PET/CT Technology Updates, Quality Assurance and Applications

Osama Mawlawi, Ph.D.
Department of Imaging Physics
MD Anderson Cancer Center

Outline
• Evolution of PET instrumentation
  • 2D ➔ 3D
  • Dedicated ➔ PET/CT
• Advantages and short comes of PET/CT
  • Possible solutions to the short comes
• QA for quantitative PET imaging
• New features in PET/CT scanners
• Future developments in PET/CT imaging

WHAT IS PET?
• Functional imaging modality as compared to structural
• Functional images show:
  • Blood flow
  • Glucose metabolism
  • Receptor density

Principles of PET Imaging
• Injection of a radioactive tracer to image chemical/biological processes.
• Radioactive tracer decays by Positron Emission.
• When the tracer is introduced into the body, its site-specific uptake can be traced by means of the labeled atom.
**Positron Decay**

\[ p = n + \beta^+ + \nu \]

- A nucleus with too low a neutron-to-proton ratio converts a proton to a neutron, emitting a positron (\(\beta^+\)) and a neutrino (\(\nu\)) to carry off the excess energy.

**Annihilation**

Detector ring

\[ 511 \text{keV} \text{ Photon} \]

LOR

\[ 511 \text{keV} \text{ Photon} \]

Nucleus

Positron

E=mc^2

\[ \text{Electron and mass is } 9.11 \times 10^{-31} \text{ kg} \]

\[ c = 3.0 \times 10^8 \text{ m/s} \]

\[ 1 \text{ joule } = 1 \text{ kg m}^2/\text{s}^2 \]

\[ 1 \text{ e} = 1.602 \times 10^{-19} \text{ coulomb} \]

\[ 1 \text{ eV } = 1.602 \times 10^{-19} \text{ J} \]

Thus: \[ E = 1.02 \text{ MeV} \]
Quantification: Power of PET

- Measured Data
- Random subtract
- Normalize
- Dead time
- Correct Geometry
- Calculate/restore scatter
- Correct Attenuation
- FBP or IR reconstruction
- Ideal measured data

Image reconstruction

- SCAM PROFILE
- A
- LSFB
- Flow Function
- B
- LSF
- C
- D
- Dead time

after the application of several corrections
Overall LOR Determination process

Physical Properties of PET Scintillators

8x8 Scintillation block  Block / PMT setup

8x8 Scintillation block  Block / PMT setup
Type of recorded events

Scatter  Random  True

Total events = Trues + Randoms + Scatter

2D vs 3D PET imaging

Inter-plane Septa

Line source 2D in air  Line source 2D in water

Line source 3D in water
Increase in sensitivity in 3D over 2D
- less injected activity → less cost
- less patient exposure
- shorter scanning time

Quantification: Power of PET
- Measured data
- Random subtract
- Normalize
- Dead time
- Correct Geometry
- Calculate/subtract scatter
- Correct Attenuation
- FBP or IR reconstruction → Ideal measured data

Attenuation is dependant on the path length and not the depth of the source of activity

Four ways to get an attenuation map
1) Measured (MAC)
2) Calculated (CAC)
3) Segmented (SAC)
4) CT based (CTAC)
Dedicated PET Imaging

- Emission (2D mode)
- Transmission (scans are interleaved)
- 5 to 6 bed positions
- 8 min per position
- 5 EM, 3 Tx
- Total scan duration 50-60 min

Disadvantages of dedicated PET imaging techniques

- Transmission
  - Noise due to low gamma ray flux from rod source
  - Transmission is contaminated by emission data
- Scan duration
  - Time consuming (emission & transmission)
  - Increased patient movement (image blurring)
- Efficiency
  - Decreased patient throughput
  - Difficulty in correlating images to other diagnostic modalities accurately

\[ SUV = \frac{\text{Measured activity} \times \text{Patient weight}}{\text{Injected dose}} \]
**PET/CT: rationale**

- Short duration, low noise CT-based attenuation correction
- Improved patient throughput (< 30 min total scan duration)
- Combines functional (PET) and anatomical (CT) imaging
- PET and CT components can be operated independently
- Fully quantitative, whole-body images for SUV calculation
- Improved patient comfort and convenience (single scan)
- Improved imaging accuracy for therapy planning & monitoring

