Araştırma Makalesi
Research Article

The effectiveness of Transcranial Doppler (TCD) in detection of vasospasm in patient with subarachnoid hemorrhage

SUBARAKNOİD KANAMALI HASTADA VAZOSPAZMIN SAPTANMASINDA TRANSKRANİAL DOPPLER'İN (TCD) ETKİNLİĞİ

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ABSTRACT

Aim: Vasospasm in cerebral arteries is one of the important causes of mortality and morbidity in aneurysm surgery due to ischemia and remains a current problem in neurosurgery. Controversy regarding the clinical significance of cerebral vasospasm arises from the fact that there is no acceptable, objective measure for tracking the course of vasospasm. Transcranial Doppler (TCD) is used in clinics as a practical noninvasive method to understand vasospasm. However, the effectiveness of this method, which was developed as the first noninvasive method in the detection of vasospasm, has not yet been determined. The aim of this study is to monitor vasospasm after subarachnoid hemorrhage with TCD, to compare the data with the clinical evaluation of the patient, imaging methods and Digital Subtraction Angiography (DSA) results, and to reveal the clinical diagnostic power of the TCD method.

Material And Methods: For this purpose, Fisher grouping of 50 patients in our clinic, who were followed up with the diagnosis of subarachnoid, was performed. Median cerebral artery (MCA), anterior cerebral artery (ASA), posterior cerebral artery (PCA) and bacillary artery (BA) TCD were performed and analyzed according to four criteria. TCD was repeated in different situations. Vasospasm was confirmed by DSA and correlated.

Results: In blood flow measurements with TCD, the most prominent spasm was seen in Fisher 3, as theoretically expected. According to Fisher, vasospasm was 31% in fisher group 2 and 27% in fisher group 3. The most prominent vasospasm in patients was detected in MCA aneurysm bleeding. The artery with the highest agreement between DSA and clinical findings was found to be MCA (94.44%). The artery with the highest agreement between angiography and TCD flow rates was BA (88%). The artery with the highest concordance between TCD flow rates and clinical findings was found to be BA (89%). Considering the postoperative examinations; BA (85%) was the artery with the highest concordance with clinical and TCD flow rates. This artery is respectively; It was followed by MCA (84%), ACA (70%), PCA (P1 and P2) (57%).

Conclusion: Although there are many methods such as DSA in the detection of vasospasm in patients with subarachnoid hemorrhage, TCD has a special importance as a noninvasive method.

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Patients should be looked at at least once a day so that the examination can provide better guidance. For this reason, it is a fact that it will be beneficial for both the patient and the clinician to have TCD, which is a noninvasive examination, next to the patient in every intensive care unit or related clinic where patients undergoing treatment for vascular pathology are hospitalized.

Key Words: Neurosurgery, cerebral artery, subarachnoid bleeding, vasospasm, Transcranial Doppler

ÖZ

Amaç: Serebral arterlerdeki vazospazm, anevrizma cerrahisinde iskemiye bağlı mortalite ve morbiditenin önemli nedenlerinden biridir ve beyin cerrahisinde güncel bir sorun olmaya devam etmektedir. Serebral vazospazmın klinik önemine ilişkin tartışma, vazospazmın seyrini izlemeye yönelik kabul edilebilir, objektif bir ölçümün bulunmamasından kaynaklanmaktadır. Transkraniyal Doppler (TCD), kliniklerde vazospazmı anlamak için pratik, invaziv olmayan bir yöntem olarak kullanılmaktadır. Ancak vazospazmın tespitinde ilk noninvaziv yöntem olarak geliştirilen bu yöntemin etkinliği henüz belirlenmemiştir. Bu çalışmanın amacı TCD ile subaraknoid kanama sonrası vazospazmı izlemek, verileri hastanın klinik değerlendirmesi, görüntüleme yöntemleri ve Dijital Subtraksiyon Anjiyografi (DSA) sonuçlarıyla karşılaştırmak ve TCD yönteminin klinik tanı gücünü ortaya koymaktır.

Gereç ve Yöntemler: Bu amaçla kliniğimizde subaraknoid tanısıyla takip edilen 50 hastanın Fisher gruplaması yapıldı. Median serebral arter (MCA), anterior serebral arter (ASA), posterior serebral arter (PCA) ve basiller arter (BA) TCD'si dört kritere göre yapıldı ve analiz edildi. TCD farklı durumlarda tekrarlandı. Vazospazm DSA ile doğrulandı ve ilişkilendirildi.

Bulgular: TCD ile yapılan kan akımı ölçümlerinde teorik olarak beklendiği gibi en belirgin spazm Fisher 3'te görüldü. Fisher'a göre vazospazm Fisher grup 2'de %31, Fisher grup 3'te ise %27 idi. Hastalarda en belirgin vazospazm MCA anevrizması kanamasında saptandı. DSA ile klinik bulgular arasında en yüksek uyumun olduğu arterin MCA (%94,44) olduğu belirlendi. Anjiyografi ve TCD akım hızları arasında en yüksek uyumun olduğu arter BA (%88) idi. TKD akım hızları ile klinik bulgular arasında en yüksek uyumun olduğu arterin BA (%89) olduğu belirlendi. Ameliyat sonrası muayenelere bakıldığında; BA (%85) klinik ve TCD akım hızları ile en yüksek uyum gösteren arterdi. Bu arter sırasıyla; Bunu MCA (%84), ACA (%70), PCA (P1 ve P2) (%57) takip etti.

