Requirements for Quantitative PET imaging

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Workshop on Implementing the DICOM 3.0 Standard for Radiation Therapy Multi-Institutional Trials
Image-Guided Therapy QA Center, April 14, 2004

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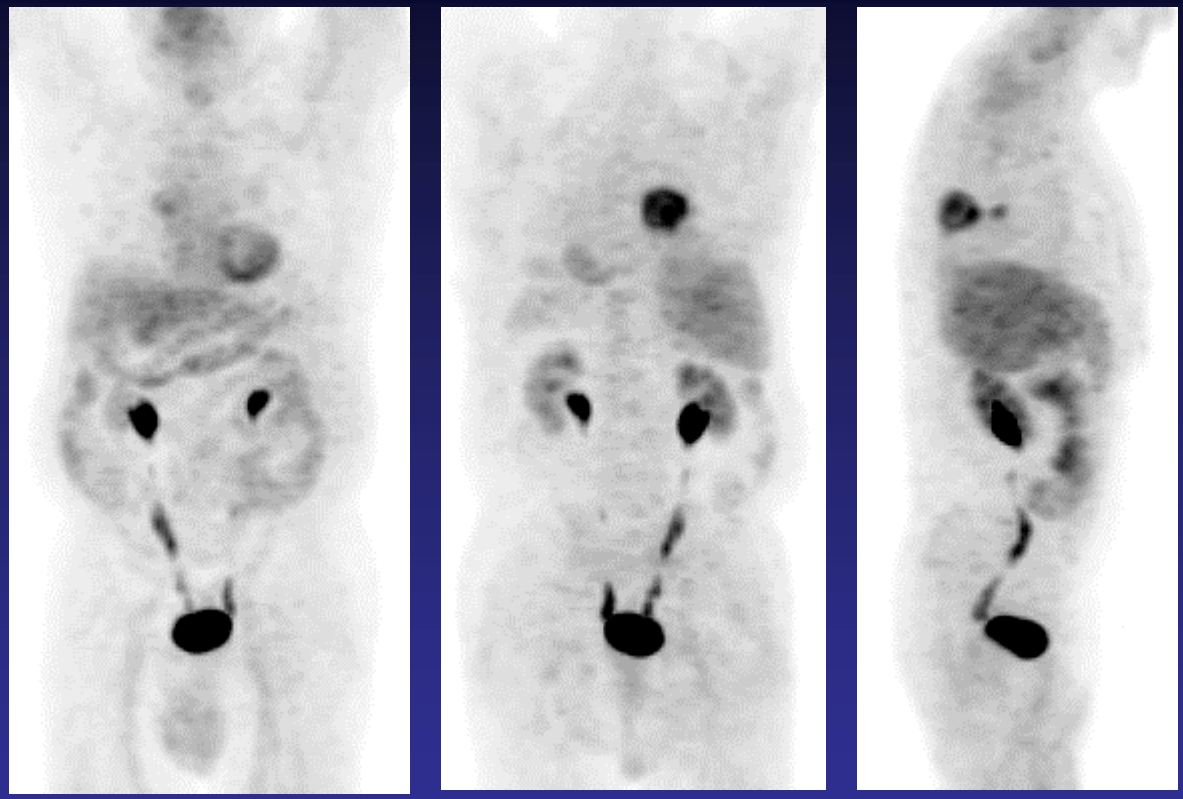
FDG-PET



ANT **POST** **R LAT**

FC 11/17/19 PF9531

Why should we quantify?

