ПЭТ-КТ ПРИ РАКЕ ЛЕГКИХ

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PET-CT IN LUNG CANCER

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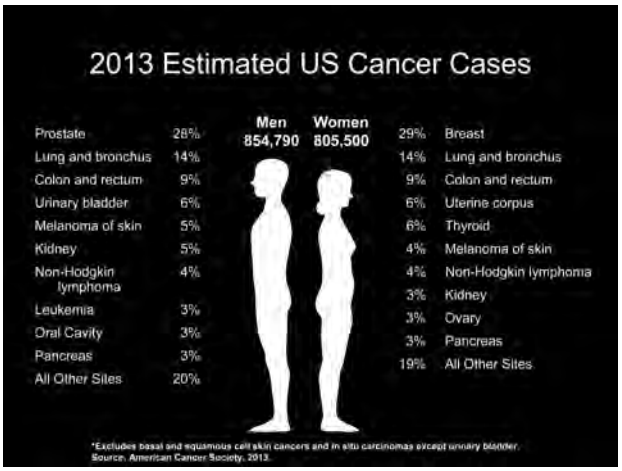
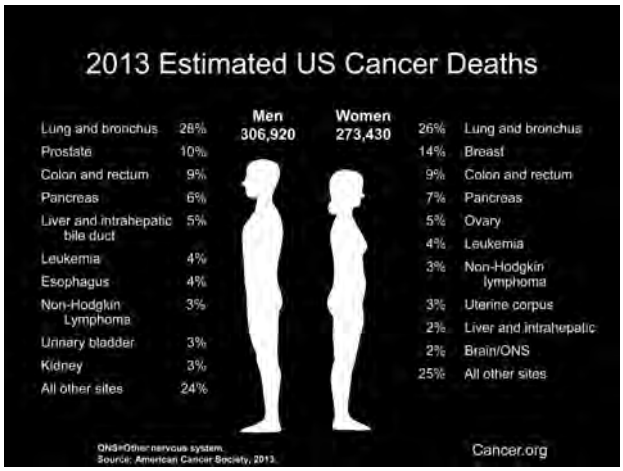
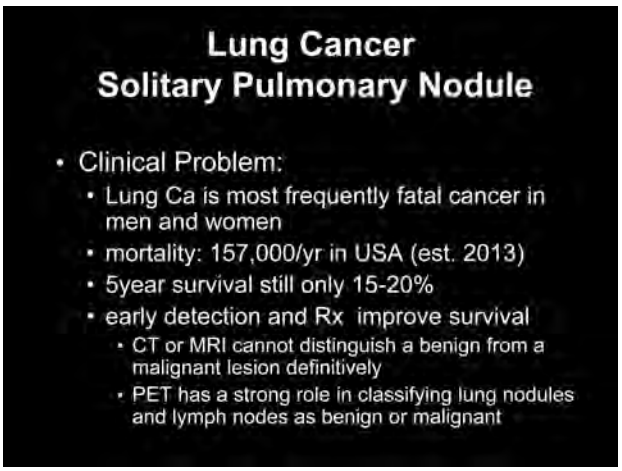
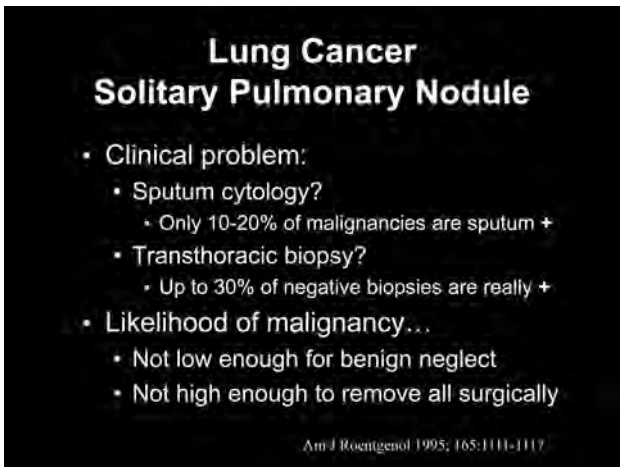
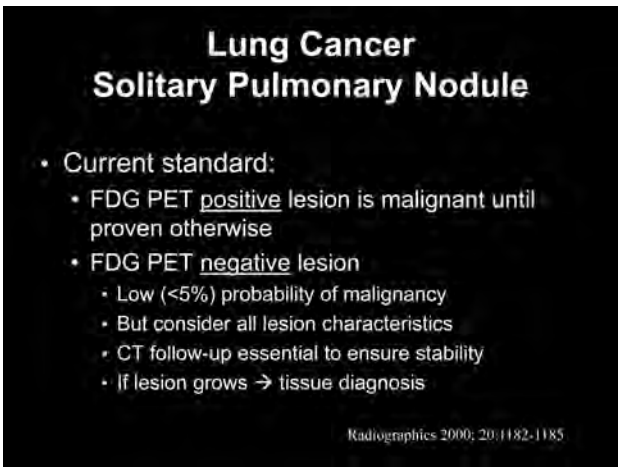
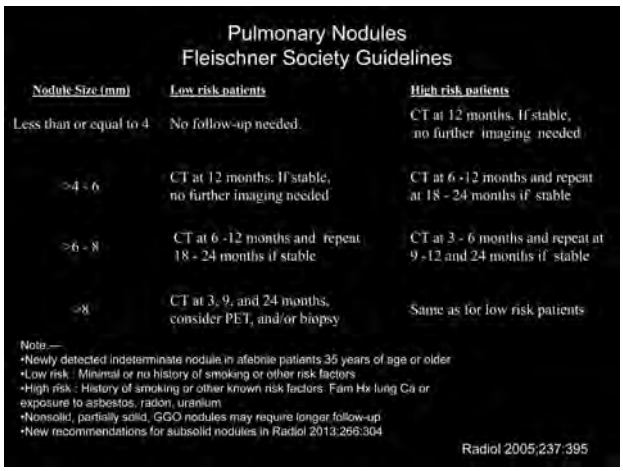












