Dural sinus thrombosis and pseudotumor cerebri: unexpected complications of suboccipital craniotomy and translabyrinthine craniectomy

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Object. The goal of this study was to document the hazards associated with pseudotumor cerebri resulting from transverse sinus thrombosis after tumor resection. Dural sinus thrombosis is a rare and potentially serious complication of suboccipital craniotomy and translabyrinthine craniectomy. Pseudotumor cerebri may occur when venous hypertension develops secondary to outflow obstruction. Previous research indicates that occlusion of a single transverse sinus is well tolerated when the contralateral sinus remains patent.

Methods. The authors report the results in five of a total of 107 patients who underwent suboccipital craniotomy or translabyrinthine craniectomy for resection of a tumor. Postoperatively, these patients developed headache, visual obscuration, and florid papilledema as a result of increased intracranial pressure (ICP). In each patient, the transverse sinus on the treated side was thrombosed; patency of the contralateral sinus was confirmed on magnetic resonance (MR) imaging. Four patients required lumboperitoneal or ventriculoperitoneal shunts and one required medical treatment for increased ICP. All five patients regained their baseline neurological function after treatment. Techniques used to avoid thrombosis during surgery are discussed.

Conclusions. First, the status of the transverse and sigmoid sinuses should be documented using MR venography before patients undergo posterior fossa surgery. Second, thrombosis of a transverse or sigmoid sinus may not be tolerated even if the sinus is nondominant; vision-threatening pseudotumor cerebri may result. Third, MR venography is a reliable, noninvasive means of evaluating the venous sinuses. Fourth, if the diagnosis is made shortly after thrombosis, then direct endovascular thrombolysis with urokinase may be a therapeutic option. If the presentation is delayed, then ophthalmological complications of pseudotumor cerebri can be avoided by administration of a combination of acetazolamide, dexamethasone, lumbar puncture, and possibly lumboperitoneal shunt placement.

KEY WORDS - suboccipital craniotomy • translabyrinthine craniectomy • transverse sinus thrombosis • pseudotumor cerebri • magnetic resonance venography • endovascular thrombolysis • lumboperitoneal shunt

Durational sinus thrombosis is a rare and potentially serious condition. Its pathogenesis is associated with several clinical conditions, including infection accompanied by thrombophlebitis, hematological disorders, disseminated malignancy, tumor compression, dehydration, trauma, use of contraceptive medications, arteriovenous malformations with shunt placement, and intracranial surgery. Venous hypertension is a result of venous outflow obstruction and is the cause of pseudotumor cerebri. Adverse effects of the increased intracranial pressure (ICP) include headache, visual obscuration, and blindness.

Transverse and sigmoid sinus occlusions are usually asymptomatic, particularly when the affected sinus is nondominant or when collateral circulation is rich. In our series, we document the potential hazards of pseudotumor cerebri caused by transverse sinus thrombosis when the contralateral sinus is patent. Ophthalmological complications are avoided with treatment, including direct endovascular thrombolysis of the clot; administration of steroid; carbonic anhydrase inhibiting; diuretic medications, and lumboperitoneal shunt placement. We present the results in five patients who developed pseudotumor cerebri after undergoing suboccipital craniotomy or translabyrinthine craniectomy for tumor resection. We also discuss the radiographic findings, treatment, and prevention of secondary pseudotumor cerebri.

Clinical Material and Methods

Initial Surgery

Between 1991 and 1995, 107 patients underwent suboccipital craniotomy or translabyrinthine craniectomy at our institution. Five patients developed secondary pseudotumor cerebri from unilateral transverse sinus thrombosis; their demographic characteristics and clinical course are summarized in Table 1. Each patient underwent preopera-
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Illustrative Case

This 43-year-old man (Case 5) presented with a 6-month history of progressive hearing loss. He underwent MR imaging that revealed a 2.5-cm left-sided acoustic neuroma, which was resected via a translabyrinthine craniectomy. The jugular bulb was exposed and patency was preserved. Three weeks postsurgery the patient reported headache, nausea, vomiting, and fullness of the skin flap overlying the operative site. Funduscopic examination revealed bilateral papilledema. Computerized tomography (CT) scanning demonstrated fluid under the flap but no hydrocephalus. Magnetic resonance venography demonstrated fluid under the flap but no hydrocephalus. Magnetic resonance venography demonstrated fluid under the flap but no hydrocephalus.

