RESEARCH PAPER

Neurologia i Neurochirurgia Polska
Polish Journal of Neurology and Neurosurgery
2022, DOI: 10.5603/PJNNS.a2022.0063

ISSN: 0028-3843, e-ISSN: 1897-4260

Relevance of admission hyperglycaemia and diabetes mellitus to efficacy and safety of mechanical thrombectomy in stroke patients

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ABSTRACT

Introduction. The relevance of diabetes mellitus (DM) to the efficacy of mechanical thrombectomy (MT) has been the subject of few studies and with only inconclusive results.

Objectives. This study aimed to evaluate the effect of DM and admission hyperglycaemia on the efficacy and safety of MT in stroke patients.

Material and methods. This retrospective study analysis focused on the relevance of admission hyperglyacemia and DM to the functional status of patients treated with MT at the Upper Silesian Medical Centre of the Silesian Medical University in Katowice, Poland.

Results. 417 stroke patients (median age 70 years) were qualified for the study. There were 103 patients (24.70%) with DM. Admission hyperglycaemia ≥ 140 mg% was found in 91 patients (21.82%), of whom 69 were diagnosed with DM before or during hospitalisation. The parameters with the strongest effect on the functional status on days 7, 90 and 365 were: age, and neurological status according to the National Institutes of Health Stroke Scale (NIHSS) on the first day of ischaemic stroke before MT. The angiographic effect indirect after MT and patient functional status on days 7, 90 and 365 were comparable between the groups, regardless of the DM burden. The frequency of symptomatic intracranial bleeding 24 hours after MT was comparable between patients with and patients without DM ($p = 0.092$).

Model based on parameters were age, NIHSS on the first day of ischaemic stroke, an when score in Thrombolysis In Cerebral Infarct (TICI) showed good predictive attributes for the functional status of patients in the acute period (day 7). Age, a lack of admission hyperglycaemia, and the neurological state on day 1 of ischaemic stroke (before MT) were the key parameters for a favourable outcome (≤ 2 points on the modified Rankin Scale, mRS) on day 90. Admission hyperglycaemia ≥ 140 mg/dL, regardless of the presence or absence of DM, had a negative effect on achieving a good functional status one week after stroke onset.

Conclusions. Diabetes mellitus has a neutral effect on the angiographic and clinical outcomes of mechanical thrombectomy in stroke patients. It does not increase the risk of intracranial haemorrhage after instrumental therapy. It is admission hyperglycaemia, rather than diabetes mellitus, that is a predictor of poor functional status in patients treated with thrombectomy. According to our results, the patient's neurological status, age, and the outcome of thrombectomy are relevant to the functional status in the acute ischaemic stroke period.

Key words: stroke, thrombectomy, diabetes mellitus, mRankin, NIHSS

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Received: 27.03.2022 Accepted: 12.09.2022 Early publication date: 17.11.2022

Introduction

Over the last five years, the evidence for the efficacy and safety of endovascular therapy in patients with stroke related to large vessel occlusion (LVO) has been growing. Recanalisation resulting from mechanical thrombectomy has been observed in up to 92% of patients, although only 46% of those were fully independent three months later [1, 2]. The main cause of failure is arterial reocclusion despite a previous successful angiographic result directly following an instrumental restoration of arterial patency. This applies to 9% of patients in the first 24 hours after MT [3–6]. DM increases the risk of stroke and of neurological deterioration in the acute phase of stroke, and the risk of stroke recurrence is also present [7–9]. It increases the risk of bleeding complications post-thrombolysis [10]. DM causes endothelial damage and impairment of cerebrovascular reactivity [11–14]. Metabolic disorders associated with DM, regardless of diabetic angiopathy, can adversely affect the nervous tissue during acute ischaemia. Previous studies have identified DM and hyperglycaemia on admission as important predictors affecting the outcomes in stroke patients treated with recanalisation therapies [15–17]. Hyperglycaemia in acute ischaemic stroke increases the risks of haemorrhagic transformation of an infarct focus, of haemorrhage following thrombolysis, and of death in the short-term follow-up after stroke [7, 10, 16, 18]. A probable mechanism for the adverse effects of hyperglycaemia is associated with increased blood-brain barrier permeability, impaired cerebrovascular reactivity, and increased susceptibility to reperfusion injury [18]. Negative effects concerning hyperglycaemia on metabolic processes in the penumbra can also be significant. Therefore, we should suspect that hyperglycaemia could impact upon the effect of mechanical thrombectomy and be relevant to the functional status of the patient, especially in the acute period. Patients with admission hyperglycaemia and hyperglycaemia on the first day of stroke significantly less frequently return to a favourable functional status following MT than do those with normal admission glycaemia [19].

