PET/MR Increases Sensitivity of Lesion Detection in Drug Refractory Epilepsy Patients

Epilepsy is the fourth most common neurological disorder—following migraines, stroke, and Alzheimer’s—with approximately 50 million people affected worldwide. Treating patients suffering from epilepsy is most effective when the origin of their seizures can be localized to one or more regions of the brain.1,2

The Mayo Clinic (Rochester, MN) is a world renowned leader in healthcare and medical research, ranked as the top overall hospital in the US by U.S. News & World Report, as well as #1 in more specialties than any other hospital in the country. This preeminence extends to multiple diseases and care areas, including epilepsy.

Since January 2016, Mayo has been utilizing PET/MR (SIGNA® PET/MR, GE Healthcare) for epilepsy cases.

According to Robert J. Witte, MD, PET/MR Executive Chair, Mayo did scan epilepsies with PET/CT. However, upon acquisition of the new PET/MR system, the Mayo Clinic has increased the number of PET studies in epilepsy.

“When you have a high-quality PET scan, you can see the abnormalities more clearly,” says Geoffrey B. Johnson, MD, PhD, Nuclear Medicine Division Chair. “The MR scan is key; but having more than one dataset, such as the PET data, helps guide the radiologist’s eye.”

Robert J. Witte, MD,
is PET/MR Executive Chair and Associate Professor of Radiology at Mayo Clinic in Rochester, MN.
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Dr. Geoffrey B. Johnson, MD, PhD, is Nuclear Medicine Division Chair and Assistant Professor of Radiology at Mayo Clinic in Rochester, MN.

Dr. Witte shares a statement from Jeffrey W. Britton, MD, Epilepsy Division Chair: “PET/MR has increased our utilization of FDG in epilepsy. Its primary niche is in the evaluation of patients with intractable focal epilepsy, with whom the routine MR is negative. In these patients, pre-scheduling of imaging and other testing is important for efficient evaluation and expedited decision making. Many of our patients have intractable epilepsy and have undergone MR imaging prior to coming to Mayo. In such cases, the chance that our epilepsy MR protocol will reveal an abnormality not seen by prior centers is low.

“In select cases, we are moving our practice to pre-schedule PET/MR as our initial imaging modality instead of just using our usual MR protocol. We have a few cases where PET/MR pointed to an area of the brain that fit with the patient’s other localization data and allowed further scrutiny of MR, which revealed relevant subtle structural abnormalities not previously appreciated.”

Dr. Robert J. Witte

“Further, Dr. Witte sees potential clinical and workflow benefits from the simultaneous acquisition—and that could also impact cost by reducing the number of MR sequences. He explains that Mayo has two MR protocols for epilepsy. One MR protocol can take up to 40 minutes to complete. If the addition of PET-FDG can help the clinician target and scrutinize the important area(s) to investigate, then there is the potential to decrease that imaging time by a quarter or a third, then that’s a big win where we can make significant improvements in the patient workup.”

That’s the whole point of what we are doing with PET/MR; we spend a lot of time on the MR side adding sequences to discover the pathology. If by combining these together we can decrease that imaging time by a quarter or a third, then that’s a big win where we can make significant improvements in the patient workup.”

In some of these cases, Dr. Witte adds, PET/MR has been helpful in imaging areas of the brain for targeted surgery.

Overall, Dr. Johnson and Dr. Witte have been very happy with the initial results. They found PET/CT was not especially useful and in general the resolution of PET has not been sufficient. However, the combination of the new PET with MR in a single exam is making a difference.

“A busy practice with a high volume will need to evaluate patients in a timely fashion,” Dr. Witte says. While fusing MR and PET has historically been an option, there are more benefits with a simultaneous scan. “This is especially true for small lesions, such as 1 cm focal cortical dysplasia where we require optimal fusion and co-localization.”
Dose reduction and MR sequences

Patient dose may also be reduced when using PET/MR compared to PET/CT. MR has no ionizing radiation, but with the high sensitivity of Mayo’s SIGNA PET/MR, the injected FDG dose has also decreased from 12 mCi down to 5 mCi. “We are getting superb images with the tracer, and the lower injected dose may lead to more noisy images, but this is the best trade off especially for our pediatric patients,” says Dr. Johnson. “We’ve decreased patient dose by 60% going from PET/CT to PET/MR.”

At Mayo, several MR sequences are key in an epilepsy patient workup. Double inversion recovery is the primary 3D...
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localization of the epileptogenic zone. In these cases, the clinician may also implant intracortical electrodes (stereo-EEG) to verify this hypothesis followed by a cortectomy, or the removal of a specific area of the cerebral cortex.

“(Simultaneous) PET/MR increases the sensitivity of both scans,” she adds. “There is often information we can use from the scans to help the neurosurgeon remove only what is needed.”

