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Factors Affecting Functional Outcomes and Mortality After Thrombectomy for Basilar Artery Occlusions: Recanalization Time and Collateral Scoring

Baziler Arter Oklüzyonlarında Trombektomi Sonrası Fonksiyonel Sonlanım ve Mortaliteyi Etkileyen Faktörler; Rekanalizasyon Süresi ve Kollateral Skorlama

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Abstract

Objective: There is still insufficient evidence in the current guidelines for the endovascular treatment (EVT) of basilar artery occlusions (BAO). This study aims to investigate the factors affecting the functional outcomes and mortality of patients after basilar artery thrombectomy at 3 months.

Materials and Methods: In this study, the clinical, radiological, and interventional procedural features of 22 patients who underwent basilar artery thrombectomy in our stroke center between 2016 and 2021 were evaluated retrospectively. The patients were divided into two groups according to their 3-month mortality and morbidity, and they were evaluated in terms of the statistical significance of comorbidity, BAO level and collateral status, symptom recanalization time, and general anesthesia status.

Results: In the patient group with the highest 3-month mortality rate, the symptom recanalization time was found to be significantly longer (P = 0.034), whereas in the patient group with high posterior cerebral system collateral scores, 3-month functional outcomes were found to be significantly improved (P = 0.022).

Conclusion: In the EVT of BAOs, the mortality rate of patients increases as the recanalization time increases, and patients with higher posterior cerebral system collateral scores are more likely to benefit from the basilar artery thrombectomy procedure.

Keywords: Basilar artery occlusion, endovascular treatment, collateral scoring

Öz

Amaç: Baziler arter oklüzyonlarında (BAO) endovasküler tedavi (EVT) seçeneği için mevcut kılavuzlarda halen yeterli kanıt düzeyine ulaşılamamıştır. Bu çalışma, baziler arter trombektomisi sonrası hastaların üçüncü ay fonksiyonel sonlanımları ve mortaliteleri üzerine etki eden faktörleri araştırmayı amaçlamaktadır.

Gereç ve Yöntem: Çalışmada inme merkezimizde 2016-2021 yılları arasında baziler arter trombektomi işlemi yapılan 22 hastanın klinik, radyolojik ve girişimsel işlem özellikleri retrospektif olarak değerlendirildi. Hastalar üçüncü ay mortalite ve morbidite durumlarına göre iki gruba ayrılarak komorbidite, baziler arterin oklüzyon seviyesi ve kollateral durumu, semptom rekanalizasyon zamanı ve genel anestezi alma durumuna göre anlamlılık açısından istatistiksel olarak değerlendirildi.

Bulgular: Üçüncü ay mortalite oranı yüksek olan hasta grubunda semptom-rekanalizasyon zamanının istatistiksel olarak anlamlı düzeyde uzun olduğu (P = 0,034), posterior serebral sistem kollateral skorları yüksek olan hasta grubunda ise üçüncü ay fonksiyonel sonlanımların istatistiksel olarak anlamlı oranda iyi olduğu saptandı (P = 0,022).

Sonuç: BAO'nun EVT'de rekanalizasyon zamanı uzadıkça hastaların mortalite oranında artma izlenmiştir ve posterior serebral sistem kollateral skorları fazla olan hastaların, baziler arter trombektomi işleminden fayda görme olasılıklarının daha yüksek olduğu saptanmıştır.

Anahtar Kelimeler: Baziler arter oklüzyonu, endovasküler tedavi, kollateral skorlama

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Introduction

Basilar artery occlusion (BAO) is an uncommon fatal condition in patients with acute ischemic stroke related to its location (1,2,3). In cases of acute ischemic infarct of the basilar artery that do not result in death, severe disability is common (3). Because it is such a devastating disease, stroke neurologists and interventional physicians interested in this area are at the forefront of research, and it is our research topic.

What makes BAO an important research subject is that thrombectomy, the most promising treatment for acute ischemic infarct, is included in the American Heart and Stroke Association (AHA/ASA) guidelines only at class IIb, level of evidence C (4). Although thrombectomy of anterior brain system infarct is described in the literature as a class I, level of evidence A treatment, its inability to treat this artery, which is at the back of the brain, is among the reasons for conducting this study (4).