Lung Cancer and PET Solitary Pulmonary Nodule

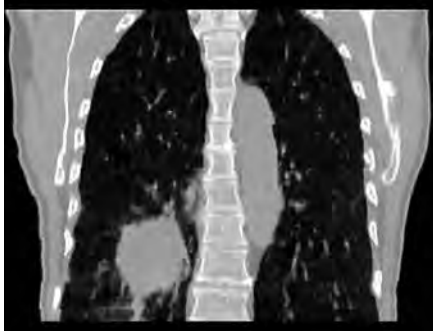
- False **Positives** (macrophage glucose uptake)
  - Granulomas: TB, Histo, Crypto, Apergillus
  - Inflammation: Sarcoid, Wegener's
  - Rheumatoid nodules
  - Aggressive neurofibroma
- False **Negatives**
  - Bronchoalveolar Ca (57%) Carcinoid (85%)
  - Very small lesions (<1cm..but limits shrinking)
  - Hyperglycemia

What is "positive"?

SUV pitfalls

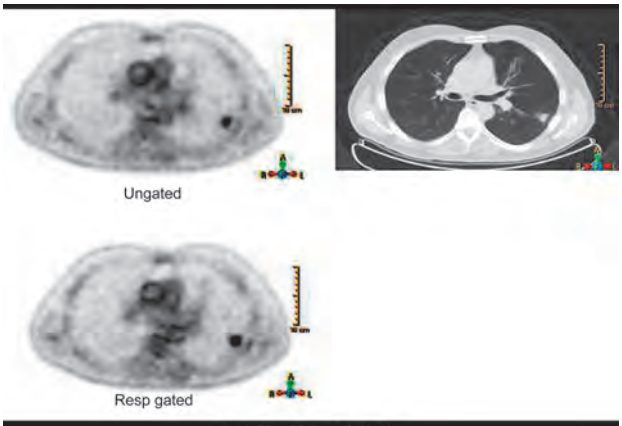
- A semi-quantitative target:background ratio
- Lesion size critical
- Published values based on old reconstruction algorithms and are pre PET-CT
- Affected by documentation of dose, time, BMI
- Best used as adjunct to, not replacement for, image interpretation
- Used to characterize **LESIONS**
- Normal high SUV in:
  - *brain* - *heart* - *kidneys* - *bladder*
  - *bowel artifact* - *infiltrated dose*

Tumors move

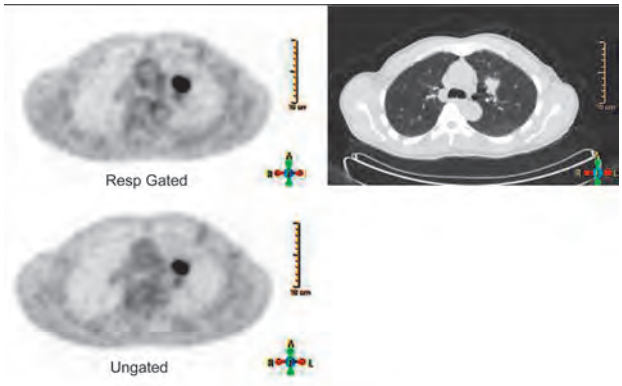


Problems for:

