Sudan University of Sciences and Technology

College of graduate studies

Study of Smokers Lungs Diseases Using CT

دراسة أمراض الرئة للمدخنين بإستخدام الأشعة المقطعية

A thesis submitted for partial fulfillment of M.Sc. degree in diagnostic radiologic technology

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الآية

قال تعالى:

﴿وَأَنْفِقُوا فِي سَبِيلِ اللَّهِ وَلَا تُلْقُوا بِأَيْدِيكُمْ إِلَى التَّهْلُكَةِ ۛ وَأَحْسِنُوا ۛ إِنَّ اللَّهَ يُحِبُّ الْمُحْسِنِينَ﴾

صدق الله

العظيم

البقرة : 195

Dedication

To my family

To my wife

To my Teachers

To my friends and colleagues

Acknowledgments

Thank my God who enable me to realize the genuine meaning of success, ambitious living my dream come through and giving me.

My gratitude to my supervisor Dr. Duha Abdu Mohammed, she did not hesitate to devote her knowledge and time for me, and giving her positive arguments in the field of radiology and computerized tomography.

I also grateful acknowledge the help of the staff of Alzaytona specialized hospital, Royal scan hospital, Fudail diagnostic center and Alyaa specialized hospital for their role in collection of data.

Special thanks to everyone participated in this work by any way either encourages advising or appreciating our research.

Abstract

The main aim of the research to study smokers lungs diseases using CT. The problem of this research is that there is wide spread of lung disease among smokers and most of diagnostic tools not effective in diagnosis of this disease. The importance of this research is that using CT in smokers patients will help in diagnosis and calculate the direct effect of smoking on the lungs.

The CT protocol used is HRCT which use a narrow beam collimation to take thin slices images of the lung parenchyma of the patient. Data was collected and analyzed by Excel and SPSS software. The number of patients included in the study was (100) patients. The most affected age groups were in the fifth and sixth decades of age, constituting the majority representing (53%).

The result of the study showed that the majority of the patients were presented with respiratory infection (97%), and all patients were presented with dyspnea and chest pain. HRCT showed 37% of patients were had chronic bronchitis, while emphysema, emphysema plus chronic bronchitis and lung cancer represent (32%, 19% and 12%) respectively.

This study showed that patients with smoking duration about (15-24) years, represent 49% of all cases had chronic bronchitis, emphysema, emphysema plus chronic bronchitis and lung cancer, this represent percentage (16%, 51%, 26%,and 6%) respectively.

This study recommended that health care systems should raise the medical awareness about the risks of smoking, methods of cessation and the health effect issues to all Sudanese population generally and smokers specially.

خلاصة البحث

الهدف الأساسي من هذا البحث هو دراسة أمراض الرئة للمدخنين بإستخدام الأشعة المقطعية. مشكلة البحث تمثلت في إنتشار أمراض الرئة بين المدخنين ومعظم وسائل التشخيص الأخرى غير فعالة في تشخيص هذه الأمراض. تتمثل أهمية البحث في أن إستخدام الأشعة المقطعية في المرضى المدخنين يساعد في تشخيص وحساب الأثر المباشر للتدخين على الرئتين.

تم عمل الأشعة المقطعية بإستخدام نظام الأشعة المقطعية عالي الدقة والذي يستخدم بدوره حزمة إشعاع ضيقة لأخذ شرائح صورية رقيقة لأنسجة الرئة للمريض.

تم جمع البيانات ومن ثم تحليلها عن طريق برنامجي Excel and SPSS.

عدد المرضى الذين شملتهم الدراسة (100) مريض. وأكثر الفئات العمرية إصابة هم في العقد الخامس و السادس ويمثلون نسبة (53%).

أظهرت نتائج هذه الدراسة أن معظم المرضى كانو مصابين بإلتهابات الجهاز التنفسي بنسبة (97%) وأن جميع المرضى لديهم ضيق في التنفس وآلام في الصدر. أظهرت الأشعة المقطعية عالية الدقة أن (37%) من المرضى لديهم التهاب الشعب الهوائية المزمن، بينما أظهرت إنتفاخ الرئة، وإنتفاخ الرئة مع التهاب الشعب الهوائية المزمن وسرطان الرئة بنسبة (32%، 19%، 12%) بالترتيب.

أظهرت هذه الدراسة أن المرضى الذين تتراوح فترة تدخينهم بين (15-24) سنة يمثلون نسبة 49% من الحالات جميعا ولديهم التهاب الشعب الهوائية المزمن، وإنتفاخ الرئة، وإنتفاخ الرئة مع التهاب الشعب الهوائية المزمن، وسرطان الرئة بنسبة (16%، 51%، 26%، 6%) بالترتيب.

أوصت هذه الدراسة بأنه يجب على أنظمة الرعاية الصحية رفع الوعي الطبي عن مخاطر التدخين وطرق وقفه ونشر آثاره الصحية للمجتمع السوداني بشكل عام وللمدخنين بشكل خاص.

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Abbreviations

Abbreviation	Meaning
AAT	Alpha α-1 Anti Trypsin
AC	A typical Carcinoid
CAT	Computerized Axial Tomography
CT	Computed Tomography
COPD	Chronic Obstructive Pulmonary Disease
DILD	Diffuse Interstitial Lung Disease
DLCO	Diffusing capacity of the Lung for Carbon monoxide
EX	A prefix meaning former
FEV	Forced Expiratory Volume
FOV	Field Of View
FRC	Functional Residual Capacity
HRCT	High Resolution Computed Tomography
HU	Hounsfield Unit
IV	Intra Venous
PFT	Pulmonary Function Test
PH	Potential of Hydrogen
RB	Respiratory Bronchiolitis
RBILD	Respiratory Bronchiolitis Interstitial Lung Disease
RV	Residual Volume
SD	Standard Deviation
TC	Typical carcinoid
TLC	Total Lung Capacity

1.1 Introduction:

The respiratory system extends from the nose and upper airway to the alveolar surface of the lungs, where gas exchange occurs. Inhaled tobacco smoke moves from the mouth through the upper airway, ultimately reaching the alveoli. As the smoke moves more deeply into the respiratory tract, more soluble gases are adsorbed and particles are deposited in the airways and alveoli. The substantial doses of carcinogens and toxins delivered to these sites place smokers at risk for malignant and nonmalignant diseases involving all components of the respiratory tract including the mouth. Tobacco smoke, which comprises an aerosol (a mixture of solid and liquid particles) and gases, has thousands of chemical components, including many well-characterized toxins and carcinogens. Many of these components are in the gas phase, and others are components of the particles. Components of tobacco smoke with the potential to injure the lungs through a variety of mechanisms. Notably, cigarette smoking has very strong oxidant potential in that both the gas and tar phases contain high concentrations of free radicals. (Van der H, et al. 2004)

Cigarette smoking harms the lungs and the established link between smoking and lung cancer does not need to be repeated here. There is now a general awareness that smoking, over many years, can cause specific disorders such as emphysema and chronic bronchitis. What is less well appreciated is that there is a spectrum of other lung disorders that have more recently been attributed to cigarette smoking. Such an accumulation has been termed respiratory bronchiolitis (RB). In the majority of patients RB causes no symptoms, but a minority of smokers will develop symptoms of a diffuse interstitial lung disease (DILD). Respiratory bronchiolitis-interstitial

lung disease (RBILD) is the clinical manifestation of interstitial lung disease in smokers who have the pathological abnormality of RB. (Sujal and David, 2013)

In the absence of any obvious radiographic correlate of such subtle changes, there was a hiatus in the understanding of the pathogenetic and clinical aspects of cigarette smoking-induced lung disease. High resolution computed tomography (HRCT) has lifted the veil on many facets of smoking-related disease, notably the distribution and interplay between interstitial and emphysematous disease, airways changes, and longitudinal changes in the lungs of cigarette smokers. (Boiselle and David, 2008)

1.2. Problem of the study:

Conventional radiographs depict a three-dimensional object as a two-dimensional image for chest, this results in overlying tissues being superimposed on the image, with wide spread of smoking in community causing serious lungs diseases need to be well diagnosed.

1.3. Objectives of the study:

1.3.1. General objectives:

To study smokers lungs diseases using CT.

1.3.2. Specific objectives:

-To relate the lung diseases and age group.

-To relate the lung diseases and amount of cigarettes smoked.

-To relate the lung diseases and duration of smoking.

-To record the most common changes for lungs related to smoking that will appear in HRCT.

1.4. Over view of the study:

Chapter one: Introduction.

Chapter two: Theoretical background and literature review.

Chapter three: Material and methods.

Chapter four: Results.

Chapter five: Discussion, conclusion and recommendation.

2.1. Theoretical background

2.1.1. Anatomy

2.1.1.1. The Lungs:

The lungs lie within the thoracic cavity, surrounded by visceral pleura and the pleural cavity. The superior extremity of the lung is called apex. The concave surface that rests on the diaphragm is called the base. The outer surface adjacent to the ribs is called the costal surface. The surface facing the mediastinum is the mediastinal surface. The site where structures passing through the root of the lung actually contact pulmonary tissue is called the hilum. (Jack T, 2003)

The right lung is divided into superior, middle and inferior lobes by an oblique and a horizontal fissures. The upper, oblique fissure separates the inferior from the middle and upper lobes, and corresponds closely to the left oblique fissure, although it is less vertical, and crosses the inferior border of the lung approximately 7.5 cm behind its anterior end. The short horizontal fissure separates the superior and middle lobes. The small middle lobe is cuneiform and includes some of the costal surface, the lower part of the anterior border and the anterior part of the base of the lung. (SusanStandring, 2008)

The left lung is divided into a superior and an inferior lobe by an oblique fissure which extends from the costal to the medial surfaces of the lung both above and below the hilum. A left horizontal fissure is a normal variant found occasionally. The superior lobe, which lies anterosuperior to the oblique fissure, includes the apex, anterior border, much of the costal and most of the medial surfaces of the lung. At the lower end of the cardiac notch a small process, the lingula, is usually present. The larger inferior lobe lies behind and below the fissure, and contributes almost the whole of the base, much of the costal surface and most of the posterior border of the lung. (SusanStandring, 2008)

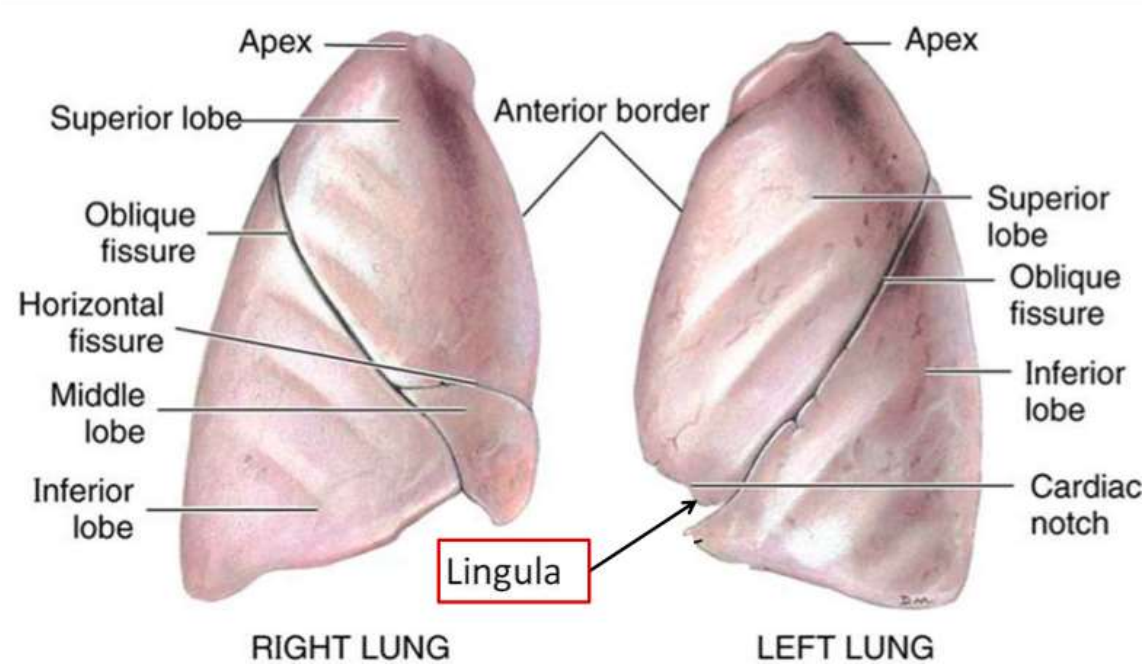

Figure (2-1): shows anatomy of the lungs**.** (www.studyblue.com)

