Vascular complications of vestibular schwannoma surgery: a comparison of the suboccipital retrosigmoid and translabyrinthine approaches

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Object. Vascular complications of the surgery for vestibular schwannomas (VSs) can have devastating consequences; however, there is scant literature on the systematic analysis of the different types of complications. In this context, the authors of this study analyzed these complications, with particular interest in the role of surgical approach in their occurrence.

Methods. The charts of 391 patients who had undergone 413 procedures for VS during a 24-year period were reviewed retrospectively. A suboccipital retrosigmoid (RS) approach was used in 338 procedures, and the translabyrinthine (TL) route in 75. Postoperative hemorrhage or infarction was identified and stratified according to the complication type and surgical approach.

Postoperative vascular complications were encountered in 11 procedures (2.7%), and their incidence was the same for both the RS and TL approaches. Of these complications, eight were hemorrhagic (two cerebellopontine angle, one intracerebellar, and five epidural hematomas) and three were ischemic in nature. Five patients (45.4%) had a complete recovery, and four patients (36.4%) a partial recovery; two patients (18.2%) died. The overall procedure-related mortality rate was 0.5% (two of 413 procedures): 0.3% (one of 338 procedures) for the RS approach and 1.3% (one of 75 procedures) for the TL approach (p > 0.05).

Conclusions. In this study, the overall incidences of vascular complications in VS surgery were similar for the RS and TL approaches. Regardless of the preferred surgical route, this group of complications carries a significant risk of morbidity and therefore warrants special consideration in the management of VSs.

Key Words • vestibular schwannoma • complication • retrosigmoid approach • translabyrinthine approach • cerebellopontine angle

The postoperative course of patients who have undergone surgery for VS can be complicated by a number of conditions, and can have devastating consequences; however, there is scant literature on the systematic analysis of the different types of complications. In this context, the authors of this study analyzed these complications, with particular interest in the role of surgical approach in their occurrence.

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The charts of 391 consecutive patients who had undergone 413 procedures for VS in otoneurosurgical collaboration between 1980 and 2004 were retrospectively reviewed. Non–vestibular schwannoma lesions of the CPA and malignant schwannomas were excluded from our analysis. In addition, VSs that had been treated via a combined surgical approach were excluded because of the relatively small number of patients in that group. The RS approach was used in 338 procedures, and the TL in 75. All patients who underwent the RS approach had been placed in the park-bench position during surgery.

Patients with a CPA, cerebellar, or epidural hematoma as well as brainstem or cerebellar infarcts on postoperative imaging were identified and stratified according to the complication type and surgical approach. In one patient who had undergone surgery in the pre–MR imaging era, a brainstem infarct was diagnosed based on persistent postoperative complications encountered in our practice, in which these two techniques are commonly used.

Clinical Material and Methods

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neurological deficits given that the computed tomography scans had been inconclusive.

The Fisher exact test was used, when appropriate, for statistical analysis of the groups.

Results

Vascular complications were detected in 11 patients (2.7%); eight were male and three were female, with a mean age of 46 years. The overall incidence of vascular complications was the same, regardless of whether the surgery had been performed via an RS approach (nine of 338 procedures) or a TL approach (two of 75 procedures; Table 1). The mean tumor size was 28.9 mm–29.3 mm in patients treated via the RS approach and 26 mm in those treated via the TL approach.

Hemorrhagic Complications

Eight patients experienced hemorrhages: a CPA hematoma was found in two patients, a cerebellar hemorrhage in one, and an epidural hematoma in five. The RS approach was used in seven patients, and the TL route was preferred in one. Symptoms were detected within the first 72 hours after the initial surgery. All patients presented with progressive signs of cerebellar dysfunction, cranial nerve deficits, headache, vomiting, and deterioration in their level of consciousness. In all cases, the hematoma was promptly evacuated. Among the five patients with an epidural hematoma, the source of bleeding was identified as the muscle in two patients and as the occipital artery in two; no source was identified in the remaining patient. The hematoma extended up to the ipsilateral occipital region in one patient, necessitating an additional occipital craniotomy. In both cases of an isolated CPA hematoma, no active bleeding source was identified at the time of reexploration; however, injury to the high jugular bulb during drilling of the internal auditory canal on initial surgery was suspected of being the bleeding source in one of these cases. In one patient, partial resection of the cerebellar hemisphere had been performed during the initial surgery because of swelling, and also the lesion was bleeding heavily.

In our series, both patients with a CPA hemorrhage died despite prompt evacuation of the hematoma, resulting in a procedure-related mortality rate of 0.5%. With regard to the surgical route, the mortality rate was 0.3% (one of 338 procedures) for the RS approach and 1.3% (one of 75 procedures) for the TL approach (p > 0.05). Patient outcome according to the complication type and surgical route are shown in Tables 2 and 3, respectively.

