



# **ROLE OF PET-CT IMAGING IN STAGING OF BRONCHOGENIC CARCINOMA**

**Thesis**

Submitted for partial fulfillment Of the M.D. Degree in  
Radiodiagnosis

By

**Islam Mohamed Sameh Ebrahim**

M.B.B.Ch, M. Sc Radiodiagnosis  
Ain Shams University

Under Supervision of

**Prof. Dr. Hesham Mahmoud Ahmed Mansour**

Professor of Radiodiagnosis  
Faculty of medicine - Ain shams University

**Prof. Dr. Ahmed Fathy Abdel Ghany**

Professor of Radiodiagnosis  
Faculty of medicine - Ain Shams University

**Dr. Amir Louis Louka**

Lecturer of Radiodiagnosis  
Faculty of Medicine - Ain Shams University

**Faculty of Medicine  
Ain Shams University**

**2016**

## **Acknowledgement**

*First and foremost, thanks to **Allah**, to whom I am grateful for any success achieved in my life.*

*I would like to express my deepest gratitude and extreme appreciation to **Prof. Dr. Hisham Mahmoud Mansour**, Professor of Radiodiagnosis, Faculty of Medicine, Ain Shams University, for his kind supervision, advices, constructive encouragement, generous help and guidance throughout the whole work which could not be a fact without his guidance and kind help.*

*I would like to express my great thanks to **Prof. Dr. Ahmed Fathy Abdel Ghany**, Professor of Radiodiagnosis, Faculty of Medicine, Ain Shams University and **Dr. Amir Louis Louka**, Lecture of Radiodiagnosis, Faculty of Medicine, Ain Shams University for their kind advice and help throughout the whole work.*

*I would like to express my respect, appreciation and thanks to my **wife, family and friends** for their assistance, encouragement and their pray for me.*

# List of Contents

<i>Title</i>	<i>Page</i>
<i>Abbreviations</i>	-
<i>List of figures</i>	-
<i>List of tables</i>	-
<i>Introduction and aim of the work</i>	1
• <i>Review of Literature:</i>	4
- <i>Anatomy of the Lung and Tracheobronchial tree</i>	4
- <i>Pathology of Bronchogenic carcinoma</i>	33
- <i>Role of PET-CT in diagnosis of Bronchogenic Carcinoma</i>	44
• <i>Patients and methods</i>	82
• <i>Results</i>	89
• <i>Illustrative cases</i>	101
• <i>Discussion</i>	125
• <i>Summary and Conclusion</i>	132
• <i>References</i>	134
• <i>Arabic Summary</i>	-----

## ***Abbreviations***

<b>Abbreviation</b>	<b>Name</b>
<b>18F</b>	<i>Fluorine -18</i>
<b>99m TC MDP</b>	<i>99m Technetium-methylene diphosphonate</i>
<b>ATP</b>	<i>Adenosine Tri-Phosphate</i>
<b>BAC</b>	<i>Broncho-alveolar Carcinoma</i>
<b>Cm</b>	<i>Centimeters</i>
<b>COPD</b>	<i>Chronic Obstructive Pulmonary Disease</i>
<b>CT</b>	<i>Computed tomography</i>
<b>CXR</b>	<i>Chest X Ray</i>
<b>FDG</b>	<i>Fluorodeoxyglucose</i>
<b>G</b>	<i>Gauge</i>
<b>Gy</b>	<i>GRAY</i>
<b>HU</b>	<i>Hounsfield Unite</i>
<b>IASLC</b>	<i>International Association for the Study of Lung Cancer</i>
<b>LMSB</b>	<i>Left main stem bronchus</i>
<b>MBq</b>	<i>Megabecquerel</i>
<b>Mci</b>	<i>Millicurie</i>
<b>MIP</b>	<i>Maximum Intensity Projection</i>
<b>Mm</b>	<i>Millimeters</i>
<b>NPV</b>	<i>Negative predictive Value</i>
<b>NSCLC</b>	<i>Non-small cell lung cancer</i>
<b>PA</b>	<i>Postero-Anterior</i>
<b>PET</b>	<i>Positron emission tomography</i>
<b>PPV</b>	<i>Positive Predictive Value</i>
<b>RMSB</b>	<i>Right main stem bronchus</i>
<b>SCC</b>	<i>Squamous Cell Carcinoma</i>
<b>SCLC</b>	<i>Small cell lung cancer</i>
<b>SPN</b>	<i>Solitary Pulmonary Nodule</i>
<b>STD</b>	<i>Standard deviation</i>
<b>SUV</b>	<i>Standardized uptake value</i>