**Improved patient throughput**

- Replace Tx scan by CT scan
- 3-5 min Tx scan duration
- 5-7 FOVs ➔ 15-35 min of Tx scanning
- CT scan for whole body is about 1 min
- About 30 min of time saving per patient
- Dedicated PET scan duration of 50 min
- PET/CT scan duration of 20 min
Combines functional and Anatomical data

CT based attenuation correction

Attenuation Scaling with Energy

- Attenuation Values are Energy Dependent
- Water (Soft Tissue) and Bone are Different
- Solution is to Segment Image into Tissue and Bone and Scale Separately

Converting CT Numbers to Attenuation Values

- For CT values < 0, materials are assumed to have an energy dependence similar to water
- For CT values > 0, material is assumed to have an energy dependence similar to a mixture of bone and water
- The green line shows the effect of using water scaling for all materials

\[
\frac{\mu}{\rho} (\text{cm}^2 / \text{g})
\]

Energy (keV)
Types of Artifacts

PET/CT imaging artifacts are due to:

- Contrast media
- Truncation
- Respiratory motion
- Metal implants

Converting CT Numbers to Attenuation Values

- For CT values < 0, materials are assumed to have an energy dependence similar to water.
- For CT values > 0, material is assumed to have an energy dependence similar to a mixture of bone and water.
- The green line shows the effect of using water scaling for all materials.

Contrast: Optiray 320, 100cc, 3cc/sec
61 year male with history of esophageal cancer

SUV change 1.23 to 1.90 54% inc
Truncation

Truncation artifact appears as:

1. Rim of high activity concentration (AC) at the truncation edge in the PET image.
2. Area of low activity concentration in the region extending beyond the CT FOV on the PET image due to the absence of attenuation coefficients.

Activity concentration recovered to within 5% of original value.
54 yrs. male with history of metastatic melanoma of the skin. SUV changed from 3.25 to 6.05

Metal Artifacts
Breathing Artifacts

CT scans acquired at full inspiration result in a downward displacement of the diaphragm due to the expansion of the lungs. Attenuation coefficients in this region will be underestimated since they represent air rather than soft tissue. The attenuation corrected PET images will result in a curvilinear cold area corresponding to this region.

Breathing Artifact - Curvilinear Cold Areas

Breathing Artifact

Mismatch of lesion location between helical CT and PET

Breathing Artifact

Mismatch of lesion location between helical CT and PET
Mismatch between PET and CT – Cardiac Application

Blurring due to object motion during data acquisition

Underestimation of Activity concentration

Possible solutions

Average CT – 4D CT

Courtesy of J. Brunetti, MDACC

Stationary

Moving
Mismatch 1: CT diaphragm position lower than PET

Mismatch 2: CT diaphragm position higher than PET

+57%

Mismatch lead to a false positive response to chemo.

A true negative response when misregistration is removed with ACT.

Impact on treatment planning

Previous GTV was outlined based on CT and clinical PET without motion correction. New GTV was redefined based on the correct information from PET with ACT.
Gated PET (used to image repetitively moving objects: cardiac, respiratory)

- Prospective fixed forward time binning
- Ability to reject cycles (cardiac) that don’t match
- Single 15 cm FOV Gated PET
- User defined number of bins and bin duration
- As number of bins increase, the duration and motion per bin decreases. However images will be noisy unless acquired for longer durations.

4D-Gated PET

Impact of Whole-body Respiratory Gated PET/CT

- The max SUV of the lesion goes from 2 in the static image to 6 in the respiratory-gated image sequence

Phantom Study

<table>
<thead>
<tr>
<th>Volume (cc)</th>
<th>Slice 1</th>
<th>Slice 2</th>
<th>Slice 3</th>
<th>Slice 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (16.5 cc)</td>
<td>316</td>
<td>313</td>
<td>299</td>
<td>228</td>
</tr>
<tr>
<td>2 (8.4 cc)</td>
<td>218</td>
<td>218</td>
<td>190</td>
<td>118</td>
</tr>
<tr>
<td>3 (4 cc)</td>
<td>218</td>
<td>218</td>
<td>190</td>
<td>118</td>
</tr>
<tr>
<td>4 (2 cc)</td>
<td>218</td>
<td>218</td>
<td>190</td>
<td>118</td>
</tr>
<tr>
<td>5 (1 cc)</td>
<td>218</td>
<td>218</td>
<td>190</td>
<td>118</td>
</tr>
<tr>
<td>6 (0.5 cc)</td>
<td>218</td>
<td>218</td>
<td>190</td>
<td>118</td>
</tr>
</tbody>
</table>

