# Risk Factors for Postoperative Cerebral Vasospasm After Surgical Resection of Acoustic Neuroma

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BACKGROUND: **Cerebral vasospasm is an important cause of morbidity after subarachnoid hemorrhage, but can also occur after resection of acoustic neuroma. This study aimed to identify factors associated with postoperative cerebral vasospasm in patients with acoustic neuroma.**

METHODS: **This was a retrospective analysis of patients with acoustic neuroma (diagnosed by preoperative magnetic resonance imaging and postoperative pathology) treated between April 2013 and February 2014 in a hospital in China. Patients with other intracranial abnormalities, postoperative vasoactive drug use, or postoperative abnormalities in consciousness, vital signs, blood electrolytes, or arterial blood gases were excluded. The neurilemmoma was removed using the suboccipital retrosigmoid sinus approach, with care taken to minimize bleeding and protect the facial, trigeminal, and lower cranial nerves and brainstem. Flow velocities in the bilateral internal carotid, middle cerebral, and anterior cerebral arteries, assessed with transcranial Doppler ultrasonography before surgery and on postoperative days 1, 3, 5, 7, and 9, were used to detect cerebral vasospasm (mild, 120–140 cm/s; moderate, 141–200 cm/s; severe, >200 cm/s). Factors associated with vasospasm were identified by univariate and multivariate analyses.**

RESULTS: **Forty-three (53.8%) of the 80 patients (36 men) included were diagnosed with cerebral vasospasm: 5 (11.6%) were categorized as mild, 36 (83.7%) as moderate, and 2 (4.7%) as severe. Multivariate analysis showed that younger patient age, larger tumor size, and firm tumor consistency were independently associated with postoperative cerebral vasospasm ($P$ <0.05).**

CONCLUSIONS: **Younger patient age, larger tumor size, and firmer tumor consistency were independently associated with postoperative cerebral vasospasm in patients with acoustic neuroma.**

## INTRODUCTION

Risk factors for cerebral vasospasm include the presence of a thick cisternal clot, younger age, poor clinical grade, cigarette smoking, hypertension, and intracerebral hemorrhage (5, 9, 10). Identifying risk factors for cerebral vasospasm can facilitate the use of prophylaxis, early diagnosis, and timely intervention (8).

Transcranial Doppler ultrasonography is a noninvasive technique that has been validated against angiography for the detection of vasospasm in the anterior and middle cerebral arteries (15, 26). Postoperative evaluation of patients with this technique allows for timely intervention, for example, with triple-H therapy (25), when vasospasm is detected.

Cerebral vasospasm has also been reported after traumatic brain injury (21) and surgical resection of brain tumors (2). Manipulation of brain structures during surgery can contribute to the pathogenesis of cerebral vasospasm (23). Postoperative cerebral vasospasm has been reported after surgical resection of acoustic neuroma (7, 14, 16, 32), and may not be uncommon in this setting. However, no study has investigated the risk factors for cerebral vasospasm in patients treated surgically for neurilemmoma.

The present retrospective study was designed to identify risk factors associated with postoperative cerebral vasospasm in patients with acoustic neuroma, with particular focus on tumor characteristics. Our novel findings that cerebral vasospasm is not uncommon in these patients, and is associated with larger tumor

**Key words**
- Acoustic neuroma
- Cerebral vasospasm
- Risk factors
- Transcranial Doppler ultrasound

**Abbreviations and Acronyms**
CI: Confidence interval
OR: Odds ratio
SAH: Subarachnoid hemorrhage

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size and firm tumor consistency, highlight the importance of postoperative monitoring to ensure timely therapeutic intervention when necessary.