The rate of futile recanalization (defined as no clinical improvement in a patient after recanalization of an occluded artery) is very high in basilar artery thrombectomy, which is a major reason for not being included in the guidelines as a class I, level of evidence A treatment (5,6). Therefore, it is vital to identify the differences between the patient group undergoing posterior system large-vessel thrombectomy and that undergoing anterior system large-vessel thrombectomy.

This study aimed to identify the factors affecting the 3-month functional outcomes and mortality rates of patients who underwent basilar thrombectomy in our stroke center between 2016 and 2021.

Materials and Methods

All data can be accessed through the corresponding author of this paper.

Patients

The data used in our article are the recorded clinical features and radiology images of our patients. Consent was obtained from all our patients and approved by the Ethics Committee of the University of Health Sciences Türkiye, Istanbul Medeniyet University Goztepe Training and Research Hospital (approval no: 2022/0010, date: 26.01.2022). Our study group consisted of 22 patients admitted to our stroke center diagnosed with acute ischemic stroke between 2016 and 2021 who had BAO in their computed tomography angiography (CTA) results and underwent thrombectomy.

Radiological Images

Standard non-contrast computed tomography (NCCT) was performed using a multislice CT scanner (SOMATOM Sensation 16; Siemens, Erlangen, Germany), with initial results for all patients obtained at 120 kV, 170 mA, with a thickness of 5 mm. The NCCT was followed by a CTA on the same scanner using a helical scan technique. A CTA was then performed by scanning from the vertex to the aortic arch. Non-ionic contrast media (80–120 ml) was administered into the antecubital vein at 3–5 ml/s. Images were triggered by the appearance of contrast media in the superior sagittal sinus, and the CTA source image was reconstructed at a 1.0 mm thickness in axial planes at 0.7 mm thickness intervals.

Endovascular Treatment

The procedures were performed by an interventional neurologist with international experience. All eligible patients were given 0.9 mg/kg of intravenous recombinant tissue-type plasminogen activator (rtPA) within 4.5 h of symptom onset. If a BAO corresponding to stroke symptoms was identified on the CTA, the patient was brought to the angiography suite for endovascular treatment (EVT). Manual aspiration with a CATALYST aspiration catheter (Stryker, Fremont, CA, USA) or a SOFIA intracranial aspiration catheter (MicroVention, Tustin, CA, USA) was the first-line EVT. If this technique did not achieve recanalization, combined stent retrieval techniques were used with a Solitaire stent system (Covidien, Irvine, CA, USA) or Trevo stent system (Stryker, Fremont, CA, USA). Recanalization was assessed using postprocedural angiography, and successful recanalization was defined as having a modified treatment in cerebral infarction ≥2b flow on the thrombolysis in cerebral infarction scale.

Clinical and Imaging Analysis

We retrospectively analyzed patients' medical records to collect demographic, clinical, and angiographic data. The initial neurological status of each patient was evaluated using the National Institutes of Health Stroke Scale (NIHSS) score at admission. The occlusion site of the basilar artery was subdivided into distal, mid, and proximal BAO [the proximal segment, extending from the vertebrobasilar junction to the origin of the anterior inferior cerebellar arteries (AICAs), the middle segment from the origins of the AICAs to the origin of the superior cerebellar arteries (SCAs), and the rostral segment from the origin of the SCAs to its rostral end], in accordance with the basilar artery on computed tomography angiography (BATMAN) score (7). Underlying basilar artery stenosis was evaluated using a postprocedural angiogram. The patients' modified Rankin scale (mRS) scores were assessed at admission and 3 months, and a favorable outcome was defined as a 3-month mRS score ≤2. The 3-month mortality rate was also calculated. We assessed the posterior circulation collateral status using the reported BATMAN. The scoring system is based on the presence of arterial filling in the CTA, and scores are assigned as follows: 1 point for both vertebral arteries (considered as 1 segment), 1 point for the proximal segment of the basilar artery, 1 point for the middle segment of the basilar artery, 1 point for the distal segment of the basilar artery, 1 point for the presence of each P-1 PCA segment, and 2 points for completing each posterior communicating artery (PCom). In addition, 1 point is awarded instead of 2 for completing a hypoplastic PCom. Therefore, a score of 10 indicates normal arterial filling of the posterior circulation, and a score of 0 indicates the non-filling of the posterior circulation (Figure 1).