- Intra-patient comparison of uptake in one investigation (e.g. tumor to organ)
- Temporal intra-patient comparison (e.g. before/after treatment)
- Inter-patient comparisons
  - *- to normals*
  - *- to other patients of same population*
  - *- to patients of other disease populations*
- Assessment of uptake dynamics/function

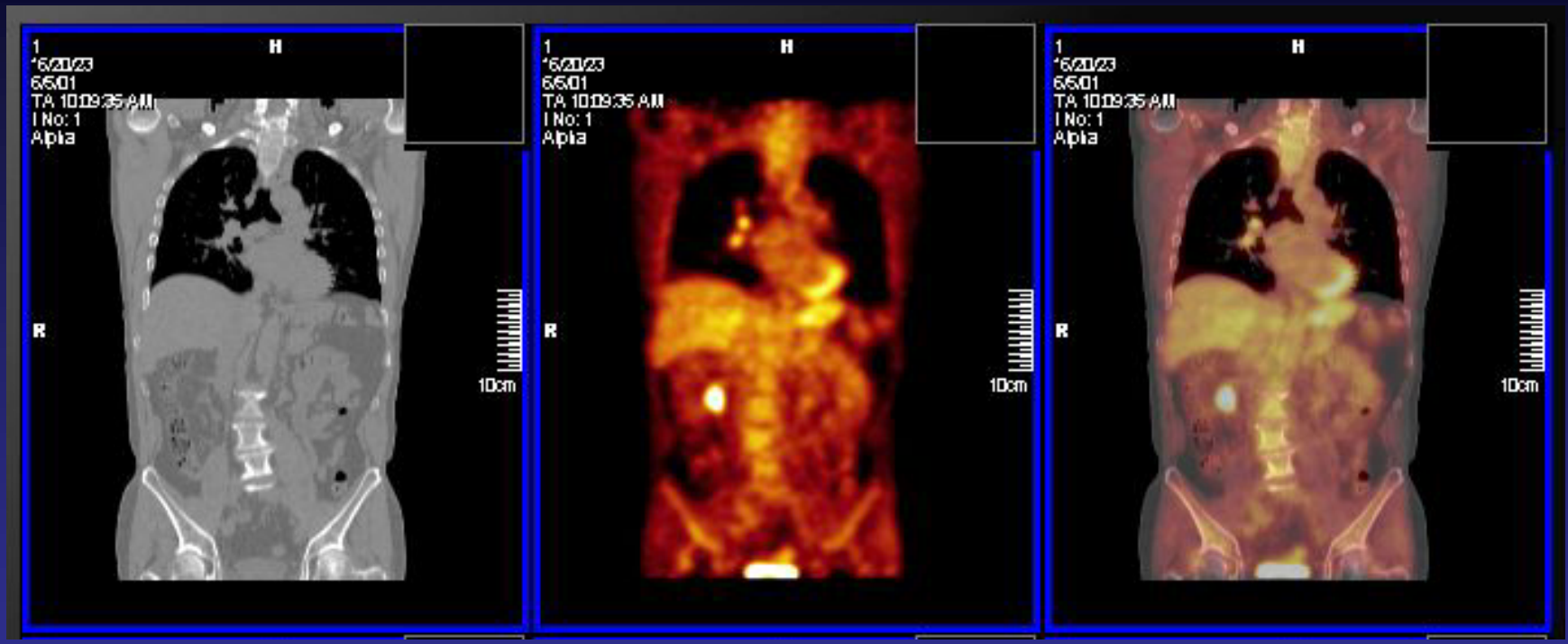
PET/CT Scan

CT Scan used for attenuation correction

Faster (1 minute vs 12 minutes)

More accurate

PET/CT Benefit: Added Anatomy for better PET Diagnostic



Standardized Uptake Value (SUV)

$$SUV = \frac{\text{Pixel value (cts.) x calibration factor (kBq/cts.)}}{\text{Injected activity (kBq/kg) x body weight (kg)}}$$