• The max SUV of the lesion goes from 2 in the static image to 6 in the respiratory-gated image sequence

 Courtesy of P. Kinahan, UW
New CT Application... Advantage

4D CT

Respiratory tracking with Varian RPM optical monitor
CT images acquired over complete respiratory cycle

Respiratory motion defined retrospective gating

4D-PET/CT

Phantom Study

Sphere-to-Background Ratio: 5.18
Total Activity: 2.49mCi
Scan Duration: 3 min
Number of Time Bins: 10
Phantom Study Results

Quality Assurance in Quantitative PET/CT

Definitions

• Quality Assurance
  - “systematic monitoring and evaluation of the various aspects of a project, service, or facility to ensure that standards of quality are being met”

• Quality Control
  - “an aggregate of activities (as design analysis and inspection for defects) designed to ensure adequate quality especially in manufactured products”

Quantitative PET Performance

3 Factors that may affect SUV measurements

• Patient Compliance
  - Fasting
  - Blood Glucose levels

• Scan Conditions
  - Scan time post injection
  - Patient anxiety/comfort during uptake (room temperature, etc.)
  - Patient motion during acquisition
  - PET/CT artifacts

• Intrinsic System Operating Parameters
  - Calibration
  - QA – Maintenance of operating parameters
  - System performance characterization
  - Image processing algorithms
PET Detector Array Format and Design

- Detector Array consists of 35 modules (0-34)
- Each module consists of 8 blocks (0-7)
- Each block consists of 8 x 6 BGO crystal array
- 1 Timing circuit per crystal pair
- $35 \times 8 \times (8 \times 6) = 13440$ total detectors

PET Detector Calibration Overview

- Installation, Calibration, Install Board, etc.
- Update Gains
- Update Position Map
- Energy Update
- CTC
- DQA Check
- Setup Base

PET Daily QA Scan

- Uses Ge-68 source pin that rotates across face of detector array
- Includes a ~2 min normalization component in which counts from the source flood are acquired
- Also includes a daily CTC after flood acquisition is complete
- Generates a visual map of detector array used to validate detector functionality
- Generates statistics used to indicate scanner performance

Daily Quality Assurance Baseline

- A baseline QA acquisition is taken after Singles and Coincidence calibration are performed following installation of the system
- A baseline QA acquisition is also performed whenever a detector block or circuit board has been replaced
- Used to construct ratio image comparing current DQA results with this baseline acquisition
Daily Quality Assurance Scans

- **Purpose**
  - To ensure that optimal clinical images will be obtained from the scanner on a daily basis.
  - To quantitatively compare scan results with manufacturer and institutional specifications and standards.
  - To enforce appropriate device usage by the technologist.
  - To allow baseline data to be available in order to derive functional trends in image quality.
Coincidence Calibrations

- Well Counter Correction (WCC)

Pre-calibrated Phantom

- Pros
  - Eliminates need to prepare a source, fill and calibrate a phantom
- Cons
  - Based on phantom manufacturer's dose calibrator readings
  - Patient studies based on site dose calibrator readings
  - Therefore, there exists a potential discrepancy between the dose calibrators used to calibrate the scanner, and the dose calibrators used to assay the doses of patient studies performed on the scanner (un-correlated)

Normalization effects

Good Norm

Bad Norm
Effect of bad Normalization

Increased activity due to error in normalization

SUVmax = 4.5

Effect of wrong WCC

Effects of Bad Blocks

Baseline

Effects of Bad Blocks

Baseline
Effects of Bad Blocks

Quantitative PET Performance

3 Factors that may affect SUV measurements
- Patient Compliance
  - Fasting
  - Blood Glucose levels
- Scan Conditions
  - Scan time post injection
  - Patient anxiety/comfort during uptake (room temperature, etc.)
  - Patient motion during acquisition
  - PET/CT artifacts
- Intrinsic System Operating Parameters
  - Calibration
  - QA – Maintenance of operating parameters
  - System performance characterization
  - Image processing algorithms

Effect of Reconstruction Algorithm
Effect of scan duration and count density on maximum AC

