Postoperative Radiographic Findings Following Acoustic Neuroma Removal

ABSTRACT—This paper assesses the radiographic findings seen on early postoperative CT following acoustic neuroma resection. CT head scans were routinely obtained from 86 patients within 24 hours of tumor resection via a translabyrinthine or retrosigmoid approach. Repeat CT scans were performed in those patients with abnormal clinical symptoms. The abnormalities seen on postoperative CT included cerebellar hematoma (nine patients), cerebral and/or cerebellar infarction (six patients), CSF leak at the incision (two patients), subdural hematoma (two patients), hydrocephalus (one patient), and residual acoustic neuroma (two patients). An unexpected CT finding was ipsilateral temporal lobe lucency, suggesting venous edema, ischemia, and/or infarction in 16% (14/86) of patients. Overall, the clinical complication rate was 8%, and subclinical CT abnormalities were seen in 17% of patients. Temporal lobe venous edema, ischemia, or infarction is a complication of translabyrinthine resection of acoustic neuroma, and is thought to be due to obstruction of an inferior temporal lobe draining vein. Some cases may be related to intraoperative interruption of the superior petrosal sinus or petrosal vein, and/or coagulation of the sigmoid sinus dural margins, interruption of an inferior temporal vein, or venous hypotension. Care in dealing with the superior petrosal and sigmoid sinuses at surgery is needed. (*Skull Base Surgery*, 6(4):199–205, 1996)

A variety of complications may accompany acoustic neuroma surgery.^{1–5} Our study was undertaken to determine whether routine immediate postoperative computed tomographic (CT) scanning of the head was necessary following the resection of acoustic neuromas. Retrospective review of a group of 86 patients included evaluation of CT scans routinely obtained in the first 24 hours following resection, and comparison with follow-up CT scans obtained in those with abnormal postsurgical symptoms in the first 1 to 3 weeks.

CT-documented abnormalities and clinical complications associated with acoustic neuroma surgery will be correlated. Posterior fossa venous anatomy may help to explain the unexpected cases of temporal lobe venous ischemia, infarction, and hemorrhage seen on CT following transtemporal approaches for acoustic neuroma removal.

MATERIALS AND METHODS

Between July 1988 and May 1994, 104 consecutive cases of acoustic neuroma were surgically removed through a variety of transtemporal approaches. Of these cases, our records were incomplete in 18 cases, and the remaining 86 cases were retrospectively reviewed (Table 1). CT head scans were routinely obtained within 24 hours of tumor resection utilizing a GE 9800 scanner, at 10 mm or 5 mm consecutive slice thickness. Repeat CT scans were performed in those with clinical symptoms up to 21 days later.

CT abnormalities were dated and tabulated for each case (Table 2) and summarized (Table 3), including grading of the size of postoperative cerebellar hematoma (Grade 1—small, Grade 2—moderate, Grade 3—large, Grade

Table 1. Surgical Approaches to Acoustic Neuroma Resection

<i>Surgical Approach</i>	<i>Total # of Patients</i>	<i># of Patients with a CT Abnormality</i>	<i># of Patients with Temporal Lobe Lucency</i>	<i># of Patients with Clinical Abnormality</i>
TLC	46	15	11	4
TLC-TC	15	3	2	3
TLC-TC-RS	3	2	2	0
TLC-RS	1	1	2	0
RS	21	2	0	0

TLC = Translabrynthine, TC = Transcochlear, RS = Retrosigmoid

4-rupture of blood into the fourth ventricle), hydrocephalus, subdural hematoma (SDH), cerebral and/or cerebellar infarction (CVA), temporal lobe lucency indicating edema, ischemia or infarction, and CSF leak. Treatment by shunts and drainage is listed. Subtotal resection, listed as a CT abnormality, was planned in two patients according to the patient's age and tumor size.

RESULTS

Twenty-three of the 86 patients (25%) demonstrated an abnormality on a postoperative CT scan (Tables 2, 3). CT visualization of cerebellar hematoma was seen in nine patients, cerebral and/or cerebellar infarct in six, CSF leak at the incision in two, SDH in two, and hydrocephalus in one patient. Clinical complications were seen in seven patients (8% of the total), including subcutaneous fluid from CSF leak at the wound in two patients (Fig. 1), cerebral and/or cerebellar infarction in four patients (Figs. 1, 2), low-density supratentorial SDH in two patients (Fig. 2), and a cerebellar hematoma causing hydrocephalus (Fig. 3). Four of these seven patients had more than one clinically significant abnormality.

