OPTIMIZING FUSION IN MOLECULAR IMAGING

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Purpose Of Image Fusion

- Assures lesion being evaluated is the same lesion seen on MRI, CT
- Assists in radiation therapy planning
- Confirms diagnostic information concerning lesions seen on CT or MRI
- Defines normal anatomy
Combine Functional And Anatomical Imaging

Anatomical imaging provided by CT and MR

Functional imaging provided by PET
Benefits of Image Fusion for Your Department

1. Correlation with Multiple Modalities:
   • Localization, staging
   • Follow Chemo- or Radiotherapy before & after
   • Guide for future Biopsy

2. Integration of Nuclear Medicine Data into other Modalities
   • Improve diagnostic confidence
   • Improve cost
     - by reducing equivocal studies
Early Coincidence Detection-1996
Current PET Imaging

61y/o Male-2005

32 y/o Male-2006
Benefits

- Better definition of anatomical localization
- Useful for all nuclear studies
- Allows integration of anatomic & functional images
- Improve accuracy of interpretation
- Improved localization can decrease cost for subsequent chemotherapy & radiation therapy
Benefits Of Image Fusion

- Assesses response to therapy
- Guides more precise biopsy
- PET/CT increases patient throughput
- Guides chemotherapy and radiation therapy
Radiation Therapy Cradle
PREPARATION OF MOLDED STYROFOAM CRADLE
Fiduciary Markers
PET/CT Fusion on RT Planning System
PET Alignment
Using a Narrow SUV
CT & PET Fused In Radiation Therapy
Features
• Functional Studies combined with Anatomical Studies
  • Multiple integrated Display
  • Integrated 3D rendering

Requirements
• Use Standard DICOM to import Data (CT or MR)
  • Register any isotope
  • Viable Tumor in TI-201 Brain SPECT with CT/MR
  • Ga-67 SPECT with Tc-99m SPECT or CT/MR
  • F-18 FDG with CT/MR
Lesion Detection

- Increase in F-18 FDG uptake can be seen in most malignant lesions
- Uptake time is 60 to 90 minutes
- Correct fusion with CT or MRI improves confidence to accurately localize PET lesion
- Accurate differentiation of tumor tissue from adjacent organs is important

To Enhance or Not to Enhance, JNM, Vol 45, pg 56s-65s, Jan 2004
52 y.o. patient with history of metastatic squamous cell cancer of left posterior cervical lymph node from unknown primary. PET/CT localized the primary in the region of the left tonsil.
Types of Image Fusion

- **Visual** – Side by side comparisons of PET and CT

- **Software** – Requires network transfer of prior CT or MRI to PET workstation. Manual or automated fusion done with manufacturer’s software packages

- **Hardware** – PET/CT; the PET and CT image are physically aligned together

- The ability to import outside CT, MRI
Visual Fusion
Software Fusion
Fused PET/MRI

- 27-year-old female with malignant glioma
- MR suggests possible radiation necrosis
- Fused image shows the posterior portion of the lesion has FDG concentration (arrow) consistent with tumor
- Fused images from separate devices
Clinical History:
60y/o male glioblastoma

MRI Findings:
Progression of the right posterior parietal mass lesion since the previous examination

FDG Findings:
Findings consistent with persistent or recurrent brain tumor in the right posterior parietal region which is highly metabolically active.

Impact of Image Fusion:
In this case, fusion imaging confirmed the suspected recurrent brain tumor.

Loyola University Medical Center, NM Department
PET/CT SCANNERS

Gemini GXL
www.medical.philips.com

SceptreP3
hitachimed.com
PET/CT SCANNERS

Discovery ST

www.gemedicalsystems

The BIOGRAPH LSO PET/CT Scanner at Hong Kong Baptist Hospital
# SYSTEM SPECIFICATIONS

<table>
<thead>
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<th>Scanner</th>
<th>CT slice options</th>
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<td>BGO</td>
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Hardware Fusion
Fused PET/CT

- Patient with distal esophageal carcinoma
- Fused PET/CT shows hot lesion overlying distal esophagus
- Separate device study with software fusion
Fused PET/CT

- 44-year-old female post hysterectomy and oophorectomy for cervical cancer
- Fused PET/CT shows recurrence in the peri-aortic nodes
- Fused on a single device
biograph™ - Recurrent Lung Cancer

CT: 50 mAs; 130 KVp; pitch 1; 5 mm slices  
PET: 9 mCi of FDG; 5 min / bed; 5 bed positions; 2.4 mm slices

65 year old male, 180 lbs, with hx of Recurrent Lung Cancer. Previous PET study reported Rt lung lesions.