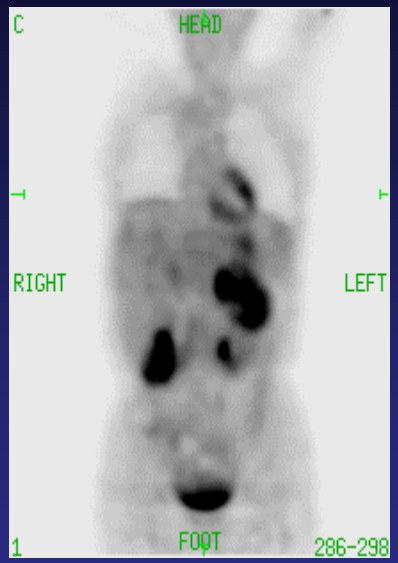
$$SUV_{lean} = \frac{\text{Pixel value (cts.) x calibration factor (kBq/cts.)}}{\text{Injected activity (kBq/kg) x lean body weight (kg)}}$$

$$SUV_{surface} = \frac{\text{Pixel value (cts.) x calibration factor (kBq/cts.)}}{\text{Injected activity (kBq/cm}^2\text{) x body surface (cm}^2\text{)}}$$

PET is Quantitative

- Standard PET corrections
  - Scatter
  - Attenuation
  - Randoms
  - Normalization
  - Calibration
  - Decay

