Neuroimaging

Neuroimaging refers to the set of techniques used to visualize the structure and function of the nervous system, particularly the brain. It is essential in clinical neurology, neurosurgery, psychiatry, and neuroscience research.

Categories

Structural Neuroimaging

- **CT (Computed Tomography)**:
  - Best for: acute hemorrhage, skull fractures, hydrocephalus.
  - Pros: Fast, widely available.
  - Cons: Radiation exposure.
- **MRI (Magnetic Resonance Imaging)**:
  - Best for: brain tumors, demyelination, infarcts, malformations.
  - Common sequences:
    - T1-weighted: anatomy
    - T2-weighted / FLAIR: edema, lesions
    - DWI/ADC: acute stroke
    - SWI/GRE: microbleeds, calcifications
  - Advanced:
    - 3D volumetry
    - High-field MRI (3T/7T)

Functional Neuroimaging

- **fMRI (Functional MRI)**:
  - BOLD signal (blood oxygenation level dependent).
  - Used in pre-surgical planning and cognitive studies.
- **PET (Positron Emission Tomography)**:
  - Tracer uptake (e.g., FDG for glucose metabolism).
  - Detects early changes in tumors and neurodegenerative diseases.
- **SPECT (Single Photon Emission CT)**:
  - Brain perfusion studies.
  - Often used in epilepsy diagnosis.

Electrophysiological Imaging (Complementary)

- **EEG (Electroencephalography)**:
  - High temporal resolution for seizures and cortical function.
- **MEG (Magnetoencephalography)**:
  - Measures magnetic fields from neuronal activity.
  - Localizes functional cortex.

Advanced Techniques

- **DTI (Diffusion Tensor Imaging)**:
  - Shows white matter tracts (tractography).
  - Key for neurosurgical navigation.
- **MR Spectroscopy (MRS)**:
  - Analyzes brain metabolites: NAA, choline, lactate.
- **ASL (Arterial Spin Labeling)**:
  - Measures cerebral perfusion without contrast.

Clinical Applications

- Tumor detection and grading
- Preoperative planning in neurosurgery
- Stroke and penumbra identification
- Dementia (atrophy and hypometabolism)
- Epileptic focus localization
- Traumatic brain injury assessment