In recent years, the effects of stress hyperglycaemia (SH) due to stroke in patients burdened with DM, and in those with no such burden, have been receiving some attention [20–22]. The phenomenon of SH has not been investigated in depth. The mechanisms of the effect of SH and DM-related hyperglycaemia on neural tissue are different, and the clinical sequelae in stroke patients may vary. Determining the impact of hyperglycaemia and DM on MT outcomes might modify the selection criteria for endovascular stroke therapy. It could also allow us to optimise the management of hyperglycaemic therapy in the acute stroke period.

The purpose of this study was to evaluate the effect of DM and hyperglycaemia upon hospital admission, and on the efficacy and safety of MT in patients with acute ischaemic stroke associated with LVO.

Material and methods

This retrospective study included patients hospitalised in the Upper Silesian Medical Centre of the Silesian Medical University in Katowice between 2019 and 2021 because of stroke. The patients met the main criterion — they suffered from stroke in the course of large vessel occlusion and they were treated with MT within six hours following stroke onset. We did not qualify cases with incomplete medical data. In this study, all patients were analysed based on age at the time of their first stroke, the presence of comorbidities (DM, atrial fibrillation (AF), arterial hypertension (AH), coronary heart disease (CHD), lipid disorders (LD), > 70% atherosclerotic carotid artery stenosis (CAS, ipsilaterally to the acute ischaemic brain lesion), peripheral artery disease (PAD) in lower extremities, blood glucose concentration when admitted to hospital, the angiographic effect according to the score in TICI directly after MT, and the rate of intracranial bleeding (ICB) after MT including symptomatic ICB (sICB). Neurological status on the first day of stroke was evaluated using the NIHSS and the functional status according to the mRS was examined on days 7, 90 and 365 after stroke, in accordance with the mRS scale.

AF was diagnosed on the basis of previous patient records or electrocardiogram (ECG), or 24-hour ECG monitoring performed during stroke-related hospitalisation.

AH was diagnosed in accordance with the recommendations of the European Society of Cardiology [23]. The diagnosis of DM was based on previous medical history or it was made by a diabetologist during hospitalisation. Diagnostic criteria for DM included the following: a fasting plasma glucose level ≥ 126 mg/dL (7.0 mmol/L), or 2-hour plasma glucose level ≥ 200 mg/dL (11.1 mmol/L) during a 75-g oral glucose tolerance test, or a random plasma glucose level ≥ 200 mg/dL (11.1 mmol/L) in a patient with classic symptoms of hyperglycaemia, or a haemoglobin A1c (HbA1c) level ≥ 6.5%. Blood glucose level ≥ 140 mg/dL on admission to hospital was defined as admission hyperglycaemia. A diabetologist consulted each patient with incorrect admission glycaemia (≥ 140 mg/dL).

LD were defined according to the ESC Guidelines for the Management of Dyslipidemias. LD were diagnosed when at least one of the following features was present: hypercholesterolemia with total cholesterol concentration ≥ 5 mmol/ml (≥ 190 mg/dL) or LDL-C ≥ 3 mmol/l (≥ 115 mg/dL) and/ or hypertriglyceridemia with triglyceride concentration ≥ 1.7 mmol/l (≥ 150 mg/dL).

The NASCET (North American Symptomatic Carotid Endarterectomy Trial) criteria were used to assess the degree of stenosis of the common carotid artery and/or internal carotid artery.

