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Role of PET/CT in Management of Chest Tumors

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ABSTRACT

OBJECTIVE: to identify the role of PET-CT in management of chest tumors.

PATIENTS AND METHODS: Whole body PET/CT study was performed on 32 patients of variable primary & secondary chest tumors who were under evaluation for primary or secondary chest tumors by recent CT, referred for staging before treatment and / or follow up after treatment.

RESULTS: Our findings indicate that FDG PET/CT has an important impact on diagnosis & management of chest tumors , as it delineated the metabolic activity of the disease in 19 patients (59.4 %), outlined the metabolic activity of the tumoral residue in 6 patients (18.75%) , differentiated between tumoral residue & post irradiation pneumonitis in 1 patient (3.1%), followed up the therapeutic response in 4 patients (12.5 %), differentiated between residual mass & post therapeutic fibrosis in 1 patient (3.1%) and delineated the metabolic activity of the disease for preparing for BMT in 1 patient (3.1%) and so had an impact on the management of chest tumor patients.

CONCLUSION: By recognizing the relevant radiologic and metabolic behavior of chest tumors, understanding the appropriateness of staging disease with the TNM classification system, and being familiar with potential imaging pitfalls, PET/CT can make an important contribution to diagnosis, treatment and outcome in chest tumor patients.

Key words: PET/CT – Chest Tumors – Management.

INTRODUCTION

In oncological imaging, the goals are lesion detection and localization, lesion characterization, proper staging, and treatment success. Some of these goals require precise anatomical imaging, whereas others demand molecular techniques. It was, therefore, easily acknowledged that FDG-PET and CT are complementary, and the employment of the two is imperative in the oncological clinical practice**(16)**.

Lung cancer is the leading cause of cancer-related deaths, Lung cancer is classified as either non–small cell or small cell lung cancer, with the former accounting for 87% of all lung cancers. The descriptors of the internationally used TNM (tumor-node-metastasis) classification system for staging various cancers include the size of and the degree of locoregional invasion by the primary tumor (T), the extent of regional lymph node involvement (N), and the presence or absence of intrathoracic or distant metastases (M). The goal of such a classification system is to assist clinicians in planning treatment, determining prognosis, evaluating treatment results, and facilitating information exchange between multiple centers(**18).**

The management of oncology patients depends on accurate local staging of tumor spread, the identification of nodal involvement and distant metastases. Staging is important at diagnosis, assessing treatment plans, determining prognosis and evaluating response to treatment(**3).**

Indications of PET/CT in chest tumors include the evaluation of the solitary pulmonary nodule, the staging of NSCLC, SCLC, mesothelioma and lymphoma, the monitoring of treatment response, and the assessment for recurrent tumor after radio/chemotherapy. PET-CT is a very powerful imaging tool in thoracic oncology. PET-CT is more accurate than PET or CT **(8).**

PATIENTS AND METHODS

This is a cross sectional study included 32 patients who were under evaluation for primary or secondary chest tumors by recent CT, referred

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for staging before treatment and/ or follow up after treatment.

The exclusion criterion was for uncontrolled diabetic patients .

Patients included performed one or more of the following: 4 patients out of 32 patients had initial PET/CT for staging, intermediate PET/CT and end of treatment PET/CT and follow up, 24 patients out of 32 patients had intermediate PET/CT and end of treatment PET/CT and follow up and 7 patients out of 32 patients had intermediate PET/CT study.

The study population was split into two major groups :-

Group I included 27 patients with primary chest tumors which are subgrouped into

I-A: lung cancer patients (n=8) (25.00%)

I-B Pleural tumors patients(n=2) (6.25%)

I-C chest wall tumors patients (n=3) (9.38%)

I-D Mediastinal tumors patients (n=7) (21.88%)

I-E lymphoma patients (n=7) (21.88%)

Group II: included **5** patients with secondary chest tumors (15.63%)

3 patients had metastatic breast cancer

1 patient had metastatic papillary thyroid cancer

1 patient had metastatic colonic adenocarcinoma

Group	Frequency	Percent
I A	8	25.00%
I B	2	6.25%
I C	3	9.38%
I D	7	21.88%
I E	7	21.88%
II	5	15.63%
Total	32	100.00%

Table(1) percentage of each subgroup in the study

Patient preparation

Adequate patient preparation rules were strictly followed. Patients were instructed to fast, except for glucose-free hydration for 4–6 h before injection of 18F- FDG.