Sonuç: Subaraknoid kanamalı hastalarda vazospazmın tespitinde DSA gibi birçok yöntem mevcut olmasına rağmen TCD noninvaziv bir yöntem olarak ayrı bir öneme sahiptir. Muayenenin daha iyi rehberlik sağlayabilmesi için hastaların günde en az bir kez bakılması gerekir. Bu nedenle damar patolojisi nedeniyle tedavi gören hastaların bulunduğu her yoğun bakım ünitesinde veya ilgili klinikte, noninvaziv bir muayene olan TCD'nin hastanın yanında bulundurulmasının hem hasta hem de klinisyen açısından faydalı olacağı bir gerçektir.

Anahtar Kelimeler: Beyin cerrahisi, serebral arter, subaraknoid kanama, vazospazm, Transkranial Doppler

Cerebral vasospasm, as a multifactorial phenomenon, constitutes one of the main problems of today's neurosurgery practice and especially in cerebrovascular surgery. Despite many treatment modalities, cerebral vasospasm remains the leading cause of neurologic sequelae and death in patients admitted to hospital after subarachnoid hemorrhage (1). Since it cannot be predicted exactly in which patients with subarachnoid hemorrhage will experience symptomatic vasospasm, and it is considered that it is very difficult to reverse once clinical vasospasm occurs, the value of easy and noninvasive recognition of cerebral vasospasm in advance and vasospasm prophylaxis will be appreciated. Different clinics have different protocols for the diagnosis and treatment of cerebral vasospasm, resulting in different results and interpretations. Although different diagnostic methods are used in the diagnosis of cerebral vasospasm, it has not been clarified to what extent which one is effective, useful and guiding, and most importantly, its ability to predict cerebral vasospasm. In this study, transcranial Doppler (TCD) was used in addition to angiographic vessel measurements, computerized tomography, and clinical grading, which are routinely used in the diagnosis of cerebral vasospasm in neurosurgical practice (2, 3). The most important reason why we prefer TCD; This is due to the fact that TCD application is noninvasive compared to angiography. On the other hand, reasons such as the fact that it can be repeated at the patient's bedside and as often as desired, its low cost, and the fact that it is an easy-to-use system that does not need a specially equipped room are also reasons for preference. With the routine application of TCD, the necessary adjustments can be made in the treatment by determining the arterial blood flow velocity. Initiation of treatment of vasospasm should be based on TCD findings, not symptomatic.

METHODS

The study was conducted on a total of 90 patients diagnosed with subarachnoids. Of these patients, 43 (47%) were male and 47 (53%) were female (Table A).

Table A: Gender distribution of the number of patients included in the study

MALE	FEMALE
43 (47 %)	**47 (53 %)**

The distribution of patients according to Fisher grouping was determined (Table B).

Table B: Distribution of patients according to Fisher grouping (87 patients). Of these 87 patients, 50 were used for the study.

Group 1	**19 patients (22%, 7 male, 12 female)**
Group 2	**28 patients (31%, 15 male, 13 female)**
Group 3	**24 patients (27%, 11 male, 13 female)**
Group 4	**16 patients (18.5 male, 11 female patients)**

Median cerebral artery (MCA), anterior cerebral artery (ASA), posterior cerebral artery (PCA) and bacillary artery (BA) TCD of the patients were performed and examined. TCD patient comes to the clinic 1-3. day 2-5 postoperatively, in correlation with DSA. day and repeated to confirm vasospasm. Vasospasm was confirmed and correlated with DSA. Systolic and diastolic blood flows were measured with TCD, and the mean flow velocity and pulsatility index from these values were calculated according to the formula in Table C (Table C). Fifty patients, whose TCD was completed at all stages, participated in the study. The results were entered into the SPSS and the averages were compared with the ONOVA method. P<0.05 was considered statistically significant.

Table C: Systolic and diastolic blood flows were measured by TCD, and the mean flow velocity and pulsatility index from these values were calculated according to the following formulas:

Mean blood flow velocity	=(((Systole)-(Diastol/3))+Diastol)/2)
Pulsatility Index	=(Systolic blood flow-Diastolic blood flow)/Mean blood flow velocity

