

# Sudden Death Due to Vestibular Schwannoma: Caution in Emergent Management

\*Aydin Mohammadi and \*†Nicholas Jufas

\*Kolling Deafness Research Centre, University of Sydney and Macquarie University; and †Discipline of Surgery, Sydney Medical School, University of Sydney, Sydney, NSW, Australia

**Objective:** To enhance understanding of the possible dangers of large vestibular schwannomas and their potential to cause sudden death through rare situations such as brain herniation precipitated by cerebrospinal fluid pressure shifts.

**Patient:** An otherwise healthy 32-year-old woman with a magnetic resonance imaging demonstrating a cystic cerebellopontine angle mass, presumptive for vestibular schwannoma, experienced sudden onset of headaches, nausea, and vomiting.

**Intervention:** The patient was admitted to the intensive care unit, started on anticonvulsants, investigated with serial computed tomography (CT) scans, and then elective intubation and ventriculostomy when her condition worsened.

**Main Outcome Measure(s):** Clinical and radiological findings, as well as outcome of interventions.

**Results:** In the first hours of admission, the patient underwent serial CT scans that demonstrated fourth ventricle compression and hydrocephalus. When the patient's con-

dition worsened, elective intubation was undertaken and an external ventricular drain was inserted. Very high intracranial pressures were noted despite cerebrospinal fluid drainage. Postoperative CT and magnetic resonance imaging demonstrated ascending transtentorial and tonsillar herniation as well as scattered cortical infarcts. Brain death was determined and care was withdrawn 5 days later.

**Conclusion:** This is a very rare patient report of sudden death caused by a large vestibular schwannoma despite assertive emergent management. There was no intratumoral or intracranial haemorrhage. Brain death was likely a result of ascending transtentorial herniation that can occur with large posterior fossa tumors and be exacerbated by cerebrospinal fluid shifts after ventriculostomy. **Key Words:** Acoustic—Brain death—Hydrocephalus—Intracranial hypertension—Neuroma—Ventriculostomy.

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Vestibular schwannomas (VSs) are benign nerve sheath tumors that constitute approximately 10% of all nonmalignant primary intracranial tumors and around 90% of all cerebellopontine angle lesions (1). Surgical treatment now carries mortality rates that are around 1% or less (1,2).

Death is an extremely rare outcome of VS in its preoperative state. Intratumoral haemorrhage should be suspected when sudden neurological deterioration occurs in a patient awaiting definitive management. This has been reported and although rare, is associated with use of anticoagulants and/or trauma (3). Death despite optimal treatment has only been reported in two patients (4,5).

Hydrocephalus and intracranial hypertension caused by a VS is much more likely with a larger tumor size. In the absence of an acute bleed, these conditions typically develop insidiously and can either be addressed before or in conjunction with definitive surgery (6,7).

Death caused by sequelae of intracranial hypertension in the absence of an acute bleed in VSs is an extremely rare occurrence and not well reported. This article reports the sudden death of a 32-year-old woman 10 days after initial presentation and presumptive diagnosis of a VS, and less than 12 hours after deterioration of her previously stable condition. A precipitous decline occurred after placement of a ventriculoperitoneal shunt.

The objective of this report is to heighten awareness of rare but possibly serious sequelae of VSs, to alert clinicians to the indicators of these and to suggest management options should they be encountered.

## METHODS AND RESULTS (PATIENT REPORT)

A previously healthy 32-year-old woman was referred for right-sided progressive hearing loss. She reported mild disequilibrium, altered sensation of the ipsilateral face, and altered taste over the ipsilateral tongue for the past 2 weeks.

Cranial nerve examination was normal except for decreased sensation in all trigeminal nerve branches on the right and audiometric confirmation of a dead right ear. Fine horizontal left nystagmus was present when

Address correspondence and reprint requests to Dr. Nicholas Jufas, B.Sc., M.B.B.S., F.R.A.C.S., M.S., Kolling Deafness Research Centre, Kolling Building, Royal North Shore Hospital, St Leonards, NSW 2065, Australia; E-mail: drnicholasjufas@gmail.com

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**FIG. 1.** Axial T2-weighted MRI scan, providing radiological confirmation of the clinical diagnosis of right-sided CPA mass lesion. The lesion displays imaging features characteristic for a cystic vestibular schwannoma. CPA indicates cerebellopontine angle; MRI, magnetic resonance imaging.

looking left, as well as a coarse, jerking right nystagmus when looking right. Known as Bruns' nystagmus, it is associated with larger tumor size, generally greater than 35 mm (8). There was no gross ataxia present.

