Posterior fossa Hodgkin’s lymphoma radiographically mimicking an arteriovenous malformation: illustrative case

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Background

Intracranial Hodgkin’s lymphoma (HL) is an exceedingly rare condition that is at an increased risk of misdiagnosis and mismanagement, especially when initial radiographic evidence points to an alternative pathology.

Observations

The authors describe the case of a 75-year-old female who presented with a posterior fossa lesion initially concerning for a vascular malformation on computed tomography imaging due to perilesional hypervascularity. Subsequent angiography revealed a developmental venous anomaly (DVA) but no arteriovenous shunting. The patient’s clinical history combined with magnetic resonance imaging findings prompted a tissue biopsy, which demonstrated a rare case of central nervous system (CNS) HL. The neoangiogenesis of this CNS HL with an adjacent DVA contributed to the original radiographic misdiagnosis of an arteriovenous malformation. HL’s angiogenic potential, coupled with the proangiogenic environment induced around DVAs, may have contributed to this rare CNS HL metastasis to the cerebellum. The potential misdiagnosis of posterior fossa CNS HL has also been seen in several prior cases reviewed herein.

Lessons

Hypervascular tumors, especially when associated with an adjacent DVA, should also be considered when first evaluating suspected intracranial vascular lesions. Although rare, CNS HL should be included in the differential diagnosis for patients with a prior history of HL.

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Abbreviations

ADC = apparent diffusion coefficient; AVM = arteriovenous malformation; CNS = central nervous system; CT = computed tomography; CTA = CT angiography; DVA = developmental venous anomaly; GBM = glioblastoma; HL = Hodgkin’s lymphoma; MRI = magnetic resonance imaging; MRS = magnetic resonance spectroscopy; PET = positron emission tomography; RT = radiation therapy; VEGF = vascular endothelial growth factor.

Keywords

intra cranial Hodgkin’s lymphoma; developmental venous anomaly; central nervous system Hodgkin’s lymphoma; posterior fossa lymphoma metastasis; neuroradiology

Notes

Hodgkin’s lymphoma (HL) is a hematological malignancy arising from B lymphocytes, in which central nervous system (CNS) involvement is extremely rare, seen in only 0.02%–0.5% of cases. HL typically presents as a supratentorial parenchymal lesion associated with various focal neurological deficits, seizures, and mass effect symptoms similar to those in other intracranial space-occupying lesions. Histopathological diagnosis requires a tissue sample demonstrating the classic Reed-Sternberg cells expressing CD15 and CD30. The literature regarding the treatment of CNS HL is limited due to the disease’s rarity; however, case reports and series generally describe resection followed by a combination of radiation therapy (RT) and chemotherapy, such as doxorubicin, bleomycin, vinblastine, and dacarbazine. Rare neoplasms, such as CNS HL, are often low on the differential diagnosis of intracranial lesions and naturally carry an increased risk for misidentification and potentially delayed diagnosis and treatment. This risk can be compounded by various imaging features that mimic more common intracranial lesions. For instance, the presence of a dural attachment has been reported in several cases of histopathologically confirmed CNS HL, which the authors had originally thought were meningiomas. Furthermore, significantly vascularized tumors can sometimes be mistaken for vascular malformations, potentially confounding the initial diagnostic workup. A few cases of hypervascular anaplastic oligodendrogliomas have been reported in which the original radiographic diagnosis was arteriovenous malformation (AVM) based on magnetic resonance imaging (MRI). Similarly, cases of...
hypervascular glioblastomas (GBMs) and hemangioblastomas have been initially mistaken for AVMs based on significant flow voids on MRI and arteriovenous shunting on angiography. In all of these cases, the patients underwent conventional catheter angiography to evaluate each lesion’s angioarchitecture before obtaining a final tissue diagnosis due to significant tumor neovascularization.

The neovascularization potential of CNS HL has yet to be explored in the literature. However, non-CNS HL has been associated with significant angiogenesis promoted by its tumor microenvironment and the expression of various endothelial growth factors. When compared to healthy individuals, patients with HL have been shown to have a significantly higher number of endothelial progenitor cells as well as increased concentrations of vascular endothelial growth factor (VEGF) A in the bloodstream. This angiogenic potential likely contributes to tumor growth and metastasis, which may factor into its presentation in the CNS. We describe the case of an older female who presented with a posterior fossa lesion initially suspected to be a vascular malformation but later revealed by angiography and tissue diagnosis to be a rare case of CNS HL. We used the CARE case report guidelines and checklist when writing this report.

