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Original Research

Mechanical Thrombectomy in Acute Ischemic Stroke: Do Patients Admitted During On-Hours Exhibit Better Results?

Cemile Haki,[1] Kaya Sarac,[2] Mehmetcan Yilmaz,[1] Suat Kamisli[1]

[1]Department of Neurology, University of Health Sciences, Bursa Faculty of Medicine, Bursa City Hospital, Bursa, Türkiye
[2]Department of Radiology, University of Health Sciences, Bursa Faculty of Medicine, Bursa City Hospital, Bursa, Türkiye

Abstract

Objectives: Mechanical thrombectomy (MT) has revolutionized stroke care over the past decade. Thus, we aimed to assess whether presenting during off-hours affects workflow times, clinical outcomes, and mortality of patients with acute ischemic stroke (AIS) undergoing MT at our center and, if there is an impact, to identify areas for improvement in the treatment of acute stroke.

Methods: A total of 263 consecutive patients who underwent MT between January 2020 and April 2023 were included in the study. The patients were categorized into two groups: those who presented during on-hours (Group 1) and those who presented during off-hours (Group 2).

Results: Among the 263 patients enrolled in the study (131 men and 132 women; mean age: 69.49±12.22 years; age range: 25–95 years), 74 (28.14%) were admitted to the hospital during on-hours, and 189 (71.86%) were admitted during off-hours. Of these patients, 30 (40.54%) and 68 (35.98%) from Groups 1 and 2, respectively, had good outcomes in the third month. The groups showed similar demographics, treatment-related characteristics, and outcomes, with no significant differences detected. The only notable difference was that the percentage of Diffusion-Weighted Magnetic Resonance Imaging (DW-MRI) was notably greater in the off-hours group (p=0.044).

Conclusion: The results indicate that MT performed on patients presenting during off-hours yielded similar workflow times, successful recanalization, and clinical outcomes to MT performed on patients presenting during on-hours.

Keywords: Acute ischemic stroke, mechanical thrombectomy, off-hours, on-hours, outcomes

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In Türkiye, the burden of strokes is particularly profound. It ranks among the top causes of mortality and functional impairment, resulting in serious social, economic, and healthcare consequences.[1] Beyond the immediate health impact, stroke leads to high direct treatment costs and substantial indirect expenses due to the loss of productivity and long-term care needs.[2,3]

Mechanical thrombectomy (MT) has revolutionized stroke care over the past decade. It is now considered the standard of care for eligible patients with proximal large-vessel occlusion (LVO), offering significantly better outcomes than medical management alone when performed within the recommended time windows.[4] Numerous randomized controlled trials and real-world data have demonstrated

Address for correspondence: Cemile Haki, MD. Department of Neurology, University of Health Sciences, Bursa Faculty of Medicine, Bursa City Hospital, Bursa, Türkiye
Phone: +90 532 471 31 51 **E-mail:** cemilehaki@gmail.com

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that MT can improve functional independence, reduce disability, and enhance the long-term quality of life in acute ischemic stroke (AIS) patients. However, the effectiveness of MT is highly time-sensitive. Several studies have shown that delays in reperfusion significantly reduce the likelihood of favorable neurological outcomes.[5,6]

Wang et al.[7] reported that a majority of ischemic stroke patients presenting to the emergency department with known admission times arrived during off-hours. Meta-analyses, systematic reviews, and large-scale observational studies have reported associations between off-hours presentation and increased morbidity, worse functional outcomes, and higher mortality in AIS.[8–10] Among patients undergoing MT, the results regarding the effect of interventions during off-hours are conflicting in terms of time parameters and clinical outcomes.[11–16] Thus, in this study, we aimed to assess whether presenting during off-hours affects workflow times, clinical outcomes, and mortality among patients with AIS undergoing MT at our center and, if there is an impact, to identify areas for improvement in the treatment of AIS.