Haemorrhagic lesions were evaluated based on a head CT performed 24 hours after MT and using the European Cooperative Acute Stroke Study (ECASS) scale. ICB was defined as symptomatic when the neurological status deteriorated due to ICB, with an increase of at least 4 points on the NIHSS during the 24 hours following MT (i.e. the difference between the NIHSS evaluated before MT and 24 hours after the procedure).

Explanation of mechanical thrombectomy method

The hospital's Interventional Neuroradiology Department performed the mechanical thrombectomy procedures using a Siemens Axiom Artis Zee Bi-Plane machine, a state-of-theart device. Alternatively, if the angiosuite was unavailable, a monoplane machine was available for the procedure to be performed in the Vascular Surgery Cath-lab or the Interventional Cardiology Cath-lab. The patient underwent general anaesthesia or conscious sedation in accordance with their preference and/or clinical condition. MT was performed by a single operator who was part of a multidisciplinary team composed of two neuroradiologists, three vascular surgeons, and four interventional cardiologists. Neurologists initially qualified the patients, arranged the logistics, and provided postoperative care.

MT was commonly performed with stent retrievers (Trevo, Catch, Soliter, Tiger) and an 8F Balloon Guide Catheter (Flow Gate 2). In a few cases, distal aspiration (Penumbra, Sofia, Cathalist) or a combination of stent retrievers and distal aspiration was used.

After consulting a legal opinion, the approval of the Bioethics Committee of the Medical University of Silesia in Katowice was not required, since this study was not a medical experiment.

Statistical analysis

The prevalence of comorbidities or specific conditions listed above was assessed among all the patients, and after dividing them into those with DM and those without it. The results obtained in the mentioned groups were compared.

Multivariate analysis was then performed to identify the factors which were important for obtaining a good angiographic effect (TICI = 2b-3) after MT, as well as those concerning the functional status of all the patients and of those with DM on days 7, 90 and 365.

We constructed multivariable models using ordinal logistic regression for ordinal outcomes. Model variable selection procedures covered automatic selection (stepwise, forward and backward) as determined in accordance with the AIC and BIC criteria. The accuracy of model predictions was evaluated by implementing the multiclass AUC estimator and the leave-one-out procedure. R 3.6.1 was used to perform all statistical analyses.

Logistic regression was used to analyze the following variables: age, sex, AF, AH, CHD, DM, LD, > 50% CAS, smoking, TICI, PAD, sICD after intervention, NIHSS before MT, recombinant tissue plasminogen activator (rtPA), pre-stroke anticoagulation, pre-stroke antiplatelet therapy, hemicraniectomy, and glycaemia ≥ 140 mg% upon admission. These same parameters were analysed as being independent factors for a good functional state (mRS ≤ 2) of stroke patients on three time points after MT (i.e. on days: 7, 90, and 365 after stroke onset). An analysis of the potential impact of admission hyperglycaemia as well as of DM on the functional status at two time points (days 7 and 90) was also performed.

The size of each subgroup was determined using Chi squared power calculation, i.e. by assuming a significance level of 0.05, we calculated that to achieve the test power of 0.8, each of the groups would have 54 patients. The condition was met, but not for the group with hyperglycaemia, and we recommend careful interpretation of the results.

Results

Our study eventually enrolled 417 patients treated with mechanical thrombectomy for cerebral stroke. A total of 421 stroke patients, median age 70 years (range 20–92), 47.7% of them female, who were admitted and hospitalised in 2019–2021 and who were treated in the ultra-acute ischaemic stroke period (≤ 6 hours) with mechanical thrombectomy, were initially qualified for the retrospective study. We excluded (because of incomplete medical records) four patients who underwent MT. Of the 417 patients included, 254 (61.2%) were treated with rtPA + MT.

The study group included 134 (32.13%) patients undergoing antithrombotic therapy. Because of AF, 55 (13.18%) patients used anticoagulation therapy (for at least one month before MT) — 24 patients were using warfarin, 16 were using rivaroxaban, eight were using dabigatran, and seven were using apixaban. The correct therapeutic results of INR (2.5–3.2) were observed in 16 patients (66.6% of whom used warfarin). The other 79 (18.94%) patients used antiplatelet therapy including aspirin — 51 (12.23%) in monotherapy, 16 (3.83%) clopidogrel, and 12 (2.87%) a duotherapy of aspirin with clopidogrel.

