Study on the Clinical, Imaging, and Pathological Characteristics of 18 Cases with Primary Central Nervous System Vasculitis

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Background: To summarize the characteristics of primary central nervous system vasculitis from clinical, imaging, and pathological aspects by retrospective study. *Methods:* From March 2015 to December 2017, the data of the inpatients of primary central nervous system vasculitis in first Hospital of Jilin University were collected, and their clinical manifestation, imaging, and pathological characteristics were analyzed by using a descriptive method. *Results:* There were 18 patients, 10 males (55.56%) and 8 females (44.44%) separately. The age ranges from 16 years old to 49 years old, with the median age of 32 years old. There were 8 cases (44.44%) of epileptic seizure, 6 cases (33.33%) of abnormal behavior and cognition, 10 cases (55.56%) with sensorimotor abnormalities, 4 cases (22.22%) with dizziness, 4 cases (22.22%) with headache, 2 cases (11.11%) with facial pain, 2 cases (11.11%) with blurred vision, and 2 cases (11.11%) with unstable walking. Eight patients (44.44%) were identified with cerebral spinal fluid abnormalities. There were 12 cases (66.67%) with bilateral lesions and 6 cases (33.33%) with unilateral lesions, including the frontal lobe (18 cases, 100%), the parietal lobe (10 cases, 55.56%), the temporal and occipital lobe (8 cases, 44.44%). There were 12 cases (66.67%) combined with subcortical white matter involvement, 6 cases (33.33%) combined with meningeal involvement, 2 cases (11.11%) complicated with basal ganglia involvement and 2 cases (11.11%) complicated with spinal cord involvement. Most of the lesions were with unclear border (16 cases, 88.89%), 2 cases (11.11%) were with clear border. Cortical atrophy was identified in 6 cases (33.33%). There were 12 cases (66.67%) with the enhancement of the lesions and meningeal. The 3D Vessel Wall magnetic resonance imaging (VW-MRI) showed uniform thickness in all patients (18/18) with contrast enhancement of the vessel wall of the vasculitis artery. *Conclusions:* The clinical manifestation and imaging in primary central nervous system vasculitis are diverse. The 3D VW-MRI could achieve quantification assessment of vasculitis and provide more utility for primary angiitis of the central nervous system.

Key Words: PACNS—primary central nervous system vasculitis—Vessel Wall MR imaging—VISTA—clinical characteristics

Abbreviations: PACNS, primary angiitis of the central nervous system; VW-MRI, Vessel Wall MR imaging; VISTA, volume isotropic turbo spin-echo acquisition

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Background

Primary angiitis of the central nervous system (PACNS), also known as primary cerebral vasculitis, is an unidentified, noninfectious, nonautoimmune disease that mainly occurs in the central nervous system, mostly involving the small and medium vessels and pial vascular vessels of the brain.[1] The incidence of PACNS is very low, but the pathological damage is significant, and the clinical diagnosis is difficult, which brings about great inconvenience to the clinical work.[2]

The clinical manifestations of PACNS are rather diverse. Precise diagnosis can be quite challenging due to the lack of vital laboratory tests or imaging features. Brain biopsy is still the gold standard for diagnosis, but due to the procedure's invasive feature, it has its own limitations. Thus, it is crucial to summarize the clinical cases of PACNS. As for the imaging approaches, traditional angiographies such as CTA (computed tomography angiography), MRA (magnetic resonance angiography), or DSA (digital subtraction angiography) were difficult to differentiate PACNS from other mimics due to the similar luminal findings, like tapering of the vessel lumen and multiple stenosis.[3] Recently, Vessel Wall magnetic resonance imaging (VW-MRI) has been used to evaluate cerebral vessels because it could directly show the vessel wall as well as the lumen, thus it can assist to differentiate various vasculopathies.

The purpose of our study was to summarize the typical clinical characteristics and imaging performance of PACNS, especially the value of 3D VW-MRI sequence in providing more thorough and detailed information in detection, diagnosis, evaluation, and follow-up for PACNS.

Methods

In reporting the current study, the standards for reporting diagnostic accuracy studies were followed. The study was not publicly registered.

Study Subjects

From March 2015 to December 2017, the data of 18 cases of inpatients of PACNS in the first Hospital of Jilin University were collected, and their clinical manifestations, imaging, and pathological characteristics were analyzed by descriptive methods. All patients met the primary central nervous system vasculitis diagnostic criteria established by Calabrese in 1988: (1) the presence of an acquired otherwise unexplained neurological or psychiatric deficit; (2) the presence of either classic angiographic or histopathological features of angiitis within the CNS; and (3) no evidence of systemic vasculitis or any disorder that could cause or mimic the angiographic pathological features of the disease. MRI imaging and pathological findings of the selected patients were retrospectively analyzed.