Magnetic resonance imaging (MRI) was expedited for the patient and was performed 5 days after initial review. It demonstrated a large 40-mm cystic cerebellopontine angle tumor on the right, presumed to be a VS. There was associated mass effect on the brainstem and fourth ventricle without radiological evidence of hydrocephalus (Fig. 1). Urgent planning for definitive surgical management was instituted. The remainder of the patient report has been compiled from review of admission and inpatient notes and reports.

Five days after her initial MRI, the patient reported a sudden onset of severe right-sided headaches and nausea, blurred vision, and a brief loss of consciousness for several seconds. She was retrieved by ambulance to a tertiary referral hospital. On admission she experienced several episodes of apparent seizure activity that involved extensor posturing and grossly abnormal eye movements, lasting for approximately 30 seconds.

She was started on intravenous phenytoin and levetiracetam for seizure prophylaxis, 6-hourly dexamethasone and admitted to an intensive care unit.

Within 1 hour after admission, a computed tomography (CT) scan of the brain was performed demonstrating some dilation of the third and lateral ventricles, indicative of mild hydrocephalus, although there was no evidence of transependymal oedema. There was no evidence of an intratumoral bleed and gray-white matter differentiation was preserved.

Almost 5 hours after this scan, the patient experienced a further episode of posturing, associated with unresponsiveness for several minutes, bradycardia to 50 bpm and bilaterally dilated pupils. After this she returned to being awake and alert, with pupils equal and reactive to light and no bradycardia.

Two hours later, she underwent a second CT brain scan, which was essentially unchanged. Within 1 hour of this second scan, the patient experienced further episodes of posturing with frequency increasing every 30 minutes, each time recovering to baseline. As a result, a decision was made by treating teams to electively intubate the patient in preparation for insertion of an external ventricular drain (EVD). Immediately prior the patient was alert, conscious, and able to provide surgical consent.

The patient taken to the operative room and underwent craniotomy at Kocher's point on the right and EVD insertion. Cerebrospinal fluid (CSF) was noted to be under high pressure with 15 ml drained. Postprocedure the patient had bilateral dilated and nonreactive pupils. The drain was opened with further rapid drainage of 15 ml of CSF and no change in the status for the patient. The patient was not hypotensive or bradycardic at any point with heart rate above 60 bpm and mean arterial pressure above 90 mm Hg.

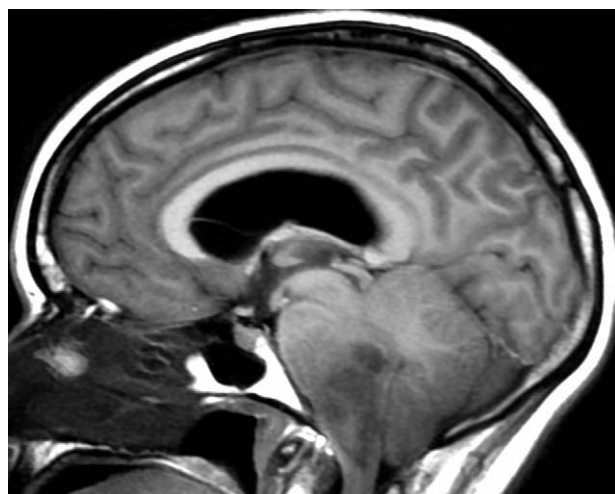
Within an hour postprocedure, the patient underwent a third CT brain scan. Although the ventricular drain was patent, there was evidence of diffuse cerebral oedema, loss of gray-white matter differentiation, and effacement of cisterns and residual subarachnoid spaces.

An MRI scan was performed soon after this, which showed T2/FLAIR hyperintensity correlating with ill-defined areas of diffusion restriction involving the cerebral hemispheres and brain stem bilaterally. There was ascending transtentorial herniation with effacement of interpeduncular and quadrigeminal cisterns and widespread sulcal effacement. There was also tonsillar herniation below the foramen magnum by approximately 6 mm (Fig. 2).

Multispecialty input suggested an unsurvivable neurological insult, supported by four vessel cerebral angiogram demonstrating patent flow in only one vertebral artery. Life support was withdrawn after discussion with patient's family, who were fully supportive of organ donation.

## DISCUSSION

Vestibular schwannomas are benign tumors that can potentially be life-threatening because of their location in the cerebellopontine angle and insidious growth. Increased detection of smaller tumors has meant that it



**FIG. 2.** Midline sagittal T1-weighted fluid-attenuated inversion recovery MRI scan performed 6 hours after insertion of EVD. There is effacement of the interpeduncular and quadrigeminal cisterns, upward displacement of the midbrain, and widespread sulcal effacement. EVD indicates external ventricular drain.

is now unusual for VSs to present when large and requiring urgent resection (9).

