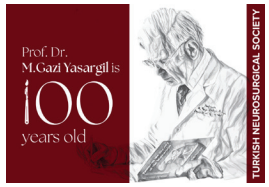
Turk Neurosurg 35(4):537-545, 2025
DOI: 10.5137/1019-5149.JTN.48420-25.2

Original Investigation

Cerebrovascular-Endovascular

Received: 14.01.2025
Accepted: 08.04.2025
Published Online: 25.06.2025



The Initial Experience of Turkish Neurosurgical Stroke Centers: A National Study

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ABSTRACT

AIM: To evaluate the clinical and radiological outcomes of newly established Turkish neurosurgical stroke centers , and to assess their competency in managing acute ischemic stroke from June 2023 to June 2024.

MATERIAL and METHODS: We retrospectively analyzed data from 69 patients (mean age = 69.06 ± 13.48 years) from three stroke centers in Türkiye by reviewing hospital records and patient interviews, focusing on demographic variables, comorbidities, treatment methodologies, outcomes (using the Modified Rankin Scale (mRS)), stroke severity (using the National Institutes of Health Stroke Scale [NIHSS]), Alberta Stroke Program Early CT (ASPECT) scores, reperfusion status (using the modified Thrombolysis in Cerebral Ischemia (mTICI) score), complications, blood glucose levels, and creatinine levels.

RESULTS: Of 392 acute ischemic stroke patients, 280 (71.4%) had no identifiable occlusion, 43 (11%) were out of the MT time window, and 69 (17.6%) underwent MT, with 57 (14.5%) having LVO and 12 (3%) MVO. Final reperfusion (mTICI ≥2b) was achieved in 78.3% of MT patients, and 29% achieved favorable outcomes (mRS ≤2) at three months. Younger age, lower baseline NIHSS, and higher ASPECT scores correlated with better outcomes, while elevated blood glucose (>127.50 mg/dL) and creatinine (>0.80 mg/dL) were linked to worse mRS scores. Complications occurred in 21.7%, including symptomatic intracranial hemorrhage in six patients.

CONCLUSION: While Turkish neurosurgical stroke centers have made significant strides in managing acute ischemic stroke, challenges remain in optimizing patient outcomes. This initial experience underscores the need for further research, continued training, and educational standardization for neurosurgeons in endovascular techniques to improve patient care.

KEYWORDS: Acute ischemic stroke, Mechanical thrombectomy, Stroke center, Neurosurgeon

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ABBREVIATIONS: Mrs: Modified rankin scale, **NIHSS:** National institutes of health stroke scale, **LVO:** Large vessel occlusion, **MVO:** Medium vessel occlusion, **ASPECT:** Alberta stroke program early CT, **Mtici:** Modified thrombolysis in cerebral ıschemia, **ESO:** European stroke organization, **AHA:** American heart association, **ASA:** American stroke association, **MT:** Mechanical thrombectomy, **TA:** Thromboaspiration, **CT:** Computed tomography, **MRI:** Magnetic resonance imaging, **ICH:** Intracranial hemorrhage, **DWI:** Diffusion-weighted imaging, **IV-Tpa:** Intravenous tissue plasminogen activator, **SBP:** Systolic blood pressure, **WBC:** White blood cell, **DC:** Decompressive hemicraniectomy, **Sich:** Symptomatic ICH, **IQR:** Interquartile range, **ROC:** Receiver operating characteristic, **ICA-T:** Internal carotid artery terminus, **MCA:** Middle cerebral artery, **BA:** Basilar artery, **SAH:** Subarachnoid hemorrhage, **EVD:** External ventricular drainage, **AUC:** Area under the curve

INTRODUCTION

Stroke is the second leading cause of death and a major reason for disability across the globe. The burden of stroke has been consistently increasing, particularly in low- and middle-income countries (13). Since 2015, multiple pivotal randomized controlled trials have been published that revolutionized the management of acute ischemic stroke (5,6,14,15). The current guidelines for the management of acute stroke given by the European Stroke Organization (ESO) (32), and the American Heart Association (AHA)/American Stroke Association (ASA) recommend thrombolysis, mechanical thrombectomy (MT), and thromboaspiration (TA) as the primary treatment methods (16). Among these, MT is a recent and well-researched technique, which, in conjunction with intravenous thrombolysis, is considered the gold standard for the management of ischemic strokes of the anterior cerebral vessels within the first 6 hours (24).

