POSITRON EMISSION TOMOGRAPHY (PET) WITH \(^{18}\text{F}\)-DEOXY-GLUCOSE

Clinical Experience

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Professor of Radiology and Pediatrics

October 2008
Topic

New Findings

Review 2007
PET vs. CT

Sensitivity and Specificity

for Tumor
<table>
<thead>
<tr>
<th>Cancer Type</th>
<th>Staging</th>
<th>Sensitivity</th>
<th>Specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bladder Cancer</td>
<td>Staging</td>
<td>76%</td>
<td>87%</td>
</tr>
<tr>
<td>Brain Tumor</td>
<td>Diagnosis</td>
<td>91%</td>
<td>n/a</td>
</tr>
<tr>
<td>Brain Tumor</td>
<td>Recurrence</td>
<td>79%</td>
<td>77%</td>
</tr>
<tr>
<td>Breast Cancer</td>
<td>Diagnosis</td>
<td>90%</td>
<td>n/a</td>
</tr>
<tr>
<td>Breast Cancer</td>
<td>Staging</td>
<td>91%</td>
<td>88%</td>
</tr>
<tr>
<td>Breast Cancer</td>
<td>Mediastinal</td>
<td>85%</td>
<td>n/a</td>
</tr>
<tr>
<td>Breast Cancer</td>
<td>Distant Metastases</td>
<td>80% to 97%</td>
<td>n/a</td>
</tr>
<tr>
<td>Cervical Cancer</td>
<td>Lymph Node Staging</td>
<td>75% to 91%</td>
<td>n/a</td>
</tr>
<tr>
<td>Cervical Cancer</td>
<td>Recurrence/Restaging</td>
<td>85% to 100%</td>
<td>n/a</td>
</tr>
<tr>
<td>Colorectal Cancer</td>
<td>Diagnosis/ Staging</td>
<td>85%</td>
<td>34%</td>
</tr>
<tr>
<td>Colorectal Cancer</td>
<td>Recurrence</td>
<td>97%</td>
<td>79%</td>
</tr>
<tr>
<td>Gastroesophageal Cancer</td>
<td>Diagnosis</td>
<td>90%</td>
<td>81%</td>
</tr>
<tr>
<td>Gastroesophageal Cancer</td>
<td>Staging</td>
<td>73%</td>
<td>50%</td>
</tr>
<tr>
<td>Head &amp; Neck Cancer</td>
<td>Diagnosis</td>
<td>93%</td>
<td>66%</td>
</tr>
<tr>
<td>Head &amp; Neck Cancer</td>
<td>Staging</td>
<td>87%</td>
<td>75%</td>
</tr>
<tr>
<td>Liver/Hepatocellular Cancer</td>
<td>Staging</td>
<td>77%</td>
<td>38%</td>
</tr>
<tr>
<td>Lymphoma</td>
<td>Staging</td>
<td>94%</td>
<td>76%</td>
</tr>
<tr>
<td>Lymphoma</td>
<td>Recurrence</td>
<td>87%</td>
<td>92%</td>
</tr>
<tr>
<td>Disease</td>
<td>Sensitivity</td>
<td>Specificity</td>
<td></td>
</tr>
<tr>
<td>---------------------------------</td>
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<td>------------------------------</td>
<td></td>
</tr>
<tr>
<td></td>
<td>PET CT</td>
<td>PET CT</td>
<td></td>
</tr>
<tr>
<td>Melanoma –</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Staging</td>
<td>83% 88%</td>
<td>91% 75%</td>
<td></td>
</tr>
<tr>
<td>Metastases</td>
<td>84% 58%</td>
<td>97% 70%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Thinner lesions (&lt;1.5 mm)</td>
<td></td>
</tr>
<tr>
<td>Lung Cancer (Non-Small Cell) –</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diagnosis</td>
<td>96% 67%</td>
<td>73% n/a</td>
<td></td>
</tr>
<tr>
<td>Staging</td>
<td>83% 64%</td>
<td>91% 74%</td>
<td></td>
</tr>
<tr>
<td>Recurrence</td>
<td>98% 72%</td>
<td>92% 95%</td>
<td></td>
</tr>
<tr>
<td>Solitary Pulmonary Nodules –</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diagnosis</td>
<td>95% 35% to 100%</td>
<td>84% 70% to 93%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>size; granulomas bronchioalveolar</td>
<td></td>
</tr>
<tr>
<td>Ovarian Cancer –</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diagnosis</td>
<td>90% 82%</td>
<td>90% 53%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>bowel; low malignant potential; benign</td>
<td></td>
</tr>
<tr>
<td>Pancreatic Cancer –</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diagnosis</td>
<td>94% 82%</td>
<td>90% 75%</td>
<td></td>
</tr>
<tr>
<td>Staging</td>
<td>70% n/a</td>
<td>93% n/a</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Size; diabetes; islet cell; pancreatitis;</td>
<td></td>
</tr>
<tr>
<td>Prostate Cancer –</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Staging</td>
<td>57% n/a</td>
<td>100% n/a</td>
<td></td>
</tr>
<tr>
<td>Recurrence</td>
<td>26% 33%</td>
<td>n/a n/a</td>
<td></td>
</tr>
<tr>
<td>Sarcomas –</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soft Tissue – Diagnosis</td>
<td>91% n/a</td>
<td>88% n/a</td>
<td></td>
</tr>
<tr>
<td>Osteosarcoma – Diagnosis</td>
<td>100% n/a</td>
<td>n/a n/a</td>
<td></td>
</tr>
<tr>
<td>Testicular Cancer –</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Staging</td>
<td>82% 59%</td>
<td>94% 87%</td>
<td></td>
</tr>
<tr>
<td>Thyroid Cancer –</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Follicular – Diagnosis</td>
<td>78% n/a</td>
<td>100% n/a</td>
<td></td>
</tr>
<tr>
<td>Hurthle cell – Diagnosis</td>
<td>87% n/a</td>
<td>100% n/a</td>
<td></td>
</tr>
<tr>
<td>Papillary – Diagnosis</td>
<td>73% n/a</td>
<td>86% n/a</td>
<td></td>
</tr>
<tr>
<td>Unknown Primary –</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Staging</td>
<td>82% 33%</td>
<td>71% 64%</td>
<td></td>
</tr>
</tbody>
</table>
NORMAL FDG DISTRIBUTION

- Brain (gray matter)
- Heart
- Testicles
- Kidneys, Ureters, Bladder
- Stomach (and esophagus)
- Bowel
- Brown Fat (cold activated)
- Liver and Spleen
- Bone marrow
- Muscles
NORMAL FDG DISTRIBUTION (NPO)
NORMAL FDG; BROWN FAT
ABNORMAL FDG DISTRIBUTION

- Most Malignant Tumors
- Some Benign Tumors
- Infections (esp. Fungal)
- Inflammations (DJD, Aortitis, Pancreatitis)
- Radiation Reaction (Pneumonitis, Osteitis)
- Activated Bone Marrow
ABNORMAL FDG DISTRIBUTION

Breast Cancer
ABNORMAL FDG DISTRIBUTION: Bone Marrow Activation
FDG PET

CLINICAL EXPERIENCE AND

REVIEW OF LITERATURE
FDG-PET CLINICAL APPLICATIONS

- **TUMORS**
  Diagnosis, Staging,
  Response to Therapy,
  Recurrence

- **BRAIN**
  Tumors and Infections,
  Epilepsy, Dementias, etc.

- **HEART**
  Myocardial Viability
FDG-PET IN TUMOR OF UNKNOWN ORIGIN:
LOCALIZATION OF PRIMARY TUMOR
A 39yo female presents with RUQ pain

Ultrasonogram showed a right peri-diaphragmatic mass. CT and MRI confirmed the mass. CT also showed a hilar LN but no other lesions.

FDG-PET FOR TUMOR OF UNKNOWN ORIGIN
Biopsy of the mass showed adenocarcinoma with a differential including digestive tract as origin.
FDG-PET FOR TUMOR OF UNKNOWN ORIGIN

Transaxial cuts

Sagittal cuts

Coronal cuts

High-intensity focal activity in the known hepatic metastasis but also in the left pararenal space c/w primary, colon cancer
Correlation of FDG-PET with the CT of the abdomen

Retrospectively, a mass lesion was present in the perirenal space on the recent CT (colon cancer).
FDG PET IN TUMOR OF UNKNOWN ORIGIN
Localization of Primary

Total Patients: 27 patients diagnosed with head and neck carcinoma of unknown primary.

Cervical and abdominal ultrasound, panendoscopy, and CT or MRI failed to locate the site of primary cancer.

PET showed the primary in 7/27 patients (26%).
PET showed the primary or additional previously unknown metastases in 13/27 patients (48%).

University of Cologne, Cologne, Germany
Otolaryngology-Head and Neck Surgery, September 2000, pp294-301
FDG PET IN TUMOR OF UNKNOWN ORIGIN
Localization of Primary

Total Patients: 53 with cervical adenopathy or other metastatic lesions.

CT, MRI, Ultrasound, Colonoscopy did not indicate primary source.

PET showed the primary in 21/53 patients (41%).

*Philipps University, Marburg, Germany*

*Journal of Nuclear Medicine, May 2000, 41, pp816-822.*
FDG PET IN TUMOR OF UNKNOWN ORIGIN
Localization of Primary

Total Patients: 42 patients diagnosed with neck metastatic carcinoma of unknown primary.

They had undergone extensive clinical, laboratory, imaging and biopsy and no primary site was indicated.

