Cranial magnetic resonance imaging findings of leptomeningeal contrast enhancement after pediatric posterior fossa tumor resection and its significance

Case report

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In this report, the authors illustrate the potential shortfalls of early postoperative MR imaging following resection of a posterior fossa tumor. The authors present the cases of a 10-month-old boy and a 14-year-old boy with posterior fossa tumors that were surgically resected and monitored immediately postoperatively with MR imaging. The MR imaging study obtained immediately postresection while the children were still anesthetized revealed enhancing elements in both patients, which were suggestive of leptomeningeal metastases. When this signal was followed on subsequent MR images, it was no longer visible. The patients are both recurrence free at the time of this publication. These cases demonstrate that early postoperative MR imaging findings for leptomeningeal metastases may be unreliable after excision of posterior fossa tumors and may have potential implications for intraoperative MR imaging techniques currently under development. (DOI: 10.3171/2010.4.PEDS1058)

KEY WORDS • false-positive finding • magnetic resonance imaging • pediatric tumor • postoperative imaging • posterior fossa • tumor

Cancers of the CNS are the most common solid malignancy in pediatric patients.²,³,¹¹ Of intracranial brain tumors affecting the pediatric population, between 60 and 70% develop in the posterior fossa. These tumors include astrocytomas, medulloblastomas, and ependymomas. The current standard of care includes the surgical removal of these tumors followed by adjuvant therapy with chemotherapy or radiation therapy.¹¹ Advances in neuroimaging have enabled earlier diagnosis and improved surgical outcomes. Intraoperative or early postoperative MR imaging allows neurosurgical teams to evaluate the success of tumor resection immediately postoperatively, and it facilitates further surgery if required.²,⁹,¹⁴

We describe 2 children who exhibited increased signal intensity at areas distant to surgical beds on Gd-enhanced MR images obtained immediately postoperatively. These signals mimicked leptomeningeal metasta-

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Case 1

History and Examination. This previously healthy 14-year-old boy presented to our institution with a 2-month history of posterior neck spasms, nausea, vomiting, headaches, and occasional double vision. An MR imaging study revealed an enhancing lesion in the posterior fossa with growth through the right foramen of Luschka and through the foramen magnum extending into the upper cervical spine. The most caudal extent of the tumor was posterolaterally on the right within the thecal sac.
Operation. Seven days later the patient underwent excision of the lesion. Initially, a right frontal external ventricular drain was placed. The patient was then placed prone, and a posterior fossa craniotomy and C-1 laminectomy was done. The tumor was internally debulked with the Cavitron Ultrasonic Surgical Aspirator (Integra LifeSciences). Eventually, we were able to dissect the tumor off the cerebellum without any difficulty.

Pathological examination revealed a medulloblastoma. Analysis of the CSF was negative for tumor cells, but an arachnoid mater biopsy was positive for disease, which was subsequently treated as a high-risk medulloblastoma. The patient underwent MR imaging 58 minutes postoperatively to look for residual tumor, and radiology noticed areas of T1 signal shortening along the margins of the craniotomy, in keeping with blood products. The posterior fossa tumor had been resected, but a small amount of T1 signal shortening was seen within the resection cavity, which was hypointense on T2-weighted imaging and was thought to represent a small amount of hemorrhage. Some hyperintense T2 signal abnormality in the adjacent parenchyma of the right cerebellar hemisphere was seen, also extending into the vermis. Abnormal enhancing tissue was seen extending into the interpeduncular cistern, which was not present on the preoperative MR imaging done 7 days previously (Fig. 1).

Postoperative Course. On follow-up imaging performed 3 months postoperatively, the enhancing element was no longer present. The patient has been monitored for longer than 5 years and has no evidence of relapse. The patient was treated adjuvantly with both chemotherapy and radiotherapy.

Case 2

History and Examination. This 10-month-old boy presented to our institution with failure to thrive. The child was lethargic and had increasing difficulty with breast and formula feeding over a 3-week period. Feedings were frequently complicated by emesis, and assessment suggested delayed development. On presentation, the child was in the 3rd percentile for weight and head circumference, and in the 25th percentile for length. The child was born prematurely at 35 weeks by spontaneous vaginal delivery. The pregnancy history was complicated by maternal use of ser-
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traline hydrochloride and risperidone. Marijuana and alcohol were also used during the first trimester.

Magnetic resonance imaging revealed a large heterogeneous-appearing tumor that demonstrated patchy enhancement, arising in the region of the floor of the fourth ventricle along with evidence for extension through the foramen of Magendie. The lesion measured approximately 4 cm (superoinferiorly) × 3 cm (anteroposteriorly) × 2.3 cm. The cerebral aqueduct, third ventricle, and the lateral ventricles were all enlarged along with abnormal increased T2 signal within the white matter adjacent to the lateral ventricles compatible with a component of transependymal flow of CSF.

