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Tumors of the superior medullary velum in infancy and childhood: report of 6 cases

Clinical article

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Object. The superior medullary velum (SMV) is a thin lamina of white matter located between the superior cerebellar peduncles horizontally and between the midbrain and cerebellum vertically. The SMV has not previously been described as the primary location of a posterior fossa tumor, although it can be secondarily invaded by a tumor from the cerebellum or quadrigeminal plate. This paper aims to define clinical and radiological features of tumors primarily arising from the SMV during childhood.

Methods. The authors observed 6 infants and children harboring neoplasms of the SMV who were treated at Ann & Robert Lurie Children's Hospital of Chicago (formerly Children's Memorial Hospital) in Chicago, Illinois. Pathological diagnosis of the neoplasms was an atypical teratoid/rhabdoid tumor (ATRT) in 5 patients, and a juvenile pilocytic astrocytoma (JPA) in the remaining child. The tumors were diagnosed during infancy in all patients, with ages ranging from 3 months to 10 months, except for the patient with a JPA (diagnosed at 5 years old). All patients presented with signs and symptoms of increased intracranial pressure due to obstructive hydrocephalus.

Results. Characteristic MRI features were noted, consistent with a mass in both the fourth ventricle and the cerebellomesencephalic fissure and quadrigeminal cistern, resulting in the circumferential displacement of the neural structures surrounding the SMV. The tumor was removed effectively in gross-total fashion through the occipital transtentorial approach in all patients. This approach offers a wide exposure of the region. However, all infants with ATRT suffered tumor dissemination and died between 4 and 11 months after diagnosis, in spite of radical resection and oncological treatment. The 1 child with JPA is alive and well 30 months after tumor resection.

Conclusions. To the best of the authors' knowledge, this is the first description in the literature that focuses on tumors originating from the SMV. This entity must be promptly recognized on preoperative radiological studies to carefully plan the subsequent surgical and clinical management.
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Key Words • **atypical teratoid/rhabdoid tumor** • **cerebellar tumor** • **occipital transtentorial approach** • **pineal tumor** • **quadrigeminal plate** • **superior medullary velum** • **oncology**

The SMV is a thin lamina of white matter forming the roof of the upper part of the fourth ventricle. The SMV forms a V-shape, narrow rostrally and broader caudally. It stretches between the superior cerebellar peduncles and is bordered by the inferior colliculi rostrally and the superior vermis caudally, with the folia and lingula on the dorsal surface of the SMV's lower half. Even when secondarily invaded by cerebellar vermian tumors, the SMV usually continues to be recognized on preoperative MRI.[23] Quadrigeminal plate and pineal region tumors can extend to the SMV, but usually manifest when they are still confined to the midbrain.[21] The primary occurrence of a tumor originating from the SMV has not been described in the scientific literature to date.

Tumors originating from the SMV may have been bundled in pineal, tectal plate, fourth ventricle, or superior vermian tumors. These tumors, however, manifest a specific pattern of growth: they extend from the fourth ventricle to the quadrigeminal cistern, displacing the quadrigeminal plate anteriorly and the central lobule and culmen of the superior vermis posteriorly. The displacements of these structures improve following tumor resection. Also, postresection MRI shows direct communication of the fourth ventricle to the quadrigeminal cistern

Abbreviations used in this paper: ATRT = atypical teratoid/rhabdoid tumor; EVD = external ventricular drain; JPA = juvenile pilocytic astrocytoma; SMV = superior medullary velum; SP = subdural peritoneal; VP = ventriculoperitoneal.

This article contains some figures that are displayed in color online but in black-and-white in the print edition.

with laterally displaced superior cerebellar peduncles. We strongly suspect these tumors originate at the SMV based on the anatomical correlation. In this paper, keeping these inclusion criteria in mind, we report 6 such patients, attempting to define the clinical and radiological features of this entity as well as the consequent surgical implications. Finally, the anatomy and embryology of the SMV are reviewed to correlate with tumor occurrence.

Methods

This study was approved by the Institutional Review Board of Children's Memorial Hospital (now named Ann & Robert Lurie Children's Hospital of Chicago). Six infants and children affected by a tumor of the SMV were treated at Children's Memorial Hospital in Chicago, Illinois, from 2004 to 2010 (Table 1). Three patients were boys and 3 were girls. Their ages at diagnosis ranged from 3 months to 10 months in all, except for 1 child who was diagnosed at 5 years of age. Tumor histology was verified in all patients, with an ATRT revealed in the 5 infants. In the remaining 5-year-old child, a JPA was diagnosed. Computed tomography and MRI were obtained in all patients. The ATRTs showed little or no enhancement after intravenous contrast infusion. All patients presented with signs or symptoms of raised intracranial pressure related to obstructive hydrocephalus. Two patients showed a mild impairment of ocular movements, although Parinaud syndrome was not detected in any patient. The child with a JPA presented with gait ataxia.