Statistical Analysis

The Number Cruncher Statistical System 2007 (Kaysville, UT, USA) program was used for the statistical analysis. Data distribution was evaluated using the Shapiro–Wilk test and descriptive statistical methods. The Mann–Whitney U test was used for a two-group comparison of continuous variables, and Pearson's Chi-square test was used for the categorical data analysis. Characteristic curve and area under the curve (AUC) analyses were used to determine sensitivity and specificity to separate patients by time from symptom recanalization to mortality.

A simple regression analysis was undertaken to determine the factors affecting 3-month mRS and mortality. Significance was determined at $P < 0.05$.

Results

The 22 eligible patients included 12 (54.5%) men (mean age: 61.7 ± 11.3 years; median NIHSS score at symptom onset: 20), and favorable outcomes (mRS ≤2) were achieved in 27.2% (6/22) of patients. The baseline characteristics are summarized in Table 1. The baseline collateral scores were compared using the BATMAN scores [median (interquartile range): 8 (5–9) versus 6 (4–7)] and found to be higher in the favorable functional outcome ($P < 0.001$) and survival groups ($P < 0.019$). Table 2 summarizes the effect of the endovascular procedure characteristics on 3-month functional outcomes and 3-month mortality.

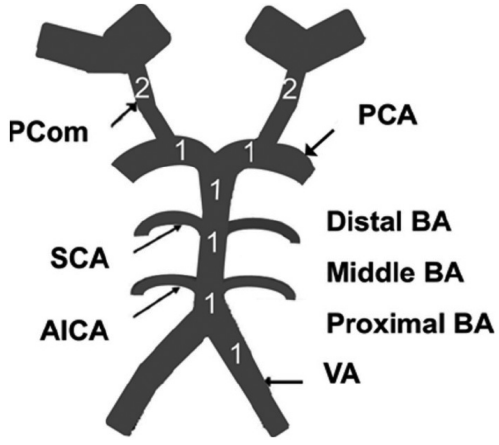

Figure 1. Basilar artery on computed tomography angiography score arterial segments
AICA: Anterior inferior cerebellar artery, BA: Basilar artery, PCA: Posterior cerebral artery, PCom: Posterior communicating artery, SCA: Superior cerebellar artery, VA: Vertebral artery

The symptom recanalization time [median (interquartile range): 480 min (150–3030) versus 330 min (50–540); $P < 0.001$] was higher in the mortality group.

The administration of general anesthesia in the mortality group was higher than that in the survival group ($P = 0.001$ and $P < 0.01$, respectively), which was statistically significant.

The mRS scores at 3 months were significantly higher in patients who received general anesthesia during EVT ($P = 0.023$ versus $P < 0.05$).

Using a receiver operating characteristic curve analysis, the symptom recanalization time predicted favorable outcomes and a cutoff time of 458 min (AUC: 0.76; $P = 0.034$) for identifying patients at risk of mortality (Table 3, Figure 2).

When the regression coefficients in Table 4 are examined, they reveal that the mortality rate increases with the delayed symptom-to-recanalization time [odds ratio (OR): 12.800; $P < 0.001$]. In addition, the BATMAN score (OR: 0.222; $P < 0.001$) has a significant positive effect on the 3-month mRS score.

Table 1. Comparison of baseline characteristics between patients with favorable and poor outcomes and mortality rates at 3 months

