Diagnosis and Management of Dural Sinus Thrombosis following Resection of Cerebellopontine Angle Tumors

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Abstract

Objective Lateral sinus thrombosis is a potentially devastating but seldom studied complication of cerebellopontine angle (CPA) tumor surgery. Systemic anticoagulation in the early postoperative period has often been avoided due to the potential risks of intracranial hemorrhage.

Design Retrospective review.

Setting Tertiary referral center.

Main Outcome Measures The goal of this study was to identify the frequency, treatment, and outcomes in patients who develop postoperative venous sinus thrombosis following CPA tumor surgery and receive early systemic anticoagulation.

Results Of 43 patients with CPA tumors, we report five patients (11.6%) with transverse and/or sigmoid sinus thrombosis following resection of the tumor, four of which were detected on routine early postoperative noncontrast computed tomography (CT) scan. The thrombosis was confirmed in all cases with CT venography or magnetic resonance venography. Affected patients had significantly larger tumors than controls and tended to undergo longer operations. These patients were treated with immediate anticoagulation (intravenous heparin, followed by Coumadin for 6 months) without complication.

Conclusion Venous sinus thrombosis is an underrecognized complication of CPA surgery, but it can be diagnosed in the early postoperative period by noncontrast CT imaging. Early postoperative initiation of systemic anticoagulation appears safe and effective to prevent the progression of thrombosis and its consequences.

Keywords

- ▶ venous sinus thrombosis
- ▶ cerebellopontine angle tumor
- ▶ acoustic schwannoma
- ▶ complications
- ▶ anticoagulation

Introduction

Thrombosis of the transverse and sigmoid sinus is a well-known and potentially devastating complication of the surgical approaches used to treat vestibular schwannomas and other cerebellopontine angle (CPA) tumors.^{1,2} Although there is a paucity of published data regarding outcomes and

treatment options in the postoperative period, there is literature on the setting of spontaneous thrombosis and that secondary to traumatic head injury and infection.^{3–6} In these cases systemic anticoagulation is generally recommended as the initial management.^{3,6–8} However, following neurosurgical procedures, most reports indicate avoidance of

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anticoagulation due to the risk of postoperative intracranial hemorrhage.^{2,6,9} We report our experience of five cases of early transverse and sigmoid sinus thrombosis following retrosigmoid and translabyrinthine approaches to the CPA that were successfully treated with early systemic anticoagulation.

Methods

We conducted a retrospective analysis of all patients who underwent CPA tumor surgery between January 2008 and December 2012 at the Alfred Hospital and identified a cohort of 43 patients. As part of the vestibular schwannoma protocol at our institution, all patients underwent magnetic resonance imaging (MRI) preoperatively, and all patients underwent a routine computed tomography (CT) noncontrast imaging day 1 postoperatively. All postoperative imaging was rereviewed for this study. Statistical analysis was completed using a two-tailed *t* test for continuous data and chi-square tests for categorical data (using Microsoft Excel v.12.2.5).

Results

Surgical Characteristics

Of the 43 patients, 29 underwent a translabyrinthine approach, 12 had a retrosigmoid approach, and 2 underwent a middle fossa approach. Twenty-six of the patients were women (60%). Five of the patients (four were women) developed postoperative dural sinus thrombosis (►Table 1). All five patients who developed postoperative thrombosis had undergone a translabyrinthine approach. There was no significant difference in the age of the patients who experienced a dural thrombosis (52 years [range: 29–66]) compared with those who did not (58 years [range: 22–75]) (►Table 2). The average body mass index (BMI) for patients who experienced a postoperative thrombosis was 28.4, which was not significantly different from those who did not have this complica-

tion (27.4). Review of the histopathology revealed vestibular schwannomas in all cases of postoperative thrombosis. Four of the five patients who had a postoperative thrombosis had tumors located on the right side; 21 of the remaining 38 patients (55%) had lesions on the right. The average maximum diameter of the lesion for those patients who did not experience a thrombosis was 1.8 cm (range: 0.8–3.5); that of the patients who were diagnosed with a thrombosis was 3.24 cm (range: 2.7–3.5). This was a statistically significant difference in size ($p < 0.001$) (►Table 2).

The average length of the operation (including anesthesia time) in patients who did not have a postoperative thrombosis was 8 hours (range: 4.5–13.5); that of those who had a dural thrombosis postoperatively was 10.10 hours (range: 9–11). This was not significantly different ($p = 0.07$). There was no venous injury in any case. Mannitol was not given in any of the cases. Preoperative MRI revealed right-sided dominance of the transverse sinus in four of the five cases with one case revealing no dominance. All four patients with right-sided dominance developed thrombosis in the right dural sinuses. In the remaining patients, 21 (55%) revealed right-sided dominance, 8 (21%) were left dominant, and 9 (24%) revealed no dominance.

