HEMANGIOBLASTOMA of the CNS is a rare benign tumor of vascular origin, primarily occurs in the 3rd to 5th decades of life, and occurs most commonly in the cerebellum. Thus, hemangioblastoma in children, particularly those involving regions other than the cerebellum and spinal cord (such as the brainstem and the cerebral hemispheres), is quite uncommon. Von Hippel-Lindau (VHL) disease is associated with approximately 10% of patients with hemangioblastoma. The patients with VHL disease have retinal capillary hemangioma and tend to have multiple hemangioblastomas of the CNS, multiple cysts, and tumors in the pancreas, liver, kidney, and lung. The typical MRI finding of hemangioblastoma is described as a cystic mass with a small, vascular, intensely enhancing mural nodule. However, a solid hemangioblastoma is not uncommon, particularly in small, asymptomatic tumors. If present, serpentine flow voids in the solid portion of the tumor on MRI may strongly suggest the diagnosis.

Perfusion MRI demonstrating tumor vascularity is one of the advanced MRI techniques commonly used for evaluating brain tumors. Dynamic susceptibility-weighted contrast-enhanced (DSC) imaging has been used for differentiating various tumor types by using the relative cerebral blood volume (rCBV) ratio. Perfusion MRI can also be obtained without the injection of an exogenous contrast agent using the arterial spin labeling (ASL) technique. ASL imaging can provide measurements of blood flow in brain tumors. Dynamic contrast-enhanced (DCE) imaging has been recently used principally for evaluating the permeability of brain tumors by using the transfer constant (Ktrans), rate constant (Kep), interstitial volume (Ve), and blood plasma volume (Vp) values.

Exceedingly higher vascular perfusion has been demonstrated with DSC and ASL MRI in adult patients with hemangioblastoma. However, to the best of our knowledge, this feature has not been reported in children with hemangioblastoma. Therefore, in this paper we report on a child with a hemangioblastoma involving the medulla oblongata, in whom highly increased tumor perfusion de-
Hemangioblastoma on perfusion MRI

The case report describes a previously healthy 12-year-old boy who presented with generalized tonic-clonic seizures. On admission, the patient complained of a tingling sensation on his right thigh, which was gradually improved. A neurological examination and laboratory tests were unremarkable. A T1 hypointense and T2 hyperintense mass, approximately 2.4 cm in size, with a poorly defined margin was identified in the right posterolateral aspect of the lower medulla on brain MRI (Fig. 1A and B). The mass showed increased water diffusion on the apparent diffusion coefficient map, and no hypointense signals suggesting hemorrhage, neovascularity, or dilated vessels on susceptibility-weighted imaging. Single-voxel proton MR point-resolved spectroscopy obtained in the mass revealed no identifiable metabolites. Two MRI techniques, including ASL and DCE imaging, were performed to evaluate tumor vascularity and vascular permeability in this patient. However, DSC imaging was not performed, because low diagnostic yield resulting from pronounced artifacts and geometrical distortion involving the small medullary lesion was anticipated. Noncontrast perfusion imaging using a pseudo-continuous ASL method was acquired with a single-shot gradient-echo echo-planar imaging (EPI) technique (labeling duration 1650 msec, post-label delay 1700 msec, TR/TE 4130/14 msec, flip angle 90°, number of signal averages 1, SENSE [sensitivity encoding] 2.5, FOV 220 × 220 mm, matrix 90 × 90 pixels, slice thickness 6 mm, number of slices 19, acquisition time 4 minutes 15 seconds). The perfusion images, generated by subtracting the labeled image from the nonlabeled image at each slice position, showed well-defined round hyperintensity in the medullary lesion comparable to the signal intensities of the internal carotid arteries, indicating highly increased blood flow in

![Fig. 1](https://example.com/fig1.jpg)

**FIG. 1.** Imaging findings in the patient. A coronal reformatted FLAIR MR image (A) reveals ill-defined hyperintensity of the lesion, central to right (arrows). A coronal contrast-enhanced T1-weighted MR image (B) demonstrates a well-defined small nodular enhancement (arrow) in the right side of the lesion. An axial pseudo-continuous ASL image (C) shows a small, round, hyperintense lesion (long arrow) in the right posterolateral aspect of the lower medulla comparable to the signal intensity of the right internal carotid artery (short arrow), indicating vascular tumor perfusion (rTBF ratio 11.8). An axial image (D) obtained during the arterial phase of DCE imaging shows the locations of 4 regions of interest: L1, the left vertebral artery; L2, the center of the nodular enhancing lesion; L3, the nodular enhancing lesion; and L4, the normal-appearing medulla. A time-intensity curve (E) demonstrates that the curve pattern of the enhancing lesion (L2 and L3) is almost identical to that of the left vertebral artery (L1). The measured values in the enhancing lesion (arrow) were very low (−0.9 ± 1.8 min⁻¹) on the Ktrans map (F) and very high (1.3 ± 0.9, arbitrary unit) on the Vp map (G), indicating negligibly low vascular permeability and highly increased blood plasma volume. Figure is available in color online only.
On microscopic examination, the diagnosis of hemangioblastoma was performed without any complications. The prominent vessels were identified at the right posterolateral stroma of clear vacuolated cells (Fig. 2 right). Gross-total removal was confirmed at the operation. The histological findings of a rich and tightly packed capillary network in a blastoma was made by identifying the typical histological features of hemangioblastoma. Instead of DSC imaging, pseudo-continuous ASL and DCE imaging were performed to evaluate tumor vascularity and permeability in our case.

Operation and Postoperative Course

At surgery, a well-defined, pinkish-gray mass with prominent vessels was identified at the right posterolateral side of the lower medulla (Fig. 2 left). Gross-total removal of the mass was performed without any complications. On microscopic examination, the diagnosis of hemangioblastoma was made by identifying the typical histological findings of a rich and tightly packed capillary network in a stroma of clear vacuolated cells (Fig. 2 right).