## SUBJECTS AND METHODS

### Enrollment of Patients

This was a retrospective analysis of patients with acoustic neuroma treated surgically at Ward XI of the Neurosurgery Department, Beijing Tiantan Hospital, China, between April 2013 and February 2014. The inclusion criteria were: acoustic neuroma diagnosed preoperatively by magnetic resonance imaging as a space-occupying lesion in the region of the internal auditory canal and cerebellopontine angle, and confirmed postoperatively as a neurilemmoma by pathologic examination; patient body temperature, heart rate, blood pressure, respiration, and blood electrolytes were monitored daily after surgery, and no abnormalities detected (to exclude possible influence of these factors on the analysis); and postoperative arterial blood gas analysis (carried out daily) confirmed that pH was maintained at 7.35–7.45, partial pressure of oxygen was maintained at >95 mm Hg, partial pressure of carbon dioxide was maintained at 35–45 mm Hg, and oxygen saturation was maintained at >96% (to exclude abnormalities in blood gases affecting arterial blood flow velocity). The exclusion criteria were pre-existing chronic diseases such as hypertension, diabetes mellitus, and cardiovascular disease; postoperative computed tomography evidence of intracranial hematoma (including blood in the subarachnoid space or the cisterns), ischemia and/or swelling of the cerebellar hemisphere and brainstem, acute hydrocephalus, or increased intracranial pressure; postoperative pulmonary or encephalic infection; postoperative impaired consciousness; or postoperative use of vasoactive drugs (to exclude possible effects of these agents on the analysis). Patients with long history of smoking (>10 years) were excluded from the study. Patients with a short history of smoking are asked to quit smoking for at least 2–3 weeks before surgery. The study was approved by the ethics committee of Beijing Tiantan Hospital, China.

### Surgical Management of the Acoustic Neuroma

The operation was carried out by a trained and experienced surgeon, using the suboccipital retrosigmoid sinus approach. All surgeries were performed in the lateral position, with the head and body in a natural position, which would not lead to postoperative brain swelling/edema and hyperemia. The tumor within the membrane of the neurilemmoma was removed under the guidance of electrophysiologic monitoring, with care taken to protect the facial nerve, trigeminal nerve, lower cranial nerves, and brainstem. Care was also taken to minimize the amount of bleeding during surgery (fluids were administered if necessary to maintain blood pressure) and to prevent blood from entering the subarachnoid space during the process of tumor removal.

### Assessment of Cerebral Vasospasm

The flow velocities and frequency spectra of the bilateral internal carotid, middle cerebral, and anterior cerebral arteries were assessed before surgery and on postoperative days 1, 3, 5, 7, and 9, using a transcranial Doppler ultrasonography diagnostic system (Multi-Dop X system; DWL, Hamburg, Germany). Cerebral vasospasm was defined on the basis of mean blood flow velocity using the criteria proposed by Aaslid et al. (1) and Seiler et al. (24): mild, 120–140 cm/s; moderate, 141–200 cm/s; and severe, >200 cm/s.

### Data Collection

The following information was extracted from the medical records: patient age and gender, magnetic resonance imaging parameters, tumor size, surgical method used, the presence or absence of adhesion between the acoustic neuroma and the trigeminal nerve, the presence or absence of adhesion between the acoustic neuroma and brainstem, and the consistency (firm or soft) of the acoustic neuroma, as judged by the operating surgeon.

### Statistical Analysis

SPSS 18.0 software (SPSS Inc., Chicago, USA) was used for the statistical analysis. Measurement data are presented as means ± standard deviations, and categorical data as percentages. For analysis of the risk factors associated with cerebral vasospasm after surgical resection of acoustic neuroma, the included patients were allocated into 2 groups based on whether or not postoperative vasospasm occurred. Comparisons of measurement data between groups were performed using the independent samples t-test. Categorical data were compared between groups using Pearson's $\chi^2$ test. Multivariate analysis was performed using backward logistic regression analysis to identify independent risk factors for cerebral vasospasm. $P < 0.05$ was considered statistically significant.

## RESULTS

### Patient Characteristics

A total of 80 patients (36 men; mean age, 45.84 ± 11.00 years) were included in the study (Table 1). No patient received preoperative radiation therapy. Before surgery, the blood flow velocities and frequency spectra of the internal carotid, middle cerebral, and anterior cerebral arteries (determined using transcranial Doppler ultrasonography) were normal in all patients. During surgery, blood loss was <400 mL in all patients. Postoperatively, 43 of the 80 patients (53.8%) were diagnosed with cerebral vasospasm, based on measurements of the mean blood flow velocities and frequency spectra (particularly of the middle cerebral and anterior cerebral arteries). Of these 43 patients, 5 (11.6%) were categorized as having mild vasospasm, 36 (83.7%) as having moderate vasospasm, and 2 (4.7%) as having severe vasospasm. In patients diagnosed with cerebral vasospasm, a progressive increase in flow velocity was observed, along with characteristic changes in the morphology of the frequency spectrum (including blunting of the systolic peak and signal aliasing due to vortex turbulence).

### Univariate Analysis of Factors Associated with Cerebral Vasospasm

The occurrence of postoperative vasospasm was significantly associated with younger patient age, larger tumor size, adhesion of the acoustic neuroma to the trigeminal nerve or brainstem, and firm tumor consistency ($P < 0.05$; Table 1). The proportion of female patients was numerically higher in the group exhibiting