On postoperative day one (POD #1), 11 of the 86 patients (13%) showed an abnormality (Table 3), three (3.5%) of which were clinically significant (one cerebellar hemorrhage, one cerebral infarction, and one CSF leak). None were reoperated in the first 24 hours postoperatively. The clinically significant cerebellar hematoma was associated with rupture of blood into the fourth ventricle and hydrocephalus requiring a shunt, performed on POD #2. In seven of the nine cases in which postoperative blood was seen in the tumor bed, cerebellopontine angle cistern (CPA), or cerebellar parenchyma on POD #1 CT scan, the volume of the subclinical hemorrhage was commensurately small. The early CSF leak at the incision was treated with lumbar drain on POD #4 due to progression of the fistula.

Twelve patients (14%) showed abnormality on the delayed CT scan alone (POD #2-16). Delayed clinical complications included one patient with a CSF leak at the wound noted on POD #14, which was treated with lumbar drain on POD #21, and two patients with SDHs noted on POD #14 and #16, one of whom was shunted on POD #21.

An unexpected CT finding of 14 of the 86 patients

(16%) was lucency, suggesting edema, ischemia, or infarction anterior to the petrous bone in the ipsilateral inferior temporal lobe. No retraction of the temporal lobe was performed intraoperatively. Of the 14 patients, 2 demonstrated temporal lobe lucency on POD #1, while 12 cases were seen on later CT scans. Three patients had clinical infarction of the ipsilateral temporal lobe (12 to 18 cm³): two had resection of the superior petrosal sinus and packing of the ipsilateral cavernous sinus due to intraoperative bleeding (one of whom had sacrifice of the petrosal vein) and the third had petrosal vein sacrifice alone. A total of five patients with temporal lobe lucency on CT had documented sacrifice of the superior petrosal sinus, but three did not show clinical infarction. One patient demonstrated a temporal lobe hematoma (7 cm³) on POD #1 which did not necessitate evacuation (Fig. 4). All 15 patients with temporal lobe abnormality on postoperative CT had a translabrynthine resection.

Overall, cerebral and/or cerebellar infarction was seen on CT in 6 of the 86 patients, 4 of whom had clinical symptoms of infarction—3 of which included the inferior left temporal lobe. Infarcted areas included the cerebellum (3 patients), temporal lobe (3 patients), occipital lobe (1 patient), and frontal lobe (1 patient), and 2 patients demonstrated more than one area of infarction. Most infarcts were not seen on POD #1 CT scan but were visualized in five of the six patients on scans repeated on POD #3 to #5 because of clinical symptoms. One patient with CVA seen on CT, not demonstrated clinically, was substantiated on a 1-year follow-up MRI scan. Two of the six patients had predisposing arterial vascular disease, including one patient with prior contralateral carotid endarterectomy and ipsilateral occluded common carotid artery experiencing a frontal infarct. The other patient had a history of idiopathic hypertrophic subaortic stenosis and cardiomyopathy, experienced intraoperative ventricular fibrillation and cardiac arrest, and was resuscitated. Subsequent cerebellar infarction was seen on CT but not noted clinically.

Subclinical CT findings seen in 11 asymptomatic patients included cerebellar infarction, temporal lobe lucency, temporal lobe intracerebral hematoma, and small areas of hemorrhage in cerebellar parenchyma and/or CPA. One of the asymptomatic patients showed a Grade 4 cerebellar parenchymal hemorrhage on CT (Fig. 3).