Earlier, endovascular treatments in Türkiye were administered exclusively by radiologists; however, over the past 20 years, neurosurgeons have also been receiving training in endovascular techniques, particularly in countries like Japan and South Korea. Eventually, these neurosurgeons started practicing endovascular procedures and established hybrid neurosurgery clinics in Türkiye, leading to significant advancements in stroke interventions. In 2019, the Turkish Ministry of Health issued the Stroke Centers Directive authorizing specialists in radiology, neurology, neurosurgery, and cardiology to perform interventional procedures for stroke treatment, along with establishing the required case volumes for practitioners. This national-level study evaluated the clinical and radiological outcomes of the newly established neurosurgical stroke centers in Türkiye over one year to determine their competency levels.

MATERIAL and METHODS

Ethics approval was obtained from Pamukkale University Non-Interventional Clinical Research Ethics Committee, with the approval number 14 and date 06.08.2024.

Study Design and Sample Selection Criteria

In Turkish stroke centers, patients arriving at the emergency department are initially evaluated by emergency medicine specialists. Following this, a consultation with the neurology clinic is promptly initiated. Occlusions of the internal carotid artery terminus (ICA-T), M1 branch of the middle cerebral artery (MCA), and basilar artery (BA) are classified as large vessel occlusions (LVO), while occlusions of the M2 and M3 branches of the MCA, as well as the anterior and posterior cerebral arteries, are considered medium vessel occlusions (MVO) (26). If the neurology team determines an indication for mechanical thrombectomy after clinical and radiological assessment (e.g., identifying LVO or MVO), the patient is referred to a specialist from radiology, neurology, neurosurgery, or cardiology for the procedure, depending on the center's expertise and resources.

In this study, we retrospectively reviewed patient data from three stroke centers in Türkiye obtained through hospital systems and telephone interviews from June 2023 to June 2024. Ethical approval was obtained from the relevant ethics committee prior to conducting the study. Patients aged ≥18 years who were treated at these stroke centers were assessed for demographic variables, comorbidities, treatment methodologies, and outcomes measured by the Modified Rankin Scale (mRS). Patients were considered eligible for MT if they had a large vessel occlusion (determined by computed tomography (CT) or magnetic resonance imaging (MRI) angiography) and a National Institutes of Health Stroke Scale (NIHSS) score of ≥6 upon admission; intracranial hemorrhage (ICH) was ruled out via a non-contrast CT scan. Additionally, patients were included if they presented within the first 6 h and the infarct involved less than one-third of the territory as shown on a diffusion-weighted (DWI) MRI. With symptom onset of ≥6 hours, the presence of a DWI-Fluid-Attenuated Inversion Recovery mismatch was used as the criteria to undergo MT. Patients with posterior circulation strokes were not excluded. For those arriving within the first 4.5 h, intravenous tissue plasminogen activator (tPA) (IV-tPA) was administered in the Neurology Department (16).

Data for the following variables were extracted for all patients – age, gender, comorbidities, presence of myocardial infarction at the time of stroke, use of premorbid oral anticoagulants, current smoking status, time from the last "known well" status to hospital arrival, door-to-puncture time, systolic blood pressure (SBP), blood glucose levels, white blood cell (WBC) count, creatinine levels, pre-stroke mRS scores, baseline NIHSS scores, Alberta Stroke Program Early CT (ASPECT) scores, use of tPA, occlusion site, treatment types, manufacturer details of the thrombectomy device, complications including hemorrhage and reperfusion, need for decompressive hemicraniectomy (DC), the modified Thrombolysis in Cerebral Ischemia (mTICI) score, and mRS scores three months after the procedure.