PET Quantitation



corrected image

calibration

kBq/ml

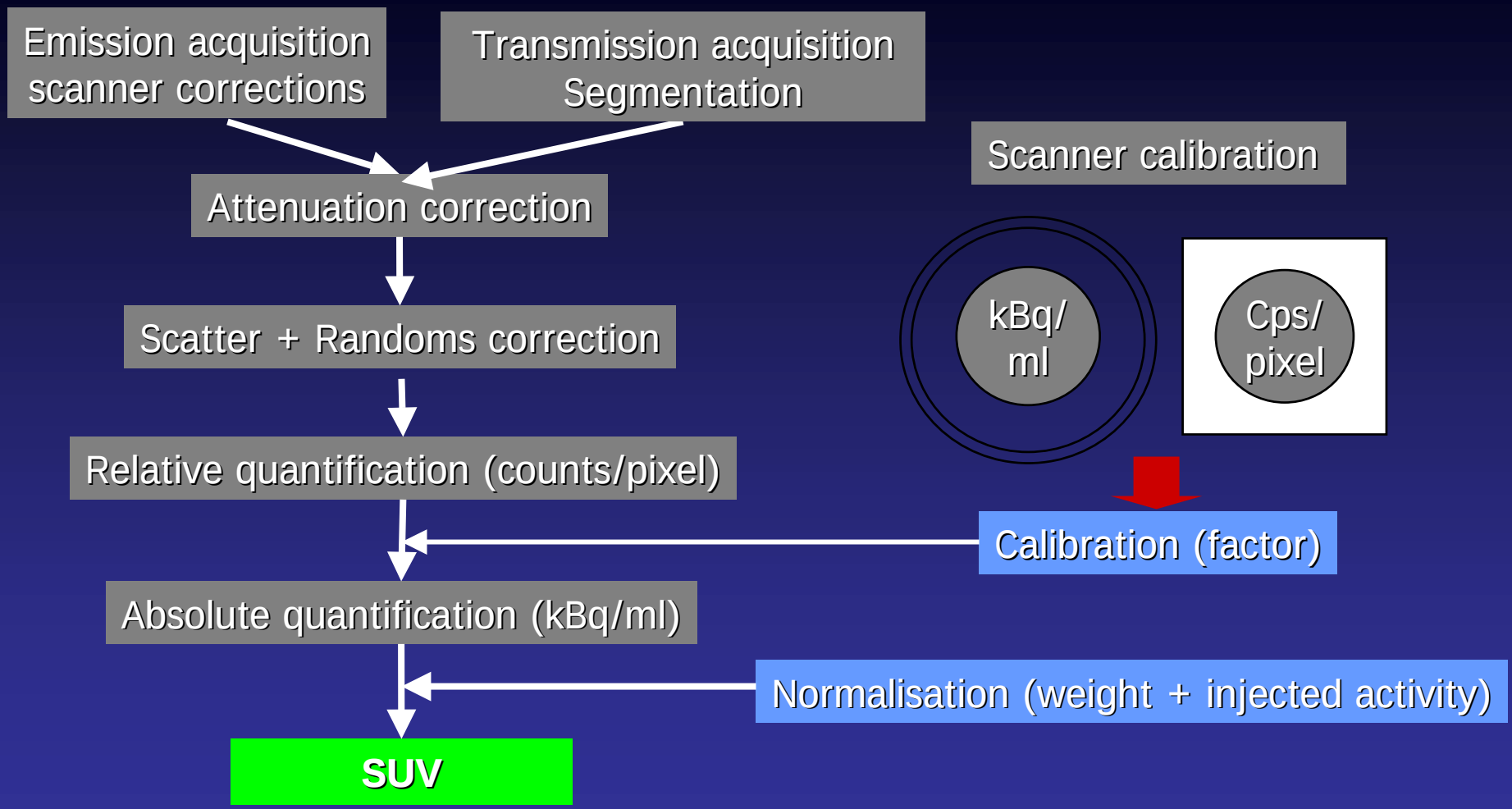
absolute

Normalization
(inj. activity, body weight)