Of the 86 patients operated for acoustic neuroma, 21

Table 2. Patients' CT Findings and Treatment

Case	Surgery	Abnormal CT POD#1	Hematoma, Cerebellar	Hydrocephalus	Subdural Hematoma	Shunted	Temp. Lobe Lucency	CVA on CT	CSF Leak at Wound	Subtotal Resection
1. EV	TLC	Yes	POD#1 GR4	POD#1	—	POD#2	—	—	—	—
2. CS	TLC	No	—	—	POD#16 front, temp. parietal	POD#21	POD#6	—	—	—
3. JB	TLC	Yes	—	—	—	—	POD#3 small, POD#7 mod	—	—	—
4. SZ	TLC	Yes	POD#1 GR1	—	—	—	POD#5 small	—	—	—
5. MF	TLC	No	—	—	—	—	—	—	—	—
6. KT	TLC/TC/RS	Yes	POD#1 GR1	—	—	—	POD#5 mod	—	—	—
7. HC	TLC	No	—	—	—	—	POD#2 small	POD#1-occ/cerebellar,	—	—
8. WB	TLC/TC	Yes	—	—	—	—	POD#5 large	POD#5-temp.	—	—
9. JR	TLC	No	—	—	—	—	—	POD#5-cerebellar (not clinical)	—	—
10. DB	TLC	No	POD#2 GR2	—	—	—	POD#2 small to mod	—	—	—
11. NO	TLC	Yes	—	—	—	—	POD#1 GR2 temp. hematoma	—	—	—
12. AJ	TLC	No	—	—	—	—	POD#4 mod	POD#4 cerebellar peduncle, temp. (not clinical)	—	—
13. VP	TLC/TC	No	—	—	POD#14, bilat. temp. parietal, front	—	—	POD#14, lumbar drain on POD#21	—	—
14. AS	TLC	No	—	—	—	—	—	POD#3 front	—	—
15. GH	TLC/TC	Yes	POD#1 GR1	—	—	—	POD#4 mod	POD#4 temp	—	—
16. JM	LTC	Yes	—	—	—	—	POD#4 mod	POD#4 temp	POD#1, lumbar drain on POD#4	—
17. AC	TLC	No	POD#5 GR1	—	—	—	—	—	—	Yes
18. JD	TLC	No	—	—	—	—	POD#2 small	—	—	—
19. RH	RS	Yes	POD#1 GR1	—	—	—	—	—	—	—
20. TL	TLC/TC/RS	Yes	POD#1 GR1	—	—	—	POD#1 small to mod	—	—	—
21. EZ	TLC/RS	Yes	POD#1 GR1	—	—	—	POD#1 small	—	—	—
22. HF	TLC	No	—	—	—	—	POD#7 small	—	—	—
23. SC	RS	No	—	—	—	—	—	—	—	Yes

Temp. = Temporal; Occ. = Occipital; Front. = Frontal; Mod = Moderate; GR = Grade

Table 3. Early vs. Delayed CT Abnormalities

	Total # of Patients (out of 86)*	Abnormality Seen on POD#1 CT*	Abnormality Noted Only on Delayed CT*	# of Patients With Clinical Abnormality
CSF leak from incision	2	1	1	2
Cerebellar hematoma	9	7	2	1
Temporal lobe hematoma	1	1	—	—
Subdural hematoma	2	—	2	2
CVA	6	1	5	4
Temporal lobe lucency	14	2	12	3**
Hydrocephalus	1	1	—	1
Subtotal resection***	2	—	2	—
Total # of abnormal patients	23	11	12	7

*Some patients are listed in more than 1 category in the table; **Are included in the 4 patients with clinical infarction; ***Planned subtotal resection.

Figure 1. CT scan on POD #4 demonstrates a subcutaneous fluid collection at the wound (open arrow), and a lumbar drain was placed as treatment for this CSF leak. A 4 × 2 cm left temporal lobe lucency is compatible with cerebral infarction in this patient who experienced expressive aphasia noted on POD #3 following a translabyrinthine resection which included removal of the superior petrosal sinus, sacrifice of the petrosal vein, and packing of the ipsilateral cavernous sinus due to intraoperative bleeding.

(24%) had retrosigmoid resection alone and 76% had translabyrinthine approach—46 patients with translabyrinthine craniotomy (TLC) alone, and 19 patients with TLC combined with transcochlear (TC) and/or retrosigmoid (RS) approach (Table 1). Of the 23 patients with an abnormal postoperative CT, only 2 had RS approach alone, and 21 had translabyrinthine resection—15 with translabyrinthine craniotomy alone and 6 combined with transcochlear and/or RS. All seven of the patients who experienced a clinical complication, correlation of which was seen on CT, had a TLC resection.