Results

All patients underwent pre- or intraoperative external ventricular drainage for hydrocephalus, and gross-total tumor resection was attained through an occipital transtentorial approach. The extent of tumor resection was evaluated postoperatively on MRI, confirming gross-total resection in all patients.

Postoperatively, 3 patients required a VP shunt for persistent hydrocephalus, and 2 received an SP shunt for progressive subdural CSF collection; all 5 of these patients had ATRTs. Four infants with ATRT were also treated with chemotherapy, and another was treated using chemotherapy followed by radiation therapy.

All infants with ATRT died between 4 and 11 months after the diagnosis; 4 due to diffuse CSF dissemination and 1 (Case 2) due to sepsis. However, none showed recurrence at the primary tumor site. The 1 child with JPA experienced no recurrence following tumor resection alone and remained neurologically intact during follow-up over 30 months.

Illustrative Cases

Case 1

This 9-month-old girl presented to an outside hospital due to failure to thrive, delayed developmental milestones, and full anterior fontanel. A large, heterogeneous, midline posterior fossa mass located in the tectocerebellar region causing massive ventriculomegaly was detected on CT. She was subsequently transferred to Children's Memorial Hospital due to rapidly deteriorating neurological status with lethargy and intermittent posturing. Magnetic resonance imaging of the brain revealed obstructive hydrocephalus caused by an inhomogeneous minimally enhancing tumor extending from the fourth ventricle to the quadrigeminal cistern (Fig. 1). After placement of an EVD, the infant's condition improved. On the following day an occipital craniotomy was performed with the patient prone. A posterior interhemispheric transtentorial approach was used and the posterior fossa tumor was directly exposed after tentorium sectioning (Fig. 2 left). The tumor was soft and friable, but quite vascular. A gross-total resection was attained. Following the resection, the quadrigeminal plate was identified to be thin and rostrally displaced, and the superior vermis was displaced posteriorly. Both the third and fourth ventricles were within the surgical view (Fig. 2 right). Postoperative MRI confirmed complete resection of the tumor (Fig. 3).

Histopathological findings were consistent with primary ATRT. Genetic testing revealed pathogenic mutation of the *INI1* gene in her brain tumor cells, whereas the *INI1* gene sequence in peripheral blood cells was normal.

Postoperatively, she recovered well without neurological deficits, although she received early intervention for her delayed developmental milestones. The child received multiagent systemic chemotherapy, including intrathecal methotrexate through an Ommaya reservoir. Two months after the surgery an SP shunt was placed for increased subdural CSF collection. She received external beam radiation therapy to the primary tumor site 3–4 months after the craniotomy. At 6 months postoperatively, MRI showed no evidence of disease. However, she suffered a spontane-

TABLE 1: Clinical summary of patients harboring a tumor of the SMV*

Case No.	Age at Diagnosis	Sex	Symptoms	Pathology	Chemotherapy/ Radiation	Shunt Type	Follow-Up/Outcome
1	9 mos	F	failure to thrive, delayed developmental milestones, bulging AF	ATRT	chemotherapy + radiation	SP	died (10 mos)/diffuse CNS metastasis
2	10 mos	F	macrocephaly, bulging AF	ATRT	chemotherapy	VP	died (4 mos)/sepsis, single metastasis
3	4 mos	M	macrocephaly, bulging AF, esotropia	ATRT	chemotherapy	SP	died (5 mos)/diffuse CNS metastasis
4	3 mos	M	macrocephaly, bulging AF	ATRT	chemotherapy	VP	died (4 mos)/diffuse CNS metastasis
5	6 mos	F	macrocephaly, bulging AF	ATRT	chemotherapy	VP	died (5 mos)/diffuse CNS metastasis
6	5 yrs	M	gait instability, emesis	JPA	none	none	alive (32 mos)/normal, no recurrence

* All patients underwent gross-total resection. Abbreviation: AF = anterior fontanel.

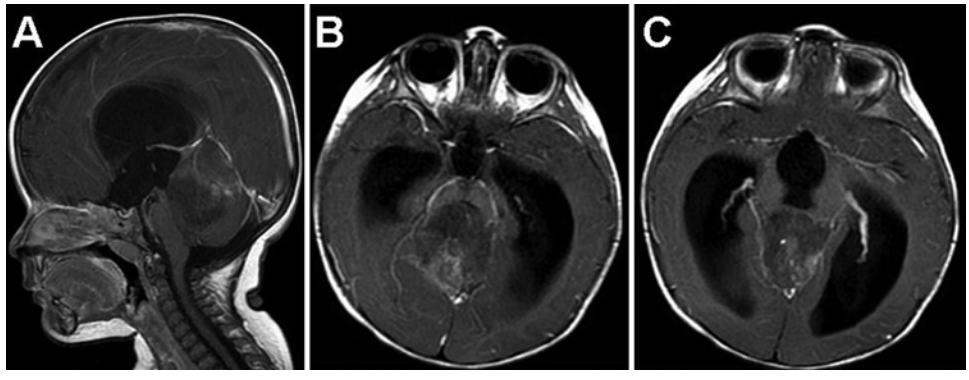

Fig. 1. Case 1. Preoperative sagittal **(A)** and axial **(B and C)** T1-weighted MR images after contrast infusion demonstrate a bulky heterogeneously enhancing infratentorial ATRT, associated with obstructive hydrocephalus. The quadrigeminal plate is thin and displaced anterosuperiorly and the cerebellar vermis and fastigium are displaced posteriorly due to a mass extending from the fourth ventricle and quadrigeminal cistern.

ous hemorrhage in the cerebellum and cerebrum on her left side 3 months later. Subsequently the patient developed diffuse CSF dissemination but without recurrence at the primary tumor site. She died 10 months after diagnosis.

