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CT and MRI Findings of Intracranial Cavernous Hemangioma Malformation

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Abstract: *Objective:* To investigate the computed tomography (CT) and magnetic resonance imaging (MRI) features of cavernous hemangioma malformation (CHM) to enhance diagnostic accuracy. *Methods:* The CT and MRI findings and clinical information of 23 patients with CHM were retrospectively analyzed. *Results:* CT examinations were conducted in 7 cases, while MRI was utilized in 23 cases. Additionally, SWI was employed in 5 cases and enhanced imaging techniques were applied in 14 cases. Among the observed lesions, 20 cases presented with a singular lesion, whereas 3 cases exhibited multiple lesions. The lesions were located in 8 frontal lobes, 6 cerebellums, 2 brainstems, 6 temporal lobes, 1 basal ganglia, 3 parieto-occipital lobes, and 2 thalamus regions. The nodules appeared as quasi-circular lesions with clear or well-defined boundaries. They presented as isodense lesions on CT scans, with one lesion showing peritumoral edema. On MRI, T1-weighted imaging (T1WI) demonstrated isointense signals, while T2-weighted imaging (T2WI) showed isointense and hyperintense signals. Additionally, 10 lesions exhibited a low signal ring on T2WI. Diffusion-weighted imaging (DWI) revealed nodular or isointense low signals, while susceptibility-weighted imaging (SWI) displayed enlarged areas of low signal. Fourteen lesions underwent contrast-enhanced scanning, with 2 lesions showing no obvious enhancement, 1 lesion demonstrating mild to moderate enhancement, and 11 lesions exhibiting significant enhancement. Notably, 6 of these enhanced lesions were surrounded by small blood vessels. *Conclusion:* Cavernous hemangioma malformation is more commonly found in individual cases. CT alone lacks specificity, making it prone to misdiagnosis. A more comprehensive evaluation of cavernous hemangioma malformation can be achieved through a combination of MRI, DWI, SWI, and enhanced examination, providing valuable references for clinical assessment.

Keywords: Cavernous hemangioma malformation; Intracranial; CT; MRI; Diagnosis

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1. Introduction

Cavernous hemangioma malformation (CHM), also known as cavernous angioma or cavernous hemangioma, is a type of cerebral vascular malformation. It may manifest sporadically, with developmental venous abnormalities, or it may be familial [1,2]. Despite typical magnetic resonance imaging (MRI) features, the imaging manifestations of certain lesions can be complex due to hemorrhage and cystic degeneration. A

retrospective analysis of routine computed tomography (CT) and MRI sequences, including diffusion-weighted imaging (DWI), susceptibility-weighted imaging (SWI), and enhanced examinations, was conducted in 23 patients with surgically confirmed intracranial cavernous hemangioma malformation. The aim was to enhance understanding and preoperative diagnosis of this condition and provide better references for clinical decision-making.

2. Materials and methods

2.1. Clinical presentation

A total of 23 patients diagnosed with CHM, confirmed by pathology from January 2012 to January 2024, were included in the study. The cohort consisted of 11 males and 12 females, with ages ranging from 14 to 69 years. Nine cases presented clinical symptoms such as chest tightness, back pain, and cough, while one case exhibited binocular fatigue. Additionally, nine cases were incidentally discovered during routine health physical examinations. No endocrine abnormalities were found in the remaining cases. This study was reviewed and approved by the hospital's Ethics Committee, and patient-informed consent was not required.

2.2. Imaging technical

A CT plain scan was performed in 7 cases using the Somatom Definition scanner. The tube voltage was set at 120 kV, with a current of 35 mAs, and a slice thickness of 8 mm. MRI was performed in 23 cases, SWI in 5 cases, and enhanced MRI in 14 cases. The MRI was conducted using a Philips Ingenia 3.0T MR scanner with a dedicated cranial coil. Scan parameters were as follows: FSE T2WI, repetition time (TR)/echo time (TE), 4,000/115 msec; T1WI, TR/TE 600–900/10−20 msec; FLAIR, TR/TE 6,000–9,000/120 msec; DWI, TR/TE 2,163–2,626/78–97 msec; contrast-enhanced TR/TE 8–214/2.5–4 msec. A matrix size of 256 × 256, slice thickness of 53.6 mm, and FOV of 256 mm × 256 mm were used.