Scan protocol

The scan was performed 40–60 min after IV injection of (3.7 MBq/Kg; maximum dose 370 MBq) (0.1 millicurie/kilogram (mCi/kg); maximum dose = 20 mCi/kg) of 18F- FDG. The patients were examined in supine position. A whole body examination was performed starting from skull base to mid thighs.A PET emission scan was performed over several bed positions (5 to 7), each with an axial field of view of approximately 15 cm per bed position with an in-plane spatial resolution of 4 mm covering the same field of view as with CT. IV contrast administration (120 mL of a low-osmolarity iodinated contrast agent (Ultravist 300®,Schering, Berlin, Germany) and negative oral contrast agent (water) for bowel were used.

Data interpretation

Images were reconstructed and viewed on workstation (Syngo Multimodality Workplace, Siemens Medical Solutions), which provided multi-planar reformatted PET, CT and fused PET/CT images with linked cursors as well as MIP PET images in video mode. On interpreting fused PET/CT images, lesions were considered positive when areas of intense FDG uptake (> liver or mediastinal blood pool). Lesions were considered negative when lacking high FDG uptake (≤ liver or mediastinal blood pool) despite suspicious corresponding CT findings if any.

RESULTS

The study included 32 patients of variable chest malignancies (19 male patients, 13 female patients; mean age ± standard deviation SD: 40.19 ± 17.087 years; age range:14-65 years).

The indications for PET/CT examination were variable; 19 patients (59.38 %) were referred for assessment of treatment response, 5 patients (15.63%) for follow up at variable disease stages, 2 patients (6.25%) were referred for assessment before BMT , 3 patients (9.38%) was referred for assessment of locoregional recurrence/residue or distant metastasis, 1

patient (3.13%) was referred for assessment of activity of the residual mass post operatively,1 patient (3.13%) was referred for assessment before determination the treatment line and 1 patient (3.13%) was referred for differentiation between tumoral residue or irradiation pneumonitis (Table 2).

Aim of the study	Frequency	Percent
Assessement before Preparation for BMT	2	6.25 %
Assessement of locoregional recurrence/residue or distant metastasis	3	9.38 %
Assessment of activity of the residual mass	1	3.13%
Assessment of treatment response	19	59.38%
Determination of treatment line	1	3.13 %
differeniate between residue or irradiation pneumonitis	1	3.13%
Follow up	5	15.63%
Total	32	100.0%

Table (2) The analysis of the aim of the study

28 patients received CTH, 14 received RTH and 12 patients underwent surgery,It is to be noted that in most of patients received mixed lines of treatment that mentioned formerly.

CT images were analyzed and we found that in 20 patients out of 32 patients CT images were not conclusive for evaluation of disease process , in 5 patients not conclusive for mass residual follow up, in 2 patients not conclusive for post-operative residual versus postoperative changes, & in 2 patients it was not conclusive for therapeutic response follow up ,in 1 patient it was not conclusive for differentiating between tumoral residue or irradiation pneumonitis, in 1 patient not conclusive for differentiating between residual mass & post therapeutic fibrosis and in 1 patient Not conclusive for evaluation of the disease for preparing for BMT(Table 3).

	Frequency	Percent
Not conclusive for differentiate between tumoral residue or irradiation pneumonitis	1	3.1%
Not conclusive for differentiating between residual mass & post therapeutic fibrosis	1	3.1%
Not conclusive for mass residual follow up	5	15.6%
Not conclusive for post operative residual/postoperative changes	2	6.3%
Not conclusive for evaluation of disease process	20	62.5%
Not conclusive for evaluation of the disease for preparing for BMT	1	3.1%
Not conclusive for therapeutic response follow up	2	6.3%
Total	32	100.0%

Table (3) Percentage of not conclusive CT findings

Then the fused PET/CT images were analyzed and 31out of 32 patients were positive for metabolically active FDG avid tumoral masses and one patient was negative (Table 4).

	Frequency	Percent
Negative study	1	3.125%
Positive study	31	96.88%
Total	32	100%

Table (4) Percentage of positive & negative cases on PET/CT studies

And we reported findings beyond PET/CT resolution in 2 patients out of 32 patients in the form of multiple subcentimetric pulmonary nodules (Table 5).

Findings beyond PET/CT resolusion	Frequency	Percent
Multiple subcentimetric pulmonary nodules beyond PET/CT resolution	2	6.3%
No	30	93.8%
Total	32	100.0%

Table (5) Percentage of Findings beyond PET/CT resolution

On follow up studies, 8 patients had disease progression, 7 patient had a negative study (complete remission), 7 patients had disease regression , 4 patient had stationary course , 1 patient had stationary course followed by progressive course , 1 patient had regressive course followed by progressive course , 1 patient marked disease regression then progression then complete remission and 3 patients didn't come for follow up (Table 6).