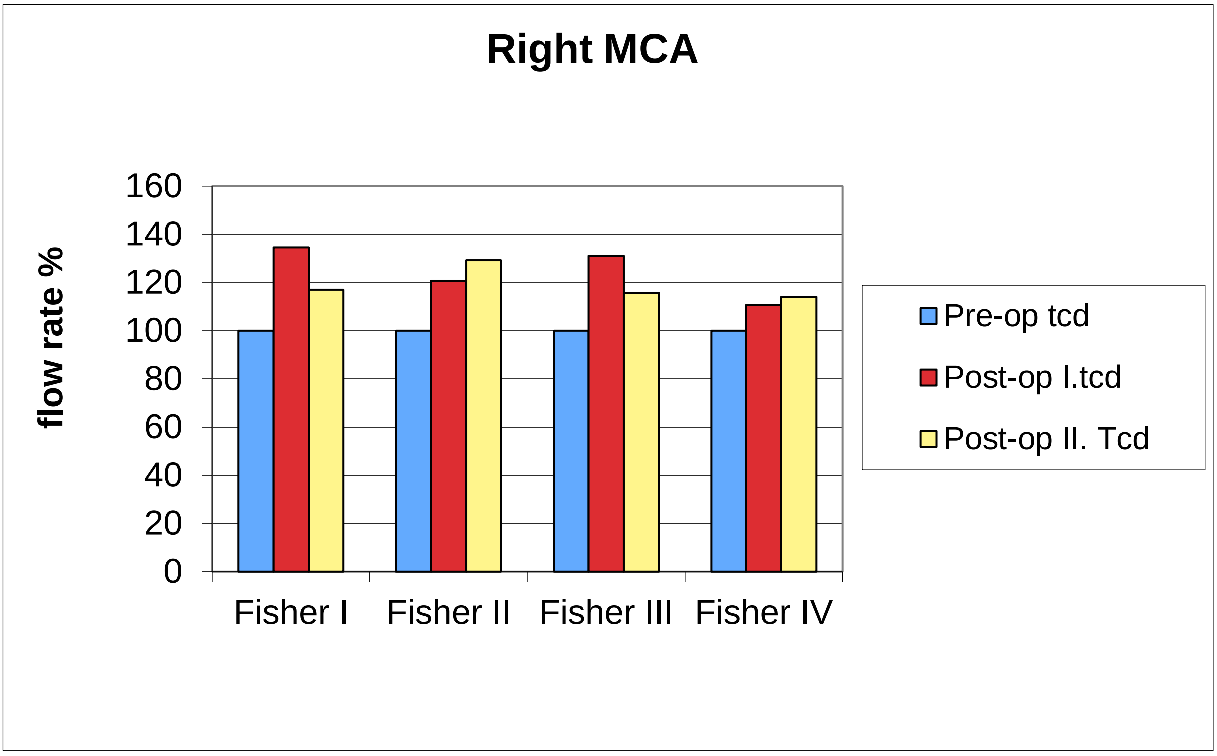
RESULTS

We reached many results and evaluated according to the clinical findings of the patients, TCD and DSA tests. In the examination of MCA; Preoperative ; The accuracy of clinical findings with angiography was 94% (84 out of 90 patients). The accuracy of TCD flow rates with angiography was 75% (65 of 87 patients). The accuracy of clinical findings and TCD flow rates was found to be 67% (58 of 87 patients). postoperative; The accuracy of clinical and TCD flow rates was 84% (47 out of 56 patients). Angiographic, clinical and TCD flow rates of each of the 2 patients who underwent postoperative DSA were compatible with each other. In the examination of ACA; preoperative; The accuracy rate of clinical findings with angiography was found to be 92% (83 of 90 patients). The accuracy rate of TCD flow rates with angiography was found to be 70% (62 of 89 patients). The accuracy of clinical findings and TCD flow rates was 72% (62% of 87 patients). Postoperative; The accuracy of clinical findings and TCD flow rates was 71% (36 of 51 patients). Angiographic, clinical and TCD flow rates of each of the 2 patients who underwent postoperative DSA were compatible with each other. In the Examination of PCA (P1); Preoperatively, the accuracy rate of clinical findings with angiography was found to be 90% (81 of 90 patients). The accuracy of TCD flow rates with angiography was 74% (64 of 87 patients). The accuracy of clinical findings and TCD flow rates was 74% (64 of 87 patients). The accuracy rate of postoperative clinical findings and TCD flow rates was 57% (28 of 49 patients). TCD flow rates, clinical findings and DSAs of 2 patients who underwent postoperative DSA were compatible with each other. In the examination of PCA(P2); The accuracy of clinical findings with preoperative angiography was 80% (71 of 89 patients). The accuracy of TCD flow rates with angiography was 74% (65 out of 85 patients). The accuracy of clinical findings and TCD flow rates was 81% (69 of 85 patients). Postoperative; The accuracy rate of clinical findings and TCD flow rates was found to be 57% (28 of 49 patients). Angiographic, clinical and TCD flow rates of each of the 2 patients who underwent postoperative DSA were compatible with each other. In BA Examination; preoperative ; The accuracy of clinical findings with angiography was 78% (70 of 90 patients). The accuracy of TCD flow rates with angiography was 88% (76 of 86 patients). The accuracy of clinical findings and TCD flow rates was 90% (77 of 86 patients). postoperative; The accuracy of clinical and TCD flow rates was 85% (41 of 48 patients). Angiographic, clinical and TCD flow rates of each of the 2 patients who underwent postoperative DSA were compatible with each other. According to the test results; Considering the preoperative examinations; The artery with the highest agreement between DSA and clinical findings was found to be MCA (94%) (Table1, Chart 1).

Table 1: Mean of right MCA TCD measurements

right MCA	Pre-op TCD	Post-op I.TCD	Post-op II.TCD
Fisher I	78.88095	106.1111	92.29487
Fisher II	69.88889	84.47778	90.29487
Fisher III	71.48485	93.7381	82.68182
Fisher IV	83.40476	92.3	95.125

Graph 1: Although not statistically significant in right MCA TCD blood flow measurements, the increase in blood flow observed over time is seen in the graphs.



