Brain tumour mimics on neuroimaging

Dr Nikhil Birdi
Specialist registrar radiology

Dr Priya Bhatnagar
Consultant neuroradiologist

Royal Victoria Infirmary, Newcastle upon Tyne
priya.bhatnagar@nuth.nhs.uk

There are multiple non-neoplastic lesions that can mimic intracranial neoplasms on neuroimaging. The differentiation between neoplasms and these tumour-like lesions is essential to making the correct management decisions, not least because there is significant morbidity and mortality associated with brain biopsy and surgery. It is important for us as radiologists to be aware of these conditions so we can raise this possibility and advise the clinicians about appropriate and often non-surgical expectant management. There are a variety of lesions including inflammatory, granulomatous, infective, metabolic and vascular processes that can look like a tumour. Here we present a few such pathologies along with helpful clues and specific neuroradiological features to correctly characterise them. Clinical history is also very important and sometimes a big clue to the diagnosis.

Cerebral abscess

Focal bacterial infections of the brain parenchyma containing pus can often be mistaken for neoplasms on neuroimaging. The commonly seen symptoms of headache, seizures, focal neurological deficit, nausea and vomiting are fairly non-specific, however patients are usually pyrexial with raised inflammatory markers on blood tests.

Non-contrast CT head will typically show an ill-defined low density lesion. There will be surrounding low density oedema with mass effect. Contrast-enhanced CT demonstrates a well defined smooth enhancing rim around the lesion.

On MRI, they demonstrate low T1 and high T2 fluid signal within the lesion. The capsule varies from iso to mildly hyperintense on T1 and low signal on T2 and shows avid rim enhancement after administration of contrast. There is usually evidence of surrounding signal change of low T1 and high T2 signal intensity around it representing oedema.

Diffusion weighted imaging (DWI) shows restricted diffusion of the pus content (high signal on diffusion imaging with corresponding low signal on the ADC map) within the abscess. Susceptibility weighted imaging (SWI) usually shows a smooth and complete low intensity rim with the characteristic double-rim sign of a hyperintense line within the low intensity rim. DWI and SWI can help distinguish abscesses from glioblastomas, which typically do not show central restricted diffusion and often have an incomplete and irregular rim on SWI without the double-rim sign. Abscesses also tend to have smooth walls compared with glioblastomas and metastases. The ring-enhancement seen in tumefactive demyelination lesions will often be incomplete and with relatively minimal mass effect for the size of the lesions.

Tumefactive demyelination

Sometimes acute inflammatory demyelination presents with a large, focal, mass-like, aggressive-looking lesion that can be mistaken for a neoplasm on imaging. It is most frequently seen in women, usually young or middle aged, who often present with acute focal neurological deficits.

On MRI, the lesions have relatively less mass effect and surrounding vasogenic oedema than neoplasms. The lesions also sometimes demonstrate various layers of signal intensities, best demonstrated on diffusion-weighted imaging. There is often a ring of restricted diffusion and an incomplete ring type enhancement, the open aspect of the ring facing the cortex. This is a characteristic feature on imaging, which supports the diagnosis of demyelination rather than a neoplasm. They show good response to steroids so follow-up imaging can be performed to assess and confirm this.

Infarcts

Arterial cerebral infarcts result from sudden interruption of blood flow to the brain parenchyma and present with rapid onset of focal neurological deficits corresponding to the part of the brain involved.

At different stages of maturation, the infarcts can sometimes be mistaken for a tumour. In particular, subacute infarcts can demonstrate post-contrast enhancement and also mass effect. The clues to the differentiation are recognising the specific vascular territory and involvement of the cortex and the white matter in a wedge shaped distribution. In addition, acute infarcts will demonstrate restricted diffusion for seven to 10 days and subacute infarcts may demonstrate T1 hyperintensity in a gyral distribution due to cortical laminar necrosis. Furthermore, early follow-up scans will demonstrate evolution and maturation of the infarcts with gliosis and volume loss.

Venous infarcts commonly occur secondary to venous sinus thrombosis and resultant high venous pressure. This can result in haemorrhage within them and look like a haemorrhagic tumour. On CT, one may see a dense clot sign on non-contrast and an empty delta sign on the post-contrast scan. There will be absence of normal flow voids within the venous sinuses on the non-contrast MRI and a filling defect on the post-contrast sequences.

Cerebral amyloid angiopathy related leucoencephalopathy

Cerebral amyloid disease is caused by the accumulation of cerebral amyloid-B in small vessels. This compromises the integrity of these vessels, resulting in lobar haemorrhages. Patients are usually elderly, normotensive, with a background of dementia and present with stroke-like symptoms.

It is the non-haemorrhagic subset – cerebral amyloid angiopathy related inflammation – that is a less obvious diagnosis on CT and conventional MRI due to the absence of a lobar haematoma and can be mistaken for a tumour. This is an angiitis that typically affects slightly younger patients who will often present with non-specific symptoms of cognitive decline, headaches and seizures.

Unenhanced CT shows low density subcortical white matter vasogenic oedema with mass effect. No enhancement is seen with contrast, unless a focal amyloidoma is present, which is rare.
MRI demonstrates focal abnormal signal change within the cortex and diffuse oedema (high T2 signal) within the subcortical and deep white matter. Sulcal enhancement may be seen on post-contrast T1 imaging.