Acetazolamide therapy was initiated, and the patient’s headaches and nausea resolved over the next month; however, the skin flap remained full and his vision deteriorated. Repeated lumbar punctures were performed with opening pressures of 40 cm H2O. Neuroophthalmologic evaluation revealed 20/50 visual acuity in the right eye and 20/30 in the left. No afferent pupillary defect was present. Visual field testing revealed moderate enlargement of both blind spots, and papilledema was present bilaterally. Despite treatment with acetazolamide and lumbar punctures, the patient did not improve.

The patient then underwent unsuccessful balloon angioplasty of the stenotic segment of the left-sided transverse sinus. The pressure gradient between the proximal left-sided transverse sinus and the left-sided jugular bulb was 24 mm Hg, which indicated a significant stenosis; after repeated dilations, the difference decreased to 14 mm Hg. After balloon dilation, MR venography demonstrated persistence of the narrowed segment. Placement of a stent to dilate this segment was unsuccessful. The patient remained symptomatic and underwent placement of a lumboperitoneal shunt, after which all symptoms resolved.

Results

All five patients presented with headache and visual obscuration. They suffered from papilledema and active retinal hemorrhage, and eye examinations demonstrated visual field deficits and significant esotropia. The cerebrospinal fluid (CSF) pressure on lumbar puncture was 33 and 40 cm H2O in the patients in Cases 3 and 5, respectively.

Radiological Evaluation

Preoperative MR studies demonstrated the mass (that is, acoustic neuroma, meningioma) and bilateral patency of the transverse and sigmoid sinuses. Retrospective review of the MR images, with close attention to the venous outflow, revealed right side–dominant transverse and sigmoid sinuses in Cases 1 to 3. In each of these patients, the right side was also the occluded and surgically treated side. Although the patients in Cases 4 and 5 did not have a dominant drainage pattern, there was moderate narrowing of the proximal sigmoid and transverse sinuses, respectively, on the right side, which was opposite the occlusion. Each patient underwent CT scanning on postoperative Day 1. In one of the five patients (Case 2) evidence of right transverse sinus occlusion was demonstrated (Fig. 1 left). A study obtained in a second patient (Case 3) demonstrated occlusion of the transverse sinus 6 weeks postsurgery.

After they manifested symptoms and signs of elevated ICP, all patients underwent MR imaging (Figs. 1 right, 2, and 3) and the patients in Cases 2 (Fig. 4), 4, and 5 underwent MR venography. Thrombosis of the transverse and sigmoid sinuses was demonstrated in all patients, except Case 5, in whom MR venography images demonstrated stenosis of the distal transverse sinus.

Treatment and Clinical Outcome

All patients were treated initially with acetazolamide (500 mg twice/day), dexamethasone (2–4 mg every 6 hours), and naproxen, which provided symptomatic relief. The patients in Cases 2 and 5 required periodic lumbar punctures and underwent lumboperitoneal shunt placement 6 weeks after the initial surgery. The patient in Case 3 underwent emergency lumboperitoneal shunt placement.
because of papilledema and visual loss. The patient in Case 4 was treated only with acetazolamide, dexamethasone, and naproxen therapy. Symptoms resolved in all five patients, and results of ophthalmological examinations returned to normal, as did their vision.