	Mortality			mRS		
	No (n = 9)	Yes (n = 13)	*P*	Low (mRS ≤2) (n = 7)	High (mRS ≥3) (n = 15)	*P*
Age	60.22 ± 8.39	62.85 ± 13.25	0.461[a]	57.29 ± 6.21	63.87 ± 12.73	0.138[a]
Sex (men)	5 (55.6%)	7 (53.8%)	0.639[b]	4 (57.1%)	8 (53.3%)	0.616[b]
Admission NIHSS score	18 (8–25)	20 (6–28)	0.840[c]	12 (8–25)	20 (6–28)	0.522[c]
Localization of occlusion						
Proximal basilar	3 (33%)	6 (46.2%)	0.439[b]	2 (28.6%)	7 (46.7%)	0.372[b]
Mid basilar	2 (22.2%)	2 (23.1%)	0.684[b]	1 (14.3%)	4 (26.7%)	0.477[b]
Distal basilar	4 (44.4%)	4 (30.8%)	0.416[b]	4 (57.1%)	4 (26.7%)	0.182[b]
Basilar atherosclerosis	5 (55.6%)	8 (61.5%)	0.561[b]	4 (57.1%)	9 (60.0%)	0.628[b]
BATMAN score	8 (5–9)	6 (4–7)	0.019[c]*	8 (5–9)	5 (4–7)	0.001[c]*
Symptom-to-door time	120 (15–465)	240 (45–2880)	0.403[c]	120 (15–465)	240 (45–2880)	0.323[c]
Risk factors (%)						
Diabetes	3 (33.3%)	7 (53.8%)	0.305[b]	2 (28.6%)	8 (53.3%)	0.268[b]
Hypertension	7 (77.8%)	11 (84.6%)	0.550[b]	6 (85.7%)	12 (80.0%)	0.622[b]
History of smoking	2 (22.2%)	4 (30.8%)	0.523[b]	1 (14.3%)	5 (33.3%)	0.349[b]
History of ischemic stroke	2 (22.2%)	2 (15.4%)	0.550[b]	2 (28.6%)	2 (13.3%)	0.378[b]
Atrial fibrillation	1 (11.1%)	7 (53.8%)	0.052[b]	1 (14.3%)	7 (46.7%)	0.161[b]

[a]Student's t-test, [b]Chi-square test, [c]Mann–Whitney U test, *$P < 0.05$. BATMAN: Basilar artery on computed tomography angiography score, mRS: Modified Rankin score, NIHSS: National Institutes of Health Stroke scale

Discussion

The present study achieved two crucial results. First, the factor most affecting 3-month clinical outcomes among patients who had undergone basilar artery thrombectomy was the patient's posterior system collateral scores. Second, the predictor of the 3-month mortality rate in the same patient group was the symptom recanalization time.

The first conclusion that can be drawn from our study is that patients with effective posterior system collateral, following BAO, have more time to achieve recanalization because they are likely to have less perfusion damage. This indicates that the predictor factor of positive outcomes based on this analysis is the collateral score and low perfusion damage.

The second lesson that can be drawn from our study is that the recanalization time affects the mortality rate in patients who underwent basilar artery thrombectomy. The data demonstrate that survival was positive in the group with effective collateral regardless of the recanalization time; if the recanalization time is prolonged, the mortality rate increases in the group with poor collateral.

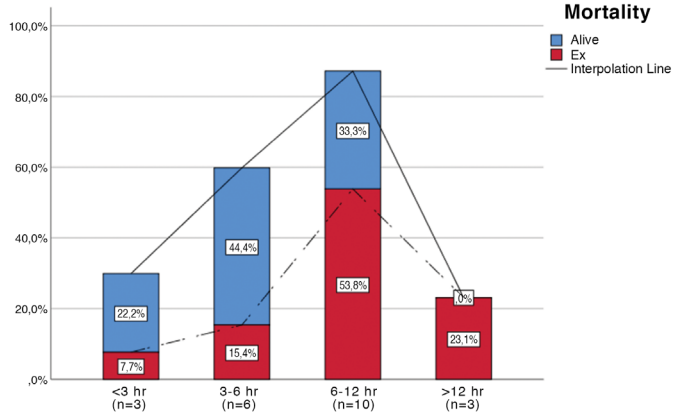

Figure 2. Mortality rate at 3 months according to grouping by timeline (time to recanalization from symptom onset: <3, 3–6, 6–12, and >12 h)

In our center, we use general anesthesia or conscious sedation during EVT and select the anesthesia protocol by evaluating the patient's neurological status before the procedure. In this study, patients with a low Glasgow Coma scale score (8 or less) received general anesthesia during the thrombectomy procedure, in line with our standard protocol.

A recent meta-analysis reported that conscious sedation was associated with improved 3-month clinical outcomes when compared with general anesthesia (8). Similarly, an endovascular therapy following imaging evaluation for ischemic stroke analysis revealed that patients who underwent thrombectomy with conscious sedation in an extended time window experienced a higher likelihood of 3-month functional independence when compared with those who had general anesthesia (9). However, recently published randomized clinical trials (i.e., sedation vs intubation for endovascular stroke treatment, anesthesia during stroke, and general or local anesthesia in intra-arterial therapy), comparing general anesthesia and conscious sedation during mechanical thrombectomy, have not confirmed the superiority of conscious sedation over general anesthesia (10,11,12).