Effect of smoothing on measured AC

Max SUVbw in different spheres

<table>
<thead>
<tr>
<th>A</th>
<th>3D IR 2t 20sub</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>3D FORE 2t 5sub</td>
</tr>
<tr>
<td>C</td>
<td>3D FORE 5t 28sub</td>
</tr>
<tr>
<td>D</td>
<td>3D FORE FBP</td>
</tr>
</tbody>
</table>

Max SUVbw in different spheres

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
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</thead>
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<tr>
<td>A</td>
<td>10.8</td>
<td>5.3</td>
<td>5.6</td>
<td>5.7</td>
<td>5.8</td>
</tr>
<tr>
<td>B</td>
<td>6.8</td>
<td>3.2</td>
<td>3.3</td>
<td>3.4</td>
<td>3.5</td>
</tr>
<tr>
<td>C</td>
<td>10.3</td>
<td>4.2</td>
<td>4.3</td>
<td>4.4</td>
<td>4.5</td>
</tr>
<tr>
<td>D</td>
<td>10.4</td>
<td>4.3</td>
<td>4.4</td>
<td>4.5</td>
<td>4.6</td>
</tr>
</tbody>
</table>
Effect of ROI type

New PET Scanner Features

PET data acquisition of different duration per FOV

LIST Mode

- Time ticks are fixed at 1 msec intervals.
- The number of events between time ticks depends on the amount of activity in the field of view.
- The more activity, the more the events between time ticks.
- Very flexible, data can be rebinned as static, dynamic, or gated.
- Requires large amount of memory.
LIST data format

Section of a list file (41MB) using a 25MBq (0.7mCi) Ga-68 rod source acquired for a duration of 15 seconds.

Advantages of List mode acquisition:

- Ability to post process the data using different prescriptions.
- Mode of acquisition can be varied (static, dynamic, gated…).
- Duration of the scan can be changed (compare different scan durations).
- Chop off data segments based on user definition.

LIST Mode

List mode allows rebinning of acquired data into different durations.
Section of a list file (141 MB) using a 25 MBq (0.7 mCi) Ge-68 rod source acquired for a duration of 15 seconds.

**LIST data format**

Tick mark
Trigger input
Trigger allows for double gating – resp and cardiac

**New PET Scanner Designs**

**Improved sensitivity with TrueV SIEMENS**

- **thicker LSO crystals**
  - 20 mm ➞ 30 mm
  - LSO volume increase: 50%
  - Sensitivity increase: 40%
  - ★ planar sensitivity

- **extended axial FOV**
  - 16.2 cm ➞ 21.6 cm
  - LSO volume increase: 30%
  - Sensitivity increase: 77%
  - ★ volume sensitivity

**Advantages of the extended Axial Field-of-View**

- increased sensitivity = shorter imaging per bed (or more counts)
- larger axial FOV = fewer bed positions for same axial coverage
- reduction in imaging time (or dose) of ~2 for comparable quality
Biograph TruePoint performance

Noise Equivalent Count Rate

Patient NECRs

Activity (kBq/ml)

96 kcps @ 31 kBq/ml

161 kcps @ 31 kBq/ml

95 kcps @ 34 kBq/ml

Biograph TruePoint

Sensitivity (cps/kBq)

Biograph TP 4.49

TrueV 8.10

Spatial resolution (mm)

transverse

Biograph TP 4.1

TrueV 4.2

axial

Biograph TP 4.6

TrueV 4.7

Scatter (%) (425 keV)

Biograph TP 34%

TrueV 34%

SUV = 18.6

BrainPET for MAGNETOM Trio, A Tim System

Siemens Medical Solutions

Innovation is in our genes.

Molecular Imaging

Staging head and neck cancer Biograph 6 TrueV

Scan duration: 10 min

SUV = 18.6

BrainPET for MAGNETOM Trio, The first results

Works in Progress. The information about the product is preliminary. The product is under development and is not commercially available in the U.S., and its future availability cannot be ensured.

First ever in-vivo images simultaneously acquired by MR and PET (17.11.06)

Siemens Medical Solutions

Innovation is in our genes.

Molecular Imaging
BrainPET for MAGNETOM Trio, A Tim System
The first results

Artif fact free imaging even with the most demanding applications

T2 TSE  PET  MR-PET  ADC

Diffusion EPI sequence applied during PET acquisition.

