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RESEARCH

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Predictors of three months mortality after endovascular mechanical thrombectomy for acute ischemic stroke

Wafaa M. Farghaly[1], Mohamed A. Ahmed[1], Ahmed El-Bassiouny[2], Ahmed A. Hamed[1] and Ghaydaa A. Shehata[1*]

Abstract

Objective: This study aims to determine predictive factors of mortality within 3 months after mechanical thrombectomy (MT) for patients with acute ischemic stroke (AIS).

Methods: This prospective cohort study was carried out at Assiut University stroke center in collaboration with Ain Shams University Egypt. Forty-four patients with anterior circulation AIS underwent MT between the first of January 2020 to the end of December 2020. They were evaluated for detection of death rates and identification of risks of 3-month mortality after MT.

Results: This study comprised 44 patients (52.3% male) with a mean age of 64.3 years. The mean time from onset to femoral arterial puncture was 304.1 min. The mean Alberta Stroke Program Early CT Score (ASPECTS) and National Institutes of Health Stroke Scale (NIHSS) score were 9.3 and 19.2, respectively. The 3-month mortality rate was 13.6%. Univariate analyses found that higher baseline NIHSS score (mean 22.2 vs. 18.7, $p = 0.021$), absence of good collateral (16.7% vs. 68.4%, $p = 0.02$), longer duration of procedure ≥ 60 min (66.7% vs. 23.7%, $p = 0.032$), lower rates of successful recanalization (83.3% vs. 28.9%, $p = 0.01$) and developing symptomatic intracerebral hemorrhage (33.3% vs. 5.3%, $p = 0.026$) were associated with 3-month mortality. Multivariate analyses found that low rates of successful recanalization (OR 0.081; 95% CI 0.009–0.780, $p = 0.030$) remained significant independent predictive factor of 3-month mortality.

Conclusion: Successful recanalization was an independent predictor of 3-month mortality after MT.

Keywords: Stroke, Mortality, Large vessel occlusion, Thrombectomy, Endovascular

Introduction

Acute ischemic stroke (AIS) is one of the most common causes of disability and death in developing countries [1]. In Egypt, the prevalence of ischemic stroke was 797 of 100,000 [2].

Randomized controlled trials (RCTs) have confirmed the efficacy of mechanical thrombectomy (MT) in patients with AIS caused by large vessel occlusions within 6 h from symptom onset [3–7]. Recently the time extended to 24 h from symptom onset with a good mismatch between infarct core and ischemic penumbra [8, 9].

Lack of neuro-interventionists, comprehensive stroke units, stroke triage systems, and high treatment cost are the major barriers to broader accessibility of endovascular thrombectomy (EVT) among developing countries [10].

*Correspondence: ghaidaa.abozaid@med.aun.edu.eg; ghaydaa83@yahoo.com

[1] Department of Neurology and Psychiatry, Faculty of Medicine, Assiut University, Assiut 71515, Egypt
Full list of author information is available at the end of the article

Randomized controlled trials have proven a notable improvement in functional independence rates after EVT. However, these trials have not demonstrated any change in the death rate after EVT compared to medical treatment [11].

Despite a lot of research concerned with predictors of disability after MT, studies focused on predictors of mortality are limited [12–16]. Therefore this study aims to determine predictive factors of mortality within 3 months after MT.

Patients and methods

Patients

This prospective cohort study, registered trial (NCT03608644), was carried out at Assiut University stroke center in collaboration with Ain Shams University Egypt. Forty-four patients with anterior circulation AIS underwent MT between the first of January 2020 to the end of December 2020. The inclusion criteria were as follows: (1) age ≥ 18 years; (2) The National Institutes of Health Stroke Scale score (NIHSS) of ≥ 6; (3) cerebral infarction in the anterior circulation (internal carotid artery (ICA), middle cerebral artery (MCA) M1 segment, or both); (4) access to EVT within 6 h from onset.

The medical ethical review board of Assiut and Ain Shams University approved the study—approval number 17200215, and we obtained informed consent from the patients and/or their relatives. Patients who had a history of old stroke with a disability of more than 3 as evaluated by a Modified Rankin Scale (mRS) were excluded from the analysis. Also patients or their relatives can request to be removed from the study at any point.

Method

All included patients were subjected to demographic, clinical, and imaging data evaluation.