One year follow-up MR scans were accessible in five patients whose early postoperative CT scans had shown temporal lobe lucency and two of whom had clinical infarction. Four of the five follow-up MR scans showed residual encephalomalacia.

DISCUSSION

Reported complications of acoustic neuroma surgery include facial nerve weakness, CSF leak, meningitis that may be associated with a CSF leak, injury to anterior inferior cerebellar artery (AICA), posterior fossa hemorrhage and hematoma at the CPA which may cause hydrocephalus due to fourth ventricular compression, cerebellar infarction, or edema. Other uncommon complications include late cerebellar abscess, supratentorial subcortical white matter hemorrhages, and incomplete tumor removal if the tumor is densely adherent to the AICA or to the brainstem.¹ Abnormalities seen on our postoperative CT scans included cerebellar hematoma, cerebral and/or cerebellar infarction, CSF leak at the incision, supratentorial SDH, hydrocephalus, residual acoustic neuroma, and unexpected temporal lobe venous ischemia.

Figure 2. Two weeks after translabyrinthine resection of a recurrent left acoustic neuroma, this patient developed right lower extremity weakness and foot drop. CT at POD #16 showed: A: left ventricular compression and midline shift to the right by a chronic left frontal and temporal SDH (arrow), subsequently evacuated on POD #21, and B: left temporal lobe lucencies (curved arrows) not present on POD #1, compatible with edema, ischemia, or infarction, in this patient in whom the superior petrosal sinus had been removed, and a rent in the sigmoid sinus was tamponaded with oxidized regenerated cellulose.

Figure 3. Noncontrast CT on POD #1 shows: A: Blood at the CPA cistern cerebellar parenchyma, and within the fourth ventricle (arrow A) which is shifted to the left and compressed, and B: dilataion of the temporal horns of the lateral ventricles and cerebellar hemorrhage.

Figure 4. Routine CT scan on POD #1 after trans-labyrinthine resection of a right acoustic neuroma shows an asymptomatic 2 cm right temporal lobe intracerebral hematoma (arrow). Incidental left cerebellar arachnoid cyst.

Clinically significant CT abnormality was seen in 8% of patients overall; in 3% of patients on POD #1. Abnormalities demonstrated on the POD #1 CT scans included seven cases of blood in the posterior fossa (some may have been blood mixed with oxidized regenerated cellulose packing) and only one of these abnormalities was clinically significant, causing hydrocephalus. None of the patients were reoperated on POD #1. Clinically significant CT abnormalities were seen in 5% to 6% of patients on delayed scans: POD #3 to #16. Many of the CT abnormalities—such as infarcts, SDH, and CSF leak at the incision—were visualized only on delayed scans performed due to clinical symptoms.

We have shown CT evidence of temporal lobe venous ischemia following trans-labyrinthine resection of acoustic neuroma in 22% (14/65) of those who had a trans-labyrinthine approach, accounting for 16% (14/86) of our total group of acoustic neuroma cases resected by various approaches. Temporal lobe hemorrhage (7 cm³) was seen in one patient, and may have been an asymptomatic hemorrhagic venous infarct. There is a greater reported incidence of hematoma in venous occlusion than in arterial occlusion.⁶ Of the 15 patients exhibiting CT abnormality in the temporal lobe, 3 had clinical left temporal lobe infarction. These temporal lobe clinical infarcts were seen in two patients with resection of the superior petrosal sinus and migration of packing material

into the ipsilateral cavernous sinus due to intraoperative bleeding, one of whom had sacrifice of the petrosal vein, and in the third patient in whom the petrosal vein alone was sacrificed. The onset and severity of clinical symptoms is usually milder in venous occlusive disease than in arterial occlusions, and the symptoms are often reversible if venous drainage is restored.⁶ The neurologic deficits in our three patients with temporal lobe infarcts resolved within 7 days. The etiology of the postoperative temporal lobe ischemia, infarction, and hemorrhage, limited to cases of trans-labyrinthine resection, lies in the venous anatomy.