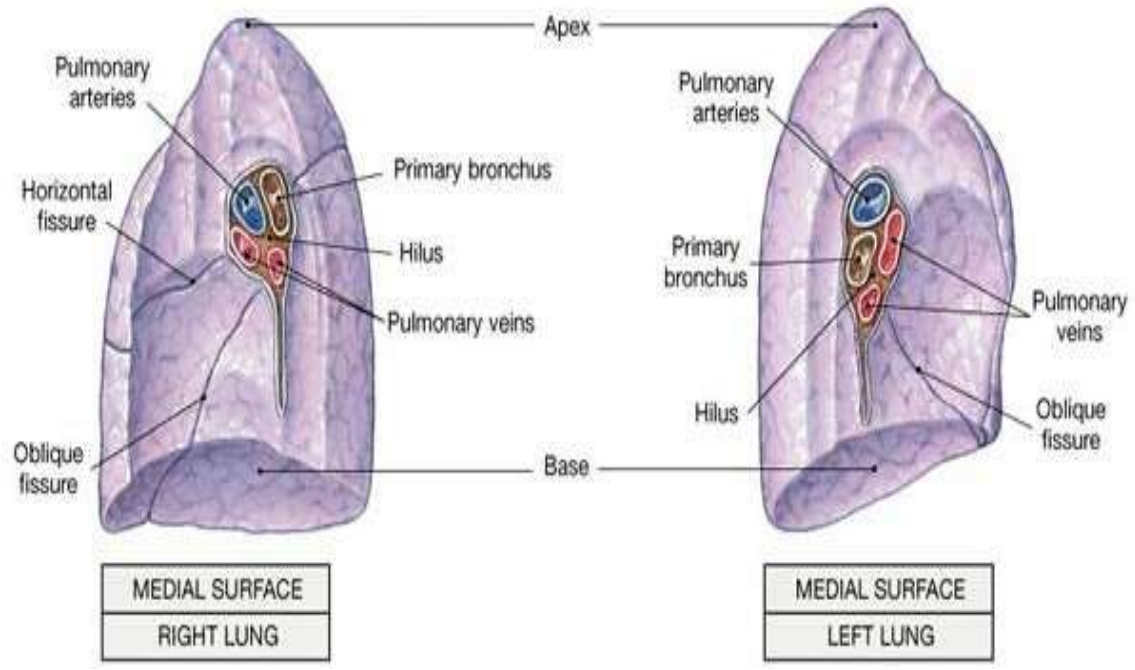

Figure (2-2): Medial surface of right and left lungs. (www.suggest-keywords.com)

2.1.1.2. Trachea

The trachea is a mobile cartilaginous and membranous tube. It begins in the neck as a continuation of the larynx at the lower border of the cricoid cartilage at the level of the 6th cervical vertebra. In adults, the trachea is about 4.5 in. (11.25 cm) long and 1 in. (2.5 cm) in diameter. The fibroelastic tube is kept patent by the presence of U-shaped bars (rings) of hyaline cartilage embedded in its wall. The posterior free ends of the cartilage are connected by smooth muscle, the trachealis muscle.

Blood Supply of the Trachea: the upper two thirds are supplied by the inferior thyroid arteries and the lower third is supplied by the bronchial arteries. (Richard S. Snell, 2012)

2.1.1.3. The Bronchi

The trachea bifurcates behind the arch of the aorta into the right and left main bronchi. The bronchi divide dichotomously, giving rise to several million terminal bronchioles that terminate in one or more respiratory bronchioles. Each respiratory bronchiole divides into 2 to 11 alveolar ducts that enter the alveolar sacs. The alveoli arise from the walls of the sacs as diverticula. The right main bronchus is wider, shorter, and more vertical than the left and is about 1 in. (2.5 cm) long. Before entering the hilum of the right lung, the main bronchus gives off the superior lobar bronchus. On entering the hilum, it divides into a middle and an inferior lobar bronchus. The left main bronchus is narrower, longer, and more horizontal than the right and is about 2 in. (5 cm) long. It passes to the left below the arch of the aorta and in front of the esophagus. On entering the hilum of the left lung, the principal bronchus divides into a superior and an inferior lobar bronchus. (Richard S. Snell, 2012)

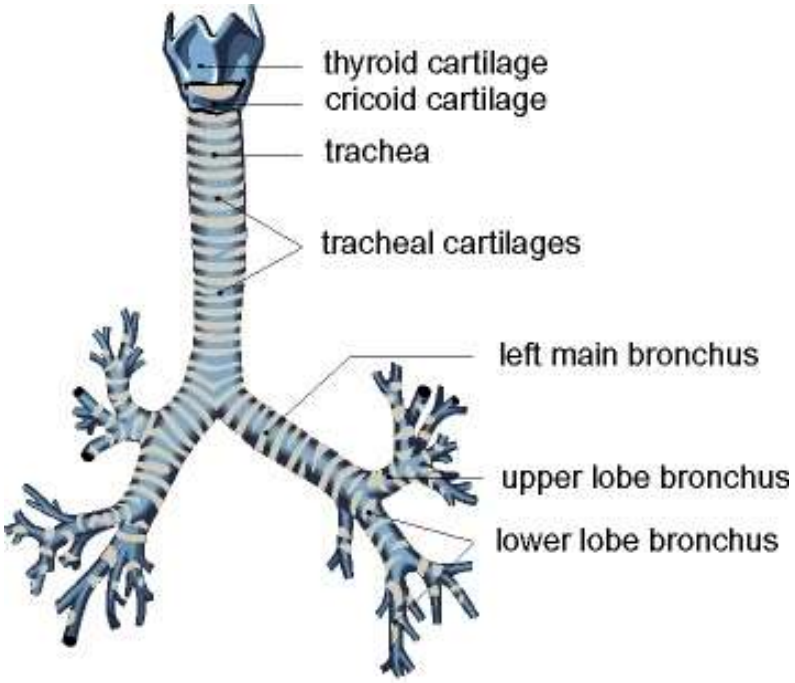

Figure (2-3): The cartilages of the larynx, trachea and bronchi: anterior aspect. (www.flicker.com)

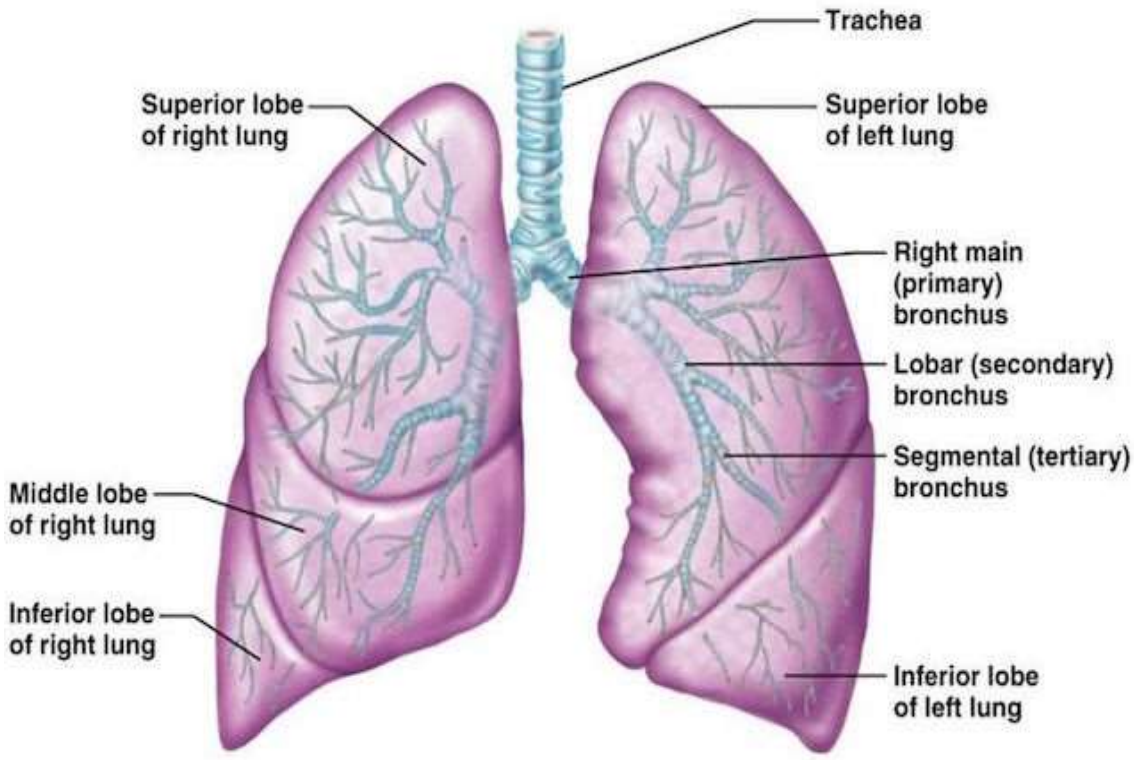

Figure (2-4): illustrate the relations between trachea, main bronchus and lobes of the right and left lung. (blog.etobb.com)

2.1.1.4. Vasculature of the Lung

The two or three small bronchial arteries from the descending aorta supply oxygen and nutrients to the bronchial tree probably as far as the smallest bronchiole. If there are two such vessels, one goes to each lung; if there are three bronchial arteries, the left lung gets two of them. The bronchial arteries also supply blood to the nerves, lymphatic tissue, walls of the large vessels, and connective tissue septa of the lungs. (Jack T, 2003)

Venous blood from the larger bronchi enters bronchial veins that empty into the azygos and hemiazygos systems. Venous blood from the smaller bronchi and from the capillary network around the alveoli empties into the pulmonary veins. (Jack T, 2003)

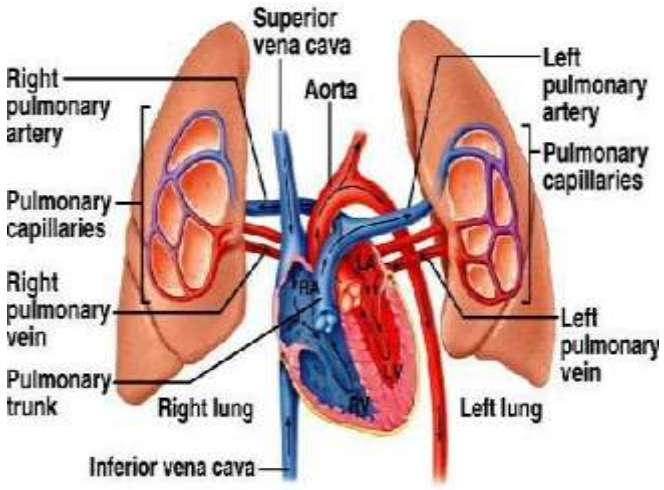

Figure (2-5): shows blood supply of the lungs. (www.kullabs.com)

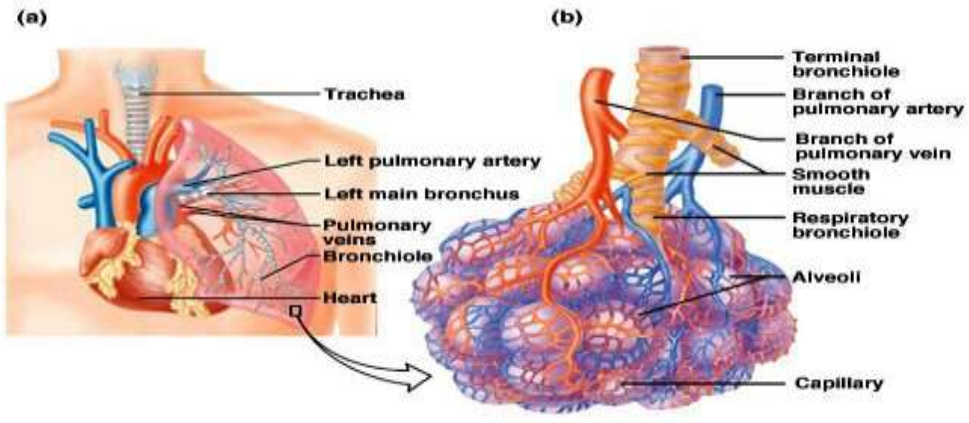

Figure (2-6): shows blood vessels and airwaves. (www.easynotecards.com)

2.1.2. Physiology

The main functions of the respiratory system:

-Breathing or ventilation.

