term outcome after intra-arterial treatment of ischemic stroke in the MR CLEAN pretrial cohort. *J Neurol Sci*. 2016;371:1–5. doi:10.1016/j.jns.2016.10.003

8. Suh SW, Shin BS, Ma H, et al. Glucose and NADPH oxidase drive neuronal superoxide formation in stroke. *Ann Neurol*. 2008;64:654–663. doi:10.1002/ana.21511
9. Kamada H, Yu F, Nito C, et al. Influence of hyperglycemia on oxidative stress and matrix metalloproteinase-9 activation after focal cerebral ischemia/reperfusion in rats: relation to blood-brain barrier dysfunction. *Stroke*. 2007;38:1044–1049. doi:10.1161/01.STR.0000258041.75739.cb
10. Ennis SR, Keep RF. Effect of sustained-mild and transient-severe hyperglycemia on ischemia-induced blood-brain barrier opening. *J Cereb Blood Flow Metab*. 2007;27:1573–1582. doi:10.1038/sj.jcbfm.9600454
11. Kawai N, Keep RF, Betz AL. Hyperglycemia and the vascular effects of cerebral ischemia. *Stroke*. 1997;28:149–154. doi:10.1161/01.STR.28.1.149
12. Cao W, Ling Y, Wu F, et al. Higher fasting glucose next day after intravenous thrombolysis is independently associated with poor outcome in acute ischemic stroke. *J Stroke Cerebrovasc Dis*. 2015;24:100–103. doi:10.1016/j.jstrokecerebrovasdis.2014.07.029
13. Yue F, Zhang G, Tang R, et al. Age- and sex-related changes in fasting plasma glucose and lipoprotein in cynomolgus monkeys. *Lipids Health Dis*. 2016;15:111. doi:10.1186/s12944-016-0280-x
14. Elahi D, Muller DC, McAloon-Dyke M, et al. The effect of age on insulin response and glucose utilization during four hyperglycemic plateaus. *Exp Gerontol*. 1993;28:393–409. doi:10.1016/0531-5565(93)90066-M
15. Akintola AA, van den Berg A, Altmann-Schneider I, et al. Parameters of glucose metabolism and the aging brain: a magnetization transfer imaging study of brain macro- and micro-structure in older adults without diabetes. *Age*. 2015;37:9802. doi:10.1007/s11357-015-9802-0
16. Wilson CH, Shalini S, Filipovska A, et al. Age-related proteostasis and metabolic alterations in Caspase-2-deficient mice. *Cell Death Dis*. 2015;6:e1615. doi:10.1038/cddis.2014.567
17. Ruhe RC, Curry DL, Herrmann S, et al. Age and gender effects on insulin secretion and glucose sensitivity of the endocrine pancreas. *Am J Physiol*. 1992;262:R671–676. doi:10.1152/ajpregu.1992.262.4.R671
18. Burattini R, Di Nardo F, Boemi M, et al. Deterioration of insulin sensitivity and glucose effectiveness with age and hypertension. *Am J Hypertens*. 2006;19:98–102. doi:10.1016/j.amjhyper.2005.07.001
19. Tanaka R, Ueno Y, Miyamoto N, et al. Impact of diabetes and prediabetes on the short-term prognosis in patients with acute ischemic stroke. *J Neurol Sci*. 2013;332:45–50. doi:10.1016/j.jns.2013.06.010
20. Jia Q, Liu G, Zheng H, et al. Impaired glucose regulation predicted 1-year mortality of Chinese patients with ischemic stroke: data from abnormal glucose regulation in patients with acute stroke across China. *Stroke*. 2014;45:1498–1500. doi:10.1161/STROKEAHA.113.002977
21. De Silva DA, Ebinger M, Christensen S, et al. Baseline diabetic status and admission blood glucose were poor prognostic factors in the EPITHET trial. *Cerebrovasc Dis*. 2010;29:14–21. doi:10.1159/000255969
22. Yao T, Zhan Y, Shen J, et al. Association between fasting blood glucose and outcomes and mortality in acute ischaemic stroke patients with diabetes mellitus: a retrospective observational study in Wuhan, China. *BMJ open*. 2020;10:e037291. doi:10.1136/bmjopen-2020-037291
23. Osei E, Fonville S, Zandbergen AA, et al. Glucose in prediabetic and diabetic range and outcome after stroke. *Acta Neurol Scand*. 2017;135:170–175. doi:10.1111/ane.12577
24. Tura A, Pacini G, Moro E, et al. Sex- and age-related differences of metabolic parameters in impaired glucose metabolism and type 2 diabetes compared to normal glucose tolerance. *Diabetes Res Clin Pract*. 2018;146:67–75. doi:10.1016/j.diabres.2018.09.019
25. Smajlovic D. Strokes in young adults: epidemiology and prevention. *Vasc Health Risk Manag*. 2015;11:157–164. doi:10.2147/VHRM.S53203
26. van Alebeek ME, Arntz RM, Ekker MS, et al. Risk factors and mechanisms of stroke in young adults: the FUTURE study. *J Cereb Blood Flow Metab*. 2018;38:1631–1641. doi:10.1177/0271678X17707138
27. Gokcal E, Niftaliyev E, Asil T. Etiological classification of ischemic stroke in young patients: a comparative study of TOAST, CCS, and ASCO. *Acta Neurol Belg*. 2017;117:643–648. doi:10.1007/s13760-017-0813-8
28. Luc K, Schramm-Luc A, Guzik TJ, et al. Oxidative stress and inflammatory markers in prediabetes and diabetes. *J Physiol Pharmacol*. 2019;70. doi:10.26402/jpp.2019.6.01
29. Fiorentino TV, Prioletta A, Zuo P, et al. Hyperglycemia-induced oxidative stress and its role in diabetes mellitus related cardiovascular diseases. *Curr Pharm Des*. 2013;19:5695–5703. doi:10.2174/1381612811319320005
30. Nie Q, Zhu L, Zhang L, et al. Astragaloside IV protects against hyperglycemia-induced vascular endothelial dysfunction by inhibiting oxidative stress and Calpain-1 activation. *Life Sci*. 2019;232:116662. doi:10.1016/j.lfs.2019.116662
31. Meza CA, La Favor JD, Kim DH, et al. Endothelial dysfunction: is there a hyperglycemia-Induced Imbalance of NOX and NOS? *Int J Mol Sci*. 2019;20:3775. doi:10.3390/ijms20153775
32. Amin EF, Rifaai RA, Abdel-Latif RG. Empagliflozin attenuates transient cerebral ischemia/reperfusion injury in hyperglycemic rats via repressing oxidative-inflammatory-apoptotic pathway. *Fundam Clin Pharmacol*. 2020;34:548–558. doi:10.1111/fcp.12548