

RESEARCH ARTICLE



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Evaluation of Application Value of Transcranial Doppler (TCD) in the Inspection of Cerebral Vasospasm After the Treatment of Intracranial Aneurysm



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Abstract: Objective This study aimed to explore the application value of transcranial doppler (TCD) in the inspection of cerebral vasospasm (CVS) after the treatment of intracranial aneurysm.

Methods: 105 cases of patients with confirmed intracranial aneurysm were divided into two groups based on the two different treatments - craniotomy and aneurysmal clipping or interventional embolization therapy. TCD was applied to monitor the conditions of CVS of 105 cases, and case study research method was used to analyze and conclude the TCD inspection data of patients with intracranial aneurysm detected after operation.

Results: The sensitivity of TCD in the detection of CVS was 83% and the specificity was 88%. Further, the incidence rate of CVS in the group treated with interventional embolization therapy was higher than that of the group treated with aneurysm clipping.

Conclusions: TCD, which can be used to guide the adjustment of treatment and avoid complications, is an effective method in monitoring CVS after the treatment of intracranial aneurysm.

Keywords: Transcranial Doppler (TCD), Cerebral Vasospasm (CVS), intracranial aneurysm, craniotomy, aneurysmal clipping.

1. INTRODUCTION

CVS is a serious as well as common complication of intracranial aneurysms accompanied with subarachnoid hemorrhage (SAH). CVS can usually lead to a variety of symptoms including neurological dysfunctions, which have serious effects on the rehabilitation and prognosis of patients. For a long time, the diagnosis of CVS mostly relied on digital subtraction angiography (DSA) [1]. However, DSA contains invasive operation, in addition, DSA cannot be used for real-time monitoring. Therefore, DSA is being gradually replaced by transcranial doppler (TCD). TCD has many advantages like noninvasiveness, repeatability, real-time reflection on cerebral hemodynamic changes *etc.* [2]. So far, this method has become one of the dominant methods in the detection of CVS. In this study, TCD technology was used to monitor and guide the treatment of patients, and the application values of TCD technology in the diagnosis and treatment of CVS after SAH was evaluated.

2. MATERIALS AND METHODS

2.1. Clinical Data

From March 2012 to June, 2015, 134 cases of SAH patients diagnosed in our hospital were selected. Those patients

included 77 males and 57 females, and the age ranged from 36 to 65 years with an average age of 45.10±8.23 years. According to Hunt & Hess Grading system, all the 134 patients were classified as follows: Grade 1(10 cases), Grade 2(34cases), Grade 3(43 cases), Grade 4(37 cases), Grade 5(10 cases). Among those 134 patients with intracranial aneurysms, anterior communicating artery aneurysm was found in 40 patients, posterior communicating artery aneurysm was found 45 patients, middle cerebral artery aneurysm was found in 40 patients and posterior circulation aneurysm was found in 9 patients. Craniotomy and aneurysm clipping was performed for 75 patients, 30 patients were treated with interventional embolization therapy and non-surgical treatment was performed for 29 cases. Twenty patients died. All aneurysms were confirmed by DSA or surgery. All patients were examined multiple times by TCD before or after operation.

2.2. Inspection Methods

In the present study, Multi-Dop X2 type TCD analyzer (with 2.0MHZ probe), which was from DWL company (German), was used for TCD detection. Supine position was used during the detection, probe was placed in preauricular region of temporal window in the side aneurysm occurred to detect the blood flow velocity in middle cerebral artery (MCA). At the same time, the blood flow velocity of extracranial internal carotid artery (eICA) was measured

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below the angle of mandible. Sampling depth in different parts was also variable, the sampling depth of 50 ~ 60mm was applied for MCA and the sampling depth of 15 ~ 20mm was applied for eICA. All patients received advanced systemic anesthesia. Then through pterion, patients were treated with craniotomy for aneurysm clipping or interventional embolization therapy. The time points of TCD detection were as follows: before operation, 1 day after operation, 2 ~ 4 days after operation, 5 ~ 7 days after operation and 8 ~ 14 days after operation.

