Continuing Medical Education Article

Dual-Modality Imaging: Combining Anatomy and Function

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Disclosure

In accordance with ACCME Revised Standards for Commercial Support and SNM Conflict-of-Interest Policy, the author has indicated that he serves as a consultant for Siemens Molecular Imaging, the company that manufactures one of the PET/CT scanner designs. No other potential conflict of interest relevant to this article was reported. Disclosure of a relationship is not intended to suggest or to condone bias but is made to provide participants with information that might be of potential importance to their evaluation of the activity.

Target Audience

This article contains information of value to physicians, physicists, engineers, medical technologists, and anyone interested in dual-modality medical imaging.

Objectives

On successful completion of this activity, participants should be able to:

1. Discuss the historical and clinical basis for dual-modality imaging.
2. Outline current instrumentation for combined PET/CT imaging.
3. Describe recent advances in CT and PET instrumentation.
4. Understand the implementation of CT-based attenuation correction (CT-AC).
5. Assess the importance of artifacts associated with CT-AC.

Questions

1. Although many of the drawbacks of software fusion techniques have been addressed by the hardware approach, which one of the following is still a strength of software fusion?
   A. The mismatch due to patient respiration can be solved.
B. The total scanning time for CT and PET is less than for combined PET/CT.
C. Any 2 imaging modalities can be coregistered.
D. Separate scans registered post hoc are more tolerable for the patient.

2. In current PET/CT scanners, which one of the following parameters does not affect the spatial resolution in the PET image that can be achieved for a clinical whole-body patient scan?
A. The noncolinearity of the annihilation photons from the positron-electron annihilation.
B. The diameter of the rings of block detectors.
C. The size of the individual crystals in the block detector design.
D. The width of the time window defining a coincidence event.

3. The introduction of new, fast scintillators for PET such as LSO and GSO offers significant improvement in scanner performance, compared with the previous BGO-based PET scanners. However, the one remaining advantage that BGO has is…
A. An increased photofraction that results in higher detection efficiency.
B. Faster rise time that allows a shorter coincidence time window.
C. More light output that allows the use of smaller detector elements.
D. An improved energy resolution based on the increased amount of light.

4. Fast scintillators such as LSO and GSO offer the possibility of measuring the time difference between the arrival of photons in opposing detectors—the time of flight (TOF). Compared with non-TOF, images reconstructed with TOF information have…
A. More counts and therefore lower statistical noise.
B. A higher signal-to-noise ratio throughout the image.
C. An improved spatial resolution resolving smaller details.
D. Less background due to scattered photons.

5. Image quality improves as the sensitivity of the PET scanner increases and more annihilation events are acquired in a given scanning time. The most significant way to improve the 3D sensitivity of current PET scanner designs is by…
A. Increasing the intrinsic efficiency of the detectors.
B. Decreasing the coincidence time window.
C. Increasing the number of detector rings in the scanner.
D. Increasing the diameter of the detector rings.

6. The combined PET/CT scanner reduces or eliminates imaging and registration problems associated with…
A. The presence of $^{18}$F-FDG in the bladder of the patient.
B. Metallic artifacts due to dental fillings or prostheses.
C. Differences in the position of the patient between the 2 scans.
D. Differences in the respiration of the patient between the 2 scans.

7. Which of the following is required for accurate registration of PET and CT data sets?
A. A patient couch with essentially zero vertical deflection over the whole body range.
B. A fully integrated PET and CT detector system within a single gantry.
C. Completely unified PET and CT software operated from a single console.
D. The ability to acquire PET and CT data sets simultaneously to minimize motion.

8. The use of CT images to generate attenuation correction factors for the PET data is a major advantage of PET/CT scanners. The significant advantages of CT-based attenuation correction, compared with a standard PET transmission scan, include all except which of the following?
A. CT images are acquired much more rapidly than a standard PET transmission scan.
B. The higher x-ray flux results in much lower noise in the CT images.
C. The spatial resolution of the CT scan is much higher than that of the PET scan.
D. A simple threshold is required by the energy scaling algorithm.

9. In a typical PET/CT protocol, the CT scan is acquired first, followed by the PET scan. The advantage of acquiring the scans in this order is that…
A. The radiation dose to the patient is reduced.
B. Whole-body images are available rapidly after the PET scan has been completed.
C. Patient motion is minimized.
D. The range of the PET scan can be chosen to match that of the CT scan.

10. A major factor affecting the quality of whole-body images acquired with current PET/CT scanner designs is the size (weight) of the patient. With the current levels of obesity in the U.S. population, this is a significant problem. All of the following strategies for imaging larger patients are recommended except…
A. For BGO-based PET/CT scanners with septa, acquire data in 2D mode.
B. For LSO- and LYSO-based scanners, 3D acquisition is recommended.
C. The incorporation of TOF data may improve the signal-to-noise ratio for larger patients.
D. Injecting an increased level of activity into the patient will significantly improve image quality.