PET showed the primary in 20/42 patients (48%) confirmed by additional investigation in 10 patients (24%).

PET resulted in significant modification of radiation Tx (24%)

Johansen; Laryngoscope 112(11); 2009-14, 2002 // Copenhagen

2003 review
FDG PET IN TUMOR OF UNKNOWN ORIGIN
Localization of Primary

Patients with neck LN cancer of UO have work up including MR
A median of 7 diagnostic tests detected primary tumor in 25%

Of the remainder 42 patients PET suggested Primary Tumor in 26 patients (67%), which was confirmed in 18(43%)

Additional Dissemination was found in 5 patients

Treatment selection influenced in 29 patients (69%)

Topic

New Findings

Review 2007
New Findings

Review 2007
FDG-PET IN LUNG CANCER

Current Research

a) Late imaging at 2-3 hr post FDG injection differentiate tumors (relatively increasing activity) from inflammation (relatively decreasing activity)

b) Respiratory motion correction increases sensitivity
FDG PET/CT for LUNG Cancer (Small Cell Lung Cancer)

TISSUE CHARACTERIZATION / STAGING / EFFECT OF THERAPY
A smoker has a suspicious nodule in the lung (CT). FDG-PET for lung lesions were among the first applications.
Participation 2b

\(^{18}\text{FDG-PET in LUNG CANCER Initial Diagnosis}\)
The study is positive for tumor: a Cavitating Lesion in the lung (NSCLC by biopsy)
The study is positive for tumor: Lesions in the lung with Metastases
FDG-PET IN LUNG CANCER:

Case 2e: Specificity for Pulmonary Nodules

Asymptomatic patient with a solitary pulmonary nodule (SPN) in LUL by CT

NO FDG UPTAKE in the region of the SPN

Biopsy was NEGATIVE for tumor.
Asymptomatic patient with a solitary pulmonary nodule in RLL by CT

High-intensity FDG accumulation in the SPN c/w tumor.
No metastasis.

Biopsy: Non small-cell lung cancer (NSCLC)
FDG-PET IN LUNG CANCER

**Sensitivity:** > 90% for lesions larger than 1 cm
(Broncho-Alveolar 50-60%)

**Specificity:** > 80%

False (+): Granulomas (active)
Fungal Infections
Radiation Pneumonitis
Prospective Study:

96 pts with lesions 1-7cm (3.44 cm); 24 controls
86 cancers: 44 adenocarcinomas, 30 squamous, 4 SC, 3 LC, 5 misc.
8 benign lesions

FDG-PET

97% Sensitive  80% Specific

FDG-PET IN LUNG CANCER AT UM

131 pts with SPN (before or after biopsy)

PRIMARY LESIONS
FDG: 1 FN

STAGE IIIA N2 : NODAL DETECTION
CT: Se = 45% Spe = 92%
PET-FDG: Se = 95% Spe = 95%

Internal Review: June 1999 (Katariya, et al)
59 yo with lung cancer for staging

FDG positive in the L. LUNG & LIVER, (known by CT) but also in the SKELETON and PELVIS, (retrospectively present on CT)
## Literature Review

### FDG-PET IN LUNG CANCER STAGING

**Detection of Mediastinal Nodes**

<table>
<thead>
<tr>
<th></th>
<th>Sensitivity</th>
<th>Specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT</td>
<td>75%</td>
<td>66%</td>
</tr>
<tr>
<td>PET</td>
<td>91%</td>
<td>86%</td>
</tr>
</tbody>
</table>

Total Patients=102, prospective


<table>
<thead>
<tr>
<th></th>
<th>Sensitivity</th>
<th>Specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT</td>
<td>63%</td>
<td>60%</td>
</tr>
<tr>
<td>PET</td>
<td>93%</td>
<td>94%</td>
</tr>
</tbody>
</table>

103 Patients

*From Gupta in Annals of Surgery 1999 Vol.229, No.2, 286-291*
### FDG-PET IN LUNG CANCER STAGING

#### Detection of Mediastinal Nodes

<table>
<thead>
<tr>
<th>Method</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>PPV</th>
<th>NPV</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT</td>
<td>74%</td>
<td>78%</td>
<td>55%</td>
<td>88%</td>
</tr>
<tr>
<td>PET side by side CT</td>
<td>59-76%</td>
<td>77-89%</td>
<td>48-62%</td>
<td>84-91%</td>
</tr>
<tr>
<td>PET/CT registered</td>
<td>71-76%</td>
<td>89-96%</td>
<td>70-86%</td>
<td>90-91%</td>
</tr>
</tbody>
</table>

130 Nodal Stations in the mediastinum and hila by Biopsy

*Aquino: J Computed Tomography 27(4);479-84 2003 // Massachusetts Gen.*
FDG-PET IN LUNG CANCER
Re-Staging

Patient s/p partial pneumonectomy for SPN, now for reevaluation
Positive brain MRI (L cerebellar) and questionable lung CT

High-intensity FDG uptake in the BRAIN and the AORTO-PULMONARYWINDOW
FDG-PET IN LUNG CANCER
Response to Treatment

Patient with history of lung cancer after chemotherapy

GOOD RESPONSE TO THERAPY
FDG-PET IN LUNG CANCER
Effect on Patient Management

STAGING
FDG-PET: Se: 91%   Spe: 86%
(CT/MR Se: 75%   Spe: 66%)

Changed Management in 54% Pts

FDG-PET IN LUNG CANCER
Effect on Patient Management

STAGING
FDG-PET: Accuracy: 83% (p<.005)
(CT Accuracy: 65%)

Changed Management in 19% Pts

Marom EM, et al. Staging non-small-cell lung cancer with whole-body PET.

Radiology 1999; 212:803-809.
FDG-PET IN LUNG CANCER
Effect on Staging and Treatment

Prospective Study with 153 Patients

107 pts: Cleared by PET, treated with curative radical Tx
(reduction of target volume with RTx in 5 pts
including 5 changed to Sx treatment)

46 pts: Due to PET, changed to palliative Tx

5 pts: PET was ignored - 4 died and one has mult. mets.

MacManus MP, et al. F-18 Fluorodeoxyglucose positron emission tomography
staging in radical radiotherapy candidates with non-small-cell lung
FDG-PET IN LUNG CANCER
Effect on Patient Management

Solitary Pulmonary Nodules:
Prevents biopsy of benign lesions (high NPV),
more important when thoracotomy prevented

Staging NSCL:
Detects metastasis missed by CT (20%)
Detects tumor inaccessible to mediastinoscopy (6%)

PET Cost:
Balances against cost of avoided procedures

Gambhir et al, JNM  1996; 37:1428-1436
Solitary Pulmonary Nodule indeterminate by CT PET correctly identified the primary and hilar and mediastinal involvement.

FDG PET can accurately characterize an indeterminate solitary pulmonary nodule with a 98% sensitivity using visual analysis.

“PET + CT is significantly more accurate than CT alone in LN staging of NSCLC.”

“Whole body FDG PET improves detection of extrathoracic metastases in patients with non-small cell lung cancer otherwise eligible for operation.”


Topic

New Findings

Review 2007
Topic

New Findings

Review 2007
FDG-PET IN
BRAIN TUMORS
A patient with lung cancer has CNS symptoms
Brain lesion with activity comparable to the lung lesion

Brain Metastasis from a lung cancer

\textsuperscript{18}FDG-PET in metastatic brain lesions
Patient with cavitating lung lesion on CT and also a brain lesion.

The PET showed all lesions c/w tumor. Biopsy: NSCLC

BRAIN TUMORS: TISSUE CHARACTERIZATION

PET total body study

PET brain study
A patient with ovarian cancer has CNS symptoms
Brain lesion with activity comparable to the ovarian lesion

\(^{18}\text{FDG-PET in metastatic brain lesions}\)
$^{18}$FDG-PET in metastatic brain lesions

Brain lesion with activity comparable to the ovarian lesion

Brain Metastasis from an ovarian cancer
FDG/PET studies differ depending on the grade of the tumor:
High grade: visualized
Low grade: not-visualized

Amino acid Imaging (methionine)
Visualizes both High and Low grade
Low grade Tumor
Low grade Tumor

High grade Tumor
HIV positive patient with CNS symptoms
CT: Toxoplasma or lymphoma of the R basal ganglia
Thallium-201 study to differentiate
and FDG PET 15 days into treatment for Toxoplasma
Participation 6b

Brain CT: Inconclusive

Thallium SPECT: Inconclusive
Participation 6c

Brain CT: Inconclusive

CT

Thallium SPECT: Inconclusive

THALLIUM EARLY

THALLIUM LATE

FDG-PET
TOXOPLASMOSIS

Participation 6d

Brain CT: Inconclusive

PET: Decreased activity=Toxoplasma

Thallium SPECT: Inconclusive
DIFFERENTIATING TUMOR FROM INFECTION

CT: Ring-Enhancing Lesion: Tumor vs. Toxoplasmosis
Thallium study was questionable.
PET (15 days into treatment for toxoplasma): toxoplasmosis
FDG PET for BRAIN TUMOR RECURRENCE: NEGATIVE

MRI: Questionable Lesion: Tumor vs. Necrosis

PET: No uptake = No recurrence
FDG-PET for BRAIN TUMOR RECURRENCE: POSITIVE

77yo male with history of grade IV glioma s/p debulking + RTx
MRI: Tumor/Necrosis?