Illustrative Case

A 75-year-old female had a history of metastatic HL diagnosed 1 year prior to presentation that was treated with brentuximab vedotin, doxorubicin, vinblastine, and dacarbazine (AAVD regimen) with complete remission on positron emission tomography (PET) scanning 6 months prior to presentation. She presented to the emergency department with a 1-week history of intermittent headaches and vertigo. Neurological examination revealed no focal deficits. Head computed tomography (CT) demonstrated a 2.3 × 2.2-cm right cerebellar hyperdensity with surrounding edema and significant compression of the fourth ventricle with moderate hydrocephalus (Fig. 1A and B), suspected to be a subacute hemorrhage. CT angiography (CTA) showed conspicuous vascularity circumferentially with a larger, more prominent vessel extending from the lesion along the lateral right cerebellum (Fig. 1C and D). Given the hypervascularity of the lesion on initial imaging, she was initially suspected to have a ruptured AVM and was admitted to the neurosurgical intensive care unit on a nicardipine drip for strict blood pressure control.

Cerebral angiography was performed the following day to assess the nature of the suspected vascular lesion. While no nidus or arteriovenous shunting was observed, a right cerebellar developmental venous anomaly (DVA) was seen draining into the tentorium and the torcula with no evidence of arteriovenous shunting. The necessary patient informed consent was obtained in this study.

Axial (A) and coronal (B) noncontrast head CT images from admission showing a 2.2 × 2.3-cm hyperdensity in the medial aspect of the right cerebellar hemisphere with moderate surrounding edema and crowding of the posterior fossa. Corresponding axial (C) and coronal (D) CT angiograms of the head reveal a prominent abnormal vessel superolateral to the hyperdense lesion, as well as some hypervascularity noted circumferentially around the lesion (best seen on the coronal image). Anteroposterior (E) and lateral (F) images from the early venous phase of a right vertebral artery injection, as part of a diagnostic catheter angiogram, reveal the presence of a large right superior cerebellar DVA (blue arrowheads) draining toward the tentorium and the torcula with no evidence of arteriovenous shunting.

Patient Informed Consent

The necessary patient informed consent was obtained in this study.
Discussion

Observations

In this case, the hypervascularity and adjacent DVA mimicking an AVM, combined with the rarity of CNS HL, largely contributed to the delay in diagnosis. CNS lymphomas are typically hyperdense on non-contrast CT because of their high cellular density and high nuclear/cyttoplasmic ratio. A large AVM nidus can often appear as a hyper-density on noncontrast CT, especially when associated with an acute or subacute hemorrhage, which accounted for the initial concern in this case. After angiography revealed no nidus or arteriovenous shunting and the presence of the DVA, MRI was performed and demonstrated features highly suggestive of lymphoma. On conventional MRI without contrast, the hypercellularity of CNS lymphoma gives it an isodense appearance relative to gray matter. Homogeneous contrast enhancement on MRI is generally seen in immunocompetent patients, with ring-enhancing lesions being more common in immunocompromised patients due to the higher rate of necrosis. It is important to note that steroids were not given to our patient prior to her imaging studies, as steroids have been shown to decrease contrast enhancement in CNS lymphoma likely due to normalization of the blood-brain barrier. As seen in our patient, lymphomas demonstrate restricted water diffusion on diffusion-weighted imaging with corresponding low apparent diffusion coefficient (ADC) values consistent with high cell density. As another tool in the arsenal of diagnostic imaging, MRS utilizes nuclear magnetic resonance, which can distinguish specific compounds based on their resonant frequency and how they vary with their surrounding chemical environment. The combined evidence of MRI and MRS findings, along with the patient's history and lack of arteriovenous shunting on catheter angiography, ultimately prompted our decision to biopsy this lesion.