- Localization
- Quantification (SUV)
- Correlation PET/CT
- Therapy planning



Peripheral Lung Nodule



Central Lung Nodule

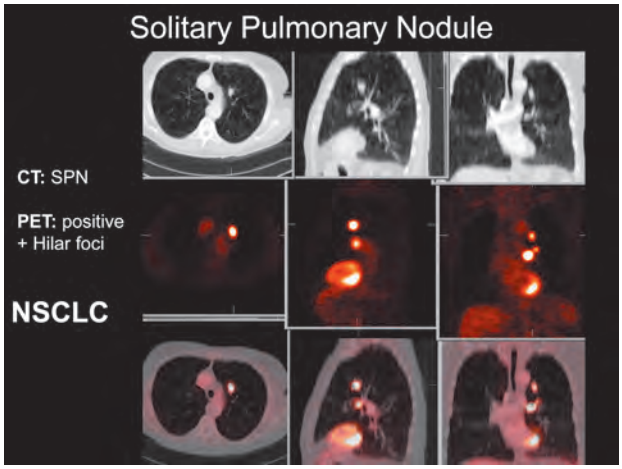
Solitary Pulmonary Nodule

- Meta-analysis of 1,474 lesions
- FDG PET detected SPN malignancy:

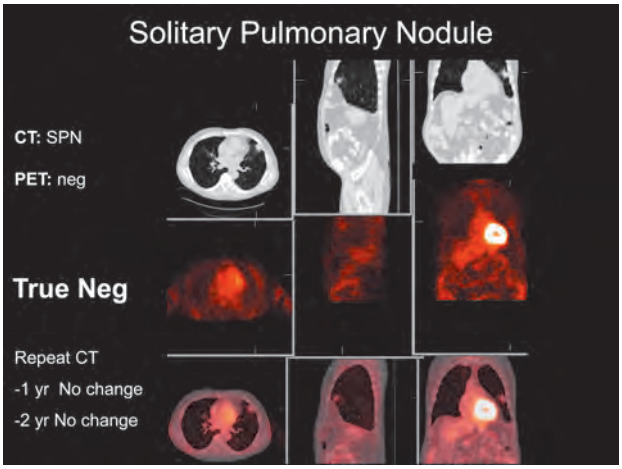
Sensitivity 97%
Specificity 74%

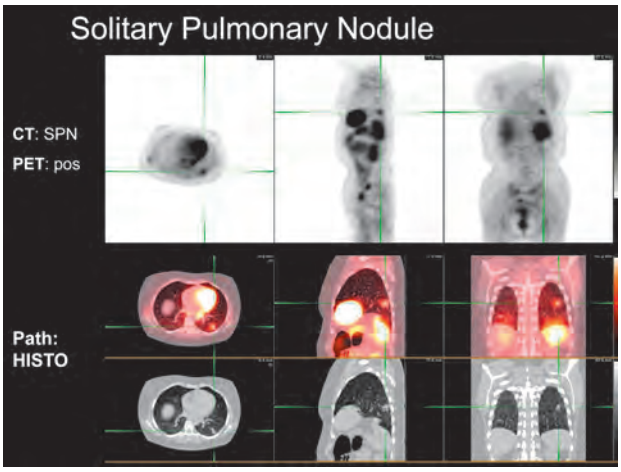
JAMA 2001;285:914

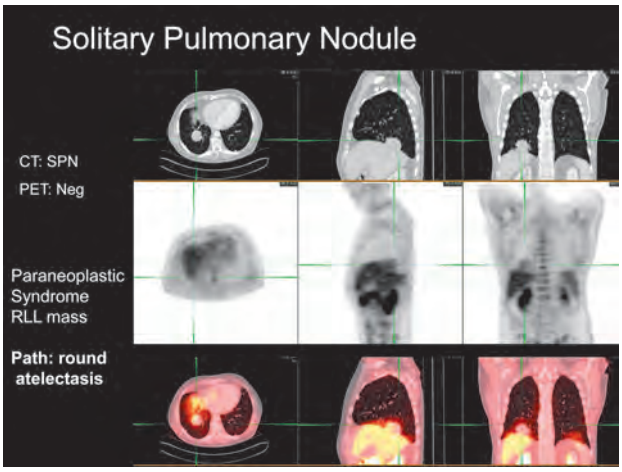
Solitary Pulmonary Nodule

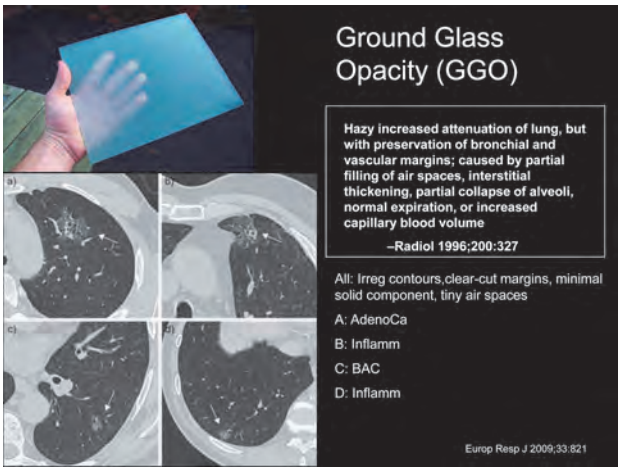


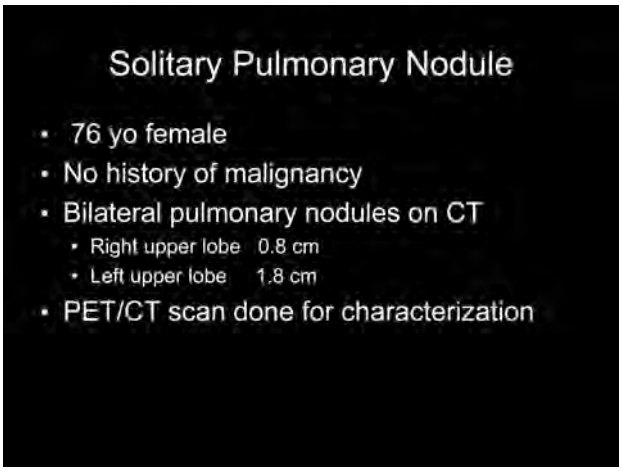
Solitary Pulmonary Nodule

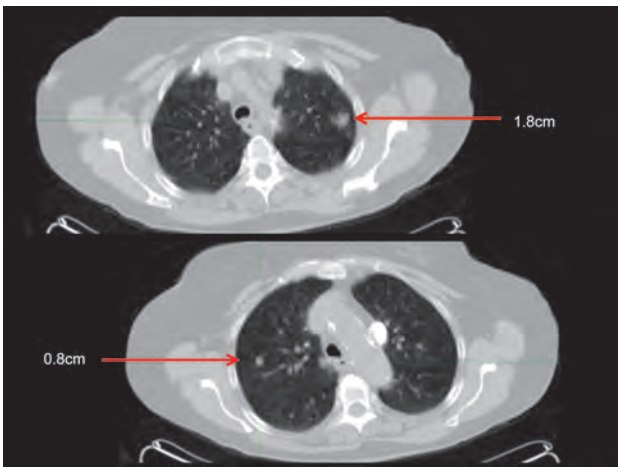


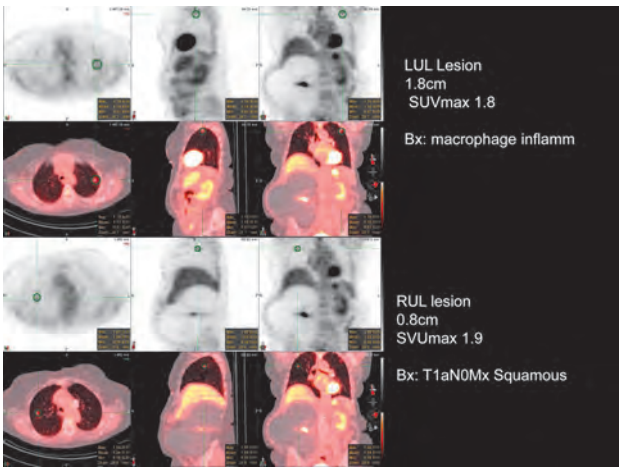

