Primary central nervous system lymphoma MRI

Lymphomas are relatively hyperintense to gray matter on trace diffusion weighted magnetic resonance imaging and isointense to hypointense on apparent diffusion coefficient (ADC) maps, findings consistent with restricted water diffusion [1) 2) 3)].

Although the value of biopsy is universal, combining 18F positron emission tomography and corticosteroid administration is an important alternative method that may lead to the diagnosis of deep-seated lymphoma in cases with intractable histopathological confirmations [4)].

In a retrospective study of patients with Primary central nervous system lymphoma (PCNSL) treated between January 2001 and December 2011 at the Navy General Hospital (Beijing). All included patients were pathologically diagnosed with PCNSL. Specimens were obtained by stereotactic biopsy and diagnosed by pathological examination. Serological panel had to be negative for HIV.

Out of the 118 patients, 73 (61.9%) were male and 45 (38.1%) were female. Median age was 54 (range 11-83) years. All patients had B cell lymphoma. The lesions showed slightly hyperdense shadows on computed tomography (CT) images, and mostly hyperintense T1 and iso- or hyperintense T2 signals on magnetic resonance imaging (MRI). Most lesions showed patchy enhancement after enhanced scanning, and some had the characteristic “butterfly sign” on enhanced MRI. The magnetic resonance spectroscopy of PCNSL manifested as increased Cho peak, moderately decreased NAA peak, and slightly decreased Cr peak. Positron emission tomography indicated high metabolism of 18F-FDG in PCNSL lesions.

MRI is important in the diagnosis of PCNSL. Understanding the imaging features of PCNSL will help improve its diagnosis in clinics [5)].

Reported signal characteristics include:

T1

Typically hypointense to grey matter.

Primary central nervous system lymphoma (PCNSL) lesions often show avid contrast enhancement on T1-weighted contrast-enhanced MRI sequences. However, several case reports and a clinical study have described PCNSL in patients with no contrast enhancement on MRI.

T1 C+ (Gd)

typical high-grade tumours show intense homogeneous enhancement while low-grade tumours have absent to moderate enhancement

Peripheral ring enhancement may be seen in immunocompromised patients (HIV/AIDS)

T2

Variable

Majority are iso to hypointense to grey matter

Isointense: 33%

Hypointense: 20% 9 - when present this is a helpful distinguishing feature

Hyperintense: 15-47%, more common in tumours with necrosis

DWI/ADC

Restricted diffusion with ADC values lower than normal brain, typically between 400 and 600 x 10-6 mm2/s (lower than high-grade gliomas and metastases)

A number of studies have suggested that the lower the ADC values of the tumour the poorer the response to tumour and higher likelihood of recurrence

AADC is particularly useful in assessing response to chemotherapy, with increases in ADC values to above those of normal brain predictive of complete response

MR spectroscopy

Large choline peak

Reversed choline/creatinine ratio

Markedly decreased NAA

Lactate peak may also be seen

MR perfusion

Only modest if any increase in rCBV (much less marked than in high-grade gliomas, where angiogenesis is a prominent feature).

Volume

Precise volumetric assessment of brain tumors is relevant for treatment planning and monitoring. However, manual segmentations are time-consuming and impeded by intra- and inter rater variabilities.

To investigate the performance of a deep learning model (DLM) to automatically detect and segment primary central nervous system lymphoma (PCNSL) on clinical MRI.

Study type: Retrospective.

Population: Sixty-nine scans (at initial and/or follow-up imaging) from 43 patients with PCNSL referred for clinical MRI tumor assessment.

Field strength/sequence: T1 weighted image -/T2 weighted image, T1 -weighted contrast-enhanced (T1 CE), and FLAIR at 1.0, 1.5, and 3.0T from different vendors and study centers.

Fully automated voxelwise segmentation of tumor components was performed using a 3D convolutional neural network (DeepMedic) trained on gliomas (n = 220). DLM segmentations were compared to manual segmentations performed in a 3D voxelwise manner by two readers (radiologist and neurosurgeon; consensus reading) from T1 CE and FLAIR, which served as the reference standard.

Statistical tests: Dice similarity coefficient (DSC) for comparison of spatial overlap with the reference standard, Pearson's correlation coefficient ® to assess the relationship between volumetric measurements of segmentations, and Wilcoxon rank-sum test for comparison of DSCs obtained in initial and follow-up imaging.

The DLM detected 66 of 69 PCNSL, representing a sensitivity of 95.7%. Compared to the reference standard, DLM achieved good spatial overlap for total tumor volume (TTV, union of tumor volume in T1 CE and FLAIR; average size 77.16 ± 62.4 cm3 , median DSC: 0.76) and tumor core (contrast enhancing tumor in T1 CE; average size: 11.67 ± 13.88 cm3 , median DSC: 0.73). High volumetric correlation between automated and manual segmentations was observed (TTV: $r = 0.88$, $P < 0.0001$; core: $r = 0.86$, $P < 0.0001$). Performance of automated segmentations was comparable between pretreatment and follow-up scans without significant differences (TTV: $P = 0.242$, core: $P = 0.177$).

Data conclusion: In clinical MRI scans, a DLM initially trained on gliomas provides segmentation of PCNSL comparable to manual segmentation, despite its complex and multifaceted appearance. Segmentation performance was high in both initial and follow-up scans, suggesting its potential for application in longitudinal tumor imaging.

Level of evidence: 3 TECHNICAL EFFICACY STAGE: 2 [6].

1)
Stadnik TW, Chaskis C, Michotte A, et al. Diffusion-weighted MR imaging of intracerebral masses: comparison with conventional MR imaging and histologic findings. AJNR Am J Neuroradiol 2001;22:969–76
2)
Guo AC, Cummings TJ, Dash RC, et al. Lymphomas and high-grade astrocytomas: comparison of water diffusibility and histologic characteristics. Radiology 2002;224:177–83
3)
Yamasaki F, Kurisu K, Satoh K, et al. Apparent diffusion coefficient of human brain tumors at MR

imaging. Radiology 2005;235:985–91

4)

Yamaguchi S, Hirata K, Kaneko S, Kobayashi H, Shiga T, Kobayashi K, Onimaru R, Shirato H, Tamaki N, Terasaka S, Houkin K. Combined use of 18 F-FDG PET and corticosteroid for diagnosis of deep-seated primary central nervous system lymphoma without histopathological confirmation. Acta Neurochir (Wien). 2015 Feb;157(2):187-94. doi: 10.1007/s00701-014-2290-7. Epub 2014 Dec 10. PubMed PMID: 25488176.

5)

Cheng G, Zhang J. Imaging features (CT, MRI, MRS, and PET/CT) of primary central nervous system lymphoma in immunocompetent patients. Neurol Sci. 2018 Dec 22. doi: 10.1007/s10072-018-3669-7. [Epub ahead of print] PubMed PMID: 30580380.

6)

Pennig L, Hoyer UCI, Goertz L, et al. Primary Central Nervous System Lymphoma: Clinical Evaluation of Automated Segmentation on Multiparametric MRI Using Deep Learning [published online ahead of print, 2020 Jul 13]. J Magn Reson Imaging. 2020;e27288. doi:10.1002/jmri.27288