All angiographic evaluations were conducted using the mTICI scale – mTICI grades ≤2a indicate unsuccessful recanalization, whereas grades 2b and 3 indicate successful recanalization (7). A non-contrast CT or MRI was routinely performed within 24 hours of the treatment or immediately after the procedure if the patient exhibited symptoms. Symptomatic ICH (sICH) was defined as an intracranial bleed that resulted in clinical deterioration, indicated by an increase of 4 points on the NIHSS (2). In the third month, patients with an mRS score of 0–2 were considered to have a favorable outcome, while those with an mRS score of 3–6 were classified as having a poor outcome (11).

We evaluated 392 acute ischemic stroke patients. Of these, 280 (71.4%) had no identifiable intracranial vascular occlusion, 43 (11%) were deemed out of the thrombectomy time window due to hyperintensity on MRI FLAIR sequences at presentation, and 69 (17.6%) met the inclusion criteria for MT. Within this cohort, LVO were identified in 57 patients (14.5%), and MVO in 12 patients (3%).

Endovascular Procedures

All procedures were performed under local anesthesia, with vital signs being continuously monitored through anesthesia monitoring for all patients. Arterial punctures could be performed using the transfemoral, transradial (18), or direct carotid (35) approaches; in our study, only the transfemoral approach was used. Initially, a diagnostic cerebral angiogram was conducted to determine the site of the intracranial clot. A 6-French long introducer sheath (Heety: Barty Medical, Hangzhou City, Zhejiang Province, China, or Infinity: Stryker, Ireland) was advanced into the most distal segment of the internal carotid artery. For thrombectomy procedures, when TA was planned, a distal aspiration catheter, such as SOFIA (MicroVention-Terumo, Tustin, CA, USA), Catalyst (Stryker, Ireland), Neurocatch (Taha Biomedical, Turkey), Glutton (Plusmedica, Düsseldorf, Germany), or Cylon (Zylon Tonbridge, Zhejiang Province, China) was used. In addition, a microcatheter (Excelsior XT-27, Stryker, Natick, MA), guidewire (Synchro; Stryker, Fremont, CA), and stent retriever (Aperio Hybrid: Acandis, Pforzheim, Germany, Trevo: Stryker Neurovascular, Fremont, CA, or Solitaire: ev3/Covidien, Irvine, CA) were used. Intra- or extracranial arterial stenoses were treated with balloon angioplasty (Micro Therapeutics, Irvine, CA, USA) and carotid stenting (Protégé; Medtronic, USA).

Statistical Analysis

All analyses were performed using SPSS (version 11.5). Descriptive statistics were presented as mean ± standard deviation and median (interquartile range, IQR) for continuous variables, while frequencies (percentages) were used for categorical variables. Between-group comparisons for continuous variables were performed using Student's t-test or the Mann-Whitney U test based on the normality of data distribution. Categorical variables were compared using Chi-square and Fisher's exact tests were employed. To determine the optimal cutoff value for distinguishing between favorable and poor outcomes for the 3-month mRS score, a receiver operating characteristic (ROC) curve analysis was performed and the Youden Index was computed. A p-value of <0.05 was used to determine statistical significance.

RESULTS

We included 69 patients (37 females, 53.6%) in the study with a mean age of 69.06 ± 13.48 years (Table I). The most common comorbidities identified in the study cohort were hypertension (n=27, 39.13%), coronary artery disease (n=16, 23.19%), atrial fibrillation (n=9, 13.04%), diabetes mellitus (n=9, 13.04%), and heart failure (n=7, 10.14%). Table II presents a summary of the different comorbidities observed in the cohort.