Case 2

This 10-month-old girl presented with rapidly increasing head size and a 1-month history of arrest of her developmental milestones. A head CT showed hydrocephalus associated with a heterogeneous posterior fossa tumor mass with central necrosis. Magnetic resonance imaging showed a nonenhancing tumor extending from the pineal region to the fourth ventricle with hydrocephalus (Fig. 4). Following placement of an EVD, intratumoral hemorrhage occurred on the same evening and emergency surgery was performed.

A craniotomy and tumor resection was performed through an occipital interhemispheric approach in the prone position. After tentorial sectioning, the tumor was uncovered, and the necrotic-hemorrhagic core was debulked from the quadrigeminal cistern and the fourth ventricle. A gross-total removal of the lesion was accomplished as confirmed by postoperative MRI (Fig. 5). Afterward, a VP shunt was placed because of persistent hydrocephalus. Postoperatively, the patient showed normal pupillary responses and ocular movements, and full strength, although she required physical and occupational therapy for the loss of her developmental milestones.

The diagnosis of primary ATRT was considered; genetic analysis confirmed the pathogenic mutation of the *INI1* gene in brain tumor cells and ruled out any germline mutation in peripheral blood cells. High-dose chemotherapy was started but the child died 4 months after surgery because of multiorgan failure secondary to neutropenic sepsis.

A postmortem study revealed a single metastatic focus of ATRT in the left basal ganglia, and there was no evidence of tumor at the original tumor site. The quadrigeminal plate was displaced but preserved, the distance between the superior cerebellar peduncles was wider, and the SMV was absent (Fig. 6).

Case 6

This 5-year-old boy had a 1-month history of gait instability and several episodes of vomiting 1 week prior to admission. The neurological examination results were normal except for mild papilledema. Computed tomography showed a hypodense homogeneous mass in the fourth ventricle extending to the pineal location, and advanced hydrocephalus. Magnetic resonance imaging demon-

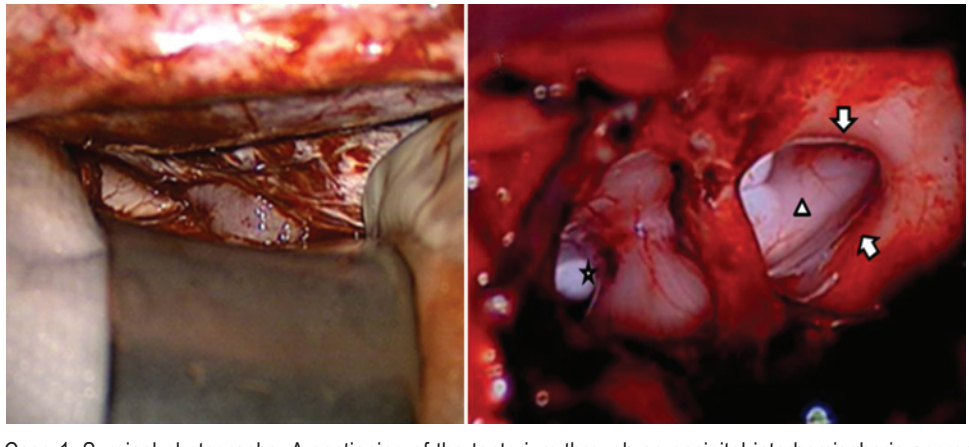

Fig. 2. Case 1. Surgical photographs. A sectioning of the tentorium through an occipital interhemispheric approach shows an ATRT directly underneath the tentorium **(left)**. The third *(asterisk)* and fourth *(arrowhead)* ventricles are noted following the resection of the tumor **(right)**. The superior cerebellar peduncles *(arrows)* are preserved.