High-intensity FDG uptake c/w TUMOR Recurrence
PET for BRAIN METASTASIS RECURRENCE: POSITIVE

MRI: Ring-Enhancing Lesion: Tumor vs. Necrosis

PET: Tumor in the middle of necrosis
PET IN BRAIN TUMORS
Review articles for all indications


2. Sfakianakis G, Sfakianaki E: Scintigraphy of Brain Tumors in “Brain Tumors, from Histology to Treatment”, A. Drevelegas Editor. Springer Verlag
   In press.
# FDG-PET IN BRAIN TUMORS

**RECCURENCE VS. NECROSIS**

Prospective study at UM/JMMC

<table>
<thead>
<tr>
<th></th>
<th>Sensitivity</th>
<th>Specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td>PET (+)</td>
<td>12/13*</td>
<td>(-) 3/3</td>
</tr>
</tbody>
</table>

Total Patients = 16,  

- **Proof**  
  - Sensitivity: Biopsy or death from tumor  
  - Specificity: Follow-up without treatment  

* recurrence of a metastatic tumor missed.  

*Avril et al*
FDG-PET IN BRAIN TUMORS
RECCURENCE v/s RADIONECROSIS

<table>
<thead>
<tr>
<th></th>
<th>Sensitivity</th>
<th>Specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td>PET</td>
<td>75%</td>
<td>81% (all tumor types)</td>
</tr>
<tr>
<td></td>
<td>65%</td>
<td>80% (metastatic tum)</td>
</tr>
<tr>
<td>PET + MRI</td>
<td>86%</td>
<td>80% (metastatic tum)</td>
</tr>
<tr>
<td>coregistered</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Chao *International J Cancer* 96(3); 191-7 2001
FDG-PET in DIFFERENTIATION OF THE PRIMARY form METASTATIC BRAIN TUMORS: “Primary is a tumor if the PET showed no other tumor”

127 Patients with Brain Masses (77 metastatic, 50 primary) had PET
Extracranial Primary Tumors were detected in 61 of the 77 patients with brain metastases
No extracranial lesion was found in 47 of the 50 patients with primary brain tumors
FDG-PET for Primary Brain Tumors had:
  Sensitivity 79%
  Specificity 94%
  PPV 95%
  NPV 75%

Jeong  J Nucl Med 43(11); 1432-7  2002
SCREENING FOR CEREBRAL METASTASIS with total body FDG-PET v/s contrast MRI

40 patients with non-cerebral Primary Tumors
Underwent whole body staging with FDG-PET
For brain metastasis FDG-PET had

Sensitivity 79%
Specificity 94%
PPV 95%
NPV 75%


PET SHOULD NOT BE USED FOR SCREENING FOR BRAIN METASTASIS

2003 review
58 patients with brain tumor were evaluated via FDG-PET for high-grade neoplasm (HGN) quantitatively. Cutoff levels for HGN: Tumor/White Matter > 1.5, Tumor/Cortex > 0.6. All results confirmed histologically.

<table>
<thead>
<tr>
<th>High-Grade Neoplasms</th>
<th>Sens</th>
<th>Spec</th>
</tr>
</thead>
<tbody>
<tr>
<td>All brain tumors</td>
<td>94%</td>
<td>77%</td>
</tr>
<tr>
<td>Glioma only</td>
<td>100%</td>
<td>67%</td>
</tr>
</tbody>
</table>

*Delbeke, Radiology, 1995, 195:47-52*
FDG-PET IN PRIMARY BRAIN TUMORS
FDG-PET as a prognostic indicator

55 patients with grade 3 or 4 malignant gliomas s/p initial surgery and radiation therapy presenting with MRI indicative of recurrence vs. radiation necrosis.

<table>
<thead>
<tr>
<th>FDG uptake</th>
<th>Median survival</th>
<th>2yr survival</th>
</tr>
</thead>
<tbody>
<tr>
<td>Higher than</td>
<td></td>
<td></td>
</tr>
<tr>
<td>the adjacent cortex:</td>
<td>20 mo.</td>
<td>50%</td>
</tr>
<tr>
<td>Lower than</td>
<td></td>
<td></td>
</tr>
<tr>
<td>the adjacent cortex:</td>
<td>10 mo.</td>
<td>6%</td>
</tr>
</tbody>
</table>

FDG-PET IN PRIMARY BRAIN TUMORS
Directing Stereotactic Biopsies

43 patients with suspected brain tumors evaluated with CT and PET-guided biopsy.

PET increased the positive results yield from 82 to 96%.

In 8 patients, biopsies were obtained in PET + lesions in regions that appeared normal on CT with contrast. 8/8 trajectories were tumor-positive.

In 6 patients, biopsies were obtained in PET-lesions in regions that appeared abnormal on CT only. 6/6 were not diagnostic.

FDG-PET IN PRIMARY BRAIN TUMORS
Directing Stereotactic Biopsies

PET increased the positive results yield from 82 to 96%.

FDG-PET IN PRIMARY BRAIN TUMORS

Impact on patient management

75 glioma patients undergoing FDG-PET as part of clinical evaluation with MRI and/or CT. Changes in management based on FDG-PET alone were tabulated.

<table>
<thead>
<tr>
<th>Cases</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Debulking withheld</td>
<td>5</td>
</tr>
<tr>
<td>Chemo withheld</td>
<td>4</td>
</tr>
<tr>
<td>Chemo initiated</td>
<td>7</td>
</tr>
<tr>
<td>“Other” Rx withheld</td>
<td>9</td>
</tr>
<tr>
<td>Total</td>
<td><strong>25 (28%)</strong></td>
</tr>
</tbody>
</table>

Topic

New Findings

Review 2007
Topic

New Findings

Review 2007
Current Research

Late imaging at 2-3 hr post FDG injection shows metastatic lesions in the liver not shown at 1 hr
Patient with biopsy-diagnosed colorectal cancer for staging multiple metastases
FDG-PET IN COLORECTAL CANCER
Initial Diagnosis / Staging

<table>
<thead>
<tr>
<th></th>
<th>PET</th>
<th>CT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity</td>
<td>85%</td>
<td>34%</td>
</tr>
<tr>
<td>Specificity</td>
<td>71%</td>
<td>92%</td>
</tr>
<tr>
<td>PPV</td>
<td>95%</td>
<td>50%</td>
</tr>
<tr>
<td>NPV</td>
<td>99%</td>
<td>86%</td>
</tr>
<tr>
<td>Accuracy</td>
<td>94%</td>
<td>81%</td>
</tr>
</tbody>
</table>

Total Patients = 48

A patient with history of colorectal cancer treated is now evaluated for recurrence (rising CEA)
No lesions were reported on CT originally
FDG-PET IN COLORECTAL CANCER Recurrence
PET-FDG was positive
No lesions were reported on CT originally but the PET was positive behind the bladder.
No lesions were reported on CT originally but the PET was positive behind the bladder. Review of the CT after PET showed the recurrence.
A patient with a history of Rectal Cancer treated is evaluated for recurrence due to rising CEA. A contrast CT was reported negative.
S/P rectal cancer operated and treated. CT was interpreted negative.
S/P rectal cancer operated and treated. CT was interpreted negative.

PET: High-intensity FDG activity in posterior pelvis c/w recurrence.
FDG-PET IN COLORECTAL CANCER
Retrospectively, a lesion was appreciated on the recent CT.
FDG PET in COLORECTAL cancer (Staging): Enters PET / CT
# FDG-PET IN COLORECTAL CANCER

## Localization of Recurrence

<table>
<thead>
<tr>
<th></th>
<th>Sensitivity</th>
<th>Specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT</td>
<td>79%</td>
<td>73%</td>
</tr>
<tr>
<td>PET</td>
<td>94%</td>
<td>87%</td>
</tr>
</tbody>
</table>

Total Patients = 1,387

*J. of Nuclear Medicine. Vol. 42, No. 5, May 2001 (Supplement)*
## FDG-PET IN COLORECTAL CANCER

### Localization of Recurrence

<table>
<thead>
<tr>
<th>Recurrence</th>
<th>Sensitivity</th>
<th>Specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT</td>
<td>73%</td>
<td>75%</td>
</tr>
<tr>
<td>PET</td>
<td>93%</td>
<td>58%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Local Recurrence</th>
<th>Sensitivity</th>
<th>Specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>75%</td>
<td>100%</td>
</tr>
<tr>
<td></td>
<td>100%</td>
<td>86%</td>
</tr>
</tbody>
</table>

Total Patients = 42

### Effect on Management

- PET upstaged 8/30 pts (27%)
- PET altered management of 16/42 pts (38%)

---


*2003 review*
# FDG-PET IN COLORECTAL CANCER

## Localization of Recurrence

### TABLE IV. Efficacy of FDG PET in Detecting Unsuspected Distant Recurrences in Preoperative Staging

<table>
<thead>
<tr>
<th>Reference</th>
<th>Patients (No.)</th>
<th>Unsuspected metastases detected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delbeke et al.</td>
<td>61</td>
<td>17</td>
</tr>
<tr>
<td>Valk et al.</td>
<td>78</td>
<td>9</td>
</tr>
<tr>
<td>Beets et al.</td>
<td>16</td>
<td>11</td>
</tr>
<tr>
<td>Lai et al.</td>
<td>34</td>
<td>4</td>
</tr>
<tr>
<td>Flamen et al.</td>
<td>103</td>
<td>25</td>
</tr>
</tbody>
</table>

*Bombardieri et al: Seminars in Surgical Oncology. 2001;  20:134-146*
Recurrence in the pre-sacral space and metastasis in both ovaries correctly identified.
New Findings

Review 2007
New Findings

Review 2007
FDG-PET IN
HEAD and NECK CANCER
A patient with a history of Squamous Cell Cancer of the Face
FDG-PET for staging was performed
FDG-PET IN HEAD AND NECK CANCER
Preoperative LN staging

High-intensity FDG uptake in the tumor of the FACE
FDG-PET in HEAD and NECK Ca

Preoperative LN staging
High-intensity FDG accumulation in a supraclavicular Lymph Node
FDG-PET IN HEAD and NECK CANCER
Detection of Lymph Node Metastasis

<table>
<thead>
<tr>
<th></th>
<th>Sensitivity</th>
<th>Specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT</td>
<td>85%</td>
<td>86%</td>
</tr>
<tr>
<td>PET</td>
<td>96%</td>
<td>90%</td>
</tr>
</tbody>
</table>

Total Patients = 54
Confirmation with histopathology

*Annals of Surgery, vol.231, pp.229-234*
FDG-PET IN HEAD AND NECK CANCER
Preoperative LN staging

FDG-PET alone correctly staged > 70%
   and only understaged < 15% of patients.