Detection of the Dural Thrombosis

In four of the five cases, the thrombosis was asymptomatic and detected on routine postoperative CT brain imaging within 24 hours of surgery (►Fig. 1). In the final patient, the thrombosis presented 5 weeks following the surgery with new neurologic symptoms of ataxia and right-sided incoordination and a right cerebellar venous infarction. The initial postoperative CT brain imaging did not show any evidence of thrombosis at that time.

The diagnosis was confirmed with CT venography (CTV) or MR venography (MRV) in all our patients (►Fig. 2). In four of the five patients, the thrombosis was in the dominant sinus. In one of the cases, the transverse sinus was completely

Table 1 Characteristics of patients with transverse and sigmoid thrombosis

Case no.	Age, y, sex	Tumor diameter Side and pathology	Postoperative day of diagnosis	Postthrombosis symptoms	Treatment	Postoperative complication/ Symptoms at 6 mo
1	29/F	35 mm Right-sided VS	Day 1	None	Immediate IV heparin/ Coumadin 6 mo	Nil
2	66/F	33 mm Right-sided VS	Day 1	None	Immediate IV heparin/ Coumadin 6 mo	Nil
3	55/F	35 mm Left-sided VS	Day 2	None	Immediate IV heparin/ Coumadin 6 mo	Nil
4	57/F	32 mm Right-sided VS	Day 1	None	Immediate IV heparin/ Coumadin 6 mo	Mild vaginal hemorrhage
5	52/M	27 mm Right-sided VS	Day 35	Ataxia and cerebella signs	Immediate IV heparin/ Coumadin 6 mo	Improvement in cerebella signs

Abbreviations: F, female; IV, intravenous; M, male; VS, vestibular schwannoma.

Note: Demographic characteristics and clinical course in five patients with transverse and sigmoid thrombosis following translabyrinthine approaches for tumor resection.

Table 2 Patient demographics and characteristics

	No postoperative thrombosis	Postoperative thrombosis
No. of patients	38	5
Age, y (range)	58 (22–75)	52 (29–66)
Sex	16	1
Male	22	4
Female		
Pathology	38 VS	5 VS
Average maximal diameter, mm ^a , range	18 (8–35)	32.4 (27–35)
Operative duration, h (range)	8 (5.5–13.5)	10.10 (9–11)
Type of operation	24	5
Translab	12	0
Retrosigmoid	2	0
Middle fossa		
Postoperative CTB	No thrombosis	5 sinus thrombosis
Sinus dominance	21	4
Right	8	0
Left	9	1
None		
BMI	27.4	28.4

Abbreviations: BMI, body mass index; CTB, computed tomography of brain; middle fossa, middle fossa approach; retrosigmoid, retrosigmoid approaches; translab, translabyrinthine; VS, vestibular schwannoma.

^a*p* < 0.001.

occluded; in the other four cases, it was partially occluded. In four of the five cases, the sigmoid sinus was also occluded, completely in two of these.

Treatment of Thrombosis

In all cases intravenous heparin, with an activated partial thromboplastin time (aPTT) target of 50 to 60 was started immediately (no bolus was administered) and continued for 5 days. The aPTT was monitored every 6 hours (as is the standard practice at our institution), and all patients were in the therapeutic range within 24 hours of heparin initiation. The heparin was started ~ 24 hours after surgery in those patients whose thrombosis was detected on postoperative day 1. This was followed with Coumadin for the following 6 months. The international normalized ratio target was 2 to 2.5. Once the Coumadin reached the therapeutic target, it was monitored by the patient's local medical practitioner at 2-week intervals. CT imaging conducted 48 hours following the initiation of anticoagulation did not reveal any new hemorrhage in our five patients. Following the commencement of anticoagulation, no patient developed any new neurologic symptoms or radiologic evidence of new intracranial hemorrhage. One patient who presented 5 weeks postoperatively with a right cerebellar infarct had symptomatic improvement following anticoagulation. One patient developed minor vaginal hemorrhage while on anticoagulation that did not require any intervention. At 6-month follow-up, all patients were asymptomatic, and repeat venography revealed complete resolution of the thrombosis in four of the patients and partial resolution in the remaining patient.