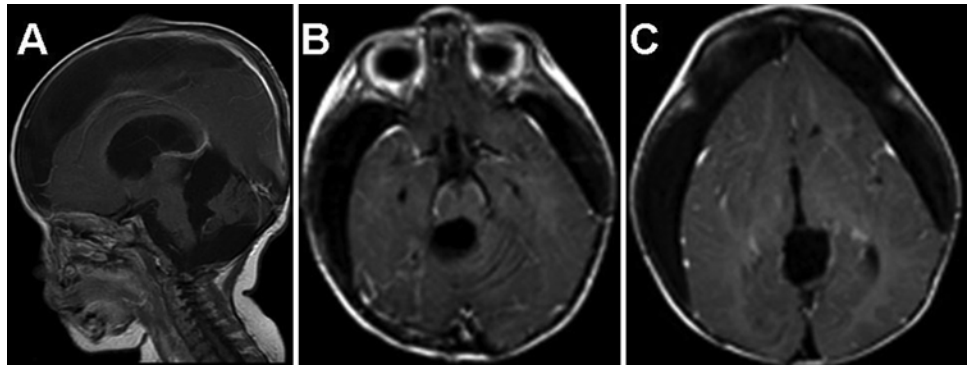

Fig. 3. Case 1. Postoperative sagittal **(A)** and axial **(B and C)** T1-weighted MR images after contrast infusion demonstrate complete resolution of the ATRT with preserved quadrigeminal plate, cerebellar vermis, and fastigium.

strated a large posterior fossa lesion with heterogeneous T1-weighted signal and inhomogeneous enhancement after contrast medium administration, in association with obstructive hydrocephalus. The mass was present in the upper fourth ventricle directly extending and filling the quadrigeminal cistern with the quadrigeminal plate anteriorly and the superior vermis posteriorly (Fig. 7).

With the patient prone, a right occipital craniotomy was performed following placement of an EVD. The pineal region was approached through a posterior interhemispheric route. A tentorium section allowed immediate exposure of the lesion in the quadrigeminal cistern. After easily separating the vein of Galen from the anterior cranial portion of the tumor, the mass was internally debulked. Posteriorly, the superior vermis was displaced backward and its pial layer was preserved during tumor excision. The lateral portions of the tumor were dissected from the superior cerebellar peduncles. In the deep aspect of the surgical field, the fourth ventricle was entered. The floor and walls of the fourth ventricle were spared from neoplastic infiltration. Posteriorly,

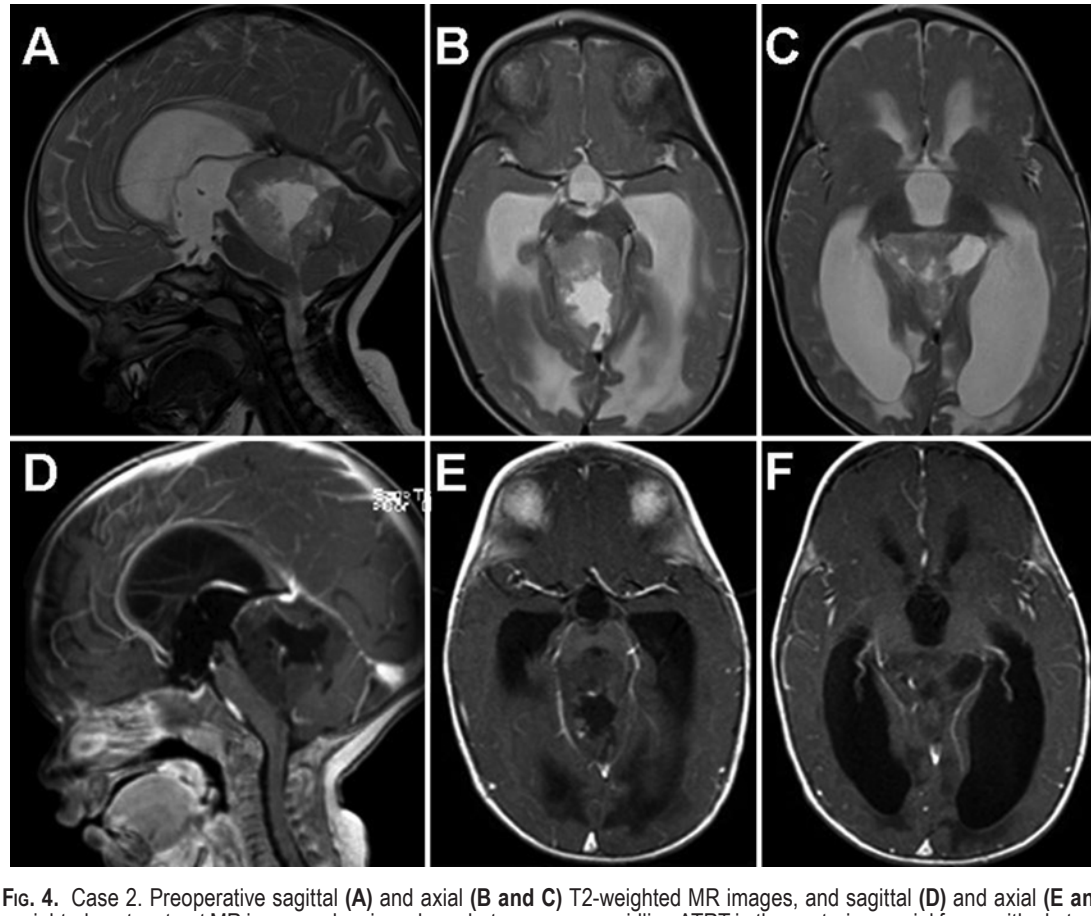

Fig. 4. Case 2. Preoperative sagittal **(A)** and axial **(B and C)** T2-weighted MR images, and sagittal **(D)** and axial **(E and F)** T1-weighted postcontrast MR images, showing a large heterogeneous midline ATRT in the posterior cranial fossa with obstructive hydrocephalus. Note the quadrigeminal plate is pushed anterosuperiorly and the vermis is pushed posteriorly due to the tumor. The axial images show laterally displaced superior cerebellar peduncles and a flattened quadrigeminal plate.