-External respiration: exchange of gases between inhaled air and blood.

-Internal respiration: exchange of gases between blood and tissue fluids.

-Cellular respiration.

-Regulation of blood pH, which occurs in coordination with the kidneys.

-Defense against microbes.

-Control of body temperature due to loss of evaporate. (Wikibooks.org, 2015)

2.1.2.1. Phases of respiration

Respiration occurs in two phases:

1. Inspiration during which air enters the lungs from atmosphere.

2. Expiration during which air leaves the lungs.

During normal breathing, inspiration is an active process and expiration is a passive process. (K Sembulingam, 2012)

2.1.2.2. Muscles of respiration

Respiratory muscles are of two types:

-Inspiratory Muscles: include primary inspiratory muscles which is diaphragm, and accessory inspiratory muscles.

-Expiratory Muscles: include primary expiratory muscles which are the internal intercostal muscles, and accessory expiratory muscles which are the abdominal muscles. (K Sembulingam, 2012)

2.1.2.3. Work of Breathing:

Work of breathing is the work done by respiratory muscles during breathing to overcome the resistance in thorax and respiratory tract. During respiratory processes, inspiration is active process and the expiration is a passive process. So, during quiet breathing, respiratory muscles perform the

work only during inspiration and not during expiration. During the work of breathing, the energy is utilized to overcome three types of resistance:

-Airway resistance.

-Elastic Resistance of Lungs and Thorax.

-Non-elastic Viscous Resistance. (K Sembulingam, 2012)

2.1.2.4. Mechanics of Pulmonary Ventilation

The lungs can be expanded and contracted in two ways: (1) by downward and upward movement of the diaphragm to lengthen or shorten the chest cavity, and (2) by elevation and depression of the ribs to increase and decrease the anteroposterior diameter of the chest cavity. Normal quiet breathing is accomplished almost entirely by the first method, that is, by movement of the diaphragm. During heavy breathing, however, the elastic forces are not powerful enough to cause the necessary rapid expiration, so that extra force is achieved mainly by contraction of the abdominal muscles.(Arthur C. Guyton, 2006)

2.1.2.5. Alveolar Ventilation

The ultimate importance of pulmonary ventilation is to continually renew the air in the gas exchange areas of the lungs, where air is in proximity to the pulmonary blood. These areas include the alveoli, alveolar sacs, alveolar ducts, and respiratory bronchioles. The rate at which new air reaches these areas is called alveolar ventilation.(Arthur C. Guyton, 2006)

2.1.3. Pathology

Cigarette smoking yields more than 4000 constituents. These carbon monoxide, hydrogen cyanide, aldehydes, cadmium (linked to emphysema), ammonia, nicotine and benz (a) anthracene and benzopyrene (both potent carcinogens). Nicotine is elaborated by the tobacco root and makes cigarettes addictive. The lungs absorb 85% and it causes increase in heart rate, blood pressure and cardiac output. Chronic obstructive pulmonary disease (COPD) encompasses three pathologic entities, which are considered separately pathologically , but often coexist: chronic bronchitis, pulmonary emphysema and small airways disease.(David Alvesion, 2008)

The reason of COPD for male predominance is unknown. The most aetiologic factor in COPD is cigarette smoking; other include occupation, especially dust- associated such as coal mining, and alpha α-1 antitrypsin (AAT) deficiency. The wide variation in susceptibility of smokers to the development COPD is at least genetic. (David Alvesion, 2008)

2.1.3.1. Chronic bronchitis:

was defined functionally by the medical research council as chronic or ecurrent increase in the volume of bronchial secretions, sufficient to cause expectoration on most days for a minimum of three month of the years, for not less than two successive years, which cannot be attributed to other cardiac cycle or pulmonary disease. The presence of chronic bronchitis very common in smokers is not good marker of functional impairment. The symptoms have insidious onset, with morning smoker's cough and gradually worsening external dyspnea, especially in damp weather.(David Alvesion, 2008)

2.1.3.2. Emphysema:

Permanent enlargement of the air spaces of the lung distal to terminal bronchioles accompanied by destruction of their walls is called emphysema. Emphysema may be pure but in majority of cases it is accompanied by chronic bronchitis. Types of emphysema:

Centriacnar (centrilobular) emphysema.-

Panacinar (panloular) emphysema.-

Distal acinar (paraseptal) emphysema.-

Irregular (para-cicatrical) emphysema. -

Pathogenesis: smoking is an important etiologic factor in emphysema by the following mechanism:-

Smoking causes accumulation of neutrophils and macrophages in alveoli which rich in elastase, stimulates release of elastase from neutrophils which destroys elastic alveolar walls. Smoking also inhibits alpha 1 antitrypsin and thus decreases net antielstase activity in smokers.

Clinical features of Emphysema: dyspnea, forced expiration, wheezing with prolonged expiration and cough, weight loss. Chest becomes barrel-shaped. (Danish, 2010)

2.1.3.3. Carcinoid tumors:

Carcinoid tumors are low-grade malignant neuroendocrine tumors similar to those seen, for example in the gut. They are divided into typical (TC) and atypical (AC) forms. The latter is smoking-related. Can be classified according to the location into:

-Centrally located: arising from main lobar or segmental bronchus like: adenocarcinoma and small cell carcinoma.

-Peripherally located: arising from smaller bronchi or bronchioles like: adenocarcinoma and large cell carcinoma.(Danish, 2010)

Types of carcinoid tumors:

-Squamous cell carcinoma: much more common in men than in women. Usually arise centrally in major bronchus. Often preceded by atypical metaplasia or dysplasia in the bronchial epithelium, which then transforms to carcinoma. Strong association with cigarette smoking.

Clinical features: develop due to proximal location e.g. cough, hemoptysis, lobar or segmental lung collapse and post obstructive pneumonia.(Danish, 2010)

-Bronchioloalveolar carcinoma: it involves peripheral parts of lung, either as a single nodule or multiple diffuse nodules that may coalesce to produce pneumonia-like consolidation. Tumor cells are tall and columnar. Most of the tumors are well differentiated with little an aplasia.(Danish, 2010)

-Small cell (oat cell) carcinoma: most aggressive type of lung tumors, incurable by surgical means. It tends to infiltrate widely and metastasized early. Arise most often centrally, there is an early involvement of hilar and mediastinal lymph nodes. About 25% of bronchogenic tumors are small cell carcinoma.(Danish, 2010)

-Large cell carcinoma: probably represent those squamous cell carcinoma and adenocarcinoma that are so un differentiated that they cannot be recognized. Usually bulky and arise peripherally. Poor prognosis due to early distant spread.

Clinical feature: cough with sputum, hemoptysis and breathlessness due to lung collapse resulting from bronchial obstruction.(Danish, 2010)

2.1.4. Diagnostic tools:

i. Physical examination: inspection, palpation, percussion and auscultation.
ii. Laboratory methods: routine laboratory blood, urine tests and Microbiological tests.
iii. Histological and cytological examination.
iv. Respiratory function tests: Spirometry - Lung capacity and airway resistance -Diffusing capacity -Blood gas analysis -Cardiopulmonary exercise testing -Respiratory muscle function measurement -Control of ventilation -Diagnosis of sleep breathing disorders -Right heart catheterization -Intensive care monitoring.
v. Imaging techniques: Chest x-ray - Computed tomography CT - Pulmonary and bronchial angiography –Fluoroscopy -Magnetic resonance imaging -Ultrasonography -Nuclear medicine techniques. (G. John Gibson, et al. 2013)

2.1.4.1. Computed tomography CT:

Computed tomography (CT) scanning, also known as computerized axial tomography (CAT) scanning, is a diagnostic imaging procedure that uses X-rays in order to present cross-sectional images ("slices") of the body. Cross sections are reconstructed from the measurements of attenuation coefficients of X-ray beams in the volume of the object studied. CT is based on the fundamental principle that the density of the tissue passed by the X-ray beam can be measured from the calculation of the attenuation coefficient. So, CT allows the reconstruction of the density of the body, by two dimensional section perpendicular to the axis of the acquisition system. (Goldman LW, 2008)

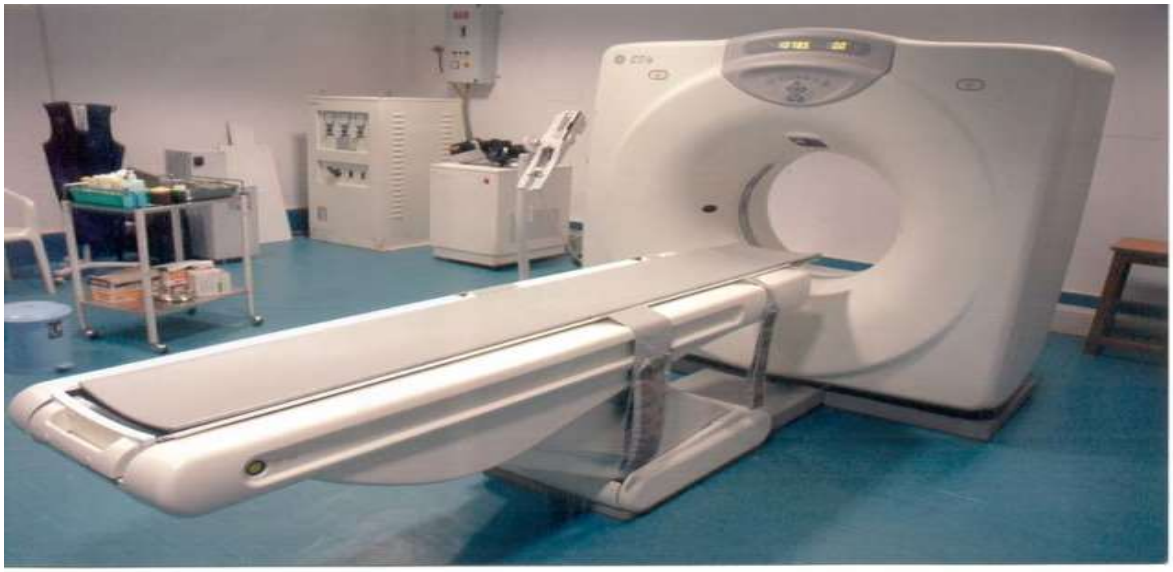

Figure (2-7): shows CT scan machine.

(http://www.infiniteunknown.net/wp-content/uploads/2009/12/ct-scan.jpg)

2.1.4.2. CT generations:

First generation: used one detector, pencil-like X-ray beam and translate-rotate system with average duration of scan: 25-30 mins.

Second generation: used multiple detectors, fan shaped x-ray beam and translate-rotate system with average duration of scan: less than 90 sec.

Third generation: used multiple detectors originally 288; newer ones use over 700 arranged in an arc, fan shaped x-ray beam and rotate-rotate system with average duration of scan: approximately 5 sec.

Fourth generation: used multiple detectors more than 2000 arranged in an outer ring which is fixed, fan shaped x-ray beam and rotate-fixed system with average duration of scan: few seconds.

Fifth Generation: used detector ring, electron beam scanner and stationary-stationary system with average duration of scan: 50 msec.