**Discussion**

Current teaching implies that unilateral thrombosis or sacrifice of a transverse sinus is tolerated when the contralateral sinus is patent. In this study, five patients developed pseudotumor cerebri secondary to unilateral thrombosis or stenosis of a transverse sinus after undergoing a suboccipital craniotomy or translabyrinthine craniectomy for resection of a tumor. The prevalence and morbidity of transverse sinus occlusion and pseudotumor cerebri can be minimized with thorough preoperative evaluation and imaging, surgical techniques directed to prevent sinus occlusion, and rapid treatment if pseudotumor develops.

**Preoperative Evaluation**

The presence of medical risk factors such as protein C and S deficiencies, diabetes mellitus, systemic lupus erythematosus, pregnancy, puerperium, use of oral contraceptives, and Behçet’s disease, should be determined before surgery. These conditions may give rise to a hypercoagulable state, which increases the risk of cerebral sinus thrombosis. Preoperative evaluation should also be carefully evaluated using preoperative neuroimaging studies. Most patients undergo MR imaging, from which information can be obtained concerning sinus patency. The torcular herophili, or confluence of the sinuses, is the variable dilation of the superior sagittal sinus (SSS). The right transverse sinus, which is usually the dominant sinus, drains the SSS. However, Zouaoui and Hidden found in their study of sinus anatomy that the right transverse sinus was dominant 51% of the time and that a partial or total agenesis of one transverse or sigmoid sinus existed in 19.6% of their cases. Although it would be valuable to determine the sinus anatomy by using preoperative MR venography, the low incidence (4.6%) of this complication does not warrant the added expense. However, we do advocate pre-
operative MR venography in planning skull base procedures involving the sigmoid sinus. Significant variations in sinus anatomy should prompt the surgeon to consider the possible consequences of an occlusion.

Radiological Investigation

Although dural sinus thrombosis is best diagnosed using digital subtraction angiography, noninvasive imaging techniques are desirable. Findings on CT scans that are suggestive of dural sinus thrombosis include: high-density clots in cortical veins (cord sign),\textsuperscript{10} in the dural sinuses (dense vein sign),\textsuperscript{6} or in the torcular herophili in cases of SSS thrombosis (delta sign);\textsuperscript{27} filling defects in the SSS after administration of iodinated contrast enhancement (empty delta sign) in cases of SSS thrombosis;\textsuperscript{27} and secondary signs such as congested cortical veins, tentorial or gyral enhancement, and white matter edema.\textsuperscript{1,14,24}

In the patients in Cases 2 and 3 the CT findings were consistent with the dense vein sign, indicating a thrombus in the right transverse sinus. The thrombus was present on the postoperative scan obtained on Day 1 in Case 2 and on a scan obtained 6 weeks postsurgery in Case 3 when symptoms continued that were consistent with increased ICP.

Magnetic resonance images obtained with spin-echo, gradient-echo, and MR angiography techniques provide noninvasive, direct visualization of the dural sinuses and can be used to assess sinus flow abnormalities.\textsuperscript{17,26} The thrombus within a sinus emits a variable signal intensity on MR imaging that varies with clot age. Acute-stage blood clot (deoxyhemoglobin) is usually displayed as isointense on T\textsubscript{1}-weighted spin-echo images and hypointense on T\textsubscript{2}-weighted images. As the clot ages and methemoglobin forms, the signal intensity of blood increases, first on T\textsubscript{1}-weighted and later on T\textsubscript{2}-weighted images.\textsuperscript{11} However, other causes of increased signal within a sinus that simulate a blood clot must be excluded, including turbulent or slow flow, flow entry phenomena, even echo rephasing, and flow compensation techniques.\textsuperscript{4,13} These factors can be excluded using multiplane imaging and flow-enhancing gradient-echo techniques (including MR angiography) along with the routine spin-echo images.\textsuperscript{13,19,24} The combined MR and angiography studies are sufficient, and they obviate the need for conventional techniques.

