Nuclear Medicine Techniques in Pulmonology

- Single most important application of pulmonary scintigraphy: Evaluation of suspected PE
- Other indications
  - Quantitative analysis of relative lung perfusion before lobectomy/pneumonectomy
  - ARDS

VENTILATION SCINTIGRAPHY

Radiopharmaceuticals

Radioactive gases

- Xe^{133} (most common)
- Xe^{127}
- Kr^{81m}
- Xe^{133}: t1/2 – 5.27 days

  Relative low energy

  (81-Kev)of its photon

  Difficult to perform V scan after using Tc^{99m} for Q scan

∴ V scan performed first in combined V/Q scan

Radioaerosols

- DTPA

  (Tc^{99m} Pentetate)
- Ideal aerosol

  size: 0.1-0.5μ
- Localize in alveoli without significant large airway deposition

Protocol for xenon-133 ventilation scintigraphy

- Technique: Radioactive gas
- Patient preparation: None
- Dosage and route of admission
  - Xenon133:10 to 20mCi dosage by inhalation
- Procedure
  - Use a wide-field-of-view camera with a parallel hole, all purpose collimator and a 20% window centered at 81 keV
  - The patient is seated with the camera positioned in the posterior view

  - First breath: patient exhales fully and is asked to take a maximal inspiration and hold it long enough, if possible, to obtain 100k counts
  - Equilibrium: Obtain two sequential 90 sec images while the patient breathes normally
  - Washout: Obtain sequential 45 sec posterior image then left and right posterior oblique images and a final posterior image
- Sitting position better: full Dm excursion, easier to obtain oblique views
- Radio aerosols:
  - DTPA Nebulized over several min.[25-75mCi]
  - Views obtained [similar to gas studies]

PERFUSION SCINTIGRAPHY

- Tc^{99m} labelled Human Albumin Microspheres (Tc^{99m} HAM)
- Tc^{99m} labelled macroaggregated albumin (Tc^{99m} MAA)

↓

(Commonly used)

- Tc99m MAA: 10-30μ
- Clearance from lungs
  - Mech. degradation of particles to smaller size → Phagocytosed by RES after passing into systemic circulation
- T1/2 : 2-3 hrs
- Dose: 60,000-400,000 particles/dose

PROTOCOL FOR TECHNETIUM-99M MACROAGGREGATED ALBUMIN PERFUSION SCINTIGRAPHY

Patient preparation and precaution

- Right-to-left shunts are a relative contraindication
- Pregnant women: Adjust dosage and observe requirement for a minimum of 60,000 particles
- Pulmonary hypertension or pneumonectomy: Reduce number of particles to 60, 000

Dosage and Route of Administration

- Tc-99 MAA: 4 mCi (148 MBq) adult dosage
- Intravenous administration over several respiratory cycles with the patient supine

Procedure

- Use a wide-field of-view gamma camera with a low energy high-resolution or all-purpose collimator and a 20% window centered at 140keV
- Obtain anterior, posterior, right lateral, left lateral and right and left lateral posterior oblique images (anterior oblique images optimal)
- Obtain 500K to 750K counts/image

- Precaution
  - Avoid drawing blood into syringe

    ↓

    Avoid spurious “Hot Spots”
  - Agitate syringe before inj.

    ↓

    Avoids setting out and aggregation of particles

APPEARANCE OF NORMAL SCINTIGRAMS

Ventilation Scan

Wash in image	: Homogenous distr. of Xe^{133}
equilibrium phase	: Homogenous
washout phase	: Progressive/uniform ↓ in activity from lung

Aerosol Study

- Distr. Similar to gas study

Perfusion Scan

- Normal/healthy individual
  - Homogenous uniform distr.
- Extra pul. Activity:
  - Positive– Rt. – Lt. shunt
  - Radiopharmaceutical contaminant in preparation

PULMONARY EMBOLISM

V/Q Mismatch Concept

- V/Q match - both scintigrams abnormal
  - defect of equal size
- V/Q mismatch - Abnormal perfusion in an area of normal ventilation or much larger perfusion abnormality then ventilation defect

Terminology for V/Q scan

- Segmental defect
  - Characteristically wedge shaped and pleural based, segmental anatomy of the lung

- Large segmental defect
  - >75% of a lung segment
- Moderate segmental defect
  - 25%-75% of a lung segment
- Small segment defect
  - <25% of a lung segment
- Non-segmental defect
  - Not conform to segmental anatomy, not appear wedge shaped or neither conforms to segmental anatomy nor appears wedge shaped

Causes of Non-segmental Defects

- Tumors
- Pleural effusion
- Trauma
- Hemorrhage
- Bullae
- Cardiomegaly
- Mediastinal and hilar adenopathy
- Atelectasis
- Pneumonia
- Aortic ectasia or aneurysm

Revised PIOPED Criteria	PIOPED II V/Q Scan Criteria
High probability (>80%) Two or more large mismatched segmental perfusion defects or the equivalent in moderate or large and moderate mismatched defects	High Scan probability Two or more large mismatched segmental defects or the equivalent in moderate or large and moderate defect
Intermediate Probability (20%-79%) One moderate to one half large mismatched segmental perfusion defects or the equivalent in moderate segmental perfusion defects Single matched V/Q defect with clear chest radiograph Difficult to categorize as low or high, or not described as low or high	Intermediate-indeterminate scan probability One half to one and one half segmental equivalents, difficult to categorize as high, Multiple opacities with associated perfusion defects
Low probability (<19%) Non-segmental perfusion defects Any perfusion defect with a substantially larger chest radiographic abnormality Perfusion defects matched by ventilation abnormality provided that there are a clear chest radiography and some areas of normal perfusion in the lungs Any number of small perfusion with a normal chest radiograph	Low Scan Probability A single matched V/Q defect More than three small segment lesions Probable pulmonary embolism mimic: one lung mismatched (without) with absent perfusion, solitary lobar mismatch Mass or other radiographic lesion causing all mismatch, moderate-sized pleural effusion Marked heterogeneous perfusion