2.3. Determination Criteria of Cerebral Vasospasm

Determination criteria were as follows: (1) with intracranial pressure symptoms; (2) symptoms fluctuated or progressive aggravation observed in patients after treatment; (3) the consciousness of patients changed from sobriety to drowsiness or coma, or from coma to sobriety and back to coma again; (4) neurological symptoms occurred in patients; (5) cerebral edema, delayed hemorrhage, infection, hydrocephalus and some other syndromes were excluded. The patient met the combination of one of the former four criteria and the last one criterion was diagnosed with cerebral vasospasm. TCD detection showed that the blood velocity of MCA of mild cerebral vasospasm, moderate cerebral vasospasm and severe cerebral vasospasm were in the range of 120 ~ 140 cm/s, 140 ~ 200cm/s and above 200 cm/s, respectively [3]. At the same time, the index of Lindgard (the index refers to the ratio of the mean blood velocity of MCA to the mean blood velocity of eICA) > 3 was also exploited for the confirmation of cerebral vasospasm. All the patients with CVS in the study were confirmed by DSA.

2.4. Statistical Analyses

All of the data in the experiment were analyzed by SPSS 12 software. Variance analysis was applied to analyze the measurement data of each group, and $p < 0.05$ was considered to be statistically significant.

3. RESULTS

3.1. The Sensitivity and Specificity of TCD in the Detection of CVS

DSA was regarded as the gold standard for the diagnosis of CVS; the mean blood velocity of $MCA \geq 120$ cm/s was regarded as the standard for the diagnosis of CVS. The calculation showed that the sensitivity of TCD in the detection of CVS after intracranial aneurysm surgery was 83%, and the specificity was 88% (Table 1).

3.2. The Cerebral Blood Velocity by TCD Detection After Surgical Treatment of Intracranial Aneurysms

105 cases of patients were treated with surgical treatment with eICA/MCA as the target vessels. The results of TCD detection showed that the blood velocity of MCA increased significantly at 5 ~ 7 days after operation, while the blood velocity of eICA decreased slightly at the same time (Table 2).

3.3. The Relationship between the Occurrence of Symptomatic Cerebral Vasospasm and the Mean Blood Velocity of MCA

In this study, there were 50 patients who suffered from symptomatic cerebral vasospasm, and the incidence rate was 47.6%. Corresponding ischemic symptoms occurred in 32 patients who were diagnosed as moderate and severe VCS by TCD. The mean blood velocity of MCA in affected patient is higher than or equal to 140cm/s. There were significant differences in the ratio of symptomatic VCS between the patients with the mean blood velocity of $MCA \geq 140$ cm/s and the patients with the mean blood velocity of $MCA < 140$ cm/s ($p < 0.05$) (Table 3).

3.4. The Comparison of Cerebral Vasospasm After Craniotomy and Aneurysm Clipping and Interventional Embolization Therapy

In this study, 75 cases of intracranial aneurysm patients were treated with craniotomy, and VCS was observed in 43

Table 1. The inspection result of TCD and DSA in the diagnosis of cerebral vasospasm among 105 cases of patients.

Inspection Result of TCD	Diagnosis Results of DSA		In Total
	Positive	Negative	
Positive	55	9	64
Negative	20	21	41
In total	75	30	105

Table 2. The blood velocity of MCA and eICA in 105 cases of patients by TCD detection.

Vessels	The Blood Velocity (cm/s)			
	1 Day Postoperatively	2 ~ 4 Days Postoperatively	5 ~ 7 Days Postoperatively	8 ~ 14 Days Postoperatively
MCA	50.3±14.1	61.4±21.7	131.4±32.4	120.2±36.5
eICA	38.1±10.1	33.4±11.2	30.6±9.6	35.7±11.5

Table 3. The relationship between the occurrence of symptomatic cerebral vasospasm and the mean blood velocity of MCA.

The Mean Blood Velocity of MCA	Symptomatic CVS	Non-symptomatic CVS	In Total
< 140cm/s	20	53	73
≥140cm/s	30	2	32
In total	50	55	105

cases by TCD detection. 30 cases of patients received interventional embolization therapy, and VCS was observed to be in 21 cases by TCD detection. Statistical analysis showed that there was a significant difference in the incidence of CVS between those two groups of patients, $p < 0.05$ (Table 4).