Complete medical and history evaluation, including the history of hypertension (HTN), diabetes mellitus (DM), dyslipidemia, smoking, and history of previous cardiovascular events (like ischemic heart disease (IHD), rheumatic heart disease (RHD), and atrial fibrillation (AF)).

Clinical assessment of body mass index (BMI), baseline mean arterial blood pressure (MAP) and baseline blood glucose, in addition, clinical presentation at admission, and time from onset to femoral arterial puncture, use of recombinant tissue plasminogen activator (rtPA), initial NIHSS score [17], and door to puncture times evaluated.

All patients subjected to a comprehensive evaluation by non-contrast brain computer tomography (CT) to exclude cerebral hemorrhage. The early ischemic signs were detected and scored using Alberta Stroke Program Early CT Score (ASPECTS) [18]. Arterial imaging of the cerebral circulation with computed tomography angiography (CTA) was done to confirm the existence of large vessel occlusion and allow localization of the occluded vessel.

Endovascular treatment

Endovascular thrombectomy was performed under conscious sedation or general anesthesia using a femoral artery approach. An 8F guide catheter was inserted into the target carotid artery. The angiographic collateral grade was evaluated with the American Society of Interventional and Therapeutic Neuroradiology/Society of Interventional Radiology (ASITN/SIR) scale [19]. Two techniques were used, including the stent-based thrombectomy technique ($n=29$) or the direct aspiration first-pass thrombectomy technique ($n=8$) or both ($n=7$). The intraoperative data were recorded, including the following; intraoperative average MAP, the number of attempts, duration of the procedure, type of stent retriever used, and carotid stenting if performed. Successful recanalization after MT was defined as modified Treatment in Cerebral Ischemia (mTICI) grade 2b or 3 [20].

Follow-up data

Follow-up of patients was done after MT to identify rates and risk factors of 3-month mortality. Special attention was paid to the development of symptomatic intracerebral hemorrhage (sICH), defined as any hemorrhagic transformation on the 1-week follow-up CT or MRI scan associated with an increase of 4 points or more in the NIHSS score or death [21].

Statistical analysis

Quantitative variables are described as mean and standard deviation, while qualitative data are expressed as numbers and percentages. We performed overall descriptive statistics for demographic, clinical, imaging, treatment, and follow-up data. Comparisons of these variables between cohorts with and without 3-month mortality were performed using Pearson Chi-square for categorical, and Student's t-tests for continuous variables and a multivariate logistic regression analysis was performed to identify independent predictors for mortality at 3 months. Variables with a P-value < 0.05 in the univariate analysis on mortality were included in a multivariate logistic regression analysis. P-value < 0.05 value was considered significant. All statistical analyses were performed with SPSS software (version 21.0; IBM SPSS, Chicago, IL, USA).

Result

The mean age of patients was 64.3 ± 10.6 years; males were more than females (52.3% versus 47.7%). Right-sided weakness is associated with aphasia in 54.5%, and most cases (86.4%) presented with gaze palsy. Blood glucose at admission was 146.7 ± 54.7 mg/dl, and baseline MAP was 99.3 ± 10.5 mmHg. The mean time from onset to femoral arterial puncture was 304.1 ± 60.9 min, while the mean initial NIHSS score was 19.2 ± 3.5, which is significantly higher among deceased cases (22.2 ± 3.8) than among those who are alive (18.7 ± 3.2). HTN was the most commonly encountered (54.5%) risk factor, followed by DM (45.5%) and smoking (36.4%). As regards radiological findings, the mean ASPECT score was 9.3 ± 1.1. MCA M1 with ICA (tandem lesion) (36.4%) was encountered with a higher proportion among deceased cases (66.7%) than alive patients (31.7) (Table 1).

Only 25% of patients receive IV rtPA before MT. The mean time from the door to the groin was 38 ± 11.4 min. Good collaterals as detected by (ASITN/SIR) was recorded with a significantly higher proportion among living patients (68.4%) than deceased patients (16.7%), and the duration of the procedure was significantly longer than 60 min in deceased cases (66.7%) than alive patients (23.7%).