The mean pre-stroke mRS score and the median (IQR) NIHSS score at admission of the study cohort were 0.072 ± 0.312 (range: 0–2; median 0) and 15 (5–24), respectively. The occlusion was located in the ICA-T in 13 patients (18.8%) one of which was a tandem occlusion, the M1 segment in 41 patients (59.4%), the M2 segment in 12 patients (17.4%), the BA trunk in two patients (2.9%), and the BA tip in one patient (1.5%). Seven of the 13 ICA occlusions were on the right side, while 25 out of the 41 M1 occlusions were right-sided; out of the 12 M2 occlusions, eight cases were left-sided. The median (IQR) ASPECT score on initial imaging was 8 (4–10). The median (IQR) time from last "known well" status to hospital arrival was 3 hours (0–6 hours), while the median (IQR) door-to-puncture time was 1 hour (1–5 hours) (Table I).

Regarding treatment methodologies, MT was performed in nine patients (13%), MT plus TA in 39 patients (56.5%), and TA alone in 21 patients (30.5%). Additionally, two patients received intraarterial tPA, carotid stenting was done in two patients, and balloon angioplasty in six patients (Table I). Final nearly complete reperfusion (mTICI grade ≥2b) was achieved in 54 of the 69 patients (78.3%), while complete reperfusion (mTICI grade 3) was noted in 41 patients (59.4%).

Treatment-related complications were observed in 15 patients (21.7%) (Table I) – nine patients experienced subarachnoid hemorrhage (SAH), while six patients had sICH. DC was performed in 12 patients (including four cases of external ventricular drainage, EVD), and EVD alone was performed in two patients.

At the third-month follow-up, the median (IQR) mRS score of the study cohort was 4 (0–6). Statistically significant differences were observed between patients with favorable (0–2) and poor (3–6) mRS scores regarding age, baseline NIHSS score, ASPECT score, complication rates, and use of DC ($p < 0.05$ each). The average age of patients with poor mRS scores was 71.96 ± 11.04 years compared to 61.95 ± 16.37 years for those with favorable mRS scores. Likewise, patients with poor mRS had significantly higher baseline NIHSS scores, whereas those with favorable mRS had higher ASPECT scores. None of the patients with complications had a favorable mRS score at the 3-month follow-up, whereas 37% of those without complications had a favorable mRS. Additionally, none of the patients who underwent DC had a favorable mRS, compared to 35.1% of those who did not undergo DC (Table I).

Table I: Baseline Demographic and Clinical Characteristics of the Study Patients Stratified Based on the mRS Score at the Third-Month Follow-Up (n=69)