Sixth Generation: used slip ring technology, helical CT X-ray source and detector array rotate continuously as the patient table is moved progressively through the scanner. (Saunders J, 2011) (Bushberg JT, 2002)

Seventh Generation: the most recent generation of CT scanner consists of a multiple detector array and a cone shaped x-ray beam. (Saunders J, 2011) (Bushberg JT, 2002)

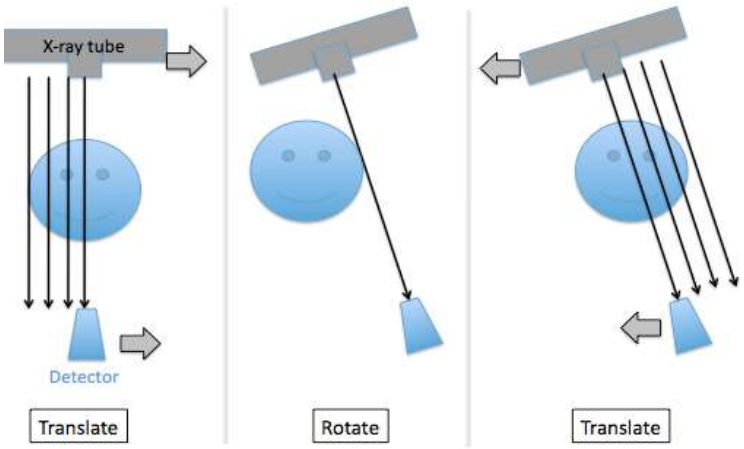

Figure (2-8): first generation scanners used translation and rotation. (http://199.116.233.101/index.php/generations_of_ct_scanners)

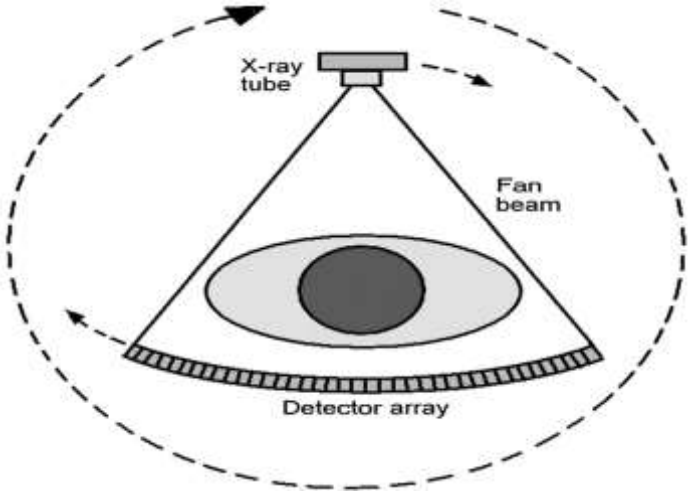

Figure (2-9): second generation CT scanners. (tech.snmjournals.org)

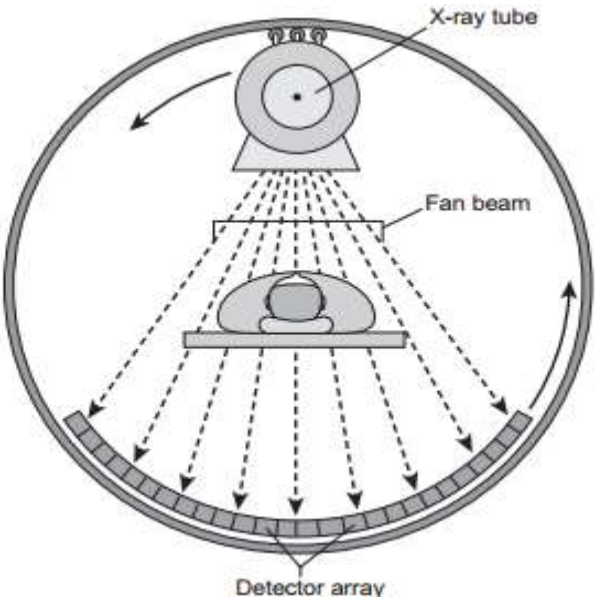

Figure (2-10): third generation of CT scanners. (Lois E. Romans 2011)

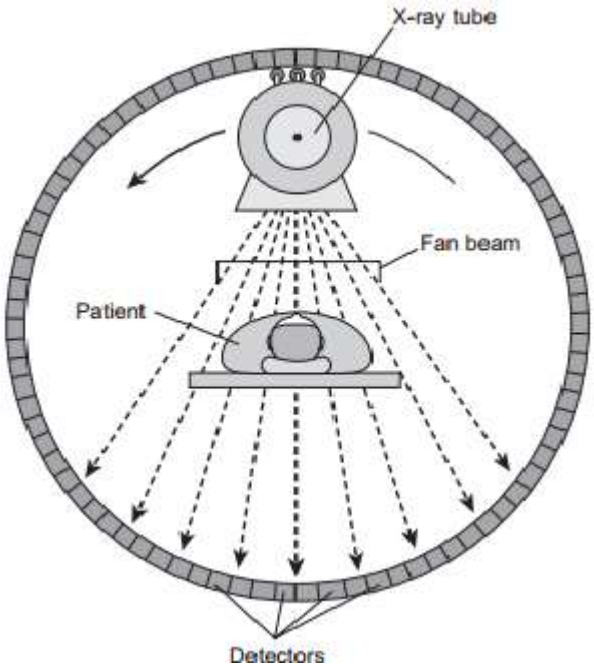

Figure (2-11): fourth generation of CT scanners. (Lois E. Romans 2011)

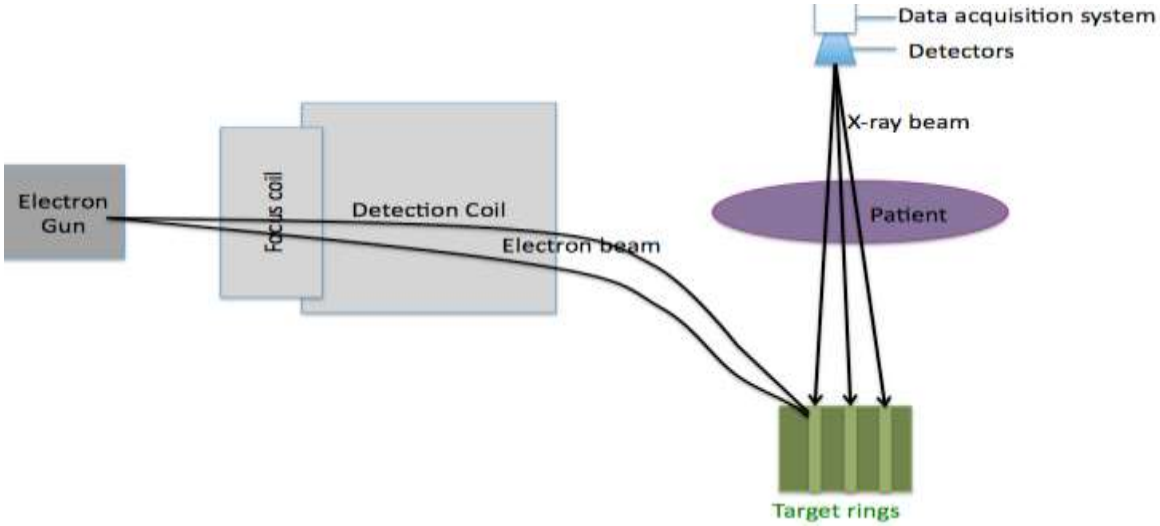

Figure (2-12): fifth generation of CT scanners. (http://199.116.233.101/index.php/generations_of_ct_scanners)

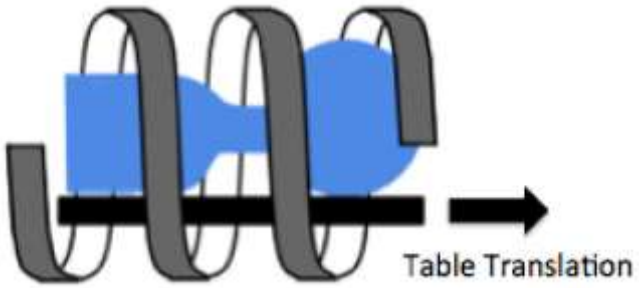

Figure (2-13): sixth generation of CT scanners.

(http://199.116.233.101/index.php/generations_of_ct_scanners)

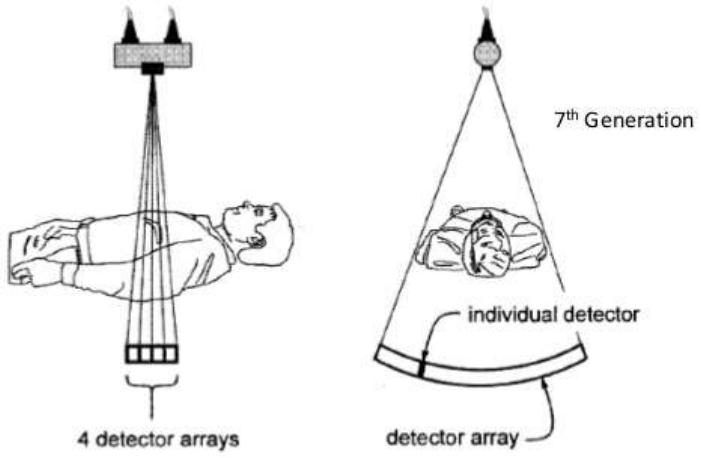

Figure (2-14): seventh generation of CT scanners.(www.slideshare.net)

2.14.3. The procedure work:

x-ray emitted from rotating x-ray tube pass through the patient's body. Different tissues absorb this radiation in different amount. Radiation leaving the body is recorded by an array of detectors that are mounted on the gantry along with the x-ray tube. During each rotation about 1000 images of x-ray beam are recorded. These images are then reconstructed by a computer into a very detailed two-dimensional view of the interior of the body. As the x-ray source rotates and, at the same time, the patient lying on the examination table advances through the scanner at constant rate, the x-ray beam follows a spiral path-hence, the term "spiral" CT scanning. (Amel Hegazi 2011)

2.1.5. CT technique for lungs:

2.1.5.1. Preparation:

Patient should dress comfortably but avoid any clothing in the chest area that has a zipper, snaps or jewelry, since metal objects may affect the CT images. Women should always inform their physician or the x-ray technologist if there is any possibility that they are pregnant. The CT scanner is a large unit with a hole running directly through its center, patient lies on a table that can move up or down and can slide into and out of the center of the cavity. (Amel Hegazi 2011)

2.1.5.2. Positioning:

Most thoracic protocols are performed while the patient lies in a supine position on the scan table with the arms elevated above the head. In a few instances, primarily high resolution CT protocols of the lungs, additional scans are obtained with the patient in the prone position. Using the shortest scan time possible helps to reduce artifacts created by respiratory motion. Whenever possible, scans of the chest should be acquired within a single

breath-hold, as this will prevent misregistration that may be caused by uneven patient breathing between scans. (Lois E. Romans 2011)

2.1.5.3. Protocol:

A routine chest protocol includes both soft tissue and lung windows to evaluate mediastinal structures in conjunction with lung tissue. Scans extend from the lung apices to under the diaphragm (including the adrenals when there is history of certain carcinomas). The administration of IV contrast media is dependent on the clinical indication and the preference of the radiologist.(Lois E. Romans 2011)

2.2. Previous studies:

-Yasunaga K et al. (2013) had studied Emphysema in asymptomatic smokers: quantitative CT evaluation in correlation with pulmonary function tests. To provide quantitative information on emphysema in asymptomatic smokers in correlation with pulmonary function tests (PFT).The study population included 75 smokers (current smokers: n=39; ex-smokers: n=36) and 25 nonsmokers who underwent volumetric high-resolution CT of the chest with automated quantification of emphysema and PFTs. Current smokers had a higher percentage of emphysema in the right lung (P=0.041) and right upper lobe (P=0.037). The overall percentage of emphysema did not differ according to the Gold stage (P=0.77). Smokers with emphysema had significantly higher mean values of FRC (P=0.012), RV (<0.0001) and TLC (P=0.0157) than smokers without emphysema but no significant differences were found in neither the mean values of TLCO nor in expiratory flows (P>0.05). Correlations were found between the percentage of emphysema and (a) cigarette consumption of current (r=0.34215; P=0.0330) and ex-smokers (r=0.44104; P=0.0071); and (b) alterations of TLC, FRC, RV and DLCO of smokers.