Discussion

Dural venous sinus thrombosis is a potentially devastating condition with the potential to cause severe headaches

Fig. 1 (A) Left-sided acoustic schwannoma with patent sinus (arrow). (B) Postoperative noncontrast computed tomography brain radiography at day 1 reveals a hyperintense left-sided sigmoid sinus suggestive of a sinus thrombosis (arrow). (C) Computed venography (CTV) confirms a left-sided partial transverse sinus, complete left-sided sigmoid, and partial left-sided internal jugular sinus thrombosis (arrow). (D) CTV imaging at 3 months reveals resolving thrombosis (arrow). The patient remained asymptomatic throughout.

Fig. 2 (A) Axial magnetic resonance imaging revealing a right-sided acoustic schwannoma with patent sinus (arrow). (B) Postoperative noncontrast computed tomography brain radiography at day 1 reveals a hyperintense right-sided transverse sinus suggestive of a sinus thrombosis (arrow). (C, D) Postoperative magnetic resonance venography (MRV) with three-dimensional (3D) reconstruction confirms a right-sided partial transverse sinus (arrow). (E, F) MRV with 3D reconstruction at 6 months reveals complete resolution of right transverse sinus thrombosis (arrow).

(70–90%), intracranial hemorrhage (up to 25% of patients), infarction (27%), papilledema (15%), focal neurologic deficits (22%), seizures, and reduced mental status.^{6,7,10} Reports on the outcome of vestibular schwannoma surgery seldom report on postoperative dural sinus thrombosis being considered or diagnosed when postoperative complications such as edema, chronic headaches, and hydrocephalus have occurred.¹¹ Although systemic anticoagulation therapy is considered the treatment of choice for sinus thrombosis, its use has been very limited in the postoperative period due to the risk of catastrophic intracranial hemorrhage.²

The Unknown Natural History of Postoperative Dural Thrombosis

Keiper et al, in one of the largest case series on symptomatic postoperative sinus thrombosis, found 5 (3 females and 2 males) of 107 patients (4.6%) developed pseudotumor cerebri as a postoperative complication following suboccipital or translabyrinthine craniotomy.⁹ Four of these had ves-

tibular schwannoma; one had a meningioma. All of these patients presented with headaches and visual disturbance (visual field deficits and esotropia) from 1 to 35 days postoperatively (median: 17 days). Two of these patients experienced known sinus laceration at the time of the procedure.⁹ MRI/MRV was used to detect unilateral thrombosis in all patients. Three patients required lumbar peritoneal shunting, one urgently due to papilledema and acute visual failure. Two patients were treated medically (acetazolamide and dexamethasone with naproxen).⁹ No patients were anticoagulated or underwent successful endovascular treatment; however, symptoms resolved in all five cases following treatment.⁹

Interestingly, all of the patients reported by Keiper et al⁹ became symptomatic with the median time to diagnosis of 17 days postoperatively, and only one patient was detected on the postoperative CT brain imaging. In our study, thrombosis was detected in four of five patients in the immediate postoperative period with routine noncontrast CT imaging. Our study emphasizes the importance of routine postoperative imaging in the first 24 hours and careful review of the transverse and sigmoid sinuses in this patient cohort. All 43 patients had early postoperative CT imaging, and none of the 38 patients without diagnosed thrombosis developed symptoms that could be attributed to sinus thrombosis. We had only one patient who was diagnosed after the first 48 hours, and that patient was the only individual who became symptomatic. We hypothesize that the early detection and treatment of these patients may alter the natural history of the disease and prevent some of them from subsequently developing symptoms such as those seen in the series of Keiper et al.⁹ Ideally, a controlled prospective trial would be required to test this hypothesis, but this is unlikely given the ethical considerations.

Detection of Postoperative Sinus Thrombosis

The detection of postoperative sigmoid thrombosis can be challenging because noncontrast CT often has poor sensitivity for this condition and can easily be missed on routine review of the imaging.¹² Findings suggestive of thrombosis include high-density clots in cortical veins (cord sign),¹³ dural sinuses (dense vein sign),¹⁴ and torcular herophili (delta sign).¹⁵ The diagnostic tests of choice are typically MRV or CTV that delineates the thrombosis as a filling defect.¹² Given the limitations associated with noncontrast CT, all patient with suspected dural sinus thrombosis on clinical or radiologic grounds should undergo a CTV or MRV to confirm the diagnosis. T1-weighted images can show high signal when the thrombosis is subacute, leading to a potentially false negative. However this can be negotiated by review of three-dimensional time-of-flight MRV that reveals loss of flow-related enhancement and thus confirms the diagnosis.¹⁶ All of our patients subsequently proceeded to CTV or MRV to confirm sinus thrombosis. In our series no false-positive initial CT images were identified. On retrospective review of all postoperative CT imaging, no false-negative errors were detected.

