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Original article

mQUALITY OF ACUTE STROKE CARE AT THE DEPARTMENT OF URGENT NEUROLOGY / UNIVERSITY CLINIC FOR NEUROLOGY: ANALYSIS OF PROCESS METRICS AND OUTCOES DURING THE FIRST HALF OF 2025

Arsovska Anita[1,2], Angelova Aleksandra[1,2], Mitrevska Velkov Jasmina[1,2], Karimani Jetmir[3], Gashpar Glorija[4], Hasani Shpresa[1], Janevski Petar[2,5], Kukoska Teodora[6], Cvetkovska Bisera[1], Alili Dafina[7], Axhami Bekim[8], Dimovski Filip[9], Trpchevski Filip[10]

[1]University Clinic for Neurology, Skopje, Republic of North Macedonia
[2]Faculty of Medicine, Ss. Cyril and Methodius University, in Skopje, Republic of North Macedonia
[3]General Hospital "Ferid Murad" Gostivar, Republic of North Macedonia
[4]PHI Special hospital for geriatric and palliative medicine "13 November", Bitola, Republic of North Macedonia
[5]University Clinic for Radiology, Skopje, Republic of North Macedonia
[6]PHI Vevchani, Republic of North Macedonia
[7]General hospital Debar, Republic of North Macedonia
[8]General City Hospital "8th September", Skopje, Republic of North Macedonia
[9]General City Hospital Ohrid, Republic of North Macedonia
[10]PHO Polyclinic "Zhelezara", Skopje, Republic of North Macedonia
e-mail: anita70mk@yahoo.com

Abstract

Introduction: Rapid reperfusion improves acute stroke outcomes. Guidelines recommend intravenous thrombolysis (IVT) within 60 min in ≥ 75% of eligible patients and 45 min in ≥ 50%. Endovascular therapy (EVT) should start within 90 min, with brain imaging completed in ≤ 25 min and interpreted in ≤ 45 min. This study assessed local compliance during early 2025.

Aim: To compare acute stroke process metrics, treatment rates, and outcomes between Q1 and Q2 2025 at the Department of Urgent Neurology, University Clinic for Neurology in Skopje, and benchmark against standards.

Material and methods: We retrospectively analyzed hospital and RES-Q registry data for all acute stroke admissions from January–June 2025. Variables included demographics, stroke type, time metrics, reperfusion rates, post-acute care indicators, and discharge outcomes.

Results: Q1: 79 patients (88.6% ischemic), median NIHSS 14, onset-to-door 180 min, door-to-imaging 26 min (48% ≤25 min). IVT in 29% (DTN 53 min: 57% ≤60 min, 43% ≤45 min); EVT 1% (door-to-groin 194 min). Q2: 28 patients (78.6% ischemic), NIHSS 13, onset-to-door 105 min, imaging 20 min. IVT rose to 35%, EVT to 15%, combined IVT+EVT 5%, recanalization 55%. DTN worsened to 87 min; door-to-groin improved to 93 min (meeting target). Carotid imaging rose from 65% to 83%.

Conclusion: In early 2025, imaging compliance and EVT use improved, with faster onset-to-door and door-to-groin times. However, DTN performance declined in Q2, and pre-hospital notification was lacking. Focused workflow optimization and EMS engagement are needed to achieve IVT benchmarks.

Keywords: stroke, quality improvement, time-to-treatment, thrombolytic therapy, thrombectomy

Introduction

Stroke is a leading cause of mortality and long-term disability worldwide, with significant public health and socioeconomic impact[1]. In Eastern Europe, including North Macedonia, the incidence of stroke and related mortality remain higher than in many Western European countries[2,3]. Rapid reperfusion through intravenous thrombolysis (IVT) or endovascular therapy (EVT) has been shown to significantly improve functional outcomes[4-6]. The therapeutic benefit of these interventions is highly time-dependent, as demonstrated by the 'time is brain' concept[7]. International guidelines from the European Stroke Organisation (ESO) and the American Heart Association/American Stroke Association (AHA/ASA) recommend that at least 75% of eligible patients receive IVT within 60 minutes of arrival, and at least 50% within 45 minutes[8,9]. For EVT in patients with large-vessel occlusion, a door-to-groin puncture time of ≤ 90 minutes is advised[10]. Rapid neuroimaging, computed tomography (CT) within 25 minutes of arrival and interpretation within 45 minutes, is essential for diagnosis and treatment planning[11].