-Mohamed H et al. (2013) had studied Rate of progression of CT-quantified emphysema in male current and ex-smokers. To investigate the effect of length of smoking cessation and clinical / demographical factors on the rate of emphysema progression and FEV1-decline in male heavy smokers.3,670 male smokers with mean (SD) 40.8 (17.9) pack years underwent chest CT scans and pulmonary function tests at baseline and after 1 and 3 years follow-up. Smoking status (quitted ≥5, ≥1-<5, <1 years or current smoker) was noted. Rate of progression of emphysema and FEV1-decline after follow-up were assessed by analysis of variance adjusting for age, height, baseline pulmonary function and emphysema severity, pack years, years in

study and respiratory symptoms. The quitted ≥5 group was used as reference. Median (Q1-Q3) emphysema severity,<-950 HU, was 8.8 (5.1 - 14.1) and mean (SD) FEV1 was 3.4 (0.73) L or 98.5 (18.5) % of predicted. The group quitted '>5 years' showed significantly lower rates of progression of emphysema compared to current smokers, 1.07% and 1.12% per year, respectively (p<0.001). Current smokers had a yearly FEV1-decline of 69 ml, while subjects quit smoking >5 years had a yearly decline of 57.5 ml (p<0.001).

-Miller M et al. (2011) had studied Persistent airway inflammation and emphysema progression on CT scan in ex-smokers observed for 4 years. Ten ex-smokers with COPD-E who had quit smoking underwent chest CT scans to document the extent of COPD-E, assessment of lung function (FEV(1) and diffusing capacity of lung for carbon monoxide), sputum induction for biomarkers of inflammation (measured by enzyme-linked immune sorbent assay), and blood cotinine levels at baseline and approximately 4 years later. Normal healthy subjects (n = 7) and normal current smokers with no CT scan evidence of COPD-E (n = 8) served as sputum biomarker comparison groups. After approximately 4 years of not smoking (documented by cotinine levels), ex-smokers with COPD-E had persistent increased levels of mediators of inflammation in sputum (myeloperoxidase, leukotriene B4, IL-8, monocyte chemo attractant protein-1, matrix metalloprotease-9), which was associated with significant progression of COPD-E on chest CT scan.

-Remy-Jardin M et al. (2002) had studied Longitudinal follow-up study of smoker's lung with thin-section CT in correlation with pulmonary function tests.To evaluate thin-section computed tomography (CT) in depicting longitudinal changes in the lung parenchyma.One hundred eleven volunteers underwent sequential examination with thin-section CT and pulmonary function tests over a mean period of 5.5 years. According to

their smoking habits between initial evaluation (T0) and follow-up (T1), the subjects were classified as persistent current smokers (n = 57), persistent nonsmokers (n = 31), persistent ex-smokers (n = 13), or quitters (n = 10). Significant differences in CT findings between T0 and T1 were seen in only the group of persistent current smokers, who showed a higher frequency of emphysema (40% vs. 26%; P =.005) and ground-glass attenuation (42% vs 28%; P =.02). Individual analysis of follow-up CT scans in the 19 persistent current smokers with micro nodules at T0 demonstrated (a) no changes in seven cases, (b) a higher profusion of micro nodules in seven cases, and (c) replacement of micro nodules with emphysema in five cases. Subjects with emphysema and/or areas of ground-glass attenuation at T0 had a significantly more rapid decline in lung function than did those with a normal CT scan.

-Mastora I et al.(2001) had studied Assessment of the relationship of CT findings with smoking history and pulmonary function test results. To evaluate the frequency and morphologic characteristics of air trapping in volunteers with various smoking habits. Two hundred fifty volunteers (133 women, 117 men; mean age, 39 years), including 144 smokers, 47 ex-smokers, and 59 nonsmokers, prospectively underwent inspiratory and expiratory high-spatial-resolution computed tomography (CT) and pulmonary function tests (PFTs). The frequency and characteristics of air trapping were evaluated according to the population's smoking habits and PFT results. No relationship was found between air trapping and functional indexes of small-airway disease when the CT pattern of air trapping was considered. The strongest relationship between CT abnormalities and functional alterations at the small-airways level was between inspiratory CT features of bronchiolitis: ground-glass opacity, ill-defined micro nodules, bronchiolectasis, and air flow at low lung volumes.

3. Material and Methods

This study is descriptive analytic study.

3.1. Materials:

3.1.1. Patient:

The target population of this study is series of 100 Sudanese smokers patients with respiratory issues, requested to do HRCT by physicians, within age range from 20 to ≥ 60 years old.

3.1.2. Machine:

Toshiba aquilion 64 slice CT.

3.2. Methods:

3.2.1. Preparation for the CT scan:

Patient should dress comfortably but avoid any clothing in the chest area that has a zipper, snaps or jewelry, since metal objects may affect the CT images. Women should always inform their physician or the x-ray technologist if there is any possibility that they are pregnant.

3.2.2. Technique:

High resolution computerized tomography (HRCT) used a narrow beam collimation to take thin slice images of the lung parenchyma.

Patient position: supine.

The examination usually takes 5 to 10 minutes, including preparation time. The actual scan time is less than 30 seconds.

3.2.3. Protocol:

Slice thickness: 0.625-1.25 mm.

Scan time: 0.5-1 minute.

Collimation: 1.5-3 mm.

Matrix size: 512×512 pixels.

FOV: 35cm.

Reconstruction algorithm: high spatial frequency.

Window: lung window.

3.2.4. Data collection:

The data was collected by data collection sheet which designed to satisfy all variable (patient age, history of disease, duration of smoking, amount of cigarettes per day, signs and symptoms and CT findings). (appendices)

3.2.5. Area and duration of the study:

The study was carried out in Royal scan hospital, Fudail diagnostic center, Alyaa specialized hospital and Alzytona hospital in Khartoum during period from January-June2016.

3.2.6. Data analysis and presentation:

Data was analyzed by using simple excel software and SPSS, and the data was presented as tables and figures.

Results

Table (4-1): shows frequency distribution of patients according to age group

Age group (years)	Frequency	percentage
20-39	38	38
40-59	53	53
≥60	9	9
Total	**100**	**100%**

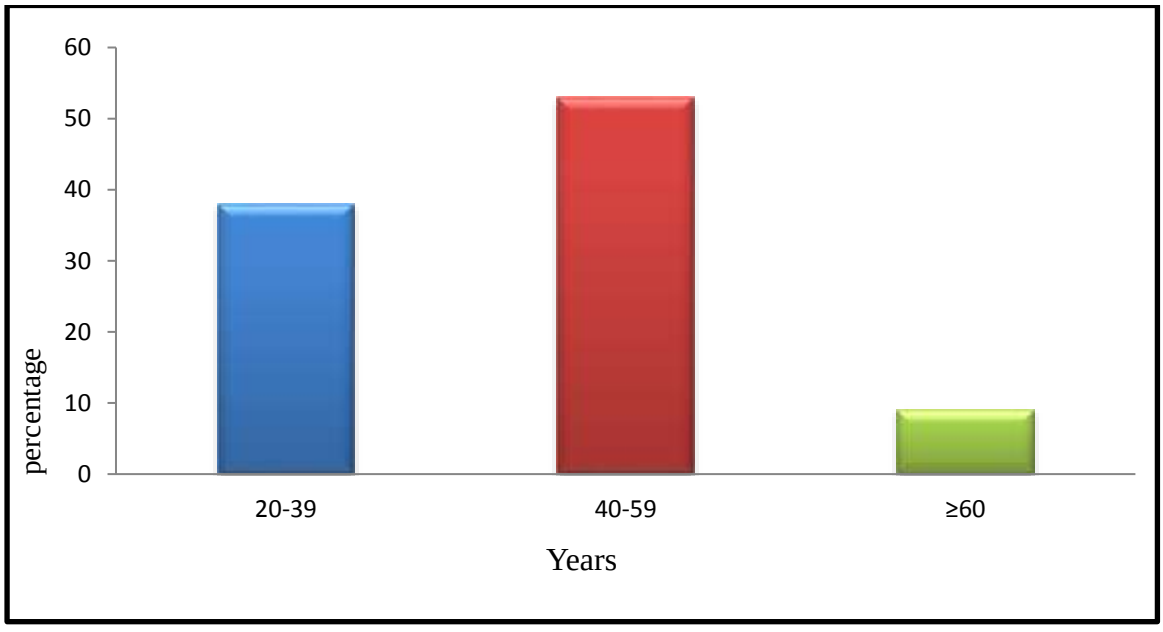

Figure (4-1): illustrate the relation between age group and the frequency.

Table (4-2): shows frequency distribution of smokers according to duration of smoking

Duration (years)	Frequency	Percentage
<15	30	30
15-24	51	51
≥25	19	19
Total	**100**	**100%**

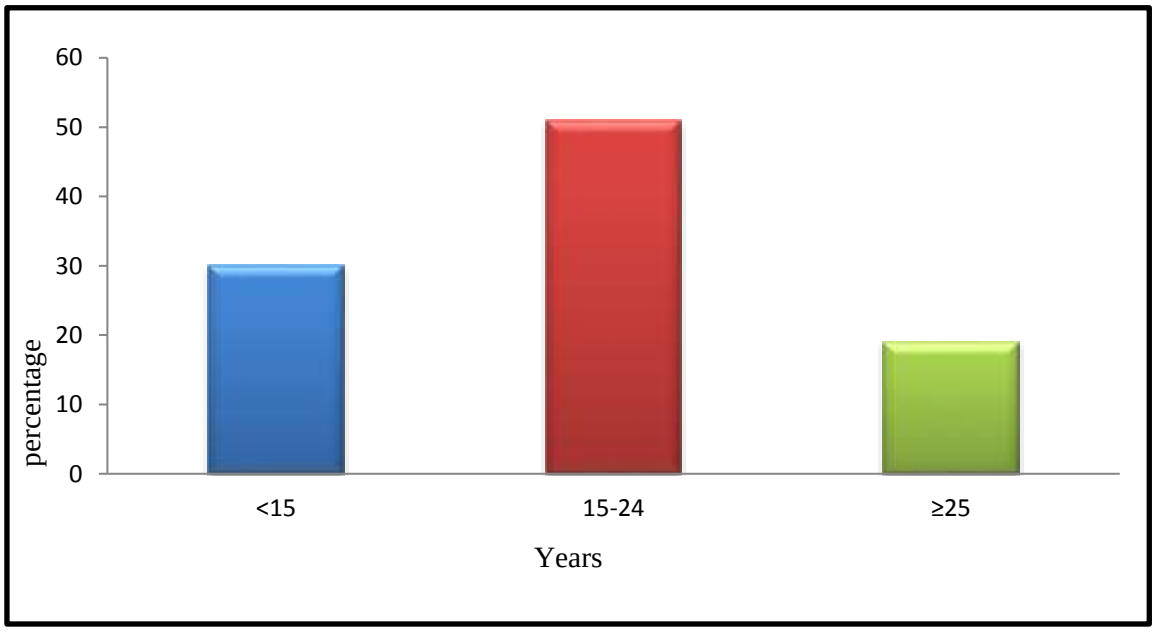

Figure (4-2): illustrate duration of smoking

Table (4-3): shows frequency distribution of smokers according to number of cigarettes smoked per day

No. of cigarettes	Frequency	Percentage
<10	13	13
10-14	41	41
15-19	27	27
≥20	19	19
Total	**100**	**100%**