	Very low Scan probability Non-segmental lesion Perfusion defect smaller than radiographic lesion Two or more V/Q matched defects with regionally normal chest radiograph One to three small segmental perfusion defect Stripe sign present around the perfusion defect Pleural effusion of one third with no perfusion defect
Normal No perfusion defect	Normal perfusion Scan No perfusion defect

- High probability scan : Likelihood of PE: 80%
- (N) perfusion scan : Likelihood < 5%
- Accuracy
  - PIOPED trial : Specificity - 97%
    Sensitivity - 41%
  - Occurrence of PE in: Low probability – 12%
    : Normal study – 4%

D/D of V/Q mismatch

- Acute pulmonary embolism
- Chronic pulmonary embolism
- Other causes of embolism (drug abuse, iatrogenic)
- Bronchogenic carcinoma (other tumors)
- Mediastinal or hilar adenopathy with obstruction of pulmonary artery or veins
- Hypoplasia or aplasia of pulmonary artery
- Swyer-James syndrome
- Post radiation therapy
- Vaculities
  - Chr PE: Most common cause of false +ve interpretation
  - Hilar mass compressing pul artery $\rightarrow$ mimics PE

V/Q Match Abnormalities

- Chronic obstructive pulmonary disease
- Bronchitis and bronchiectasis
- Blebs and bullae
- Congestive heart failure
- Pulmonary edema
- Pleural effusion
- Asthma
- Pulmonary trauma, hematoma
- Inhalation injury
- Mucus plugs
- Bronchogenic carcinoma (other tumors)

PIOPED STUDY

- 933 recruited
- 931 → V/Q scan 755 → Pul. Angio.
- PE → 251 (33%)
- High probability 88% had PTE
- Intermediate probability 33% had PTE
- Low probability 12% had PTE
- Normal Scan excluded PE

[JAMA 1990; 263: 2753-59]

Systematic review and meta analysis of strategies for Dx of suspected PTE

- *Roy PM et al*
  - 48 articles analyzed
  - 11004 pts with suspected PTE
  - 3329 pts had PTE (30% prevalence)
  - Mod. – High pre-test probability

    High Probability V/Q

    Spiral CT +ve

    CSG +ve

    } > 85% post test probability
  - Low clinical probability – above results req. confirmation by Pul. Angio.

- Low – Mod clinical Probability
  - Negative quantitative D-Dimer test (<500μg/L)
  - Spiral CT –ve
  - CSG –ve
  - Normal/near normal lung scan

  } <5% post test probability

- High clinical probability → above results req. confirmation by Pul. Angio.

