PET Brain MRI

RTS 8

What is Proton Emission Tomography Magnetic Resonance Imaging?

An innovative phenomenon in the diagnostic imaging world that is increasing in popularity and becoming the industry standard is PET scanning. Positron Emission Tomography (PET) is a different approach to diagnose diverse pathologies and differentiation of tissues. “PET is one of the most powerful imaging modalities that can provide functional information about specific organ or body systems at a molecular level.”[1] PET scans on its own does not provide clear and precise visualization of anatomy because it lacks high spatial resolution.[1] PET MRI scanners use radioactive iodine, amino acid and other radiopharmaceuticals to monitor treatment response of tumors, improved differentiation of tumor recurrence and other body systems. PET MRI imaging also provides beneficial information on tumor metabolism and behavior.[1]

Configurations

Adapting photomultiplier technology with magnetic field insensitive avalanche photodiodes is not easy. PET detectors must be invisible to the MRI and artifacts cannot interfere with field gradients and or MRI radiofrequencies. On top of that, the MRI scanner must be modified to accommodate for PET detectors to allow data collection without interference from either of the PET or MRI scanner.[3] Three possible types of configurations Tandem, the most straight forward approach, Insert, and a Fully Integrated configuration. Tandem is a table is moving between two scanners. An Insert configuration is when the PET gantry is compactly placed inside the bore of the MRI scanner, the transverse Field of View is reduced as a result of the configuration (see Figure 1).[3] PET detectors in the scanner must be capable of operating a in a powerful magnetic field on top of that the RF shield should be designed to maintain homogeneity of the MRI magnetic field with the PET detectors in the scanner.[3] A continuous PET scan can run between 15-20 mins depending on the body part. A dynamic study requires extensive data collection and can run from 20-40 mins.[4] A Standard Protocol for a PET MRI exam are T2 weighted turbo spin echo and T2 FLAIR (fluid attenuated inversion recovery) sequcences.[4]

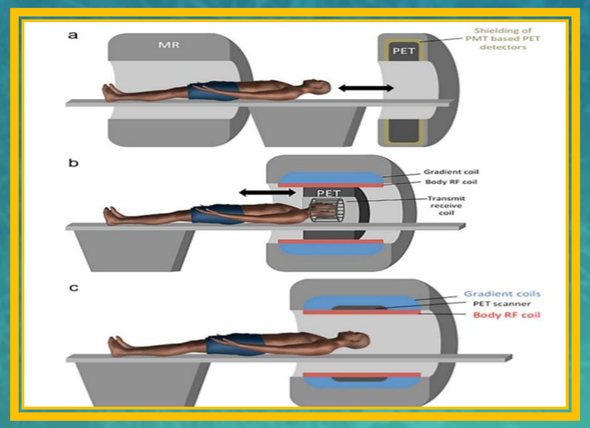

Fig 1. Types of PET MRI Configurations.[3]

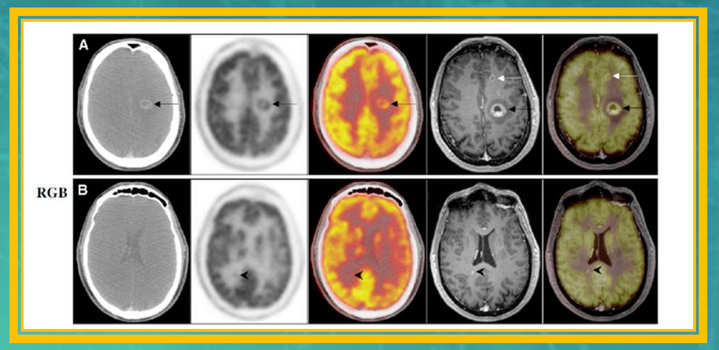

Fig 2. F-FDG Uptake in PET MRI and CT Images.[3]

Table 1. Comparisons between PET MRI and CT.[2]

	Strengths	Limitations
PET/CT	• Widely available • Established imaging protocols • Evidence proven indications • Familiarity among ordering providers • Quantitative accuracy well established • Imaging of small pulmonary nodules • Exams performed in as little as 30 minutes	• Limited soft tissue contrast • Fast CT exam does not provide extra time for PET acquisition • IV contrast not routinely used • If focused MRI needed, must be additional exam • Ionizing radiation from CT component
PET/MRI	• Improved soft tissue contrast • Added value of DWI • Increased available time to collect PET data • Better motion correction • Convenience and time savings with combined exams • Use of MRI specific contrast agents • No ionizing radiation from MRI component	• Limited availability • Protocols and indications still in development • Require technologist knowledgeable in both NM and MRI • Quantitative accuracy still being determined • Exams may take 1 hour or longer • Limited evaluation of pulmonary parenchyma

Oncology

Dynamic contrast-enhanced imaging techniques using MRI have been used to obtain measure of tumor vascularity and hemodynamic.[4] PET can deliver delicate measurements of glucose metabolism, amino acid and nucleoside turn over, membrane biosynthesis, somatostatin receptor expression and hypoxia using a variation of radiotracers.[3] Choline (Cho) is the primary metabolite of interest for neuro-oncology studies. It is made of a mix of choline compounds, (phosphocholine and glycerofosfocholine phosphartidycholine).[4] Increase signal from the choline is specific to the tissues of the brain.[3] F-Flurodeoxyglucose (F-FDG) is a radiopharmaceutical and the standard for aerobic energy metabolism, oxidative glycolysis in imaging.[3] FFDG is the most frequently used radiopharmaceutical for PET. What special about F-FDG is the ability to penetrate the blood-brain barrier and its distribution is equivalent to a brain prefusion. F-FDG measure the energy metabolism of the brain tissue, the F-FDG levels increase when neuronal activity is increased (see Figure 2).[3]

Fun Fact

The first simultaneous PET/MRI study was performed on a healthy 66-year-old volunteer. T2 weighted turbo spin echo was used along with time of flight MRI angiography and MRI spectroscopy. Image reconstruction was roughly 20 minutes.[3]

References

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4. Ferda J, Ferdová E, Hes O, Mraček J, Kreuzberg B, Baxa J. PET/MRI: Multiparametric imaging of brain tumors. Current neurology and neuroscience reports.