Variables		mRS Score			p-value
		Overall	Poor	Favorable	
Age (years)	Mean ± SD	69.06 ± 13.48	71.96 ± 11.04	61.95 ± 16.37	**0.010[b]**
	Median (Min–Max.)	71.00 (19.00–90.00)	73.00 (41.00–90.00)	67.00 (19.00–81.00)	
Gender, n (%)	Female	37 (53.6)	25 (67.6)	12 (32.4)	0.497[c]
	Male	32 (46.4)	24 (75.0)	8 (25.0)	
Comorbidity, n (%)	No	6 (8.7)	2 (33.3)	4 (66.7)	0.054[d]
	Yes	63 (91.3)	47 (74.6)	16 (25.4)	
Myocard Infractus, n (%)	No	67 (97.1)	48 (71.6)	19 (28.4)	0.499[d]
	Yes	2 (2.9)	1 (50.0)	1 (50.0)	
Premorbid oral anticoagulants, n (%)	No	20 (29.0)	14 (70.0)	6 (30.0)	0.906[c]
	Yes	49 (71.0)	35 (71.4)	14 (28.6)	
Current smoker, n (%)	No	65 (94.2)	47 (72.3)	18 (27.7)	0.574[d]
	Yes	4 (5.8)	2 (50.0)	2 (50.0)	
Time from the last “known well” to hospital arrival (h)	Mean ± SD	3.14 ± 1.50	3.08 ± 1.67	3.28 ± 0.99	0.328[b]
	Median (Min.-Max.)	3.00 (0.00–6.00)	3.00 (0.00–6.00)	3.00 (1.00–5.50)	
Door to puncture time (h)	Mean ± SD	1.57 ± 0.86	1.68 ± 0.94	1.28 ± 0.53	0.096[b]
	Median (Min–Max.)	1.00 (1.00–5.00)	1.00 (1.00–5.00)	1.00 (1.00–3.00)	
Baseline NIHSS score	Mean ± SD	15.23 ± 4.69	16.69 ± 4.27	11.65 ± 3.69	**<0.001[a]**
	Median (Min–Max.)	15.00 (5.00–24.00)	17.00 (8.00–24.00)	12.00 (5.00–20.00)	
ASPECT Score	Mean ± SD	7.34 ± 1.78	7.00 ± 1.88	8.25 ± 1.06	**0.017[b]**
	Median (Min–Max.)	8.00 (4.00–10.00)	7.00 (4.00–10.00)	8.50 (6.00–10.00)	
tPA, n (%)	No	66 (95.7)	47 (71.2)	19 (28.8)	1.000[d]
	Yes	3 (4.3)	2 (66.7)	1 (33.3)	
Occlusion site, n (%)	BA	3 (4.3)	2 (66.7)	1 (33.3)	0.486[d]
	ICA	13 (18.8)	11 (84.6)	2 (15.4)	
	MCA	53 (76.9)	36 (67.9)	17 (32.1)	
Treatment, n (%)	MT	10 (14.5)	7 (70.0)	3 (30.0)	0.061[c]
	TA	21 (30.4)	11 (52.4)	10 (47.6)	
	MT+TA	38 (55.1)	31 (81.6)	7 (35.0)	
Complication, n (%)	No	54 (78.3)	34 (63.0)	20 (37.0)	**0.003[d]**
	Yes	15 (21.7)	15 (100.0)	0 (0.0)	
Decompressive Hemicraniectomy, n (%)	No	57 (82.6)	37 (64.9)	20 (35.1)	**0.014[d]**
	Yes	12 (17.4)	12 (100.0)	0 (0.0)	
TICI Score, n (%)	TICI < 2b	15 (21.7)	14 (93.3)	1 (6.7)	0.051[d]
	TICI ≥2b	54 (78.3)	35 (64.8)	19 (35.2)	

Mean: *Average,* ***SD:*** *Standard Deviation,* ***Min:*** *Minimum,* ***Max:*** *Maximum,* ***mRS:*** *Modified Rankin Scale,* ***TICI:*** *Thrombolysis in Cerebral Infarction,* ***tPA:*** *Tissue Plasminogen Activator,* ***ASPECT:*** *Alberta Stroke Program Early CT Score,* ***NIHSS:*** *National Institutes of Health Stroke Scale,* ***BA:*** *Basilar Artery,* ***MCA:*** *Middle Cerebral Artery,* ***ICA:*** *Internal Carotid Artery,* ***MT:*** *Mechanical Thrombectomy,* ***TA:*** *Thromboaspiration.*
[a]Student’s t-test, [b]Mann-Whitney U test, [c]Chi-Square test, [d]Fisher’s exact test

Table II: Summary of the Different Comorbidities Observed in the Cohort

Comorbidity	n (%)
Hypertension	27 (39.13)
Coronary artery disease	16 (23.19)
Atrial fibrillation	9 (13.04)
Diabetes mellitus	9 (13.04)
Heart failure	7 (10.14)
Chronic obstructive pulmonary disease	4 (5.80)
Coronary bypass surgery	5 (7.25)
Stenting	3 (4.35)
Mitral valve replacement	2 (2.90)
Rectum cancer	1 (1.45)
Schizophrenia	1 (1.45)
Hypertrophic cardiomyopathy	1 (1.45)
Epilepsy	1 (1.45)
Pneumonia	1 (1.45)
Hypothyroidism	1 (1.45)
Anxiety disorder	1 (1.45)
Parkinsonism	1 (1.45)
Breast cancer	1 (1.45)
Lung cancer	1 (1.45)
Nephrotic syndrome	1 (1.45)

Similarly, at the third-month follow-up, patients with favorable and poor mRS scores showed statistically significant differences concerning blood glucose and creatinine levels ($p < 0.05$), that is, those with a poor mRS score had significantly higher mean blood glucose and creatinine levels (Table III). The pre-stroke mRS values were favorable for all patients; however, by the third month, 71% of the patients experienced a deterioration in their mRS scores, while 29% maintained the same score.

