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ORIGINAL ARTICLE **ÖZGÜN ARAŞTIRMA**

UTILITY OF THRIVE SCORE IN ENDOVASCULAR TREATMENT OF BASILAR ARTERY OCCLUSIONS AND CLINICAL OUTCOME MARKERS

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ABSTRACT

INTRODUCTION: It is known that basilar artery occlusions (BAO) have high mortality and morbidity rates. Although it is thought that there is no difference between endovascular treatment and medical treatment; Two recently published randomized clinical trials demonstrated the effect of endovascular therapy on clinical outcome in BAO. The main aim of our study is to reveal the factors that determine the clinical outcome in endovascular treatment in this special patient group.
METHODS: We retrospectively analyzed the data of patients who underwent mechanical thrombectomy for acute BAO between October 2016 and May 2022. Patients who achieved The Thrombolysis in Cerebral Infarction (TICI) 2b-3 recanalization and whose modified Rankin Score (mRS) could be reached after 90 days were included in the study. On the ninetieth day, mRS:0-2 was accepted as a good clinical outcome. The Total Health Risk In Vascular Events (THRIVE) score was used to determine the vascular disease burden of the patients. Posterior system collateral status was evaluated with Basilar Artery on Computed Tomography Angiography (BATMAN) Score and PcomA.
RESULTS: 41 patients were included in the study, mean age of all patients was 57.4±13.3, and admission NHISS was 22.3±6.6. In 15 (36.6%) patients, mRS was detected as 0-2 on the 90th day. CT-ASPECT, BTA-ASPECT, and BATMAN scores were higher in the good clinical outcome group (p values; p=0.043, p=0.028, p=0.010, respectively). Considering the presence of PcomA between the groups, better collateral presence was found in the mRS 0-2 group (p=0.049).
DISCUSSION AND CONCLUSION: In BAO undergoing mechanical thrombectomy, THRIVE score, BT-BTA ASPECTS, presence of PcomA and BATMAN score are both radiological and clinically practical parameters that can give the clinician an idea in terms of clinical outcome before endovascular treatment.
Keywords: Basilar artery occlusion, THRIVE score, endovascular therapy.

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BAZİLLER ARTER OKLÜZYONLARININ ENDOVASKÜLER TEDAVİSİNDE THRIVE SKORU KULLANIMI VE KLİNİK SONLANIM BELİRTEÇLERİ

ÖZ

GİRİŞ ve AMAÇ: Baziller arter oklüzyonlarının (BAO) mortalite ve morbiditesinin yüksek olduğu bilinmektedir. Endovasküler tedavi ile medikal tedavi arasında fark olmadığı düşünülmesine rağmen; son yayınlanan iki randomize klinik çalışma BAO'da endovasküler tedavinin klinik sonlanım üzerine olumlu etkisini ortaya koymuştur. Çalışmamızın temel amacı bu özel hasta grubunda, endovasküler tedavide klinik sonlanımı belirleyen faktörleri ortaya koymaktır.
YÖNTEM ve GEREÇLER: Çalışmamız Ekim 2016- Mayıs 2022 tarihleri arasında akut BAO nedeniyle mekanik trombektomi uyguladığımız hastaların verilerinin retrospektif olarak incelenmesiyle oluşturuldu. The Trombolysis in Cerebral Infarction (TICI) 2b-3 rekanalizasyon elde edilen ve üç ay sonunda modifiye Rankin Skoru (mRS)'na ulaşılabilen hastalar çalışmaya dahil edildi. Üçüncü ay mRS:0-2 iyi klinik sonlanım olarak kabul edildi. Hastaların vasküler hastalık yükünü saptamak için The Total Health Risk In Vascular Events (THRIVE) skoru kullanıldı. Posterior sistem kollateral durumu Basilar Artery on Computed Tomography Angiography (BATMAN) Skoru ve posterior komünikan arter (PcomA) ile değerlendirildi.
BULGULAR: Çalışmaya 41 hasta dahil edildi, tüm hastaların yaş ortalaması 57.4±13.3, başvuru İnme şiddeti Ulusal Sağlık İnme Ölçeği (NIHSS)'leri 22.3±6.6'di. Hastaların 15 (%36.6)'inde üçüncü ay sonu mRS 0-2 olarak saptandı. BT- ASPECT, BTA-ASPECT ve BATMAN skorları ise iyi klinik sonlanım grubunda daha yüksekti (sırasıyla p değerleri; p=0,043, p=0,028, p=0,010). İyi klinik sonlanım gösteren grupta daha sık PcomA varlığı gözlendi ve kollateral durumları bu sebeple daha iyiydi (p=0,049).
TARTIŞMA ve SONUÇ: Mekanik trombektomi uygulanan BAO'da THRIVE skoru, BT-BTA ASPECTS, PcomA varlığı ve BATMAN skoru endovasküler tedavi öncesinde klinik sonlanım açısından klinisyene fikir verebilecek hem radyolojik hem de klinik kullanımı pratik parametrelerdir.