The trans-labyrinthine approach, the most direct route to the CPA, allows wide opening of the internal auditory canal (IAC) for complete gross tumor removal and early identification of the facial nerve at the lateral limit of the IAC, with little or no cerebellar retraction.^{4,5,7} Indications for trans-labyrinthine resection are lesions of the IAC and CPA which are not amenable to hearing preservation, or intracanalicular tumors without serviceable hearing. TLC is rarely used to remove small neoplasms of the IAC or CPA where hearing can be preserved. In these cases an RS or suboccipital approach would be performed.² Most acoustic neuromas can be removed by TLC regardless of size; however, the occasional large tumor may require a combined trans-labyrinthine RS approach or addition of a TC approach if there is anterior extension of the tumor.⁸ Improved exposure of the CPA during TLC has been obtained by resection of the superior petrosal sinus and its adjacent dura in some cases.⁹

Explanation of inferior temporal lobe venous ischemia requires review of the venous drainage (Fig. 5). The superficial inferior veins drain the lower lateral surface of the brain and the inferior surfaces of the temporal and occipital lobes.¹⁰ The veins of the inferior surface of the temporal lobes, including but not limited to the middle meningeal veins, drain into the superior petrosal sinus, transverse sinus, petrosal vein, and basal vein.¹¹ Interruption of the superior petrosal sinus or petrosal vein, or perioperative venous stasis in the lateral mesencephalic or petrosal veins with subsequent stasis in the superior petrosal sinus, could potentially cause venous ischemia or infarction in the temporal lobe and/or cerebellum.

The superior petrosal sinus lies within the tentorial attachment to the superior border of the petrous bone. The sinus passes backward laterally and upward from the petrous apex to connect the posterior cavernous sinus with the junction of the sigmoid and transverse sinuses. The direction of flow in the superior petrosal sinus is probably anterior, and the major contribution is from the lateral mesencephalic vein, along with contributions from the petrosal vein, inferior cerebral veins, cerebellar veins, and veins from the tympanic cavity.¹⁰

The inferior surface of the cerebral hemisphere gives branches to the petrosal vein (whose other tributaries are the pontine venous plexus and veins of the anterior cere-

Figure 5. Venous drainage patterns and anastomoses.

bellar hemisphere).¹¹ The lateral mesencephalic vein may drain downward to empty into the petrosal vein or upward to join the basal vein. A prominent anastomotic lateral mesencephalic vein may unite the basal vein with the superior petrosal sinus.¹⁰

In an acoustic neuroma of the CPA, there is usually marked stretching of the stem of the petrosal vein over the posterior aspect of the tumor.¹⁰ The veins that converge at the stem of the petrosal vein from the cerebellar hemisphere are displaced backward. When the tumor is large and extends upward, the peduncular and lateral mesencephalic veins may be elevated and displaced medially.

To avoid temporal lobe ischemia, infarction, or hemorrhage during TLC, care must be taken regarding the petrosal vein, and resection of the superior petrosal sinus should be performed only if essential. Routine MR scans in normal individuals frequently show a vein crossing just above the petrous ridge spanning the temporal lobe and the cerebellum (Fig. 6) which could be interrupted during TLC, particularly if there is resection of the superior petrosal sinus or ablation of its dural margins. During TLC, bipolar coagulation along the dura of the superior petrosal and sigmoid sinuses could contribute to venous stasis. The vein of Labbé may provide venous drainage from the temporal lobe to the contralateral side if the superior petrosal sinus and the sigmoid sinus were obliterated.

CONCLUSION

We have demonstrated an unexpected radiographic occurrence of ipsilateral temporal lobe venous ischemia, infarction, and hemorrhage following TLC resection of acoustic neuroma, in some cases possibly related to sacrifice of the superior petrosal sinus and/or petrosal veins, and some with packing of the cavernous sinus. Other cases of venous temporal lobe ischemia occurred without sacrifice of those vessels and may be related to perioperative venous stasis, perhaps due to edema at the operative site or bipolar coagulation of the dural margins of the superior petrosal or sigmoid sinuses. Potentially, direct

Figure 6. Axial proton density MR scan in a normal nonoperated patient shows an inferior temporal lobe vein (arrow) and a cerebellar vein (curved arrow) crossing the petrous ridge.

interruption of an inferior temporal lobe/cerebellar vein crossing the petrous ridge may occur.

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