Even when patients present with large and/or cystic tumors, their management is typically urgent rather than emergent (10). When raised intracranial pressure or hydrocephalus dictates more emergent management, staged resection of the tumor up to 2 weeks from the establishment of ventricular drainage has afforded acceptable surgical results with no mortality or morbidity as a direct result (2).

Most contemporary treatment algorithms now delay surgery for ventricular drainage in the presence of significant hydrocephalus until after tumor excision, and often find that it is not necessary at all (6,7).

In this patient, although symptoms of raised intracranial pressure were present, hydrocephalus was not present on radiological imaging initially and when admitted to hospital could only be classified as mild. Although pharmacological seizure prophylaxis was instituted as

recommended (11), seizure activity rarely occurs in patients with infratentorial tumors, even large ones (12). It is more likely that the documented episodes were related to intracranial pressure waves, which includes worsening headache, decerebrate posturing, pupillary changes, and bradycardia (13).

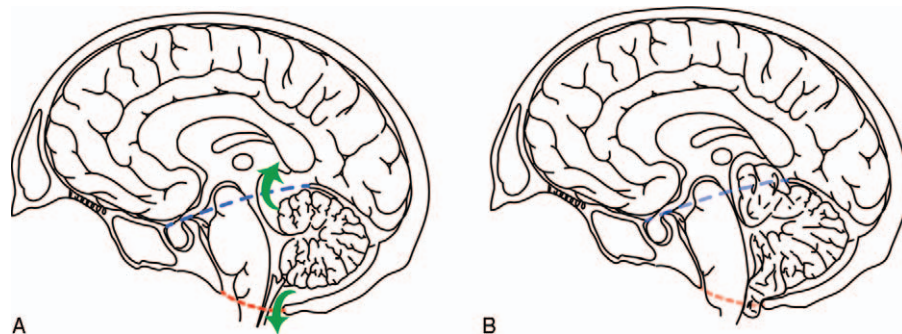
Unlike most patient reports of acute neurological decline in patients with known VSs, no intratumoral or intracranial hemorrhage was evident on any of the scans performed. Prompt and appropriate medical and surgical interventions for raised intracranial pressure were instituted and maintained as dictated by the patient's presentation and according to established guidelines and protocols (14).

A unique and unusual feature of this case is that the symptoms of intracranial hypertension appeared suddenly and spontaneously, and the patient experienced a precipitous decline despite optimal medical treatment. This may be an indicator of increased risk if a decision is made to proceed to surgical intervention urgently.

Although this case held a number of critical time points, the most significant juncture seems to be when an EVD was placed. It was at this point that an irreversible neurological decline seems to have occurred, likely because of sudden shift in cerebrospinal fluid pressure gradient precipitating ascending transtentorial herniation.

Herniation occurs when the brain tissue shifts into other intracranial compartments as a result of pressure gradients. Ascending transtentorial herniation was first described in specific detail in 1947 (15). Also known as "reverse coning," this is uniquely observed in posterior fossa tumors. Although cerebellum and brainstem herniate caudally initially, in later stages, the herniation progresses upward through the incisura tentoria (Fig. 3). This can be precipitated by ventriculostomy because of the pressure gradient created by draining supratentorial CSF (16–18).

The first report of the syndrome in 1948 describes a case in a patient with a large VS who died after ventriculostomy was performed (15). In a later literature review, at least four cases of ascending transtentorial herniation identified in the literature were because of VS,



**FIG. 3.** Midline sagittal section of brain as a pictorial representation of ascending transtentorial herniation: *A*, normal anatomy, arrows indicate direction of herniation through the free margin of the tentorium (*blue line*, upper; see online version for color) and foramen magnum (*red line*, lower; see online version for color); *B*, depiction postherniation—note herniation of cerebellum upward through the incisura tentorii, the tonsils herniating downward through the foramen magnum and the brainstem compressed forward against the clivus. Adapted from Cuneo et al. (19).

with 25% of cases overall occurring in the context of ventricular drainage (19).

### CONCLUSION

Although VSs generally carry a good prognosis, this case demonstrates that adverse events, even in the absence of haemorrhagic transformation, are possible and can rapidly lead to death. Clinicians managing patients with VSs should be cognizant of this potential risk, particularly with very large posterior fossa tumors.