103 patients with DM were included in the study group (24.70%). DM patients were not significantly different from DM-free patients in terms of their mean age. The mean duration of DM (from the time of diagnosis) in the study group was 12 years [0–21 years]. 23 patients with DM (21.35%) had used insulin therapy before stroke onset. Mean blood glucose upon hospital admission was 87 mg/dL [79–419 mg/dL], and in diabetic patients it was 129 mg/dL [81–419 mg/dL]. Hyperglycaemia ≥ 140 mg/dL was found in 91 patients (21.82%), of whom 69 were diagnosed with DM before or during hospitalisation, including two diagnosed with DM associated with chronic steroid therapy. In seven individuals (1.67%), hyperglycaemia was present upon admission but disappeared completely in the three days following stroke onset. In these cases, we identified probable stroke-associated hyperglycaemia.

The patients with DM were burdened with AF, PAD, AH and LD significantly more often than those without DM (Tab. 1).

Table 1. Characteristics of patients with and without diabetes mellitus

Parameters	All patients n = 417	DM patients n = 103	Patients without DM n = 314	FDR-adjusted p-value (DM patients vs. patients without DM)
Age [mean ± SD] mean [med. range]	67.8 ± 13.2 70 [20–92]	70.70 ± 10.46 70 [42–92]	66.82 ± 13.92 69 [20–89]	0.138
F/M	199/218	53/50	146/168	0.670
AF	108 (26.0%)	36 (34.95%)	72 (22.92%)	0.015
AH	315 (75.5%)	90 (87.37%)	218 (69.42%)	< 0.001
LD	168 (40.4%)	48 (46.6%)	104 (33.12%)	0.013
PAD in lower limbs	216 (51.79%)	67 (65.04%)	149 (47.45%)	< 0.001
CAS	51 (12.1%)	13 (12.62%)	29 (9.23%)	0.32
Previous TIA/stroke burden	89 (21.3%)	21 (20.38%)	68 (21.65%)	0.42
Smoking	126 (30.2%)	39 (37.86%)	87 (27.70%)	0.29
NIHSS mean [med. range]	12.8 ± 5.6 12 [0–43]	13.50 ± 5.68 [13; 3–30]	12.61 ± 5.52 [12; 0–43]	0.385
rtPA	254 (61.2%)	59 (57.28%)	196 (62.42%)	0.670
Hemicraniectomy	23 (5.5%)	3 (2.91%)	20 (6.36%)	0.548
Antithrombotic therapy before stroke	134 (32.1%)	44 (42.71%)	90 (28.66%)	0.099
Stroke in summer season	225 (53.95%)	56 (54.36%)	169 (53.82%)	1
TICI 2b-3	274	67 (65.04%)	207 (65.92%)	1
sICB	95	31 (30.09%)	64 (20.38%)	0.092
mRS_7d	3.93 ± 1.69	4.05 ± 1.69	3.82 ± 1.77	0.548
mRS_90d	3.77 ± 1.86	3.94 ± 1.87	3.62 ± 1.93	0.372
mRS_12m	3.82 ± 1.71	4 ± 1.82	3.65 ± 1.91	0.349

AF — atrial fibrillation; AH — arterial hypertension; CAS — carotid artery stenosis; EF — ejection fraction; F — female; FDR — false discovery rate; LD — lipid disorders; M — male; NIHSS — National Institutes of Health Stroke Scale at baseline; PAD — peripheral artery disease; rtPA — recombinant tissue plasminogen activator; sICB — symptomatic intracranial bleeding; mRS — modified Rankin Scale; mRS_7 — modified Rankin Scale on 7th day after stroke; mRS_90 — modified Rankin Scale on 90th day after stroke; mRS_12m — modified Rankin Scale 12 months after stroke; TICI — thrombolysis in cerebral infarction

Patient functional status on days 7, 90 and 365 was comparable between groups regardless of the DM burden. The burden of the sICB was comparable between patients with and without DM (Tab. 1).