If we examine our results more closely, we can determine that general anesthesia during EVT and high postprocedural NIHSS scores are associated with non-favorable (mRS ≥3) 3-month clinical outcomes (Tables 1, 2). However, the patient group with low initial NIHSS scores also had positive collateral scores, with the procedure performed with conscious sedation. All these factors, analyzed using univariate logarithmic analysis and collateral scores, were identified as independent factors for 3-month functional outcomes (Table 4).

We can reach the same conclusions for general anesthesia and postprocedural NIHSS scores (Tables 1, 2), which affect mortality. These two factors affect mortality only when the recanalization time is prolonged (Table 4), indicating that the only independent factor for mortality is the symptom-to-recanalization time.

Meinel et al. (13) researched futile recanalization in mechanical thrombectomy for BAO compared with anterior circulation. This study highlighted that BAO is associated with increased rates of futile recanalization. In addition, predictors for futile recanalization are age, stroke severity, maneuver count, and intracranial stenting.

Table 2. Procedural and clinical data between patients with favorable and poor outcomes and mortality rates at 3 months

	Mortality		*P*	mRS		*P*
	Yes (n = 9)	No (n = 13)		mRS ≤2 (n = 7)	mRS ≥3 (n = 15)	
Symptom recanalization time	330 (50–540)	480 (150–3030)	0.042[a]**	330 (50–540)	465 (150-3030)	0.067[a]
Discharge NIHSS	6 (0–28)	36 (20–40)	0.001[a]***	5 (0–8)	30.5 (19–40)	0.001[a]***
Recanalization time	30 (20–180)	60 (15–200)	0.110[a]	30 (20–180)	50 (15–200)	0.483[a]
Intravenous rtPA	4 (44.4%)	3 (23.1%)	0.276[b]	3 (42.9%)	4 (26.7%)	0.387[b]
Symptomatic ICH	2 (22.2%)	2 (15.4%)	0.550[b]	1 (14.3%)	3 (20.0%)	0.622[b]
Recanalization score	9 (100.0%)	10 (76.9%)	0.186[b]	7 (100.0%)	12 (80.0%)	0.295[b]
Isolated stent retriever technique	4 (44.4%)	7 (53.8%)	0.500[b]	4 (57.1%)	7 (46.7%)	0.500[b]
Aspiration technique	3 (33.3%)	4 (30.8%)	0.628[b]	1 (14.3%)	6 (40.0%)	0.243[b]
Combined technique	2 (22.2%)	2 (15.4%)	0.550[b]	2 (28.6%)	2 (13.3%)	0.378[b]
General anesthesia	6 (66.7%)	13 (100.0%)	0.025*	4 (57.1%)	15 (100%)	0.023*

[a]Mann–Whitney U test, [b]Chi-square test, *$P < 0.05$, **$P < 0.001$. ICH: Intracranial hemorrhage, mRS: Modified Rankin score, NIHSS: National Institutes of Health Stroke Scale, rtPA: Recombinant tissue-type plasminogen activator

According to the AHA/ASA guidelines, the basilar artery thrombectomy procedure is currently a class IIb treatment, and which patient should be admitted to the angiography unit is still a critical question (4). When we consider the part of our study that directly affects clinicians, if the patient with acute BAO has a high CTA collateral score, regardless of the duration of the patient's symptoms, the patient should be treated with thrombectomy as soon as possible.

When deciding to process patients with low collateral scores, we should consider the vital mortality threshold as 458 min at the time of symptom recanalization (Table 3).

Kwak and Park (14) investigated the factors affecting basilar artery thrombectomy and determined two separate factors for 3-month clinical outcomes; the first factor is the collateral score and the second is that occlusions in the distal part of the basilar artery have a worse clinical outcome. Although we identified the basilar artery location as proximal–mid basilar and distal in our analysis, we did not find that this affected clinical outcomes or mortality. This result should be emphasized because accessing the distal part of the basilar artery and performing the thrombectomy procedure from there is improved by using recently developed thrombectomy devices and techniques.

Sun et al. (15) stated that in a group of 187 patients with BAO treated with EVT, the collateral score had a positive effect on clinical outcomes, which is consistent with our study (5). However, Sun et al. (15) used the American Society of Interventional and Therapeutic Neuroradiology/Society of Interventional Radiology scoring system to measure collateral, whereas we used the BATMAN scoring system. In the same study, Sun et al. (15) identified tandem lesions as another predictor, and they described the negative effect of these lesions on positive clinical outcomes. In our patient population, no patient had tandem lesions, and we were unable to perform a statistical analysis.