Solitary Pulmonary Nodule
CT: SPN
PET: pos
Path:
HISTO

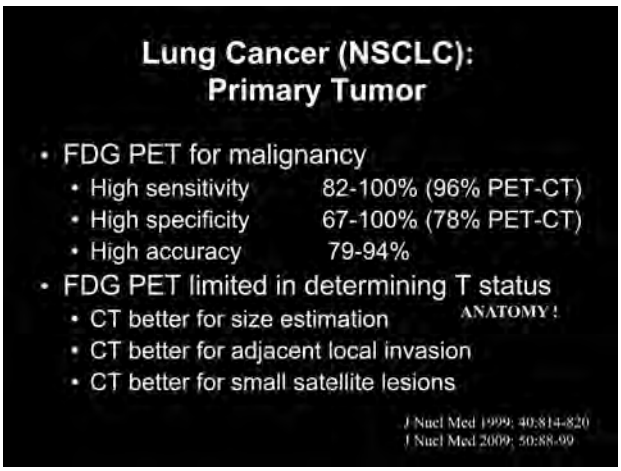

Solitary Pulmonary Nodule
CT: SPN
PET: Neg
Paraneoplastic
Syndrome
RLL mass
Path: round
atelectasis

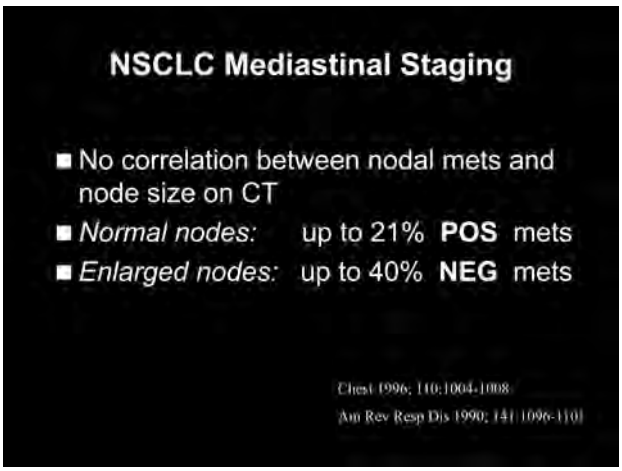

Ground Glass
Opacity (GGO)
Hazy increased attenuation of lung, but with preservation of bronchial and vascular margins; caused by partial filling of air spaces, interstitial thickening, partial collapse of alveoli, normal expiration, or increased capillary blood volume
–Radiol 1996;200:327
All: Irreg contours,clear-cut margins, minimal solid component, tiny air spaces
A: AdenoCa
B: Inflamm
C: BAC
D: Inflamm
Europ Resp J 2009;33:821