VUE Point – Iterative Reconstruction

Conventional
- Deadtime / Normalization Correction
- Randoms Correction
- Attenuation Correction

VUE Point
- Deadtime / Normalization Correction
- Randoms Correction
- Attenuation Correction
- Quadrant Scatter Correction

VUE Point HD (mid-2007 update)
- Deadtime / Normalization Correction
- Randoms Correction
- Attenuation Correction
- Quadrant Scatter Correction

VUE Point – Volume Scatter Correction

Quadrant Scatter Correction
- Direct block scatter LOR
- High activity ratio artifact

Volume Scatter Correction
- Cross block scatter LOR
- Multi-quadrant processing
- Reduced artifact potential

VUE Point – Detector Geometry Modeling

Radial Repositioning (former)
- Data into evenly spaced grid for Fourier filtering
- Crystal position model includes effects of block gaps and "average" penetration
- Output data determined by linear interpolation between data points

Detector Geometry Modeling
- Allows all corrections to be included in loop (normalization/deadtime)
- Improvement in resolution
- Eliminates noise correlogram introduced by radial repositioning
- Reduction in spoke artifact
• Targeted Iterative Reconstruction may lead to artifacts and quantitative inaccuracy if the data outside the FOV is not considered.

• A full FOV (left) and targeted FOV (center) reconstruction of a simulated phantom (blue circle indicates the bounds of the targeted region).

• Horizontal profiles through the full FOV (blue) and targeted FOV (black) are shown in the graph on the right.

A more efficient method to accomplish the targeted reconstruction can be described in the following steps:

1. Reconstruct the full SFOV at a pixel pitch greater than the desired final pixel pitch in the DFOV.
2. Zero out the pixels in this image corresponding to the DFOV.
3. Forward-project the resulting image to create a sinogram representing the activity outside the DFOV.
4. Subtract sinogram from the original data set, to leave a data set representing only activity from inside the DFOV.
5. Reconstruct this sinogram at the desired pixel pitch to create the final targeted image.

An Improved Solution: Keyhole Reconstruction

Detector Geometry Reconstruction enables normalization & deadtime to be included in the iterative reconstruction loop.

Normalization & deadtime corrections in the loop increase detector variation stability.

Phantom simulation, 300k counts, 2D image

- edge crystals with 100%, 80%, 60%, 40%, 20% efficiency of the central crystals

% degradation in efficiency of edge crystals w.r.t central crystals
Motion Freeze
Impact of Whole-body Respiratory Gated PET/CT

- The max SUV of the lesion goes from 2 in the static image to 6 in the respiratory-gated image sequence

Time-of-Flight Acquisition: Principles

\[ \Delta t = \frac{\Delta x}{c} \]

\[ \text{Back projection along the LOR} \]

Time-of-Flight and SNR, examples...

\[
\text{SNR}_{\text{TOF}} \cong \frac{B}{\Delta t} \cdot \text{SNR}_{\text{non-TOF}}
\]

<table>
<thead>
<tr>
<th>Time Resolution (ns)</th>
<th>(\Delta t) (cm)</th>
<th>SNR improvement (20 cm object)</th>
<th>SNR improvement (40 cm object)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1</td>
<td>1.5</td>
<td>3.7</td>
<td>5.2</td>
</tr>
<tr>
<td>0.3</td>
<td>4.5</td>
<td>2.1</td>
<td>3.0</td>
</tr>
<tr>
<td>0.5</td>
<td>7.5</td>
<td>1.6</td>
<td>2.3</td>
</tr>
<tr>
<td>1.2</td>
<td>18.0</td>
<td>1.1</td>
<td>1.5</td>
</tr>
</tbody>
</table>

Best measurement on LSO small crystal pair [W. Moses]

Overall present time resolution on HiRez scanner

Colon cancer 119 kg (BMI = 46.5) 30 min scan

Improvement in lesion detectability with TOF
Average-weight patient study

Tongue CA, lung mets

67 kg
BMI = 29.0

CT

20 min scan

non-TOF
TOF

Improvement in lesion contrast with TOF

Courtesy of J. Karpo

non-Hodgkin’s lymphoma 136 kg (45 BMI)

TOF tumor contrast (SUV) higher than non-TOF by 1.5
TOF tumor contrast superior to non-TOF for 10 min as well as 30 min scan

Courtesy of J. Karpo

FUTURE

Mixed acquisition protocol
**Effect on Partial voluming**

All spheres contain the same activity concentration.