Figure 1 presents the ROC curves for different variables affecting the mRS score at the 3-month follow-up. We did not find any significant area under the curve (AUC) value for SBP and WBC count in the ROC analysis. However, the ROC curve analyses for blood glucose levels and creatinine at 3 months for different mRS scores revealed statistically significant AUC values – blood glucose: cutoff=127.50 mg/dL (p=0.013; sensitivity=0.755; specificity=0.600); creatinine: cutoff=0.80 mg/dL (p<0.001; sensitivity=0.755; specificity=0.800) (Table IV).

DISCUSSION

Stroke is a critical global public health issue because of the high associated rates of morbidity and mortality (20,25). This initial stroke study exploring the effects of establishing dedicated stroke centers in Türkiye revealed that younger age, lower NIHSS scores at admission, and higher ASPECT scores were associated with favorable mRS outcomes three months after the stroke. The majority of patients (78.3%) achieved successful recanalization, and 29% of patients had a 3-month mRS score of ≤2. However, a significant proportion of patients (21.7%) developed complications. While these results may reflect low success rates compared to other studies (3,17,21,30), it is noteworthy that this is the first study

Table III: A Comparison of Different Parameters Affecting Outcomes (mRS scores) at the Third-Month Follow-up (n=69)

Parameter		mRS Score			
		Overall	Poor	Favorable	p-value
Systolic Blood Pressure (mmHg)	Mean ± SD	179.39 ± 30.94	177.72 ± 30.16	173.65 ± 28.51	0.529[a]
	Median (Min–Max)	180.00 (120.00–240.00)	180.00 (110.00–240.00)	180.00 (110.00–210.00)	
Blood Glucose (mg/dL)	Mean ± SD	168.06 ± 58.67	159.39 ± 55.73	138.15 ± 41.82	**0.013[a]**
	Median (Min–Max)	151.00 (100.00–362.00)	136.00 (96.00–362.00)	124.00 (96.00–245.00)	
White Blood Cell Count (K/uL)	Mean ± SD	11.82 ± 14.45	11.05 ± 12.30	9.14 ± 2.95	0.547[a]
	Median (Min–Max)	9.50 (0.78–106.00)	9.50 (0.78–106.00)	8.95 (4.76–14.50)	
Serum Creatinine (mg/dL)	Mean ± SD	1.17 ± 1.15	1.04 ± 0.99	0.73 ± 0.11	**<0.001[a]**
	Median (Min–Max)	1.01 (0.50–8.65)	0.87 (0.50–8.65)	0.73 (0.56–0.95)	

Mean: *Average,* ***SD:*** *Standard Deviation,* ***Min:*** *Minimum,* ***Max:*** *Maximum,* ***mRS:*** *Modified Rankin Scale.* [a]*Mann-Whitney U test*

reflecting the endovascular stroke treatment experiences of Turkish neurosurgeons.

In this study, TA was predominantly selected as the initial treatment method, as recommended in the existing literature (19). While a recent meta-analysis stated that there are no significant differences between MT and TA, they highlighted the inadequacy of current evidence to definitively determine the optimal surgical approach (31). Interestingly, the combined application of stent retrievers and TA as a first-line strategy yielded higher recanalization rates (mTICI grades 2b/3 and 3) but also presented a greater risk of SAH within 24 hours compared to direct aspiration alone. However, due to the limited number of cases in our study, we could not directly compare the effectiveness of the MT and combined methods. Despite significant technological advancements and high success rates, several randomized controlled trials have reported 4% to 29% complication rates associated with devices or procedures (5,6,14,15), which is comparable to the complication rates observed in our study (21.7%). Our complication rate of 21.7% aligns with ranges reported in landmark trials such as THRACE (5), where procedure-related complications ranged from 12% (excluding vasospasm) to 35% (including vasospasm), underscoring that our findings are within acceptable limits for an initial multicenter experience. The reported complication rate reflects the heterogeneity of experience across centers, ranging from those with emerging endovascular programs to those with more established expertise, providing a comprehensive snapshot of the national learning curve.