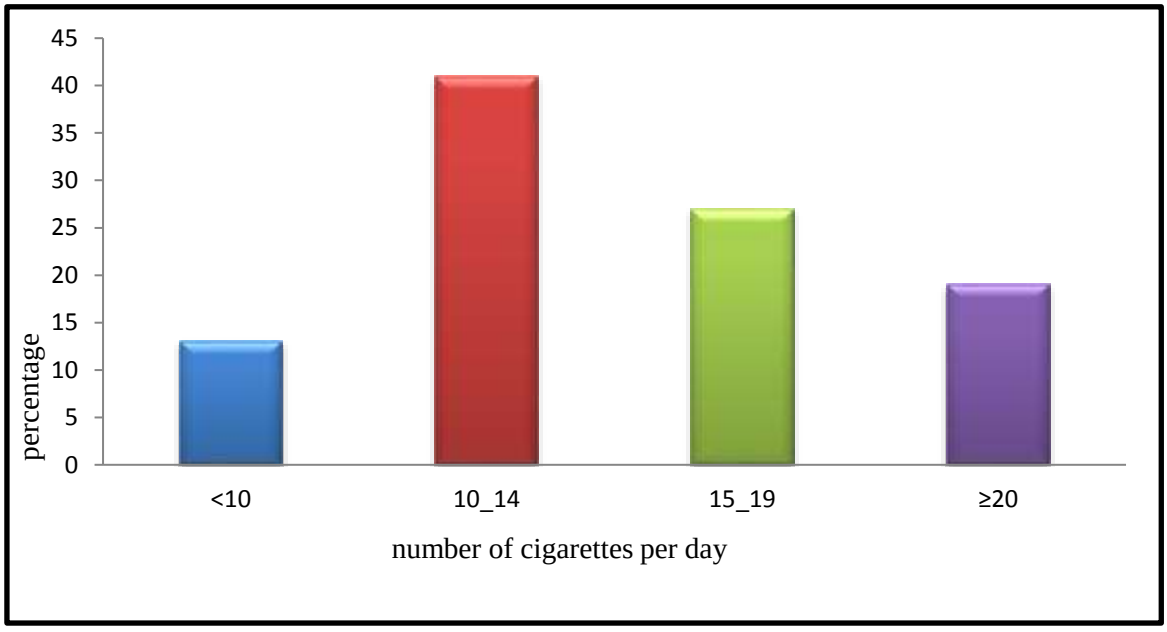

Figure (4-3): illustrate number of cigarettes smoked per day

Table (4-4): shows frequency distribution according to history of disease

History of disease	Yes		No		Total	
	Number	%	Number	%	Number	%
Recurrent respiratory diseases	97	97	3	3	**100**	**100%**
Heart disease	2	2	98	98	**100**	**100%**

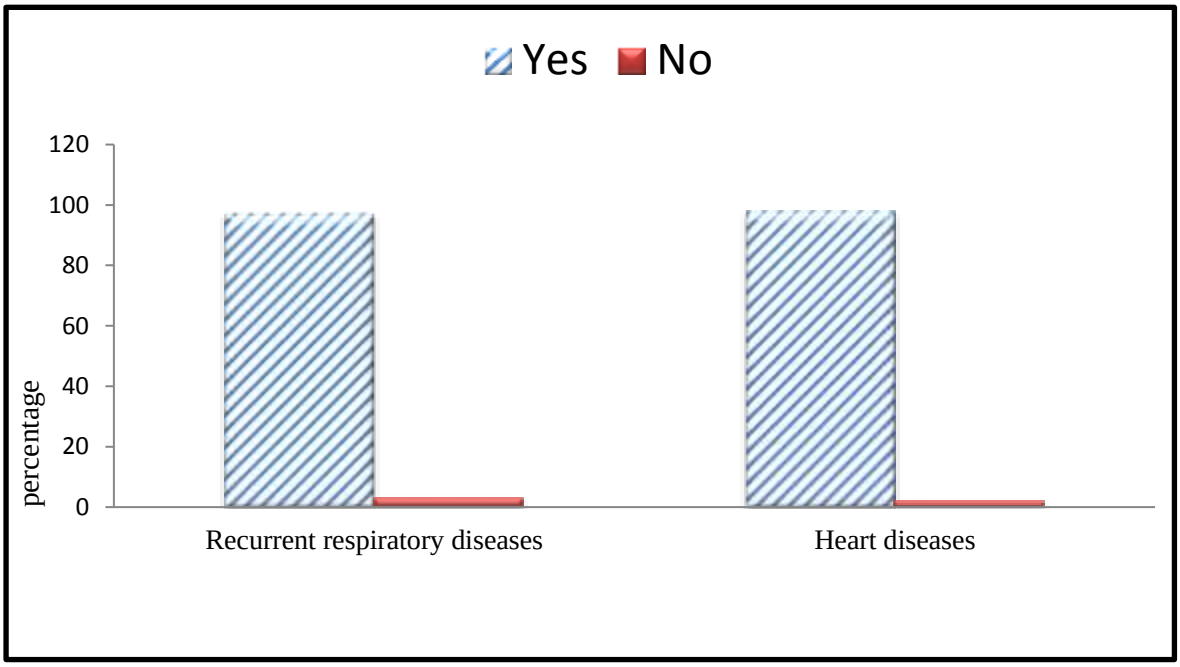

Figure (4-4): illustrate history of disease

Table (4-5): shows frequency distribution according to signs and symptoms

Signs and symptoms	Yes		No		Total	
	Frequency	%	Frequency	%	Frequency	Percentage
Dyspnea	100	100	-	-	**100**	**100%**
Chest pain	100	100	-	-	**100**	**100%**
Hemoptysis	16	16	84	84	**100**	**100%**
Cough with sputum	13	13	87	87	**100**	**100%**
Fever	30	30	70	70	**100**	**100%**
Cyanosis	10	10	90	90	**100**	**100%**

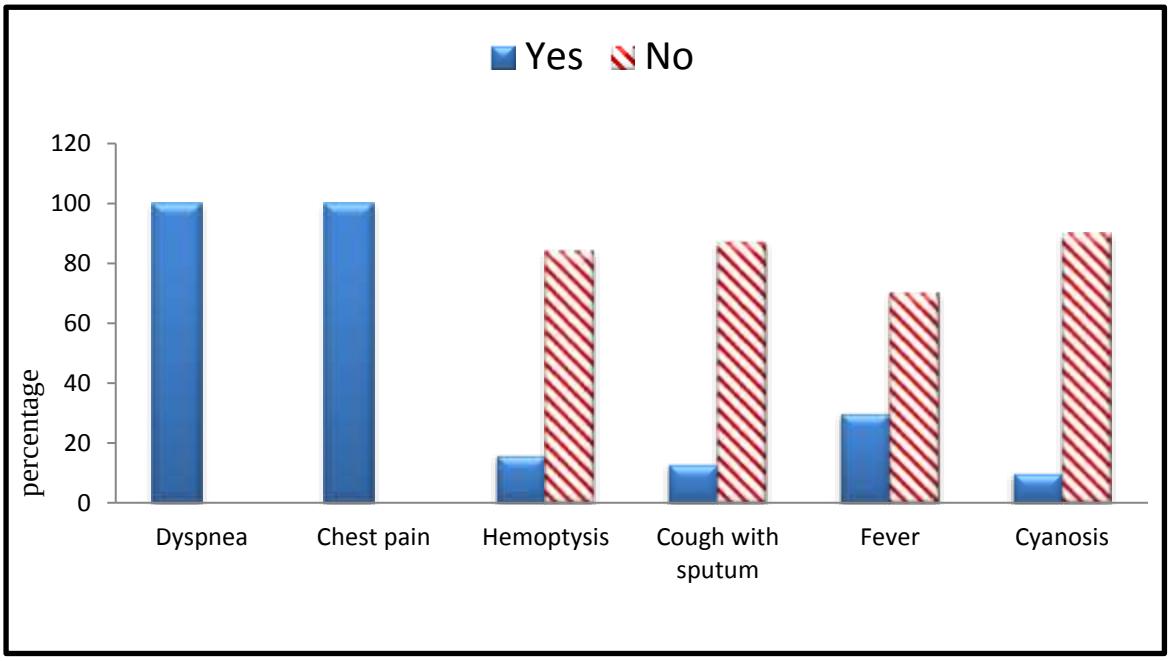

Figure (4-5): illustrate signs and symptoms

Table (4-6): shows frequency distribution according to CT findings

CT findings	Frequency	Percentage
Chronic bronchitis	37	37
Emphysema	32	32
Emphysema + chronic bronchitis	19	19
Lung Ca	12	12
Total	**100**	**100%**

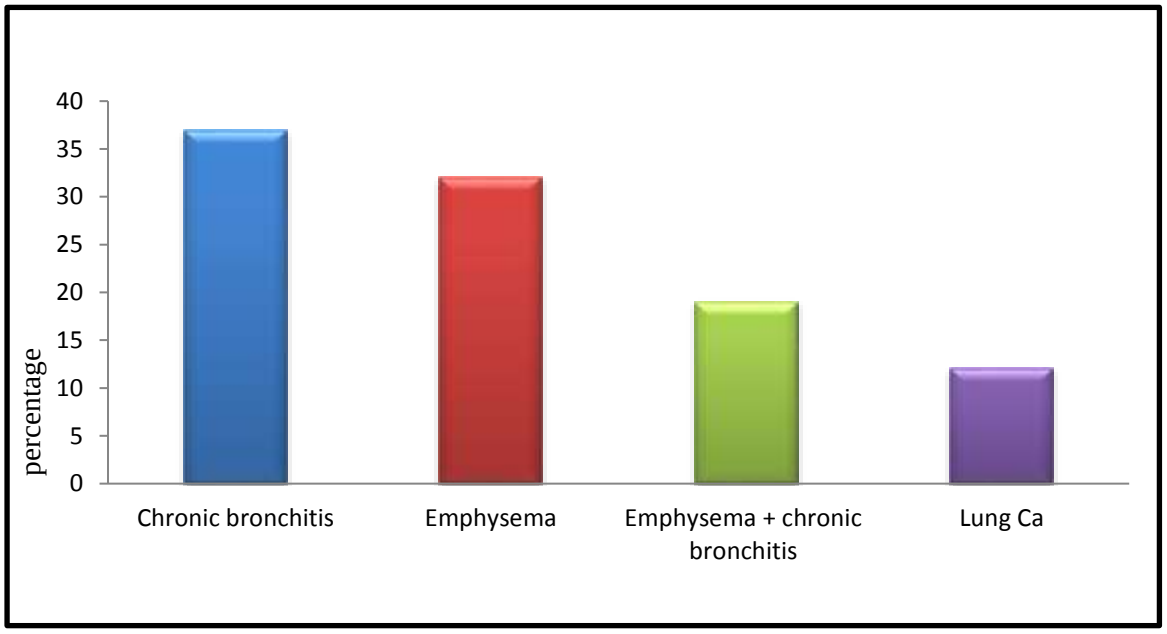

Figure (4-6): illustrate CT findings

Table (4-7): shows relationship between CT findings and age group

CT findings		Age group (years)		
		20-39	**40-59**	**≥60**
Chronic bronchitis	Bronchial wall thickening + narrowing bronchioles	16	-	-
	Bronchial wall thickening	15	-	-
	Bronchiectasis	6	-	-
Emphysema	Left lung	-	9	-
	Right lung	-	10	-
	Both lungs	-	13	-
Emphysema + chronic bronchitis	Left lung	-	5	-
	Right lung	-	5	-
	Both lungs	-	9	-
Lung Ca	Left lung	1	-	4
	Right lung	-	3	4
Chi-square	**158.21**			
d.f	**20**			
P-value	**0.0001****			

*P-value ≤ 0.05

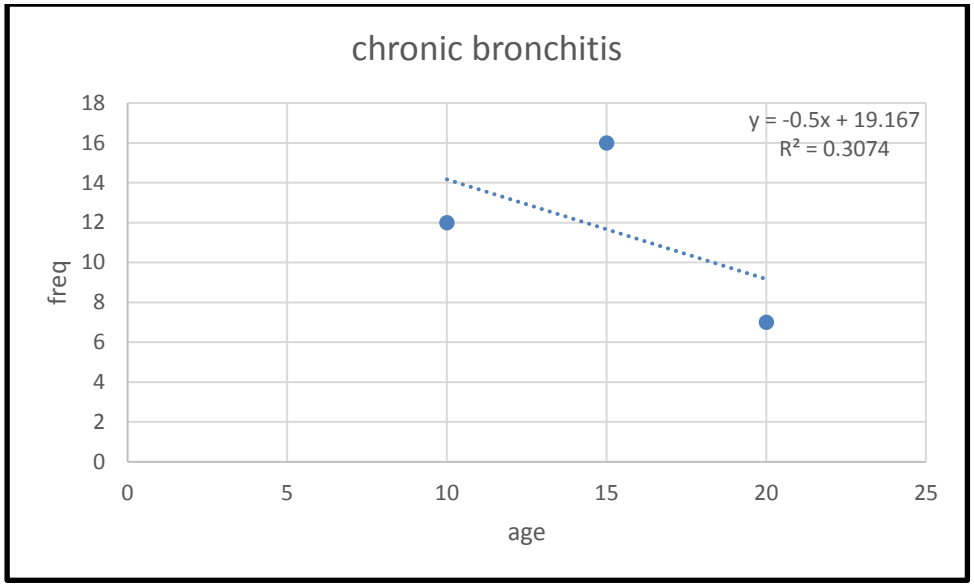

Figure (4-7): illustrate the relation between chronic bronchitis and age.