PET/CT follow up findings	Frequency	Percent
complete remission	7	21.87 %
Disease progression	8	25 %
Disease regression	7	21.87 %
marked disease regression then progression then complete remission	1	3.1 %
Regressive course followed by progressive course	1	3.1 %
Stationary course	4	12.5 %
Stationary course followed by progressive course	1	3.1%
Didn't come for follow up	3	9.3 %
Total	32	100.0%

Table (6) Percentage of various follow up disease process on PET/CT

According to these findings the 9 patients out of 32 patients were cured & 32 patient were still on treatment (Table 7)

	Frequency	Percent
Still on treatment	23	71.9%
Stopped the treatment	9	28.1%
Total	32	100.0%

Table (7) Percentage of change of management

DISCUSSION

The management of oncology patients depends on accurate local staging of tumor spread, the identification of nodal involvement and distant metastases. Staging is important at diagnosis, assessing treatment plans, determining prognosis and evaluating response to treatment**(3).** The current study is an antegrade evaluation of different categories of oncology patients suffering from chest tumors.

Current imaging studies provide valuable information, however, not specific enough to aid in clinical management. CT and MRI rely on anatomic and morphologic changes for diagnosing, staging and follow-up however; many lesions remain indeterminate making the distinction between benign and malignant disease a constant challenge. In our study 32 patients out of 32 patients had indeterminate CT findings and have to do PET/CT study. Positron emission tomography (PET) offers a different approach to diagnosis of chest diseases **(2).**

In our study we delineated the metabolic activity of the disease in 2 patients out of 8 patients in group 1-A(lung tumor patients),1 patient out of 2 patients in group 1-B (pleural tumor patients),in 1 patient out of 3 patients in group 1-C (chest wall tumors), in 5 patients out of 7 patients in group 1-D (mediastinal tumor patients),in 7 patients out of 7 patients in group 1-E (lymphoma patients), 5 patients out of 5 patients in group II (secondary chest tumors).so we agree with **(15).**

The assessment of the primary tumor extension is usually based on thoracic CT, occasionally complemented by MRI. Due to the increased image quality of MDCT, scanners can depict with greater confidence an invasion of a tumor in surrounding tissues **(19).**

In our study, PET/CT allowed better discrimination between the tumor and surrounding consolidative changes in 1 patient out of 8 patients in group A-I (lung tumors). This agrees with the study by **(6),** who stated that this differentiation helped in proper assessment of the actual size and extensions of the tumour and this is very important if the patient will have operation or radiotherapy.

Accurate mediastinal lymph node staging is particularly important, as in many cases the status of these nodes will determine whether surgical resection of lung cancer is possible **(17).**

18F-FDG PET is recommended in the official American College of Chest Physicians guidelines for noninvasive staging because of the limited value of chest CT in identifying malignant disease in mediastinal lymph nodes**(12).**

Group 1-E, included 7 patients who were referred for assessment after CTH &RTH (i.e. to differentiate between benign fibrosis and residual active lymphoma). PET/CT revealed Positive PET/CT for MA FDG lymphomatous infilteration in all patients (100%) of group 1-E, Follow up studies showed disease regression in 3 patients (42.86%) , marked disease regression followed by progression then complete remission in one patient (14.29 %) and Complete remission in one patient (14.29%), Stationary course was mentioned in one patient (14.29 %).We agree with **(4),** that PET/CT has been useful in assessment of therapeutic response, because of its improved utility in discriminating benign fibrosis (low-grade or absent 18F-FDG uptake) from residual active lymphoma.

We agree with **(1,6, 13,14,21),** that PET-CT is a valuable tool in mediastinal lymph nodes staging , but it should be considered as a good negative modality and when positive mediastinal lymph nodes are detected, invasive mediastinal staging must be performed.

In our study 30 patients out of 32 patients had chemotherapy and /or radiotherapy .PET-CT was very effective in monitoring the response of the primary tumour or the lymph node or distant metastases after chemotherapy and /or radiotherapy(case 5 figure 5)

We agree with (9, 20), that PET-CT is a good tool for monitoring of response to chemotherapy or radiotherapy

In our study , 29 patients out of 32 patients had baseline PET-CT studies then had follow up PET-CT studies after radiotherapy and/ or chemotherapy . From these studies 2 patients had disease regression course, 1 patient had disease progression course, 1 patient had disease stationary course, 1 patient had regressive course followed by progressive

course, 1 patient had stationary course followed by progressive course 1 patient had negative study (complete remission) in group 1-A(lung tumors), 1 patient had disease progression course and the other patient had disease regression course in group 1-B patients (pleural tumors) , 2 patients negative study (good therapeutic response) in group 1-C(chest wall tumors) , 1 patient had disease progression course one, two patient had disease regression course , one patient had negative study (good therapeutic response),one patient had negative study (good therapeutic response),one patient had stationary course in group 1-D(mediastinal tumors) , two patient had disease regression course, one patient had marked disease regression then progression then complete remission ,one patient had negative study (complete remission),one patient had stationary course, one patient had disease progression course in group 1-E (lymphoma patients), 3 patients had disease regression course, one patient had negative study (complete remission) and one patient had stationary course in group II (secondary chest tumors).