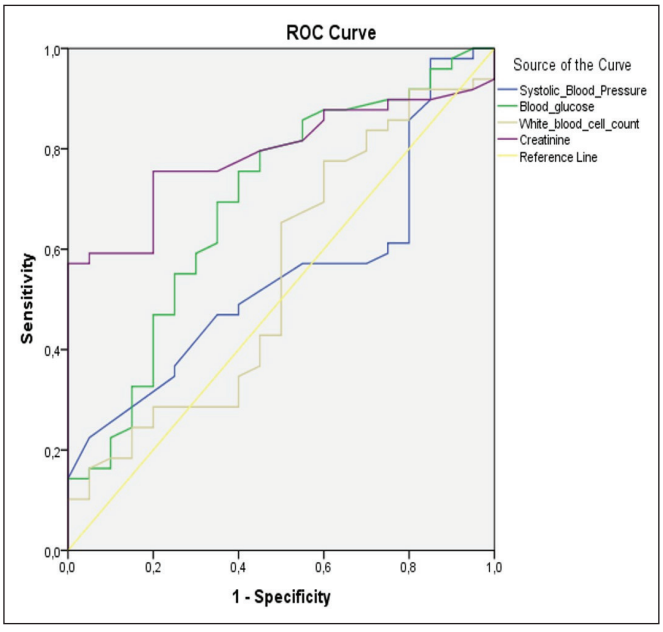

Figure 1: Receiver operating characteristic (ROC) curve for variables related to the Modified Rankin Scale (mRS) score at 3 months after stroke.

Table IV: A Comparison of Pre-Stroke Versus Third-Month mRS Scores

mRS Score		3rd Month		p-value
		Poor	Favorable	
Pre-stroke, n (%)	**Favorable**	49 (71.0)	20 (29.0)	-

mRS: *Modified rankin scale.*

Of 392 AIS patients assessed across the three centers from June 2023 to June 2024, 69 (17.6%) were eligible for MT. This included 57 patients with LVO (14.5%) and 12 with MVO (3%), proportions slightly higher than literature estimates of 11% for LVO and 9% for MVO (26). Current MT procedures in our series accounted for 5% of all AIS cases, 27% of all vascular occlusions (LVO + MVO), and 38% of LVO and M2 occlusions (26). These findings highlight the critical need for dedicated stroke centers to efficiently identify and treat this subgroup in Türkiye.

The key factors influencing favorable outcomes with posterior MT at discharge and the third-month follow-up include NIHSS scores, time to MT, and leukocytosis (4). A recent study comparing patients with anterior and posterior circulation strokes who underwent MT found that the latter had significantly lower NIHSS scores upon admission and at 24-hour post-MT (4); however, our analysis did not differentiate between anterior and posterior circulation strokes. Elevated WBC counts are associated with an increased risk of subsequent vascular events and mortality (33), whereas high SBP has been linked to unfavorable clinical outcomes. In our study, leukocytosis did not affect the three-month mRS scores, and we did not

Table V: Results of the Receiver Operating Characteristic (ROC) Curve Analysis for Variables Related to the mRS Score at Three Months After Stroke

Variables	Area	SE	p-value	95% CI for AUC (Lower-Upper)	Sensitivity	Specificity	Cut-off
Systolic Blood Pressure	0.548	0.073	0.530	0.406–0.691	0.224	0.950	205.00
Blood Glucose	0.692	0.072	**0.013**	0.551–0.833	0.755	0.600	127.50
White Blood Cell Count	0.546	0.079	0.547	0.393–0.700	0.766	0.400	7.35
Serum Creatinine	0.789	0.053	**<0.001**	0.685–0.893	0.755	0.800	0.80

SE: *Standard Error,* ***CI:*** *Confidence Interval,* ***mRS:*** *Modified Rankin Scale,* ***AUC:*** *Area Under the Curve.*

find any statistically significant correlation between WBC counts, SBP, and patient outcomes.