The University Clinic for Neurology in Skopje serves as the primary tertiary stroke referral centre in North Macedonia, making its performance in stroke care a key indicator for national practice. Participation in the national and international stroke quality registries allows benchmarking against ESO and AHA/ASA performance standards. However, local evidence on compliance with these targets is limited.

Aim

To evaluate and compare the performance of acute stroke care process metrics, treatment rates, and short-term outcomes between the first and the second quarter (Q1 and Q2, respectively) in 2025 at the Department of Urgent Neurology, University Clinic for Neurology in Skopje, and to benchmark these results against national and international guidelines.

Material and methods

This retrospective observational study analyzed prospectively collected hospital information system data and data from the RES-Q registry for all patients admitted with a confirmed diagnosis of stroke between 1 January-31 March 2025 (Q1) and 1 April-30 June 2025 (Q2). Inclusion criteria were acute ischemic stroke, intracerebral hemorrhage (ICH), and subarachnoid hemorrhage (SAH). Exclusion criteria included transient ischemic attacks, stroke mimics, and incomplete data records.

Data collected included demographics (age, sex), stroke type, baseline National Institutes of Health Stroke Scale (NIHSS) score, pre-hospital delays (onset-to-door time, EMS pre-notification), in-hospital process times (door-to-imaging, DTN for IVT, door-to-groin for EVT), treatment rates, carotid imaging performance, secondary prevention prescription rates at discharge, and functional outcomes (modified Rankin Scale [mRS] and NIHSS at discharge, length of stay).

Continuous variables are presented as medians with interquartile ranges; categorical variables as percentages. Results were benchmarked against ESO and AHA/ASA targets and compared to national registry averages where available.

Results

In Q1, 79 patients were admitted with stroke (70 ischemic, 9 ICH), median age 71 years, 53% male, median NIHSS 14. EMS pre-notification occurred in 7% of cases; median onset-to-door time was 180 minutes. All patients underwent imaging, with median door-to-imaging time 26 minutes, achieving the ≤ 25-minute target in 48% of cases. IVT was administered in 29% of ischemic stroke cases, with a median DTN of 53 minutes (57% ≤60 minutes; 43% ≤45 minutes). EVT was performed in 1% of cases, with median door-to-groin puncture time of 194 minutes.

Table 1. Comparison of Key Metrics – Q1 *vs.* Q2

Metric	Q1	Q2	Comment
Cases	79	28	↓ due to seasonal/operational factors
Ischemic stroke (%)	88.6	75	Slight drop
EMS pre-notification (%)	7	0	Needs improvement
Median onset-to-door (min)	180	105	Improved
Door-to-imaging (median, min)	26	20	Improved, met guideline in Q2
IV thrombolysis (%)	29	35	Increase
DTN (median, min)	53	87	Worsened
Mechanical thrombectomy (%)	1	15 (+5% combined)	Major increase
Door-to-groin (median, min)	194	93	Improved to target
Carotid imaging (%)	65	83	Improved
Discharge mRS (median)	5	4.5	Improved
Discharge NIHSS (median)	6	4	Improved

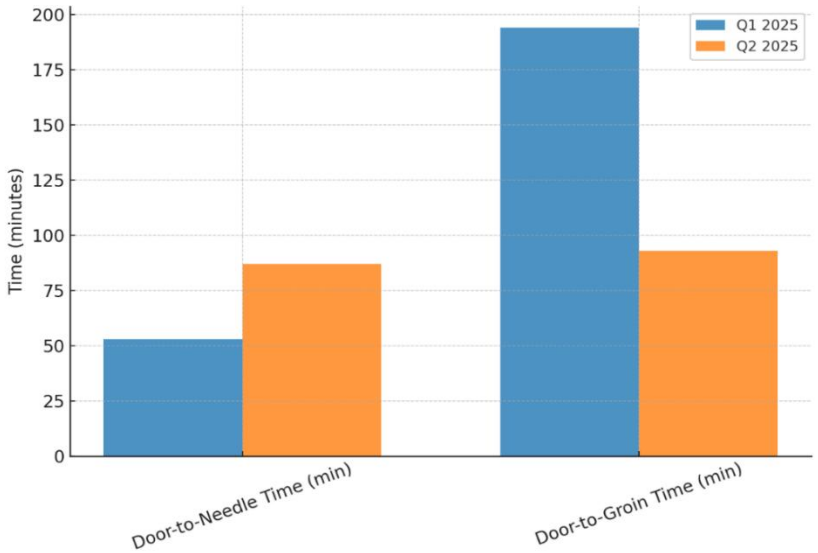

Fig. 1. Comparison of key tretmant in acute stroke care

In Q2, 28 patients were admitted (21 ischemic, 6 ICH, 1 SAH), median NIHSS 13. EMS pre-notification was 0%, but median onset-to-door time improved to 105 minutes. All patients underwent imaging, with median door-to-imaging time reduced to 20 minutes, and guideline compliance improved. IVT was given to 35% of ischemic stroke patients, but median DTN