These findings are in agreement with **(7, 10, 11),** indicating that PET/CT changed the management of patients, by resulting in the elimination of previously planned diagnostic procedures, by resulting in the initiation of a previously unplanned treatment option, or by inducing a change in the planned therapeutic approach.

CONCLUSION

So in conclusion, by recognizing the relevant radiologic and metabolic appearances of chest tumors, understanding the appropriateness of staging disease with the TNM classification system, and being familiar with potential imaging pitfalls, radiologists through PET / CT can make an important contribution to treatment and outcome in chest tumor patients

Cases

(Case 1)

Male patient, 49 years old, known to have lung cancer. Received chemotherapy PET/CT scan was requested for assessment of treatment response. PET/CT scan: revealed multiple metabolically active FDG avid wide spread lesions at the RT kidney, lungs (with lymphangitis carcinomatosa) as well as multiple abdominal & mediastinal LNs

3 months follow up study : rather stationary course

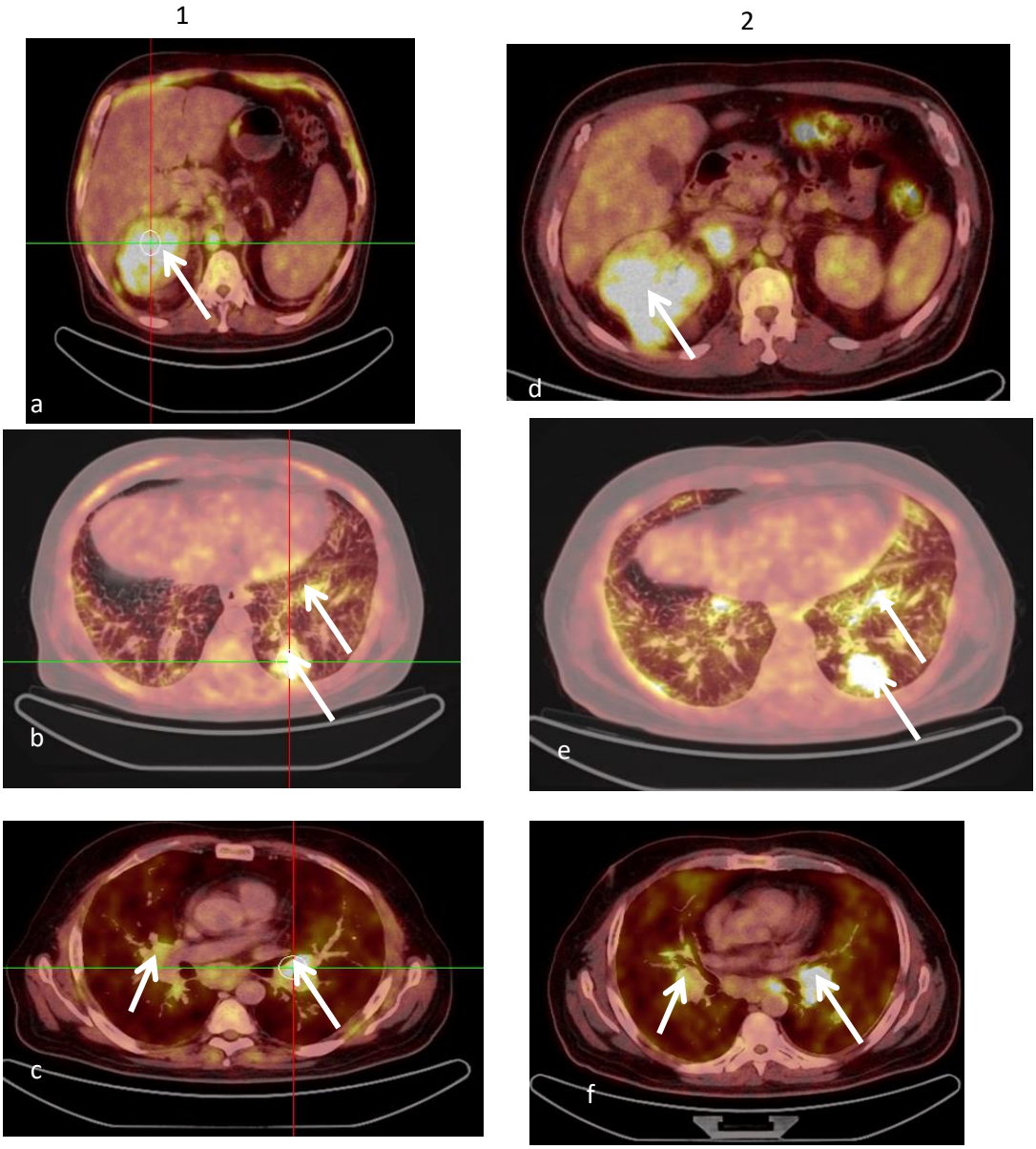

Figure (1)1-axial PET- CT (a-c) the initial study images show: multiple metabolically active FDG avid wide spread lesions (a) at the RT kidney(arrow), (b,c) left lower lung lobe, enlarged bilateral hilar LNs and extensive bilateral pulmonary metabollicaly active FDG avid linear & nodular deposits are seen extending from the enlarged hilar LNs (lymphangitis carcinomatosa) (arrows) 2- (d-f) 3 months follow up study showing rather stationary course

(Case 2): Male patient, 57 years old, known to have left lung adenocarcinoma . received chemotherapy & radiotherapy The patient was referred for assessment of the treatment response PET/CT scan: revealed metabolically active FDG avid residual primary lung tumor with hepatic & left suprarenal deposits.9 months follow up study: Regressive course of the MA FDG avid residual left lower lung lobe as well as the distant metastasis