Another issue is the analysis of the subgroup of the thrombectomy group that received intravenous rtPA simultaneously. As the literature on anterior system thrombectomy reveals, the patient group given thrombectomy plus intravenous rtPA had more positive functional outcomes than the patient group who underwent thrombectomy alone (16). The results of our analysis reveal no significant difference in positive clinical outcomes or mortality rates in the group that received intravenous rtPA compared with the group that did not.

Shore et al. (17) published the data of 28 patients who underwent basilar artery thrombectomy in 2018. Notably, in this study, because of the development of thrombectomy instruments and techniques, successful recanalization rates and the shortening of the recanalization time significantly affected mortality in the group who underwent this procedure. Our study highlights that in addition to the recanalization time of patients, collateral status is a key predictor.

Study Limitations

The limitations of our study are that we had a small number of patients, the study was retrospective, and it was conducted at a single center. Although using a single center is a limitation, the long-term and extensive experience of that center and the

Table 3. Receiver operating characteristic curve analysis of the symptom recanalization time and mortality

	Area under the curve (95% confidence interval)	Best cut-off value	Sensitivity	Specificity
Symptom recanalization time	0.76 (295.48–885.60)	458	61.5%	88.9%

Table 4. Univariate regression analysis of mortality and 3-month modified Rankin score

	Mortality Univariate analysis Odds ratio (95% CI)	*P*	mRS Univariate analysis Odds ratio (95% CI)	*P*
Age <80	0.571 (0.395–0.828)	0.999	0.667 (0.493–0.902)	0.999
Baseline NIHSS <15	1.280 (0.228–7.187)	0.779	2.667 (0.423–16.826)	0.297
BATMAN score >6	0.222 (0.036–1.370)	0.105	0.061 (0.005–0.672)	0.022*
Distal basilar occlusion	0.556 (0.095–3.246)	0.514	0.273 (0.041–1.795)	0.177
Symptom recanalization time <458 min	12.800 (1.208–135.579)	0.034*	6.857 (0.656–71.720)	0.108
Diabetes	2.333 (0.400–13.609)	0.346	2.857 (0.415–19.649)	0.286
Hypertension	1.571 (0.178–13.860)	0.684	0.667 (0.057–7.852)	0.747
Hyperlipidemia	4.400 (0.596–32.501)	0.146	3.000 (0.423–21.297)	0.272
History of smoking	1.556 (0.218–11.086)	0.659	3.000 (0.279–32.209)	0.364
History of ischemic stroke	0.636 (0.072–5.613)	0.684	0.385 (0.042–3.523)	0.398
Atrial fibrillation	9.333 (0.892–97.619)	0.062	5.250 (0.502–54.911)	0.166
Recanalization score	0.526 (0.344–0.806)	0.999	0.632 (0.448–0.890)	0.999
General anesthesia	3.167 (1.634–6.138)	0.999	4.750 (1.989–11.346)	0.999

*$P < 0.05$, BATMAN: Basilar artery on computed tomography angiography, NIHSS: National Institutes of Health Stroke Scale, mRS: modified Rankin score, CI: Confidence interval

center's interventional physician demonstrate that we are closer to achieving positive clinical outcomes with the right patient selection strategies and basilar artery thrombectomy procedures performed using the right technique. Another limitation of this study is that the different techniques and materials used and different maneuvers and number of passes performed during the thrombectomy procedure were not analyzed in relation to mortality or functional outcomes.

Conclusion

Collateral scores and symptom recanalization time were determined as two key independent factors affecting positive clinical outcomes and mortality.

Thus, future studies with more data and involving a greater number of centers will further improve our patient protocols for the EVT of BAO. Furthermore, our results should be supported by multicenter, randomized, prospective, controlled studies involving a larger number of patients.

Ethics

Ethics Committee Approval: Ethics Committee of the University of Health Sciences Türkiye, Istanbul Medeniyet University Goztepe Training and Research Hospital (approval no: 2022/0010, date: 26.01.2022).

Informed Consent: Consent was obtained from all patients.

Peer-review: Externally peer-reviewed.

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