BMJ 2005; 331: 259-63

V/Q scan & Helical CT in Suspected PTE

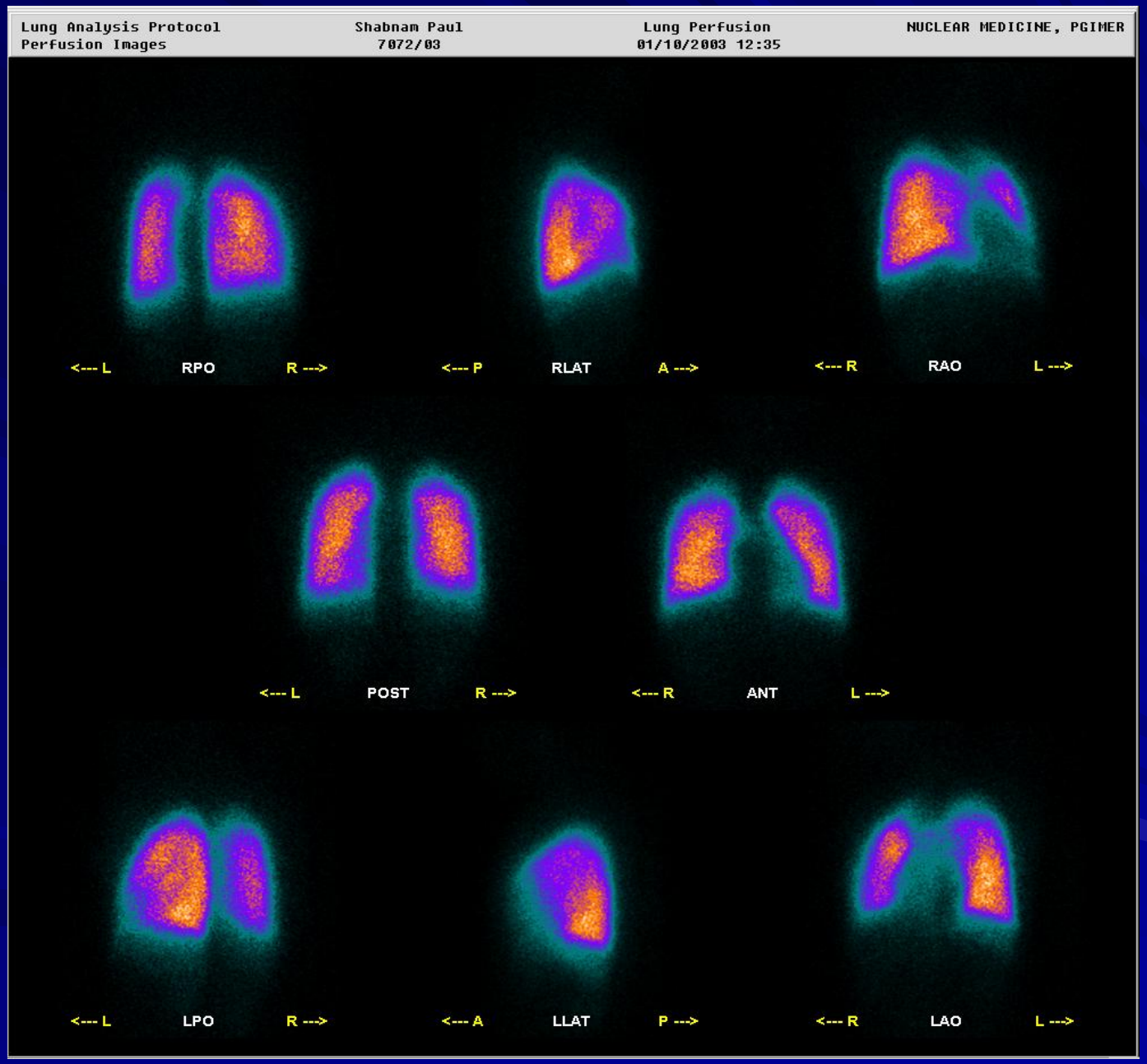
Hayashino et al

- Meta analysis of Dx performance
- 12 article included
- Pooled sensitivity for Helical CTPA – 86%

  Specificity – 94%
- V/Q scan – High probability Normal

Sensitivity	39%	98.3%
Specificity	97%	4.8%

- Conclusion:
  - Helical CT has greater discriminatory power than V/Q scan with (N) threshold to exclude PTE
  - Helical CT & V/Q scan with high probability – Similar discriminatory power in Dx. of PTE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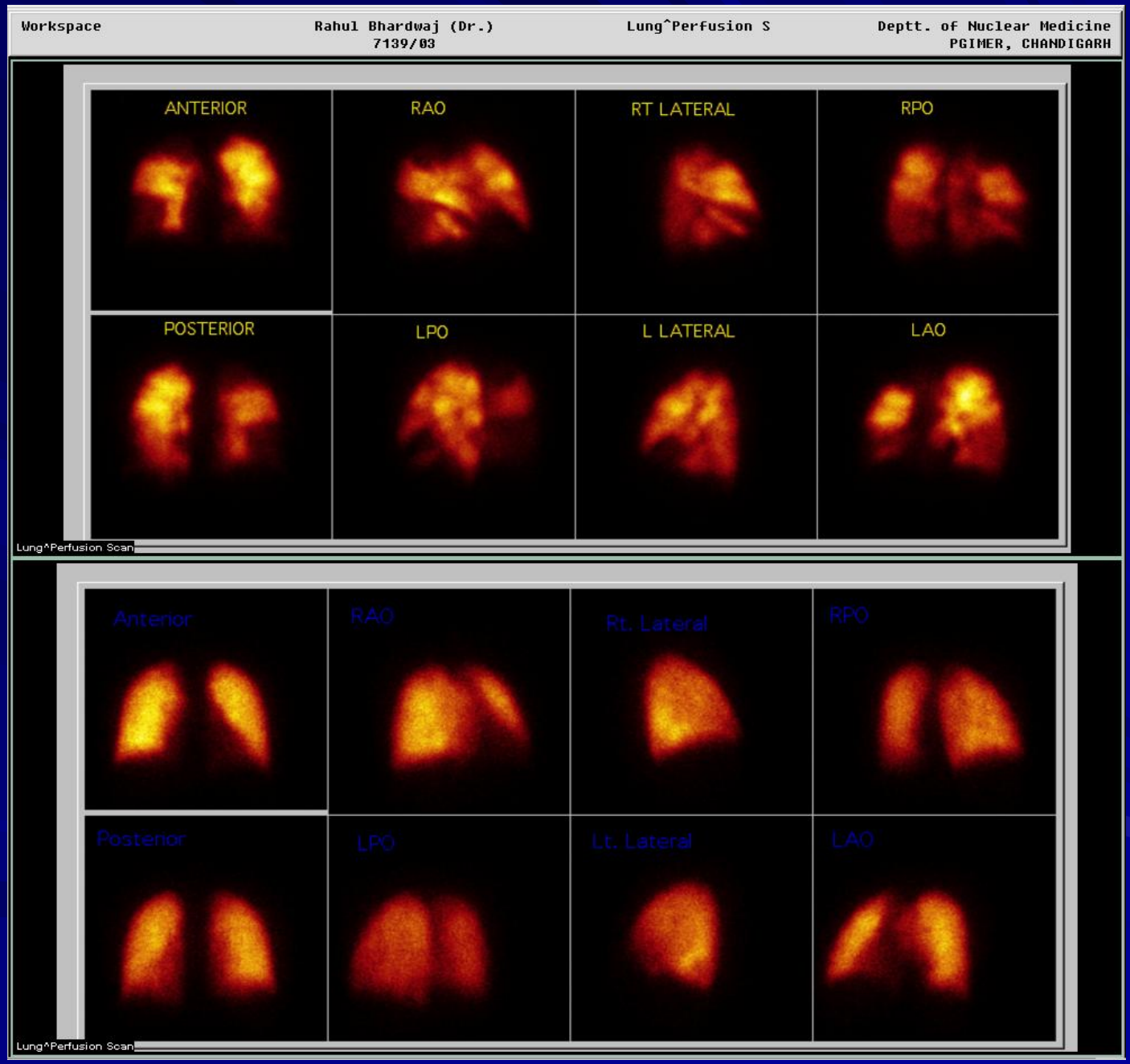
Workspace
Rahul Bhardwaj (Dr.)
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Lung^Perfusion S
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Lung^Perfusion Scan

GALLIUM & OTHER AGENTS

- Use of Ga^{67} declined over last decade

  Reasons : Lack of specificity

  : Delay between injection and imaging time

  : Relatively poor imaging characteristics

- PET/SPECT has replaced Ga scans as tumor imaging agent of choice

MECHANISM OF UPTAKE: TUMOR & INF./INFL.