This was followed by ASA (92%), P1 (90%), P2 (80), BA (78%) (Table-7, Chart 11-7). Arterial BA (88%) with the highest agreement between angiography and TCD flow rates. This was followed by MCA, P1, P2 (74%), ACA (70), respectively. The artery with the highest concordance between TCD flow rates and clinical findings was found to be BA (89%). BA was followed by P2 (81%), P1 (74%), ACA (71%), and ASM (67%), respectively. Considering the postoperative examinations; The artery with the highest concordance for clinical and TCD flow rates was found to be BA (85%). This artery is respectively; It was followed by MCA (84%), ACA (70%), P1 and P2 (57%). (Table 1-9, Graph 1-9).

Table 2: Mean of left MCA TCD measurements

left MCA	Pre-op TCD	Post-op I.TCD	Post-op II.TCD
Fisher I	66.60714	68.125	152.3846
Fisher II	65.68519	71.3	72.5
Fisher III	84.33333	96.09524	102.2879
Fisher IV	62.14286	69.8	71.16667

Graph 2: Blood flow changes according to Fisher grouping in left MCA blood flow measurements (n=50) performed in SAH patients are consistent with the results predicted by theoretical knowledge. There is an increase in the same fisher class over time, it increases up to 1, 2 and 3 according to the fisher class, and decreases in 4

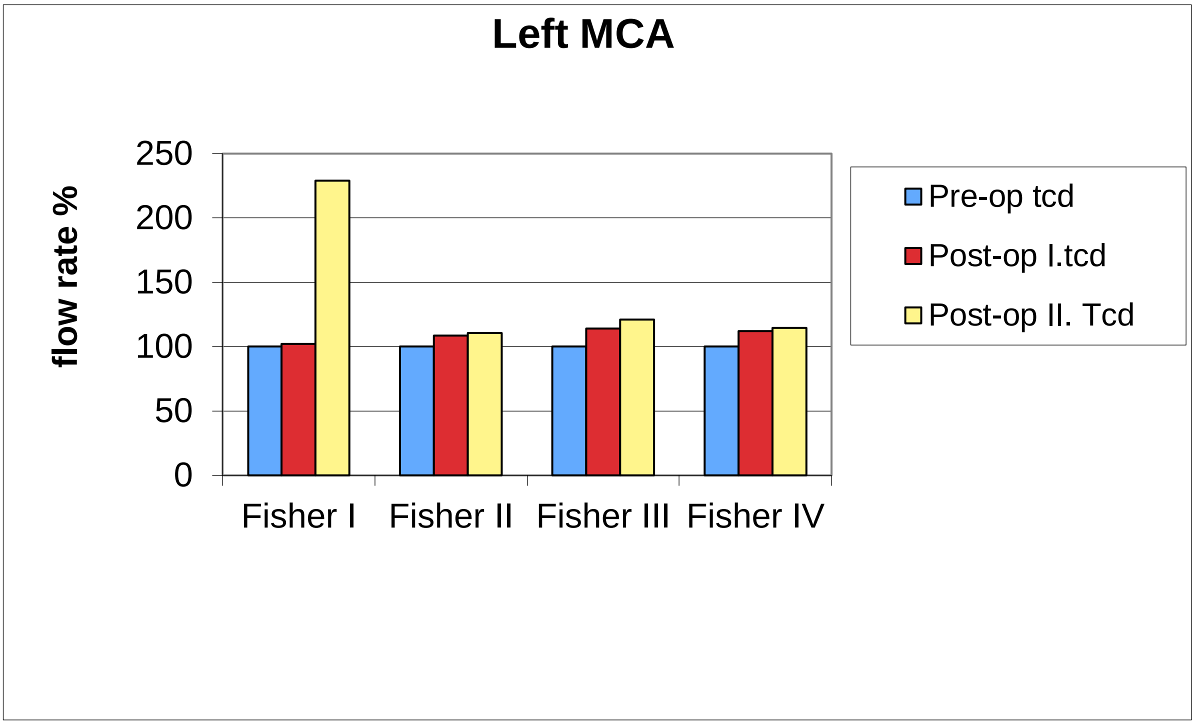


Table 3: Mean of right ASA TCD measurements

right ASA	Pre-op TCD	Post-op I.TCD	Post-op II.TCD
Fisher I	48.52381	73.97436	61.16667
Fisher II	48.2037	60.32222	69.35897
Fisher III	59.54545	49.95238	54.74242
Fisher IV	58.02381	79.73333	65.60417

Graphic 3: Right ASA-A1 segment TCDd blood flow measurements showed an increase in blood flow in the first two fisher classes and a little in Fisher 4, but these differences were not statistically significant.

