PET/MR Imaging in Cancers of the Gastrointestinal Tract

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KEYWORDS

• PET/MR imaging • Gastrointestinal tract malignancy • [18F]-2-fluoro-2-deoxy-d-glucose PET • Rectal carcinoma • Liver tumors • Treatment response

KEY POINTS

- PET/MR imaging is an evolving hybrid imaging technique with potential use in initial staging and follow-up of gastrointestinal tract malignancies.
- High soft tissue contrast resolution of MR imaging is an advantage over computed tomography for T staging of rectal carcinoma and characterization of liver lesions.
- Functional MR imaging techniques such as diffusion-weighted imaging adds to metabolic information from [18F]-2-fluoro-2-deoxy-D-glucose PET in more accurate assessment of tumor response and local recurrence after treatment of colorectal carcinoma.
- Approval of new radiotracers will widen the scope of PET/MR imaging application in non–[18F]-2-fluoro-2-deoxy-D-glucose–avid tumors.

INTRODUCTION

PET/MR imaging is an emerging new technology that combines the anatomic and functional capabilities of MR imaging and the metabolic information of PET into a single examination. This new hybrid modality was recently introduced into the clinical arena, and since then clinical data regarding the feasibility and potential applications of PET/MR imaging have been rapidly emerging, especially in oncology.[1–3] Over the last 2 decades, [18F]-2-fluoro-2-deoxy-D-glucose (FDG) PET/CT, a combination of PET using a glucose analogue FDG and CT, has established itself as a powerful tool in staging, restaging, treatment planning, and monitoring response in many malignancies.[4,5] However, the anatomic information provided by the low-dose, noncontrast CT component of the PET/CT examination is often insufficient to determine the extent of local tumor invasion or to characterize incidental lesions. In contrast, MR imaging with its superior soft-tissue contrast resolution, multiplanar imaging acquisition capability, and functional imaging capability allows better anatomic visualization of soft tissue and musculoskeletal structures compared with CT.[6,7] Moreover, MR imaging is devoid of ionizing radiation of CT; therefore, PET/MR imaging has potential of reducing radiation exposure to vulnerable pediatric and pregnant oncology populations, which often require frequent follow-up studies.[8] Therefore, PET/MR imaging integrates the advantages of MR imaging and PET and has great potential in improving lesion detection and diagnostic performance. Regardless of these advantages, PET/MR imaging is still in its nascent stage, and further prospective studies are required

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to fully establish its potential value compared with PET/CT. In this article, the current literature and potential clinical applications of PET/MR imaging in common malignancies involving the gastrointestinal (GI) tract, including liver, biliary tract, pancreatic, and colorectal tumors, are discussed.

TECHNICAL BACKGROUND

PET/MR Imaging Systems

There are 2 commercially available PET/MR imaging scanners classified as sequential and simultaneous systems.[9] The sequential PET/MR imaging has separate PET and MR imaging elements physically separated by a rotating table. The sequential design has a relatively simple construction and only minor modifications to the preexisting hardware and software but is more prone to image misregistration because of the temporal separation of the PET and MR imaging data. This design also requires a much larger area to accommodate both scanners.[10–12]

The simultaneous or integrated PET/MR imaging scanner has a complex structure with PET detectors inserted between the gradient and radiofrequency body coils of the MR imaging scanner. There is need for modifications to avoid electromagnetic interactions between 2 components and use of magnetic field–insensitive avalanche photodiodes and silicon photomultiplier detectors, which are immune to magnetic field effects. The simultaneous data acquisition has the advantages of shorter scan times and reduced misregistration as well as alleviation of the need for a large room. However, respiratory motion artifacts still remain a problem, particularly in the upper abdomen.[13–15]

PET/MR IMAGING PROTOCOL

Integrated whole-body PET/MR imaging typically consists of 2 parts, whole-body PET/MR imaging and dedicated regional MR imaging. Generally, the whole body portion of the examination is more or less the same for most malignancies, but the region-specific sequences vary with location of tumor and the clinical indication for the examination, which can potentially increase the duration of the examination. The future success of PET/MR imaging depends on workflow efficiency; therefore, a typical whole-body scan should not exceed 20 to 30 minutes.[16,17] Additionally, the length of dedicated MR imaging may be reduced by tailoring the regional MR imaging sequences according to the clinical indication. A lengthy study may not be well tolerated by some oncologic patients.[18]

Whole-Body PET/MR Imaging Protocol

Optional whole-body MR imaging sequences include DWI and short tau inversion recovery (STIR) imaging.

Whole-body DWI, which may improve diagnostic accuracy in tumors such as lymphoma,[19,20] and whole-body coronal STIR imaging have been found to improve detection of osseous lesions.[21]

Region-Specific Dedicated MR Imaging Protocols

Dedicated MR imaging sequences of regions of interest are required to better assess the local extent of disease and T staging (**Boxes 1** and **2**). DWI with apparent diffusion coefficient (ADC) maps is routinely performed, as it is useful to assess the cellularity of the primary tumor and to distinguish posttreatment inflammation and fibrosis from viable neoplasm.[22–24] DWI also improves the sensitivity of detection for lymph node and peritoneal metastases.[25,26]

Workflow

The imaging time of PET/MR imaging dependents the number of MR imaging sequences and the duration of each MR imaging sequence (**Figs. 1** and **2**). The examination protocol should be tailored to answer the specific clinical question for that particular patient.

Box 1
Protocol for GI malignancy (liver, biliary tract, and pancreatic) abdominal MR imaging

- Axial and coronal heavily T2-weighted images without fat suppression.
- Axial T1-weighted in and out of phase chemical shift gradient recalled echo (GRE) images.
- Axial DWI (b values of 50, 600, and 800).
- Axial 3-dimensional T1-weighted GRE images with fat suppression before contrast administration.
- Axial 3-dimensional T1-weighted GRE images with fat suppression acquired dynamically during multiple phases after intravenous administration of a gadolinium-based contrast agent.
- Axial 3-dimensional T1-weighted GRE images with fat suppression acquired during the hepatobiliary phase at 15 to 20 minutes if a hepatobiliary-specific gadolinium-based contrast agent was administered.
- MRCP is optional and not routinely performed.