Imaging Protocols

All patients underwent scanning on Achieva 3-Tesla scanner (Philips Healthcare, Eindhoven, The Netherlands). T1WI, T2WI, , diffusion-weighted imaging, MRA, T1 VISTA (volume isotropic turbo spin-echo acquisition), susceptibility-weighted imaging, T1-enhanced VISTA images were collected in all these patients. The scanning parameters of VISTA are as follows: oblique coronal plane acquisition; variable refocusing flip angle; repetition time, 350 ms; echo time, 19 ms; field of view = 210 mm × 210 mm; acquired voxel size = .8 mm × .8 mm × .8 mm; before and after intravenous gadolinium (.1-.2 mmol/kg). A 12-channel head coil was used for the above sequences. All the images of these 18 patients were analyzed by a senior proficiency in neuroradiology and a senior physician in neurology to evaluate the location, characteristics, and severity of the lesion.

Pathology

Brain pathology was performed in 4 cases by neurosurgery with multimodal neural navigation to assist with stereotactic brain puncture. Biopsy brain tissue was stained with hematoxylin-eosin, immunohistochemical staining including LCA, CD20, CD3, CD4, CD8, MPO, CD15, GFAP, Olig2, P53, Ki67, NeuN, NF, MBP, CD68, etc.

Statistical Analysis

The statistical analysis was descriptive, undertaken by SPSS 22.0 (SPSS, IBM, West Grove, PA). Measurement data were shown by average value ± standard deviation or median with quartile according to its normality. Enumeration data were shown by percentage.

Results

Clinical Data Characteristics

A total of 18 patients were enrolled. The rate of male/female was 5:4, age ranged from 10-47 years old, with the median age of 30 years old. Clinical manifestations were summarized as follows: epileptic seizures in 8 cases (44.4%), abnormal behavior in 6 cases (33.33%), focal sensorimotor abnormalities in 10 cases (55.56%), dizziness in 4 cases (22.22%), blunt headache in 4 cases (22.2%), facial pain in 2 cases (11.12%), blurred vision in 2 cases (11.11%), and gait disturbance in 2 cases (11.11%). Eight patients (44.44%) showed abnormality in lumbar puncture tests: IgG (immune globulin G) synthesis rate, protein increase or cell number increase (Table 1). All patients were treated with prednisone to maintain treatment after steroids pulse therapy. Each patient was followed up 3 times, with each interval of 3 months.

Table 1. *Summary of clinical, cerebrospinal fluid, pathology, and treatment of primary central*

Case	Sex	Age	Clinical manifestation	Cerebrospinal fluid examination	Biopsy	Treatment
1	F	46	Slow response for 10 months, right facial pain for 6 months	No abnormalities	/	Methylprednisolone impact/prednisone maintain
2	M	48	Convulsion for 6 months	No abnormalities	/	Methylprednisolone impact/prednisone maintain
3	M	28	Right limb numb for 10 months	Protein 48.05	/	Methylprednisolone impact/prednisone maintain
4	F	32	Memory force decline with speech disorder for 5 months	No abnormalities	/	Methylprednisolone impact/prednisone maintain
5	F	32	Dizziness for 15 days	No abnormalities	/	Prednisone 60 mg, qd/predi Pine maintenance
6	M	28	Left limb dumb for 30 days	No abnormalities	/	Methylprednisolone impact/prednisone maintain
7	M	17	Paroxysmal left upper limb jitter with consciousness unclear 5 months	No abnormalities	/	Dexamethasone/prednisone maintenance
8	M	21	Left limb weakness for 3 months	No abnormalities	/	Methylprednisolone impact/prednisone maintain
9	F	23	Right limb numb for 1 month	No abnormalities	Brain tissue edema, partial degeneration, and necrosis; glial cell hyperplasia, tissue cell response; scattered lymphocytic infiltration, partial vascular wall thickening, intravascular and perivascular lymphocytes	Methylprednisolone impact/prednisone maintain + cyc
10	F	10	Headache and convulsion for 2 months, aggravating 2 weeks	No abnormalities	A few neutral granules cell infiltration; no obvious loss of myelin staining	Methylprednisolone impact/prednisone maintain
11	F	32	Right eye blurred for 20 days	IgG level increase	/	Methylprednisolone impact/prednisone maintain
12	F	25	Memory force decline with speech disorder for 1 month	No abnormalities	/	Methylprednisolone impact/prednisone maintain
13	M	16	Left limb dumb for 30 days	No abnormalities	/	Methylprednisolone impact/prednisone maintain
14	M	19	Paroxysmal limb twitching for 4 months	No abnormalities	/	Methylprednisolone impact/prednisone maintain
15	F	25	Right eye blurred for 20 days	No abnormalities	/	Methylprednisolone impact/prednisone maintain
16	M	31	Headache for 3 months, loss of consciousness 2 weeks	High ICP, protein 490 mg/L, RBC 1200 × 10 6/L; WBC 350 × 10 6/L	A large number of lymphocytes and phagocytic cells infiltrate, subarachnoid space and perivascular and blood vessels in the brain parenchyma and lymphocytes, phagocytic cells and scattered multinucleated giant cells infiltration, part of the blood vessels are occluded	Methylprednisolone impact/prednisone maintain + cyc

Table 1 (*Continued*)

Case	Sex	Age	Clinical manifestation	Cerebrospinal fluid examination	Biopsy	Treatment
17	F	38	Left limb weakness for 6 months	No abnormalities	/	Methylprednisolone impact/prednisone maintain
18	F	24	Right limb numb for 4 months	IgG increase, white blood cells 450 × 10 6/L, lymphocyte ratio 90%, mononuclear cell ratio 10%	A number of lymphocyte and phagocytic cells infiltrate	Methylprednisolone impact/prednisone maintenance + cyclophosphamide

Abbreviations: RBC, red blood cell; WBC, white blood cell.