Gallium – 67 Citrate

- Used since 1869
- Acts as Iron analogue
- Transported in blood bound to transferrin
- Tumors:
  - ↑ transferrin receptors in malignant cells, ↑ Ga – transferrin binds to these receptors
  - Ga incorporated in intracellular lysosomes
  - ↑ Lactoferrin levels in lymphoma (Lactoferrin binds to Ga)

- **Inflammation**
  - ↑ lactoferrin levels in leucocytes & abscess fluids

    ∴ ↑ Ga uptake in infl. conditions

    [Lactoferrin released by leucocytes & Bacteria]
  - Highly conc. in sub-acute/chr. inf./infl. than acute processes
- **Normal Distr.**
  - Liver/spleen/skeletal system/colon
    varying degrees: salivary / laccrimal glands, nasal region, genitalia
  - Excreted: bowels – 80%

    kidneys – 20%

- **Study Performed**
  - Ga^{67} IV 8-10mCi
  - Whole body/localized imaging after 24-48hrs
  - Imaging can be repeated upto 96-120hrs.
- **Pt. Preparation**
  - No dietary restr.
  - No BT/Gad MRI in previous 24hrs. : interfere with normal Ga^{67} distr.

Thalium-201 Chloride

- **Mech. Of uptake**
  - Analogue of K^+ uses ATP pump
  - Co-transport mech. in tumor cells inv. K^+, Na^+, Cl^-
  - Leaky capillaries
- **Mainly accumulates at sites of tumor**
  Min. uptake in infl. focus
- **Study performed**
  - Tl201 IV 3-5mci
  - Imaging started at 20min. and continued to 60min.
  - Lymphoma, kaposi's sarcoma

    ↓
  - Delayed images

- **Pt. Preparation**
  - 4 hrs. fasting (to min. salivary and splanchinic uptake)
  - Avoid physical exertion for at least 4 hrs. (to min. skeletal muscle and cardiac uptake)
  - (N) uptake – liver/heart
- **Clinical Application**
  - Diff. between benign/malignant disease
  - Grade of malignancy
  - Response to therapy/Recurrence

- **Technetium 99m Sestamibi**
  - Useful identifying primary tumor: Parathyroid adenoma, Breast, lung, bone, brain
  - Uptake depends on blood flow/leaky capillaries/ ↑Permeability
- **Neuroendocrine Imaging Radiotracers**
  - Used for imaging Pheochromocytomas, carcinoid tumors, neuroblastoma and other neuroendocrine tumors
  - Carcinoid tumors: I^{123} MIBG – 80% sensitive
  - I^{123}-MIBG :10mCi IV followed by whole body imaging at 24 hrs.

- **Pt. Preparation**
  - KI (2dr. BD) x 1-3 days
  - No dietary restr.
- **Octreoscan**
  - Tumors esp. endocrine – high density of somatostatin receptors
  - In^{111} labelled somatostatin analogue effectively localizes tumor
  - Tc^{99m} depreotide (Neotect), somatostatin receptor binding agent helpful in evaluation of Pul. Nodules
  - 6mCi IV – Whole body imaging – 6hrs. & 24hrs.
  - Well hydrated

Gallium in Cancer

- Most avid uptake in lymphoma/Lung cancer/ sarcoma/melanoma

Lymphoma

- Staging

	Sensitivity	Specificity
HD	86-97%	100%
NHL	86-92%	100%

- Residual disease

	Ga Scan Vs	CT thorax
Sensitivity	96%	68%
Specificity	80%	60%

- Specificity reduced by inflammatory changes (benign activity lower than malignant activity more often B/L and symmetric)

- **Tl^{201} Vs Ga^{67}**
  - Good tool to evaluate malignant bone lesions

    Sensitivity – 88%

    Specificity – 94%
  - Inferior to Ga in staging lymphoma

- **Lung Cancer**
  - Ga has high affinity for lung cancer

    Sensitivity : 85 – 97%
  - Superseeded by FDG for tumor identification staging
  - Absence of FDG availability: Response to therapy
  - Neotect useful in SPN evaluation

    Sensitivity – 97%

    Specificity – 73%
- **Mesothelioma**
  - Ga reliable for assessing extent of Pl. inv. Only when Pl thickening > 6mm

- **Carcinoids**
  - Don’t take up Ga, FDG
  - Octreoscan and I^{123} MIBG used
  - Useful for staging
- **In summary**
  - With advent of PET

    ↓
  - Role of Ga in staging response to therapy – Has reduced
  - Useful when there is no access to PET

Inflammation/Infection

- Ga uptake generally associated with cellular infiltration rather then fibrosis
- Sarcoidosis: signs on Ga scan that suggest Dx
  - Lambda Sign: Rt. Paratracheal, B/L Hilar adenopathy resembles letter lambda
  - Panda Sign: Uptake in B/L lacrimal & parotid glands resembles panda bear
- Either or both of these patterns on Ga scan with symmetric B/L Hilar LNE or B/L interstitial opacities are highly sensitive & specific for sarcoidosis however,
- Ga scan in isolation 48% overall diagnostic sensitivity

- Panda Pattern may be seen
  - HIV
  - Sjogren's syndr.
  - RA
  - SLE
  - Head & neck RT for lymphoma
- Uptake due to
  - ↑ Capillary permeability
  - In corporation by activated infl. cell
- Various studies: Sensitivity of Ga scan for Dx 60-90% with poor specificity
- Ga scan helpful in cases when Bx is necessary for Dx but Pt. is a poor candidate for FOB→ extra thoracic site identification for safer Dx Bx

- Combination of negative Ga scan & SACE levels virtually excludes the Dx of sarcoidosis
- Ga scan more sensitive than SACE in identifying pts. with active sarcoidosis
- Clinical scenarios in which Ga scan is useful:
  - Assisting in Dx of difficult cases esp. those with isolated extra-thoracic disease
  - Identify active sites for Bx
  - Differentiating active disease from fibrosis in a lung transplant candidate