Methods

Patients who underwent MT at Bursa City Hospital for LVO during the period of January 2020 to April 2023 were included in this study. Of these patients, those who had incomplete data, were under 18 years of age, had had a stroke in the hospital, had received intravenous tissue plasminogen activator (IV tPA) from an external center and were then referred to our hospital for MT, or had received only IV tPA were excluded from the study. During the study period, 479 patients with AIS underwent reperfusion therapy, of which 263 met the eligibility criteria (Fig. 1). The study was approved by the ethics committee of Bursa City hospital (approved on September 27, 2023; Decision No: 2023-16/9) and was performed in accordance with the principles of the Declaration of Helsinki.

Our hospital is located in Bursa Province, one of Türkiye's largest provinces in the Marmara Region, which has a population of 3,250,000. Our hospital is one of the few major centers in South Marmara that provide MT services off-hours.

In this study, "during on-hours" was defined as weekdays from 8:00 to 16:00, while "off-hours" referred to all other times, including weekdays outside of 8:00–16:00, weekends, and public holidays (including religious holidays). Patients were categorized into two groups based on when they arrived at the emergency department: Group 1 included those who arrived during on-hours, while Group 2 consisted of those who arrived off-hours.

The severity of AIS was classified by the National Institutes of Health Stroke Scale (NIHSS) score.[17] The etiology of ischemic stroke was classified according to the Trial of Org 10172 in Acute Stroke Treatment criteria.[18] All patients underwent a control brain Computed Tomography (CT) scan 24 h after the MT procedure. Functional outcomes were assessed using the Modified Rankin Scale (mRS) at three months. An mRS score of ≤ 2 indicated a good clinical outcome, while a score of 3–6 corresponded to a poor clinical outcome. The efficacy of MT was assessed using the Modified Thrombolysis in Cerebral Infarction (mTICI) scale.[19] An mTICI score of ≥2b was considered a successful MT according to the American Heart Association/American Stroke Association (AHA/ASA) guidelines.[4,19]

We compared Group 1 and Group 2 in terms of demographics, comorbidities, stroke etiologies, Alberta Stroke Program Early CT score (ASPECT), initial NIHSS, NIHSS at 24 h, change in NIHSS at 24 h, symptomatic intracranial hemorrhage, discharge mRS, in-hospital mortality, mRS at three months, good outcome at three months (mRS ≤2), and mortality at three months. Time intervals were defined as door-to-neurologist assessment time, door-to-needle time, door-to-groin time, symptom-to-door time, symptom-to-needle time, and door-to-imaging time.

All AIS patients in our hospital are evaluated by the same neurology team. Neurologists, nurses, anesthesiologists, and anesthesia technicians provide uninterrupted healthcare services by working night shifts. The interventional neuroradiology team, consisting of five members, shares shifts equally and is called to the hospital outside regular working hours for patients requiring MT.

We evaluated whether diffusion-weighted MRI (DW-MRI) was performed in addition to CT as an imaging protocol. In our study, the off-hours group showed a significantly higher DW-MRI percentage than the on-hours group. Therefore, the patient groups were compared to examine the effect of DW-MRI acquisition on time parameters, such as clinical

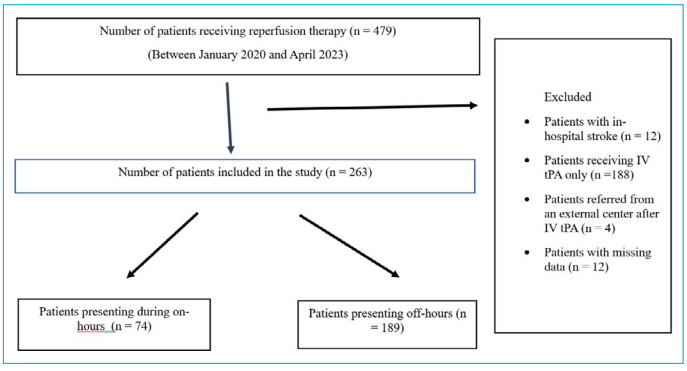

Figure 1. Flowchart: Inclusion and exclusion criteria.

outcomes and treatment initiation times, in AIS patients. Patients eligible for IV tPA treatment received 0.9 mg/kg within 4.5 h from the onset of stroke before undergoing MT. MT was conducted using a stent retriever, aspiration, or a combined strategy of both methods. The Solitaire flow restoration stent (ev3/Covidien, Irvine, CA, USA) or the Trevo NXT stent (Stryker, Kalamazoo, MI, USA) device was used as a stent retriever during thrombectomy.