Solitary Pulmonary Nodule
• 76 yo female
• No history of malignancy
• Bilateral pulmonary nodules on CT
• Right upper lobe 0.8 cm
• Left upper lobe 1.8 cm
• PET/CT scan done for characterization


1.8cm
0.8cm


LUL Lesion
1.8cm
SUVmax 1.8
Bx: macrophage inflamm
RUL lesion
0.8cm
SVUmax 1.9
Bx: T1aN0Mx Squamous


Lung Cancer (NSCLC):
Primary Tumor
• FDG PET for malignancy
• High sensitivity 82-100% (96% PET-CT)
• High specificity 67-100% (78% PET-CT)
• High accuracy 79-94%
• FDG PET limited in determining T status
• CT better for size estimation ANATOMY!
• CT better for adjacent local invasion
• CT better for small satellite lesions
J Nucl Med 1999; 40:814-820
J Nucl Med 2009; 50:88-99


NSCLC Mediastinal Staging
■ No correlation between nodal mets and node size on CT
■ Normal nodes: up to 21% POS mets
■ Enlarged nodes: up to 40% NEG mets
Chest 1996; 110:1004-1008
Am Rev Resp Dis 1990; 141:1096-1101

NSCLC Mediastinal Staging

- FDG-PET
  - sensitivity: 88%
  - specificity: 93%
- CT alone
  - sensitivity: 63%
  - specificity: 76%

Semin Nucl Med 2004; 34:134
Ann Thorac Surg 1998; 65:1811

NSCLC Mediastinal Staging

- Meta-analysis of 14 published series
  - 514 PET patients
  - 2,226 CT patients
- Mediastinal nodal metastases:

PET	Sens 79%	Spec 91%
CT	Sens 60%	Spec 77%

$p<.001$

Pre PET- CT I

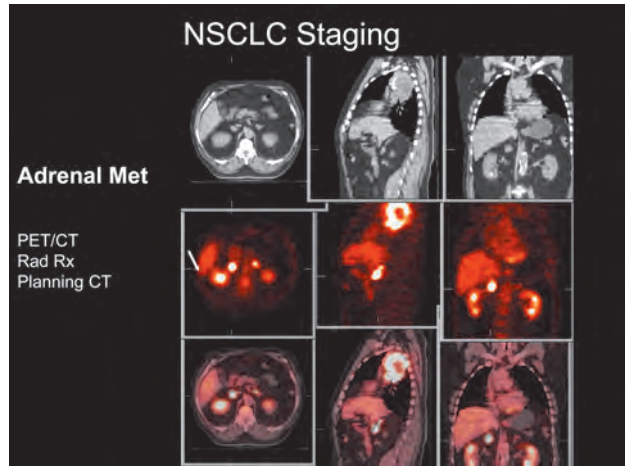
Radiol 1999;213:590

NSCLC staging: Adrenal Metastasis

- Benign vs malignant adrenal lesions difficult by conventional imaging (CI)
- MRI somewhat more useful
- FDG-PET Sens 100% Spec 80%
- positive uptake in an adrenal mass is an indication for biopsy to confirm metastatic disease

