PET (SUV) Quantitative Imaging

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PET Quantitative Approaches: Outline

- Why quantify FDG PET uptake?
- Biochemistry and kinetics of FDG
- Approaches to quantitative analysis
- Factors that affect quantitative accuracy
- Quantitative imaging what is required?





Why Quantify FDG Uptake?

- Helps identify malignancy
- Provides other information:
 - Prognosis
 - "Grade"
 - Correlation with tumor biology
- Key for assessing response
- Why not? no extra work

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Requirements for Quantitative Analysis of FDG PET Scans

- Attenuation-corrected scans
- Cross-calibration between PET tomograph and dose calibrator
- ROI analysis software
- Standard imaging time after injection
- Measurement of plasma glucose

FDG PET Quantitative Analysis

FDG Biochemistry, and Kinetics



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FDG Kinetics : Effect of Blood Clearance High metabolism Medium metabolism Metabolically Inactive Blood Time

Time is required for clearance from tissues without trapping 2011 R. Doot (after Hamburg, JNM 35:1308, 1994)

Approaches to Quantifying FDG Uptake

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FDG PET Imaging Methods

Acquisition

Injection

Qualitative Whole-body imaging

<u>Analysis</u>

Visual Inspection

Quantitative Static

Dynamic

Standard Uptake Value (SUV) Glucose Metabolic Rate

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Standard Uptake Value (SUV)					
รเ	$SUV = \frac{Tissur}{(Lister List)}$		e Tracer Activity (μCi/g)		
(Injected Dose (mCI)/Pt weight (kg))					
	<u>Tissue</u> <u>T</u> Lung		ypical FDG SUV		
			0.7		
	Bone	Marrow	1.0		
	Brea	st	0.5		
	Liver		2.5	Zasadny, Radiology 189:	
	Tumor		> 3-4	847,1993	
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Why measure in SUV (an example)?

- PET scanner measures the radioactivity per unit volume
- Typically measured as kBq/ml or $\mu Ci/ml$























Physical effects in PET

- Spatial resolution limitations
 - Positron range
 - Angular deviation of annihilation photons
 - Instrumentation limitations
 - Depth-of-interaction in detector
- Count rate limitations
 - Dead time
 - Random Coincidences
 - Scattered coincidences
- Photon attenuation

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Effect of Attenuation on Image Quality



Scans performed using the same scanner and protocols

Slide Courtesy of Paul Kinahan

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Alternate SUV Measures

- Since little uptake of FDG in adipose tissue, normalize by lean body mass (LBM, units = g/mL), with separate formulas for male & female
- Normalize by Body Surface Area (BSA, units = cm²/mL)
- Good ideas but reported as problematic in implementation since difficult to estimate true LBM or BSA based on just patient's height & weight
- Correct for plasma glucose by multiplying SUV by [glucose]/100



Quantification of FDG Uptake

Requirements for Quantitative Imaging

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Requirements for Quantitative Analysis of FDG PET Scans

- Standard patient prep and imaging acquisition
 - Attenuation-corrected scans
 - Cross-calibration between PET tomograph and dose calibrator

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ROI analysis software

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Recommendations for Patient Preparation: NCI Consensus (Shankar, JNM, 2006)

- Patient should avoid strenuous exercise for a period of 24 hours prior to FDG-PET study
- Fast > 4 hours; last meal should be low in CHO
- Measure glucose
- For the diabetic patient, first AM scan
 - Before food and medications
- Adequate hydration is necessary
- Patient's height and weight should be measured

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Recommendations for Patient Preparation (cont.)

- Use of various medications to be documented (e.g., G-CSF, corticosteroids, anxiolytics, diuretics)
- Uptake with patient in a comfortable position.
- Large bore IV in arm contralateral to any known pathology
- Dose administered should be between 5-20 mCi
- Injection scan time 50-70 minutes
 - Consistent in serial studies

(Shankar, J Nucl Med 2006)

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Quantifying FDG PET Images: Conclusions

- Quantitative analysis of FDG uptake is important in tumor imaging, especially for research
- Standard uptake values (SUV) are clinically feasible and require no extra effort
- But SUVs require attention to detail
- And SUV is less precise than more detailed quantitative analysis methods
- Protocol standardization improves quantitative precision

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