Imaging Characteristics

All patients underwent routine head MRI, MRA, and 3D VW-MRI. The results showed that 12 cases (12/18, 66.7%) were bilateral lesions and 6 cases (6/18, 33.33%) were unilateral lesions. As for the lesion distributions: frontal lobe was involved in 18 cases (18/18, 100%), parietal lobe was involved in 10 cases (10/18, 55.56%), occipital lobe was involved in 8 cases (8/18, 44.44%), and subcortical white matter was involved in 12 cases (12/18, 66.7%). The lesions were in the form of spots, slices, and cerebral gyrus; cortical atrophy with ventricular enlargement in 6 cases (6/18, 33.3%). 3D VW-MRI showed 16 cases (16/18, 88.97%) uniform thickness of the ICA (internal carotid artery) or middle cerebral artery vessel wall with contrast enhancement (Fig. 1, 2); 16 cases(16/18, 88.97%) showed the thickness and enhancement of the vertebral basilar artery system; 14 cases (14/18, 77.78%) showed the thickness and enhancement both in the anterior and the posterior circulation (Table 2). And for the images acquired during follow-ups, the stenosis had not reverted, but the enhancement intensity of which had been gradually declined (Fig 1).

Pathological Features

The brain pathology in 4 cases, manifested as brain tissue edema, partial degeneration and necrosis or brain tissue loose, dissociation; glial cell hyperplasia, tissue cell response; lymphocyte and phagocytic infiltration, partial blood vessel wall thickening, blood vessels intramural, and perivascular lymphocytes, and a few neutrophils infiltrated; part of the vascular occlusion, part of the wall of cellulose-like necrosis, myelin staining showed no significant loss (Fig 3).

Discussion

PACNS is an uncommon vasculitis that involves the central nervous system, which is still poorly understood. There is still a lack of contemporary prevalence study. Previous studies have demonstrated that the incidence of PACNS was about 2.4/million a year, with middle-aged males being the multiple.[4]

The diagnosis of PACNS is really challenging. Clinical symptoms are rather diverse, including headache, cognitive impairment, stroke, and transient ischemic attack. Patients with PACNS often show focal neurological dysfunction,[6-8] while cranial nerve damage, myelitis, or epilepsy are relatively rare. Cerebrospinal fluid examination usually would not show specific changes, maybe a slight increase in lymphocytes (average cerebrospinal fluid leukocytes 20/mL), normal sugar, increased protein (average cerebrospinal fluid protein 120 mg/dL), occasionally oligoclonal bands and the IgG level increase.[5-8] The typical lesions are usually found in subcortical white matter, deep gray matter, and cortex. Multifocal lesions could