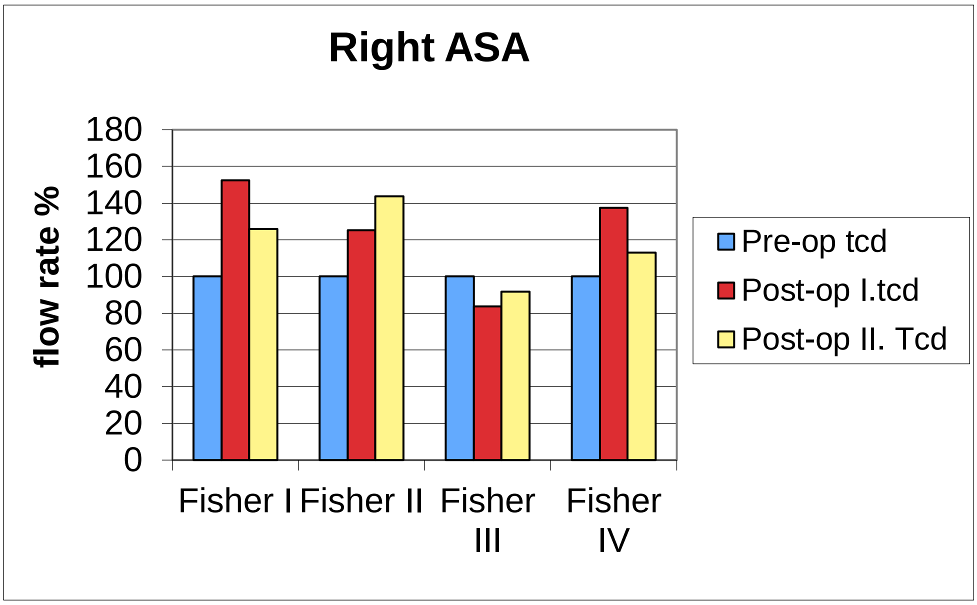


Table 4: Mean of TCD measurements of the left ASA-A1 segment

left ASA	Pre-op TCD	Post-op I.TCD	Post-op II.TCD
Fisher I	50.47619	62.92308	61.17949
Fisher II	55.34259	62.11111	57.5
Fisher III	60.34848	51.14286	62.09091
Fisher IV	59.28571	61.36667	55.72917

Graph 4: In the TCD blood flow measurements of the left ASA-A1 segment, blood flow increases were observed in the first two fisher classes and a little in Fisher 4, but these differences were not statistically significant.

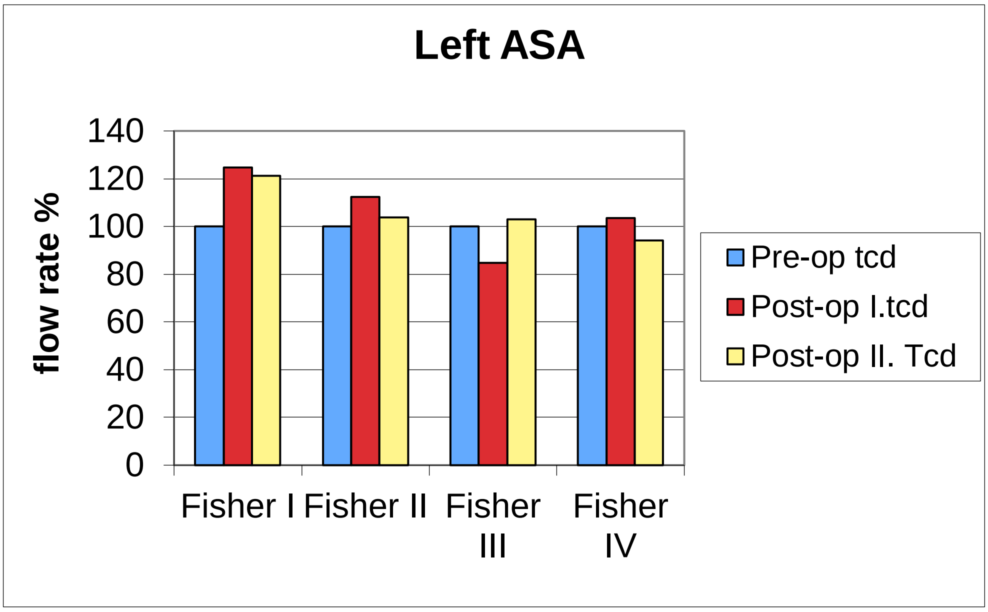


Table 5: Mean of the right P1 (1. segment of PCA) TCD measurements

right P1	Pre-op TCD	Post-op I.TCD	Post-op II.TCD
Fisher I	56.11905	94.01282	92.03846
Fisher II	51.2037	97.25556	104.9744
Fisher III	58.71212	69.5	70.54545
Fisher IV	56.28571	82.16667	95.02083

Graph 5: TCD blood flow measurements of the right P1 artery show an increase in blood flow over time. Statistically, there was no significant difference between the fisher groups.