CT, MRI, and U/S correctly staged ~50%
   and understaged ~ 25% of patients.

FDG-PET IN HEAD AND NECK CANCER
Detection of LN metastases

60 patients with head and neck carcinoma prospectively evaluated with CT, MRI, U/S, and FDG-PET all within 2 weeks of biopsy. Confirmed via pathology of 1,284 resected lymph nodes.

<table>
<thead>
<tr>
<th></th>
<th>Sens</th>
<th>Spec</th>
<th>PPV</th>
<th>NPV</th>
<th>Acc</th>
</tr>
</thead>
<tbody>
<tr>
<td>PET</td>
<td>90</td>
<td>94</td>
<td>58</td>
<td>99</td>
<td>93</td>
</tr>
<tr>
<td>CT</td>
<td>82</td>
<td>85</td>
<td>35</td>
<td>98</td>
<td>85</td>
</tr>
<tr>
<td>MRI</td>
<td>80</td>
<td>79</td>
<td>27</td>
<td>98</td>
<td>79</td>
</tr>
<tr>
<td>U/S</td>
<td>72</td>
<td>70</td>
<td>19</td>
<td>96</td>
<td>70</td>
</tr>
</tbody>
</table>

A Patient presents with recurrent right nasopharyngeal mass

A PET study was performed for restaging
Patient presents with recurrent right nasopharyngeal mass.

image without attenuation correction
Patient presents with recurrent right nasopharyngeal mass.
Patient presents with recurrent right nasopharyngeal mass

High FDG uptake in the known mass but also in an ADDITIONAL LESION ON THE LEFT

image without attenuation correction
FDG-PET in HEAD and NECK Ca Enters PET / CT

Restaging

FDG accumulation in the left vocal chord
FDG-PET IN HEAD AND NECK CANCER
Evaluation of Recurrence

43 patients with head and neck carcinoma s/p radiotherapy, presenting with signs or symptoms suspicious for recurrence evaluated with FDG-PET and CT, MRI, or CT and MRI.

<table>
<thead>
<tr>
<th></th>
<th>Sens</th>
<th>Spec</th>
<th>Acc</th>
<th>FN</th>
</tr>
</thead>
<tbody>
<tr>
<td>FDG-PET</td>
<td>91%</td>
<td>86</td>
<td>88</td>
<td>2/20</td>
</tr>
<tr>
<td>CT/MRI</td>
<td>53%</td>
<td>79</td>
<td>66</td>
<td>9/24</td>
</tr>
</tbody>
</table>

In 7/24 patients with no evidence of recurrence on CT/MRI, FDG-PET confirmed recurrence.

FDG-PET IN HEAD AND NECK CANCER
Evaluation of Recurrence

28 patients with nasopharyngeal carcinoma s/p radiotherapy, presenting with signs or symptoms suspicious for recurrence and indeterminate MRI studies

Sens Spec Acc
FDG-PET 100% 92.9% 96.4%


2003 review
50 patients with suspected primary (37) or recurrent (13) head and neck cancer underwent prospective evaluation with panendoscopy, CT, US, and FDG-PET.

<table>
<thead>
<tr>
<th>Test</th>
<th>Sens</th>
<th>Spec</th>
<th>Acc</th>
</tr>
</thead>
<tbody>
<tr>
<td>FDG-PET</td>
<td>95</td>
<td>92</td>
<td>94</td>
</tr>
<tr>
<td>CT</td>
<td>68</td>
<td>69</td>
<td>68</td>
</tr>
<tr>
<td>U/S</td>
<td>74</td>
<td>75</td>
<td>74</td>
</tr>
<tr>
<td>Panendoscopy</td>
<td>95</td>
<td>85</td>
<td>92</td>
</tr>
</tbody>
</table>

*Di Martino, Arch Otolaryngol Head Neck Surg, 2000, 126:1457-61*
Hypo-laryngeal carcinoma with central necrosis and local metastasis by PET/CT

In a prospective study of 14 consecutive patients N0-staged disease, FDG-PET was positive in 5 of 7 patients with pathologically confirmed metastasis. PET was true negative in 7 of 7 patients without pathologic evidence of metastasis.

"PET can detect head and neck tumor recurrence when it may be undetectable by other clinical methods. FDG-PET permits highly accurate detection of head and neck cancer recurrence in the posttherapy period."

"Therefore FDG-PET, which identifies viable tumor on the basis of higher glycolytic rates in neoplasm than in necrotic or reactive tissue, can be recommended for the detection of recurrent NPC when the MRI findings are indeterminate."
New Findings

Review 2007
New Findings

Review 2007
FDG-PET IN LYMPHOMA
A patient with biopsy proven Lymphoma

FDG-PET a) for Staging and b) for the Effect of Therapy
FDG-PET IN LYMPHOMA: STAGING

October: Original Staging
FDG-PET IN LYMPHOMA: STAGING

October: Original Staging: Disease Above and Below the Diaphragm
FDG-PET IN LYMPHOMA: STAGING/RESTAGING

October: Original Staging: Disease Above and Below the Diaphragm

February: Post-Therapy
FDG-PET IN LYMPHOMA: STAGING/RESTAGING

October: Original Staging: Disease Above and Below the Diaphragm

February: Post-Therapy: Residual Disease
FDG-PET IN LYMPHOMA: Enters PET / CT
# FDG-PET IN LYMPHOMA: STAGING

<table>
<thead>
<tr>
<th></th>
<th>Sensitivity</th>
<th>Specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td>PET</td>
<td>86%</td>
<td>96%</td>
</tr>
<tr>
<td>CT</td>
<td>81%</td>
<td>41%</td>
</tr>
</tbody>
</table>

Total Patients = 50

*J Nucl Med 1997; 38: 343-348*
FDG-PET IN LYMPHOMA: post-Chemotherapy Studies
Prognosis of recurrence of the disease

With Negative PET: Two-year relapse-free survival rate was 95%.

With Positive PET: Two-year relapse-free survival rate was 0.0%.

Total Patients = 44

A patient with history of Lymphoma
Is evaluated for Recurrence
A recent CT was read “negative”
FDG PET was performed
FDG PET was performed: Subhepatic disease
Correlation with CT indicated the PET lesion on the CT
FDG-PET IN HODGKIN’S LYMPHOMA: Effect on Patient Management

STAGING
Accu: 96% (95% CI) vs. CT Accu: 56% (95% CI)
Changed Management in 40% Pts

RESTAGING
Accu: 91% vs. CT Accu: 62%

RECURRENCE
Accu: 83% vs. CT Accu: 56%

FDG-PET IN HODGKIN’S LYMPHOMA: Effect on Patient Management

EFFECT ON CLINICAL STAGING

Changed Staging in 56% of Pts

28% Upstaged

28% Downstaged

EFFECT ON MANAGEMENT

Changed Management in 63% of Pts

FDG-PET IN NON-HODGKIN’S LYMPHOMA: Effect on patient management

LESION DETECTION AND STAGING
Se: 99-100%  Spe: 99-100%
Ac: 99-100%

(CT/MR Se: 80-91%  Spe: 98-100%  Ac: 95-98%)

Changed Management in 8% Pts

FDG-PET IN NON-HODGKIN’S LYMPHOMA:
Effect on patient management

EFFECT ON CLINICAL STAGING
Changed Staging in 38% Pts
18% Upstaged
7% Downstaged

EFFECT ON MANAGEMENT
Changed Management in 64% Pts

43 pts had salvage cytoreductive chemotherapy followed by high dose chemo and autologous stem-cell transplantation (ASCT)

Group 1 (6 HD, 14 NHL): PET 2-5 weeks on chemo prior to ASCT
   Median follow up 13.3 months 8 pts disease free 12 relapse/death
   PET: TN=7/8, TP=11/12, PPV=92%, NPV=88%, PAccurV=90%
      (CT:PAccurV=58%)

Group 2 (6 HD, 17 NHL) had PET 2-6 months after ASCT
   Median follow up 16.5 months 9 pts disease free 14 relapse/death
   PET: TN=8/9, TP=13/14, PPV=93%, NPV=89%, PAccurV=91%
      (CT:PAccurV=58%)

93 patients (44 HD, 49 NHL) had PET after Chemo/RadioTx
Outcome from biopsy, clinical status after more than 6 months

<table>
<thead>
<tr>
<th></th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FDG-PET:</strong></td>
<td>91%</td>
<td>81%</td>
<td>85%</td>
</tr>
<tr>
<td><strong>CT/USound:</strong></td>
<td>88%</td>
<td>35%</td>
<td>56%</td>
</tr>
</tbody>
</table>

51 patients: 13 HD, 38 NHL (35 intermediate, 3 high grade) had FDG-PET and Gallium-67

<table>
<thead>
<tr>
<th></th>
<th>Patient Sensitivity</th>
<th>Site Sensitivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>FDG-PET:</td>
<td>51 pts, 100%</td>
<td>158 sites, 100%</td>
</tr>
<tr>
<td>Gallium-67:</td>
<td>41 pts, 71%</td>
<td>113 sites, 80%</td>
</tr>
</tbody>
</table>

*Kostakoglu et al: Cancer, 94(4):679-88, 2002*
**NON-HODGKIN’S LYMPHOMA**

“The detection of viable tumor by $^{18}$F-FDG PET after the end of treatment has a higher predictive value for relapse than classical CT scan imaging.”

