What Life Scientists Should Know About Molecular Imaging

Nuclear Imaging: Physical Principles and Instrumentation

Principles of SPECT and PET

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Learning Objectives:

- To learn about the tracer principle and its importance in molecular imaging
- To understand how radiation emitted from the body is detected externally using tomographic systems
- To appreciate the key principles in forming a reconstructed image of the tracer distribution in the body

Positron emission tomography (PET) and single photon computed tomogprahy (SPECT) are nuclear medicine based imaging techniques that provide functional or biochemical information about the subject being studied. PET and SPECT are molecular imaging techniques that rely upon the tracer principle for studying human physiology and disease processes. The tracer principle will be described and how it relates to PET and SPECT imaging. Criteria for what makes a radioisotope a good candidate for human imaging will be described as well as the most common radioisotopes for PET and SPECT procedures.

Positrons are positively charged beta particles and after they are ejected from the nucleus during radioactive decay. The basic principles of positron emission and the physics behind coincidence imaging and event localization will be described. For SPECT imaging only a single gamma is produced so other methods are used to help localize where the radioactive decay occurred. The most common practice is to place a collimator in front of the SPECT detector to only allow photons traveling perpendicular to the face of the detector to be detected. Just like PET, the use of a collimator fixes a detected photon from having to have originated along a specific line of response. In addition to these principles, the methods for spatial localization within the detector system will be described.

Both PET and SPECT data are usually stored in structures called sinograms prior to image formation or image reconstruction. Analytic and iterative reconstruction methods are used to produce three-dimensional images of the activity distribution within the patient. The most common analytic image reconstruction method is filtered back projection. It is still used quite a bit for SPECT imaging; however, iterative image reconstruction techniques are now the norm for PET imaging. The basic methodologies for both filtered back projection and iterative image reconstruction will be explained. With the advent of SPECT/CT systems and a trend toward quantitative SPECT imaging, iterative reconstruction is becoming more commonplace for SPECT image reconstruction, also.

In wrapping up the presentation, an overview of clinical PET and SPECT systems and organ specific systems will be provided.

Relevant Publications:

1. Meikle SR, et al. Small animal SPECT and its place in the matrix of molecular imaging technologies. Phys Med Biol. 50:R45-R61, 2005
2. Muehllehner, G and Karp, JS. Positron emission tomography. Phys Med Biol. 51:R117-R137, 2006
3. Bushberg JT, Seibert JA, Leidholdt Jr. EM, Boone JM. The Essential Physics of Medical Imaging, Third Edition, Publisher, Lippincott Williams and Wilkins, 2011.