Stent retriever used alone in 2/3 (66%) of the samples, while aspiration technique used alone only in 18.2%. The carotid stent was performed in 31.8% of our patients. During the procedure, the mean of MAP was 96.3 ± 12.3 mmHg, and the mean number of attempts was 4 ± 2.5. Successful recanalization rate (grade 2b and 3) as evaluated by mTICI was significantly higher among alive cases (71%) than deceased cases (16.7%). The reverse was true regarding sICH, which was recorded with a significantly higher rate among deceased cases (33.3%) than alive (5.3%) (Table 2).

The multivariate analysis showed that low rates of successful recanalization (OR 0.081; 95% CI 0.009–0.780, $p = 0.030$) remained a significant independent predictive factor of the 3-month mortality (Table 3).

Table 1 Demographic, imaging, and clinical data of study patients

Variables	Total ($n = 44$)	Alive ($n = 38$)	Deceased ($n = 6$)	*P*-value
Male	23 (52.3%)	19 (50%)	4 (66.7%)	0.448
Age (mean ± SD)	64.3 ± 10.6	63.4 ± 11	69.8 ± 5.3	0.168
Right-sided weakness	24 (54.5%)	21 (55.3%)	3 (50%)	0.810
Aphasia	24 (54.5%)	21 (55.3%)	3 (50%)	0.810
Gaze palsy	38 (86.4%)	33 (86.8%)	5 (83.3%)	0.816
Time from symptom onset to femoral arterial puncture in min (mean ± SD)	304.1 ± 60.9	300.8 ± 61.8	325 ± 55	0.372
NIHSS at presentation (mean ± SD)	19.2 ± 3.5	18.7 ± 3.2	22.2 ± 3.8	**0.021**
Blood glucose at admission	146.7 ± 54.7	144.7 ± 55.6	159.2 ± 51.6	0.554
Baseline MAP (mean ± SD)	99.3 ± 10.5	99.6 ± 9.6	97.5 ± 16.2	0.649
History of HTN	24 (54.5%)	19 (50%)	5 (83.3%)	0.128
History of DM	20 (45.5%)	17 (44.7%)	3 (50%)	0.810
History of IHD	11 (25%)	10 (26.3%)	1 (16.7%)	0.612
AF	7 (15.9%)	7 (18.4%)	0 (0%)	0.252
Rheumatic heart disease	2 (4.5%)	2 (5.3%)	0 (0%)	0.565
Dyslipidemia	10 (22.7%)	9 (23.7%)	1 (16.7%)	0.703
Smoking	16 (36.4%)	12 (31.6%)	4 (66.7%)	0.097
BMI	31.6 ± 4.6	31.7 ± 4.6	30.8 ± 55.3	0.679
ASPECT score (mean ± SD)	9.3 ± 1.1	9.5 ± 1.1	9 ± 1.1	0.266
Site of occlusion				0.134
MCA M1	24 (54.5%)	23 (60.5%)	1 (16.7%)	
ICA	4 (9.1%)	3 (7.9%)	1 (16.7%)	
MCA and ICA	16 (36.4%)	12 (31.6%)	4 (66.7%)	

NIHSS National Institutes of Health Stroke Scale, *MAP* mean arterial blood pressure, *HTN*, hypertension, *DM* diabetes mellitus, *IHD* ischemic heart disease, *AF* arterial fibrillation, *BMI* body mass index, *ASPECT* Alberta Stroke Program Early CT Score, *MCA* middle cerebral artery, *ICA* internal carotid artery, *n* number, *SD* standard deviation

The data are presented as numbers (%) or mean ± SD. Statistical significance at $P < 0.05$ using Pearson Chi-square for categorical and Student's *t*-tests for continuous variables

