Whole body PET-MRI in patients with Neurofibromatosis type I: Preliminary Observations of Image Quality and Artifacts

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Target Audience: Radiologists and Nuclear Medical Physicians interested in whole-body PET-MRI hybrid system techniques.

Purpose: In clinical oncology, therapeutic approach and prognostic considerations are based on disease staging. Tumor diagnosis and tumor staging depend on morphological and molecular imaging procedures such as magnetic resonance imaging (MRI), computed tomography (CT), and positron emission tomography (PET). PET-CT is a well-established technique that brought a new perspective into the fields of clinical imaging. The major drawback is that CT provides limited soft tissue contrast and exposes to a significant radiation dose (1). It is possible to obtain sequential imaging data on stand-alone PET and MRI scanners and then fuse the images via retrospective image registration. However these methods may be operator dependent and quite challenging, particularly for disease located in regions of the body that have deformable tissues (2). Furthermore, this temporal mismatch may cause artifacts due to patient movement between the two scans or by respiratory motion (1) limiting qualitative and quantitative evaluation (3).

Whole body PET-MRI is a novel metabolic–anatomic imaging technique that overcomes some of these limitations, by allowing simultaneous data acquisition of functional and morphological images with an excellent soft tissue contrast, good spatial resolution, accurate temporal and spatial image fusion, with substantially reduced radiation dose, which is particularly relevant in pediatric applications and in patients who require multiple screening studies (1).

Despite prior publications outlining the clinical applications of this new technique, little has been written about its artifacts and pitfalls. The purpose of our presentation is to describe the image quality, practical limitations and artifacts, based on our early clinical experience with PET-MRI in patients with neurofibromatosis type 1, who underwent whole body evaluation for staging the disease.

Materials and Methods: Biograph mMR consists of a 3-T whole-body magnet with body coils optimized for minimal 511-keV photo attenuation. The PET detectors are made of lutetium oxyorthosilicate crystals in combination with MR-compatible avalanche photodiodes instead of photomultiplier tubes.

The study group included 11 patients (2 males, 9 females; mean age 23.3±18.1, median 17 years, range 6 to 61) diagnosed with neurofibromatosis type 1 with either optic glioma, due for imaging scan, or plexiform neurofibroma, due for imaging secondary to clinical signs or symptoms of progressive disease.

The whole body MRI protocol included pre and post-gadolinium 3D VIBE and coronal STIR images. Typically 4 to 6 stations were covered, depending on patient size. All imaging was performed without sedation, and the complete coil complement (head, and body coils). Patients followed conventional PET imaging protocols, and received standard dose FDG intravenously one hour prior to imaging. PET images were acquired simultaneously and attenuation correction was performed based on pre-contrast Dixon sequences using stock software. Total imaging time was approximately 35 minutes (range 25 to 45 min) for whole body imaging. Additional focused studies on the optic nerves were performed for patients with known optic gliomas, resulting in an additional 30 minutes of scan time. Images were interpreted on the MIMVISTA console. All PET-MRI studies were independently and blindly retrospectively evaluated by two different reviewers to determine the extent of artifacts, which prevent the diagnostic accuracy of the technique.

Results: All enrolled patients successfully started the scans with acquisition of the entire whole body STIR protocol. A single patient (the youngest) did not receive radiotracer, as the patient was unable to remain sufficiently motionless to justify the use of radiotracer. This was the only study considered technically inadequate from the PET/MR perspective. Two patients had severe misregistration (Fig. 1) due to significant patient repositioning during their study (of which one was secondary to a software failure during the study requiring scanner restart). Overall, all performed MR imaging was considered technically adequate for lesion evaluation. One study was considered limited in the brain/neck region secondary to dental hardware (orthodontia). A total of two patients had significant motion (one mentioned previously), however, their images were interpretable, but limited. All acquired PET images were technically adequate. Severe whole body PET/MR misregistration was encountered only in one patient of the ten with successful PET/MR combined studies. Local manual re-registration of the abdomen and lower extremities was able to eliminate the misregistration.

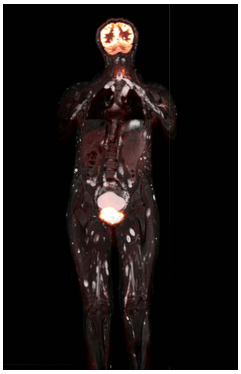

Fig.1 - Severe misregistration in the lower pelvis. Note the misregistration of the bladder between the MRI and PET data.

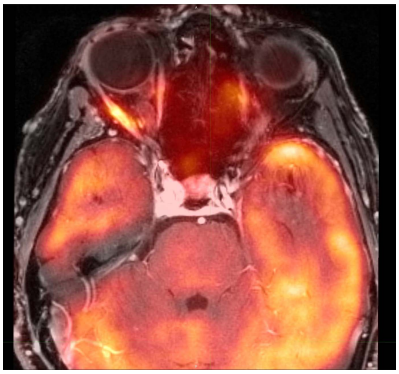

Fig.2 – Right optic nerve glioma with perfect anatomical and functional registration. Increased FDG uptake is clearly seen in the right lateral rectus muscle but not in the tumor.

Patients lesions ranged throughout the entire body, including scalp lesions, optic gliomas (Fig. 2), brachial plexus, neurofibromas along the entire spinal axis and distal peripheral nerves, abdominal and pelvic soft tissue lesions, as well as lesions in the lower extremities.

Discussion & Conclusion: Our preliminary results show that the PET-MRI modality can serve as a powerful tool in complex diseases with a diverse range of affected areas such as neurofibromatosis. The whole body STIR images served as a useful anatomic evaluation of lesion load across the entire body, even in regions that would normally be considered technically difficult for MR imaging. The PET acquisitions were technically adequate and were performed within a reasonable imaging time. Though a small number of patients demonstrated misregistration on the images not acquired simultaneously (initial PET imaging, subsequent MR imaging), the data was amenable to manual re-registration. The vast majority of studies were also successfully completed in our primarily pediatric population without the use of any sedation. Overall, other artifacts of the combined PET-MRI system were limited – primarily due to severe susceptibility artifact from metal (dental hardware).

Though this study is preliminary, it points to two of the great potential applications of PET-MRI – whole body imaging at a lower dose than PET/CT and applications in pediatric oncology.

References:

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