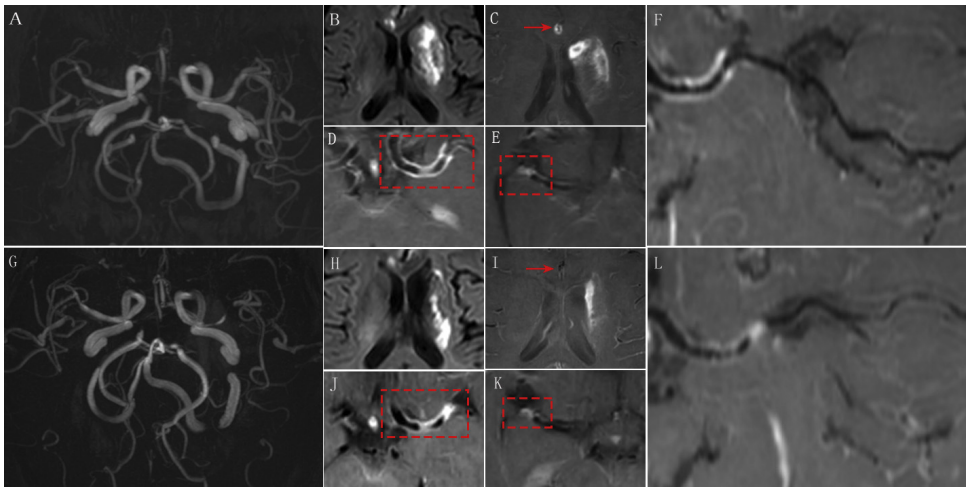

Figure 1. *The case was clinically conformed syphilitic vasculitis via cerebrospinal fluid examination and serologic test. MRA showed slightly stenosis of bilateral ACA (anterior cerebral artery) and MCA, but not apparently (A). DWI showed the left basal ganglia had acute cerebral infarction (B). 3D VW-MRI after contrast showed uniform thickness and vivid enhancement of the right ACA, the M1 segment of left MCA, the right MCA bifurcate vessel wall (C, D, E, and F). And for the images acquired during follow-ups (after 6 months), due to the patient refused treatment after discharge, the stenosis of left MCA was progressed significantly (G), the left basal ganglia presented with a new acute cerebral infarction (H), and the left MCA had a new localized stenosis and enhancement (J, L), but the enhancement intensity had been apparently declined (I, J, K, and L). F and L showed left MCA obtained by curved planar reformation.* Abbreviations*: DWI, diffusion-weighted imaging; MCA, middle cerebral artery; MRA, magnetic resonance angiography; VW-MRI, Vessel Wall-magnetic resonance imaging. (Color version of figure is available online.)*

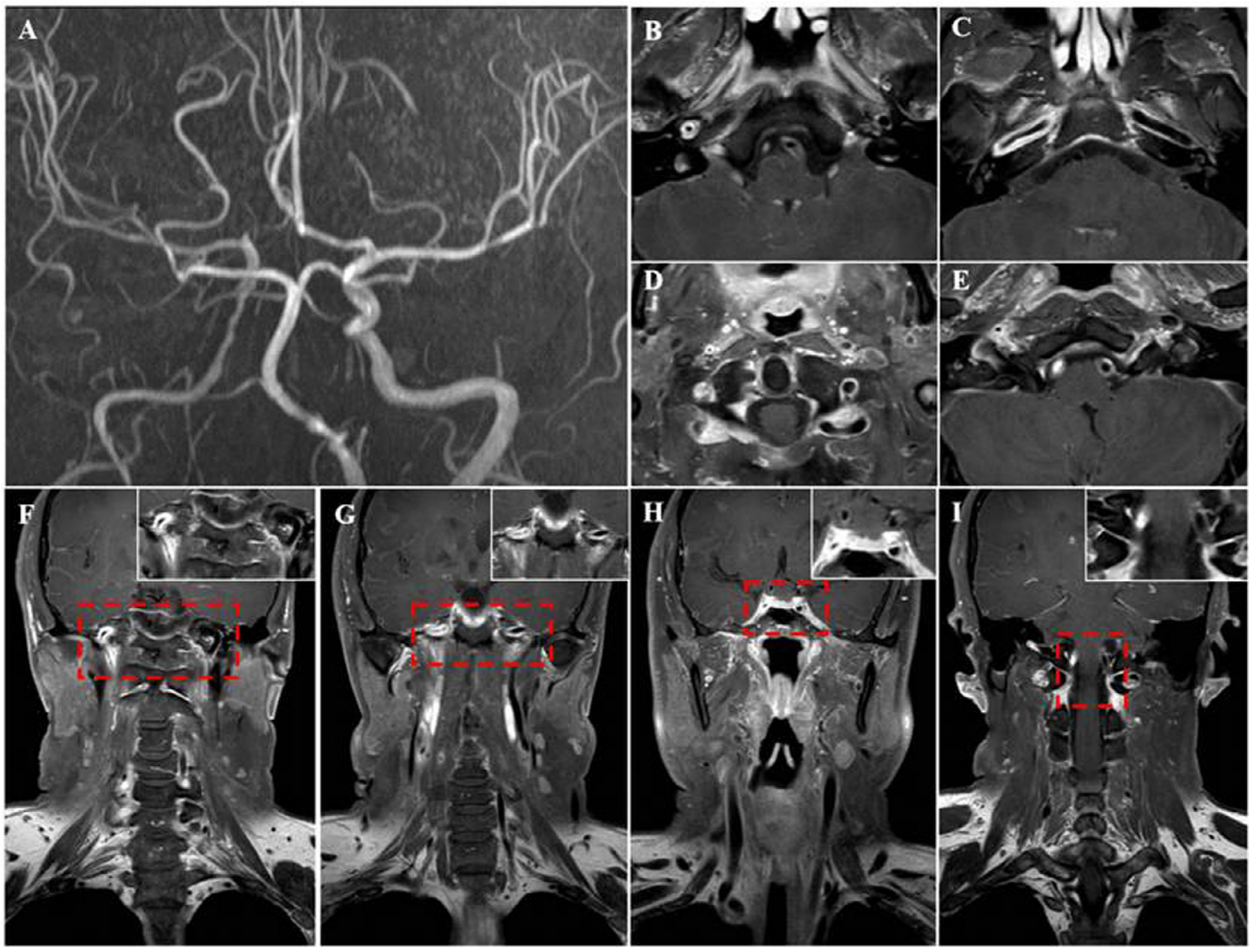

Figure 2. *MRA showed diffuse stenosis along the right ICA, the right MCA, and the right vertebral artery. (A) The 3D VW-MRI showed uniform thickness with contrast enhancement of the vessel wall of the right ICA, the right MCA, and the right vertebral artery (B-I).* Abbreviations*: MRA, magnetic resonance angiography; VW-MRI, Vessel Wall-magnetic resonance imaging. (Color version of figure is available online.)*