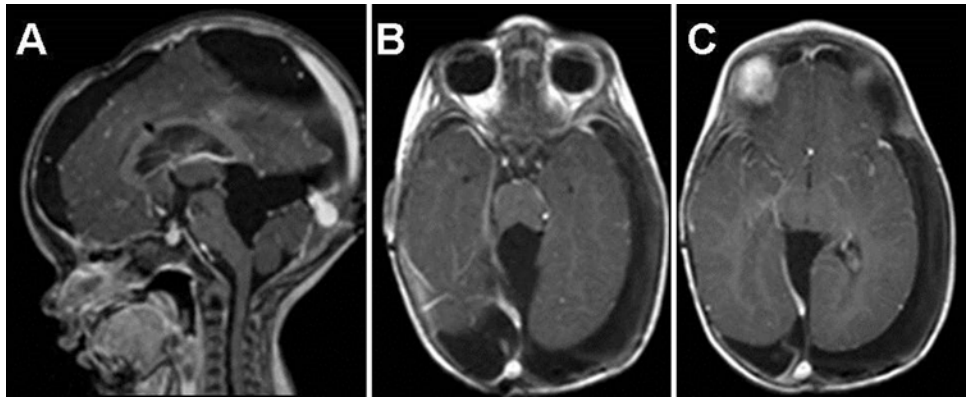

Fig. 5. Case 2. Postoperative sagittal **(A)** and axial **(B and C)** T1-weighted MR images after contrast infusion demonstrate complete resolution of the ATRT with preserved quadrigeminal plate, cerebellar vermis, and fastigium.

the tumor was removed away from the central lobule and the fastigium of the fourth ventricle, which were displaced but not invaded by the tumor. Finally, the cranial portion of the lesion was meticulously separated from the quadrigeminal plate, thus uncovering the aqueduct of Sylvius.

The pathological diagnosis was a JPA. Postoperatively, the patient quickly recovered from his preoperative neurological symptoms, and the perioperative EVD was removed without CSF diversion. The neurological examination results were normal without pupillary and ocular abnormalities. Postoperative MRI showed complete resolution of the tumor (Fig. 8). No recurrence has been observed during the follow-up period, 32 months after the removal of the tumor.

Discussion

Anatomy of the SMV

The SMV, also known as the valve of Vieussens, is a thin lamina of white matter connecting the superior cerebellar peduncles and the inferior colliculi of the tectal plate. This membrane is lined internally with ependyma and externally by the lingula, a thin and narrow tongue of the upper vermis that sits on the outer surface of the SMV, whereas the pia mater lines the upper portion of the velum that is not covered by the lingula. The external surface of the SMV is the anterior wall of the cerebellomesencephalic fissure. This fissure, also referred to as the precentral fissure, extends into the space between the cerebellum and midbrain. The velum forms the rostral

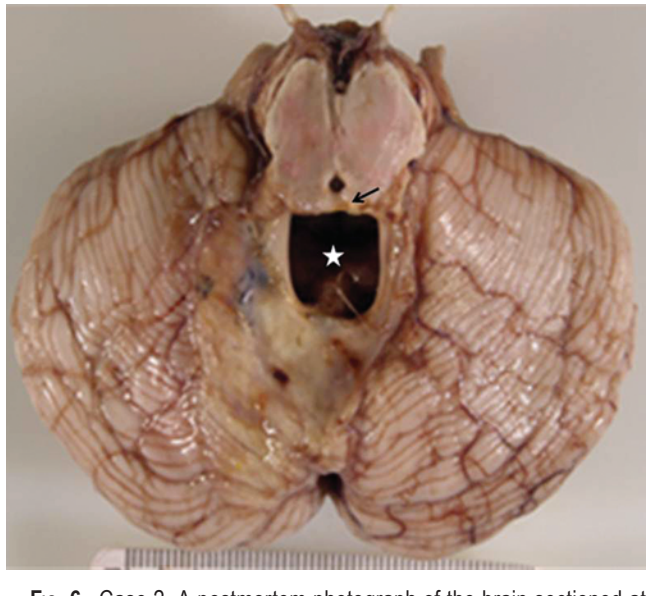

Fig. 6. Case 2. A postmortem photograph of the brain sectioned at the midbrain shows the cerebellum, fourth ventricle cavity *(asterisk)*, and the quadrigeminal plate *(arrow)*. There is a widened space between the superior cerebellar peduncles and the lack of the SMV. No tumor was noted in the original tumor location and the fourth ventricle.

