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# Temporal Variations in Mechanical Thrombectomy for Acute Ischemic Stroke: A 1-Year Single-Center Study

**Arsida Bajrami,[1] Sena Aksoy,[1] Ardian Bicaku,[2] Muharrem Sadiku,[2] Songul Senadim,[1] Serdar Geyik[3]**

[1]Department of Neurology, Istanbul Aydın University, Florya Medicalpark Hospital Stroke Center, Istanbul, Türkiye
[2]Department of Radiology, University of Pristina, Pristina, Kosovo
[3]Department of Radiology, Istanbul Aydın University, Florya Medicalpark Hospital Stroke Center, Istanbul, Türkiye

## ABSTRACT

**Objective:** Mechanical thrombectomy (MT) improves clinical outcome in acute ischemic stroke (AIS) patients. The effect of MT over the outcome of these patients is time sensitive. The onset nature of AIS is abrupt and unpredictable. Therefore, the temporal variation of onset of AIS requires a well-organized stroke chain infrastructure to minimize its impact on the clinical outcome. The term "weekend effect" has also been reported in the field of AIS. MT as a multi-disciplinary treatment requires optimal coordination of workflow and manpower to overcome the "weekend effect."

**Materials and Methods:** We retrospectively analyzed data from our prospective stroke center registry. Clinical, radiological, time-metrics, and outcome of patients who underwent MT from January to December 2023 were analyzed. The patients included in this study were divided into a daytime, nighttime, weekend, and holiday groups. Main outcome variables included favorable outcome (modified Rankin scale scores of 0–2) 3 months post-stroke as well as procedural time metrics (door-angio). Variation between subgroups was statistically analyzed.

**Results:** A total of 371 patients were compatible with the inclusion criteria. The median age was 68 (±12.9) years and the median onset National Institutes of Health Stroke Scale score 17. Detailed time-metrics analysis showed that radiology to puncture and door to puncture time were significantly lower during working hours compared to other non-working hours. No significant difference was found between working hours and nighttime, weekend, or holiday hour regarding time-metrics for both transfer and mothership patients ($p>0.001$).

**Conclusion:** Overall, analysis of the present data showed short time-metrics regardless of temporal variation. These findings emphasize the role of in hospital organization. In addition, our stroke flow organization model may encourage the building of similar models.

**Keywords:** Mechanical thrombectomy, time-metrics, weekend effect

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**Address for correspondence:** Arsida Bajrami. Department of Neurology, Istanbul Aydın University, Florya Medicalpark Hospital Stroke Center, Istanbul, Türkiye

**E-mail:** arsidabajrami@gmail.com **ORCID ID:** 0000-0002-1731-1521

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## INTRODUCTION

Mechanical thrombectomy (MT) has revolutionized the concept of acute ischemic stroke (AIS) treatment. Randomized controlled studies have demonstrated the benefit of MT in eligible AIS patients with large vessel occlusion (LVO).[1-7] Comprehensive stroke center (CSC) organization and a multi-disciplinary approachment are key factors for the effectiveness of MT treatment. Therefore, the temporal variation of AIS onset requires a well-working stroke chain infrastructure independent from working hours or days.

The Safe Implementation of Treatments in Stroke-International Stroke Thrombolysis Register large cohort evaluated the alternation of thrombolytic treatment delivery for AIS in cohorence with the pattern of AIS onset. While time of treatment was found to be an independent predictor of outcome, the number of treatment was in accordance with the diurnal pattern of stroke onset.[8] The term "weekend effect" referring to an increase in the mortality rate for hospitalizations occurring on weekends versus weekdays has also been reported in the field of AIS.[9-11] MT as a multi-disciplinary treatment requires optimal coordination of workflow and manpower to overcome the "weekend effect." The Austrian EVT Study Group large cohort analysis also found that during non-working hours intrahospital MT workflow was compromised leading to worse functional outcomes[12] Several other studies investigating the potential existence of the weekend effect over MT for AIS caused by LVO has yielded varied results.[13-16]

In this study, we examined the potential existence of differences in MT time-metrics for AIS between daytime versus nighttime, weekend, and holiday hours in our high-volume CSC for 1 year and reviewed the data reported so far.