Drug toxicity & Radiation pneumonitis

- Routine use not recommended
- May precede CXR changes
- Useful in establishing Dx in difficult cases
- Not very sensitive in Ac. Radiation Pneumonitis

Infl./Occupational/Chr. Lung disease

- Ga uptake sec. to - Ac. Infl. Component
  - ↑Alveolar capillary permeability
- Asbestosis : Ga uptake +ve in pts. With (N) CXR
  HRCT +GA scan:Helpful when clinical exam, CXR, PFT equivocal

- **CVD:** Ga scan may provide estimation of location of inflammation & help guide BAL/Bx

↓

Not routinely used

Summary

  - Ga scan sensitive indicator of non-infectious, infl. lung disease
  - However, not specific, inconvenient imaging necessitating multiple visits to Nuclear Med. Dept.
- Relegated to problem solving role rather than routine practice

Infectious Disease

- TB
  - High sensitivity for detection of active disease
  - Helpful in diff. active disease from fibrosis
- Other pul. inf: Difficult situations where inf. not readily appearent (PUO)
- Ga scan preferred over WBC scan in leucopenic pts., pediatric population

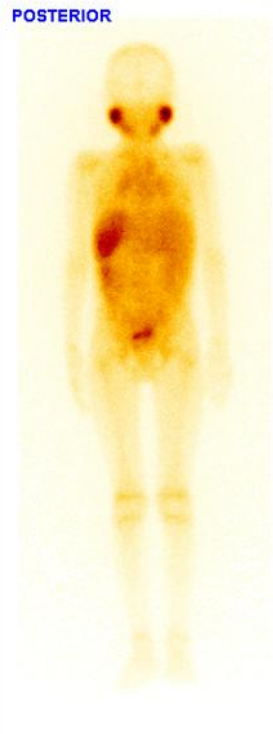
AIDS

- Diffuse Ga uptake in PCP has high sensitivity (80-96%) but poor specificity
- Negative Ga scan in pts. with (N) CXR has high negative pred. value in excluding Pul. disease
- Not routinely in PCP w/u

- **Reasons:** Poor specificity
  Delayed imaging (24-48hrs)
  HRCT favoured (sensitivity-100% specificity-89%, accuracy-90%)
- Ga scan reserved for situations where sputum analysis/BAL/HRCT – Non-diagnostic, empiric therapy not preferred
- A negative Ga scan with abnormal CXR highly suggestive of Kaposi sarcoma as KS is not Ga avid
- CMV mimics PCP but may have accompanying adrenal, lacrimal, colonic inv.
- Pul. & Parotid uptake (+) LIP
- Pul. & skeletal uptake (+) actinomycosis/nocardia

- **Summary**
  - Not used routinely
  - Used occ. in distinguishing active diseases from scarring or when there is no other source of infection apparent

Workspace	Ganesh 6546/03	Wholebody Imagin 14/08/2003 -> 16/08/2003	PGIMER Chandigarh Department of Nuclear Medici...



WB Ga-67 Scan at 48 HRS

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LUNG CANCER

Single Photon Radionuclide Imaging in Lung Cancer

- Despite the emergence of PET – widely accepted
- Interest remains in single photon techniques

↓Because COZ

Wide availability of single photon equipment

- Ga^{67} – Not useful in detecting lesions < 1.5cm
  - False negative scan in upto 22% pts. of lung ca.

    High PPV, low NPV

    Specificity for med. staging – 38-100%

∴ No current role for characterization of SPN & staging of lung ca

- Tl^{201}
  - Like Ga cannot detect lesions <2cm
  - Poor imaging characteristics
  - Not widely accepted in assessment of SPN
- Tc^{99m} tetro fosmin, Tc^{99m} – MIBI scan
  - < 1cm lesions – Poor sensitivity
  - Poor to FDG-PET in primary tumor visualization & detecting med. lymph mode metastasis
- Somatostatin receptor imaging
  - High affinity somatostatin receptors (+) variety of malignancies including SCLC
  - Lower frequency of expression in NSCLC
  - NSCLC constitutes majority of lung cancer

  ∴ This may hamper detection of malignancy within SPN
  - However studies showed sensitivity of upto 96% in lung cancer detection

PET in NSCLC

- Basics
  - FDG is a glucose analogue
  - Facilitated transport into cells via glucose memb. transporter [GLUT-1 to GLUT-7]
  - Within the cells

    FDG

    ↓ **Phosphorylation by hexokinase**

    2 deoxy-glucose-6- Phosphate (Accumulates as no further metabolism takes place)

- NSCLC
  - Increase in GLUT-1, and GLUT-3 expression
  - ↑ glucose use by tumor cells
  - Upregulation of hexokinase levels, down regulation of glu-6 phosphatase

    ↓
  - Deoxyglucose retention with in cells

SPN

- 20-50% malignant
- Existing diagnostic modalities
  - Radiology : Benign etiology suggested by
    Prolonged stability
    smooth control
    Calcification: Central/diffuse/Laminated/ Popcorn
  - However, majority of SPN after CT, remain indeterminate
  - Dual energy CT/contrast enhanced dynamic CT
    Sensitivity : 98%
    Specificity : 58%

- Histologic sampling
  - Indeterminate lesions
    ↓
  - Obtain tissue Bx
- FOB: cytology & Bx
  - ↑ yield for - central lesions
    - endobronchial component
    - Bronchus entering prox. part of lesion
- TTNB: Better for – Peripheral lesion,
  – FOB not available
  Sensitivity – 71-100%
  complications – Pneumothorax (61%)
  5-27% req. ICT
  – Haemorrhage