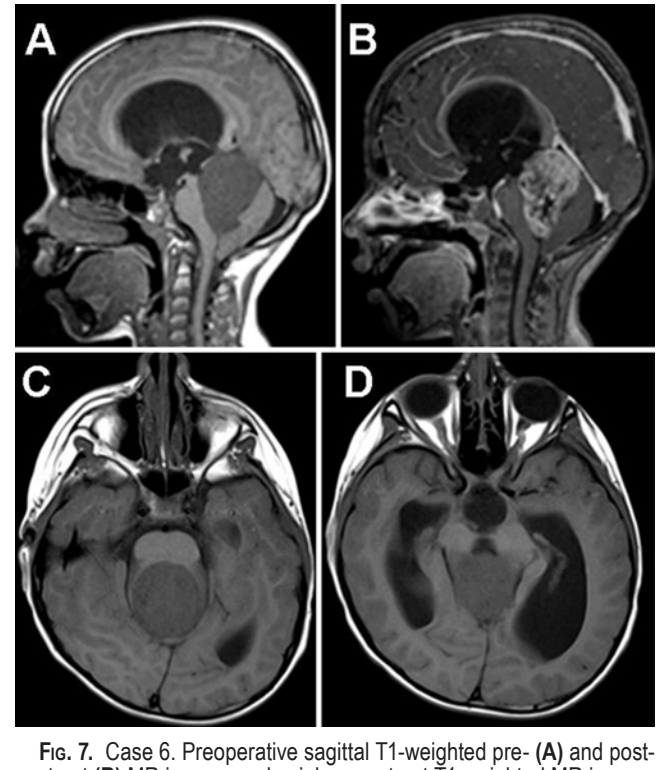

Fig. 7. Case 6. Preoperative sagittal T1-weighted pre- **(A)** and postcontrast **(B)** MR images and axial precontrast T1-weighted MR images **(C and D)** show a large homogeneous posterior fossa JPA in the fourth ventricle extending to the quadrigeminal cistern. The tumor heterogeneously enhanced after contrast infusion. Note the obstructive hydrocephalus. The quadrigeminal plate and cerebellar vermis are displaced but well preserved. Axial images show laterally displaced cerebellar peduncles.

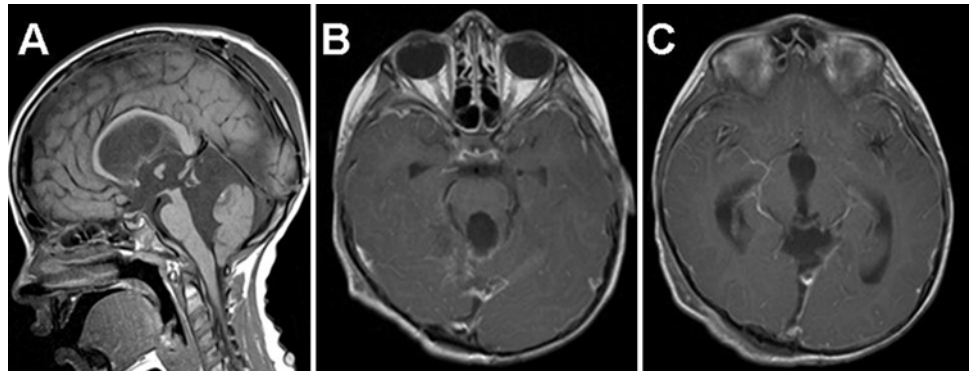

Fig. 8. Case 6. Postoperative sagittal **(A)** and axial **(B and C)** T1-weighted MR images after contrast infusion demonstrate complete resolution of the JPA with preserved quadrigeminal plate, cerebellar vermis, and fastigium. The displaced cerebellum and superior cerebellar peduncles are less displaced following the tumor resection.

half of the roof of the fourth ventricle, and on its caudal aspect it is continuous at the fastigium with the inferior medullary velum.[24,27]

Cerebellotectal and tectocerebellar febers that primarily interconnect the cerebellum and the inferior colliculus run within the SMV. The decussating fibers of the trochlear nerve bridge just caudal to the inferior colliculus.[4,8,11,27] The precerebellar branch of the superior cerebellar artery supplies this region[16] and venous drainage is provided by the superior cerebellar peduncle veins, which unite superiorly at the emergence of the trochlear nerve from the brainstem to form the vein of the cerebellomedullary fissure.[17]