## MATERIALS AND METHODS

In this retrospective, single-center observational study, we analyzed patients who underwent MT from January to December 2023. The 2023-year marks the highest volume of MT in our center (single-center, 421 MT patients, and 5 neuro-interventionalist). Time-metrics, including onset of symptoms, hospital arrival, radiology, and femoral puncture time, were retrieved from the database. All patients were followed up until 3 months post-procedure. Analyses were mainly focused on in-hospital pre-MT procedure time-metrics and variations between working and non-working hours.

In our center, all the AIS patients are admitted with the "neuro-code" notification. The "neuro-code" gives priority to all the suspected AIS patients admitted in the emergency room (ER), fastens the transfer to radiology, and mobilizes the anesthesiology and neuro-interventional team despite decision for MT or not. It is applied both during daytime and nighttime, weekend, and holidays. Our CSC organization has a MT team which consists of one neuro-interventionalist, one fellow neuro-interventionalist, three stroke nurses, and 2 stroke technicians that are on duty every day from 08:00 to 17:00. During nighttime, weekends and holidays the MT team consists of the same number of persons, among them only the neuro-interventionalist and stroke technicians are on call. For mothership patients' admission from ER, transfer to radiology and angio suite is managed by the on-site neurologist and stroke nurses. Following the decision for MT, the on-call MT team will join the hospital. For transferred patients eligible for MT, the team shall be in the hospital before the "neuro-code" announcement.

AIS patients, 18 year or older, that underwent MT within 24 h of symptom onset were included in the analyses. Patient who underwent MT after admission in the stroke unit due to clinical progression or any other reason were excluded from the analyses.

Neurologic deficit was assessed using the National Institutes of Health Stroke Scale (NIHSS) scale. Patients were recorded as mothership or transfer patients. Onset radiological examination was performed in three different modalities:

1. Diffusion-weighted (DW), perfusion-weighted in addition, or not to vascular magnetic resonance (MR) imaging
2. Computed tomography (CT), CT perfusion in addition, or not to vascular CT imaging
3. Direct to angio-suite with CT in addition of not to vascular imaging in the angio-suite.

The patients included in this study were divided into a daytime, nighttime, weekend, and holiday groups. The daytime group referred to MT performed from 8:00 to 17:00 on weekdays (Monday to Friday), while the nighttime group referred to MT performed on weekdays from 17:00 to 8:00 the next day. Weekend days were referred as to Saturday and Sunday and Holiday days were recorded according to National Turkish Holiday Calendar.

Collected data included patients' demographics, risk factors, NIHSS scale on onset and 24 h after procedure, use of intravenous recombinant tissue-type plasminogen activator (iv rt-PA), and type of imaging performed on onset and onset admission (mothership or transfer, respectively). Transfer patients' first center imaging modalities were evaluated, and a second imaging was not performed in selected patients based on the on-call doctors' decision. Triage time-metrics data were collected as follows: (1) door-to-radiology, (2) radiology-to-femoral puncture, and (3) door-to-femoral puncture.

Outcome was evaluated both using clinical and triage time-metrics findings. Clinical outcome was measured with 24 h NIHSS scale, 90-day modified Rankin scale (mRS) and mortality at 90 days. Outcome in terms of triage time-metrics was referred as door to femoral puncture in minutes.

This study conducted in accordance with the Helsinki Declaration and approved by Istanbul Aydin University Ethical Committee (approval no: 79-2025, date: April 16, 2025).

### Statistical Analysis

Statistical analyses were carried out using appropriate parametric and non-parametric tests according to the distribution of the data. Non-parametric data were expressed as median value and interquartile range, parametric data as mean and standard deviation. Differences between groups were analyzed using Student's *t*-test or Mann–Whitney U, and correlation analyzes were performed with Pearson or Spearman tests. Fisher's exact test was utilized to evaluate categorical data. P<0.05 was considered statistically significant. Missing data were not included in the analyses.

IBM® SPSS® Statistics 29.0.2 (Chicago, IL/USA) was used as statistical program.