- Thoracoscopy
  - Peripheral lung lesions
  - Complications : Mean hospital stay 2.4-5.7 days
    : Duration of ICT: 1.8-3.3 days
- Open thoracotomy
  - No definitive Dx. inspite of all less invasive diagnostic procedures

- FDG PET
  - Sensitivity : 83-100%, Specificity : 52-100%
  - PPV : 92.6%, NPV : 87%
  - Accuracy : 91.3%
- FDG-PET is more sensitive & Specific in characterization of SPN than any other currently available non-invasive method
- Either semi-quantitative/visual methods used for diff. bet benign & malignant SPN
- Most common semi-quantitative measurement is standard uptake value [suv]
- SUV of 2.5 at 1hr used to diff. bet benign and malignant SPN

- False positive cause of FDG are pred. inflammatory in origin

Causes of False-Positive Findings with FDG-PET for characterization

Granulomas

Histoplasmosis

Tuberculosis

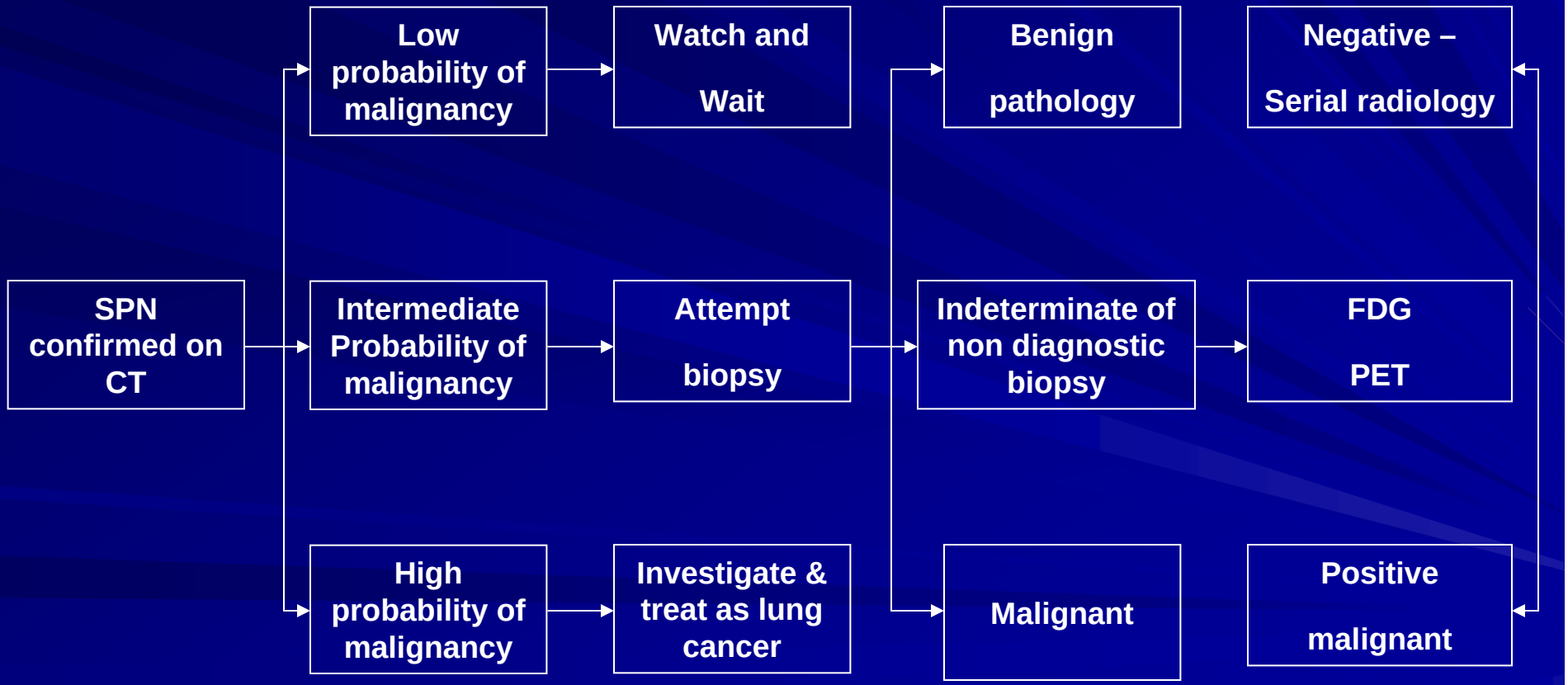
Schwannoma

Chronic inflammation
Aspergillus infection
Abscess
Acute blastomycosis
Sarcoidosis
Cryptococcus neoformans
Wegener's granulomatosis
Aggressive neurofibroma
Coccidiodomycosis

- False negative: small size (0.5cm)

  well diff. malignancies (carcinoids, well diff. adeno ca, BAC)

Current clinical algorithm for the use of FDG-PET in characterization of SPNs



Accuracy of PET for Dx of Pul Nodules/Mass

Gould MK et al

- Meta analysis
- 40 studies
- 1474 focal pul. lesion
- Sensitivity/specificity – 91.2%
- In current practice: Sensitivity-96.8% Specificity-78%
- No diff. in Dx. accuracy of Pul nodules C/w lesion of any size
- Conclusion:
  - Accurate non-invasive imaging test for Dx of Pul. Nodules/Mass lesion

JAMA 2001; 285: 914-924

Summary of Major Studies on FDG-PET in Characterization of SPN

- Studies between 1990-2001
- 2079 pts
- 73.1% malignant lesions
- Sensitivity - 95.9%
- Specificity – 79%
- PPV – 92.6%
- NPV – 87%
- Accuracy – 92%