“Persistent abnormal $[^{18}F]$FDG uptake after first-line chemotherapy in NHL is highly predictive for residual or recurrent disease. In relapsing patients, PFS was significantly shorter after a positive scan than after a negative scan.”

“…visual interpretation of marrow FDG uptake during whole-body PET scanning can identify marrow infiltration by lymphoma with an accuracy which may be at least as reliable as unilateral iliac crest biopsy. Furthermore, these data are acquired as a byproduct of a minimally invasive procedure when PET is used for routine lymphoma staging.”


**J Clin Oncol (2001) 19:414-419.**


**Chest + Abdominal NHL before therapy**

**Nearly complete resolution + BM reaction**
New Findings
FDG-PET IN MELANOMA
A patient with cutaneous Melanoma for staging
Melanoma of the right great toe diagnosed 1mo ago
Melanoma of the right great toe diagnosed 1mo ago

FDG PET in MELANOMA (Staging)

Participation 16c
Melanoma of the right great toe diagnosed 1mo ago

FDG PET in MELANOMA (Staging)

PET study showed abdominal lymph nodes confirmed by CT
# FDG-PET IN MELANOMA STAGING

## PET vs. CT

<table>
<thead>
<tr>
<th></th>
<th>Sensitivity</th>
<th>Specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT</td>
<td>55-85%</td>
<td>45-84%</td>
</tr>
<tr>
<td>PET</td>
<td>74-100%</td>
<td>77-100%</td>
</tr>
</tbody>
</table>

Total Patients = 406

*Journal of Nuclear Medicine, April 1999, pp591-603*
FDG-PET IN MELANOMA STAGING
PET vs. CT

<table>
<thead>
<tr>
<th></th>
<th>PET</th>
<th>CT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity</td>
<td>83%</td>
<td>88%</td>
</tr>
<tr>
<td>Specificity</td>
<td>91%</td>
<td>75%</td>
</tr>
<tr>
<td>PPV</td>
<td>70%</td>
<td></td>
</tr>
<tr>
<td>NPV</td>
<td>85%</td>
<td></td>
</tr>
<tr>
<td>Accuracy</td>
<td>91%</td>
<td>80%</td>
</tr>
</tbody>
</table>

Total Patients = 1,642

*J. of Nuclear Medicine. Vol. 42, No. 5, May 2001 (Supplement)*
Patient with history of old melanoma for reevaluation; CT studies were negative

PET showed a mediastinal lesion
FDG PET in MELANOMA (Restaging): Enters PET / CT

PET study showed abdominal lymph nodes confirmed by CT
**FDG-PET IN MELANOMA:**
**NODAL METASTASIS SENSITIVITY as per LESION SIZE**

Total Patients = 45 with 49 pathologically LN mets

<table>
<thead>
<tr>
<th>Size of Lesion</th>
<th>Sensitivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greater than 78 mm³</td>
<td>90%</td>
</tr>
<tr>
<td>Less than 78 mm³</td>
<td>14%</td>
</tr>
<tr>
<td>All LN tumor sites</td>
<td>49%</td>
</tr>
</tbody>
</table>

**AJCC stage**

<table>
<thead>
<tr>
<th>Stage</th>
<th>Sensitivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>0%</td>
</tr>
<tr>
<td>II</td>
<td>24%</td>
</tr>
<tr>
<td>III</td>
<td>81%</td>
</tr>
<tr>
<td>IV</td>
<td>100%</td>
</tr>
</tbody>
</table>

“For staging: An estimated 26% change was noted in management effect, based on 283 patients.”

*J. of Nuclear Medicine. Vol. 42, No. 5, May 2001 (Supplement)*
"PET provides a non-invasive imaging tool for the assessment of malignant melanoma...PET is most valuable in stage III disease, where it may alter clinical management."

In 76 non-randomized patients, FDG PET scanning demonstrated a sensitivity of 94.2%, specificity of 83.3%, overall accuracy 89%, positive predictive value 86%, and negative predictive value of 93%.

"FDG PET scanning can be helpful in managing patients with Stage III melanoma in whom further surgery is contemplated. Although false-positive areas are not uncommon, PET scans did change the management of patients 15% of the time."

---

Advanced Melanoma post therapy indicating residual disease

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British Journal of Surgery 2002, 89, 389±396


New Findings
Topic

New Findings

Review 2007
FDG-PET IN GASTROESOPHAGEAL CANCER
Most gastroesophageal cancers are locally advanced at presentation, undergo neoadjuvant chemoradiation to downstage prior to surgery. Main role PET/CT is in locally advanced disease.

No consensus re survival benefit, data suggests neoadjuvant therapy is associated with survival benefit, but this benefit may be outweighed by poor prognosis of non responders.

Early prediction of response is important, offer alternative therapy to non responders, it is suggested that progression during ineffective chemotherapy is one reason for poor survival.
A 59yo male with history of gastric cancer 
s/p subtotal gastrectomy 
CT: LUQ mass
FDG-PET IN RECURRENT GASTRO-ESOPHAGEAL CANCER
FDG-PET IN RECURRENT GASTRO-ESOPHAGEAL CANCER

FDG uptake in the region of the remaining stomach c/w RECURRENCE
FDG-PET in Staging GASTRO-ESOPHAGEAL CANCER Enters PET / CT

FDG uptake in the upper esophagus and in the stomach
FDG-PET IN GASTROESOPHAGEAL CANCER
Diagnosis and Staging

<table>
<thead>
<tr>
<th></th>
<th>PET</th>
<th>CT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity</td>
<td>80%</td>
<td>68%</td>
</tr>
<tr>
<td>Specificity</td>
<td>95%</td>
<td>81%</td>
</tr>
<tr>
<td>Accuracy</td>
<td>86%</td>
<td>73%</td>
</tr>
</tbody>
</table>

Total Lesions = 545

*J. of Nuclear Medicine. Vol. 42, No. 5, May 2001 (Supplement)*
59yo male with history of gastric cancer
s/p subtotal gastrectomy
CT: LUQ mass

FDG uptake in the region of the remaining stomach c/w RECURRENCE
FDG-PET IN ESOPHAGEAL CANCER

23yo with known esophageal cancer is evaluated for distal metastasis

FDG uptake in the PRIMARY tumor, REGIONAL LNs, and the LIVER

images without attenuation correction
FDG-PET IN ESOPHAGIAL CANCER
Distal Metastasis

PET Sens = 88% Spec = 93% Accur = 91%

Total Patients = 35

*Annals of Thoracic Surgery 1997; 64: 765-769*
FDG-PET IN ESOPHAGEAL CANCER
Malignant Nodal Groups Detection

CT
Sens = 11%  Spec = 95%  Accur = 83%

PET
Sens = 30%  Spec = 90%  Accur = 82%

Total Patients = 81

Yoon Radiology 2003 227(3) 767-70

2003 review
FDG-PET IN GASTROESOPHAGEAL CANCER
Effect on Patient Management

<table>
<thead>
<tr>
<th>Change in management</th>
<th>No. of patient studies based on</th>
</tr>
</thead>
<tbody>
<tr>
<td>For diagnosis</td>
<td>14%</td>
</tr>
<tr>
<td>For staging</td>
<td>20%</td>
</tr>
<tr>
<td>For diagnosis/staging</td>
<td>14%</td>
</tr>
</tbody>
</table>

*J. of Nuclear Medicine. Vol. 42, No. 5, May 2001 (Supplement)*
Extensive metastatic
Esophageal cancer;
PET/CT specified primary

FDG PET had an
accuracy of 82% for detecting Stage
IV disease, as compared to 64% for
CT and EUS (p = .004). PET
changed the stage indicated by
conventional imaging in 16 patients,
upstaging 11 and downstaging 5
patients.

“FDG-PET allows a highly sensitive
diagnosis and accurate whole-body
staging of symptomatic recurrent
esophageal cancer. Further studies in
asymptomatic patients are needed to
assess the potential benefit on
survival.”

“FDG-PET is a valuable tool for the
noninvasive assessment of
histopathologic tumor response after
neoadjuvant radio & chemotherapy.”
GIST

GIST includes leiomyomas, leiomyoblastomas, leiomyosarcomas.
All stain + for C-kit, tyrosine kinase growth factor receptor.

Imatinib mesylate (Gleevec) : selective tyrosine kinase receptor inhibitor,
effective when tumors resist conventional chemotherapy.

FDG PET is highly effective in evaluation of treatment response: imatinib causes rapid reduction in FDG uptake in responders, whereas major changes in tumor volume occur later.