## RESULTS

In our center, a total of 421 MT procedures were performed from January to December 2023. Only 371 patients were compatible with the inclusion criteria. The patients excluded were patients with MT performed within more than 24 hours or missing follow-up data. Figure 1 shows the inclusion flow diagram.

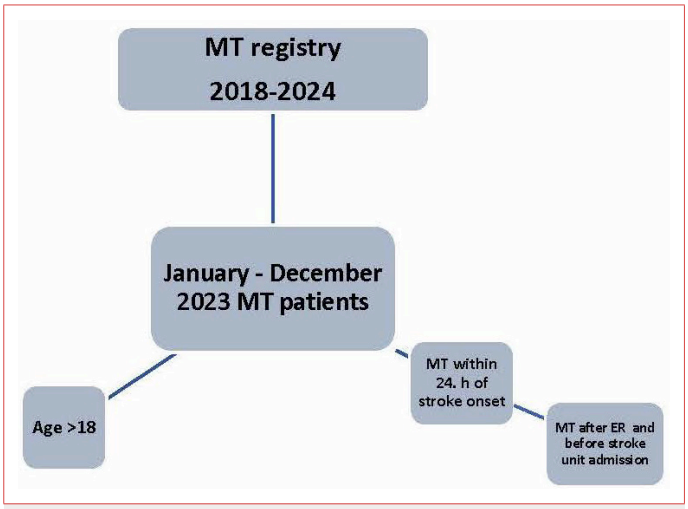


**Figure 1.** Patients inclusion criteria.
MT: Mechanical thrombectomt; ER: Emergency room

Overall, the median age was 68 (±12.9) years and 189 (50.8%) of the patients were female. Among risk factors hypertension and atrial fibrillation (74.5% and 62.6%) were the highest. The median NIHSS score on admission was 17 (±6) and 24 h NIHSS was 9 (±7). Table 1 shows the baseline demographic features and stroke risk factors. IV tPA was administered to only 15 patients (3.7%). Due to the low IV tPA administration rate, the door to IV tPA time was not included in the outcome evaluation.

No significant difference was found between working hours and nighttime, weekend, or holiday hour in terms of demographics, risk factors, and clinical features (p>0.001).

A total of 201 (54%) patients were transferred from another center and 163 (43.8%) patients were mothership patients. No significant difference was found between working hours and nighttime, weekend, or holiday hour regarding time-metrics for both transfer and mothership patients (p>0.001).

The performed baseline radiological evaluation was as follows: 239 (64.2%) DW and 117 (31.5%) CT imaging protocol. A total of 29 patients were transferred directly to the angio-suite and of those 20 (69%) patients were from the transfer group and 9 (31%) patients from the mothership group. MRI imaging protocol was the most performed protocol for all working and non-working hours. The use MRI imaging protocol was significantly higher during working hours. (p<0.001) Overall, MT of 150 (40.3%) patients was performed during daytime and 124 (%33,3) during nighttime.

The number of patients performed during the weekend days and holidays was 80 (21.5%) and 17 (4.6%), respectively. Door to radiology time during working hours, nighttime, weekend, and holidays were as follows: 14±10.9, 13.7±9.1, 12.5±7.4, and 10.3±6.2 min. Radiology to puncture and door to puncture

**Table 1.** Demographic features and stroke risk factors

| **Demographics** | |
|---|---|
| Age (mean±SD) | 68.2±12.99 |
| Female sex (*n*, %) | 189 (50.8) |
| Risk factors | |
| Diabetes (*n*, %) | 100 (26.9) |
| Hypertension (*n*, %) | 277 (74.5) |
| Hyperlipidemia (*n*, %) | 221 (59.4) |
| Atrial fibrillation (*n*, %) | 233 (62.6) |
| CAD (*n*, %) | 81 (21.8) |
| Smoking (*n*, %) | 132 (35.5) |