Statistical Analysis

IBM SPSS Statistics for Windows version 25.0 (IBM Corp., Armonk, NY, USA) was used. We examined histograms and Q-Q plots to assess whether the data followed a normal distribution. Depending on the type of data, we applied the appropriate statistical analysis. We presented continuous variables as means with standard deviations for normally distributed data and as medians with interquartile ranges for non-normal data. Categorical variables were described using frequencies and percentages. Depending on the distribution, the continuous variables were compared using either the Student's t-test (for normal data) or the Mann–Whitney U test (for non-normal data). For the categorical variables, we applied the chi-square, Fisher's exact, and Fisher–Freeman–Halton tests where appropriate. A p-value under 0.05 was used as the threshold for statistical significance.

Results

A total of 263 patients (131 men and 132 women) were included in the study. The mean age was 69.5 years, with a range of 25–95. Among these patients, 74 (28.1%) were admitted during on-hours, while 189 (71.9%) presented outside of those hours. Moreover, 169 patients (64.26%) presented at our hospital, while 94 patients (35.74%) were referred from other hospitals. A total of 241 patients (91.63%) received only MT treatment, while 22 patients (8.37%) received both IV tPA and MT treatments.

Recanalization was successful for 67 patients (90.54%) in the on-hours group and 165 patients (87.30%) in the off-hours group. Fifteen patients (20.27%) in the on-hours group and 45 patients (24.59%) in the off-hours group died in hospital. Thirty patients (40.54%) in the on-hours group and 68 patients (35.98%) in the off-hours group had a good outcome in the third month. Seventeen cases (22.97%) in the on-hours group and 59 cases (31.22%) in the off-hours group were mortal in the third month. The off-hours group showed a significantly higher DW-MRI percentage than the on-hours group (p =0.044). As shown in Table 1, the demographics, disease and treatment characteristics, and outcomes were similar.

The patients who underwent DW-MRI experienced significantly longer door-to-groin times than those who did not (p=0.017). We observed similar outcomes across the DW-MRI groups in terms of hemorrhage, time of door-to-neurologist, mRS at discharge, good outcome at discharge, mortality in hospital, mRS at the third month, time of door-to-needle, good outcome at the third month, and mortality at the third month (Table 2).

Discussion

In the present study, no significant differences were found in the demographic characteristics, comorbidities, workflow times, or clinical outcomes between patients who presented during on-hours and those who presented off-hours. The only notable difference was that the percentage of DW-MRI was notably greater in Group 2 than in Group 1. It was observed that presentation off-hours did not affect workflow times, clinical outcomes, or mortality in patients with AIS undergoing MT at our center.

The data in the reviewed literature indicate that a greater share of ischemic stroke patients was admitted to hospitals off-hours[7] and that the majority of patients who underwent MT were reported to present off-hours.[13, 20, 21] In our study, a greater proportion of patients (71.86%) presented to the emergency department off-hours.

Studies investigating the effect of being admitted to hospital off-hours or on weekends on patients with AIS undergoing MT have reported varied results. Several investigations reported that clinical outcomes following stroke interventions were comparable in terms of whether the procedures were performed during standard hours or outside of them.[13–15] Other studies reported a tendency toward worse clinical outcomes among patients presenting off-hours,[11,12] whereas some studies revealed better clinical outcomes among patients admitted to hospital off-hours.[16]

Benali et al.[16] (2021) observed that 90-day functional results significantly improved in patients treated during nighttime hours compared with those treated in the daytime. In the current study, no differences were observed in discharge and three-month good outcomes, in-hospital and three-month mortalities, or discharge and three-month mRS between patients undergoing MT who presented on-hours and those who presented off-hours.