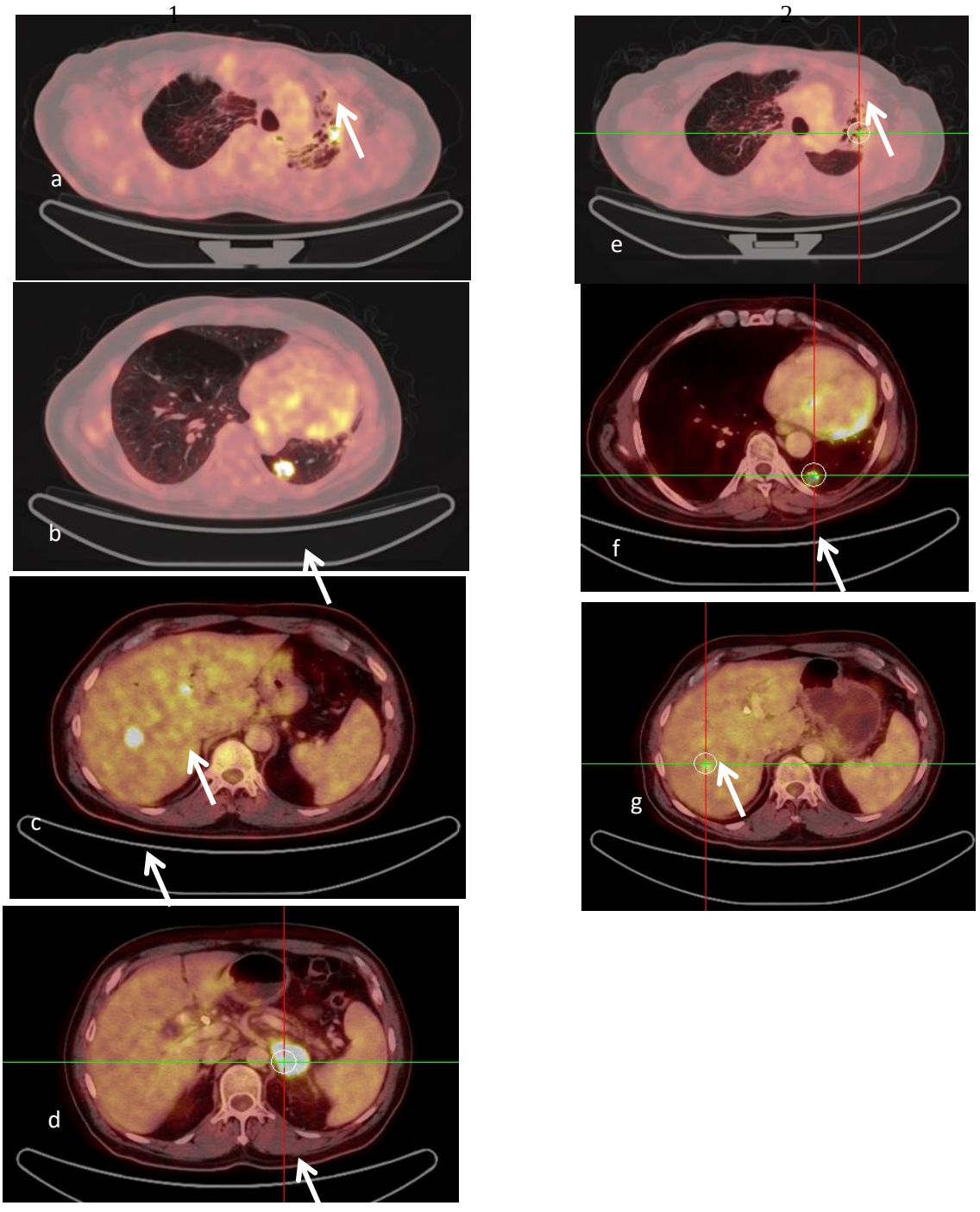

Figure (2)1-axial PET- CT (a-d) the initial study images show: a- significant collapse of the left upper lung lobe with ipsilateral mediastinal shift with bilateral apical pulmonary cystic changes (likely post irradiation changes) (arrows)b-- metabolically active FDG avid mass lesion is seen at the left lower lung lobe(arrows) , (c,) multiple metabolically active FDG avid hepatic deposits (arrows) ,d- metabolically active FDG avid mass lesion is seen at left suprarenal gland (arrow)2-(e-g) 9 months follow up images show regressive course

(Case 3)

Male patient, 42 years old, known to have left mesothelioma. The patient received chemotherapy& radiotherapy after surgical excision and was referred for assessement of treatment response. PET/CT scan: metabolic active FDG avid local tumoral recurrence at the mediastinal pleura with nodal ,hepatic & muscular deposits