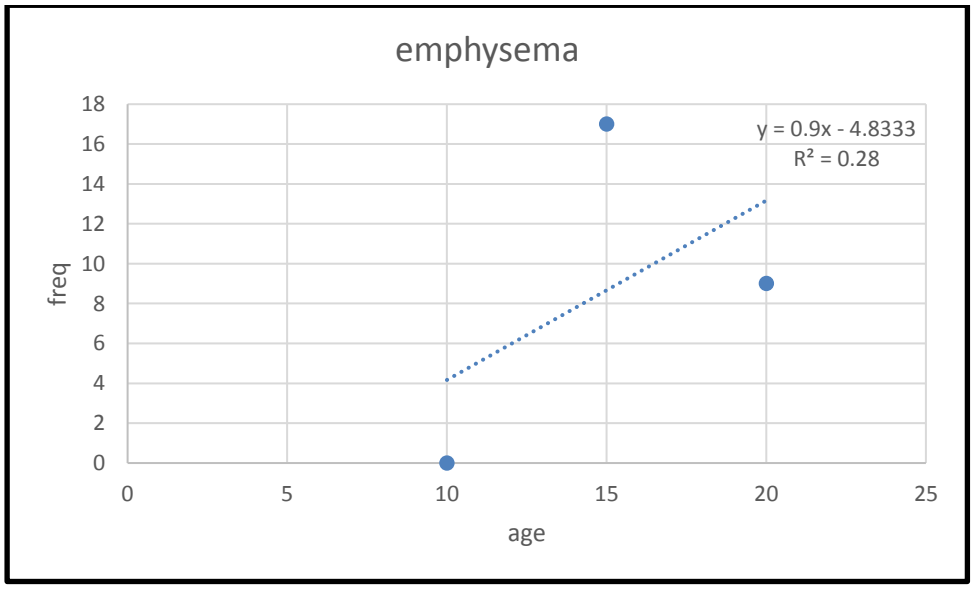

Figure (4-8): illustrate the relation between emphysema and age.

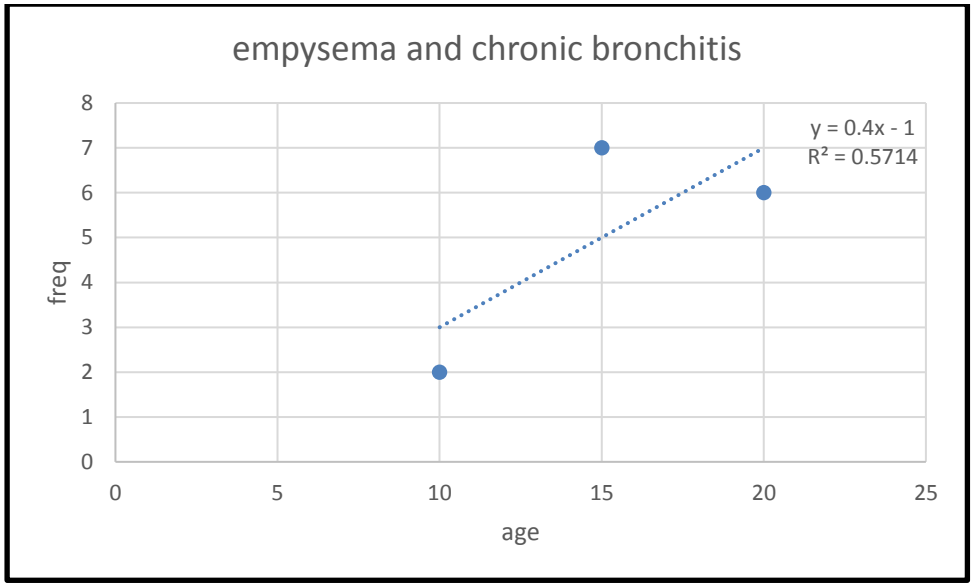

Figure (4-9): illustrate the relation between emphysema and chronic bronchitis and age.

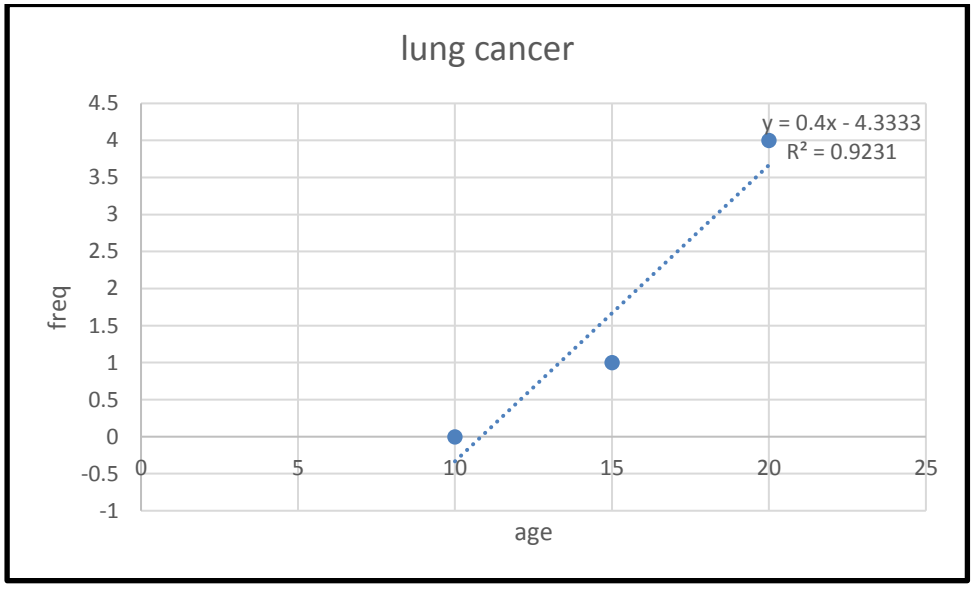

Figure (4-10): illustrate the relation between lung cancer and age.

Table (4-8): shows relationship between CT findings and duration of smoking

CT findings		Duration (years)		
		<15	**15-24**	**≥25**
Chronic bronchitis	Bronchial wall thickening + narrowing bronchioles	12	4	-
	Bronchial wall thickening	12	3	-
	Bronchiectasis	6	1	-
Emphysema	Left lung	-	6	3
	Right lung	-	10	-
	Both lungs	-	9	4
Emphysema + chronic bronchitis	Left lung	1	2	2
	Right lung	1	4	-
	Both lungs	1	7	1
Lung Ca	Left lung	-	1	4
	Right lung	-	2	5
Chi-square	**92.28**			
d.f	**20**			
P-value	**0.0003****			

*P-value ≤ 0.05

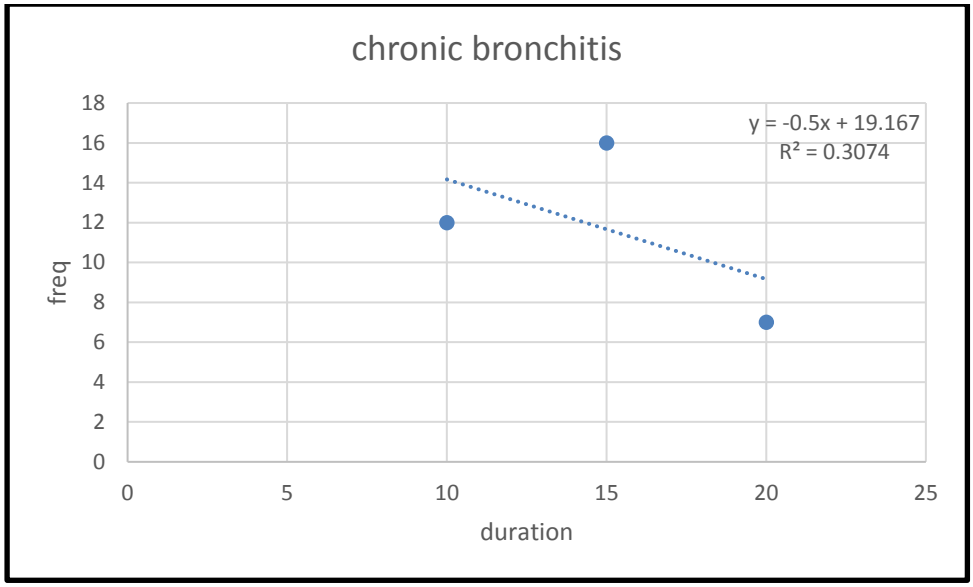

Figure (4-11): illustrate the relation between chronic bronchitis and duration of smoking.

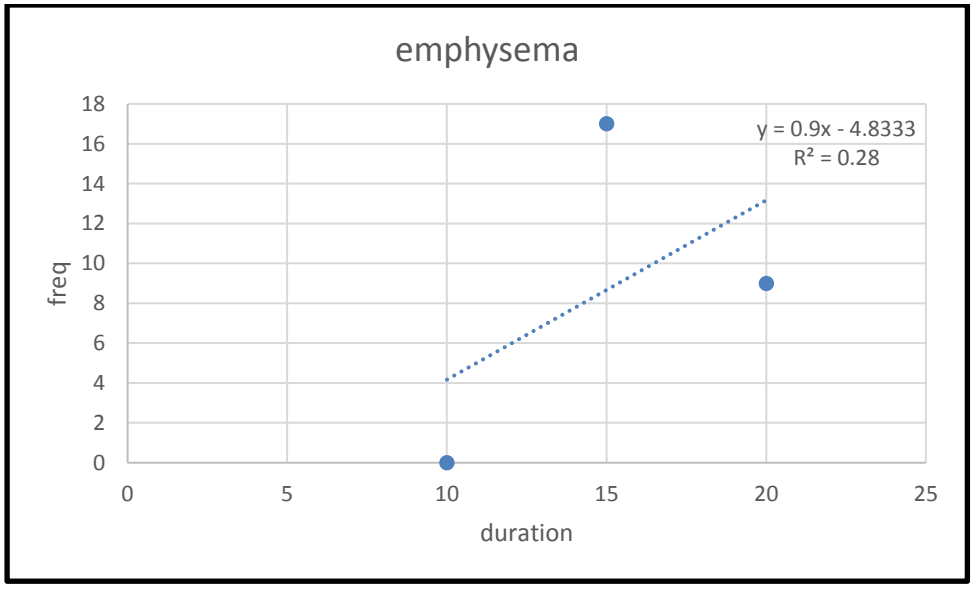

Figure (4-12): illustrate the relation between emphysema and duration of smoking.