<b>TB</b>	<i>Tuberculosis</i>
<b>UICC</b>	<i>Union International Cancer Control</i>
<b>VALSG</b>	<i>Veterans Administration Lung Cancer Study Group</i>

# List of Figures

<b>Figure No.</b>	<b>Title</b>	<b>Page No.</b>
<b>1</b>	<b>Anatomy of the lung</b>	4
<b>2</b>	<b>Anatomical relationship of the extra-thoracic trachea</b>	5
<b>3</b>	<b>Anatomical relationship of the main bronchi</b>	6
<b>4</b>	<b>Illustration of the main, lobar and segmental bronchial division</b>	8
<b>5</b>	<b>Diagram showing lung lobes and fissures</b>	10
<b>6</b>	<b>Bronchopulmonary segments</b>	11
<b>7</b>	<b>The major divisions of the mediastinum</b>	14
<b>8</b>	<b>Diagram showing components of the pleura</b>	15
<b>9</b>	<b>Lymphatic drainage of the lungs</b>	19
<b>10</b>	<b>PA chest radiograph</b>	22
<b>11</b>	<b>lateral chest radiograph</b>	24
<b>12</b>	<b>Axial CT Lung and Mediastinal windows</b>	25
<b>13</b>	<b>Axial CT lung window showing segmental bronchi</b>	28
<b>14</b>	<b>Axial CT images mediastinal window showing vascular anatomy of the pulmonary hila</b>	30
<b>15</b>	<b>Axial CT and PET-CT images showing hypermetabolic solitary pulmonary nodule with spiculated borders in left upper lobe consistent with malignancy.</b>	45
<b>16</b>	<b>Axial CT, PET-CT and Follow up CT images showing infection mimicking malignancy in a 30-year-old man with no symptoms and a right lower lobe mass detected at chest radiography performed for a routine occupational health examination.</b>	46
<b>17</b>	<b>Axial CT and PET-Ct images showing negative neuroendocrine tumor in a 59-year-old woman.</b>	47

<b>18</b>	<b><i>Axial dynamic CT, PET and PET-CT images showing right upper lobe small adenocarcinoma with negligible 18F-FDG uptake.</i></b>	47
<b>19</b>	<b><i>Axial CT, PET and PET-CT images showing lung carcinoma in upper right lung with ipsilateral mediastinal lymph-node metastasis. Integrated PET-CT images ruled out invasion of the chest wall.</i></b>	49
<b>20</b>	<b><i>Axial CT, PET and PET-CT images showing malignant pleural effusion in right hemithorax with hypermetabolism.</i></b>	50
<b>21</b>	<b><i>Axial PET-CT showing a primary mass in the left lung and a right lower paratracheal lymph node both of which demonstrate intense radiotracer uptake. Metastatic involvement of the lymph node was confirmed at mediastinoscopic resection.</i></b>	52
<b>22</b>	<b><i>Axial CT, PET and PET-CT images showing true-positive mediastinal lymph node metastasis from right lower lobe adenocarcinoma</i></b>	53
<b>23</b>	<b><i>Axial CT and axial and coronal PET images showing hypermetabolic subcentimetric ipsilateral mediastinal lymph node metastasis from primary right upper lobe lung cancer.</i></b>	54
<b>24</b>	<b><i>Axial CT and PET-CT images and photograph of the adreno-nephrectomy specimen showing metastatic adrenal mass from lung adenocarcinoma.</i></b>	56
<b>25</b>	<b><i>Axial CT and PET-CT images showing adrenal adenoma in a patient with lung adenocarcinoma.</i></b>	56
<b>26</b>	<b><i>Coronal PET and axial, sagittal and coronal PET-CT images showing bone metastases in the right superior pubic ramus.</i></b>	57
<b>27</b>	<b><i>Axial CT, PET-CT and Coronal PET images showing hepatic and bone metastatic lesions not seen on CT.</i></b>	58
<b>28</b>	<b><i>Axial CT, PET and PET CT images showing the</i></b>	61