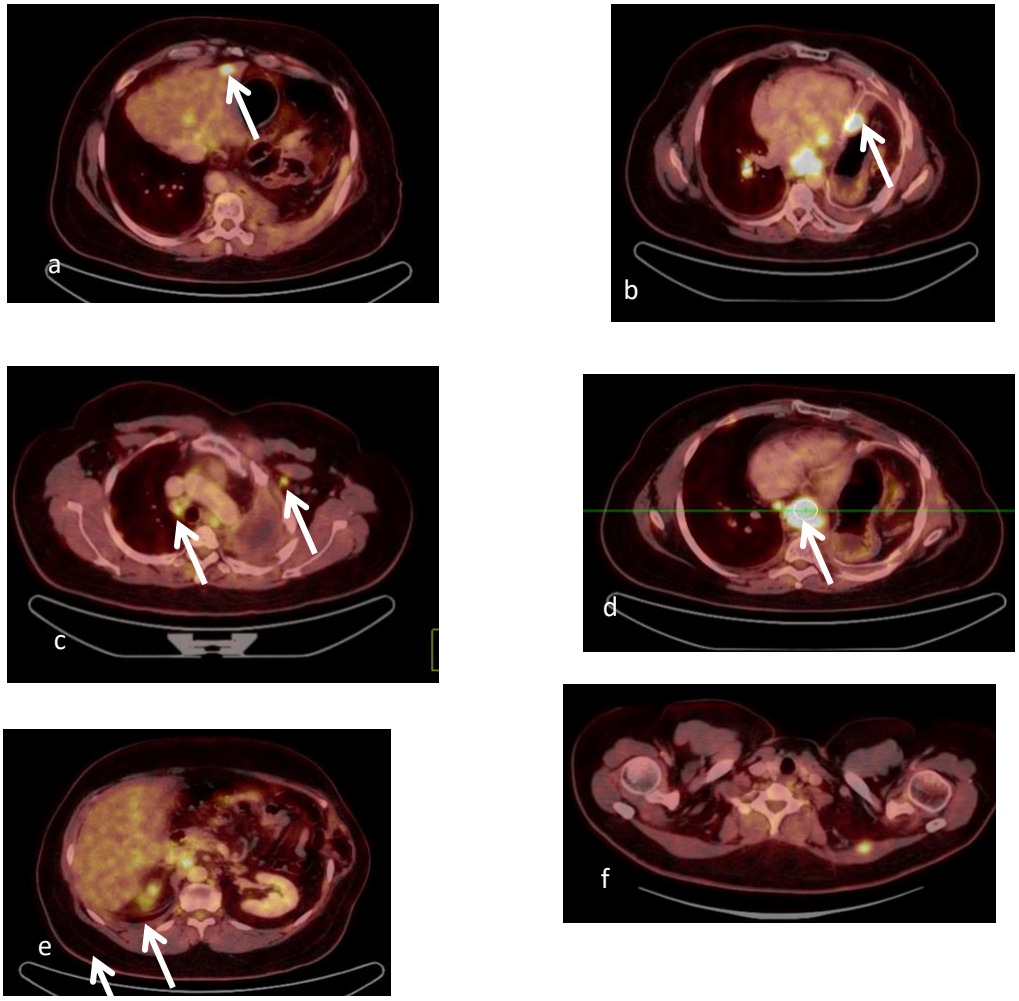

Figure (3)1-axial PET- CT (a-f) images show: a,b focal metabolically active FDG avid soft tissue thickening is seen at the site of mediastinal pleura, c-multiple metabolically active FDG left axillary and mediastinal nodal deposits the largest is seen at the subcarinal LN image (d) (arrows), e- Metabollicaly active focal hepatic deposits at hepatic right lobe (arrows),f- focal FDG uptake is seen over the left trapezius muscle (arrow)

(Case 4)

Female patient, 19 years old, known to Ewing sarcoma at the superior mediastinum underwent surgical excision followed radiotherapy. The patient was referred for assessment of the residual mass .PET/CT scan: negative study (good therapeutic response with ongoing fibrosis at the RT superior mediastinum)

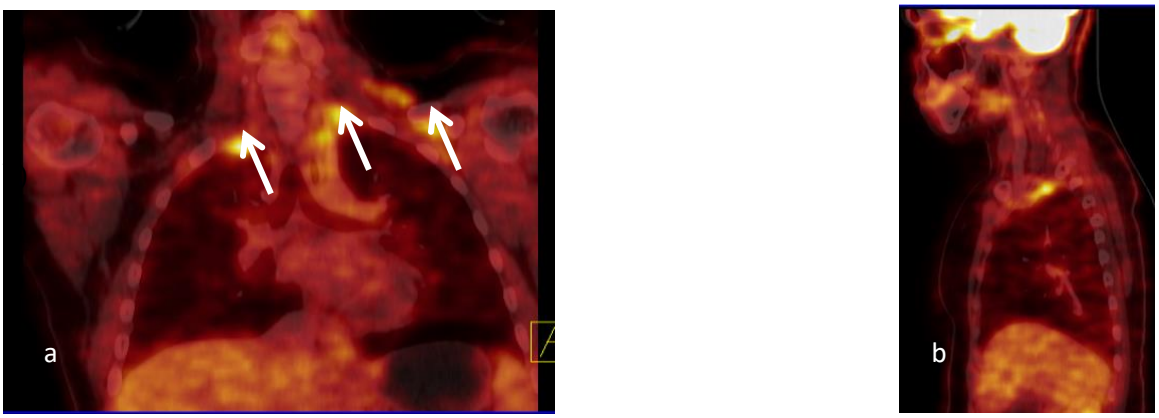

Figure (4) a-b coronal and sagittal PET/CT images show negative study for metabollicaly active FDG avid tumoral residue versus recurrence at the superior mediastinum , Note the the multiple focal FDG avid accumulation seen at the cervical and supraclavicular regions more noted at the left side consistent with normal variant brown adipose tissue FDG uptake (arrows)

(Case 5)

A male patient, 34 years old, known to have thymoma underwent surgical excision followed by chemotherapy was referred for assessment of the residual tumor PET/CT scan: MA FDG avid residual superior mediastinal mass lesion associated with MA FDG avid RT paratracheal LN.

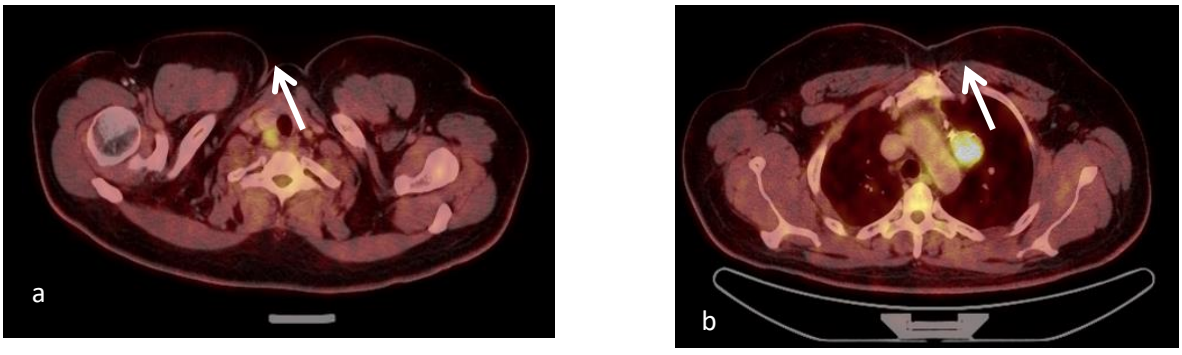

Figure (5) a-b axial PET/CT images show a- Metabollicaly active FDG avid residual superior mediastinal mass lesion (arrow) associated with MA FDG avid RT paratracheal LN (image b) (arrow)

References

1-Bill´e , Pelosi E, Skanjeti A *et al.(*2009) Preoperative intrathoracic lymph node staging in patients with non-small-cell lung cancer: accuracy of integrated positron emission tomography and computed tomography. European Journal of Cardio-Thoracic Surgery ,36: 440–445.