Fusing two separate scans—the PET and MR—is more complicated and time consuming, she adds. One simultaneous PET/MR scan is more comfortable for the patient, but a real clinical benefit is the ability to localize a lesion on a structural MR scan initially considered as normal, thanks to focal hypometabolism on a PET scan.

Further improvements in PET/MR imaging of epilepsy patients could be accomplished with the development of more specific radiotracers, Dr. Habert adds.

References

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Hospital Pitié-Salpêtrière

At the Public Hospital of Paris, Hospital Pitié-Salpêtrière, patients with refractory partial epilepsy undergo a pre-surgical workup for localization of the epileptogenic zone. The exam includes a video EEG recording and neurological examination supplemented by the patient’s clinician history. The patient then undergoes a structural MR exam to help the clinician determine if the epilepsy is the result of a lesion that could be resected.

According to Dr. Marie-Odile Habert, MD, a nuclear medicine physician, there are two clinical protocols utilized at Hospital Pitié-Salpêtrière before an eventual surgical resection. If the patient has mesial temporal lobe epilepsy, they undergo a PET/MR to determine if there is mesial temporal sclerosis associated with temporal hypometabolism. In cases with positive findings, the patient then undergoes surgical resection—either an anterior temporal lobectomy or an amygdalohippocampectomy. At Hospital Pitié-Salpêtrière, more than 80% of patients with mesial temporal lobe epilepsy improve after surgery, Dr. Habert says.

In cases where the patient has extratemporal epilepsy and the lesion visualized on MR is not consistent with EEG findings, the patient undergoes interictal PET-FDG and ictal SPECT, if possible, to help hypothesize the localization of the epileptogenic zone. In these cases, the clinician may also implant intracortical electrodes (stereo-EEG) to verify this hypothesis followed by a cortectomy, or the removal of a specific area of the cerebral cortex.

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References
**Case 1**

Patient with a case of suspected occipital lobe epilepsy.

**Findings**

Structural MR is normal: No structural lesion detected with FLAIR sequence or asymmetric perfusion 3D ASL. Right occipital ictal hyperperfusion localized on subtraction ictal SPECT co-registered MR (SISCOM). Patient underwent PET/MR, which demonstrated right temporo-occipital hypometabolism in interictal PET/MR, that is much more widely distributed than as depicted on the SISCOM image.

**Utility of hybrid PET/MR**

Images and case courtesy of Hospital Pitié-Salpétrière.
Case 2

Patient with temporal lobe epilepsy.

Findings

MR initially interpreted as normal. Patient underwent PET/MR, which enabled direct comparison of structural MR with metabolic PET information.

PET/MR demonstrated mild hypometabolism in the left mesial and anterior temporal areas, allowing the identification of a subtle left parahippocampal hyperintensity on T2 images (arrow) consistent with a focal cortical dysplasia. In this case, PET/MR increased the sensitivity of lesion detection.

Utility of hybrid PET/MR

Images and case courtesy of Hospital Pitié-Salpêtrière.

Robert J. Witte, MD, is PET/MR Executive Chair and Associate Professor of Radiology at Mayo Clinic in Rochester, MN. He completed his MD at the University of Nebraska, College of Medicine; finished his fellowship in neuroradiology at Froedtert & The Medical College of Wisconsin; and completed his residency in radiology at the Nebraska Medical Center. He’s board-certified in Nuclear Medicine, Diagnostic Radiology, and Neuroradiology.

Geoffrey B. Johnson, MD, PhD, is Nuclear Medicine Division Chair and Assistant Professor of Radiology at Mayo Clinic in Rochester, MN. He received his MD/PhD in Immunology, completed his fellowship in Nuclear Radiology, and finished his residency in Diagnostic Radiology at the Mayo School of Graduate Medical Education. He’s certified by the American Board of Radiology and the American Board of Nuclear Medicine.

Mayo Clinic is a nonprofit medical practice and medical research group based in Rochester, MN, with additional campuses in Scottsdale and Phoenix, AZ, and Jacksonville, FL. The health system employs more than 4,500 physicians and scientists and 57,100 allied health staff. Founded in 1889, Mayo Clinic is committed to clinical practice, education and research, providing expert, whole-person care to everyone who needs healing.

Marie-Odile Habert, MD, is a nuclear medicine physician and senior lecturer at the Public Hospital of Paris, Hospital Pitié-Salpêtrière in Paris, France.

The Hospital Pitié-Salpêtrière is a renowned teaching hospital in Paris, France, and part of the Assistance publique – Hôpitaux de Paris (AP-HP), the largest hospital system in Europe and one of the largest in the world. The system is comprised of 15,800 physicians working across 44 hospitals, offering services in 52 branches of medicine, serving more than 5 million patients annually.