Age, lack of admission hyperglycaemia, and neurological state according to NIHSS on the 1st day of stroke (before MT) were the key parameters for a favourable outcome on day 90 (Tab. 2).

We did not identify the important parameters for obtaining the TICI 2b-3 by analysing the same parameters as listed in the tables above (Suppl. Tab. 1).

In multivariate analysis related to all of the patients, the parameters with the strongest effect on the functional status on days 7, 90 and 365 were: age and NIHSS on the first day of stroke before MT. The model based on attributes: age, NIHSS on the first day of stroke, TICI showed good predictive attributes for the functional status of patients in the acute period (day 7) (Tab. 3).

DM burden was not a statistically significant independent factor for the functional status at the three time-points under study: on days 7, 90 and 365 after the onset (Tab. 3, Suppl. Fig. 1). Hyperglycaemia ≥ 140 mg/dL upon hospital admission, regardless of the presence or absence of DM, had a negative effect on achieving a good functional status one week after onset (Table 4). Admission hyperglycaemia had a neutral impact on the functional state on day 90 (Tab. 4).

In univariate analysis related to diabetic patients with admission hyperglycaemia, the following key factors were identified for achieving a good functional state: NIHSS score before MT for a good functional state on day 7 (FDR-adjusted p-value = 0.018), and a lack of peripheral artery disease for a good functional state on day 90 (FDR-adjusted p-value = 0.033). In diabetic patients without admission hyperglycaemia, we did not identify any independent parameter with a strong effect on functional status on day 7, and we identified only one factor for obtaining a good status on day 90 i.e. the NIHSS score before MT (FDR-adjusted p-value = 0.013).

Discussion

The main finding of our study is that admission hyperglycaemia in the ultra-acute period of stroke, and not the presence of DM, is an *a priori* parameter relevant to the

Table 2. Characteristics of patients with good and poor functional status according to mRS on 90th day after mechanical thrombectomy

Parameters	All patients n = 417	Patients with 0-2 mRS n = 120	Patients with 3-6 mRS n = 297	FDR-adjusted p-value
Age [mean ± SD] mean [med. range]	67.8 ± 13.2 70 [20–92]	64.83 ± 13.02 67 [23–89]	68.96 ± 13.17 72 [20–92]	0.009
F/M	199/218	552/68	147/150	0.631
AF	108 (26.0%)	29 (24.16%)	79 (26.59%)	0.752
AH	308 (75.5%)	85 (79.83%)	223 (75.08%)	0.752
LD	152 (40.43%)	43 (35.83%)	109 (36.7%)	0.752
PAD in lower limbs	216 (52.94%)	67 (55.83%)	149 (50.16%)	0.603
CAS	42 (12.1%)	10 (8.33%)	32 (10.77%)	0.631
Smoking	115 (37.1%)	29 (24.16%)	86 (28.95%)	0.631
Hyperglycaemia	31 (7.43%)	1 (0.83%)	30 (10.10%)	0.012
DM	103 (25.31%)	24 (20%)	79 (26.59%)	0.557
NIHSS mean [med. range]	12.8 ± 5.6 12 [0–43]	9.96 ± 4.96 [0–26]	13.99 ± 5.39 [3–43]	< 0.001
rtPA	255 (61.45%)	76 (63.33%)	179 (60.26%)	0.752
Hemicraniectomy	23 (5.52%)	2 (1.66%)	21 (7.07%)	0.238
Antithrombotic therapy before stroke	134 (32.13%)	36 (30%)	98 (32.99%)	0.752
Stroke in summer season	225 (53.96%)	69 (57.5%)	156 (52.52%)	0.646
Stroke onset to groin puncture time mean [med. range]	255.3 ± 67.44 255 [5–405]	245.7 ± 73.30 [5–395]	259.1 ± 64.78 [72–405]	0.361

AF — atrial fibrillation; AH — arterial hypertension; CAS — carotid artery stenosis; EF — ejection fraction; F — female; FDR — false discovery rate; LD — lipid disorders, M — male; NIHSS — National Institutes of Health Stroke Scale at baseline; PAD — peripheral artery disease; rtPA — recombinant tissue plasminogen activator