*CAD: Coronary artery disease, SD: Standard deviation

**Table 2.** Overview of patients according to admission time

| | Working hours (n=150) | Night time (n=124) | Weekend (n=80) | Holiday (n=17) | p |
|---|---|---|---|---|---|
| Demographics | | | | | |
| Age (mean±SD) | 67.9±13.7 | 68.5±12.3 | 69±11.8 | 65.1±16.8 | 0.86 |
| Female sex (*n*, %) | 75 (50) | 62 (50) | 44 (55) | 7/17 (41.2) | 0.73 |
| Risk factors | | | | | |
| Diabetes (*n*, %) | 39 (26) | 40 (32.3) | 17 (21.3) | 3 (17.6) | 0.25 |
| Hypertension (*n*, %) | 104 (69.3) | 97 (78.2) | 64 (80) | 11 (64.7) | 0.14 |
| Hyperlipidemia (*n*, %) | 84 (56) | 84 (67.7) | 44 (55) | 8/17 (47.1) | 0.17 |
| Atrial fibrillation (*n*, %) | 90 (60) | 82 (66.1) | 49 (61.3) | 11 (64.7) | 0.7 |
| CAD (*n*, %) | 33 (22) | 32 (25.8) | 12 (15) | 3 (17.6) | 0.3 |
| Smoking (*n*, %) | 55 (36.7) | 47 (37.9) | 24 (30) | 6 (35.3) | 0.67 |
| Clinical features | | | | | |
| NIHSS on admission (mean±SD) | 16.7±5.9 | 16.7±5.9 | 16.3±6.3 | 16.6±6.7 | 0.98 |
| NIHSS 24$^{th}$ h (mean±SD) | 9.2±7.6 | 9.5±7.9 | 8.6±7.7 | 5.7±6.9 | 0.11 |
| Time metrics | | | | | |
| Door to radiology (mean±SD) | 14±10.9 | 13.7±9.1 | 12.5±7.4 | 10.3±6.2 | 0.51 |
| Radiology to puncture (mean±SD) | 25.9±17.9 | 37.3±27.7 | 49.6±33.4 | 34.8±24.1 | <0.05 |
| Door to puncture (mean±SD) | 42.5±39.5 | 51±30 | 63.4±36.2 | 45.7±27.3 | <0.05 |
| Imaging | | | | | |
| CT (*n*, %) | 54 (36) | 46 (37.1) | 16 (20) | 1 (5.9) | 0.004 |
| MRI (*n*, %) | 83 (55.3) | 73 (58.9) | 67 (83.8) | 15 (88.2) | <0.05 |
| Direct-to-angio (*n*, %) | 18 (12) | 9 (7.3) | 1 (1.3) | 1 (5.9) | 0.036 |
| Admission | | | | | |
| Transfer (*n*, %) | 83 (55.3) | 66 (53.2) | 44 (55) | 8 (50) | 0.96 |
| Mothership (*n*, %) | 64 (42.7) | 55 (44.4) | 35 (43.8) | 8 (50) | 0.96 |

*CAD: Coronary artery disease; SD: Standard deviation; CT: Computed tomography; MRI: Magnetic resonance imaging; NIHSS: National Institutes of Health Stroke scale

time were significantly lower during working hours compared to other non-working hours. (p<0.001) Table 2 shows an overview of the above parameters according to the temporal variation.

In terms of clinical outcome, 24 h NIHSS did not differ between working hours and night-time, weekend and holidays. (p>0.001) Furthermore, 90 day mRS and mortality did not differ between working and non-working hours. (Table 3) However, door to femoral puncture was found significantly lower during working hours (p<0.001) (Fig. 2) Therefore, although clinical outcome was the same between working and non-working hours that the triage overall was achieved faster during working hours. In

**Table 3.** (a) 90 day mRS stratified by temporal variation and (b) mortality stratified by temporal variation

| | mRS 0-2 | mRS 3-5 | mRS 6 |
|---|---|---|---|
| Time | | | |
| Nighttime | 68 | 29 | 26 |
| Daytime | 88 | 36 | 26 |
| Weekend | 46 | 20 | 14 |
| Holiday | 14 | 2 | 1 |