Am J Roentgenol 1997;168:1357

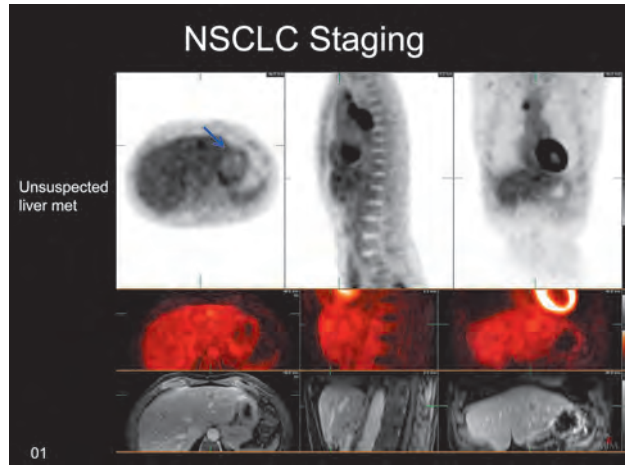
NSCLC Staging



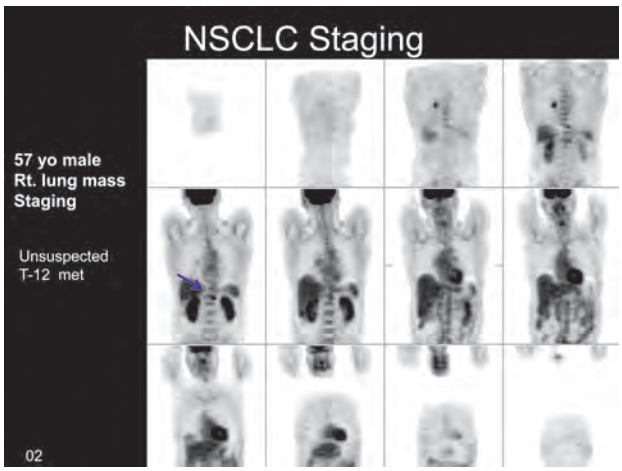
NSCLC Staging: Distant Metastases

- FDG PET finds unsuspected extra-thoracic spread in 6-24% of cases
  - More likely in stage III (locally advanced)
- May equal or exceed bone scan sensitivity
- FDG-avid effusion is likely malignant
- CNS and GU sensitivity limited
  - High background in these areas

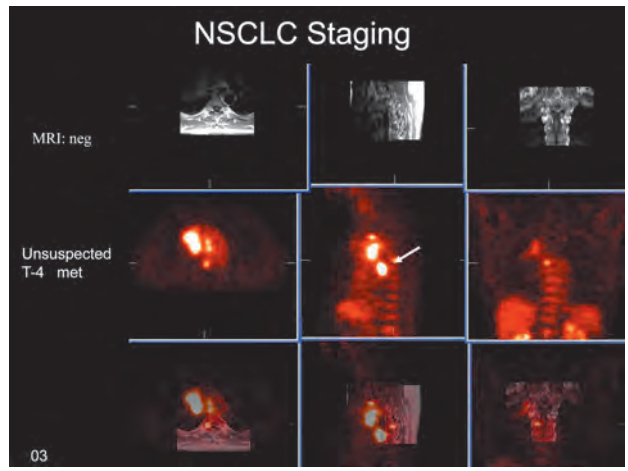
NSCLC Staging



NSCLC Staging



NSCLC Staging



NCSLC Staging before & after PET

- 153 consecutive pts with new Dx
- Treatment plans +/- PET compared
- PET staged: **33%** up **10%** down
- PET impact:
  - High 54pts (35%)
  - Med 39pts (25%)
  - Low 46pts (30%)
  - No 14pts (9%)

J Nucl Med 2001; 42:1596

NSCLC Staging before & after PET

Impact of PET

- **High** 54 pts (35%)
  - 34 pts curative → palliative
  - 6 pts palliative → curative
  - 15 pts modality change
- **Medium** 39 pts (25%)
  - Changed radiation Rx volume

NSCLC Staging before & after PET

Impact of PET

- **Low** 46 pts (30%)
  - PET results concordant with conventional
  - Treatment proceeded as planned
- **NO** 14 pts (9%)
  - PET information not considered in plan
  - Accuracy of PET confirmed by follow-up
    13/14 death from mets
    1/14 later chest wall resection

NSCLC Staging before & after PET

Pre PET Stage	Post PET Stage I	II	III	IV	*Total*	% down	% up
I	24	3	13	5	*45*	0	47
II	1	9	8	2	*20*	5	50
III	6	4	51	19	*80*	13	24
IV	2	1	1	4	*8*	50	0
Total	*33*	*17*	*73*	*30*	*153*	10	33

J Nucl Med 2001; 42:1596

NSCLC Staging before & after PET

- Clinical impact of PET (Summary):
- Treatment plan changed in 60/153 patients
  - 39% Overalll
  - 22% General treatment plan modified
    - Usually curative to palliative
    - Due to unsuspected lesions found at PET
  - 25% Radiation treatment volume modified

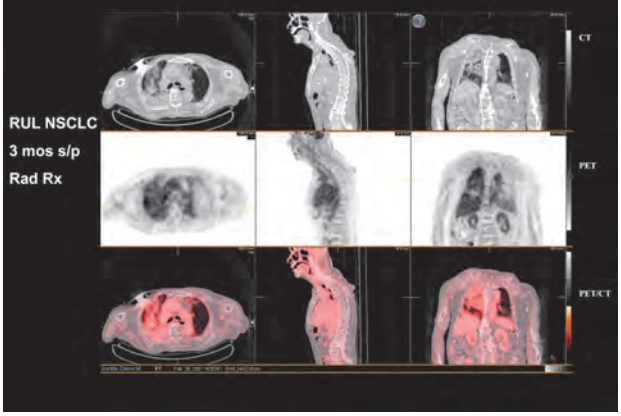
J Nucl Med 2001; 42:1596

NSCLC Restaging: Residual or Recurrent Disease

- 126 Pts with FDG PET before and after therapy
  PET Sens 100% Spec 92%
  CT Sens 71% Spec 95%
- Dx confirmed by Path (31) or progression by imaging (29)
- PET more accurate than CT alone to distinguish recurrence from scar