2.3. Image analysis

The imaging data of all patients were analyzed to evaluate the location, size, shape, boundary, density, and signal enhancement of the lesions.

3. Results

There were 20 cases of a single lesion and 3 cases of multiple lesions. The distribution of the lesions was as follows: 8 in the frontal lobe, 6 in the cerebellum, 2 in the brainstem, 6 in the temporal lobe, 1 in the basal ganglia, and 3 in the parieto-occipital lobe. Additionally, there were 2 cases located in the thalamus. The length and diameter of the lesions ranged from 0.6 to 3.5 cm. Plain CT scans revealed equal or high density in 7 cases, with CT values ranging from 20 to 85 Hounsfield units (HU). The CT value exceeded 60 HU in 6 cases, and one of the lesions exhibited peritumoral edema (**Figure 1**).

The lesions exhibited iso-high and iso-hypointensity on T1WI, as well as iso-hypointensity or hypointensity on T2WI. Specifically, 10 cases showed a low signal ring around the lesions on T2WI, and 7 cases showed nodular hypointensity or iso-hypointensity on DWI (**Figure 2**). Additionally, 5 SWI examinations revealed hypointensity and enlarged lesions. Enhanced scans were conducted in 14 cases, with 2 cases showing no obvious enhancement, 1 case demonstrating mild to moderate enhancement, and the remaining cases displaying significant enhancement. Notably, small blood vessels around the lesion were observed in 6 of these cases (**Figure 3**).

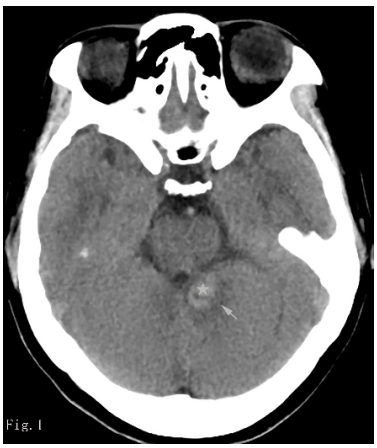

Figure 1. Female, 42 years. Presented with intermittent headache and dizziness for the past month. CT plain scan revealed a circular high-density shadow (star) near the fourth ventricle of the right and left cerebellar hemispheres, surrounded by a circular low-density edema band (arrow).

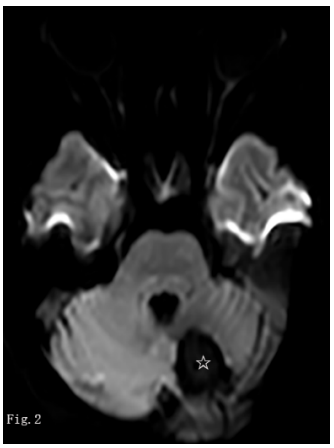

Figure 2. Female, 46 years. Presented with dizziness for the past 4 days. The DWI image of the left cerebellar hemisphere showed a low signal (star).

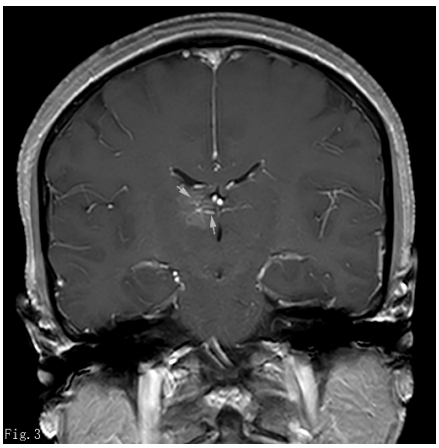

Figure 3. Female, 46 years old. Presented with limb convulsions for 20 years, aggravated over the past month. T1WI enhanced scan revealed abnormally enhanced signal shadows in the right dorsal thalamus, along with multiple small blood vessel shadows (arrow).

4. Discussion

This retrospective study aimed to analyze the CT and MRI multi-modality imaging of intracranial cavernous hemangiomas to improve lesion analysis, enhance preoperative diagnostic accuracy, and provide imaging reference for its management strategy.