One recent meta-analysis covering 26 studies and about 82,850 patients and examining the effect of being admitted to hospital off-hours for MT treatment on AIS outcomes found that off-hours stroke treatments had a significantly lower likelihood of achieving successful recanalization compared with treatments during routine hours.[11] Similarly, another meta-analysis of 19 studies (approximately

Table 1. Summary of variables by group

	Groups			
	All patients (n=263)	**On-hours (n=74)**	**Off-hours (n=189)**	**p**
Age (n=263)	69.49±12.22	70.50±12.32	69.09±12.20	0.401
Sex (n=263), %				
Male	131 (49.81)	38 (51.35)	93 (49.21)	0.754
Female	132 (50.19)	36 (48.65)	96 (50.79)	
Comorbidities (n=263), %				
Heart diseases	142 (53.99)	47 (63.51)	95 (50.26)	0.053
Diabetes mellitus	81 (30.80)	18 (24.32)	63 (33.33)	0.202
Prior cerebrovascular disease	47 (17.87)	13 (17.57)	34 (17.99)	1.000
Prior transient ischemic attack	9 (3.42)	1 (1.35)	8 (4.23)	0.452
Hypertension	178 (67.68)	56 (75.68)	122 (64.55)	0.112
Hyperlipidemia	33 (12.55)	10 (13.51)	23 (12.17)	0.929
Smoking (n=263), %	49 (18.63)	11 (14.86)	38 (20.11)	0.421
Alcohol use (n=263), %	10 (3.80)	2 (2.70)	8 (4.23)	0.730
First application (n=263), %				
Another hospital	94 (35.74)	27 (36.49)	67 (35.45)	0.875
Our hospital	169 (64.26)	47 (63.51)	122 (64.55)	
Etiology (n=257), %				
Large artery atherosclerosis	96 (37.35)	26 (35.14)	70 (38.25)	0.338
Cardio embolism	99 (38.52)	34 (45.95)	65 (35.52)	
Other determined reasons	3 (1.17)	1 (1.35)	1 (1.10)	
Undetermined reasons	59 (22.96)	13 (17.57)	46 (25.14)	
ASPECT (n=263), %	10 (10 - 10)	10 (10 - 10)	10 (10 - 10)	0.068
≤ 9	55 (20.91)	10 (13.51)	45 (23.81)	0.093
10	208 (79.09)	64 (86.49)	144 (76.19)	
Circulation (n=263), %				
Posterior	31 (11.79)	5 (6.76)	26 (13.76)	0.171
Anterior	232 (88.21)	69 (93.24)	163 (86.24)	
DW-MRI (n=263), %	174 (66.16)	42 (56.76)	132 (69.84)	0.044
Intervention (n=263), %				
Only MT	241 (91.63)	68 (91.89)	173 (91.53)	1.000
IV tPA + MT	22 (8.37)	6 (8.11)	16 (8.47)	
NIHSS, %				
Admission (n=263)	14 (10–18)	14.5 (10–18)	14 (10–18)	0.917
24th hour (n=254)	11 (4–18)	11 (5–16)	11 (4–19)	0.926
Change (n=254)	−2 (−6–0)	−2 (−7–0)	−1 (−6–0)	0.618
Door-to-neurologist time, min (n=263)	20 (10–42)	22.5 (10–42)	20 (10–44)	0.940
Door-to-needle time, min (n=22)	71 (55–90)	73.5 (67–81)	71 (48.5–91)	0.606
Door-to-groin time, min (n=263)	100 (70–140)	90 (70–125)	101 (72–148)	0.082
Symptom-to-door time, min (n=263)	120 (58–196)	110 (51–196)	120 (60– 193)	0.442
Symptom-to-needle time, min (n=22)	145 (120–180)	133.5 (100–201)	146 (123–178.5)	0.825
Door-to-CT time, min (n=228)	18 (10–26)	19 (10–27)	18 (10–25)	0.696
Door-to-CT angiography time, min (n=243)	27 (16–53)	25 (15–43)	27.5 (18–58)	0.074
Door-to-DW-MRI time, min (n=142)	29 (13–48)	22 (7–59)	30.5 (17.5–47.5)	0.272
TICI (n=263), %				
TICI 0	15 (5.70)	1 (1.35)	14 (7.41)	0.052
TICI 1	13 (4.94)	3 (4.05)	10 (5.29)	
TICI 2A	3 (1.14)	3 (4.05)	0 (0.00)	
TICI 2B	52 (19.77)	15 (20.27)	37 (19.58)	
TICI 2C	6 (2.28)	1 (1.35)	5 (2.65)	
TICI 3	174 (66.16)	51 (68.92)	123 (65.08)	

Table 1. Summary of variables by group (Cont.)