Anahtar Sözcükler: Baziller arter oklüzyonu, THRIVE skoru, endovasküler tedavi.

INTRODUCTION

In recent years, there have been promising developments in endovascular treatment methods for acute ischemic stroke. Yet, despite successful recanalization and aggressive medical treatment in basilar artery occlusion (BAO), 75% of patients still experience severe disability or death (1). Although the BASICS and BEST studies found no superiority of endovascular therapy over medical therapy, the BOACHE study demonstrated better clinical outcomes with endovascular therapy in patients with a National Health Stroke Scale (NIHSS) stroke severity ≥ 6 BAO between 6-24 hours. Five large studies showing the superiority of endovascular treatment in anterior system strokes published in 2015 created similar excitement (2-4). This finding was supported by the ATTENTION study comparing the endovascular and medical treatment of BAO with NIHSS ≥ 10 and admitted within the first 12 hours, which found endovascular treatment to be superior to medical treatment (5). The primary aim of the present study was to reveal the factors of poor prognosis despite successful recanalization in this particular patient population and to analyze the patient population with a good prognosis.

Secondly, this study aimed to examine the effect of THRIVE score, which has been shown to be associated with prognosis in anterior system strokes, also in posterior system strokes, and further reveal the relationship between clinical outcome and parameters such as ASPECTS, PcomA presence, and BATMAN score, which can be obtained from CT and CTA images taken before the intervention in almost every patient.

METHODS

This retrospective study examining the data of patients who underwent mechanical thrombectomy due to acute basilar artery occlusion between October 2016 and May 2022 was conducted in accordance with the ethical standards of the Declaration of Helsinki. It was approved by Eskisehir Osmangazi University Non-Interventional Clinical Research Ethics Committee (Date: 26.04.2022 Number: 39). Informed consent was not obtained from the patients due to the retrospective design of the research, but informed consent was obtained from the first-degree relatives of the patients before the procedure. The

data of the patients were obtained from file records, and radiological and laboratory examination results were reached using the hospital automation system. Patients over 18 years of age, with pre-procedure computed tomography (CT) and computed tomography angiography (CTA) images, post-procedure Thrombolysis in Cerebral Infarction (TICI) 2b-3 recanalization and accessible third month modified Rankin Score (mRS) were included in the study. Third month mRS:0-2 was accepted as a good clinical outcome. Stroke severity was calculated using the National Health Stroke Scale (NIHSS).

The Alberta Stroke Program Early CT Score (pc-ASPECT) was used to evaluate early signs of ischemia in the acute posterior system. pc-ASPECT is a 10-point scale that assesses early ischemic changes in the thalamus, occipital cortex, cerebellar hemispheres, midbrain, and pons. The Basilar Artery on Computed Tomography Angiography (BATMAN) was used to evaluate collateral circulation. A total of 10-point BATMAN score was assigned as follows: 1 point for the vertebral artery segment, 1 point for the proximal segment of the basilar artery (vertebrobasilar junction to AICA), 1 point for the middle segment (AICA to SCA), 1 point for the distal segment (SCA to rostral) 1 point for each patent P1 segment, 2 points for each non-fetal PcomA (1 point for hypoplastic PcomA), or 3 points for the fetal PcomA complex.