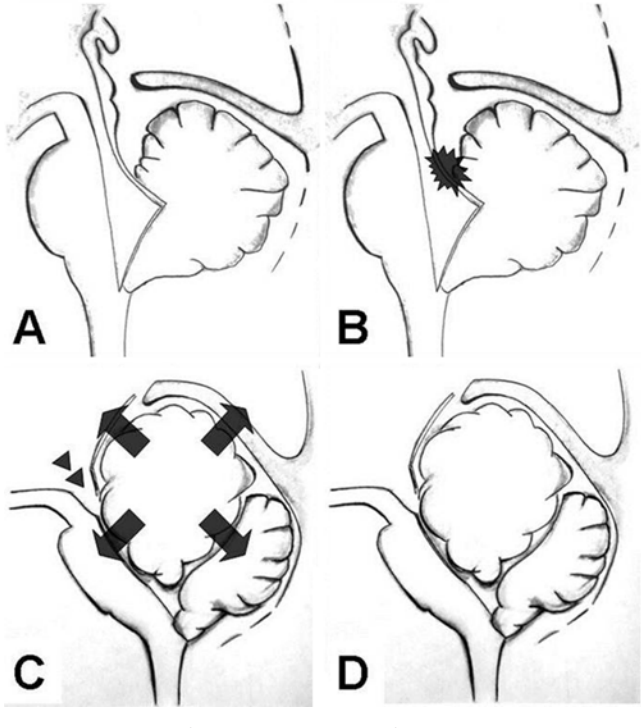

Fig. 9. Drawing of the normal anatomy of the neural structures within the posterior cranial fossa in the sagittal plane **(A)**. A tumor primarily arising from the SMV **(B)** grows by invading the fourth ventricle and the cerebellomesencephalic fissure, thus circumferentially displacing the surrounding structures (**C**, *arrows*). The caudal portion of the aqueduct is obstructed by tectal compression/distortion, while its entrance could be dilated by the supratentorial hydrocephalus (**C**, *arrowheads*). Cerebellum and brainstem are arranged by compression in a V-shaped manner, and the tectal plate is thinned and upwardly displaced **(D)**.

Embryology of the SMV and its Tumorigenesis

The segmentation of the neural tube results in the formation of the neuromeres, namely intrinsic compartments restricting the movement of cells. The isthmus develops at the junction of mesencephalon and metencephalon, thus serving as an organizing center for both the midbrain and the hindbrain differentiation.[13] Hence, two lateral cerebellar primordia form by the proliferating cells from the rhombic lips of the alar plate of the metencephalon. A mixed origin from the mesencephalic neuromere and the first rhombomere has been previously proposed.[5]

The isthmus drives the origin of the dorsal midline structures leading to the fusion of cerebellar primordia. An isthmic domain contributes to link the cerebellar vermis to the inferior colliculi and also provides a substratum for midline cerebellar fusion. Another restricted isthmic midline domain produces divergent flow of cells that populate the roof plates of the caudal midbrain and anterior hindbrain. Therefore, the SMV derives from an isthmic-derived territory, and its maldevelopment interferes with midline cerebellar fusion.[9]

The *homeobox* genes play a crucial role in segmentation and subsequent patterning. Among them, Sonic hedgehog regulates the midbrain-hindbrain morphogenesis through positive regulation of the Gli activators *(GLI1)* and inhibition of the Gli repressors *(GLI3)* and controls the overall growth of this region. Sonic hedgehog also restricts *FGF8* expression to the isthmus,[10] which is essential for the differentiation of the tecto-isthmo-cerebellar region.[19]

In our series, the prevalence of ATRT in this location during infancy is of interest. Little is known about the oncogenetic mechanism of this malignant neoplasm, burdened by a dismal prognosis.[26] Atypical teratoid/rhabdoid tumor is believed to arise from neural crest cells[25] and is characterized by the inactivation of *INI1*, also known as *SMARCB1* or *BRG1*. The encoded protein SNF5 has an oncosuppressor role by cooperating with p53 in the inhibition of *GLI1*; the loss of SNF5 causes the aberrant activation of Sonic hedgehog pathway and drives tumori-

genesis through the expression of *GLI1*, as documented by the growth of SNF5-deficient malignant rhabdoid cells in vivo and in vitro.[6] Interestingly, Sonic hedgehog and *GLI1* are also crucially involved in the morphogenesis of the tectocerebellar midline structures, as mentioned previously. The correlation between embryogenesis and tumorigenesis is well characterized by the involvement of Sonic hedgehog signaling in medulloblastoma.[1] Further studies should shed light on the role of Sonic hedgehog in the oncogenesis of ATRT.

Clinical Presentation and Imaging Characteristics

To date, the SMV has never been described as a site of primary occurrence of brain tumor, probably as a consequence of the difficulty in recognizing this condition on preoperative imaging studies. These tumors have often been categorized as pineal region tumors, tectal plate tumors, superior vermian tumors, or fourth ventricle tumors. In our series, the large dimensions of the tumor at diagnosis often subvert the normal anatomy of this region.