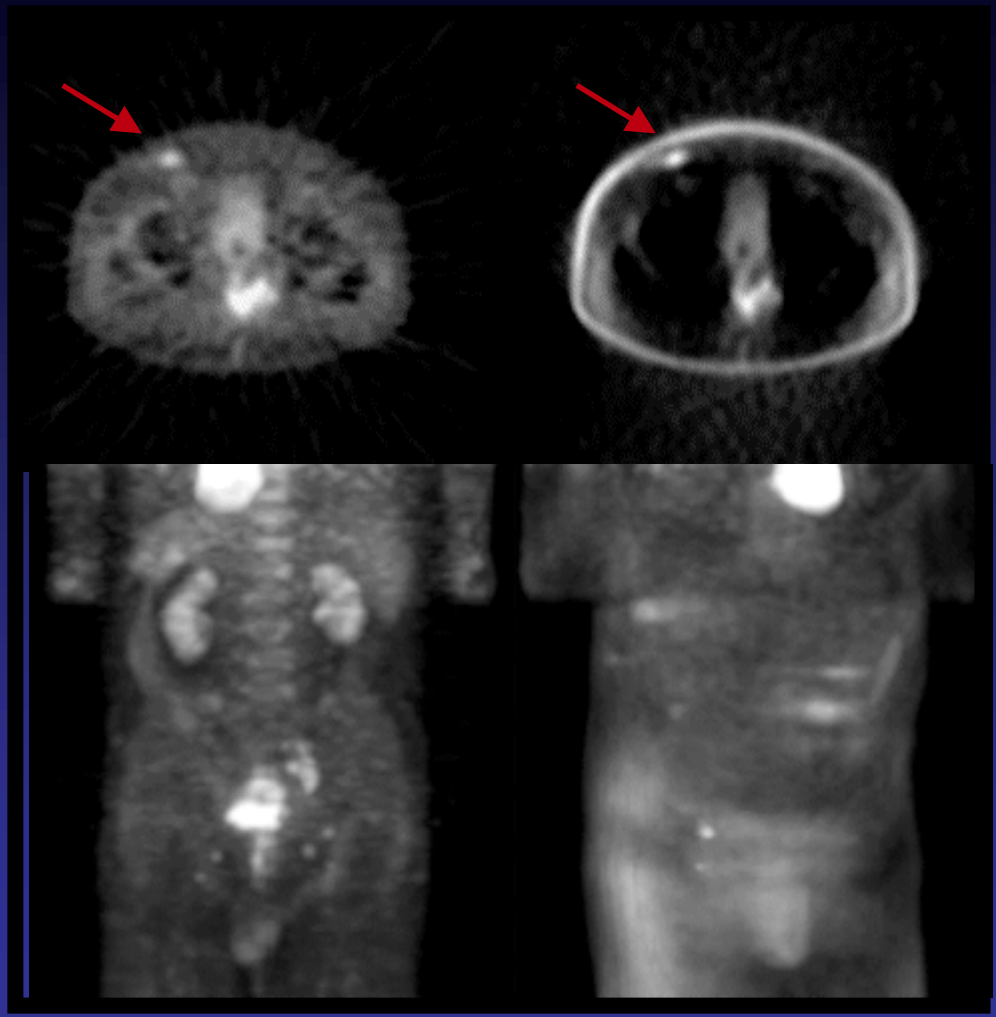
SUV

relative

The process of generating quantitative PET data



Benefits of Attenuation



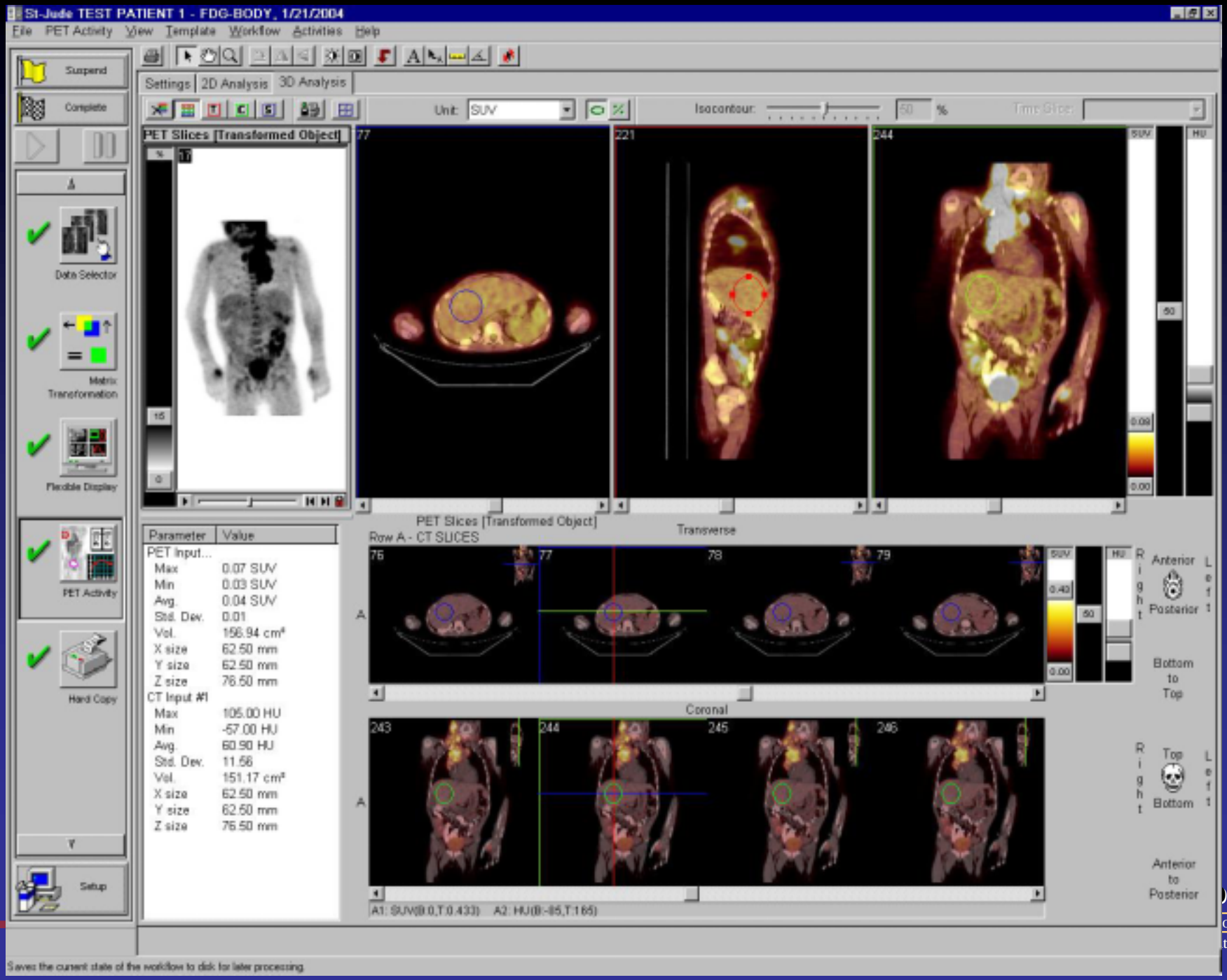
Transaxial Slices

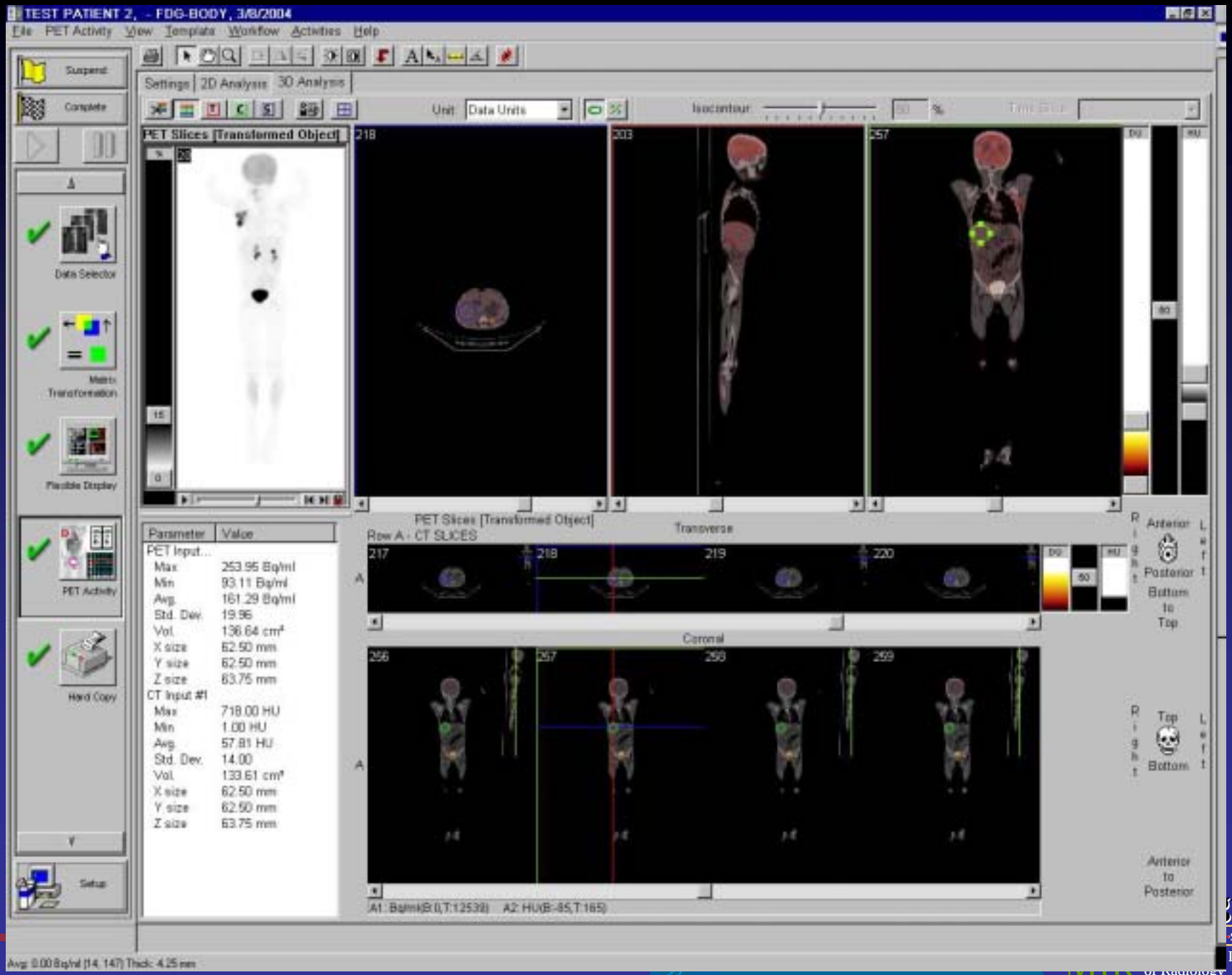
Volume Rendered

Attn Corrected

No Correction

Discovery LS data imported in ANALYZE


St-Jude TEST PATIENT 1 - FDG-BODY, 1/21/2004
File PET Activity View Template Workflow Activities Help
Suspend
Complete
Data Selector
Matrix Transformation
Flexible Display
PET Activity
Hard Copy
Setup
Settings 2D Analysis 3D Analysis
Unit: SUV
Isocontour:
PET Slices [Transformed Object]
Parameter Value
PET Input...
Max 0.07 SUV
Min 0.03 SUV
Avg. 0.04 SUV
Std. Dev. 0.01
Vol. 156.94 cm³
X size 62.50 mm
Y size 62.50 mm
Z size 76.50 mm
CT Input #1
Max 105.00 HU
Min -57.00 HU
Avg. 60.90 HU
Std. Dev. 11.66
Vol. 151.17 cm³
X size 62.50 mm
Y size 62.50 mm
Z size 76.50 mm
PET Slices [Transformed Object]