VSs also have the capacity to cause significant intracranial hypertension and/or hydrocephalus that may trigger emergent management. This may involve ventriculostomy as a first-line surgical measure. Although this helps to reduce intracranial pressure and allow monitoring acutely, it may also precipitate ascending transtentorial herniation syndrome. This syndrome has also been shown to develop spontaneously without a triggering event.

In the presence of a known large posterior fossa mass, decompressive craniotomy should be anticipated if a ventriculostomy is to be undertaken for deterioration because of raised intracranial pressure or hydrocephalus (17,20). An alternative may be to proceed to emergent tumor resection first, reserving the placement of a ventriculostomy drain if required after pressure in the posterior fossa is reduced as recommended for routine urgent management. Ultimately, it can only be theorized whether modification of this patient's management would have resulted in a better outcome.

### REFERENCES

1. Samii M, Matthies C. Management of 1000 vestibular schwannomas (acoustic neuromas): Surgical management and results with an emphasis on complications and how to avoid them. *Neurosurgery* 1997;40:11–21.
2. Talfer S, Dutertre G, Conessa C, Desgeorges M, Poncet J-L. Surgical treatment of large vestibular schwannomas (stages III and IV). *Eur Ann Otorhinolaryngol Head Neck Dis* 2010;127:63–9.
3. Niknafs YS, Wang AC, Than KD, Etame AB, Thompson BG, Sullivan SE. Hemorrhagic vestibular schwannoma: Review of the literature. *World Neurosurg* 2014;82:751–6.
4. Yates CW, Weinberg M, Packer MJ, Jacob A. Fatal case of tumor-associated hemorrhage in a large vestibular schwannoma. *Ann Otol Rhinol Laryngol* 2010;119:402–5.
5. Misra BK, Rout D, Bhiladvala DB, Radhakrishnan V. Spontaneous haemorrhage in acoustic neurinomas. *Br J Neurosurg* 1995;9:219–22.
6. Atlas MD, Perez de Tagle JRV, Cook JA, Sheehy JP, Fagan PA. Evolution of the management of hydrocephalus associated with acoustic neuroma. *Laryngoscope* 1996;106:204–6.
7. Pirouzmand F, Tator CH, Rutka J. Management of hydrocephalus associated with vestibular schwannoma and other cerebellopontine angle tumors. *Neurosurgery* 2001;48:1246–53.
8. Lloyd SKW, Baguley DM, Butler K, Donnelly N, Moffat DA. Bruns' nystagmus in patients with vestibular schwannoma. *Otol Neurotol* 2009;30:625–8.
9. Hughes M, Skilbeck C, Saeed S, Bradford R. Expectant management of vestibular schwannoma: A retrospective multivariate analysis of tumor growth and outcome. *Skull Base* 2011;21:295–302.
10. Fundová P, Charabi S, Tos M, Thomsen J. Cystic vestibular schwannoma: Surgical outcome. *J Laryngol Otol* 2000;114:935–9.
11. Fonkem E, Bricker P, Mungall D, et al. The role of levetiracetam in treatment of seizures in brain tumor patients. *Front Neurol* 2013;4:153.
12. Sperling MR, Ko J. Seizures and brain tumors. *Semin Oncol* 2006;33:333–41.
13. Tandon PN, Ramamurthi R. *Textbook of Neurosurgery*. 3rd ed. Three Volume Set. New Delhi, India: JP Medical Ltd., 2012;43–51.
14. Rangel-Castilla L, Rangel-Castillo L, Gopinath S, Robertson CS. Management of intracranial hypertension. *Neurol Clin* 2008;26:521–41.
15. Ecker A. Upward transtentorial herniation of the brain stem and cerebellum due to tumor of the posterior fossa with special note on tumors of the acoustic nerve. *J Neurosurg* 1948;5:51–61.
16. Kalavakonda C. *Textbook of Contemporary Neurosurgery* (Vols. 1 and 2). Thamburaj VA, ed. New Delhi, India: JP Medical Ltd., 2012;110.
17. Bleck TP. *Textbook of Clinical Neurology*. In: Goetz CG, ed. Philadelphia, PA: Elsevier Health Sciences; 2007. pp. 14–15.
18. Gurajala I, Brahmmaprasad V, Rajesh A, Ramachandran G, Purohit AK. Reverse brain herniation following ventriculoperitoneal shunt. *Indian J Anaesth* 2012;56:585–7.
19. Cuneo RA, Caronna JJ, Pitts L, Townsend J, Winestock DP. Upward transtentorial herniation: Seven cases and a literature review. *Arch Neurol* 1979;36:618–23.
20. Kase CS, Wolf PA. Cerebellar infarction: Upward transtentorial herniation after ventriculostomy. *Stroke* 1993;24:1096–8.