Table 2. *Imaging findings of primary central nervous system vasculitis*

Case	Involved vessel	Lesion location	Morphology	T1/T2/DWI sequence	SWI/MRA sequence	3D-VM MRI
1	LMCA,RICA,RVA,BA	Bilateral ganglia, corona radiata, bilateral cerebellar hemispheres	Patchy, unclear	Low signal in T1/high signal in T2/high signal	No abnormality/ normal	Involved vessel enhanced and vessel wall thickening
2	RMCA,RVA,BA	Right frontotemporal lobe; left occipital lobe	Cortical atrophy	Low signal in T1/high signal in T2/normal	Local cortex low signal/stenosis of RMCA	Involved vessel enhanced and vessel wall thickening
3	RMCA,LMCA,LVA,BA	Bilateral ganglia, corona radiata, left insula	Patchy, unclear	Low signal in T1/high signal in T2/high signal	Local cortex low signal/stenosis of RMCA,LMCA	Involved vessel enhanced and vessel wall thickening
4	LMCA,RVA,BA	Left frontotemporal lobe, right cerebellar hemisphere	Irregular patchy	Low signal in T1/high signal in T2/high signal	Normal/stenosis of LMCA and RVA	Involved vessel enhanced and vessel wall thickening
5	LMCA,RMCA,LVA	Bilateral ganglia, corona radiata	Patchy, unclear	Low signal in T1/high signal in T2/high signal	Normal/normal	Involved vessel enhanced and vessel wall thickening
6	RMCA,RVA,BA	Right frontal lobe and left occipital lobe, corpus callosum	Patchy, unclear	Low signal in T1/high signal in T2/high signal	Normal/normal	Involved vessel enhanced and vessel wall thickening
7	RMCA,VA	Right ganglia,bilateral corona radiata	Irregular patchy	Iso signal in T1/high signal in T2/normal	Local cortex low signal/stenosis of RMCA	Involved vessel enhanced and vessel wall thickening
8	LICA,RVA,BA	Left temporal lobe, right cerebellar hemisphere	Patchy, unclear	Low signal in T1/high signal in T2/high signal	Local cortex low signal/stenosis of LICA	Involved vessel enhanced and vessel wall thickening
9	RICA,LMCA,LVA,BA	Right frontal lobe and left ganglia	Patchy, unclear	Low signal in T1/high signal in T2/normal	Normal/stenosis of LICA	Involved vessel enhanced and vessel wall thickening
10	RMCA,RICA,BA,LVA	Right insula and right temporal lobe; left cerebellar hemisphere	Irregular patchy	Low signal in T1/high signal in T2/high signal	Local cortex low signal/stenosis of RMCA	Involved vessel enhanced and vessel wall thickening
11	LICABA	Left temporal lobe, bilateral cerebellar hemisphere	Mottled, unclear	Slightly high in T1/high signal in T2/high signal	Local low signal/stenosis of LICA	Involved vessel enhanced and vessel wall thickening
12	RMCA,LMCA,LVA,BA	Bilateral ganglia, corona radiata, bilateral cerebellar hemispheres	Irregular patchy	Low signal in T1/high signal in T2/high signal	Normal/stenosis of bilateral MCA and BA	Involved vessel enhanced and vessel wall thickening

(*continued on next page*)

Table 2 (*Continued*)

Case	Involved vessel	Lesion location	Morphology	T1/T2/DWI sequence	SWI/MRA sequence	3D-VM MRI
13	RICA	Right frontotemporal lobe	Patchy, unclear	Low signal in T1/high signal in T2/normal	Normal/stenosis of RICA	Involved vessel enhanced and vessel wall thickening
14	RMCA	Right insula and right corona radiata	Patchy, unclear	Low signal in T1/high signal in T2/high signal	Normal/stenosis of RMCA	Involved vessel enhanced and vessel wall thickening
15	LICA,LMCA	Left ganglia and radiata	Mottled, unclear	Low signal in T1/high signal in T2/normal	Normal/stenosis of LICA and LMCA	Involved vessel enhanced and vessel wall thickening
16	LVA	Left cerebellar hemisphere	Patchy, unclear	Low signal in T1/high signal in T2/high signal	Normal/ stenosis of LVA	Involved vessel enhanced and vessel wall thickening
17	BA	Left cerebellar hemispheres	Patchy, unclear	Low signal in T1/high signal in T2/normal	Normal/ stenosis of BA	Involved vessel enhanced and vessel wall thickening
18	RMCA	Right temporal lobe	Patchy, unclear	Low signal in T1/high signal in T2/normal	Normal/ stenosis of RMC	Involved vessel enhanced and vessel wall thickening