	<b><i>value of PET-CT in radiotherapy planning in patients with lung cancer</i></b>	
<b>29</b>	<b><i>Chest x-ray and axial PET CT images showing the value of PET-CT in assessment of therapeutic response of right lung cancer after chemotherapy with mild change of the size of the lesion.</i></b>	63
<b>30</b>	<b><i>Axial CT, PET and PET CT images showing the value of PET-CT in assessment of therapeutic response of right lung cancer after radiotherapy</i></b>	64
<b>31</b>	<b><i>Axial CT and PET/CT images showing the value of PET-CT in accurate identification of residual tumor within the broader region of radiation pneumonitis.</i></b>	65
<b>32</b>	<b><i>Axial CT and PET CT images showing the value of PET-CT in assessment of therapeutic response of right lung cancer after neoadjuvant chemotherapy.</i></b>	66
<b>33</b>	<b><i>Axial CT and CT images showing the value of PET-CT in early detection of post-operative residual/recurrent tumours.</i></b>	68
<b>34</b>	<b><i>Coronal PET and axial CT, PET and PET CT images showing the value of PET-CT in differentiating between residual/recurrent tumours and radiation pneumonitis.</i></b>	71
<b>35</b>	<b><i>Axial CT and PET-CT images showing the value of combined PET-CT scans in anatomic localization of suspicious lesions compared to PET or CT alone in patients with suspected NSCLC recurrence.</i></b>	73
<b>36</b>	<b><i>Coronal CT, PET and PET-CT images showing normal physiological distribution of FDG in the body.</i></b>	78
<b>37</b>	<b><i>Coronal CT, PET and PET-CT images showing physiologic bowel uptake in a patient with malignant thymoma</i></b>	79
<b>38</b>	<b><i>Phillips Ingenuity TF PET/CT 128 Slice PET-CT machine</i></b>	83
<b>39</b>	<b><i>Chart illustrates the descriptors from the 7th edition of the TNM staging system for lung</i></b>	86



	<i>cancer</i>	
<b>40</b>	<b><i>Graph showing CT and PET imaging of the lesion extent and local spread</i></b>	94
<b>41</b>	<b><i>Graph showing CT and PET imaging of the distant and lymphatic spread.</i></b>	98
<b>42</b>	<b><i>Graph showing staging of bronchogenic carcinoma based on CT to staging based on combined PET/CT imaging</i></b>	100
<b>43</b>	<b><i>Case 1</i></b>	101
<b>44</b>	<b><i>Case 2</i></b>	103
<b>45</b>	<b><i>Case 3</i></b>	106
<b>46</b>	<b><i>Case 4</i></b>	107
<b>47</b>	<b><i>Case 5</i></b>	109
<b>48</b>	<b><i>Case 6</i></b>	112
<b>49</b>	<b><i>Case 7</i></b>	113
<b>50</b>	<b><i>Case 8</i></b>	115
<b>51</b>	<b><i>Case 9</i></b>	117
<b>52</b>	<b><i>Case 10</i></b>	118
<b>53</b>	<b><i>Case 11</i></b>	119
<b>54</b>	<b><i>Case 12</i></b>	121
<b>55</b>	<b><i>Case 13</i></b>	123

# *List of tables*

<i>Table No.</i>	<i>Title</i>	<i>Page No.</i>
<b>1</b>	<b><i>Bronchopulmonary segment of the Right lung.</i></b>	<b>11</b>
<b>2</b>	<b><i>Bronchopulmonary segment of the Left lung</i></b>	<b>11</b>
<b>3</b>	<b><i>Illustrating stage grouping</i></b>	<b>42</b>
<b>4</b>	<b><i>Analysis for the local staging of the primary pulmonary lesion using the CT versus PET imaging.</i></b>	<b>93</b>
<b>5</b>	<b><i>Analysis for the distant and lymphatic staging of the primary pulmonary lesion using the CT versus PET imaging</i></b>	<b>97</b>
<b>6</b>	<b><i>Comparing the staging of bronchogenic carcinoma based on CT to staging based on combined PET/CT</i></b>	<b>99</b>
<b>7</b>	<b><i>Analysis for the comparative study of the staging of bronchogenic carcinoma based on CT to staging based on combined PET/CT</i></b>	<b>100</b>

## **Abstract**

PET/CT is extremely useful in initial staging of bronchogenic carcinoma which is very important in planning the management strategies due to its large advantages over anatomical imaging in detecting hidden lesions which is missed by the use of other imaging modalities. Detecting local and distant metastatic disease process before they are visible on conventional imaging. The main drawbacks of PET/CT staging of bronchogenic carcinoma include radiation exposure and high cost. The use of diagnostic contrast enhanced CT with PET/CT also exposes the patients for more radiation risks.

Key word

PET/CT -18F-FDG - Carcinoma - Staging - IASLC

# **Introduction and Aim of the Work**

## **Introduction:**

Bronchogenic carcinoma is one of the leading causes of cancer related mortality in both men and women throughout the world. Lung cancer is the second only to that of prostate cancer in men and breast cancer in women. Most bronchogenic carcinomas are diagnosed at late advanced stage, carrying poor prognosis (*Huq et al, 2009*).