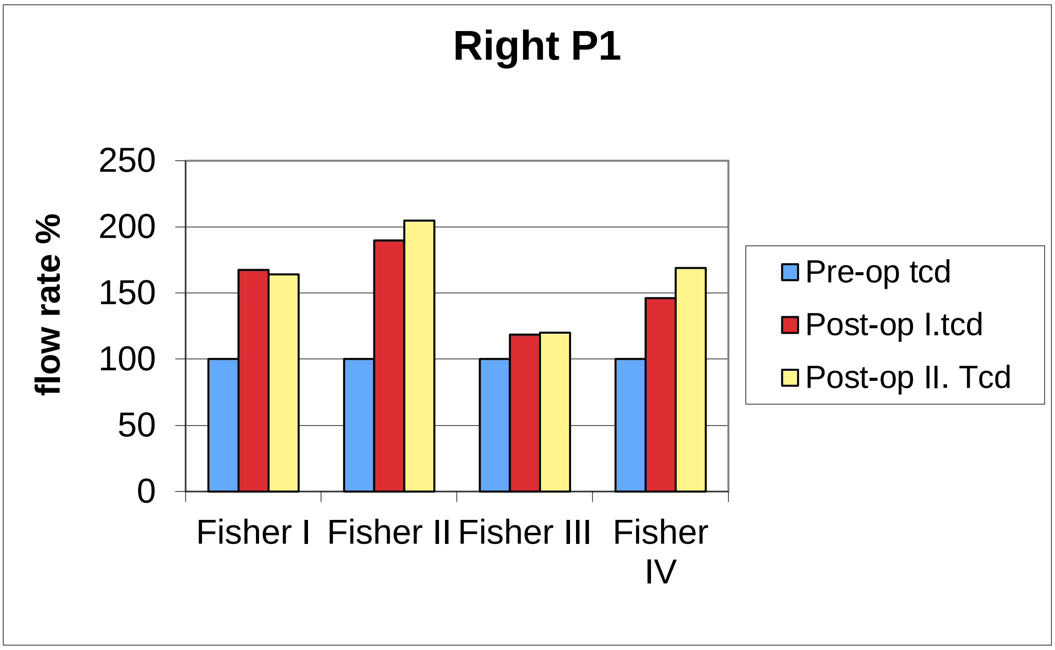


Table 6: Mean of Left P1 (1. Segment of PCA) TCD measurements

left P1	*Pre-op TCD*	*Post-op I.TCD*	*Post-op II.TCD*
Fisher I	55.36905	72.69231	77.08974
Fisher II	45.71296	67.55556	65.78205
Fisher III	61.65152	79.21429	73.59091
Fisher IV	57.78571	52.06667	60.16667

Graphic 6 : TCD blood flow measurements of the left P1 artery show an increase in blood flow over time. Statistically, there was no significant difference between the fisher groups.

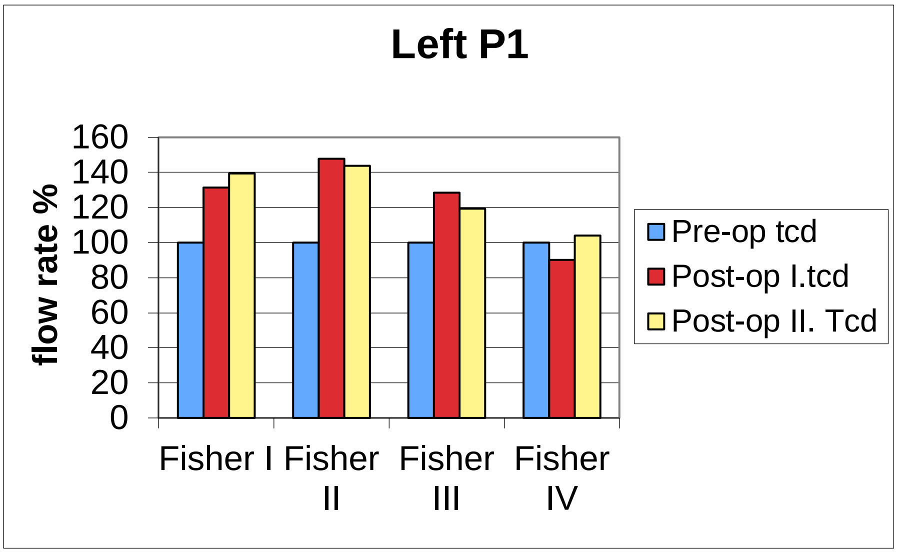


Table 7: Mean of Right P2 (2. Segment of PCA) TCD measurements

right P2	Pre-op TCD	Post-op I.TCD	Post-op II.TCD
Fisher I	53.33333	90.96154	64.78205
Fisher II	49.80392	77.80952	76.91026
Fisher III	58.26667	66.14286	64.36364
Fisher IV	44.45238	60.3	64.33333

Graph 7: In the examination of the flow velocities of the right P2 with TCD; There was no significant difference between the preoperative TCD flow rates of patients with SAH in the fisher group 1,2,3,4. In the TCD measurements performed on the 2nd postoperative day, a decreasing flow rate was detected from Fisher group 1 to 4. In the TCD flow velocity measurements performed on the 5th postoperative day, the blood flow velocity of patients with fisher group 2 SAH was higher than the others, but no significant increase was detected.