Table 2 Procedural characteristics, and follow-up data of study patients

Variables	Total ($n = 44$)	Alive ($n = 38$)	Deceased ($n = 6$)	*P*-value
Receive IV rtPA	11 (25%)	10 (26.3%)	1 (16.7%)	0.612
Time from door to groin in min (mean ± SD)	38 ± 11.4	38.4 ± 11.3	35 ± 12.2	0.5
General anesthesia	40 (90.9%)	35 (92.1%)	5 (83.3%)	0.487
Collateral grade (ASITN/SIR)				**0.021**
Good	27 (61.4%)	26 (68.4%)	1 (16.7%)	
Moderate	10 (22.7%)	8 (21.1%)	2 (33.3%)	
Poor	7 (15.9%)	4 (10.5%)	3 (50%)	
Type of procedure				0.449
Stent retriever	29 (65.9%)	26 (68.4%)	3 (50%)	
Aspiration	8 (18.2%)	7 (18.4%)	1 (16.7%)	
Stent retriever and aspiration	7 (15.9%)	5(13.2%)	2 (33.3%)	
Using distal access catheter	18 (40.9%)	14 (36.8%)	4 (66.7%)	0.167
Type of stent retriever				0.428
Solitaire™ X revascularization device	28 (63.6%)	23 (60.5%)	5 (83.3%)	
Trevo XP Stentriever™	8 (18.2%)	8 (21.1%)	0 (0%)	
Carotid stent	14 (31.8%)	13 (34.2%)	1 (16.7%)	0.391
Intraoperative average MAP (mean ± SD)	96.3 ± 12.3	96.1 ± 11.8	97.7 ± 16.5	0.78
Number of attempts (mean ± SD)	4 ± 2.5	3.9 ± 2.2	5.2 ± 3.9	0.235
Duration of procedure ≥ 60 min	13 (29.5%)	9 (23.7%)	4 (66.7%)	**0.032**
The recanalization evaluated by mTICI				**0.01**
mTICI grade 2b and grade 3	28 (63.6%)	27 (71.1%)	1 (16.7%)	
mTICI grade 2a.1 and grade 0	16 (36.4%)	11 (28.9%)	5 (83.3%)	
sICH	4 (9.1%)	2 (5.3%)	2 (33.3%)	**0.026**

rtPA recombinant tissue plasminogen activator, *ASITN/SIR* American Society of Interventional and Therapeutic Neuroradiology/Society of Interventional Radiology, *MAP* mean arterial blood pressure, *mTICI* modified treatment in cerebral ischemia, *sICH* symptomatic intracerebral hemorrhage, *n* number, *SD* standard deviation

The data are presented as numbers (%) or mean±SD. Statistical significance at $P < 0.05$ using Pearson Chi-square for categorical and Student's *t*-tests for continuous variables

Table 3 Multivariable logistic regression analysis for predictors of 3-month mortality

Variables	OR	95% CI	*P* value
The recanalization evaluated by mTICI	0.081	0.009–.780	0.030

mTICI modified treatment in cerebral ischemia, *OR* odds ratio, *CI* confidant interval

Discussion

The present study was designed to analyze a variety of predictive factors associated with 3-month mortality after MT among patients with AIS. In our study, the rate of 3-month mortality was 13.6%, which was relatively similar to pooled analysis of individual patient data by the HERMES (the Highly Effective Reperfusion Evaluated in Multiple Endovascular Stroke Trials) collaboration [11], which reported a 3-month mortality rate of 15.3%. In our study, successful recanalization (defined as mTICI ≥ 2b) occurred in 63.6%. The important finding from multivariable modeling in our study showed that low rates of successful recanalization remained a significant independent predictor of 3-month mortality after MT. Our result is compatible with a previous study by Yoon et al. 2017 [12], which demonstrated that revascularization status is one of the predictors of 3-month mortality. Furthermore, the North American Solitaire Acute Stroke (NASA) registry reported that failure of recanalization and the presence of symptomatic intracranial hemorrhage resulted in increased mortality [13].

More recent studies have shown that achieving complete restoration of blood flow to an mTICI score of 3 appeared to reduce infarct growth and improve post-thrombectomy functional independence than revascularization only to 2B [22]. Additionally, successful reperfusion may inhibit ischemic lesion extension, avoiding malignant infarction evolution responsible for mortality [23]. Consequently, the neuro-interventionalist should perform every attempt to achieve successful recanalization to decrease mortality.

Higher baseline NIHSS score, poor collateral status, long duration of the procedure and developing sICH are important findings in univariate analysis that were significantly associated with 3-month mortality after MT.

Initial NIHSS has predictive mortality after acute ischemic stroke [24, 25]. Our study is consistent with a recent study by Chen et al., who reported that high NIHSS on admission is associated with mortality at 30 days after MT [15]. However, a high NIHSS at presentation should not exclude patients from thrombectomy eligibility as management with MT gave a better outcome than medical treatment [3, 7, 26].