Two major classes of bronchogenic carcinomas are present according to the division of the WHO: Non-small cell lung cancer (NSCLC) which accounts for more than 85% of lung cancer cases and small cell lung cancer (SCLC). Non small cell lung cancer accounts has 2 major subtypes: Squamous cell carcinoma and non squamous cell carcinoma (Adenocarcinoma and large cell carcinoma) (*Koma et al, 2013*).

Management of lung cancer had significant advances seen over the past decade. The primary treatment of lung cancer and the best chance for a complete cure is achieved through the total resection of localized disease. Once developed nodal or distant metastases, primary surgical intervention is ruled out and is considered for adjuvant chemotherapy with or without radiation therapy. Accurate delineation of disease extent is therefore critical in treatment planning of patients with lung cancer (*Sundaram and George, 2011*).

## Introduction and aim of the work

---

The primary role of imaging is accurate initial staging which is very important for management strategies and evaluation of prognosis (*Koma et al, 2013*).

Functional imaging with the use of positron emission tomography (PET) is playing an increasingly important role in proper diagnosis and initial staging of malignant disease, in image guided therapy planning, and in treatment monitoring. PET imaging with the fluorine 18 labeled glucose analogue fluorodeoxyglucose (18-FDG) complements the more conventional anatomic imaging modalities of CT and MRI imaging (*Blodgett et al, 2007*).

Combined PET/CT imaging has been contributing widely to the treatment of patients through its large advantages over anatomical imaging from screening to initial staging. CT images demonstrate the anatomical information, while PET images provide the functional activity inside the patient's body. Hence, the existence of suspicious malignant cells can be diagnosed in PET images but since the structural location and position can't be defined on PET images, we need to retrieve the information from CT images (*Avazpour et al, 2009*).

Combined PET/CT imaging will become the new standard of mediastinal staging. 18F-FDG PET/CT imaging strength lies in its increased sensitivity and very high negative predictive value. It may alleviate the need for surgical staging when FDG-PET/CT studies of the mediastinum are negative (*Schimmer et al, 2006*).

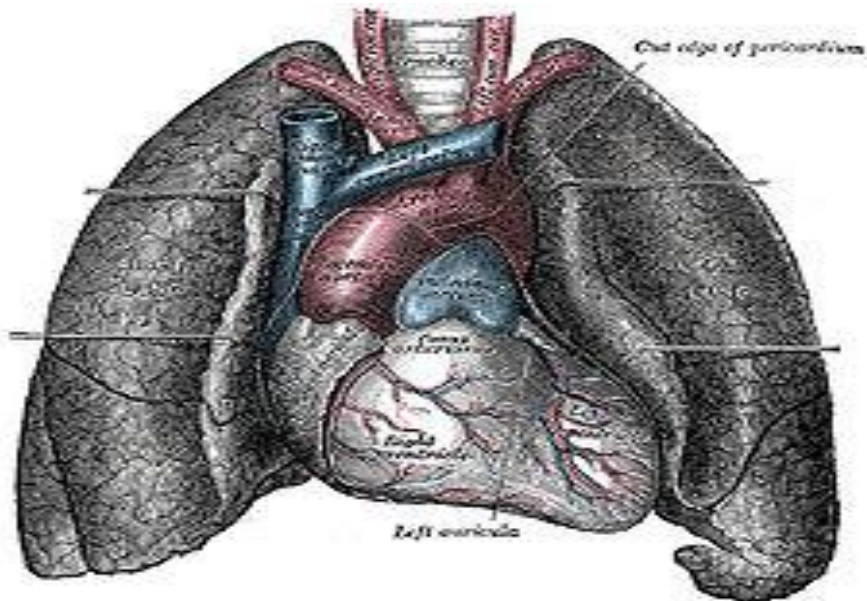
## **Aim of the work**

The aim of this work is to highlight the role of PET/CT imaging in staging of patients with Bronchogenic carcinoma.

# *Gross Lung Anatomy*

## *Overview:*

The anatomy of the respiratory system can be divided into 2 major parts, airway anatomy and lung anatomy (**Figure 1**).



*Figure 1: Anatomy of the lung (Standring, 2005).*

## *Anatomy of the tracheobronchial tree*

### *Trachea*

A solitary tube representing the entrance to the lungs' airways. Between the entrance and periphery of the airways, lies a system of branching airways that conduct the inspired air into those peripheral channels which carry alveoli in their walls