Transverse
Row A - CT SLICES
Coronal
Anterior
Posterior
Right
Left
Bottom to Top
Top
Bottom
Anterior to Posterior
A1: SUV(B:0,T:0.433) A2: HU(B:-85,T:165)
Saves the current state of the workflow to disk for later processing.


TEST PATIENT 2, - FDG-BODY, 3/8/2004
File PET Activity View Template Workflow Activities Help
Suspend
Complete
Data Selector
Matrix Transformation
Flexible Display
PET Activity
Hard Copy
Setup
Settings 2D Analysis 3D Analysis
Unit Data Units
Isocontour
PET Slices [Transformed Object]
Parameter Value
PET Input...
Max 253.95 Bq/ml
Min 93.11 Bq/ml
Avg 161.29 Bq/ml
Std. Dev. 19.96
Vol. 136.64 cm³
X size 62.50 mm
Y size 62.50 mm
Z size 63.75 mm
CT Input #1
Max 718.00 HU
Min 1.00 HU
Avg 57.81 HU
Std. Dev. 14.00
Vol. 133.61 cm³
X size 62.50 mm
Y size 62.50 mm
Z size 63.75 mm
PET Slices [Transformed Object]
Row A - CT SLICES
Transverse
Coronal
Anterior to Posterior
Top to Bottom

ACRIN protocols - Requested data

Site wishing to participate must submit 3 consecutive cases

- Attenuation images (either CT or PET based)
- PET without Atten. Corr.
- PET with Atten. Corr.

Calibration DATA

- Images of a Uniform Cylinder (20cm x 20cm) filled with a know amount of activity

Quality Control procedures:

- Standard QC on CT
- Monthly/bimonthly calibration/Normalization on PET

Summary

- PET allows quantitative measurements
  - *absolute metabolism*
  - *relative uptake*
  - *flow + uptake dynamics*
- Quantification in PET requires accurate measurement
  - *scanner calibration*
  - *scanner corrections*
  - *correction of physics effects*
- SUV's are the easiest way to implement (semi-) quantitative PET
  - *related to injected dose and body weight*
  - *allow intra- and inter-patient comparisons*
- DICOM must establish a standard way of encoding absolute activity concentration and SUV scales