Previous research confirmed the collateral flow connection with perfusion parameters [27, 28] and 3-month mortality [29]. Also, our results are in concordance with the recent meta-analysis by QIAN et al. [30], which found that good pretreatment collaterals were associated with functional independence, successful reperfusion, and decreased rate of sICH and mortality after MT. Good collaterals can support ischemic penumbra before reperfusion and decrease infarction growth [31].

Procedure time has an impact on patient outcomes after MT. A longer duration of the procedure is associated with an increase in the risk of complications and poor outcomes [32, 33]. Spiotta et al. [32] found that patients with a procedure time of more than one hour had a higher likelihood of being dead or in a persistent vegetative state. Also, time exceeding 60 min should trigger a careful assessment of the futility and risks of continuing the procedure. Patients with a longer duration of procedure usually have occlusion, which is difficult to recanalize. Also, increasing procedure time will further tax compensatory collaterals supplying an ischemic penumbra and lead to irreversible injury. In other words, a procedure with a long duration is associated with diminishing return of successful recanalization due to ischemia progression [32].

Hemorrhagic transformation is a disastrous complication of MT, particularly when associated with mass effect or neurological deterioration [34]. Our results were consistent with other study findings supporting that parenchymal ICH was associated with higher mortality rates [8, 12]. ICH can be produced from reperfusion injury after prolonged ischemia or vessel wall perforation as a technical complication of the endovascular procedure [35]. sICH is a great prognosticator of post-thrombectomy mortality that is likely modifiable by decreasing the time of endovascular thrombectomy or improving intraprocedural techniques to prevent lethal operator-induced cerebral hemorrhage [36, 37].

This study's major limitation is the small sample size because this study was done in two centers only in Egypt, where MT is still developing. With large sample size, more factors verified by univariate analysis could accept more strength as predictors of 3-month mortality and thus improve case selection of EVT. Despite this limitation, the study's strengths included the in-depth analysis of most predictor factors, which may be able to predict mortality.

Conclusion

In conclusion, low rates of successful recanalization (mTICI $\geq$ 2b or 3) remained a significant independent predictor of 3-month mortality after MT. Also, higher baseline NIHSS score, poor collateral status, long duration of the procedure, and developing sICH have a higher risk of 3-month mortality after MT. Further research is required to determine more factors associated with mortality after MT and modify it if possible.

Abbreviations

AIS: Acute ischemic stroke; RCTs: Randomized controlled trials; MT: Mechanical thrombectomy; EVT: Endovascular thrombectomy; NIHSS: National Institutes of Health Stroke Scale score; ICA: Internal carotid artery; MCA: Middle cerebral artery; mRS: Modified Rankin Scale; HTN: Hypertension; DM: Diabetes mellitus; IHD: Ischemic heart disease; RHD: Rheumatic heart disease; AF: Atrial fibrillation; BMI: Body mass index; MAP: Mean arterial blood pressure; rtPA: Recombinant tissue plasminogen activator; CT: Computer tomography; ASPECT: Alberta Stroke Program Early CT Score Program Early Computed Tomography Score; CTA: Computed tomography angiography; ASITN/SIR: American Society of Interventional and Therapeutic Neuroradiology/Society of Interventional Radiology; mTICI: Modified Treatment in Cerebral Ischemia; sICH: Symptomatic intercerebral hemorrhage; HERMES: The Highly Effective Reperfusion Evaluated in Multiple Endovascular Stroke Trials; NASA: The North American Solitaire Acute Stroke.

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Author contributions

GS: recruited participants, analysis, and interpreted data, and contributed in writing the manuscript. AH: wrote the manuscript and analysis of data. MA and WF: recruited participants, helped in data entry, analyzed, and generated result sheets and revised data interpretation and manuscript. AE: recruited patients and made endovascular thrombectomy. All authors have read and approved the final manuscript.

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Availability of data and materials

All data generated or analyzed during this study are available from corresponded on request.

Declarations

Ethics approval and consent to participate

After a detailed explanation of the study's goal, methods, potential dangers, and side effects, each participant gave written informed consent to be included in the study. The University Hospital Institutional Review Board approved the study protocol with authorization number 17200215.

Consent for publication

Not applicable.

Competing interests

The authors declare no conflicts of interests.

Author details
[1]Department of Neurology and Psychiatry, Faculty of Medicine, Assiut University, Assiut 71515, Egypt. [2]Department of Neurology and Neuro-Intervention, Faculty of Medicine, Ain Shams University, Cairo, Egypt.

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