After surgery, an ophthalmological examination disclosed a retinal capillary hemangioma on the right side in this patient. A history of retinal capillary hemangioma was also documented in the patient’s mother and maternal aunt. Abdominopelvic CT and whole-spine MRI were performed to evaluate the involvement of VHL disease in other organs and were unremarkable. A genetic study using polymerase chain reaction sequencing and multiplex ligation-dependent probe amplification eventually confirmed VHL disease in this patient by identifying a VHL gene mutation (c.208G > A [p.Glu70Lys]).

The patient recovered well without any complications and showed stable clinical follow-up results without seizures or focal neurological deficits for 1 year 7 months. His retinal capillary hemangioma was also unchanged on follow-up ophthalmological examinations.

Discussion

Perfusion MRI has been used to demonstrate tumor vascularity and angiogenesis noninvasively with good correlations with histological assessments. As a result, the imaging technique can be used to differentiate brain tumors with high tumor vascularity from those with low tumor vascularity. In this regard, a hemangioblastoma showing significantly higher vascular perfusion (rCBV ratio 7.7–11.4) can be accurately distinguished from other posterior fossa tumors with similar imaging findings on conventional MRI, such as metastases (rCBV ratio 5.3) and pilocytic astrocytoma (rCBV ratio 1.8), by using DSC MRI in adult patients. Although DSC imaging has been most commonly used for evaluating brain tumor perfusion, it is noteworthy that the pulse sequence using a single-shot gradient-echo EPI technique is vulnerable to magnetic susceptibility artifacts and image distortion, particularly pronounced at the brain-bone-air interfaces or the posterior fossa. Such degraded image quality affecting the results of DSC MRI is especially problematic in pediatric patients because pediatric brain tumors are commonly located in the posterior fossa. Consequently, DSC imaging was not performed in our case with medullary hemangioblastoma. Instead of DSC imaging, pseudo-continuous ASL and DCE imaging were performed to evaluate tumor vascularity and permeability in our case.

As in DSC imaging, the rTBF ratio measured by ASL imaging, the rTBF ratio measured by ASL

![FIG. 2. Surgical and histopathological findings. An intraoperative photograph (left) shows dilated vessels over a well-defined pinkish-gray tumor (arrows). A photomicrograph (right) demonstrates a proliferation of capillaries and large, neoplastic stromal cells with foamy cytoplasm and hyperchromatic nuclei. H & E, original magnification x100. Figure is available in color online only.](image-url)
imaging in adults was significantly higher in hemangioblastoma than in metastases (8.0 vs 3.0, p < 0.05)\(^7\) and in other brain tumors including gliomas, meningiomas, and schwannomas.\(^7\) Only a metastasis from renal cell carcinoma showed a very high rTBF ratio (16.2) comparable to that of hemangioblastoma.\(^7\) In our case, increased blood flow in the tumor on ASL imaging was almost vascular, not only according to the visual assessment, but also by the quantitative assessment (rTBF ratio 11.8), which was quite useful in suggesting hemangioblastoma as the most probable diagnosis of the tumor. ASL imaging is regarded to be particularly advantageous in children because it does not require the intravenous injection of a contrast agent at a high injection rate that is usually necessary for quality DSC imaging and it has fewer susceptibility artifacts than DSC imaging. It should be noted that all hemangioblastomas evaluated with DSC or ASL imaging have been reported in adults but not in children.\(^4–7\)

In a review article,\(^2\) the time-intensity curve pattern of DCE imaging in the solid portion of the tumor was almost identical to that in the dural venous sinus in an adult with cerebellar hemangioblastoma, as in our case. In the same case, the authors also described that the permeability map of DCE imaging showed significantly high permeability in the solid portion of a cerebellar hemangioblastoma.\(^2\) However, the latter description is probably incorrect because hemangioblastoma characteristically shows very high vascularity and low vascular permeability, actually proven by high Kep and Vp values and low Ktrans and Ve values in our case. Because we have only limited experience with DCE imaging in hemangioblastoma, we need further evidence to confirm this low vascular permeability initially described in our case.

Compared with pilocytic astrocytomas showing no or minimal peritumoral edema, hemangioblastomas tend to demonstrate moderate to severe peritumoral edema on conventional MRI.\(^3\) Our case also showed considerable peritumoral edema. In contrast, serpentine flow voids on MRI, one of the characteristic findings of hemangioblastoma, were not identified, even on susceptibility-weighted imaging in our case. As a result, preoperative angiography or embolization was not performed. However, dilated vessels were recognized around the tumor at surgery, which was deemed responsible for vascular tumor perfusion on ASL and DCE imaging. A clinical history of VHL disease was not established at initial presentation in our case, which complicated the preoperative diagnosis of the medullary tumor. After histological confirmation of the medullary tumor, we found a retinal capillary hemangioma in the patient as well as a family history of retinal capillary hemangioma. Finally, the association of medullary hemangioblastoma with VHL disease was confirmed by a genetic study in this patient.

In conclusion, although medullary hemangioblastoma rarely occurs in children, we could demonstrate that vascular tumor perfusion depicted by ASL and DCE imaging was very useful for distinguishing hemangioblastoma from other pediatric medullary tumors with similar conventional MRI findings (such as pilocytic astrocytoma, oligodendroglioma, and ganglioglioma) in a child with VHL disease.

References


Author Contributions

Conception and design: Goo. Acquisition of data: Goo. Analysis and interpretation of data: Goo. Drafting the article: Goo. 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: Goo. Administrative/technical/material support: both authors. Study supervision: Goo.

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