2-Bybel et al.(2006) PET and PET/CT imaging: What clinicians need to know. Cleveland and clinic journal of medicine,73 (12) :1075-1087

3-Carty FL, Shortt CP, Shelly MJ *et al.*(2011) PET/CT, whole-body MRI, and whole-body CT in the diagnosis, staging, and follow-up of malignancy. J Surg Radiol., 2(2):111-20

4-Cronin C, Sword R, Truong M *et al.(*2010) Clinical Utility of PET/CT in Lymphoma. AJR ; 194:W91–W103

5- Darling GE, Maziak DE, Inculet RI *et al.*(2011) Positron emission tomography-computed tomography compared with invasive mediastinal staging in non-small cell lung cancer results of mediastinal staging in the early lung positron emission tomography trial.Journal of Thoracic Oncology; 8: 1367–1372

6- De Wever W, Stroobants S, Coolen J *et al.*(2009) Integrated PET/CT in the staging of non small cell lung cancer:technical aspects and clinical integration. Eur Respir J; 33:201–212.

7- Erasmus JJ, Rohren E and Swisher SG (2009) Prognosis and Reevaluation of Lung Cancer by Positron Emission Tomography Imaging. Proc Ann Thorac Soc; 6: 171-179.

8-Gosselin R, Smeets P, Delrue L *et al.(*2007) PET-CT in chest diseases: a short overview .JBR–BTR, 90: 120-121.

9-Hutchings &Barrington (2009): PET/CT for therapy response assessment in lymphoma. J Nucl Med; 50:21S–30S

10-Kazama et al(2005) FDG PET in the evaluation of treatment for lymphoma: clinical usefulness and pitfalls. RadioGraphics; 25:191–207

11-Keidar Z *et al* (2004):PET-CT using 18F-FDG in suspected lung cancer recurrence: diagnostic value and impact on patient management.J Nucl Med;45(10):1640–1646.

12-Kuehl H , Veit P, Rosenbaum S J *et al.(*2007): Can PET/CT Replace Separate Diagnostic CT for Cancer Imaging? Optimizing CT Protocols for Imaging Cancers of the Chest and Abdomen. Journal of Nuclear Medicine,. 48 (l) :45S-57S

13-Liu BJ, Dong JC, Xu CQ *et al.(*2009): Accuracy of 18FFDG PET/CT for lymph node staging in non-small-cell lung cancers. Chinese Medical Journal;122: 1749–1754

14- Perigaud C, Bridji B, Roussel C *et al .(*2009): Prospective preoperative mediastinal lymph node staging by integrated positron emission tomography-computerized tomography in patients with non-small-cell lung cancer. European Journal of Cardio-Thoracic Surgery; 36:731–736

15- Rohren EM, Turkington TG, Coleman RE *et al.* (2004): Clinical Applications of PET in Oncology. Radiology; 231:305-332

16-Saif M , Tzannou I, Makrilia N *et al.* (2010): Role and cost effectiveness of PET/CT in management of patients with cancer Yale J Biol Med.; 83(2): 53–65

17- Steinert HC (2011) PET and PET-CT of lung cancer .Methods in Molecular Biology; 727:33–51.

18- UyBico SJ, Wu CC, Suh RD *et al.* (2010) Lung Cancer Staging Essentials: The New TNM Staging System and Potential Imaging Pitfalls .RadioGraphics; 30:1163–1181

19- Verschakelen JA, De Wever W and Bogaert J (2004) Role of computed tomography in lung cancer staging. Curr Opin Pulm Med;10:248–255.

20- Vikram K and Suzanne L (2008) PET-CT imaging of lung cancer.In:Clinical PET-CT in radiology .USA:Springer;163-180.

21-Yang WF, Tan GZ, Fu Z *et al.* (2009) Evaluation of the diagnostic value of (18)F-FDG PET-CT and enhanced CT for staging of lymph node metastasis in non-small cell lung cancer. Chinese Journal of Oncology;31: 925–928.