Course: How Other Modalities Compare/Compete/Complement

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Highlights

- Radionuclide imaging: SPECT/CT, PET/CT, PET/MRI is used to measure body function with an injection of nanomolar concentrations that can be measured noninvasively.
- Applications include the assessment of blood flow, metabolism, cardiac efficiency, dementia, neurotransmitter physiology, cancer, ligand binding, cell to cell communication.
- Technology advancements include time-of-flight PET (<300 picosecond coincidence timing resolution), solid state detectors (semiconductor gamma ray detectors, Si, Ge, CdTe, CdZnTe [CZT], HgI2, TlBr) and solid state photo detectors (semiconductor signal amplification, PIN, SiPMs, APDs).
- Future of imaging will involve hybrid imaging of SPECT, PET, CT and MRI.

TITLE: Nuclear Medicine

TARGET AUDIENCE: Clinicians, imaging scientists, and manufacturers of medical imaging equipment with interest in hybrid imaging of human anatomy and physiology.

OBJECTIVES: – After this presentation, one will be able to list 1) nuclear medicine applications in cardiology, neurology, and oncology, 2) types of solid state gamma ray detectors, 3) various solid state photo detectors, and 4) applications of hybrid PET and MRI in the diagnosis of disease and monitoring therapeutic intervention.

PURPOSE: – To illustrate how nuclear medicine is used in the assessment and treatment of disease and contributes to the study of common anatomical and physiological questions in animal and human biology; and may compliment MRI to improve the sensitivity and specificity of diagnosing disease and in planning therapeutic intervention.

METHODS & RESULTS: – Radionuclide (nuclear medicine) imaging modalities of SPECT/CT and PET/CT use the injection of radiotracers for functional and quantitative biomolecular assessments of the human body. The significance of this is that one can use nuclear medicine imaging for noninvasively assessing body function by injecting nanomolar concentrations that do not perturb the function of the body. Currently, the primary application of SPECT/CT is cardiac imaging of ischemia, while PET/CT finds important applications in diagnosis of myocardial ischemia, detection of primary tumors and metastases, and evaluation of brain dementia such Alzheimer's disease. The clinical need has pushed the technology while at the same time new developments in technology have advanced clinical protocol investigations. For SPECT the standard Anger camera technology is still the primary technology in commercial cameras supplied to clinics; however, the technology is changing due to the need for improved energy resolution using solid state detectors (CZT) and dose reduction using dedicated cardiac scanners. New protocols have also significantly reduced the dose administered to patients using low dose/high dose imaging in the assessment of cardiac ischemia instead of imaging with two different radiopharmaceuticals. Hybrid imaging has become an important tool with PET/CT imaging of tumors and time-of-flight (TOF) has furthered improved whole body imaging by reducing the detection of scatter and improving lesion contrast. Advances in semiconductor

technology is making hybrid PET/MRI viable. PET/MRI has the potential to revolutionize imaging of cardiac function with the potential to obtain information about cardiac efficiency that is so important in the evaluation of heart failure and in the study of the aging process. It is expected in the future that PET/MRI will become part of the radiological armamentarium for diagnosing disease and monitoring therapeutic intervention.

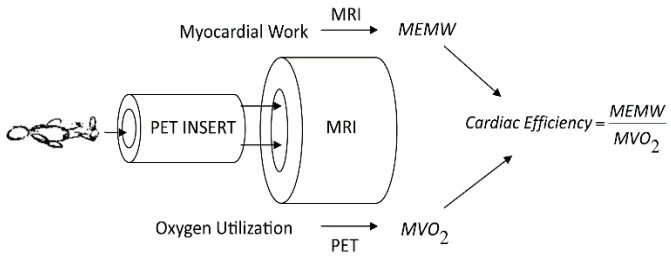

Figure 1 – Future hybrid PET/MRI technology will be able to study changes in myocardial efficiency due to remodeling post-MI and with progression of heart failure in humans. Myocardial external minute work (MEMW) is determined using MRI and nonlinear finite element (FE) mechanical models of stress. Oxygen utilization is measured using PET imaging of ^{11}C-acetate. This provides a measure of cardiac efficiency that can be correlated to the metabolism of other energetic substrates such as glucose and fatty acids.

CONCLUSION: – SPECT/CT and PET/CT are important modalities used in research and clinical medicine that provide important quantitative information about anatomy and function using tracer quantities that do not perturb membrane or intracellular physiology or global gene expression. Future advances in hybrid imaging will bring together the advances of nuclear and magnetic resonance imaging in the development of PET/MRI imaging equipment both for human and small animal studies.

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