increased to 87 minutes. EVT was performed in 15% of cases (including 5% combined IVT+EVT), with median door-to-groin puncture time of 93 minutes.

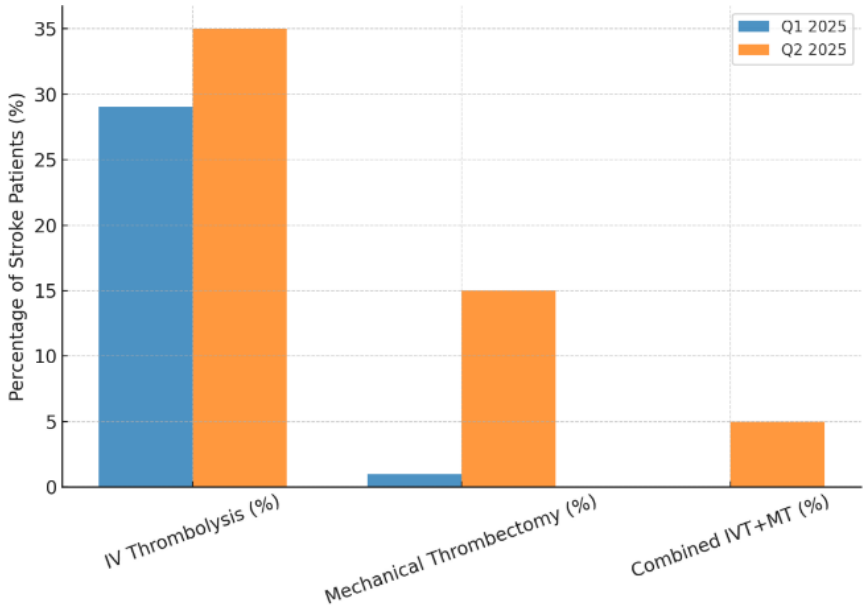

Fig. 2. Reperfusion therapy rates in Q1 vs Q2 2025

Table 1 summarizes the main process and outcome metrics for Q1 and Q2 2025. Imaging times improved in Q2, with median door-to-imaging falling from 26 to 20 minutes, meeting the ESO target. Reperfusion therapies were more frequently administered in Q2: IV thrombolysis rose from 29% to 35%, and mechanical thrombectomy increased from 1% to 15%, with an additional 5% receiving combined IVT+MT. The recanalization rate reached 55% in Q2. However, median DTN time worsened from 53 to 87 minutes (Figure 1 and Figure 2). Door-to-groin time improved markedly from 194 to 93 minutes, reaching the ≤ 90-minute target in most Q2 cases. Post-acute measures, such as carotid imaging (65% to 83%) and anticoagulation at discharge for atrial fibrillation, also improved.

Discussion

This comparative analysis of Q1 and Q2 2025 performance at the Department of Urgent Neurology, University Clinic for Neurology in Skopje highlights substantial improvements in certain process measures, alongside persistent challenges in others. Imaging efficiency improved markedly in Q2, with a median door-to-imaging time of 20 minutes, well within the ESO-recommended 25-minute target[5], and exceeding the performance of many European centers [8]. This gain, likely aided by workflow adjustments and prioritization of stroke imaging, is a critical success, as early neuroimaging directly impacts eligibility for reperfusion[13].

Mechanical thrombectomy utilization increased from 1% to 15%, with an additional 5% receiving combined IVT+MT (Figure 2). This reflects both growing local capability and adherence to best practice in treating LVO[4,5]. Notably, door-to-groin puncture times improved from 194 to 93 minutes (Figure 1, Figure 2), aligning with international benchmarks[7]. This acceleration suggests that interventional workflows have become more streamlined.