	Groups			
	All patients (n=263)	**On-hours (n=74)**	**Off-hours (n=189)**	**p**
Successful recanalization, mTICI ≥ 2b (n=263), %	232 (88.21)	67 (90.54)	165 (87.30)	0.603
Hemorrhage (n=255), %	84 (32.94)	24 (32.43)	60 (33.15)	1.000
Symptomatic	27 (10.59)	7 (9.46)	20 (11.05)	0.929
Asymptomatic	57 (22.35)	17 (22.97)	40 (22.10)	
APACHE score (n=254)	11.18±6.37	10.74±6.66	11.35±6.26	0.488
Intubation (n=257), %	94 (36.58)	24 (32.43)	70 (38.25)	0.463
Duration of intubation, days (n=257)	0 (0–6)	0 (0–6)	0 (0–7)	0.410
Length of stay in hospital, days (n=257)	6 (3–15)	6.5 (3–14)	6 (3–16)	0.810
mRS, discharge (n=257)	4 (2– 5)	4 (2–5)	5 (2– 5)	0.315
Good outcome, mRS ≤ 2, discharge (n=257), %	78 (30.35)	24 (32.43)	54 (29.51)	0.755
Mortality, in hospital (n=257), %	60 (23.35)	15 (20.27)	45 (24.59)	0.563
mRS, 3rd month (n=263)	4 (1–6)	3 (1–5)	4 (1–6)	0.230
Good outcome, mRS ≤ 2, 3rd month (n=263), %	98 (37.26)	30 (40.54)	68 (35.98)	0.491
Mortality, 3rd month (n=263), %	76 (28.90)	17 (22.97)	59 (31.22)	0.240

Descriptive statistics were presented using mean±standard deviation for normally distributed continuous variables, median (25^{th}–75^{th} percentile) for non-normally distributed continuous variables, and frequency (percentage) for categorical variables. ASPECTS: Alberta Stroke Program Early CT Score; DW-MRI: Diffusion-weighted MRI; CT: Computed tomography; IV tPA: Intravenous tissue plasminogen activator; MT: Mechanical thrombectomy; NIHSS: National Institutes of Health Stroke Scale; m TICI: Modified Thrombolysis in Cerebral Infarction; APACHE II: Acute Physiology and Chronic Health Evaluation II; mRS: Modified Rankin Scale.

Table 2. Summary of variables with regard to DW-MRI

	Diffusion MR		p
	No (n=89)	**Yes (n=174)**	
Door-to-neurologist time, min (n=263)	20 (10–35)	22 (10–48)	0.099
Door-to-needle time, min (n=22)	63.5 (49–90)	74.5 (65–88)	0.575
Door-to-groin time, min (n=263)	90 (67–121)	105.5 (75–150)	0.017
Hemorrhage (n=255), %	33 (38.37)	51 (30.18)	0.188
Symptomatic	13 (15.12)	14 (8.28)	0.209
Asymptomatic	20 (23.26)	37 (21.89)	
mRS, discharge (n=257)	4 (2–6)	4 (2–5)	0.982
Good outcome, mRS, discharge (n=257), %	25 (28.74)	53 (31.18)	0.687
Mortality, in hospital (n=257), %	23 (26.44)	37 (21.76)	0.495
mRS, 3rd month (n=263)	3 (1–6)	4 (1–6)	0.489
Good outcome, mRS, 3rd month (n=263), %	36 (40.45)	62 (35.63)	0.445
Mortality, 3rd month (n=263), %	27 (30.34)	49 (28.16)	0.713

Descriptive statistics were presented using median (25th–75th percentile) for non-normally distributed continuous variables and frequency (percentage) for categorical variables. mRS: Modified Rankin Scale.

14,185 patients) reported reduced successful recanalization rates for patients who presented off-hours versus those who presented on-hours.[12] Conversely, a large registry paper by Ding et al.[13] found no difference in recanalization success between off-hours and on-hours thrombectomy cases. In our study, no statistically significant difference was found in the mTICI classification between patients who underwent MT during off-hours and those treated during on-hours. The successful recanalization rate was 87% for the off-hours group and 91% for the on-hours group.