Similarly, Ohata et al,² in their retrospective analysis of 174 patients who had undergone pre-sigmoid transpetrosal

tumor resection, found seven cases of sigmoid sinus thrombosis. Only two were detected early, both intraoperatively, and both underwent intraoperative surgical repair. Only one of their patients had anticoagulation, which was started on day 4 postoperatively after the development of severe dysphasia. The patient had experienced a known sinus laceration intraoperatively, which was sealed with a fibrinogen-soaked sponge.¹⁷ She subsequently developed a massive subcutaneous hematoma and required reoperation where the sinus was found to have reopened and required further repair. In our series we did not have any patient develop intracranial hemorrhage, confirmed on repeat imaging, despite starting anticoagulation within 48 hours of the operation in almost all cases. It should be noted that none of our patients had a sinus laceration or significant trauma to the sinus, and our findings may not apply to this subgroup of patients.

Sinus thrombosis may result from otitis media or mastoiditis via the spread of infection either directly or via the mastoid emissary vein to the sigmoid sinus.¹⁷ In these cases the patients are symptomatic and usually present with headaches, neck stiffness, fever, and otalgia.⁴ Ropposch et al⁴ treated six pediatric patients who presented with sinus thrombosis as a complication of mastoiditis with intravenous antibiotics and anticoagulation (usually heparin and low molecular weight heparin) followed by surgical mastoidectomy (five cases) with or without thrombectomy (three cases).⁴ They reported no complications of therapy and resolution of the symptoms. Several studies have found no additional benefit from thrombectomy.^{18,19}

Risk Factors for the Development of Postoperative Sinus Thrombosis

The risk factors for the development of postoperative thrombosis include mechanical injury to the sinus during the operation, excessive manipulation of the sinus, prolonged fixed retraction on the sinus causing complete or partial occlusion, surgery-induced injury with packing or compressing of the sinus, dehydration (particularly from the use of mannitol), pregnancy or the oral contraceptive pill (OCP), infection (meningitis, mastoiditis, and otitis media) and hematologic disease.^{2,7} One of the patients was taking the OCP, another was a current smoker, and a third was found to be positive for lupus anticoagulant on the postoperative thrombophilia screen. It is also of note that two of the five patients were overweight (BMI: 25–30), and the remaining three were obese (BMI: 30–35). Although this was not significantly different from those patients who did not experience a thrombosis, our patient cohort was relatively small.

We propose a further risk factor, namely the size of the lesion on preoperative MRI. In our patient cohort, patients who had a postoperative dural sinus thrombosis had a significantly larger lesion than those who did not. This may simply reflect that larger lesions required longer operative times for resection, although those times were not found to be statistically significant. A larger patient cohort would be required to assess the relationship between duration of the operation and the likelihood of a postoperative thrombosis.

In our series we found that all those who had a postoperative thrombosis underwent a translabyrinthine approach, whereas no patient undergoing a retrosigmoid or middle fossa approach developed the complication. Although our patient cohort was not large enough to make this finding significant, it may suggest that patients who undergo a translabyrinthine approach should be carefully assessed for clinical and radiologic signs of dural thrombosis in the postoperative period. It also suggests that adequate perioperative hydration, avoiding adjuncts that may contribute to dehydration such as mannitol and meticulous sinus handling (including minimal/intermittent retraction and regular inspection of the sinus to ensure it remains moist) intraoperatively are particularly important in the translabyrinthine approach. Covering the sigmoid and transverse sinus with a moist cottonoid with regular irrigation to avoid overheating beneath the intense microscope light is also recommended.

Although there was a trend toward shorter operating times with retrosigmoid or middle fossa approaches (a mean of ~ 7 hours) when compared with the translabyrinthine approach (a mean of 8.5 hours), this was not significant. This may reflect the small sample size in the retrosigmoid/middle fossa group. However, the size of the tumor was significantly smaller in those patients who underwent a retrosigmoid or middle fossa approach ($p < 0.02$), which may explain why these patients in our cohort were less likely to develop a thrombosis. In the translabyrinthine approach, the venous sinus is completely unroofed and often undergoes posterior retraction to widen up the presigmoid operative window, especially for larger tumors. It is thus not surprising that only the translabyrinthine patients developed thrombosis, particularly for the larger tumors.