PET/CT study showed new lesion in colon.

Injected Dose: 9 mCi of FDG

Patient scanned 150 min post injection

Images courtesy of Siemens Medical Systems
Alzheimer’s Disease

54 year old female, 68.2 kg (150 lbs)
Decreased glucose metabolism in posterior parietal association cortex in patient with memory problems.

Data Courtesy of PET Medical Imaging Center, Grand Rapids, MI, Dr. Paul Shreve

Scan protocol:
- HI-REZ PET:
  - 555 MBq (15 mCi) $^{18}$F-FDG
  - 60 minute uptake time
- AW-OSEM (3i8s5g)
  - 10 minutes
- 16 slice CT:
  - 150 mAs
  - CareDOSE
  - 120 kV
  - 0.75 mm collimation
  - 2.0 mm slice thickness
52 year old female, 52.7 kg (116 lbs) - Adenoma carcinoma of right parotid gland, post resection, for restaging.

Recurrent FDG-avid mass in right parotidectomy bed and metastasis to sub-centimeter right II and III jugular lymph nodes.

Scan protocol:
- HI-REZ PET:
  - 15 mCi $^{18}$F-FDG
  - 90 min uptake time
  - AW-OSEM (3i8s7g)
  - 336 matrix
- 10 minutes per bed
- 16 slice CT:
  - 130 mA
  - 120 kVp
  - 0.75 mm collimation
  - 2 mm slice thickness
  - IV contrast: 2.5 ml/sec
  - 45 sec delay

Data Courtesy of PET Medical Imaging Center, Grand Rapids, MI, Dr. Paul Shreve
• 42 year old female, 136 lbs.
• HI-REZ technology demonstrates the finest resolution and exceptional image quality.
• Scan protocol: CT 154 mAs, 120 kV, 1.5 mm acquired slice width, 3 mm reconstruction increment
• PET 11.1 mCi $^{18}$F-NaF; scan performed 60 min post-injection, AW-OSEM (4i8s), 4 min/bed
28 year old female, 68 kg (150 lbs). Newly diagnosed Hodgkin’s disease through left cervical lymph node biopsy.

PET/CT for initial staging. Extensive lymphadenopathy with markedly increased FDG uptake, all of them above the diaphragm, consistent with the patient’s known history of Hodgkin’s disease.

**Scan protocol:**

PET: Pre and Post - 15.0 mCi $^{18}$F-FDG, 60 minute uptake time, AW-OSEM (4i8s)

CT: Pre - 82 mAs, 130 kV, 5 mm slice thickness; Post - 70 mAs, 130 kV, 5 mm slice thickness

Data Courtesy of Barnes Jewish Hospital, St. Louis, MO, Dr. Barry Siegel
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Data Courtesy of Barnes Jewish Hospital, St. Louis, MO, Dr. Barry Siegel
Steps for Successful Fusion

- Patient Preparation
- Maintain Camera Calibrations
- Acquisition Parameters
- Data Transfer (Software Fusion)
- Assessment of Fusion
Patient Preparation

- Patient Scheduling
- NPO minimum of 4-6 hrs prior to injection
- No strenuous exercise
- Check glucose level
- Injection of tracer
- Patient must disrobe and place on gown
- Ask patient about CT contrast allergies and give oral contrast
Patient Positioning

- Perfect centering of target organ is critical for counting efficiency. Use scout view to determine scan length.
- Pillows and other positioning devices may be used to immobilize patient and maintain patient comfort.
- Patient motion is prohibited during the emission and transmission studies to prevent imaging artifacts.
PET Acquisition and Image Processing

- Set up & acquire data adhering strictly to protocol
- Assure raw data is adequate
- Apply correct filters and reconstruction algorithms
PET Attenuation Correction

- Removes attenuation artifacts and improves image fusion
- Improves cardiac studies
- Improves visualization of deep structures
  - Mediastinum
  - Abdomen
Attenuation Artifacts