Abbreviations: BA, basilar artery; DWI, diffusion-weighted imaging; LMCA, left middle cerebral artery; LV, left vertebral artery; MRA, magnetic resonance angiography; RICA, right internal carotid artery; RMCA, right middle cerebral artery; RV, right vertebral artery; SWI, susceptibility-weighted imaging.

involve both the cortex and the subcortex, with MRI T2WI and fluid-attenuated inversion recovery showing high signal in the specific region.[9] The brain biopsy is still the golden standard for diagnosing PACNS. The pathological diagnostic criteria from the University of Michigan are as follows: at least 2 or more layers of lymphocytes infiltrating the pericardial vessels or meningeal vascular wall or perivascular area; necrosis or suspicious necrosis of the affected vessel wall structure change; cytoplasm is pink or nuclear concentration, with or without astrocyte condensation or gliosis; neurotropic cell manifestations; brain parenchymal edema; exclusion of other pathologies diagnosis.[10-11]

Due to brain biopsy's invasive nature, pathology diagnosis still has its own limits. Brain imaging could help to thoroughly evaluate the brain parenchyma as well as the cerebral vessels. Traditional angiographies such as CTA, MRA, or DSA were difficult to differentiate PACNS from other mimics due to the similar luminal findings, like tapering of the vessel lumen and multiple stenoses.[3] Recently, VW-MRI has been used to evaluate cerebral vessels because it could directly show the vessel wall as well as the lumen, thus it can assist to differentiate various vasculopathies.

In addition to the above-mentioned clinical features, the most often symptoms of PACNS patients in our study were focal neurological disabilities, behavioral abnormalities, and epileptic seizure. Among other characteristics, only 2 cases of this study were associated with blunt headache. The incidence of headache was 33.33% (6/18), which was less than half, different from PANCS reported by Yao Sheng et al.[12] In imaging characteristics, this study showed that bilateral lesions are more common than unilateral lesion. The frontal lobe in the most common involved region (18/18, 100%), followed by partial lobe and occipital lobe. Subcortical white matter was often involved, while the basal ganglia, meninges, and spinal cord were not as common. The morphological features of brain lesions in PACNS can be characterized as dotted, patchy, and cerebral gyrus. Most of the lesions are unclear. The lesions can exhibit different signal characteristics in different sequence at different periods. Long T1 and long T2 is the most common seen signal change. Lesions could exhibit different enhancement performances at different periods. Meninges, soft meninges can be enhanced in most patients, but it is not necessary for diagnosing PACNS.[13] The characteristics of blood vessel or meningeal vascular wall or perivascular lymphocyte infiltration are consistent. All patients in this study had abnormalities in MRA. Also, in these 18 cases, 10 of which involved both anterior and posterior circulation, and the vasculopathy may be asymptomatic. As for vessel wall thickening and enhancement pattern, 25 involved vessels showed arterial wall thickening with contrast enhancement in all patients. Since 3D VW-MRI is an isotropic sequence, it can apply reconstruction in any angle and get the head and neck vasculature in relatively shorter time.