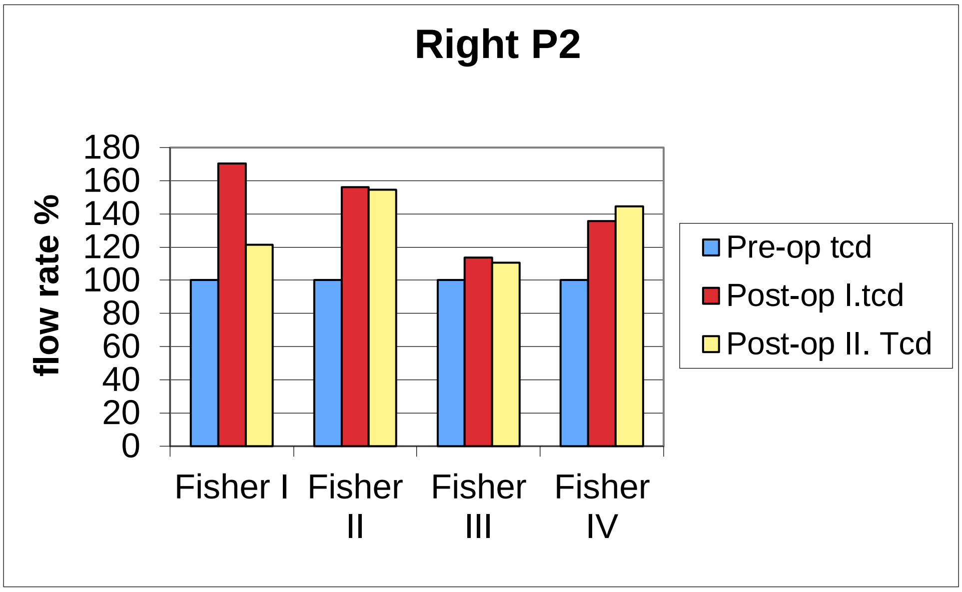


Table 8: Mean of Left P2 (2. Segment of PCA) TCD measurements

left P2	Pre-op TCD	Post-op I.TCD	Post-op II.TCD
Fisher I	54.89286	62.20513	67.65385
Fisher II	51.02083	64.85897	65.5
Fisher III	63.83333	76.66667	70.41667
Fisher IV	61.80952	59.16667	69.75

Graph 8: In Fisher group 1,2,3,4 SAH analysis of Left P2 with TCD preoperative (at the time the patient came to the hospital) flow velocity, progressively increasing vasospasm was detected from fisher groups 1 to 4. In the TCD examination performed on the 2nd postoperative day, it was determined that the flow velocity was higher in patients with group 3 SAH 2 compared to the others.

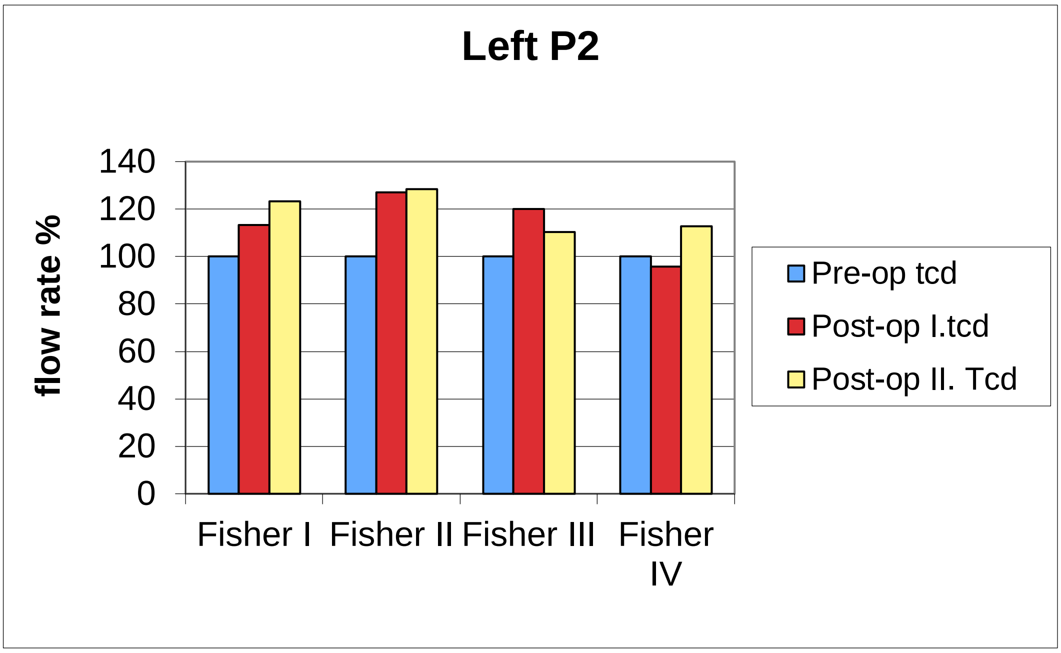
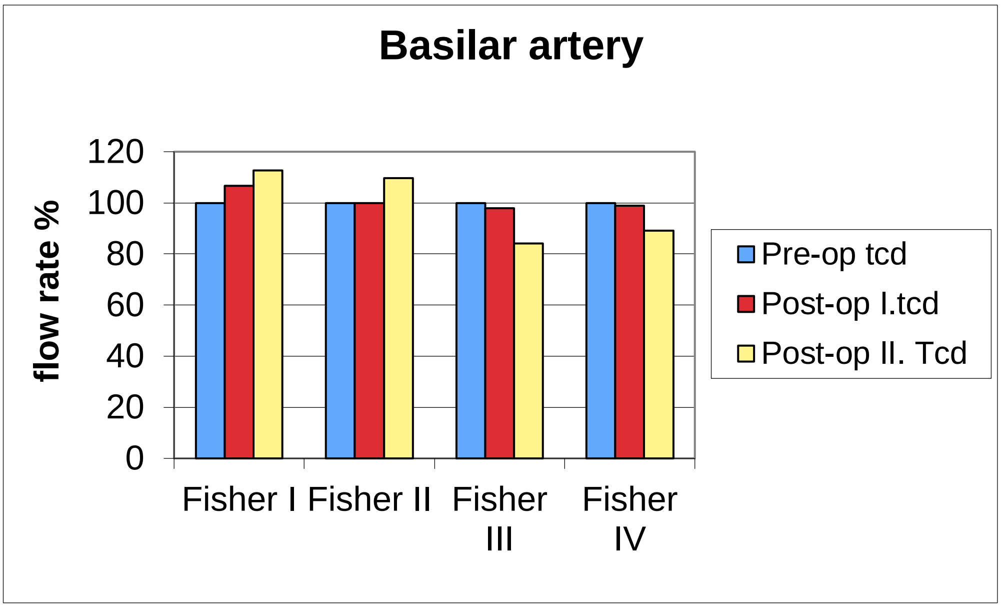


Table 9: Mean of Basilar Artery TCD measurements.