<table>
<thead>
<tr>
<th>Sphere diameter</th>
<th>Standard 8 x 8 detector</th>
<th>HI-REZ 13 x 13 detector</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recovery (%)</td>
<td>100</td>
<td>28</td>
</tr>
<tr>
<td></td>
<td>90</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>80</td>
<td>28</td>
</tr>
<tr>
<td></td>
<td>70</td>
<td>37</td>
</tr>
</tbody>
</table>

Profile (10 mm)

**Depth of interaction**

**Quantitative PET Performance**

3 Factors that may affect SUV measurements:

- **Patient Compliance**
  - Fasting
  - Blood Glucose levels
- **Scan Conditions**
  - Scan time post injection
  - Patient anxiety/comfort during uptake (room temperature, etc.)
  - Patient motion during acquisition
  - PET/CT artifacts
- **Intrinsic System Operating Parameters**
  - Calibration
  - QA – Maintenance of operating parameters
  - System performance characterization
  - Image processing algorithms

**Thank You**
All of the following are types of events that a PET scanner detects except:

<table>
<thead>
<tr>
<th>Percentage</th>
<th>Type of Recorded Events</th>
</tr>
</thead>
<tbody>
<tr>
<td>25%</td>
<td>True Events</td>
</tr>
<tr>
<td>25%</td>
<td>Scatter Events</td>
</tr>
<tr>
<td>25%</td>
<td>False Events</td>
</tr>
<tr>
<td>25%</td>
<td>Random Events</td>
</tr>
</tbody>
</table>

Total events = Trues + Randoms + Scatter

Attenuation in PET imaging is dependent on:

<table>
<thead>
<tr>
<th>Percentage</th>
<th>Type of Recorded Events</th>
</tr>
</thead>
<tbody>
<tr>
<td>25%</td>
<td>Annihilation photons path length</td>
</tr>
<tr>
<td>25%</td>
<td>Depth of annihilation event in the radioactive source</td>
</tr>
<tr>
<td>25%</td>
<td>Amount of radioactivity present in the source</td>
</tr>
<tr>
<td>25%</td>
<td>Number of detectors in the scanner</td>
</tr>
</tbody>
</table>

\[
P_1 = e^{-\mu L_1} \quad P_2 = e^{-\mu L_2} \quad P_1 \cdot P_2 = e^{-\mu L}
\]

Attenuation is dependant on the path length and not the depth of the source of activity.

Four ways to get an attenuation map:
1) Measured (MAC)
2) Calculated (CAC)
3) Segmented (SAC)
4) CT based (CTAC)
All of the following are advantages of PET/CT imaging over dedicated PET imaging except:

- **1.** Shorter total scan duration
- **2.** Better image resolution
- **3.** Low noise attenuation correction
- **4.** Automatic fusion of functional and anatomical images

**Disadvantages of dedicated PET imaging techniques**

- **Transmission**
  - Noise due to low gamma ray flux from rod source
  - Transmission is contaminated by emission data
- **Scan duration**
  - Time consuming (emission & transmission)
  - Increased patient movement (image blurring)
- **Efficiency**
  - Decreased patient throughput
  - Difficulty in correlating images to other diagnostic modalities accurately

**Truncation artifact in PET/CT imaging:**

- **1.** Reduces activity concentration in the affected area
- **2.** Increases the activity concentration in the affected area
- **3.** Has no effect on activity concentration in the area of interest
- **4.** Affects mainly small size patients

**Truncation artifact appears as:**

1. Rim of high activity concentration (AC) at the truncation edge in the PET image
2. Area of low activity concentration in the region extending beyond the CT FOV on the PET image due to the absence of attenuation coefficients.
Activity concentration recovered to within 5% of original value

All of the following are PET/CT artifacts due to the use of CT for attenuation correction of PET data except:

- 25% 1. Contrast media artifact
- 25% 2. Tube current artifact
- 25% 3. Metallic artifact
- 25% 4. Breathing motion artifact

Types of Artifacts

PET/CT imaging artifacts are due to:

- Contrast media
- Truncation
- Respiratory motion
- Metal implants

A well counter calibration in PET imaging is used to:

- 25% 1. Correct for variations in image uniformity
- 25% 2. Correct for variations in detector gains
- 25% 3. Correct for differences in detector coincidence timing
- 25% 4. Transform detected count rate to activity concentration
Coincidence Calibrations

- Well Counter Correction (WCC)