Ischemic Complications

Infarcts developed in three patients, all of whom had presented with signs and symptoms of cerebellar and/or brainstem dysfunction. The onset of symptoms occurred within the first 24 hours after surgery in all but one of these patients, who had been treated via the TL approach. This latter patient’s bilateral vision deteriorated and cerebellar and brainstem symptoms appeared 72 hours after surgery. Results of MR imaging and MR venography revealed bilateral occipital venous infarction with a hemorrhagic component (Fig. 1 left) and thrombosis of the ipsilateral sigmoid and transverse sinuses (Fig. 1 right), respectively. In one of the patients treated via an RS approach, a posterior inferior cerebellar artery infarct was detected. Bleeding from this artery had occurred during surgery and necessitated coagulation of the vessel at that time. The remaining patient underwent surgery via an RS approach in the pre–MR imaging era. The tumor was firm and very adherent to the brainstem, and intraoperative bleeding from a major brainstem vein was encountered, necessitating vessel coagulation.

There were no deaths in this group. The patient with bilateral occipital infarction had a complete recovery, and the other two patients had a partial recovery (Table 2).

Discussion

Hemorrhagic Complications

The most common type of postoperative bleeding after surgery for a CPA tumor is an intradural CPA hemorrhage.30 Other sources of bleeding include brainstem, cerebellar, and epidural hematomas. Note that rare occurrences of intraventricular37 or supratentorial epidural hemorrhage30 (in a patient with a ventricular drain) have also been reported. When a supratentorial intraparenchymal hemorrhage is encountered after CPA surgery, it is usually a consequence of venous infarction but can also occur due to unexpected conditions such as a coincidental undetected arteriovenous malformation.30 In 33 to 40% of cases, bleeding is detected within the first 24 hours postsurgery; one half of these cases require surgical intervention.30,33,34 Cerebellopontine angle hematomas have a worse prognosis compared with that for other common types of postoperative bleeding, with a mortality rate of 25 to 50%.33,34 In our experience, patients with a postoperative epidural hematoma had a relatively better outcome, whereas both patients with CPA hematomas died.

Cystic and/or unencapsulated tumors have been reported to increase the risk of postoperative hematoma.30 In the majority of cases, however, the exact source of bleeding may be difficult to identify at the time of reexploration.34 Injury to the venous structures such as torn bridging veins to major sinuses31 or the jugular bulb (as in one of our cases) may be responsible for insidious postoperative bleeding and can be missed more easily than an overt arterial counterpart. Yama kamii and colleagues30 have suggested that the lateral or prone positions may have some advantages over the semisitting position in this context: the semisitting position reduces intracranial venous pressure and shrinks the peritumoral veins—decreasing the likelihood of major venous bleeding at the time of surgery—and therefore may lead one to overlook a bleeding vein until a postoperative hematoma

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develops. In contrast, troublesome venous bleeding would be more likely during surgery performed with the patient in the lateral or prone position, which would therefore require more meticulous hemostasis at the time of the primary surgery.

### Ischemic Complications

The majority of brainstem infarcts after CPA surgery occur as a result of tumor adherence to the brainstem and its vessels. Therefore, every effort should be made to avoid perforating artery interruption during brainstem dissection. It is important to remember that recurrent perforating arteries can initially course toward the internal auditory canal but subsequently turn medially and supply the brainstem. Preservation of the arachnoid plane remains an important, if not the most important, principle in avoiding injury to these structures. Although distal anterior inferior cerebellar artery infarcts can be relatively benign, the artery should be preserved. At times, however, this vessel can be included within the tumor due to tethering between the involuting walls of the tumor capsule and can pose a challenge.

Good knowledge of the CPA veins is crucial to avoiding vascular complications; the lateral medullary vein, vein of cerebellomedullary fissure, vein of middle cerebellar peduncle, and vein of cerebellopontine fissure run between the tumor and the brainstem. Although the petrosal veins can be sacrificed with relative safety, one should avoid injuring the vein of cerebellopontine fissure in particular, because it is formed by the convergence of many veins draining the petrosal surface of the cerebellum and because the consequence could be cerebellar venous infarction and hemorrhage. In this context, the RS approach gives an improved view and allows better identification and control of the vascular supply of the brainstem, especially in large adherent tumors.

Vasospasm is another pathological entity, which has been

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**TABLE 2**

<table>
<thead>
<tr>
<th>Complication Type</th>
<th>No. of Patients (%)</th>
<th>GOS Score</th>
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<tr>
<td></td>
<td>Total</td>
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</tr>
<tr>
<td>CPA hem</td>
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<td>0</td>
</tr>
<tr>
<td>cerebellar hem</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>epidural hem</td>
<td>5</td>
<td>4 (80)</td>
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<tr>
<td>infarct</td>
<td>3</td>
<td>1 (33.3)</td>
</tr>
<tr>
<td>total</td>
<td>11</td>
<td>5 (45.4)</td>
</tr>
</tbody>
</table>

* GOS = Glasgow Outcome Scale; hem = hemorrhage.

