

Modern methods for the diagnosis of central nervous system diseases (MRI, CT, EEG)

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Abstract

Modern diagnosis of central nervous system (CNS) diseases relies on combining structural imaging (CT, MRI) with functional and electrophysiological methods (EEG and advanced neuroimaging). CT is fast and widely available, making it the first-line tool in many emergencies (e.g., suspected hemorrhage, major trauma). MRI provides superior soft-tissue contrast and higher sensitivity for many parenchymal pathologies, including early ischemia, inflammation, tumors, and demyelination. EEG captures real-time brain electrical activity and is essential for seizure detection, epilepsy classification, encephalopathy evaluation, and ICU monitoring. Advanced neuroimaging—such as CT/MR angiography and perfusion imaging, diffusion techniques (DWI/DTI), functional MRI, PET/SPECT, and MR spectroscopy—adds vascular, metabolic, connectivity, and biochemical information that improves differential diagnosis, staging, and treatment planning. Optimal diagnostic pathways depend on clinical context (acute vs chronic), suspected pathology (vascular, infectious, neoplastic, degenerative), patient factors (age, implants, renal function), and safety considerations (radiation exposure, contrast risks).

Keywords:

CNS diseases; neurodiagnostics; neuroimaging; computed tomography (CT); magnetic resonance imaging (MRI); diffusion-weighted imaging (DWI); CT angiography (CTA);

Modern diagnosis of central nervous system (CNS) diseases is built on combining structural imaging (CT and MRI) with functional/electrophysiological tests (EEG) and advanced neuroimaging that adds vascular, perfusion, and metabolic information. In acute settings—such as head trauma, sudden severe headache, or suspected stroke—non-contrast CT is often the first test because it is fast, widely available, and excellent for detecting intracranial hemorrhage, mass effect, and fractures. At the same time, CT uses ionizing radiation, so dose optimization and appropriate indication are important considerations in clinical practice. When vascular pathology is suspected, CT can be extended to CT angiography (CTA) to

evaluate arterial occlusion, stenosis, aneurysm, or dissection, and in many stroke pathways CT perfusion can help estimate tissue at risk versus established infarct (depending on protocol and availability).

MRI is the most informative routine tool for many non-emergency or subacute CNS conditions because it provides superior soft-tissue contrast and more sensitive detection of parenchymal lesions. MRI is widely used to diagnose and monitor disorders such as stroke (especially early ischemia), brain and spinal cord tumors, inflammation/infection, vascular abnormalities, epilepsy-related structural causes, abnormal brain development, and neurodegenerative disorders, as well as multiple sclerosis and other demyelinating diseases.

EEG (electroencephalography) complements imaging by measuring brain electrical activity with very high time resolution. It is one of the main tests used to help diagnose epilepsy, clarify seizure type, and detect seizures that may not have obvious clinical signs (for example, in altered consciousness or intensive care settings). EEG also supports assessment of diffuse brain dysfunction (encephalopathies), sedation effects, and monitoring for nonconvulsive seizure activity when imaging cannot answer a functional question. Advanced neuroimaging methods extend diagnostic power beyond routine CT/MRI: angiographic imaging (CTA/MRA/MRV) clarifies vessel disease; perfusion imaging (CTP/MR perfusion) assesses hemodynamics; diffusion tensor approaches can evaluate white-matter tract integrity; and metabolic techniques such as PET/SPECT or MR spectroscopy can help characterize tumors, differentiate dementias in selected cases, or support presurgical epilepsy evaluation.

Conclusion

Modern CNS diagnosis works best as a multimodal strategy: CT provides rapid emergency triage (especially for hemorrhage and trauma), MRI offers high-sensitivity structural characterization (ischemia, tumors, inflammation, demyelination), and EEG supplies real-time functional evidence for seizures and encephalopathies. Advanced neuroimaging (angiography, perfusion, diffusion/tractography, fMRI, PET/SPECT, spectroscopy) adds vascular, hemodynamic, connectivity, and metabolic insight—improving differential diagnosis and treatment planning. The highest diagnostic accuracy comes from selecting the method based on clinical timing (acute vs chronic), suspected pathology, availability, and patient safety factors.