Operation. Three days later the tumor was removed. The child was brought to the operating room, and a right frontal external ventricular drain was placed. A posterior fossa craniotomy and partial C-1 laminectomy was done. The tumor was internally debulked and circumferentially dissected off the floor of the fourth ventricle. A small amount of tumor was adherent to the vagal trigone. A standard closure followed, and the patient was brought to the MR imaging suite for cranial imaging.

Analysis of the CSF was negative for tumor cells. The tumor was a WHO Grade III ependymoma. The child underwent MR imaging 41 minutes postoperatively to look for any residual tumor burden. Members of the radiology department noticed a thin rim of hyperintense T1 signal in the surgical bed prior to contrast administration, possibly representing hemorrhage. There were small areas of residual enhancement noted in the area of the interpeduncular cistern and at the superior aspect of the surgical bed, suspicious for residual neoplasm (Fig. 2). The child was monitored carefully, and on the follow-up MR imaging study performed 12 days postoperatively, the enhancing element was no longer present.

Postoperative Course. The patient has undergone follow-up for 5 months since the operation and has no evidence of relapse. He is currently undergoing adjuvant chemotherapy.

Discussion

Postoperative MR imaging has become a standard in assessing residual tumor burden following neurosurgical excision of ependymomas and medulloblastomas. These images must be interpreted cautiously because of the distortion of normal neuroanatomy and neurophysiology caused by surgical manipulation. After surgery, operational beds have been shown to enhance within the brain or pia mater for periods of up to a year. Throughout
the literature, there are a number of hypotheses that have been put forward to explain MR imaging enhancements seen in the postoperative periods, which we will relate to our case.

There are several documented cases of spinal dural enhancement seen immediately after posterior fossa surgeries.\(^1,2,5,21,22\) In one paper, Kaufman et al\(^7\) reported resolving subdural spinal enhancement in children following posterior fossa surgeries when MR imaging was performed within 24 hours. Wiener et al\(^17\) also found spinal dural enhancements within 3 days of surgery that mimicked residual tumor burden. When further observed, these patients were found to be tumor free and the enhancement resolved within 2 weeks of surgery. Warmuth-Metz et al\(^16\) retrospectively reviewed the spinal images obtained in 53 patients 2–40 days postoperatively and found a number of false-positive findings. These groups attributed the changes seen to either pressure-related changes during surgery that may have caused a shift of CSF into the subdural space or meningeal irritation induced by blood from the surgery.

While both of our patients did have mild hydrocephalus prior to surgery, the observed enhancements in our study were pial not dural, and they were intracranial. In addition, we did not note any significant hemorrhaging intraoperatively. Our findings are suggestive of a process that has distorted the blood-brain barrier and allowed contrast to enter below the dura.

Shaw et al\(^15\) reported a case series of 5 pediatric patients with spinal enhancement that was noted 6–12 days postoperatively. These findings resolved within 18 days, and the group proposed that neovascularization might have led to some contrast extravasation due to open endothelial junctions in new vasculature. In our 2 cases, the short timespan between the operation and imaging would suggest that neovascularization does not properly account for the enhancements we observed given that neovascularization is unlikely to have commenced.

Jabbour et al\(^6\) reported a case of acute cerebellitis that mimicked a tumor on MR imaging. If an acute infectious process were at play in our 2 patients, this may explain the enhancements seen on imaging. The problem with this theory is that our patients were never symptomatic, and the acuity of our findings makes infection an unlikely etiology. The potential connection to the study by Jabbour et al., however, may be that inflammation caused by the infection could be the causative agent linked to the enhancing element. Similarly, inflammation induced by surgical manipulation may be the mechanism responsible for our enhancement.

This idea of inflammation causing aberrant MR images was put forward in a 2008 paper in which the authors reported on a 4-year-old boy who displayed hemicerebellar inflammation that mimicked recurrent medulloblastoma 1 month postoperatively.\(^8\) Those authors were unable to explain the cause of the inflammation, but in our report the recent surgical agitation of brain parenchyma may be the stimulus for such irritation. Cytokines have been implicated in disrupting the blood-brain barrier, and postoperatively these cytokines may be induced.\(^1\)

Our findings suggest that early postoperative MR imaging may present some false-positive findings, and we report some of the earliest MR imaging abnormalities seen after posterior fossa surgery. We propose that the etiology of this peculiar enhancement may be inflammatory, mediated by the brain’s response to surgical stress. With the move to intraoperative MR imaging, our case report provides a valuable example of a situation in which prudent assessment of preoperative and follow-up imaging will be required in trying to assess residual tumor burden. We advise that immediate postoperative imaging is not appropriate for assessing leptomeningeal disease.

**Disclosure**

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

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