### Medical Physics 2.0 Nuclear Imaging 2.0

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#### **Overview**

- Part I: Physics metrics and analytics – Opportunities for improvement of traditional methods
- Part II: Testing implication of emerging technologies
   How emerging technologies challenge current testing
   strategies
- Part III: Implementation into the clinic
  - Incorporating new metrics into the clinic
  - Other areas of focus for improving the practice

#### PART I: PHYSICS METRICS AND ANALYTICS

- Uniformity Analysis
- Spatial Resolution
- Detectability Index



Traditional image analysis
 Pixel value-based

Integral Uniformity 
$$\% = \frac{N_{max} - N_{min}}{N_{max} + N_{min}} x \ 100$$









### • Structured Noise Index (SNI)

	Estimated Integral UFOV	Estimated Integral CFOV	Structured Noise Index		
Sensitivity	62%	54%	100%		
Specificity	90%	83%	95%		
PPV	67%	50%	87%		
NPV	88%	85%	100%		
Accuracy	84%	76%	96%		
R <sup>2</sup>	0.426	0.462	0.766		
Nelson JS, et al. J Nucl Med. Jan 2014; 55:169-174					





- Traditional methods
  - LSF reporting FWHM somewhat limited
    - Different shaped peaks can have same FWHM
    - Scatter components fall in tails and may not be reflected





Line spread function (LSF): FWHM = 3.8mm, FWTM = 7.1 mm

4 quadrants resolved

### PART I PART II PART II PART III PART III

#### Modulation Transfer Function

- Complete characterization of system performance
- Eliminate subjectivity of routine QC analysis

+	









Modeling quantitative imaging performance

$$d' = \int \frac{MTF^2}{NPS} * task function$$

- Figure of merit for a clinical task based on system performance
  - How does this non-uniformity impact clinical image quality?

### Part I Conclusions

Part III

• There is an opportunity to update our metrics in clinical use

Part I

- New metrics provide full characterization of system performance
- New metrics improve sensitivity in identifying change
- Metrics can be combined to predict clinical performance

#### PART II: TESTING IMPLICATION OF EMERGING TECHNOLOGIES

- Solid State Detectors
- Hybrid Systems











- Changing the definition of current testing:
  - Energy resolution testing for all clinically used isotopes
  - Bad pixel analysis
  - Stationary SPECT acquisitions
    - No more COR
    - No planar imaging (for SPECT-only systems)
    - Sensitivity across FOV

# PART II PART III PART III PART III

Improved energy resolution





Aarsvold, JN, et al. 2012 IEEE

- MP not only testing SPECT/PET, but also CT/MR
  - Changing the definition of current testing:
    - -May not need to perform full CT/MR stand alone testing
    - -Co-registration testing
    - -Attenuation correction evaluation

# PART I PART II PART II PART III PART III

• Co-registration evaluation (1.0)

#### Manufacturer designed

Calibrated to one table location

Processed within the 'black box'



# PART II PART II PART III PART III PART III

Co-registration & Attenuation Correction
 evaluation (2.0)



CT Medial Line Extraction







- Gated acquisitions
- Whole body acquisitions – Resolution, Uniformity, Sensitivity
- Multi-FOV acquisitions – WB and SPECT

Part I

### Part II Conclusions

Part III

- New developments challenge our traditional evaluation strategies
- Important to know how system is used clinically and test accordingly

#### PART III: IMPLEMENTATION INTO THE CLINIC

- Integrating New Metrics & Analytics
- Utilizing d'
- Protocol/Dose Optimization and Dose Monitoring
- Communication Within the Clinic

# PART I PART II PART II PART III Integrating New Metrics/Analytics

Automated QC Analysis Programs



# PART I PART II PART III PART III PART III

Automated QC Analysis Programs

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- Automated QC Analysis Programs
  - Maintain database of NPS and MTF
  - Can generate a d' report
    - -What effect will that slight non-uniformity have on my clinical images?



- May need organ/task specific phantoms for better precision
- Need to define set of clinical tasks





- · Instrumentation has dramatically improved
- · Great opportunity to revisit injected activities
- Based on recorded injected activity, calculate and database EDE and organ doses
- Why all the trouble?
  - Effect on age, gender (risk)
  - Total exam dose (if hybrid or multiple parts to exam)
  - Combine with other modalities
  - Protocol optimization tool











- Optimization is a team effort
- · Open line of communication is important





### Part II Conclusions

Part III

- New image quality metrics will be useful in the clinical practice
- Great opportunity & need to investigate protocol and dose optimization
- Establish an open line of communication with clinical staff

# Final Conclusions

Part III

Part I

• There are <u>a lot</u> of opportunities for MP to take a lead role in improving the practice of clinical nuclear imaging.