**TABLE 3**

<table>
<thead>
<tr>
<th>Surgical Approach</th>
<th>No. of Patients (%)</th>
<th>GOS Score</th>
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</thead>
<tbody>
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<td></td>
<td>Total</td>
<td>5</td>
</tr>
<tr>
<td>RS</td>
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<td>5 (55.6)</td>
</tr>
<tr>
<td>TL</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>total</td>
<td>11</td>
<td>5 (45.4)</td>
</tr>
</tbody>
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*FIG. 1. Left: Postoperative axial fluid-attenuated inversion-recovery image showing a bilateral occipital venous infarct with a hemorrhagic component. Right: Magnetic resonance venography, anteroposterior view, demonstrating occlusion of the left transverse and sigmoid sinuses.*

![Postoperative axial fluid-attenuated inversion-recovery image showing a bilateral occipital venous infarct with a hemorrhagic component.](image1.png)

![Magnetic resonance venography, anteroposterior view, demonstrating occlusion of the left transverse and sigmoid sinuses.](image2.png)
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shown to occur after the resection of skull base tumors\textsuperscript{1,15,22} and can occasionally be responsible for infarction.

Postoperative Cerebellar Signs: Infarction and Cerebellar Retraction

One patient who had undergone surgery before the MR imaging era was included in our analysis; because computed tomography studies had been inconclusive, the finding of a postoperative infarct was based on persistent postsurgical cerebellar symptoms. Briggs and colleagues\textsuperscript{4} found infarcts in only one third of the patients with postoperative onset of ataxia. Hegarty and associates\textsuperscript{13} suggested that injury to the lateral portion of the cerebellar hemisphere, which could occur during cerebellar retraction, would lead to little or transient dysfunction. In contrast, persistent dysfunction is more likely to result from an injury (mainly vascular) to the structures that provide afferent and efferent connections to the cerebellum (for example, the cerebellar peduncles). The need for cerebellar retraction has long been seen as one of the disadvantages of the RS approach given its concomitant higher risk for cerebellar injury. Note, however, that in a recent case controlled study, no difference in long-term cerebellar function was found between patients treated via the RS and those treated via the TL approach.\textsuperscript{17}

Occlusion of the Sigmoid Sinus

In one of the patients in our study, venous infarction of the bilateral occipital lobes developed together with a hemorrhagic component due to occlusion of the sigmoid and transverse sinuses. Keiper and associates\textsuperscript{16} have reported the incidence of sinus thrombosis in as many as 4.7\% of the patients undergoing RS and TL procedures. Retraction of the sigmoid sinus during lengthy TL procedures appears to play a significant role in occlusion;\textsuperscript{16,27,11} therefore, periodic release of the retractor has been advocated. Other factors that can also contribute to sinus occlusion include mechanical or heat injury during drilling and/or overexposure of the sinus that can lead to its drying and shrinkage.\textsuperscript{16,27}

Patients with sinus thrombosis usually present with headache and visual deterioration due to raised intracranial pressure, and symptoms can begin as late as 20 days after surgery.\textsuperscript{29} The appearance of symptoms depends on various anatomical factors, such as the involvement of the dominant side,\textsuperscript{16} presence of a communicating torcular herophili, or existence of bilateral transverse sinuses, and not solely on the size of the sinus itself.\textsuperscript{27} In an atresic or hypoplastic transverse sinus, if the dominant side is compromised, circulatory failure may occur in both hemispheres; in contrast, compromise of the hypoplastic sinus may have little or no effect, depending on the development of the vein of Labbé and the degree of sinal hypoplasticity. In one of the cases in the present study, both the transverse and sigmoid sinuses were involved, despite the fact that only the latter was exposed during drilling. This finding is not surprising given that occlusion is rarely limited to one sinus.\textsuperscript{3} In the case of a sinus occlusion or the sacrifice of a sinus in a more extensive skull base approach, it is important to preserve other relevant venous structures to maintain venous circulation.\textsuperscript{16,27,36}

A hemorrhagic component is seen in 49\% of patients with venous infarction after sinus thrombosis.\textsuperscript{3} Bleeding usually occurs in the temporal lobe after CPA surgery--related sigmoid sinus occlusion.\textsuperscript{14,20,27} In the present study, it was seen in both occipital lobes, perhaps because of the multiple anatomical variations in the supratentorial veins draining to the sigmoid and transverse sinuses, as described previously.\textsuperscript{39}

Conclusions

Vascular complications of VS surgery carry a significant risk of morbidity and therefore warrant special consideration and awareness. In our experience, both the RS and TL approaches seem to have similar overall incidences of complications. Regardless of the chosen route, a meticulous surgical technique combined with the utmost care in preserving the neurovascular structures remains the ultimate factor in avoiding these incidents.

References


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