4. DISCUSSION

Cerebral vasospasm has recognized to be the main cause of death and disability in patients with intracranial aneurysms accompanied with subarachnoid hemorrhage, and the incidence rate is between 30% and 70% [4]. Therefore, timely diagnosis and treatment of VCS could be extremely helpful in the rehabilitation and prognosis of patients, which in turn reduce the morbidity and mortality [5, 6]. So far, DSA is still a common method used in the diagnosis of CVS (1). However, with the rapid development of ultrasonic imaging technology, TCD gradually received more and more attentions. TCD has the advantages of noninvasiveness, repeatability, real-time reflection on cerebral hemodynamic changes especially in the application of intracranial aneurysm detection. Some studies found that CVS could indeed improve the blood velocity of intracranial artery [7]. At present, TCD has become a commonly used method in the detection of cerebral vasospasm, and TCD could be used to diagnose cerebral vasospasm by measuring the blood velocity of MCA [8].

So far, there is no unified standard for the diagnosis of cerebral vasospasm by TCD. In this study, 105 cases of patients with intracranial aneurysm were treated with surgical treatment, and they received TCD detection after operation. The results were compared with the results of DSA examination (1). The sensitivity of TCD in the detection of CVS was observed to be 83% and the specificity was 88%. Similar large sample comparative study was also carried out by the Department of Medicine of Johns Hopkins University School, wherein the sensitivity of TCD in the detection of CVS was found to be 73% and the sensitivity was 70% [9]. So, TCD technique could be used in the diagnosis of cerebral

vasospasm for patients with intracranial aneurysm after operation.

Cerebral vasospasm usually concurs between 3 to 14 days after SAH [10]. In the present study, 105 cases of patients with intracranial aneurysm received treatment, the blood flow velocity of MCA and eICA were detected at 1 day, 2 ~ 4 days, 5 ~ 7 days and 8 ~ 14 days after operation, respectively. The results showed that the blood velocity of MCA increased significantly at 5 ~ 7 days after operation, while the blood velocity of eICA decreased slightly at the same time point. Therefore, the continuously increased blood velocity of MCA was considered to be one of important standard for the diagnosis of CVS.

CONCLUSION

The results of DSA examination showed that CVS occurred in 70% of patients with SAH caused by rupture of intracranial aneurysms. Further, 20% to 30% of patients have developed into symptomatic CVS and delayed nerve damage [11]. In the present study, 105 cases of patients with intracranial aneurysm received treatment, postoperative observation indicated that there were 50 cases of symptomatic CVS, and the occurrence rate was 47.6%. Moreover, the measurement of the blood velocity by TCD has significant clinical value in guiding postoperative treatment. So, when the blood velocity of MCA is increased continuously, timely and effective intervention measures can effectively avoid the serious consequences.

At present, there were mainly two kinds of methods in the treatment of intracranial aneurysms, including craniotomy and aneurysm clipping, and interventional embolization therapy [12]. However, there was no conclusion on whether or not there were differences between those two methods in inducing CVS. This study found that, though TCD detection, the occurrence rate of CVS in patients accepting craniotomy and aneurysm clipping was lower than that in patients accepting interventional embolization therapy. Further, the occurrence rate of moderate and severe CVS in the group treated with craniotomy and aneurysm

Table 4. The comparison of cerebral vasospasm after craniotomy for aneurysm clipping and interventional embolization therapy.

TCD	Craniotomy for Aneurysm Clipping	Interventional Embolization Therapy	In Total
Positive	43	21	64
Negative	32	9	41
In total	75	30	105

clipping (53.3%) was significantly lower than that in the group treated with interventional embolization therapy (70.0%). So, TCD technique has many favorable features including noninvasiveness, repeatability, real-time reflection on cerebral hemodynamic changes, *etc.* (2). In addition, TCD technique also offers earlier diagnosis of CVS compared with DSA. So, TCD can be used to guide the adjustment of treatment and avoid serious complications in the near future.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Not applicable.

HUMAN AND ANIMAL RIGHTS

No Animals/Humans were used for studies that are base of this research.

CONSENT FOR PUBLICATION

Not applicable.

CONFLICT OF INTEREST

The authors confirm that this article content has no conflict of interest.

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