- Hot Skin
- Hot Lungs
- Cold Center

Attenuation Corrected image
DATA SETS TO FUSE

- CT - only one transverse image series
- MRI - axial image series, preferably the AXIAL T1 post Gadolinium series
- Ability to fuse volume as a whole or any organ area
Data Transfer

Transfer images via computer network utilizing DICOM - Digital Image COmmunications in Medicine

Requirements:

- Properly configured network connections
- Compatibility of systems
- Coordination with CT, MRI sections
GENERATING CT & MRI VOLUMES

- Convert single-slice CT or MRI data to multiple-slice volume that matches the PET image volume
- Match slice thickness
- Slice overlap
Factors Affecting Accuracy of Image Fusion

- Patient positioning
- Internal organ movements
- Attenuation correction
- Errors in fusion procedure
- Artifacts

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Types of Artifacts

- Overcorrection of AC caused from CT Contrast
- High density oral contrast
- Patient motion
- Respiratory differences between PET & CT
- Metal devices (pacemakers, Central Lines, etc.)
- Arm location (truncation)
Diaphragmatic Artifact

CT Attenuation Correction
Diaphragmatic Artifact

PET/CT

- CT breath-hold/PET breathing studies

- It appears on the PET only, that the disease is in the lung and liver
- Disease is actually contained in the liver only.
Head PET/CT with dental work & low dose CT...you will see the difference beam hardening has on image.

CT Attenuation Correction
Dental Artifact

Cs-137 AC Source
Excessive Activity In Fiduciary Markers
Standardized Uptake Value (SUV)

- SUV is the ratio of the concentration of activity in a structure to the average concentration in the entire body.
- Scan at the correct time interval every time patient is scanned.
- Image fusion with CT or MRI can accurately measure the tumor diameter which can then be used to make a partial volume correction and improve the accuracy of SUV.
Fusion with CTA
Fusion With SPECT

- Interactive tool to correlate two images in 3D space
- Correlates anatomic and functional images
- Data Sets from multiple modalities can be used to aid in diagnosis and staging
- SPECT/CT units use CT images for accurate attenuation correction and fusion
  - Improve accuracy of current myocardial perfusion studies
  - Provide for fusion capability and accurate uptake measurements of future molecular imaging agents
SPECT/CT SCANNERS

The Philips Precedence SPECT/CT scanner
The Siemens Symbia SPECT/CT scanner
The GE Millenium VG Hawkeye SPECT/CT scanner

Image Enhancement Reveals ProstaScint’s True Performance

Past

1. Traditional ProstaScint SPECT image - without correction

2. Same ProstaScint image with attenuation & scatter correction

Present

3. Separate CT scan, providing anatomical information

4. Fusion of CT and enhanced ProstaScint

Images provided by Benjamin M.W. Tsui, Ph.D., Division of Medical Imaging Physics, Department of Radiology, Johns Hopkins University
Image Enhancement Reveals ProstaScint’s True Performance

CT Alone

CT fused w/ ProstaScint

Bowel identified

Bowel activity

Internal iliac area looks normal

Internal iliac area looks abnormal
Clinical Case

- 64 y/o male with possible recurrent prostate cancer
- Rising PSA=3.5, S/P Radiation Therapy
- In-111 Prostascint scan and tagged RBC scan are performed with SPECT to rule out recurrent disease
- Tc-99m RBC Blood pool can be fused with In-111 Prostascint for anatomic correlation
Tc-99m RBC’S/In-111 ProstaScint
Image Fusion: MRI & Brain SPECT

Reference Study: IMAGE FUSION
Patient ID: Brain
View ID: MRI_reference
Exam Date: 19970212

Active Study: IMAGE FUSION
Patient ID: Brain
View ID: SPECT_active_REG
Exam Date: 19970212

3D Window Controls
Rotate:
Zoom:
Pan:
Render 3D Image
Rendering Options...
Cutplane Options...

Slice 67
Slice 68
Slice 69
Slice 70
Slice 67
Slice 68
Slice 69
Slice 70
Conclusions

- Image fusion can be a powerful tool if time is taken to create and follow strict protocols
- Image fusion aids in diagnostic accuracy by giving anatomic and physiological correlation
- Also aids in the staging and follow-up of oncology patients
References

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