As previously mentioned, the extreme rarity of CNS HL was another contributing factor to this patient’s delay in diagnosis and initial suspicion of a more common vascular lesion. A recent review by Lee et al. identified 47 cases of intracranial HL between 1980 and 2023. The average age at diagnosis of CNS HL was 53.3 years, and only 16 lesions were found in the posterior fossa, as seen in Table 1. Homogeneous contrast enhancement on CT or MRI, with 44% having dural attachments, but none were associated with an adjacent vascular lesion or noted hypervascularity. When imaging was performed, the most common initial suspected lesion solely based on imaging was menigioma, largely based on the presence of a dural attachment and homogeneous enhancement. Angiography was performed in only 1 of these lesions showing an “avascular mass” (the reason for this imaging was not reported, but it was likely utilized for surgical planning). Of these 16 posterior fossa CNS HL cases, 13

FIG. 2. Coronal (A) and axial (B) postcontrast T1-weighted MRI at the level of the medulla and the pons (C) showing a homogeneously enhancing right paramedian cerebellar lesion with irregular borders and the previously noted large venous anomaly superolateral to the lesion. Axial T2 fluid-attenuated inversion recovery MRI (D) at the level of the pons demonstrating significant edema surrounding the lesion and extending to the right brachium pontis and medial left cerebellar hemisphere. A flow void is notable at the area of the venous anomaly. Axial diffusion-weighted MRI (E) and ADC map (F) showing moderate diffusion restriction throughout the right cerebellar lesion. MRS (G) of the right cerebellar mass demonstrating an elevated choline/creatine ratio and elevated lipid peaks suggestive of a malignant neoplasm, especially concerning for lymphoma.
were resected, 6 were treated with chemotherapy, 13 were treated with RT, and 1 was additionally treated with immunotherapy.

In addition to the general rarity of CNS HL (especially in the posterior fossa), the initial imaging findings in this case, including perilesional hypervascularity with a large draining vein—later determined to be a DVA—confounded the initial differential diagnosis as a presumptive vascular malformation. DVAs are vascular lesions comprising radially oriented medullary veins, or "caput medusa," draining normal brain parenchyma coalescing to form a single dilated venous structure, with a prevalence of about 3% in the general population. DVAs are mostly asymptomatic unless compression of adjacent intracranial structures by the DVA or thrombosis of the vein occurs. Observation is the typical management for these generally incidental and benign lesions, as their obliteration risks venous infarct. While there remains no consensus on the precise etiology of DVAs, most theories revolve around alterations in fetal cerebral hemodynamics that lead to compensatory DVA formation. The hemodynamics of DVAs are thought to play a role in the pathogenesis of associated cavernous malformations (cavernomas). Specifically, the chronic pressure elevation at the confluence of the caput medusa medullary veins with the main draining vein results in repeated microhemorrhages inducing cavernoma formation by activating VEGF and other angiogenic growth factors.

The proposed pathogenesis of DVA-induced cavernoma formation raises the question of whether other lesions, mainly neoplasms, can also take advantage of the proangiogenic environment surrounding DVAs. The metastatic spread of neoplasms to the CNS relies on several features of the individual cancer, with tumor angiogenesis and a proangiogenic environment playing crucial roles. Specifically, the colonization and proliferation of a metastatic lesion in the CNS depend on neoangiogenesis, largely driven by VEGF expression, which has been observed in colon carcinoma and melanoma, among other cancers. While the specific association between DVAs and CNS HL has not been previously examined, HL is also associated with increased levels of proangiogenic factors in the bloodstream, including VEGF. Hypervascular HL may be more likely to develop at the site of a DVA rather than an alternative CNS site due to the proangiogenic environment induced by the DVA. Additionally, DVAs have previously been observed in conjunction with pediatric gliomas, adult diffuse gliomas, and rare thalamic gliomas. In most of these studies regarding primary CNS neoplasms, however, the location of the DVA does not seem to impact the location of tumor development, as many DVAs are found distant from the associated lesion. The colocalization of DVAs with either primary or metastatic intracranial neoplasms has yet to be explored in the literature, although a recent case report identified a DVA inside of a large GBM. Further exploration of adjacent venous anomalies coinciding with CNS tumors may be of interest in potentially revealing novel aspects of neoplastic pathogenesis and metastatic potential.

