Identifying Image Artifacts, Their Causes, and Solutions: PET

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PET Artifacts: Case 1

Can we scan with a defective block detector?

Daily Quality Assurance (DQA) Results

- Singles counts
- Coincidence counts
- Coincidence timing offset
- Energy peak
PET Artifacts: Case 1

Uniform phantom of F-18 in water

System with Defective Block

non-TOF

TOF
PET Artifacts: Case 1

Uniform phantom of F-18 in water

System with Defective Block

System Okay
(Previous Day)

non-TOF

TOF
PET Artifacts: Case 1

Uniform phantom of F-18 in water

System with Defective Block
System Okay (Previous Day)

non-TOF

TOF

SUV: non-TOF

SUV: TOF
PET Artifacts: Case 1

Uniform phantom of F-18 in water

System with Defective Block

System Okay (Previous Day)

Discussion:

• Artifacts will depend on:
  • number of defective blocks and their location within scanner
  • activity distribution within the object
• SUVs will be affected
• TOF is more robust to data inconsistencies
Description:
• Streaks throughout reconstructed PET images

N-13 ammonia cardiac PET study
PET Artifacts: Case 2

Cause:
- Failure of two modules (16 block detectors) during the day

Resolution:
- Reboot system
- Replace hardware

Daily Quality Assurance Results (mid-day)

- Singles counts
- Coincidence counts
- Coincidence timing offset

Transaxial image
Another example:

- Intermittent failure of block detectors during scans due to a defective power supply
PET Artifacts: Case 3

Description:
- Streaks in coronal PET images
- Large photopenic areas with no apparent uptake

CT

PET with CTAC
PET Artifacts: Case 3

PET/CT Fused

PET with CTAC
PET Artifacts: Case 3

- PET/CT Fused
- PET with CTAC
- PET NAC
PET Artifacts: Case 3

Cause:
- Patient motion between CT and PET scans
- Activity appears to be outside the body
- Overcorrection of scatter
- There will be errors in attenuation correction too
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Resolution:
- Minimize motion
- Do not apply scatter correction
- Limit the scatter correction

PET/CT Fused

PET with CTAC

PET NAC

PET with CTAC No scatter correction

PET with CTAC Limit scatter correction
PET Artifacts: Case 4

Description:
- Photopenic areas of reduced uptake over diaphragm and dome of liver
PET Artifacts: Case 4
PET Artifacts: Case 4

CT

PET with CTAC

PET NAC
PET Artifacts: Case 4
PET Artifacts: Case 4

Cause:
- Respiratory motion
- Misregistration of PET and CT at the diaphragm
- CT acquired at full inspiration
- Undercorrection of attenuation

Resolution:
- Breathing techniques
- Respiratory gated PET and CT
- Apply TOF
PET Artifacts: Case 5

Description:
- Reduced blood flow in anterior region of an N-13 ammonia myocardial blood flow study

SA slices: Apex to base

Polar Map
PET Artifacts: Case 5

Cause:
• Respiratory motion
• Misregistration of the myocardium in PET and CT
• Undercorrection of attenuation
PET Artifacts: Case 5

Cause:
- Respiratory motion
- Misregistration of the myocardium in PET and CT
- Undercorrection of attenuation

Resolution:
- Re-align CT AC images onto PET images
- Re-reconstruct PET data with re-aligned CT AC images
- Limitations: Rigid body realignment with translations only
PET Artifacts: PET/MR

MR-based attenuation correction:
- Body: Dixon sequence with segmentation (tissue, fat, lung, air; no bone)
- Brain: Atlas-based (with bone; not really patient specific)
- Both methods generally work well
- Must review AC maps!
PET Artifacts: PET/MR

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Example 1: Whole body study
Example 2: Whole body study + focused brain study
PET Artifacts: PET/MR

Example 2: Whole body study + focused brain study

Whole body study

Focused brain study

Dixon InPhase  AC Map

Dixon InPhase  AC Map

No bone
10 - 20% reduction in SUV
Recommendations

If artifacts are present in PET images:

• Investigate the PET data
  • Review sinograms or singles data
  • Review PET NAC images

• Investigate the attenuation correction data
  • Review AC maps (especially for PET/MR studies)
  • Are PET images and AC maps registered?
  • Is contrast media, metal, truncation present?

To reduce artifacts:

• reduce patient motion
• use TOF whenever possible
• better algorithms to re-register PET and CT (or MR) and re-reconstruct PET
References


• Lodge MA, Mhlanga JC, Wahl RL. Effect of patient arm motion in whole-body PET/CT. *J Nucl Med* 2011;52:464P.