Several clinical studies have reported that although there were delays in workflow times for patients presenting off-hours, these did not affect the clinical outcomes. A study conducted in China involving 111 comprehensive stroke

centers and over 1,700 patients found that onset-to-door time and onset-to-reperfusion time were significantly longer in patients presenting off-hours than in those presenting during on-hours. Regardless of whether patients presented during on- or off-hours, their clinical outcomes and mortality rates were similar.[13]

Hinsenveld et al.[14] reported that delays in workflow times for patients admitted off-hours did not affect the clinical outcomes. Löwhagen Hendén et al.[22] found that among patients with AIS undergoing MT, those who arrived off-hours experienced a longer time from CT scan to recanalization. However, the time from stroke onset to CT was similar, regardless of when the patients arrived. Notably, this delay did not translate into worse clinical outcomes, as patients who came in after hours fared just as well as those treated during the day. Similarly, Weddell et al.[15] observed that patients presenting off-hours had a longer door-to-groin puncture time. Nevertheless, this did not seem to affect how well the patients recovered, as clinical outcomes were comparable between both groups.

In some studies, delays in workflow times for patients presenting off-hours and undergoing MT were linked to lower rates of functional independence. The 2023 meta-analysis by Ghozy et al.[11] also noted that key workflow intervals were significantly prolonged during off-hours—for example, onset-to-door and door-to-recanalization times were all for off-hour patients—and that these delays corresponded with worse clinical outcomes than those seen in on-hour cases. Likewise, a 2022 meta-analysis (Zha et al.[12]) reported that multiple time metrics (including door-to-groin puncture, imaging-to-groin, and onset-to-recanalization, among others) were significantly longer for off-hour presentations and that such prolonged timelines were linked to an overall a tendency toward poorer prognosis for those patients.

Interestingly, Zha et al.[23] found that onset-to-door time was shorter for patients presenting outside working hours. This study found that arrival or treatment off-hours did not affect the in-hospital workflow or clinical outcomes. In the present study, presentation off-hours did not affect workflow times for patients with AIS undergoing MT at our center.

Neuroradiologists performing MT being present at the hospital during on-hours but requiring them to come to the hospital when called off-hours could potentially cause delays in hospital workflows. However, we did not observe any extension in workflow times at our center, even during procedures off-hours.

Nevertheless, the percentage of patients undergoing DW-MRI was significantly higher among those presenting off-hours than among those presenting during on-hours. The door-to-groin puncture time was significantly longer for patients who underwent DW-MRI than for other patients. In our study, performing DW-MRI on patients did not affect the clinical results. DW-MRI may be preferred during off-hours, as less experienced physicians are on duty and DW-MRI can be performed quickly due to lower patient density.

Despite its contributions, our study has several limitations. First, the retrospective nature and single-center design of the current study can be considered a limitation. Second, the effects of off-hours in Türkiye may vary depending on the coordination of stroke treatment in different regions. Third,, it would have been beneficial to divide the analysis into different times of the day to assess mortality, workflow, and other clinically important measures. Fourth,, given the large number of variables tested, there remains a potential risk of type I error due to multiple comparisons, although only two variables reached statistical significance. This should be considered when interpreting isolated p-values.

Finally, there was no significant difference in stroke severity, stroke etiology, baseline NIHSS, or ASPECT scores between the patients admitted during and those admitted out of office hours, indicating that the results obtained were independent of these variables, which could affect clinical outcomes.

Conclusion

In our cohort of patients with AIS who underwent MT, we found no significant differences between those who presented during on-hours and those who arrived outside of these hours. The key parameters, namely workflow times, success rate of vessel recanalization, functional outcomes at three months, overall clinical recovery, and mortality rates, were comparable between the two groups. These findings suggest that the quality and efficiency of care were consistently maintained, regardless of the time of patient presentation.

Disclosures

Ethic Committee Approval: The study was approved by the Bursa City Hospital Clinical Research Ethics Committee (date: 27.09.2023 number: 2023-16/9).

Peer-review: Externally peer-reviewed.

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