Eur Resp J 1999; 14: 1378-1380

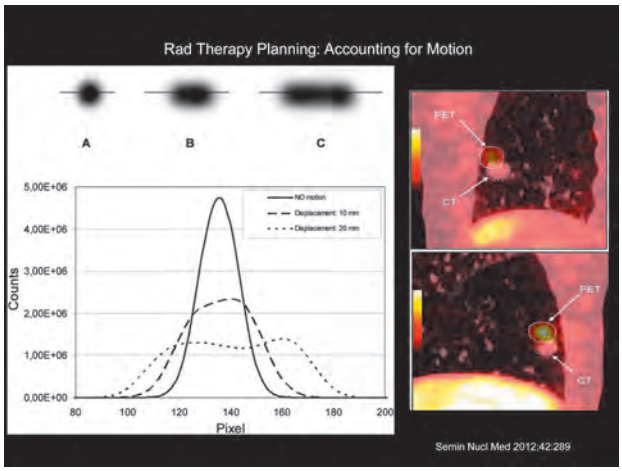
Radiation Pneumonitis

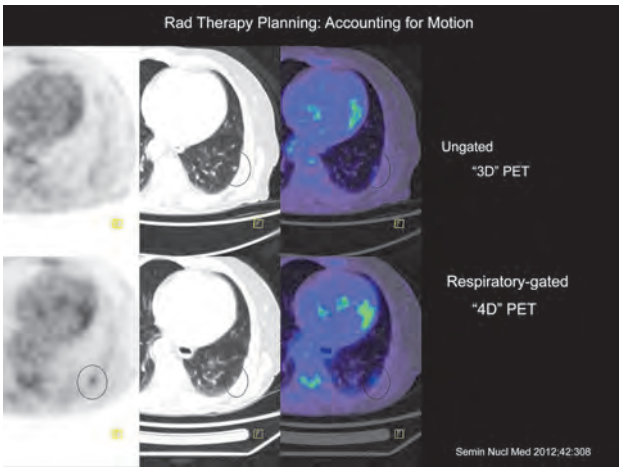


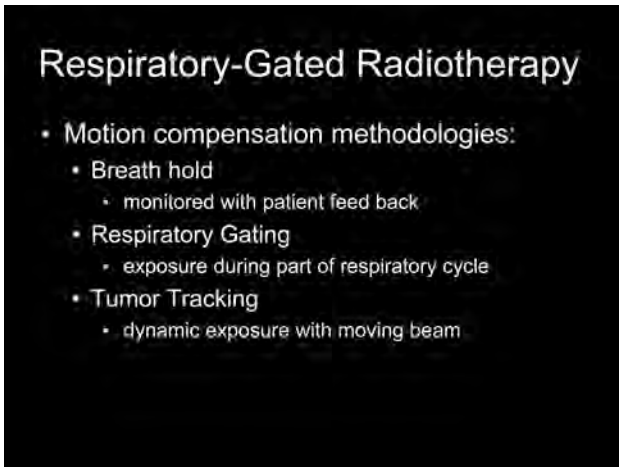
Radiotherapy Treatment Planning

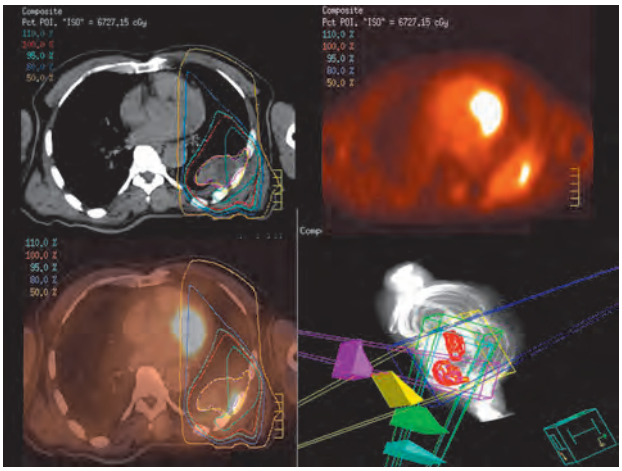
Effect of Image Registration Accuracy on Plan

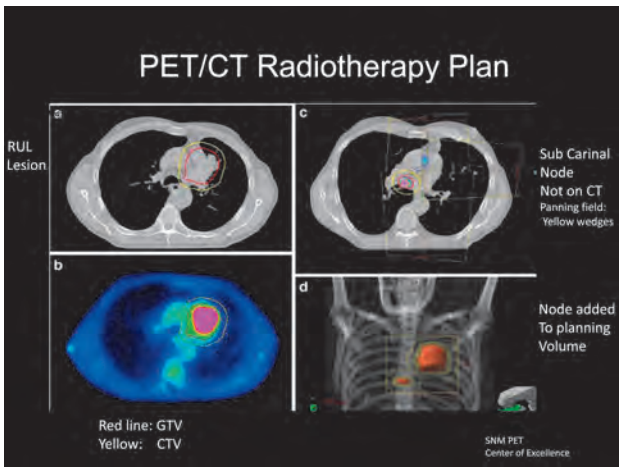
- Plan
  - **GTV** – Gross Tumor Volume - defined by Therapist
  - **PTV** – Planned Target Volume - includes added volume to account for micro-metastases
  - **CTV** – Clinical Tumor Volume - includes simulation setup error