Conversely, door-to-needle times worsened from a median of 53 minutes in Q1 to 87 minutes in Q2 (Figure 1), with fewer patients meeting the ≤ 60-minute target. This may reflect

logistical delays in balancing thrombolysis and thrombectomy pathways, a phenomenon observed in centers scaling up endovascular capacity [9]. Given the well-established time dependency of thrombolysis benefit[13,14], targeted quality improvement initiatives are needed to reverse this trend.

Pre-hospital EMS notification remained absent in Q2, down from an already low 7% in Q1. This contrasts sharply with high-performing systems where prenotification rates exceed 80%, enabling earlier activation of stroke teams and faster imaging[8,9]. National-level engagement with EMS providers is required to address this systemic barrier.

Post-acute measures, including carotid imaging and secondary prevention prescribing, showed improvement and are in line with ESO quality indicators[5]. Functional outcomes at discharge (mRS and NIHSS) improved modestly, consistent with faster imaging and increased reperfusion rates.

Overall, the Department's performance now meets or exceeds national averages in imaging and thrombectomy, but sustained attention to thrombolysis workflow and EMS coordination will be essential to fully align with international standards. The findings indicate substantial improvement in EVT rates and imaging performance between Q1 and Q2 2025. However, the increase in median DTN time in Q2, despite faster imaging, suggests delays in treatment decision-making and workflow execution. The absence of EMS pre-notification in Q2 remains a significant barrier to rapid treatment initiation.

Compared to national averages, the clinic demonstrated superior imaging compliance and higher reperfusion rates. However, performance fell short of international benchmarks for DTN efficiency. Interventions targeting pre-hospital notification systems, streamlined in-hospital protocols, and parallel processing for IVT and EVT candidates may address these gaps.

Several large-scale registries and randomized controlled trial datasets have reinforced the importance of minimizing treatment delays in acute ischemic stroke. Data from the Safe Implementation of Thrombolysis in Stroke–International Stroke Thrombolysis Register (SITS-ISTR) demonstrated that each 15-minute reduction in onset-to-treatment time yields a significant absolute increase in the probability of walking independently at discharge[12]. Similarly, pooled analysis of endovascular thrombectomy (EVT) trials, including MR CLEAN, ESCAPE, REVASCAT, SWIFT PRIME, and EXTEND-IA, showed consistent benefits across multiple patient subgroups, with faster times to reperfusion translating into improved functional independence at 90 days[13,14]. In the context of low- and middle-income countries, structural and organizational limitations, particularly regarding pre-hospital care, often contribute to treatment delays, as demonstrated in a recent review of Eastern European stroke systems[15].

Participation of North Macedonia in international stroke registries offers an opportunity to systematically evaluate stroke care processes, identify bottlenecks, and implement targeted quality improvement initiatives[16]. While tertiary centers like the University Clinic for Neurology in Skopje are equipped with advanced imaging and interventional capabilities, national-level performance remains constrained by EMS response times, limited public awareness, and inter-hospital transfer delays[17].

Limitations

This study has several limitations. First, its retrospective design is subject to potential biases, including incomplete or inaccurate data entry into the hospital information system. Second, the relatively small sample size in Q2 limits the statistical power to detect subtle changes in performance metrics or outcomes. Third, data on long-term functional outcomes beyond hospital discharge were not available, precluding assessment of sustained benefit from reperfusion

therapies. Fourth, pre-hospital variables, including exact EMS transport times and in-field triage decisions, were incompletely captured, limiting analysis of upstream delays. Finally, while guideline targets from ESO and AHA/ASA were used as benchmarks, local health system constraints must be considered when interpreting gaps in performance.

Recommendations

Based on the findings of this analysis, the following recommendations are proposed: (1) Implement structured pre-notification protocols between EMS and the stroke team to reduce door-to-needle times; (2) Develop parallel workflow pathways enabling simultaneous imaging, laboratory testing, and treatment decision-making; (3) Conduct regular simulation-based stroke team training to enhance coordination; (4) Expand public awareness campaigns to reduce onset-to-door times by encouraging early EMS activation; (5) Establish a continuous quality monitoring system leveraging registry data for real-time feedback.

Conclusion

During the first half of 2025, the Department of Urgent Neurology at the University Clinic for Neurology in Skopje achieved notable improvements in EVT access and imaging times, while IVT delivery speed declined. Strategic workflow optimization and stronger EMS coordination are recommended to improve outcomes.

Conflict of interest statement. None declared.

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