The Total Health Risk In Vascular Events (THRIVE) score was used to determine the vascular disease burden of the patients. The THRIVE score can range from 0 to 9 and consists of 1 point for 60 to 79 years old, 2 points for ≥ 80 years, 2 points for NIHSS score between 11-20, and 4 points for NIHSS score ≥ 21. Hypertension, diabetes mellitus, and atrial fibrillation are each counted as 1 point.

Statistical Analysis: The IBM SPSS Statistics Version 20.0 software package was used for statistical analysis. The patients were divided into two groups according to their mRS scores as showing and not showing good clinical outcome. mRS:0-2 was referred to as the group with good clinical outcome, and analyses were performed accordingly. The distribution of data was evaluated with the Shapiro-Wilk test. Normally distributed variables were shown as mean and standard deviation (SD), while non - normally distributed data were given as median and interquartile range (IQR). The groups were compared using the Independent sample T-test for normally distributed data and the Mann-Whitney U test for non-normally distributed data. For categorical variables, the $\chi 2$ test or Fisher's exact test was used, depending on their suitability. P values of <0.05 were considered significant. Statistically significant variables were further tested in univariate receiver operating characteristic (ROC) curve analyses, with a positive result (mRS 0-2) as the dependent variable.

RESULTS

The mean age of 41 patients included in the study was 57.4±13.3 years, and 17 (41.4%) were female. The patients' admission NIHSS was 22.3±6.6. Of the patients, 46.2% had a history of hypertension, and 39.1% were smokers. TICI 2b-3 successful recanalization was achieved in all patients after the procedure. Before mechanical thrombectomy, 9 (22.0%) patients received intravenous tissue plasminogen activator (IV-tPA) therapy. First-pass recanalization was achieved in 23 (56.1%) patients. Third-month mRS was 0-2 in 15 (36.6%) patients (Table 1).

Table 1. Demographic and clinical data of the patient population.

	All patients (n=41)
Age (mean ±SD)	57.4±13.3
Gender n(%)	
Female	17(41.4)
Male	24(58.6)
Admission NIHSS (mean ±SD)	22.3±6.6
IV tPA n(%)	9 (22.0)
Risk Factors (n, %)	
Hypertension	19(46.2)
Diabetes Mellitus	7 (16.9)
Atrial Fibrillation	6 (14.4)
Coronary Artery Disease	7 (16.9)
Smoking	16 (39.1)
Stroke history	10 (24.2)
Obesity	5 (12.1)
THRIVE score (median, IQR)	5 (4-6)
CT ASPECT score (median, IQR)	9 (8-10)
CTA-ASPECT score (median, IQR)	8 (6-10)
BATMAN score (median, IQR)	5 (4-6)
PcomA (n, %)	21 (51,2)
First pass recanalization (n, %)	23 (56.1)
mRS: 0-2 (n, %)	15 (36.6)
Mortality (n, %)	17 (41.4)

NIHSS: National Institutes of Health Stroke Scale, CT: Computed tomography, CTA: Computed tomography angiography, ASPECT: Alberta stroke program early computer tomography score, IV tPA: Intra venous tissue plasminogen activator, THRIVE: Totaled health risks in vascular events BATMAN: Basilar Artery on Computed Tomography Angiography; PcomA: Posterior communicating artery.

The clinical outcome did not differ significantly between the groups according to age, gender, admission NIHSS, iv-tPa, first-pass recanalization, and puncture recanalization time. However, the good clinical outcome group had lower THRIVE score (p=0.044) and higher CT-ASPECT, CTA-ASPECT, and BATMAN scores (p=0.043, p=0.028, p=0.010, respectively).

Considering the presence of PcomA between the groups, better collateral presence was found in the mRS 0-2 group. (p=0.049) (Table 2).

The ROC curve analysis results for good clinical outcome, i.e., confidence interval, area under the curve and p-values of CT-ASPECT, CTA-ASPECT and BATMAN scores, are summarized in Table 3.