Stroobants et al 2003  n = 21, PET at baseline and Day 8,
13 responders (11 CR, 2 PR) Progression free survival at 1 year 92% for PET responders vs 12% PET non responders.
Clinical Experience is Expanding:
GIST: Gastrointestinal Stromal Cell Tumors

A patient with history of Gastro-Intestinal Stromal Cell tumor is evaluated before and after Chemotherapy
GIST includes leiomyomas, leiomyoblastomas, leiomyosarcomas. All stain + for C-kit, tyrosine kinase growth factor receptor.
Effective Chemotherapy

GIST: Gastrointestinal Stromal Cell Tumors
Effect of Chemotherapy

Before Treatment

4 weeks on Treatment

Effective Chemotherapy
New Findings
Topic

New Findings

Review 2007
Current Research

Late imaging at 2-3 hr post FDG injection shows tumors
FDG-PET IN HEPATIC LESIONS

<table>
<thead>
<tr>
<th>Sensitivity</th>
<th>Specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lesion/Liver Uptake &gt; 2</td>
<td>90%</td>
</tr>
<tr>
<td>Lesion/Liver Uptake &gt; 1</td>
<td>93%</td>
</tr>
</tbody>
</table>

Total Patients = 110 with > 1cm hepatic lesion by CT
Malignant Lesions = 97 (Mets = 66, HCC = 23, CAC = 8)
Benign Lesions = 23 (Abscess = 3, Misc = 20)

*Delbeke, Arch Surg 1998; 133: 510-516*
FDG-PET IN HEPATOCELLULAR CARCINOMA

DIAGNOSIS of all and any size lesions (n = 20)

Se: 55% (90% for CT)

Topic

New Findings

Review 2007
Topic

New Findings

Review 2007
FDG-PET IN
BREAST CANCER
Baseline staging is not covered – Axillary node metastases most important prognostic factor in early stage breast cancer, sentinel node is the gold standard, microscopic disease below the sensitivity of PET will alter management - Sensitivity has been described as low as 20%.

While initial staging is not covered, work-up for or management of relapse is covered - when a change in treatment is being considered including restaging for locoregional recurrence or distant metastases, prior to or after a course of treatment.
Patient with breast cancer, s/p mastectomy presents with bone pain
FDG-PET IN BREAST CANCER

Extent of Tumor
FDG-PET IN BREAST CANCER

Extent of Tumor
FDG-PET IN BREAST CANCER

Extent of Tumor

Staging
FDG positive in multiple areas of the body including liver and skeleton
Bone Scan negative

Staging: Bone Metastasis

Re-Staging: Deterioration

FDG-PET IN BREAST CANCER: Enters PET / CT
# FDG-PET IN BREAST CANCER

<table>
<thead>
<tr>
<th></th>
<th>Sensitivity</th>
<th>Specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRIMARY*</td>
<td>80-100%</td>
<td>83-100%</td>
</tr>
<tr>
<td>RECURRENT or METASTATIC**</td>
<td>57-100%</td>
<td>66-100%</td>
</tr>
</tbody>
</table>

*Total Patients = 250

*Journal of Nuclear Medicine, October 1999, pp 1706-1715

**Total Patients = 383

**Journal of Nuclear Medicine, October 1999, pp 1706-1715
FDG-PET IN BREAST CANCER
Initial Diagnosis / Staging and Recurrence

STAGING (n = 117)
Se: 94%  Spe: 75%  Ac: 94%


RECURRENT (n = 57)
Se: 93%  Spe: 79%  PPV: 82%  NPV: 92%

FDG-PET IN BREAST CANCER
Initial Diagnosis/Staging and Recurrence

INITIAL DIAGNOSIS STAGING (n = 117)

Detection of breast lesions by PET:        Se: 93%   Spe: 75%
(PET for multifocal lesions   Se: 63%   Spe: 95%)
Mammography+Sonography:   Se: 32%   Spe: 95%)

Detection of axillary LNs by PET:        Se: 79%   Spe: 92%


RECURRENTE (n = 60)

Locoregional Recurrence:        Se: 89%   Spe: 84%   Ac: 87%
Distal Metastases:   Se: 100%   Spe: 97%   Ac: 98%


2003 review
FDG-PET IN BREAST CANCER
Effect of FDG-PET on Patient Management

RESPONSE TO TREATMENT (n=30)
Se: 90%  Spe: 74%

RESPONSE TO TREATMENT (N=22)
Se: 100%  Spe: 85%
FDG-PET IN BREAST CANCER
Effect of FDG-PET on Patient Management

50/160 Physician survey responders reported:

PET changed clinical stage: 36% (Upstage: 28%, Downstage: 8%)

This resulted in

Intermodality changes in 28% of patients

Intramodality changes in 30% of patients


2001

2003 review
Metastatic Breast Cancer

FDG PET yielded changes in management within the treatment modality in 30% of the patients & between treatment modalities in 28% of the patients. PET changed the clinical stage in 36% of patients.

Sensitivity, specificity, and accuracy by FDG PET for internal mammary or mediastinal nodal disease was 85%, 90%, and 88%. Blinded interpretation of CT yielded a sensitivity, specificity, and accuracy of 50%, 83%, and 70%, respectively.

The overall accuracy of FDG PET in predicting histopathological response to therapy was 88% and 91% after the 1st and 2nd courses of neoadjuvant treatment, respectively.
Topic

New Findings

Review 2007
New Findings
FDG-PET IN SARCOMAS
FDG-PET IN OSTEOSARCOMA:

Evaluation for metastasis

39 yo male with of osteosarcoma
s/p above knee amputation
CT: L Lung 2 lesions

High-intensity FDG uptake in
2 lesions in the L LUNG

Surgical Pathology: Metastatic
Osteosarcoma
FDG-PET IN OSTEOSARCOMA

PET Sensitivity = 100%

Total Patients = 26 with positive CT
Malignancy proven by histology

FDG-PET IN EWING’S SARCOMA

11 year old boy with pain and swelling of the left thigh
FDG-PET IN EWINGS SARCOMA

DETECTION OF OSSEOUS METASTASES (N=110)
Se: 100%  Spe: 96%  Ac: 97%

FDG-PET IN EWING’S SARCOMA

EVALUATION OF EFFECT OF CHEMOTHERAPY

11 yo with Ewing’s sarcoma, before, 3 mos after chemotherapy and 3 mos after additional chemotherapy and radiation therapy
FDG-PET IN EWING’S SARCOMA

DETECTION OF OSSEOUS METASTASES (N=110)
Se: 100%  Spe: 96%  Ac: 97%

FDG-PET IN MUSCULOSKELETAL LESIONS
Differentiating Benign from Malignant

45 patients had CT and/or MRI
and PET with SUV units (SUV>2.0 = tumor)

PET in differentiating malignant from benign lesions had

Sensitivity = 91.7%
Specificity = 100%

FDG-PET IN SOFT TISSUE SARCOMAS
Differentiating Benign from Malignant

15 studies 441 lesions (227 malignant and 214 benign)

Patients had PET with SUV units (SUV>2.0 = tumor)

<table>
<thead>
<tr>
<th>Sensitivity</th>
<th>Specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diagnosis of malignancy with SUV=2.0</td>
<td>87%</td>
</tr>
<tr>
<td>SUV=3.0</td>
<td>70%</td>
</tr>
</tbody>
</table>

Receiver operating characteristic curves: 92% 73%

Rhabdomyosarcoma accumulates FDG

PET is useful to determine
- Extent of disease
- Residual tumor after therapy
- Differentiate tumor from scar
- Local recurrence or distal metastasis
FDG-PET IN RHABDOMYOSARCOMA
RESIDUAL TUMOR

18 year old boy after completion of chemotherapy
FDG-PET IN SOFT TISSUE SARCOMAS

DIAGNOSIS (n = 50)
Se: 91%  Spe: 88%


STAGING (n = 20)
Se: 93%

FDG-PET IN SOFT TISSUE SARCOMAS
Effect on Patient Management

RESPONSE TO THERAPY (n = 20)
Se: 100% (poor long-term prognosis)
   71% (good long-term prognosis)

Lenzo, et al. FDG-PET in childhood soft tissue sarcoma.
Journal of Nuclear Medicine. 2000;41:96P

DETECTION OF RECURRENCE (n = 31)
Se: 88%   Spe: 92%

Dimitrakopoulou, et al. PET with FDG in soft tissue sarcomas.
Journal of Nuclear Medicine. 2000;41:303P
$^{18}$FDG AND $^{15}$OH$_2$ PET IN LIPOSARCOMA
FDG-PET IN
NEUROBLASTOMA
FDG accumulates within most neuroblastomas

It also accumulates within neuroblastomas which are MIBG negative
FDG-PET IN NEUROBLASTOMA

At diagnosis in a 2 yo girl
FDG-PET IN NEUROBLASTOMA

Recurrent neuroblastoma in a 6 month old boy
FDG-PET IN NEUROBLASTOMA
EFFECT OF THERAPY

At diagnosis and 6 months after chemotherapy: Residual tumor
Topic

New Findings

Review 2007
Topic

New Findings

Review 2007
FDG-PET IN
WILM’S TUMOR
A 3 ½ year old girl with hematuria
Topic

New Findings

Review 2007
Topic

New Findings

Review 2007
FDG-PET IN
GYNECOLOGICAL TUMORS
40yo with ovarian cancer “vigorously” treated in the pelvis. The patient is now evaluated for recurrence or metastasis.