Treatment and Outcome

The clinical course of pseudotumor cerebri ranges from benign and self-limiting to progressive with severe headaches and permanent visual loss.\textsuperscript{8} Intracranial hypertension decreases after medical treatment with acetazolamide, which is a carbonic anhydrase inhibitor that decreases the rate of CSF production.\textsuperscript{16} Once venous return from the retina and optic nerve head is unopposed, papilledema and visual symptoms resolve. Immediate relief of symptoms can be achieved using nonsteroidal antiinflammatory drugs, dexamethasone, and lumbar puncture.\textsuperscript{8} If the patient cannot be weaned from acetazolamide therapy and requires repeated lumbar punctures, then a lumbo-peritoneal shunt may be necessary.

Direct endovascular thrombolytic therapy is a safe and effective treatment for dural sinus thrombosis.\textsuperscript{2,25} In this technique a transjugular route and direct infusion of urokinase to the clot are used, avoiding the hazards of systemic anticoagulation and open craniotomy. Although this technique was not used in our patients, it might have been effective for the patients in Cases 2 and 4, because the transverse sinus thrombosis was diagnosed in the immediate postoperative period, and the sinus was not open during surgery. An acute-stage, loosely organized clot may be amenable to thrombolysis.

The patient in Case 5 underwent unsuccessful balloon angioplasty and attempted stent placement approximately 4 months after the initial surgery. Patients who present...
with pseudotumor cerebri later than the immediate postoperative period are not good candidates for endovascular therapy and should undergo shunt placement. In our experience, clots that are well organized are not easily manipulated. In this patient population, the risk of rupturing a sinus far outweighs the risk associated with lumboperitoneal shunt placement, which, in our experience, can be effective in the treatment of pseudotumor.

**Prevention of Sinus Thrombosis**

In addition to the previously mentioned clinical conditions, several intraoperative factors predispose a patient to sinus thrombosis. The following precautions can minimize the incidence of sinus thrombosis and pseudotumor in these cases.

1) Mannitol and CSF drainage are used to decrease brain volume and minimize retraction. The use of agents that produce hyperosmolality has been associated with sinus thrombosis. Therefore, maintenance of adequate hydration is important when using these agents during surgery, especially if the patient has a condition that predisposes to a hypercoagulable state. Under these conditions the surgeon may choose spinal fluid drainage only and not administer mannitol.

2) Bone exposure must be limited to what is necessary for resection of the lesion. Overexposure of the sigmoid and transverse sinuses by removal of overlying bone leads to desiccation of the dura surrounding the sinus and then shrinkage or thrombosis. Overexposure of the sinuses contributed to the development of pseudotumor in the patient in Case 5, whose sinus became stenotic during surgery but remained patent.

3) Retraction against venous structures must be minimized because limitation of flow through a sinus may lead to venous stasis and thrombosis and, thus, to sinus occlusion. If retraction against a dural sinus must be used, then the retractor must be released periodically to restore flow through the vessel.

4) A dominant sinus should not be sacrificed. In some circumstances it may be necessary to sacrifice a nondominant sigmoid sinus. However, prior to this procedure the pressure should be measured by introducing a No. 25-gauge needle into the sinus and then measuring the pressure proximally before and after occlusion with a temporary clip. If the pressure rises by more than 10 mm Hg with temporary occlusion, then the sinus should be left intact. If the sigmoid sinus is sacrificed, it is imperative to preserve all other venous anatomy in the region, such as the vein of Labbé and petrosal and other smaller bridging veins. Collateral flow is thus preserved and venous congestion, which can lead to pseudotumor, is avoided.

**Conclusions**

In our series of five patients we document that the unilateral thrombosis of a transverse sinus is not always tolerated by the patient even if the sinus is nondominant and that vision-threatening pseudotumor cerebri may result. If suspected, thrombosis is diagnosed noninvasively on MR venography. If the diagnosis is made shortly after thrombosis, direct endovascular thrombolysis with urokinase should be the primary therapy. If the presentation and diagnosis are delayed, then ophthalmological complications of pseudotumor cerebri can be avoided by treating the patient with a combination of acetazolamide, dexamethasone, lumbar puncture, and possibly lumboperitoneal shunt placement.

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