In our patient, a diagnosis of HL was suspected after angiography showed no evidence of arteriovenous shunting and MRI demonstrated

![Histopathological findings from the needle biopsy.](image)
### TABLE 1. Posterior fossa histopathologically confirmed CNS HL in the literature from 1980 to 2023

<table>
<thead>
<tr>
<th>Authors &amp; Year</th>
<th>Age (yrs)</th>
<th>Sex</th>
<th>Location</th>
<th>Imaging Findings*</th>
<th>Treatment</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Doorly et al., 1987</td>
<td>51</td>
<td>M</td>
<td>Cerebellar hemisphere</td>
<td>CT w/ contrast: “uniformly enhancing, surrounding edema, 4th ventricular compression”</td>
<td>Chemo, Rx, RT</td>
<td>NED at 1 yr</td>
</tr>
<tr>
<td>Clark et al., 1992</td>
<td>53</td>
<td>F</td>
<td>Paravermian</td>
<td>MRI w/ contrast: enhancing mass w/ area of hypointensity posteriorly, mild hydrocephalus</td>
<td>Rx, RT</td>
<td>NED at 6 mos</td>
</tr>
<tr>
<td>Johnson et al., 2000</td>
<td>55</td>
<td>F</td>
<td>Cerebellar hemisphere/ tentorial</td>
<td>MRI w/ contrast: homogeneously enhancing, dural tail, mild hydrocephalus</td>
<td>Rx, RT</td>
<td>NED at 8 mos</td>
</tr>
<tr>
<td>Figueroa et al., 2004</td>
<td>23</td>
<td>F</td>
<td>Cerebellar hemisphere</td>
<td>MRI w/ contrast: homogeneously enhancing, dural attachment</td>
<td>Chemo, Rx</td>
<td>NR</td>
</tr>
<tr>
<td>de Castro et al., 2007</td>
<td>63</td>
<td>M</td>
<td>Cerebellar hemisphere</td>
<td>MRI w/ contrast: ring enhancing, no significant surrounding edema</td>
<td>RT</td>
<td>NR</td>
</tr>
<tr>
<td>Hwang et al., 2007</td>
<td>64</td>
<td>F</td>
<td>Cerebellar hemisphere</td>
<td>MRI w/ contrast: nodular enhancing mass, surrounding edema</td>
<td>Rx, RT</td>
<td>NED at 16 mos</td>
</tr>
<tr>
<td>Gessi et al., 2013</td>
<td>77</td>
<td>M</td>
<td>Cerebellar hemisphere</td>
<td>MRI w/ contrast: homogeneously enhancing, dural attachment</td>
<td>Rx, RT</td>
<td>NED at 6 mos, died at 8 mos due to myocardial infarction</td>
</tr>
<tr>
<td>Gessi et al., 2013</td>
<td>59</td>
<td>M</td>
<td>Medulla</td>
<td>MRI w/ contrast; homogeneously enhancing</td>
<td>NR</td>
<td>NR</td>
</tr>
<tr>
<td>Kresak et al., 2013</td>
<td>70</td>
<td>M</td>
<td>Cerebellar hemisphere/ tentorial</td>
<td>MRI w/ contrast: “enhancing mass w/ edema &amp; mass effect,” “dural attachment”</td>
<td>Rx, RT</td>
<td>NED at 10 yrs</td>
</tr>
<tr>
<td>Kresak et al., 2013</td>
<td>72</td>
<td>F</td>
<td>Cerebellar hemisphere/ tentorial</td>
<td>MRI w/ contrast: homogeneously enhancing, dural attachment, surrounding edema, 4th ventricular compression</td>
<td>Rx, RT</td>
<td>NED at 6 mos</td>
</tr>
<tr>
<td>Henkenberens et al., 2014</td>
<td>47</td>
<td>M</td>
<td>Multifocal: vermian, cerebellar hemisphere, tentorial</td>
<td>MRI w/ contrast: nodular enhancing, dural attachment, surrounding edema, 4th ventricular compression, mild hydrocephalus</td>
<td>Chemo, Rx, RT</td>
<td>NED at 9 mos</td>
</tr>
<tr>
<td>Sharaf et al., 2014</td>
<td>77</td>
<td>M</td>
<td>Cerebellar hemisphere</td>
<td>MRI w/ contrast: heterogeneously enhancing, dural attachment, surrounding edema</td>
<td>Rx, RT</td>
<td>NED at 7 mos</td>
</tr>
<tr>
<td>Martinez et al., 2014</td>
<td>74</td>
<td>F</td>
<td>Pontomedullary</td>
<td>MRI w/ contrast: homogeneously enhancing, 4th ventricular compression, mild hydrocephalus</td>
<td>RT</td>
<td>NED at 6 mos</td>
</tr>
<tr>
<td>Alfaseh et al., 2019</td>
<td>38</td>
<td>M</td>
<td>Vermian</td>
<td>MRI w/ contrast: homogeneously enhancing, surrounding edema, 4th ventricular compression, mild hydrocephalus</td>
<td>Chemo, Rx, RT</td>
<td>NED at 7 yrs</td>
</tr>
<tr>
<td>Szczepanek et al., 2020</td>
<td>33</td>
<td>F</td>
<td>Vermian/intraventricular</td>
<td>MRI w/ contrast: homogeneously enhancing</td>
<td>Chemo, Rx, RT</td>
<td>NR</td>
</tr>
<tr>
<td>Fu et al., 2021</td>
<td>60</td>
<td>M</td>
<td>Cerebellar hemisphere</td>
<td>MRI w/ contrast: nodular enhancing mass, surrounding edema, 4th ventricular compression, moderate hydrocephalus</td>
<td>Chemo, Rx, Ix</td>
<td>NED at 5 yrs</td>
</tr>
</tbody>
</table>