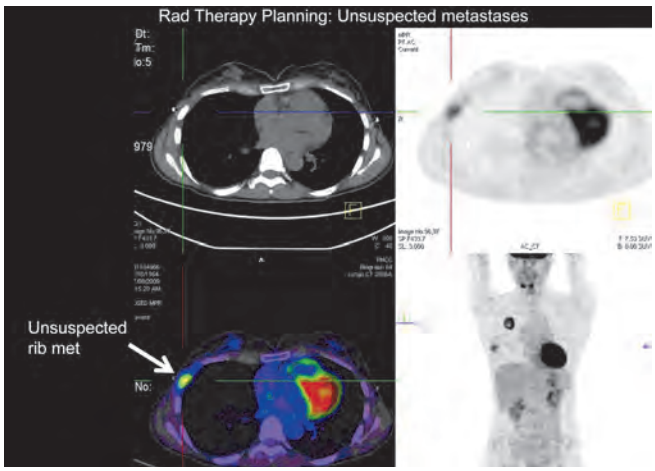

Rad Therapy Planning: Accounting for Motion
A
B
C
5,00E+06
4,00E+06
3,00E+06
2,00E+06
1,00E+06
0,00E+00
Counts
80
100
120
140
160
180
200
Pixel
PET
CT
PET
CT
Semin Nucl Med 2012;42:289

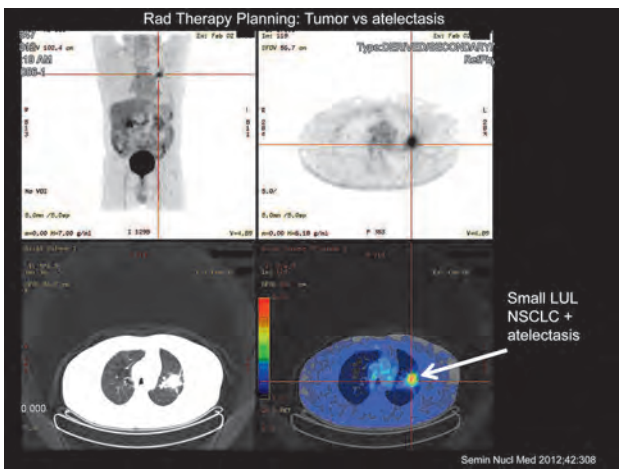

Rad Therapy Planning: Accounting for Motion
Ungated
"3D" PET
Respiratory-gated
"4D" PET
Semin Nucl Med 2012;42:308

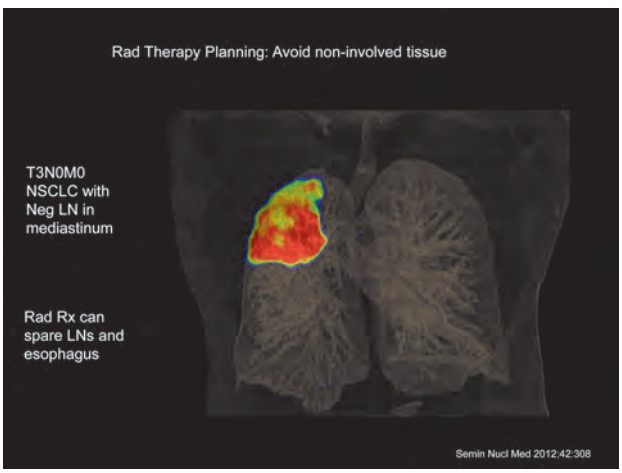

Respiratory-Gated Radiotherapy
• Motion compensation methodologies:
• Breath hold
• monitored with patient feed back
• Respiratory Gating
• exposure during part of respiratory cycle
• Tumor Tracking
• dynamic exposure with moving beam




PET/CT Radiotherapy Plan
RUL
Lesion
a
b
c
d
Sub Carinal
Node
Not on CT
Panning field:
Yellow wedges
Node added
To planning
Volume
Red line: GTV
Yellow: CTV
SNM PET
Center of Excellence


Rad Therapy Planning: Unsuspected metastases
Unsuspected
rib met


Rad Therapy Planning: Tumor vs atelectasis
Small LUL
NSCLC +
atelectasis
Semin Nucl Med 2012;42:308


Rad Therapy Planning: Avoid non-involved tissue
T3N0M0
NSCLC with
Neg LN in
mediastinum
Rad Rx can
spare LNs and
esophagus
Semin Nucl Med 2012;42:308