The prevalence of cavernous hemangiomas is 0.57%, with the number of cavernous hemangiomas ranging from 1 to 79 [3]. There were three cases of multiple occurrences in this group. The average onset age of the disease is approximately 47 years [3]. The majority of patients in this group are middle-aged and elderly individuals over 50 years old, which may be attributed to differences in treatment choices. No significant gender disparity is observed in the prevalence of this disease [3]. The proportion of female patients in this group is approximately 12 out of 23, which may be attributed to the small sample size. The most prevalent clinical manifestations include seizures, symptomatic bleeding, and focal neurological deficits, with some patients remaining asymptomatic [2]. Most patients with CHM lack specific clinical manifestations, which are mainly related to the location and size of the lesion and the infiltration of adjacent structures. The presence or absence of symptoms may be related to the plasma level [1]. Several studies have indicated that the size of CHM increases with age [3].

CHM can manifest in any part of the brain and may even be confined to the sulcus [4,5]. Supratentorial lesions are more prevalent [6,7], with the focus of the frontoparietal and temporal lobes in this group accounting for 60.7%, while the brainstem accounts for a smaller portion [8]. The percentage of brainstem lesions in this group was 7.1%, which is consistent with previous reports. The brainstem remained unaffected in patients with negative genetic testing, whereas the infratentorial region was more frequently affected in patients with mutations [9]. Most patients with CHM are well-defined, oval or circular, and obscure with surrounding tissue. On plain CT scans, it can be an isodensity or high-density lesion with calcification, and mass effect or peri-focal edema is uncommon [10]. In this group, 7 cases showed homogeneous iso- or high-density. If the CT scan shows a blood-bloody lesion, cavernous hemangioma may

be masked [2,11]. Hence, the CT findings lack specificity [10]. However, they can be utilized for prompt diagnosis. The differential diagnosis on CT includes low-grade calcified tumors, bleeding, and vascular malformations [12].

Typical MRI findings are as follows: all sequences showed characteristic hypointense margins around the lesion, especially on T2WI and SWI, such as "morula-like" or "popcorn" on T2WI and FLAIR. When CHM was very small, CHM was not evident on most conventional sequences, but only on high-resolution SWI. Gadolinium contrast enhancement varies from no to moderate levels of enhancement [10]. However, the MRI findings of patients with bleeding revealed round, oval, or lobulated mixed-signal masses, accompanied by mild edema and mass effect around them. Hemorrhagic CHMs were often accompanied by developmental venous anomalies (DVA) [13]. The lesions in this group showed iso-high, iso-hypointensity on T1WI, and iso-hypointensity, iso-hypointensity, and hyperintensity on T2WI, reflecting the signal change of the lesion to varying degrees. It is worth noting that DWI showed that the lesion was nodular hypointensity or iso-hypointensity, reflecting the diffuse condition of the lesion. Small blood vessels were observed around 6 lesions. This finding is of diagnostic reference value and suggests cerebral venous malformation, with studies indicating that its integrity should be maintained [14]. CHM mostly occurs in the supratentorial region, and recurrent intracranial hemorrhage is one of the main manifestations. SWI has significant implications for its rupture risk [4]. The correspondence between CT and SWI is also meaningful. Two cases exhibited a mulberry-like appearance, and 10 cases displayed a "hemosiderin ring" on T2WI [2], considered to be caused by repeated subclinical bleeding [10]. The MRI features are typical and occur in the brainstem, which should be differentiated from hemangiosarcoma, distinguishable by rapid lesion growth and progression of clinical symptoms [15].

Conservative treatment, microsurgical resection, and stereotactic radiosurgery are the three main options for CHM treatment [3]. One of the most controversial topics in neurology and neurosurgery practice is the management of this disease. Follow-up studies have found that lesion growth or new lesion blood may be a more sensitive biomarker for lesion activity, especially in patients with single/sporadic CHM, who are more likely to receive surgical intervention [16]. Some studies have found that surgical treatment of cavernous malformation in the basal ganglia area and thalamus can improve neurological function, but complete resection should be attempted to reduce the occurrence of re-bleeding [17]. Additionally, surgery can reduce seizures in patients with epilepsy [6], but the adverse reaction rate of infratentorial focus is higher than that of supratentorial [7]. Due to the high risk of bleeding, the treatment of CHM should be strictly followed up and actively treated [18].

5. Conclusion

CHM is a common intracranial benign disease with potentially nonspecific clinical manifestations. CT alone can lead to misdiagnosis, while an MRI plain scan combined with enhancement and SWI can better display the peripheral vascular condition, aiding clinical decision-making.

Disclosure statement

The authors declare no conflict of interest.

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