Table 3. Ordinal regression analysis of influence of clinical phenodata on mRS (0–2 points) — 7th day, 90th day and 12th month after stroke onset

Coefficients	OR	CI 95%	p-value
mRS- 7th day (mcAUC = 0.769, AIC = 128.06)			
Age	1.034	(1.009–1.06)	< 0.01
NIHSS 1d	1.103	(1.039–1.174)	< 0.01
TICI	0.506	(0.255–0.976)	0.04
mRS 90th day (mcAUC = 0.707, AIC = 98.48)			
Age	1.082	(1.032–1.143)	< 0.01
NIHSS 1d	1.269	(1.124–1.461)	< 0.0001
TICI	0.294	(0.08–1.002)	0.05
mRS 12th month (mcAUC = 0.704, AIC = 94.87)			
Age	1.098	(1.038–1.171)	0.0002
NIHSS	1.269	(1.107–1.495)	0.002

DM — diabetes mellitus; LD — lipid disorders; mRS — modified Rankin Scale; NIHSS 1d — NIHSS on the 1st day of stroke; TICI — thrombolysis in cerebral infarction

Table 4. Admission hyperglycaemia and functional state in diabetic and non-diabetic patients

Parameter	Groups	Chisq	Chisq FDR corrected p- value
mRS 7th day			
Admission hyperglycaemia	mRS < 3 *vs.* mRS ≥ 3	0.013	0.009
DM/admission hyperglycaemia	mRS< 3 *vs.* mRS ≥ 3 in DM+ *vs.* DM-	9.28E–05	0.046
mRS 90th day			
Admission hyperglycaemia	mRS < 3 *vs.* mRS ≥ 3	6.18E–06	0.133
DM/admission hyperglycaemia	mRS < 3 *vs.* mRS ≥ 3 in DM+ *vs.* DM-	5.36E–06	0.124

DM — diabetes mellitus; FDR — false discovery rate; mRS — modified Rankin Scale

clinical effect of MT as expressed by the functional status of patients in the acute period of stroke.

In this respect, the results of our study have confirmed previous observations made by other authors. But what is new is the finding that the presence of DM is not a sufficient parameter to influence the effect of MT, except when the patient's admission hyperglycaemia is above the threshold value adopted in this study. Only in combination with the neurological status, patient age, and angiographic outcome of thrombectomy was DM significant for the functional status in the acute ischaemic stroke period.

Until now, several independent factors for an unfavourable prognosis of patient functional status have been identified at three months following MT performed for cerebral stroke

These factors include an older patient's age, a low Alberta Stroke Program Early CT Score (ASPECTS), and a high NIHSS score [25, 26]. The data related to the significance of the other clinical parameters, as well as logistic parameters and technical aspects related with MT, are inconsistent or are still under evaluation [24, 26, 27]. In the last three years, there has been an increase in publications discussing the effect of DM on MT outcomes. DM and hyperglycaemia at hospital admission have been shown to have a negative effect; however, the results of previous studies are inconsistent [16, 17, 25, 28–31]. DM was identified via the GADIS score as being a significant factor for those associated with poor functional status of stroke patients treated with thrombectomy [32]. DM is not only a risk factor for atherosclerosis and stroke, but also for stroke recurrence and an early neurological deterioration in acute ischaemic stroke patients [7–9].

It is believed that due to coagulation-fibrinolysis imbalance and incorrect platelet activity, patients with DM are in a state of chronic hypercoagulability [33, 34]. Hyperglycaemia correlates with an increase in the volume of brain infarct in patients who have been subjected to thrombolytic therapy [10]. DM also increases the risk of haemorrhagic transformation of cerebral infarction in patients who have undergone thrombolysis and MT [35]. In diabetic patients, the hyperglycaemic environment contributes to poor development of collaterals (and volume of the infarct focus) [36]. Collateral failure is a result of diabetic microangiopathy. Borggrefe et al. have shown that the condition of collaterals is associated with hyperglycaemia in stroke patients [25]. The disease can impair revascularisation and reperfusion and it can increase reperfusion injury to neural tissue [36]. In our study, we did not determine an increase in the incidence of intracerebral haemorrhage in diabetic patients on the first day after MT.