Nonetheless, the origin of the tumor from the SMV rather than from surrounding structures can be preoperatively suggested by characteristic imaging findings, resulting from a typical growth pattern (Fig. 9). On sagittal images, the tumor locates on the midline, its epicenter found at the level of the SMV extending to the fourth ventricle and quadrigeminal cistern. The quadrigeminal plate, which may be hard to identify, is pushed anterosuperiorly and stretched. The superior vermis is displaced posteriorly with its folia and sulcus preserved; thus the vermis is not likely the origin of the tumor. The fastigium, although displaced posteriorly, maintains its V-shaped appearance before and after surgery, indicating the lingula is not the origin of the tumor. The brainstem is displaced anteriorly and the inferior fourth ventricle is pushed caudally, resulting in the tumor arranging in a V-shaped fashion and effacing the prepontine and retrocerebellar cisterns on sagittal MRI. Axial MRI shows the widened space between the bilateral superior peduncles and the anterior displacement of the quadrigeminal plate. The aqueduct is distorted but still recognizable on axial images and its upper portion may be dilated by the concomitant hydrocephalus. However, the evidence of a thin lamina of normal tissue between the tumor and the posterior portion of the third ventricle, representing the compressed quadrigeminal plate and the posterior commissure, should raise suspicion of a tumor primarily centered in the SMV rather than in the midbrain. In this series, all ATRTs of the SMV presented with an inhomogeneous nonenhancing or barely enhancing mass with central necrosis.

Because of its growth within the ventricular and cisternal space, the tumor can reach a prominent size prior to clinical manifestation. In contrast, primary tectal lesions are usually smaller at diagnosis, with hydrocephalus resulting from the occlusion of the aqueduct.[12,21] The absence of any gaze limitation in our series supports the origin of the tumor from the SMV, as pineal region tumors often present with Parinaud syndrome in children.[3,15]

All infants with ATRTs in this location required a CSF shunt procedure, either a VP or SP shunt 1 to 2 months postoperatively, in spite of gross-total resection. Two infants who had large subdural CSF collections were believed to have externalized hydrocephalus, which is due to direct communication of CSF from the ventricle to the subdural space. The postoperative shunt requirement for these infants, in spite of complete tumor resection, is perhaps due to insufficient subarachnoid space circulation or absorption of the CSF, or it may be due to CSF dissemination of ATRT cells.

Surgical Approaches

Preoperative suspicion of a tumor originating from the SMV is not merely speculative, because the above-described growth pattern has important surgical implications. As all cases are burdened by severe ventricular dilation, an EVD is useful to relieve intracranial pressure and minimize the retraction of the occipital lobe during the tumor resection. All of our patients in this series underwent operations through the posterior interhemispheric transtentorial approach, which allows safe, effective exposure of the mass in both the quadrigeminal cistern and the fourth ventricle. By changing the trajectory of the microscope, one can see from the anterior third ventricle to the lower fourth ventricle.[14,18]

The technique of this approach has been described in detail elsewhere.[22] Briefly, the patient is placed prone after placement of the EVD. Because of the inability to place pin fixation devices in infants, the head was secured on a well-padded horseshoe head holder; thus, securing the head position is often difficult and requires extra attention. The craniotomy is performed in the occipital location above the torcular herophili and lateral sinus, and the head is in a neutral position. A hockey stick–shaped incision allows an occipital craniotomy to be performed. Through a posterior interhemispheric approach, the tentorium is sectioned approximately 1 cm away from and parallel to the sinus rectus, depending on the need for exposure of the posterior fossa tumor. The tentorium sectioning is posteriorly extended until the displaced superior vermis is fully visualized. The tumor is readily exposed upon opening of the tentorium. The ATRT often has a necrotic and vascularized core, and internal decompression is initially performed. Thereafter, the displaced galenic venous structures, the quadrigeminal plate anteriorly, and the superior vermis posteriorly come into surgical view. In our cases, it was curious to note that the fourth cranial nerves were not visualized in any of the cases, and none of the patients showed fourth cranial nerve palsy postoperatively. Following successful tumor resection, the fourth ventricle and occasionally the third ventricle were visualized.

Although the occipital transtentorial approach has been extensively described for pineal tumors,[14,20] it has also been adopted for superior cerebellar lesions,[2] even those located off the midline,[7] because of the wide exposure ensured by tentorial sectioning. In contrast, the suboccipital supracerebellar approach offers limited exposure of the caudal portion of the tumor extending into the space of the fourth ventricle,[28] thus negatively affecting the chances of gross-total resection. Similarly, an approach through the fourth ventricle would limit resecting the portion of the tumor in the quadrigeminal cistern.

Conclusions

This is the first report describing the primary occurrence of tumors originating in the SMV. One should include this SMV tumor in the differential diagnosis of upper midline infratentorial lesions. Surgeons must recognize the distorted anatomy of the tectocerebellar structures on preoperative imaging studies that are indicative of this tumor, to carefully plan for their surgical removal. An ATRT that is prevalent in this location during infancy poses very difficult management problems because of its lack of response to presently available oncological protocols and its high rate of dissemination. Effective surgical excision is possible, which would diminish the chance of local recurrence as observed in our series, but the oncological treatment needs to target the disseminated tumor cells.

Disclosure

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author contributions to the study and manuscript preparation include the following. Conception and design: both authors. Acquisition of data: both authors. Analysis and interpretation of data: both authors. Drafting the article: both authors. Critically revising the article: both authors. Reviewed submitted version of manuscript: both authors. Approved the final version of the manuscript on behalf of both authors: Tomita. Administrative/technical/material support: both authors. Study supervision: Tomita.

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