There is substantial evidence indicating that pre-stroke elevated glucose levels are linked to adverse effects in the acute phase of stroke, serving as an independent predictor of increased infarct size, poor clinical outcomes, and higher mortality risk (12,23). Additionally, indicators of renal function, specifically serum creatinine and estimated glomerular filtration rate, also serve as significant predictors of mortality and functional outcomes in individuals with acute stroke (27). In our study, both elevated glucose and creatinine levels correlated significantly with the three-month mRS score, consistent with the literature and indicating their contribution to poor outcomes.

An ASPECT score of ≤5 is linked to having a large infarct in the literature. A previous study on acute stroke patients found that thrombectomy combined with medical care resulted in improved functional outcomes and reduced mortality rates compared with medical care alone; however, it was also associated with a higher incidence of sICH (9). In our study, no additional assessments were performed for the group with an ASPECT score of ≤5.

Training standards, competency assessments, and credentialing requirements are essential for practitioners involved in stroke interventions (10,29). A Turkish study published educational standards for neuro-interventional procedures related to endovascular treatment of acute ischemic stroke and secondary endovascular protection, which were developed by interventional neurologists (22). As neurosurgeons, we aim to establish a similar level of educational standardization which may be disseminated nationwide through multidisciplinary approaches. At present, the Turkish Neurosurgery Society organizes biannual courses that incorporate models and simulation devices for teaching neuroendovascular treatments to stroke interventionists. Additionally, post marketing studies are available for various aspiration catheters and stent retrievers from different brands (1,28,34,36); however, there is a lack of comparative data regarding the effectiveness of thrombectomy and TA tools from different brands, primarily due to insufficient sample sizes.

Limitations

The retrospective design is a significant limitation of this study, which may introduce potential bias, as well as the small number of patients, which is less than ideal. Additionally, the varying learning curves and experiences of surgeons across different clinics represent further limitations that may have influenced the study's outcomes. Furthermore, due to the small number of posterior circulation strokes in our series, we were unable to compare the effectiveness of thrombectomy between anterior and posterior circulation strokes.

CONCLUSION

As stroke continues to be a significant public health concern, adopting a multidisciplinary approach is fundamental to its treatment. Over the past two decades, Turkish neurosurgeons have increasingly engaged in endovascular therapies for stroke treatment, evolving the treatment strategies from DC to hybrid surgery. Although the clinical and radiological outcomes presented in this study may not be as favorable as those reported in other recent studies, the current study represents a preliminary attempt to understand the effects of establishing dedicated stroke centers across Türkiye. Within this framework, we should train young neurosurgeons to become proficient in interventional therapies.

Declarations

Funding: Preparation for publication of this article is partly supported by Turkish Neurosurgical Society.

Availability of data and materials: The datasets generated and/or analyzed during the current study are available from the corresponding author by reasonable request.

Disclosure: The authors declare no competing interests.

AUTHORSHIP CONTRIBUTION

Study conception and design: SC, CT, EK, FY, ET

Data collection: CE, GU, MSG, ISD, MN, RF, NC, MA, NDE

Analysis and interpretation of results: BB

Draft manuscript preparation: SC, FY

Critical revision of the article: CT, MET, MEC

All authors (SC, CT, EK, CE, GU, MSG, BB, ISD, MN, RF, ET, NC, MA, NDE, MEC, MET, FY) reviewed the results and approved the final version of the manuscript.

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