Seminars in Nucl. Med. 2002; 240-271

STAGING OF NSCLC

Existing Staging Procedures

- CT
  - Useful in T staging
  - N stage esp. mediastinum inv. Node >1cm in short axis
  - By using above criteria
  - CT has sensitivity – 78%
  - Specificity – 79% for LN mets
  - CT may over/under stage upto 40% pts.
  - Useful in detection of distant mets
  - Cerebral CT: if clinical exam reveals focal neurodeficit on finding of disseminated disease

- If solitary lesion identified – Bx preferred in v/o false positive (11%)
- Bone Scan: Skelatal mets identification
- Mediastionoscopy
  - Inoperable cases
  - Large Med. LNE

    Complications – 23%

    False Neg. – upto 10%
  - TBNA

    Sensitivity – 53%

    Specificity – 99%

    Complications – Haemorrhage

    – Pneumomediastinum

- Other Modalities
  - MRI useful for staging med LNE
  - Useful in assessment of indeterminate adrenal masses
- FDG-PET Staging the Primary
  - Poorly suited to assess the stage of primary tumor (T).
  - CT better suited → Reason: Better resolution, provides more anatomatic detail
- Staging the mediastinum
  - Sensitivity : 83.3%
  - Specificity : 92.2%
  - False positive usually d/t inflammatory pathology

Causes of False-Positive findings in FDG-PET thoracic Lymph node staging

- Bronchiectasis
- Upper respiratory tract infection/bronchitis
- Rheumatoid disease
- Proximity of tumor to mediastinum
- Pneumoconiosis
- Anthracosis/silicoanthracosis
- Hyperplastic lymph node/reactive hyperplasia/active
- Inflammation/Nonspecific inflammation
- Aspergilloma with reactive nodes
- Active granulomatous disease
- Active inflammation due to poststenotic pneumonia

- False Positive → Relatively infrequent, may result in denying a pt. potentially curative Sx

↓

∴ Recommended: Invasive Sx staging

- False Negative
  - Nodes immediately adjacent to primary tumor
  - 2 or more LN adjacent to each other but at diff. LN stations → PDG-PET not able to resolve them separately
  - Normal size nodes with microscopic foci of tumor

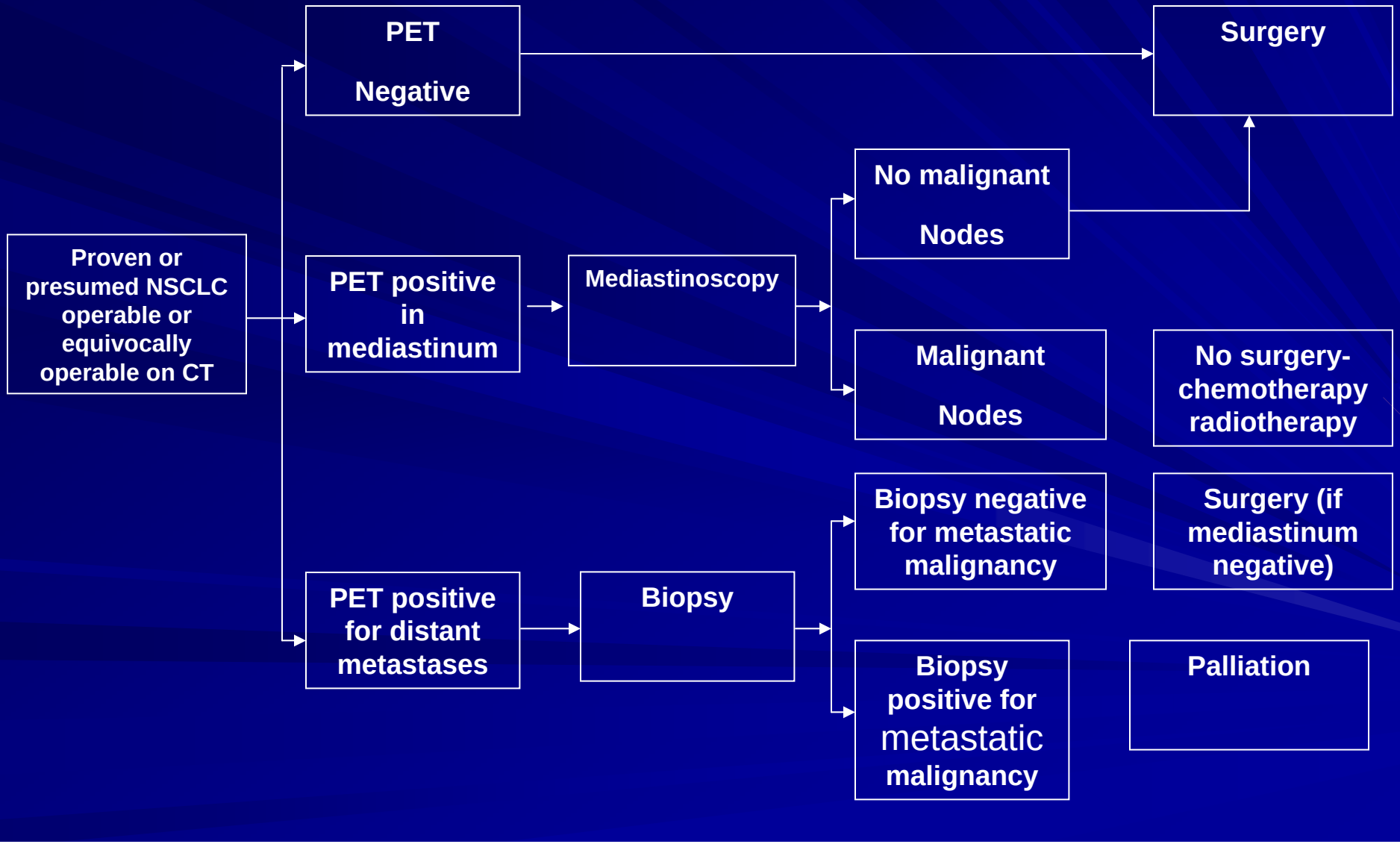
- Assessment of Distant Metastasis
  - Able to detect 94% distant mets
  - Superior in detection of distant mets c/w other modalities
  - FDG-PET relatively insensitive for cerebral mets