FDG c/w LYMPH NODE METASTASES in the MEDIASTINUM and the NECK
FDG-PET IN OVARIAN CARCINOMA
Detection of Recurrence or Metastasis

PET is sensitive in detecting recurrence (5/5 patients) as compared to CT (3/5), *
but it does not detect microscopic recurrence.**

*Gynecologic Oncology 1993; 51: 175-181
**J Reproductive Medicine 1999; 44: 775-778
PET TO DETECT RECURRENT CERVICAL CANCER

**PET**

- Sensitivity: 100%
- Specificity: 90%
- PPV: 89%
- NPV: 100%
- Accuracy: 91%

Total Patients = 101

*Kim JH et al. J. of Nuclear Medicine. 2000:41:300P.*
PET TO DETECT RECURRENT CERVICAL CANCER

<table>
<thead>
<tr>
<th>Area</th>
<th>Sensitivity</th>
<th>Specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall Recurrence</td>
<td>90%</td>
<td>100%</td>
</tr>
<tr>
<td>Local</td>
<td>80%</td>
<td>92%</td>
</tr>
<tr>
<td>Pelvic LN</td>
<td>100%</td>
<td>94%</td>
</tr>
<tr>
<td>Para-aortic LN</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>Distal Metastasis</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>


2003 Review
PET TO DETECT ADVANCED CERVICAL CANCER

No of Patients with advanced cervical cancer: 50

<table>
<thead>
<tr>
<th></th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>PET</td>
<td>86%</td>
<td>94%</td>
<td>92%</td>
</tr>
</tbody>
</table>

*Lin et al: Gynecologic Oncology: 89(1) 73-6, 2003*
DETECTION OF DISEASE RECURRENCE OVARIAN, UTERINE, CERVICAL CANCER

<table>
<thead>
<tr>
<th></th>
<th>PET</th>
<th>CT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity</td>
<td>88%</td>
<td>76%</td>
</tr>
<tr>
<td>Specificity</td>
<td>90%</td>
<td>75%</td>
</tr>
<tr>
<td>PPV</td>
<td>85%</td>
<td>77%</td>
</tr>
<tr>
<td>NPV</td>
<td>92%</td>
<td>62%</td>
</tr>
<tr>
<td>Accuracy</td>
<td>87%</td>
<td>43%</td>
</tr>
</tbody>
</table>

Total Patients = 357

*Journal of Nuclear Medicine. Vol. 42, No. 5, May 2001 (Supplement)*
FDG-PET IN PANCREATIC CANCER
Patient with history of operated pancreatic cancer is evaluated for recurrence; PET showed a lesion confirmed as tumor by CT.
FDG-PET IN PANCREATIC CARCINOMA
Detection of the Primary

<table>
<thead>
<tr>
<th></th>
<th>Sensitivity</th>
<th>Specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td>PET</td>
<td>85-100%</td>
<td>67-100%</td>
</tr>
</tbody>
</table>

Total Patients = 561

*J. Nuclear Medicine, October 1999, pp 1706-1715*
FDG-PET IN PANCREATIC CARCINOMA Diagnosis

<table>
<thead>
<tr>
<th></th>
<th>PET</th>
<th>CT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity</td>
<td>94%</td>
<td>82%</td>
</tr>
<tr>
<td>Specificity</td>
<td>90%</td>
<td>75%</td>
</tr>
<tr>
<td>PPV</td>
<td>93%</td>
<td>84%</td>
</tr>
<tr>
<td>NPV</td>
<td>92%</td>
<td>71%</td>
</tr>
<tr>
<td>Accuracy</td>
<td>92%</td>
<td>78%</td>
</tr>
</tbody>
</table>

Total Patients = 368

# FDG-PET IN PANCREATIC CARCINOMA

**Effect on Patient Management**

<table>
<thead>
<tr>
<th>Change in management</th>
<th>No. of patient studies based on</th>
</tr>
</thead>
<tbody>
<tr>
<td>For diagnosis</td>
<td>50% 26</td>
</tr>
<tr>
<td>For staging</td>
<td>36% 33</td>
</tr>
<tr>
<td>For diagnosis/staging</td>
<td>43% 65</td>
</tr>
<tr>
<td>For recurrence</td>
<td>53% 19</td>
</tr>
<tr>
<td>For monitoring response</td>
<td>16% 19</td>
</tr>
</tbody>
</table>

### FDG-PET IN PANCREATIC CARCINOMA
Differentiating Malignant from Benign Lesions

No. of patients studied 22 (16 benign, 6 malignant lesions)

<table>
<thead>
<tr>
<th>Marker</th>
<th>U/S</th>
<th>CT</th>
<th>Endoscopy</th>
<th>FDG</th>
</tr>
</thead>
<tbody>
<tr>
<td>CA19-9</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Malignant**

- **Sensitivity**: 80% 100% 100% 60% 100%
- **Specificity**: 20%

**Benign**

- **Specificity**: 73% 47% 50% 92% 88%

FDG-PET IN PANCREATIC CARCINOMA in Cystic Tumors

No. of patients studied 56

<table>
<thead>
<tr>
<th></th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>PPV</th>
<th>NPV</th>
</tr>
</thead>
<tbody>
<tr>
<td>FDG-PET</td>
<td>94%</td>
<td>97%</td>
<td>94%</td>
<td>97%</td>
</tr>
<tr>
<td>CT</td>
<td>65%</td>
<td>87%</td>
<td>69%</td>
<td>85%</td>
</tr>
</tbody>
</table>

Topic

New Findings

Review 2007
New Findings
FDG-PET IN PROSTATE CANCER
Patient 78yo with history of prostate cancer
CT: LUL Lung lesion

Medium-intensity FDG uptake in the LUL Lung c/w TUMOR
Surgical Pathology: LUNG TUMOR (squamous cell)
FDG-PET IN PROSTATE CANCER

STAGING (n = 49)
Se: 64%  Spe: 100%


RESPONSE TO THERAPY (n = 16)
Se: 81% (for advanced disease)

FDG PET IN PROSTATE CANCER

DETECTION OF RECURRENCE (n = 22)
Se: 50% (PSA > 4)

FDG IN PROSTATE CANCER
Evaluation of Bone Metastasis by FDG as Compared to the Tc-MDP Bone Scan

<table>
<thead>
<tr>
<th></th>
<th>Sensitivity</th>
<th>PPV</th>
</tr>
</thead>
<tbody>
<tr>
<td>PET</td>
<td>65%</td>
<td>98%</td>
</tr>
</tbody>
</table>

Total Patients = 22, with 202 osseous mets by bone scan
Malignancy proven by biopsy or follow up

*Radiology 1996; 199: 751-756*
New Findings
New Findings

Review 2007
FDG-PET IN
RENAL CELL CANCER
RENSAL CELL CANCER

UM/JMH case

Review 2007
FDG-PET IN RENAL CELL CANCER

DIAGNOSIS (n = 11)

Se: 89%


STAGING (n = 46)

Se: 74%

FDG-PET IN RENAL CELL CANCER

RESTAGING for ADVANCED CANCER 36 patients

For Clinical Stage Classification:

Sensitivity: 67%   Specificity: 100%   Accuracy: 89%

Biopsy proven Lesion Classification:

Sensitivity: 88%   Specificity: 75%   Accuracy: 84%

Topic

New Findings
Topic

New Findings

Review 2007
FDG-PET IN BLADDER CANCER
BLADDER CANCER

UM/JMH case

Review 2007
FDG -PET IN BLADDER CANCER

STAGING (n = 64)
Se: 67%  Spe: 86%  Ac: 80%


RECURRENT (n = 12)
Se: 60%

New Findings
Topic

New Findings

Review 2007
FDG-PET IN
THYROID CANCER
A patient with thyroid cancer is reevaluated
THYROID CANCER: IODINE v/s GLUCOSE

Positive Iodine scan
THYROID CANCER: IODINE v/s GLUCOSE

Positive Iodine scan

Many more lesions on the FDG scan
THYROID CANCER: IODINE v/s GLUCOSE

Positive Iodine scan

Many more lesions on the FDG scan

Different lesions by the two different methods
THYROID CANCER: IODINE v/s GLUCOSE Enters PET/CT

- Positive Iodine scan
- Positive FDG scan

Different lesions by the two different methods
**FDG-PET IN PRIMARY THYROID CANCER**

**Evaluation of thyroid nodules**

SUV were calculated in 16 Carcinomas and 23 Adenomas

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>SUV</th>
<th>Diagnosis</th>
<th>SUV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cancer</td>
<td>3.7 +/- 1.9</td>
<td>Hurthle cell adenoma</td>
<td>4.4 +/- 2.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Microfollicular aden.</td>
<td>1.6 +/- 0.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Degenerative goiter</td>
<td>1.2 +/- 0.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Macrofollicular aden.</td>
<td>0.9 +/- 0.1</td>
</tr>
</tbody>
</table>

For a cutoff value of SUV=2.0

FDG-PET Sens=100%, Spec=63%, NPV=100%

FDG-PET IN THYROID CANCER

Patient with history of pelvic mass invading the acetabulum and the iliac vessels, histologically mixed thyroid cancer s/p total thyroidectomy (normal thyroid) and external RAI therapy

High-intensity FDG uptake in the area of the METASTATIC THYROID TUMOR

Image without attenuation correction
FDG-PET IN THYROID CARCINOMA FOLLOW-UP FOR RECURRENCE WITH POSITIVE or NEGATIVE WHOLE BODY $^{131}$I STUDY (WBIS)

Total 222 patients with differentiated thyroid carcinoma after thyroidectomy and a mean of 3-4 times radio-iodine treatments presenting for evaluation with WBIS and FDG-PET

<table>
<thead>
<tr>
<th></th>
<th>Sens</th>
<th>Spec</th>
<th>Acc</th>
</tr>
</thead>
<tbody>
<tr>
<td>All patients (222)</td>
<td>75%</td>
<td>90%</td>
<td>83%</td>
</tr>
<tr>
<td>I Scan negative (166)</td>
<td>85%</td>
<td>90%</td>
<td>89%</td>
</tr>
<tr>
<td>I Scan positive (56)</td>
<td>65%</td>
<td>100%</td>
<td>66%</td>
</tr>
</tbody>
</table>

24 patients with WD thyroid cancer present with rising TGB and negative iodine scan evaluated via FDG-PET and CT or neck U/S.