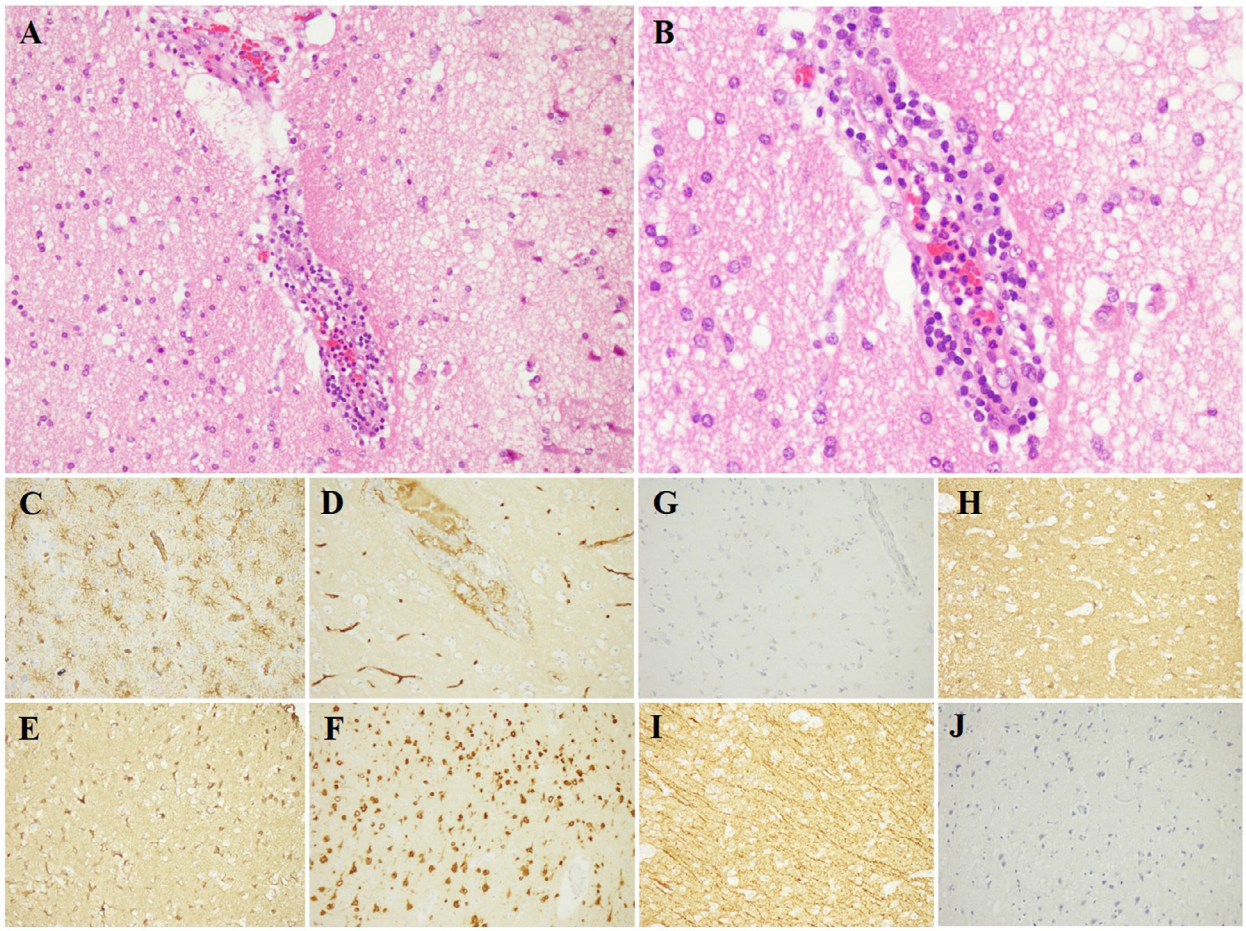

Figure 3. *(A and B) Focal brain dysplasia with small arteritis and intravascular thrombosis; encephalomalacia; disordered cortex layer; uneven distribution of neurons; neuron poloidal disorder; some neurons showed vacuoles degeneration; glial cells proliferation; vessels extensive expansion and congested, congestion with hemorrhage; local intravascular thrombosis with thrombus organization; microglia neurotropic; vasculitis; forming lymphocyte sleeve of homeocyte; inflammatory exudation and necrotic tissue. (C-J) Immunohistochemistry of CD34, GFAP, Map2, Nestin, NeuN, NF, NSE, and Vimentin: the focal brain dysplasia was FCD II A type by Palmini classification. (Color version of figure is available online.)*

On the other hand, 3D sequences can get relatively more qualified images than 2D sequences, since the slice thickness is thin enough for getting the reconstructed data.[14]

No randomized clinical trials of medical management in PACNS exist, therefore, treatment for PACNS has been derived from therapeutic strategies used in other vasculitides, from anecdotal reports, and from cohort studies. Earliest reports suggested a poor outlook with fatal outcome in most patients, and transient or doubtful effectiveness of glucocorticoids. Now, glucocorticoids alone or in combination with cyclophosphamide achieved a favorable response in most patients. Glucocorticoid therapy should be started as soon as primary CNS vasculitis is diagnosed. We recommend an initial dose of prednisone of 1 mg/kg per day (or equivalent) as a single or divided dose. If a patient does not respond promptly, cyclophosphamide should be started.[15] In an approach to reduce the toxic effects of drugs, a 3−6-month course of oral cyclophosphamide (2 mg/kg per day) might also be beneficial to induce remission in PACNS because it has proved effective in other vasculitides.[16] Intravenous pulses of cyclophosphamide (.75 g/m^2 per month for 6 months) are probably safer than is daily oral therapy, although whether the 2 regimens differ in terms of effectiveness is unclear. Infection, cancer (in particular transitional cell carcinoma of the bladder), and infertility are the most serious toxic effects of cyclophosphamide. Subsequently, consideration of a low-risk immunosuppress such as azathioprine (1-2 mg/kg daily). However, little direct evidence exists for the effectiveness of these drugs. A treatment course of 12-18 months is adequate in most patients.[17]

Thus, although there have been no controlled therapeutic trials, treatment seems to be associated with a favorable outcome in most patients. These data emphasize the need for early diagnosis, since prompt treatment frequently leads to a favorable outcome.[15] Just as our most patients, no progressive or worse symptoms appear due to timely and proper treatment during our follow-up period, and the symptom that the declined enhancement intensity is an another strong proof.