*mRS: Modified Rankin score

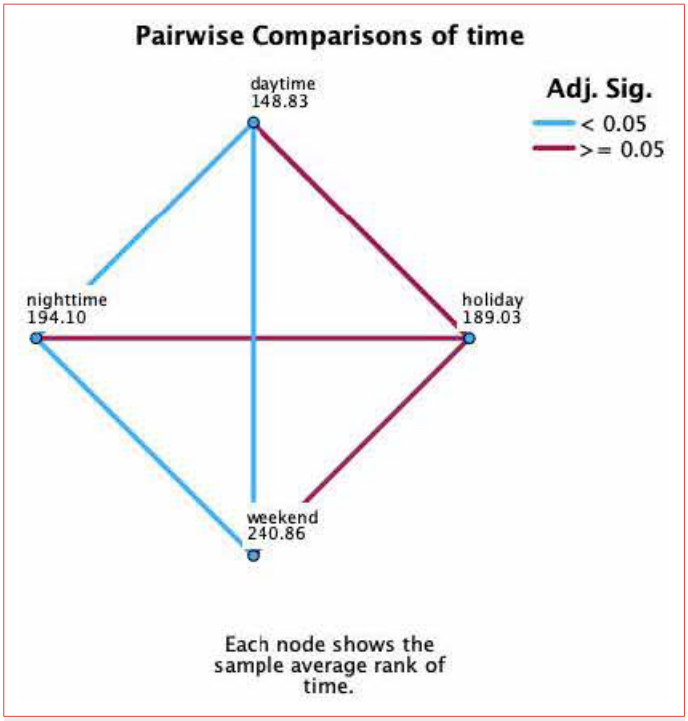


**Figure 2.** Door-to-femoral puncture time temporal variation.

addition, mRS 0–2 was achieved in approximately 58% of the patients and mortality overall was 23%.

## DISCUSSION

This study investigates outcomes after MT in patients with AIS admitted during working hours compared with those during night-time, weekend, and holiday hours. The most prominent findings indicate that our workflow is efficient at both working hours and non-working hours in terms of door- to radiology time. However, radiology to femoral puncture and door to puncture time being shorter during working hours indicates that in hospital organization is faster in performing intervention during working hours. This could be related with the neurointerventional team not being onsite during the non-working hours.

The temporal variation of AIS onset including the "weekend effect" and the impact on clinical outcome has been analyzed since the thrombolytic treatment era and goes on recently with the introduction of MT as revascularization treatment for stroke.[8,12-16] In this study, working hours and non-working hours median time are reported 42 and 63 min, respectively. Notably shorter than the time-metrics reported in present studies so far. We also did not find any significant relationship between working and non-working hours in terms of good outcome and mortality. Still, the good outcome rate was relatively high and mortality rate relatively low when compared to other studies. We believe that the short time-metrics constitute an important factor in achieving this good outcome and also are a good indicator of a well-organized stroke center which should function despite the temporal variation of stroke onset. In our study, population 33% of the patients was admitted during night-time hours.

The MR CLEAN Registry of the workflow time-metrics showed a longer door-to puncture time during off-hours (including weekends) compared to on-hours (8 am–6 pm during weeks), both longer than 120 min.[17] Other large cohorts also reported longer door-to femoral puncture times during off hours.[12-16,18] A multi-center study also shows that the majority of MT cases occur during non-work hours and is associated with implications for hospitals implementing stroke call coverage.[19]

Based on the past large cohort findings and time-metrics, we believe that it provides good insights about stroke center individuality in terms of organization. Our time-metrics emphasize the positive impact of good organization over time-metrics and consequently over outcome despite the effect of non-working hours.

### Limitations

The main limitations of the present study are its single-center and retrospective design. Therefore, the limited comparability of our findings with those from other centers should be considered when interpreting the results.

## CONCLUSION

Temporal variations of time-metrics in MT for AIS patient are an important indicator of the in-hospital stroke organization. The present findings indicating that time-metrics and outcome did not significantly differ between working and non-working hours are relevant for the careful design of stroke care, and might be applicable to other countries.

### Disclosures

**Ethics Committee Approval:** The study protocol was approved by the Istanbul Aydin University Ethics Committee (No: 79-2025, Date: 16/04/2025).

**Informed Consent:** Not declared.

**Conflict of Interest:** The authors declare that there is no conflict of interest.

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**Peer-review:** Externally peer-reviewed.

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