Basilar artery	Pre-op TCD	Post-op I.TCD	Post-op II.TCD
Fisher I	35.78571	38.19231	40.32051
Fisher II	34.90741	34.83333	38.24359
Fisher III	34.69697	33.97619	29.19697
Fisher IV	35.88095	35.46667	32

Graphic 9: Fisher classes and time-dependent changes cannot be clearly distinguished in basilar artery TCD blood flow measurements



DISCUSSION

Cerebral vasospasm, as a multifactorial phenomenon, constitutes one of the main problems of today's neurosurgery practice and especially in cerebrovascular surgery. The existence of hundreds of experimental and clinical studies published on this subject is the best indicator of the fact that there are still many aspects of cerebral vasospasm that have not been clarified. continues to be the leading cause of neurologic sequelae and death in hospitalized patients (1-9). Since it cannot be predicted exactly in which patients with subarachnoid hemorrhage will experience symptomatic vasospasm, and it is considered that it is very difficult to reverse once clinical vasospasm occurs, the value of easy and noninvasive recognition of cerebral vasospasm in advance and vasospasm prophylaxis will be appreciated. Different clinics have different protocols for the diagnosis and treatment of cerebral vasospasm, resulting in different results and interpretations. The fact that the subject of cerebral vasospasm is quite comprehensive is the main reason for this study for the diagnosis of vasospasm. Although different diagnostic methods are used in the diagnosis of cerebral vasospasm, it has not been clarified to what extent which one is effective, useful and guiding, and most importantly, its ability to predict cerebral vasospasm. Blood in the subarachnoid space is involved in the pathogenesis of cerebral vasospasm. The initiation of the coagulation process after subarachnoid hemorrhage was thought to be the initiating event of vasospasm. In our study, the blood flow velocity on the side with more blood in the subarachnoid space was found to be increased. In other words, according to clinical, angiographic and TCD findings, the amount of subarachnoid blood is related to the location of the vasospasm. Vasospasm is more likely to occur in patients with a long-term clot in cranial CT (10-17). However, a spasmogenic factor could not be blamed, and this event was attributed to immunoreactive or inflammatory events, mechanical factors, and depression of arterial metabolism with substances that provide long-term arterial contraction and inhibit vasodilation (18-24). In this study, transcranial Doppler (TCD) was used in addition to angiographic vessel measurements, SEP, computed tomography and clinical grading, which are routinely used in the diagnosis of cerebral vasospasm in neurosurgical practice (25-32). The most important reason why we prefer TCD; This is due to the fact that TCD application is noninvasive compared to angiography. On the other hand, reasons such as the fact that it can be repeated at the patient's bedside and as often as desired, its low cost, and the fact that it is an easy-to-use system that does not need a specially equipped room are also reasons for preference. The development of hypervolemia, hemodilution, and hypertensive treatments preceded TCD technology and prevented worsening of neurological deficit after SAH or angiographic vasospasm formation. With the routine application of TCD, the necessary adjustments can be made in the treatment by determining the arterial blood flow velocity. Initiation of treatment of vasospasm should be based on TCD findings, not symptomatic. In this study, we aimed to adjust the treatment accordingly in patients who routinely underwent TCD and were found to have vasospasm. Invasive treatments such as balloon angioplasty and selective papaverine injection are also used in the treatment of vasospasm. With the development of all these treatments, rapid vasospasm treatment is possible. Therefore, TCD measurement is very important to act early in the management of SAH and its most important complication, vasospasm. Controversy regarding the clinical significance of cerebral vasospasm arises from the fact that there is no acceptable, objective measure for tracking the course of vasospasm. Angiography is an invasive application that cannot be repeated very frequently. Arterial constriction causes an increase in flow velocity in the affected segment, and this change is inversely proportional to the diameter. Therefore, the development of vasospasm and arterial narrowing should be observed sensitively while recording flow rate (33, 34). It was possible to determine the flow velocity in the cerebral basal arteries with the transcranial Doppler technique. Because this method is noninvasive and reproducible when necessary, it is an ideal method for monitoring cerebral vasospasm after subarachnoid hemorrhage. Blood flow velocities determined by TCD mostly correlate with angiographic vessel diameters. This has also been demonstrated in our study. A narrowing in the diameter of the vessel with vasospasm was also found in DSAs of patients with TCD detected vasospasm. According to the newly established concept, the use of

CONCLUSION

TCD can prevent unnecessary treatment and thus avoid the cardiac complications of volume expander and hypertensive treatment. Although there are many methods such as DSA in the detection of vasospasm in patients with subarachnoid hemorrhage, TCD has a special importance as a noninvasive method. Patients should be looked at at least once a day so that the examination can provide better guidance. For this reason, it is a fact that it will be beneficial for both the patient and the clinician to have TCD, which is a noninvasive examination, next to the patient in every intensive care unit or related clinic where patients undergoing treatment for vascular pathology are hospitalized.

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