

Introduction to Nuclear Medicine Imaging

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Core concepts, techniques, and clinical relevance

1. What Is Nuclear Medicine Imaging?

Aspect	Description
Definition	A diagnostic (and therapeutic) specialty that uses small amounts of radioactive material (radiopharmaceuticals) to visualize physiological processes in the body.
Key Principle	Detects gamma photons emitted from radionuclides inside the patient and reconstructs images that reflect tissue function, not just anatomy.
Main Modalities	• Scintigraphy (planar imaging) • Single-Photon Emission Computed Tomography (SPECT) • Positron Emission Tomography (PET)
Typical Uses	• Oncology (tumor detection, staging, therapy monitoring) • Cardiology (myocardial perfusion, viability) • Neurology (brain metabolism, receptor imaging) • Endocrinology (thyroid, adrenal, bone metabolism)

2. Radiopharmaceuticals – The “Tracers”

Component	Details
Radionuclide	Emits detectable radiation (γ-rays for SPECT, positrons for PET). Common examples: • Technetium-99m (^{99m}Tc) – γ emitter, half-life 6h (SPECT) • Fluorine-18 (^{18}F) – positron emitter, half-life 110min (PET)
Carrier Molecule	Determines biological target (e.g., glucose analogue, phosphate, antibodies).
Administration	Usually intravenous; occasional oral, inhalation, or intrathecal routes.
Dosimetry	Patient radiation dose is low (comparable to a few chest X-rays); doses are optimized for image quality vs. safety.

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3. Imaging Physics Basics

Concept	SPECT	PET
Radiation Detected	Single γ photons (usually 140 keV for ^{99m}Tc)	Coincident 511 keV photons from positron annihilation
Detectors	NaI(Tl) crystals coupled to photomultiplier tubes (PMTs) or solid-state detectors	LSO/LYSO scintillators coupled to avalanche photodiodes or PMTs
Acquisition	Rotating camera acquires multiple 2D projections $\rightarrow$ tomographic reconstruction (filtered back-projection or iterative)	Ring of detectors records simultaneous photon pairs $\rightarrow$ direct 3D reconstruction
Spatial Resolution	$\sim 6\text{--}10\text{ mm}$ (depends on collimator)	$\sim 4\text{--}5\text{ mm}$ (better due to coincidence detection)
Attenuation Correction	Usually via transmission scan (e.g., CT) or uniform correction factors	Integrated CT (PET/CT) provides accurate attenuation maps

4. Typical Clinical Protocols

Study	Radiopharmaceutical	Typical Dose	Imaging Timeline
Myocardial Perfusion SPECT	^{99m}Tc -sestamibi or tetrofosmin	10–30 mCi (370–1110 MBq)	Rest $\rightarrow$ stress (pharmacologic or exercise) $\rightarrow$ 30–60 min post-injection
Bone Scan			