Advances in Instrumentation and Techniques for Quantitative Myocardial Perfusion SPECT

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Myocardial perfusion (MP) SPECT (single-photon emission computed tomography) is a leading diagnostic tool for cardiovascular disease. Its continued importance and popularity have been fueled by new advances in instrumentation and image reconstruction and processing methods. Quantitative three-dimensional (3D) image reconstruction methods that model the counting statistics in the acquired data and the physics of the imaging process have been widely adopted in clinical practice. They provide improved reconstructed image noise and accurate compensation of image degrading factors including collimator-detector blur, and photon attenuation and scatter in the patient resulting in significant improvement in both the quality and quantitative accuracy of MP SPECT images. Extension of the quantitative 3D image reconstruction method to four-dimensional (4D) has been shown to benefit 4D gated MP SPECT. Special collimators designed to provide both improved spatial resolution and increased detection efficiency have been developed and implemented on conventional SPECT systems for application to MP SPECT. The need to provide accurate attenuation compensation and anatomical correlation with MP information for individual patient has resulted in the development of multimodality SPECT/CT systems which have become standard system configuration. More recently, dedicated cardiac SPECT and SPECT/CT systems have emerged in the market place that hold great promise to advance MP SPECT a big step forward. The presentation will describe the basic principles of quantitative 3D and 4D image reconstruction methods. Advances in special collimation and SPECT/CT system designs for MP SPECT will be presented. The improvement in image quality and quantitative accuracy will be demonstrated by simulated, experimental phantom and clinical images.

Learning Objectives

1. Describe the basic principles of quantitative 3D and 4D image reconstruction methods that have led to significant improved quality and quantitative accuracy of 3D and 4D gated myocardial perfusion and SPECT images.

2. Describe the recent advances in instrumentation for improve myocardial perfusion SPECT.

3. Demonstrate the advances using simulated, experimental phantom and clinical MP SPECT images.

Presentation Outline

1. Introduction
   - What are ECT and SPECT?
   - Application of SPECT to myocardial perfusion imaging
   - Limitations of conventional FBP image reconstruction methods
   - Major image degradation factors:
     - *Photon attenuation and scatter*
     - *Collimator-detector blur*
     - *Patient anatomy and motions*

2. Quantitative 3D SPECT image reconstruction methods
   - Statistical image reconstruction methods with iterative algorithms
   - Modeling of physics of imaging process
   - Resultant significant improvements in both the quality and quantitative accuracy of SPECT images

3. Quantitative 4D SPECT image reconstruction methods
   - 4D SPECT image reconstruction methods for improved gated myocardial perfusion SPECT images
   - Compensation methods for respiratory motion effect

4. Advances in SPECT/CT instrumentation
   - Initial development for attenuation correction with low power & low cost CT
   - Correlation of functional and anatomical information
   - Recent instrumentation with diagnostic quality CT
   - Recent advances in dedicated cardiac SPECT and SPECT/CT systems

5. Advances in small animal SPECT techniques and instrumentation

6. Future of myocardial perfusion SPECT

7. Conclusions