Diagnostic Imaging Pathways - Common Procedures

Nuclear Medicine

Nuclear medicine is a functional form of imaging, compared to radiology, which assesses for structural change. It uses targeted radiopharmaceuticals to image specific physiological or pathological processes. As most diseases will affect cell function before structural changes are evident, it is a very sensitive modality especially in the early stages of disease. The majority of radiopharmaceuticals are composed of a radionuclide that is bound to cells or a chemical ligand.

The radionuclide emits gamma photons during radioactive decay, which allows localization of the radiopharmaceutical by gamma cameras. Most nuclear medicine studies are performed using ^{99m}Technetium (^{99m}Tc) as the radionuclide. It is easily produced in a generator and can be combined with many different ligands. It has a relatively short half-life of 6 hours, which reduces the radiation dose to the patient when compared with isotopes with a longer half-life. During its decay, it emits mainly gamma photons in an energy spectrum that is ideal for detection by sodium iodide crystals in the camera arrays allowing for optimal image resolution. Some investigations utilize a radioisotope in its free form, including pertechnetate for thyroid, salivary gland or Meckel's scans, Gallium for infection/inflammation or tumour imaging, and various isotopes of radioiodine (^{123}Iodine or ^{131}Iodine). In general, the dose received during a diagnostic nuclear medicine investigation is comparable to a CT scan.

The properties of the attached ligand or cell determine the organ of uptake, which allows specific radiopharmaceuticals to be chosen for different imaging indications. Red blood cells and white blood cells can be labeled for investigation of gastrointestinal bleeding and infection/inflammation respectively. The bone scan is probably the most widely requested nuclear medicine investigation. For a bone scan, ^{99m}Tc is labeled with a diphosphonate, which rapidly localizes to cortical bone and images osteoblastic activity. This process is increased in conditions such as metastases, fractures, and infection. Whilst the pattern of uptake can guide interpretation, the lack of specificity makes a clinical history essential for analysis. The distribution of activity passing through an organ with time can be analysed mathematically to derive functional data such as half-clearance times, ejection fractions, and relative perfusion.

Conventional planar scintigraphic imaging is increasingly supplemented with SPECT (Single Photon Emission Computed Tomography) to aid localization of tracer activity. By rotating the cameras, a volume of data is acquired and is subsequently reconstructed after correcting for attenuation and scatter. This dataset can be reformatted in multiple planes to suit the organ of interest. Newer machines are also equipped with a multi-detector CT in which a non-contrast low-dose CT scan is co-registered with the emission data. These hybrid systems enable accurate anatomical localization of tracer activity, increasing the specificity and diagnostic accuracy of nuclear medicine imaging.

Nuclear medicine isotopes also have a role in therapy. ^{131}Iodine is commonly used in the treatment of well-differentiated thyroid cancer and also for recalcitrant hyperthyroidism. The short-range ?-particle radiation emitted from radioiodine delivers the majority of its energy within 3-5mm in soft tissue and is used to ablate thyroid tissue. Other commonly used radiopharmaceuticals include Samarium^{153}-EDTMP for palliative treatment of metastatic bone pain, Yttrium^{90}-citrate for radiation synovectomies, and Yttrium^{90}-microspheres for radioembolisation of hepatic malignancies.

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