    Reason: High Background caused by normal cerebral FDG uptake

    [CT/MRI considered superior]
  - Osseous mets: Bone scintigraphy vs FDG-PET
  - Sensitivity 90% 90%
  - Specifity 66% 98%
- Adrenal mets: for indeterminate lesions
  - Sensitivity 80% and Specificity 80%

- Hepatic mets
  - Able to detect unsuspected hepatic mets
  - Characterizes the hepatic abnormalities identified on CT
- **Management Change**
  - Several studies have reported an overall management change between 24-40%
- **Cost effectiveness**
  - Major potential for cost saving is via
    - Minimizing invasive staging of mediastinum
    - Avoidance of inappropriate Sx in those with inoperable locally invasive or metastatic disease
- FDG-PET is most cost effective when performed on pts. With CT negative for nodal metastases with Bx to confirm PET positive results

Current clinical algorithm for use of FDG-PET in staging of NSCLC



Test performance of PET and CT for mediastinal staging in pts. With NSCLC

- Meta analysis
- 39 studies
- 1959 pts

Mediastinal staging	CT	FDG-PET
– Sensitivity	61%	85%
– Specificity	79%	90%

- PET more sensitive & less specific where CT showed enlarged nodes [100% & 78%] than when CT showed no LNE [82% & 93%]
- Conclusion
  - FDG PET more accurate than CT for Med. Staging

Ann. Intern. Med. 2003; 139: 879-92

Utility of Tc^{99m} Depreotide C/W FDG-PET & surgical staging in NSCLC

Kahn D et al

- 166 pts
- Detection of malignant disease

	PET	Tc^{99m} depreotide
– Sensitivity	96%	94%
– Specificity	71%	51%

- FDG-PET correctly stage 55% of pts C/W Tc^{99m} depreotide (45%)
- Conclusion
  - Sensitivity equal for both modalities
  - Specificity superior for PET

Chest 2004; 125: 494-501

Utility of PET in staging potentially operable NSCLC

Reed C et al

- 303 pts, 22 institutions underwent PET after routine staging

Detection of	PET	CT
N_1	42%	13%
N_2/N_3	58%	32%

- NPV for Med. node – 87%
- Mets identified in 6.3%
- Conclusion:
  - PET prevents non-therapeutic thoracotomies
  - +ve finding confirmed by mediastinoscopy
  - Mets require confirmation by biopsy

J Thorac Cardiovasc Surg 2003; 126: 1943-51

Delayed FDG-PET scan for Diff. between malignant and Benign lesions

Nakamoto Y et al

- 47 pts suspected pancreatic Ca – PET scan

	Malignant	Benign
	27	20
SUV at 2hrs.	↑22 lesions	↓17 lesions

- SUV cut off of 2.5 – 1 false –ve, 7 false +ve

  Dx accuracy – 83%

- Delayed FDG-PET scan at 2hrs post inj. May help diff. between benign and malignant lesions

Cancer 2000; 89: 2547-54

- Detection of Recurrent disease
  - Sensitivity : 97-100%
  - Specificity : 61.5-100%
- False positive results
  - Radiation pneumonitis [preferable – wait for 6mths

    Atleast – 3mths after completion of RT before performing PET scan
- False positive uptake declines with time

  ↓

∴ Some role of repeating PET scan if false +ve suspected

[curvilinear uptake S/o false +ve]

PET IN NON-MALIGNANT THORACIC DISORDERS

Pnemoconiosis

- FDG-PET studies revealed ↑ uptake
- ↑ uptake d/t infl. Cell – macrophages
  fibroblasts
- Specific radiotracer that localizes to fibroblasts and not in infl. Cell: 18F-fluoroproline
- Fluoroproline – PET studies → ↑ uptake in early fibrosis

Infection/Inflammation

- Infl. Cells at site of infl./inf. show ↑ FDG uptake
- Infl. Cells show lower level of FDG uptake C/W malignant cells
- ↑ uptake is d/t
  - ↑ GLUT expression
  - Cytokines & growth factor ↑ affinity of GLUT to FDG
- Sensitivity: 92%, Specificity: 100% in infl./inf. lesions
- **AIDS**
  - Major role of PET imaging
  - Identify correct location for further inv. Bx, Aspiration, or other modalities
  - Sensitivity & specificity of PET in localizing lesions in AIDS pts. 92% & 94% respectively

- **FUO**
  - Useful tool in this setting
  - Identifies lesions responsible for fever in >50% of pts.
  - FDG-PET compares favourably with Ga^{67} studies in PUO evaluation
  - FDG-PET may replace Ga^{67} as it gives quicker results

- **Sarcoidosis**
  - Useful in Mx of Pts with sarcoidosis
  - CXR Ab. (N) ↑ACE levels with (N) PET → may remain well without t/t
  - Not useful in Dx as findings may be confused with lymphoma
- Monitoring disease process and response to therapy
  - FDG-PET useful for this purpose in TB/Aspergillosis Alveolar echinococcosis /MAI

Role in pleural disease

- Useful in Dx & Staging of malignant mesothelioma
- Useful to determine whether there is malignant transformation of reactive pleural disease
- More accurate than CT to identify extent of disease, stage of disease in mediastinum, detect occult extra thoracic metastasis
- FDG-PET can be use to diff. benign from malignant Pl. thickening and for Dx & staging of mesothelioma
- Study can identify other focal area of metastasis or even primary in pts. with malignant Pl. effusion with unknown primary tumor
- Alternate diagnostic method to invasive tests in suspected malignant Pl. effusion esp. in pts. with equivocal findings on CT/Negative finding on pl. cytology after thoracocentesis