Table 2. Demographic and clinical characteristics by functional outcome.

	mRS: 0-2	mRS:3-6	p değeri
Age (mean ±SD)	52,8±14,0	60,0±12,3	0,136
Gender F/M	8/7	9/17	0,399
Admission NIHSS (mean ±SD)	21,3±9,4	22,8±4,5	0,559
IV tPA (n, %)	2/15 (4,8)	7/26 (17,0)	0,445
Risk Factors (n, %)			
Hypertension	5 (12,1)	14 (34,1)	0,345
Diabetes Mellitus	2 (4,8)	5 (12,1)	0,541
Atrial Fibrillation	2 (4,8)	4 (9,6)	0,579
Coronary Artery Disease	1 (2,4)	6 (14,6)	0,232
Smoking	3 (7,3)	13 (31,7)	0,118
Stroke history	4 (9,6)	6 (14,6)	0,540
Obesity	2 (4,8)	3 (7,3)	0,613
First-pass recanalization (n, %)	9/15 (%60,0)	14/26 (53,8)	0,956
Symptom recanalization time (min, mean±SD)	209,8±98,6	385,5±336,2	0,471
Puncture-recanalization time first 45 min	13/15 (86,6)	16/26 (%61,5)	0,087
THRIVE score (median, IQR)	4 (3-5)	6 (4-6)	**0,044**
CT ASPECT score (median, IQR)	10 (8-10)	7,5 (8,5-10)	**0,043**
CTA ASPECT score (median, IQR)	9 (7,5-10)	7 (6-9)	**0,028**
BATMAN score (median, IQR)	6 (5-7)	4 (3-6)	**0,010**
PcomA (n, %)	12/15 (80,0)	9/26 (34,6)	**0,049**
Glucose (mg/dL)	144,4±54,3	166,4±62,6	0,239
Systolic blood pressure (mmHg)	158,6±30,8	163,1±29,3	0,605
Diastolic blood pressure (mmHg)	91,0±12,2	92,9±11,4	0,597

NIHSS: National Institutes of Health Stroke Scale, CT: Computed tomography, ,CTA: Computed tomography angiography, ASPECT: Alberta stroke program early computer tomography score, IV tPA: Intra venous tissue plasminogen activator, THRIVE: Totaled health risks in vascular events BATMAN: Basilar Artery on Computed Tomography Angiography; PcomA: Posterior communicating artery.

Table 3. ROC curve analysis for good clinical outcome.

Variable	SE	95% C.I.	AUC	P Value
THRIVE score	0,094	0,501 to 0,868	0,685	0,051
BT-ASPECTS	0,086	0,534 to 0,884	0,709	**0,019**
BTA ASPECTS	0,089	0,546 to 0,885	0,715	**0,013**
BATMAN score	0,083	0,577 to 0,903	0,740	**0,004**

CT: Computed tomography, CTA-SI: Computed tomography angiography source images, ASPECT: Alberta stroke program early computer tomography score, THRIVE: Totaled health risks in vascular events BATMAN: Basilar Artery on Computed Tomography Angiography.

DISCUSSION AND CONCLUSION

Although endovascular treatment techniques are used in acute posterior system strokes, which patients will benefit most from this treatment remains unclear. The present study, in which we examined the factors associated with good clinical outcome in patients who underwent mechanical thrombectomy due to BAO and achieved successful recannalysis, found the good clinical outcome to be statistically significant associated with THRIVE score, ASPECT score on admission CT and CTA, presence of PcomA, and BATMAN score. The THRIVE score, which can be easily calculated at the time of admission, has been previously validated for anterior system stroke (6,7). However, Chen et al. emphasized that it is a guide for the clinical outcome not only in anterior system but also in posterior system strokes (8). To the best of our knowledge, there is no similar study in the literature examining the relationship between THRIVE score and clinical outcome in

posterior system strokes that underwent mechanical thrombectomy. In the present study, good clinical outcome was higher in patients with a score of 4 or less. Clinicians consider patient's age, vascular disease burden, and stroke severity as factors affecting clinical prognosis. Thanks to this scoring, clinical outcome can be practically predicted before the procedure.