* = immunotherapy; NED = no evidence of disease; NR = not reported; Rx = resection.
* Findings are reported when imaging was provided in the study; otherwise, findings inside quotation marks appear when no images were provided.
features concerning for lymphoma. After tissue diagnosis, the decision was made to pursue a primarily chemotherapy-based treatment paradigm rather than attempt resection, given the patient's previously robust response to chemotherapy after her initial systemic diagnosis. Additionally, the surgical risk of injuring the adjacent large DVA, which likely contributed to a significant portion of this patient's cerebellar venous drainage, was believed to be significant.

Lessons
We report a case of histopathologically confirmed CNS HL, which, in combination with likely opportunistic neoangiogenesis and adjacent DVA, radiographically mimicked an AVM on initial CTA. Conventional catheter angiography was crucial in ruling out an AVM before proceeding with the tissue biopsy that yielded a definitive diagnosis of CNS HL. The limitations of this case revolve around its nature as a single retrospective case report and the inability to draw comparisons in combination with likely opportunistic neoangiogenesis and adjacent venous drainage, which was believed to be significant.

This unique case demonstrates the need to maintain a broad differential when evaluating intracranial lesions and the thorough utilization of diagnostic imaging to eventually confirm a diagnosis. DVAs and other anatomical lesion characteristics may complicate diagnosis, especially when a rare neoplasm is involved, such as CNS HL.

As seen in this case, cerebral angiography is an invaluable tool for evaluating suspected vascular lesions on conventional brain imaging and avoiding the pitfalls associated with misdiagnosing intracranial neoplasms as vascular malformations, which can result in a delay in treatment. Although rare, CNS HL should be kept on the differential of intracranial space-occupying lesions, especially in a patient with a prior history of HL.

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References
the central nervous system. Acta Neurochir (Wien).

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Author Contributions
Conception and design: Papadimitriou, Singer, Link. Acquisition of data: McBriar, Papadimitriou, Golub, Singer, Black, Link. Analysis and interpretation of data: Papadimitriou, Golub, Donaldson, Li, Link. Drafting the article: McBriar, Papadimitriou, Golub, Donaldson, Li, Link. Reviewed submitted version of manuscript: McBriar, Papadimitriou, Golub, Li, Link. Approved the final version of the manuscript on behalf of all authors: McBriar. Administrative/technical/material support: Golub. Study supervision: Singer, Link. Final diagnosis and interpretation on histological examination: Khattar.

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