These appearances overlap with other CNS inflammatory, vasculitic and neoplastic pathologies. This is where SWI is useful and will show characteristic microhaemorrhages, which are seen as multiple low signal ‘dots’ scattered within the abnormal cortex. Other causes of microhaemorrhages on SWI include traumatic diffuse axonal injury which is usually accompanied by a history of trauma, haemorrhagic metastases which will often show post-contrast enhancement and posterior reversible encephalopathy syndrome (PRES) which usually occurs in the context of hypertensive crisis or immunosuppression.

MR spectroscopy can also be useful to exclude neoplastic causes and shows normal n-acetylaspartate (NAA)/creatine ratio and no increase in choline/creatine ratio, indicating metabolically normal underlying brain tissue in cerebral amyloid angiopathy.

Resolution of the described appearances is seen on follow-up imaging after treatment with corticosteroids or cyclophosphamide in most cases.

**Progressive multifocal leukoencephalopathy (PML)**

This is an opportunistic infection caused by the John Cunningham virus (JCV) which affects oligodendrocytes, resulting in demyelination. The diagnosis should be suspected in patients who are immunocompromised, particularly in the context of AIDS, but also patients undergoing chemotherapy, organ transplantation, rheumatic disease and multiple sclerosis patients treated with natalizumab. PML is rare in immunocompetent patients.

Unenhanced CT shows low attenuation within the subcortical and periventricular white matter, which is often asymmetrical and with no associated significant mass effect.

T1-weighted MRI shows low signal intensity in the affected regions. T2-weighted imaging reveals high signal intensity within the subcortical white matter, particularly in the u-fibres located at the periphery of the white matter, giving a characteristic scalloped appearance. There is typically no contrast enhancement, but when present, suggests PML-IRIS (immune reconstitution inflammatory syndrome) and is associated with improved survival. MR spectroscopy helps confirm PML lesions by demonstrating reduced NAA and raised lactate, choline and lipids.

In differentiating them from tumours, one must remember that PML does not exert mass effect and rarely demonstrates post-contrast enhancement. The cortex is also not involved in PML.

**Cortical dysplasias**

These represent disorders caused by cortical disorganisation. Patients usually present with a history of epilepsy but they can also be incidental findings on MRI scans and can be mistaken for low-grade gliomas.

MRI will typically show blurring of the grey-white matter junction, increased cortical thickness and an abnormal sulcal and gyral pattern. The transmantle sign is another characteristic MRI finding almost exclusive to Type 2 focal cortical dysplasia (FCD) and this describes a tapering of the high T2 white matter signal from the cortex to the ventricles. They can coexist with polymicrogyria and also demonstrate cystic change. The absence of contrast enhancement or calcifications also helps distinguish FCD from tumours.

**Conclusion**

As radiologists, we must remember that just because something looks like a focal mass lesion and turns up in the oncology MDT doesn’t mean that it is a neoplasm. We must always apply basic radiological principles and remember specific neuroradiological signs such as open ring enhancement for tumefactive demyelination, microhaemorrhages in amyloid angiopathy and restricted diffusion in the cerebral abscess etc. Considering and suggesting these conditions to the clinicians can save unnecessary biopsy and surgery for the patient with reduction in the associated morbidity and mortality.

**Further reading**


**Figure 1**

Cerebral abscess. (A) T1 post-contrast sequence shows a rounded low signal intensity lesion with rim enhancement and oedema within the left temporal lobe. (B) T2-weighted sequence shows a high signal lesion with a low signal rim and non-dependent locule of gas within it. The abscess demonstrates diffusion restriction, ie bright on DWI sequence (C) and dark on the ADC map (D).
Figure 2
Tumefactive demyelination (A) Multiple high T2 signal lesions with relatively less oedema and mass effect around them. The rim demonstrates restricted diffusion (B) and post-contrast enhancement (C) in an incomplete manner with the open aspect of the ring facing towards the cortex. This is a characteristic feature, not described with tumours.

Figure 3
Subacute infarct (A) T2 weighted and (B) FLAIR sequences demonstrate a wedge-shaped heterogeneous area involving the cortex and the white matter within the postero-medial aspect of the left temporal lobe. (C) The lesion shows hyperintensity on the T1 sequence (laminar necrosis) and enhancement on the post-contrast T1 sequence (D).

Figure 4
Cerebral amyloid angiopathy. (A) Unenhanced CT shows low-density white matter oedema within the right parieto-occipital region. (B) There is abnormal high signal within the cortex and the white matter on the T2-weighted MRI. (C) Microhaemorrhages on SWI sequence are seen as multiple low signal 'dots'. (D) Normal MR spectra of the underlying brain tissue confirms that this lesion is not a tumour.
Progressive multifocal leukoencephalopathy. Bilateral frontal subcortical and periventricular white matter low attenuation on unenhanced CT (A) and high signal on T2-weighted MRI (B). No associated mass effect or post-contrast enhancement (C). The patient was immunosuppressed and CSF analysis confirmed a diagnosis of PML.