The ischemic core is defined as severely reduced cerebral blood volume or relative cerebral blood flow. This tissue can be measured with ASPECTS (Alberta Stroke Program Early CT Score) (9,10). In BAO, the ischemic core can be calculated with posterior ASPECTS (pc-ASPECTS) (11). Despite limitations mentioned in the evaluation due to skull base bone artifact in non-contrast CT, we found that pc-ASPECTS calculated in non-contrast CT was associated with good clinical outcome. In ROC analysis, the AUC for the same parameter was 0.709. Since our study population consisted of patients with basilar artery occlusion, we can talk about severely affected brain tissue. Therefore, it seems possible to evaluate the ischemic core independently of the artifact with pc-ASPECT. However, ASPECT scores obtained from CTA source images are known to give more realistic results for both anterior and posterior systems than non-contrast CT (9,12). Puetz et al. have shown that patients with a pc-ASPECT score of <8 have poor clinical outcomes despite successful recanalization (13). Similarly, in our study, patients with pc-ASPECT scores of 7 and below in CTA had worse prognosis, while scores above 7 were associated with good clinical outcome, and the AUC value was 0.715 in ROC analysis (Figure).

Ischemia is always the result of loss of penumbra over time and lack of cerebral perfusion, which is highly correlated with the collateral flow. The growth of the ischemic core proceeds at varying rates between individuals, depending on the collateral blood flow capacity (14). Collateral flow temporarily provides cerebral blood flow, preventing the penumbra from turning into an ischemic core. Poor collateral flow has been found to be associated with a large ischemic core, large final infarction, high mortality, and poor functional outcome (15, 16).

BATMAN, which has also been shown to have prognostic value in previous studies, is a 10-point scoring system that includes the thrombus load

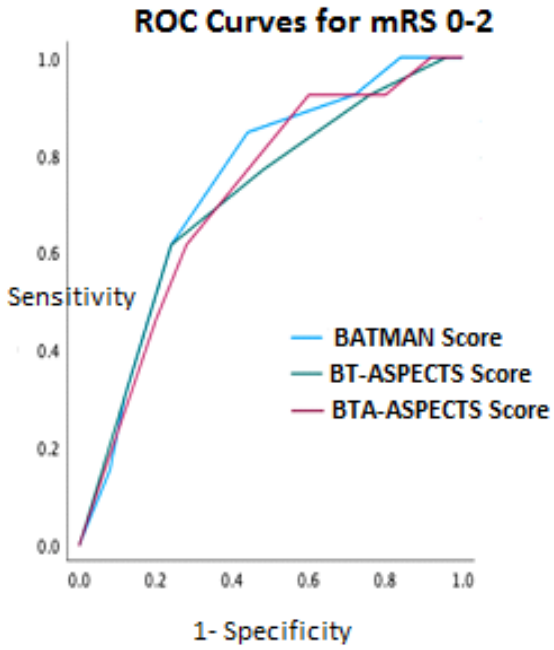

Figure. ROC curves for good clinical outcome.
Areas under the curve for BATMAN, CT-ASPECT and CTA-ASPECT scores were 0.740; 0.709 and 0.715, respectively. CT: Computed tomography, CTA-SI: Computed tomography angiography source images, ASPECT: Alberta stroke program early computer tomography score, BATMAN: Basilar Artery on Computed Tomography Angiography.

and the condition of the primary collaterals (17, 18). We also evaluated the BATMAN scoring and the presence of PcomA to determine the relationship between the patients' collateral status and good outcome, and determined that both BATMAN scores above 6 and the presence of at least unilateral PcomA were associated with good outcome.

Retrograde filling of the basilar artery with unilateral or bilateral PcomA provides blood flow to the penumbra tissue and contributes to the development of less final infarct volume. In their analysis of collaterals, Ravindren et al. reported that the absence of both PcomA reduced the chance of a good outcome by 60% (19). Also, in parallel with our results, another study showed that the presence of at least one PcomA reduces the risk of poor outcome (17).

As a conclusion, the THRIVE score, CT-CTA ASPECTS, presence of PcomA and BATMAN score are both radiological and clinically practical parameters that can give the clinician an idea about the clinical outcome in basilar artery occlusions undergoing mechanical thrombectomy.

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Ethics

Ethics Committee Approval: The study was approved by Eskişehir Osmangazi University Non-Invasive Clinical Research Ethics Committee (Date: 26.04.2022, No: 39).

Informed Consent: The authors declared that it was not considered necessary to get consent from the patients because the study was a retrospective data analysis.

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