38 lesions identified on PET
- Sens 95%
- PPV 92%
- 3 false positives
- 2 false negatives
- 6 patients with lesions not ID’d by other imaging

9/24 (38%) patients had change in management with less aggressive surgery.

Topic

New Findings

Review 2007
New Findings

Review 2007
FDG PET vs. MDP Bone Scans

Effect of Therapy
49 yo lady with R. breast cancer, s/p mastectomy is evaluated because of rising Ca 15.3
Participation 24b

Baseline Studies

Bone Scans

FDG/PET Scans
Bone Lesions are visualized better on FDG before therapy.
Bone Lesions are visualized better on FDG before therapy.
Bone Lesions are visualized better on FDG before therapy.

Results of therapy are visualized better on FDG/PET.

“FLARE”
56 yo gentleman with R Lung cancer, s/p resection is evaluated because of lumbar pain
Participation 25b

Baseline Studies

Bone Scans

FDG/PET Scans
Bone Lesions are visualized better on FDG before therapy.
Bone Lesions are visualized better on FDG before therapy.
Bone Lesions are visualized better on FDG before therapy.
New Findings

Review 2007
Topic

New Findings

Review 2007
BONE SCAN WITH $^{18}$FNa
BONE SCANNING
RADIOPHARMACEUTICALS
OLD AND NEW

$^{18}$FNa-PET BONE SCANNING:
(Reinvent the wheel)
18FNa-PET BONE SCAN v/s 99mTc-MDP-SPECT

Chronic stress to the spine: Additional information by 18F-PET

18F-PET (50µCi/kg)

99mTc-MDP-SPECT (50µCi/kg)
Topic

New Findings

Review 2007
New Findings

Review 2007
FUNCTIONAL FDG-PET BRAIN STUDIES
BRAIN FDG-PET
IN INTRACTABLE SEIZURES
$^{18}$F-DG in NEUROLOGY
FDG-PET in DEMENTIAS

PET evaluation reduces Alzheimer’s treatment costs
Quality of life improves with reduced drug therapy and delayed nursing home care

Normal  AZD
Charlton Heston Advocates the Benefits of PET for Early Alzheimer’s Detection

The AMI released a public service announcement in which Charlton Heston advocates the use of PET scans for the early diagnosis of Alzheimer’s. Heston announced earlier this year that he had been diagnosed with Alzheimer’s, after a PET scan detected signs of the disease.
FDG-PET IN EPILEPSY

Localization of Focus of Intractable Seizures (Case: Brain 1991)

The rates of the regional cerebral blood flow and of glucose metabolism of the epileptic focus are related to seizure activity. The studies depend on the time of injection of radiopharmaceutical.
**BRAIN FDG-PET IN INTRACTABLE SEIZURES: Effect of FDG-PET on Patient Management**

Localization of Focus of Intractable Seizures

Among 55 patients Interictal FDG-PET localized focus in 42 and predicted results of surgical treatment.

<table>
<thead>
<tr>
<th>Test</th>
<th>Sensitivity (%)</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interictal PET</td>
<td>76%</td>
<td>in all patients</td>
</tr>
<tr>
<td>Ictal EEG</td>
<td>66%</td>
<td>in all patients</td>
</tr>
<tr>
<td>MRI</td>
<td>27%</td>
<td>in all patients</td>
</tr>
<tr>
<td>MRI after PET</td>
<td>35%</td>
<td>in all patients</td>
</tr>
<tr>
<td>Interictal PET:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>63%</td>
<td>in non-localizing EEG</td>
</tr>
<tr>
<td>Interictal PET:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>69%</td>
<td>in non-localizing MRI</td>
</tr>
</tbody>
</table>

Interictal PET: 100% in concordance with localizing EEG/MRI

FDG-PET IN MYOCARDIAL VIABILITY
40% of the severe fixed defects on thallium studies are not scars but viable (hibernating) myocardium as indicated by glucose metabolic activity in FDG studies:

Mismatch Perfusion/FDG = Hibernating Myocardium

FDG PET in MYOCARDIAL VIABILITY

PERFUSION/METABOLISM MATCH = MYOCARDIAL SCAR

Revascularization is not needed
FDG-PET in MYOCARDIAL VIABILITY

PERFUSION/METABOLISM **MISMATCH** =
= VIABLE HIBERNATING MYOCARDIUM

REST THALLIUM

FDG PET

Short axis slices from the apex (left) to the base of the heart

Revascularization is indicated
PERFUSION / $^{18}$FDG MISMATCHES UNDERLINE THE NEED FOR REVASCULARIZATION

A. Mismatch

B. No Mismatch

In Mismatch, Revascularization Increases Survival

DiCarli AJC 1994
FDG-PET IN
INFLAMMATION AND INFECTION
FDG-PET IN
INFLAMMATION AND INFECTION

PATHOPHYSIOLOGY and APPLICATIONS

Interstitial inflammatory cells metabolize glucose
If such cells are “abundant” FDG-PET may visualize
the areas of inflammatory reaction acute or chronic

This creates diagnostic problems in Tumor imaging:
  Pneumonias, abscesses, aortitis, gastritis, esophagitis,
inflammatory/degenerative skeletal lesions etc

In certain cases it may provide useful information:
  Infected prostheses, vasculitis etc but sensitivity and
  specificity are issues which need be faced
OSTEOMYELITIS (Infection TP)

$^{67}$Ga Citrate v/s $^{18}$FDG-PET Scan

Gallium SPECT

FDG-PET
VASCULITIS: Aortitis (Non-Infectious Inflammation FP)
TOXOPLASMOSIS (Infection FP)

Toxoplasmosis (PET 15 days into treatment for Toxoplasma)
Patient s/p RTx for brain tumor
Presentation suggesting brain abscess

BRAIN ABSCESS (Infection FN)
<table>
<thead>
<tr>
<th>Condition</th>
<th>PET Sensitivity</th>
<th>PET Specificity</th>
<th>CT Sensitivity</th>
<th>CT Specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bladder Cancer - Staging</strong></td>
<td>76%</td>
<td>87%</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td><strong>Brain Tumor – Diagnosis</strong></td>
<td>91%</td>
<td>63%</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td></td>
<td>88%</td>
<td>96%</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td><strong>Breast Cancer - Staging</strong></td>
<td>79%</td>
<td>60%</td>
<td>70%</td>
<td>69%</td>
</tr>
<tr>
<td></td>
<td>77%</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td><strong>Breast Cancer - Recurrence</strong></td>
<td>85%</td>
<td>n/a</td>
<td>90%</td>
<td>n/a</td>
</tr>
<tr>
<td><strong>Cancer of Unknown Primary</strong></td>
<td>82%</td>
<td>33%</td>
<td>71%</td>
<td>44%</td>
</tr>
<tr>
<td><strong>Cervical Cancer – Lymph Node Staging</strong></td>
<td>75% to 91%</td>
<td>n/a</td>
<td>92% to 100%</td>
<td>n/a</td>
</tr>
<tr>
<td><strong>Colorectal Cancer – Diagnosis/ Staging</strong></td>
<td>85%</td>
<td>66%</td>
<td>93%</td>
<td>69%</td>
</tr>
<tr>
<td></td>
<td>86% to 100%</td>
<td>n/a</td>
<td>80% to 94%</td>
<td>n/a</td>
</tr>
<tr>
<td><strong>Colorectal Cancer – Recurrence</strong></td>
<td>86%</td>
<td>76%</td>
<td>73%</td>
<td>73%</td>
</tr>
<tr>
<td><strong>Head &amp; Neck Cancer – Diagnosis</strong></td>
<td>93%</td>
<td>56%</td>
<td>93%</td>
<td>49%</td>
</tr>
<tr>
<td><strong>Head &amp; Neck Cancer – Staging</strong></td>
<td>87%</td>
<td>75%</td>
<td>89%</td>
<td>89%</td>
</tr>
<tr>
<td><strong>Hurthle cell Thyroid Cancer – Diagnosis</strong></td>
<td>87%</td>
<td>n/a</td>
<td>87%</td>
<td>n/a</td>
</tr>
<tr>
<td><strong>Hurthle cell Thyroid Cancer – Staging</strong></td>
<td>87%</td>
<td>n/a</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>

**Limitations:**
- High uptake of normal gray matter. PET has difficulty in detecting low-grade gliomas.
- Size; Benign inflammatory conditions and fibroadenoma.
- Micrometastatic disease; PET cannot determine accurately the number of involved lymph nodes.
- PET cannot determine accurately the number of involved lymph nodes.
- PET cannot determine accurately the number of involved lymph nodes.
- PET is in close proximity of the urinary bladder.
- Physiologic bowel uptake.