In contrast, the retrosigmoid approach rarely requires complete uncovering of the whole sinus, and in addition, the sinus is generally not retracted. The potential area of injury in the retrosigmoid approach is if the mastoid emissary vein is overoccluded with a mass of Surgicel or Gelfoam, or the thrombus in this area potentially propagates into the sigmoid sinus. The middle fossa approach should not theoretically risk transverse sigmoid sinus thrombosis unless temporal lobe retraction caused a thrombosis in the vein of Labbé that propagated to the transverse sigmoid junction. Also, the middle and retrosigmoid approaches do not require the same degree of sinus exposure compared with the translabyrinthine approach, and the sinus is not subjected to the same degree of handling, retraction, and topical microscope light-source heat. Although our patients did not undergo a routine extended coagulation panel, patients with a known procoagulation profile may benefit from a retrosigmoid or middle fossa approach rather than a translabyrinthine approach.

Where the exposed sigmoid sinus is restricting the operative field during the translabyrinthine approach, fixed retraction of the sinus may be required, but great care was taken in our patients to minimize lumen narrowing of the sinus when this was done. We also recommend covering the exposed sinus with a moist linteen or cottonoid so that prolonged continuous heat emanating from the microscope light does not injure the sinus wall. None of these considerations pertain

to the retrosigmoid approach. Head elevation is a standard maneuver and may also decrease the pressure in the venous sinuses and predispose to stasis.

We also noted that a high proportion of patients (four of five) had right-sided dominance, which is in general agreement with the literature.^{20,21} This was not significantly different from those patients who did not have from a dural thrombosis. Based on the Ichijo et al²² classification of the morphology of the sigmoid sinus, we found that four of our patients had a sinus that protruded outward on the side of the operative lesion. Our study was unable to confirm this as a risk factor, but it has been suggested that a protrusive sinus type is more susceptible to injury.²

Management of Postoperative Dural Sinus Thrombosis

We have recommended 6 months of anticoagulation in patients with confirmed venous sinus thrombosis, which may seem excessive particularly when most patients with venous sinus thrombosis postresection of CPA tumors may be asymptomatic and are not currently screened by their neurosurgeons. The natural history of postoperative dural thrombosis is unknown, but Keiper et al⁹ suggest that it is not benign with five patients (~ 5% of their patient cohort) presenting with pseudotumor cerebri 1 to 35 days postoperatively. Three of five patients required surgical intervention to control symptoms of raised intracranial pressure and visual loss. Unfortunately, there was no comment as to whether they detected any asymptomatic thrombosis. A Cochrane review of patients with cerebral venous sinus thrombosis of varying etiology found that systemic anticoagulation had a nonsignificant absolute reduction in the risk of death and dependency of 13%, suggesting anticoagulation is a safe and effective treatment for this condition in general.³ Only one of our patients, who presented 5 weeks postoperatively, developed any symptoms from the thrombosis, and these improved on treatment. We strongly recommended anticoagulation because it appears safe, is the standard of treatment for nonsurgical dural sinus thrombosis, and importantly appears to be effective in preventing the development of pseudotumor cerebri.⁶

In those patients who become acutely symptomatic, treatment by endovascular clot retrieval, thrombolysis, or mechanical thrombectomy with balloon catheters can be considered.^{7,23} Similarly, if initial systemic anticoagulation fails to alleviate symptoms, particularly if the patient is deteriorating, mechanical or chemical thrombolysis would be a reasonable adjunct to systemic anticoagulation.⁶

Although intracranial hemorrhage is the most feared complication of systemic anticoagulation for postoperative sinus thrombosis, there is a small risk of extracerebral hemorrhage. In a Cochrane meta-analysis on the treatment of sinus thrombosis, an extracranial hemorrhage rate of 3% was noted.³ This emphasizes the importance of obtaining meticulous hemostasis before closure.

Conclusion

Thrombosis of the transverse and/or sigmoid sinuses occurring after intracranial surgery presents a serious dilemma for the

treating team. The risk of postoperative intracranial hemorrhage from the initiation of systemic anticoagulation must be weighed against the possibility of symptomatic thrombus propagation and subsequent neurologic deterioration if no treatment is instituted. Our data suggest that sigmoid and transverse sinus thrombosis is not uncommon following a translabyrinthine approach and can be detected in the early postoperative period by routine CT brain imaging as long as specific attention is paid to those sinuses on the operative side. Our study has found that patients with larger tumors are more likely to develop dural sinus thrombosis postoperatively. We would suggest that patients with larger tumors who have undergone extended surgical times by a translabyrinthine approach be carefully reviewed for sinus thrombosis in the early postoperative period. Our data further suggest that early postoperative initiation of systemic anticoagulation is safe and appears to be effective in the prevention of progression of thrombosis and symptom development.

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