According to data published previously, in stroke patients treated with MT the risk of intracranial haemorrhage is associated with some admission parameters, including hyperglycaemia, but not with a history of DM [37–39]. The cumulative outcome of the effect of the chronic influence of hyperglycaemia in DM and of the acute influence of MT on the endothelium may account for poorer outcomes in this patient group and for long-term follow-up results. The effect of hyperglycaemia on the structure of a thrombus occluding a large artery should also be taken into consideration. The structure of a thrombus obtained during MT from patients with DM and stroke has dominant fibrin, instead of the red blood cells which are typical for thrombus in non-diabetic patients [29]. Most probably, the composition of thrombus in DM patients makes it harder to mechanically remove it or aspirate it, which is important for the prognosis of post-stroke condition in such patients.

According to an analysis of the SWIFT trial results, hyperglycaemia increases the risk of a worse outcome at three months in post-stroke patients [40]. In the MR CLEAN study, admission hyperglycaemia (141 mg/dL) and fasting glucose (99 mg/ dL) seriously increased the risk of symptomatic intracranial haemorrhage and poor functional status [41]. According to these reports, an admission glucose level > 110 mg/dL is associated with a low rate of good clinical outcomes after MT, and glucose levels > 170 mg/dL are associated with a high risk of parenchymal haematoma [42].

Hyperglycaemia can be also caused by stress resulting from stroke. In this case, hyperglycaemia is not associated with the metabolic processes observed in DM, such as insulin resistance increasing plasminogen activator inhibitor secretion and modifying fibrinolytic activity. SH is mediated by the hypothalamic–pituitary–adrenal axis, the sympatho-adrenal system, and pro-inflammatory cytokines that cause a stress response with excessive gluconeogenesis, glycogenolysis, and insulin resistance [43].

While diabetes mellitus is a recognised risk factor for cerebrovascular diseases, the consequences of stress hyperglycaemia are not well-established. However, stress hyperglycaemia has been shown to have a negative impact on the post-stroke functional status of patients [20–22]. The mechanisms underlying the association between SH and poor clinical outcomes in stroke patients are not completely understood. Hyperglycaemia might directly cause toxic damage to the ischaemic brain due to the accumulation of lactate and intracellular acidosis; the stress-induced inflammatory response may increase circulating free fatty acids in patients with acute illnesses, thus impairing endothelium-dependent vasodilation, and SH may lead to reperfusion injury due to increased oxidative stress and inflammation [44–46]. Hyperglycaemia may augment endothelial damage at the site of contact between the endothelium and the tools used during thrombectomy.

The phenomenon of hyperglycaemia, although not fully understood as such, is both interesting and important from a practical perspective. This supports a strategy of glycaemic monitoring starting immediately after the stroke. The American Heart Association recommends close glucose monitoring on the first day of stroke in patients with values higher than 140 mg/dL [47]. Regardless of all the supporting data, the Cochrane review found that insulin therapy to keep glucose levels within normal range has no long-term benefit for the neurological status or mortality parameters, and that it increases the incidence of hypoglycaemic episodes [48].

This demonstrates that diabetic patients with acute ischaemic stroke face complex problems beyond, and independentof, the other well-known modifiable and unmodifiable parameters related to all stroke patients [49, 50].

Our study has some limitations, the most important being as follows: this was a single-center study and a retrospective study; we made no comparison between MT effects and thrombectomy types, and there was a lack of information concerning the use of statins before stroke. The majority of patients (274; 65.7%) were referred to us from other hospitals (the so-called drip-and-ship model) without complete data.

Conclusions

Diabetes mellitus has a neutral effect on the angiographic and clinical outcomes of mechanical thrombectomy in stroke patients. It does not increase the risk of intracranial haemorrhage after instrumental therapy. It is admission hyperglycaemia, and not diabetes mellitus, that is a predictor of poor functional status in patients treated with thrombectomy. According to our results, the patient's neurological status, age, and the outcome of thrombectomy, are the factors relevant to the functional status in the acute ischaemic stroke period.

Conflict of interest: *None.*
Funding: *None.*

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