Conclusions

The clinical incidence of PACNS is very low, but the nervous system damage is obvious, timely precise diagnosis and treatment is very important. From the cases and previous studies, we summarized some tips as follows:[18] First, the routine MR plain scan (including diffusion-weighted imaging and MRA) is necessary. Second, it was safe to say that the 3D VW MRI is a good choice for evaluating the specific vasculopathy as well as the whole brain vasculature more effectively. In the future, by achieving more qualified images, VW MRI may achieve quantification assessment of vasculitis and provide more utility for PACNS. Third, timely and proper glucocorticoid therapy is necessary for a better prognosis. Finally, brain biopsy should still be performed as soon as possible. The shortcoming of this study is that the sample size is small, and more samples need to be collected for further research.

Competing Interests

The authors declare that they have no conflict of interest.

Authors' Contributions

H.W.Z. and Y.Y. designed the paper. L.J.W., D.Z.K., Z.N.G., and F.L.Z. carried out the data collection, analysis, and interpretation. L.J.W. wrote the drafts with revisions made by H.W.Z., Z.N.G., and F.L.Z.

All authors contributed to the intellectual content. All authors read and approved the final manuscript.

Ethics Approval and Consent to Participate

This article was in accordance with the Helsinki Declaration and reinforced in Good Clinical Practice, and the obtained consent from the subject enrolled into the study. The research had obtained approval from the Research Ethics Committee of First Hospital of Jilin University before commencing the study. The chairman of the Research Ethics Committee of 1st Hospital of Jilin University: Yuquan Tan.

All participants agreed to participate in the study. Written informed consent was obtained from each patient or their family member before participation in the study. For participants under the age of 18, written informed consents were obtained from their father.

Consent to Publish

Written informed consent was obtained from all the patients for publication.

Informed Consent

Informed consent was obtained from all individual participants included in the study.

Availability of Data and Materials

All data generated or analyzed during this study are included in this published article (and its supplementary information files).

References

1. Birnbaum J, Hellmann DB. Primary angiitis of the central nervous system. Arch Neurol 2009;77:704-709.
2. de Boysson H, Zuber M, Naggara O, et al. Primary angiitis of the central nervous system: description of the first fifty-two adults enronlled in the French cohort of patients with primary vasculitis of the central nervous system. Arthritis Rheumatol 2014;66:1315-1326.
3. Hajj-Ali RA, Calabreses LH. Primary angiitis of the central nervous system. Autoimmun Rev 2013;12:463-466.
4. Néel A, Auffray-Calvier E, Guillon B, et al. Challenging the diagnosis of primary angiitis of the central nervous system: a single-center retrospective study. J Rhumatol 2012;39:1026-1034.
5. Cosottini M, Canovetti S, Pesaresi I, et al. 3-T magnetic resonance angiography in primary angiitis of the central nervous system. J Comput Assist Tomorgr 2013;37:493-498.
6. Hajj-Ali RA. Primary angiitis of the central nervous system: differential diagnosis and treatment. Best Pract Res Clin Rheumatol 2010;24:413-426.
7. Rodriguez-Pla A, Monach PA. Primary angiitis of the central nervous system in adults and children. Rheum Dis Clin North Am 2015;41:47-62.
8. Carolei A, Sacco S. Central nervous system vasculitis. Neurol Sci 2003;24:S8.
9. Panchal NJ, Niku S, Imbesi SG. Lymphocytic vasculitis mimicking aggressive multifocal cerebral neoplasm: MR imaging and MR spectroscopic appearance. AJNR 2005;26:642.
10. Molloy ES, Hajj-Ali RA. Primary antiitis of the central nervous system. Curr Treat Options Neurol 2007;9:169.
11. Mandell DM, Matouk CC, Farb RL, et al. Vessel wall MRI to differentiate between reversible cerebral vasoconstriction syndrome and central nervous system vasulitis: preliminary results. Stroke 2012;43:860-862.
12. Obusez EC, Hui F, Hajj-Ali RA, et al. High-resolution MRI vessel wall imaging: spatial and temporal patterns of reversible cerebral vasoconstriction syndrome and central nervous system vasculitis. AJNR Am J Neuroradiol 2014;35:1527-1532.
13. Han JS, Mandell DM, Poublanc J, et al. BOLD-MRI cerebral vascular reactivity findings in cocaine-induced cerebral vasculitis. Nat Clin Pract Neurol 2008;4:628-632.
14. Zhang L, Zhang N, Wu J, et al. High resolution three dimensional intracranial arterial wall imaging at 3T using T1 weighted SPACE. Magn Reson Imag 2015;33:1026-1034.
15. Salvarani C, Brown Jr RD, Hunder GG. Adult primary central nervous system vasculitis. Lancet 2012;380:767-777.
16. Molloy ES, Langford CA. Advances in the treatment of small vessel vasculitis. Rheum Dis Clin North Am 2006;32:157-172.
17. Salvarani C, Brown Jr RD, Calamia KT, et al. Primary central nervous system vasculitis: analysis of 101 patients. Ann Neurol 2007;62:442-451.
18. Cheng-Ching E, Jone S, Hui FK, et al. High-resolution MRI vessel wall imaging in varicella zoster virus vasculopathy. J Neurol Sci 2015;351:168-173.