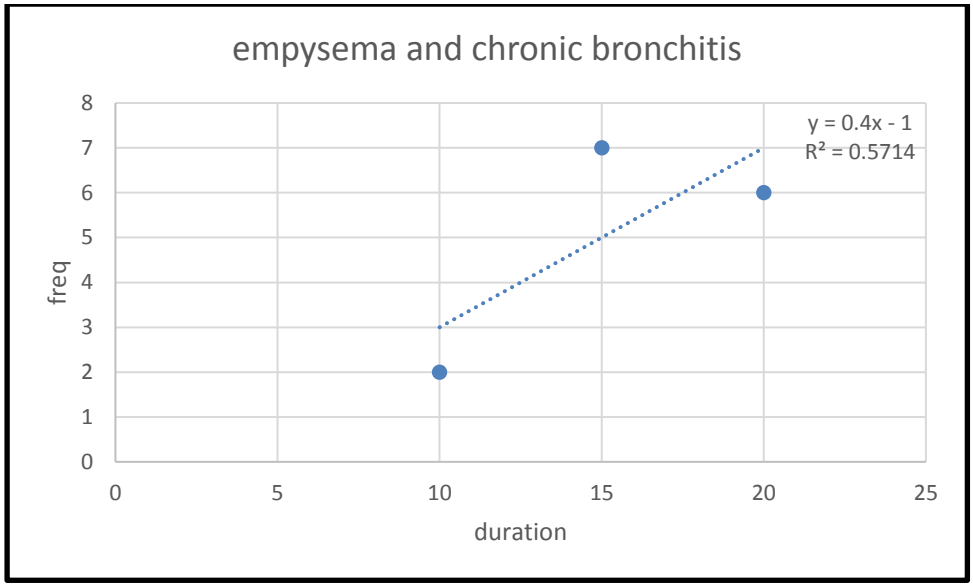

Figure (4-13): illustrate the relation between emphysema and chronic bronchitis and duration of smoking.

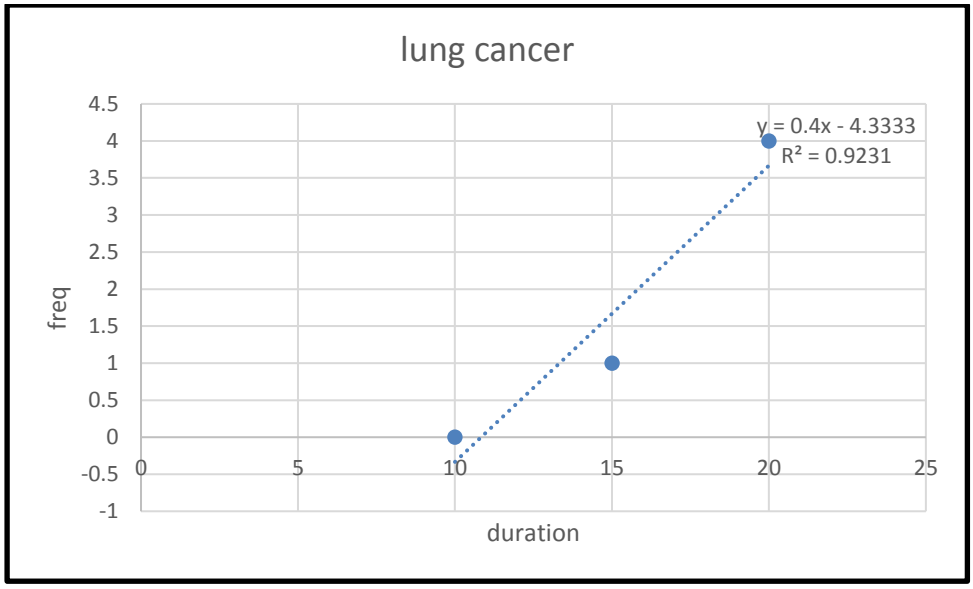

Figure (4-14): illustrate the relation between lung cancer and duration of smoking.

Table (4-9): shows relationship between CT findings and cigarettes smoked per day

CT findings		Cigarettes smoked per day			
		<10	**10-14**	**15-19**	**≥20**
Chronic bronchitis	Bronchial wall thickening + narrowing bronchioles	5	5	5	1
	Bronchial wall thickening	7	6	1	1
	Bronchiectasis	-	5	1	-
Emphysema	Left lung	-	5	4	-
	Right lung	-	6	2	2
	Both lungs	-	6	3	4
Emphysema + chronic bronchitis	Left lung	1	1	3	-
	Right lung	-	2	2	1
	Both lungs	1	4	1	3
Lung Ca	Left lung	-	-	1	4
	Right lung	-	1	3	3
Chi-square	**59.25**				
d.f	**30**				
P-value	**0.001****				

*P-value ≤ 0.05

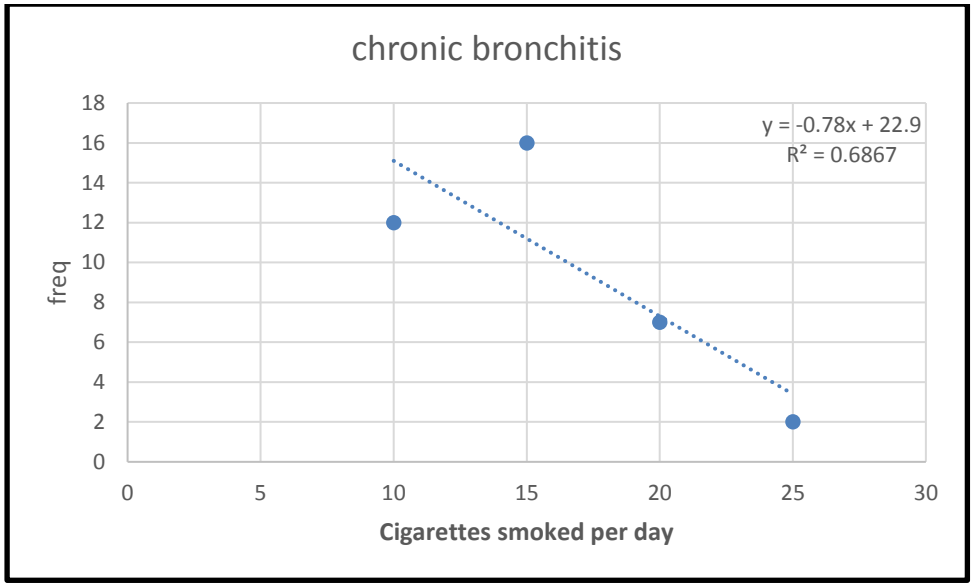

Figure (4-15): illustrate the relation between chronic bronchitis and number of cigarettes smoked per day.

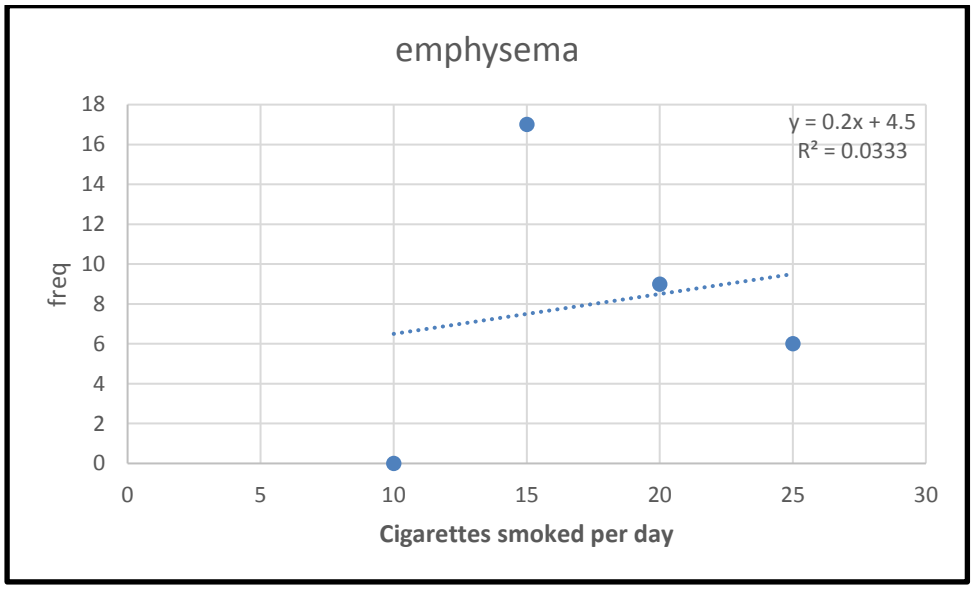

Figure (4-16): illustrate the relation between emphysema and number of cigarettes smoked per day.

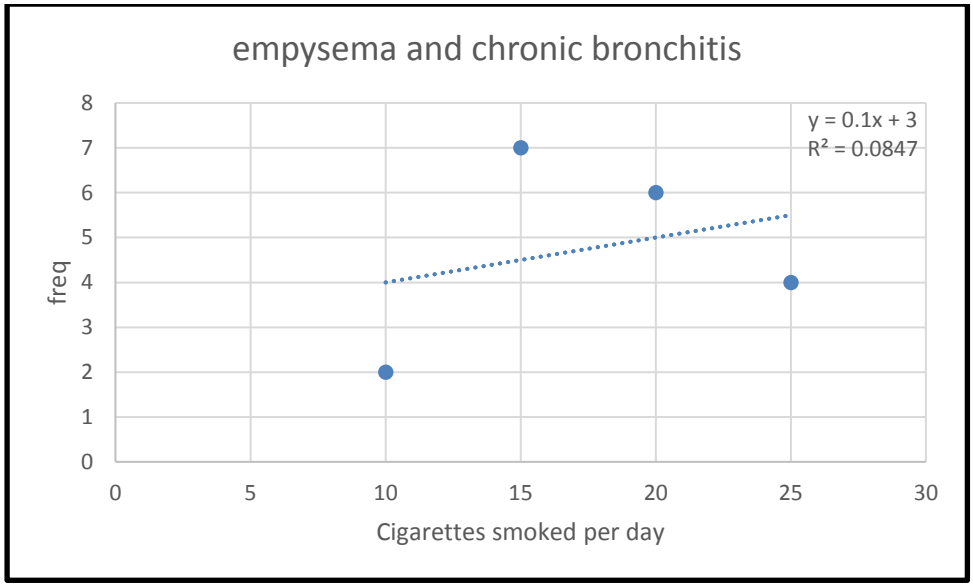

Figure (4-17): illustrate the relation between emphysema and chronic bronchitis and number of cigarettes smoked per day.

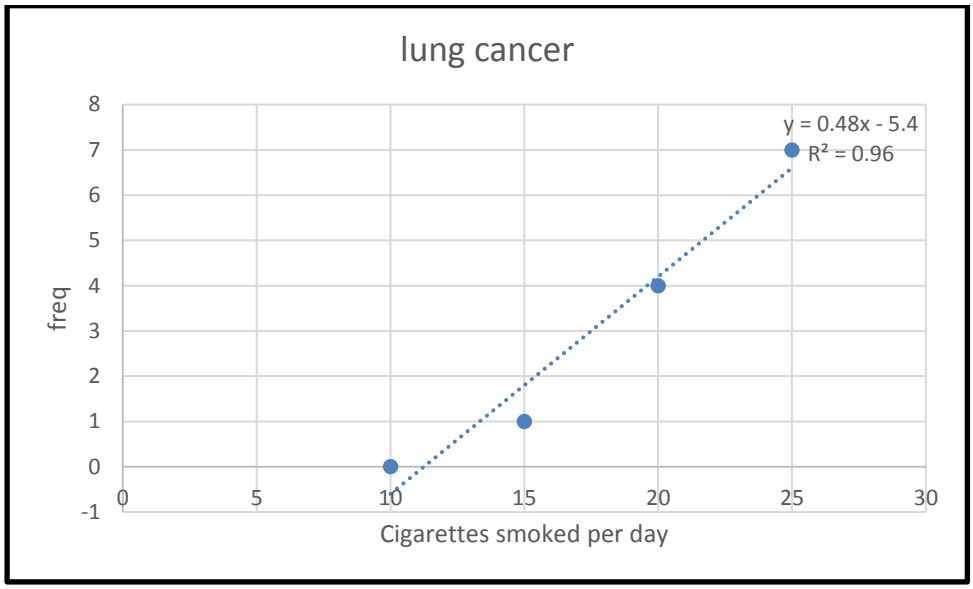

Figure (4-18): illustrate the relation between lung cancer and number of cigarettes smoked per day.

5.1 Discussion

This research shows that ages of the patients was ranging from 20 years up to 90 years old, divided into three groups, the most affected age group was (40-59) years. This is form percentage of about 53% as in table & figure (4-1).

Out of 100 cases, (30%) their duration of smoking is < 15 years, (51%) between 15-24 years, and (19%) were ≥ 25 years as in table & figure (4-2).

Out of 100 cases, (13%) smoked < 10 cigarettes per day, (41%) smoked 10-14 cigarettes per day, (27%) smoked 15-19 cigarettes per day, and (19%) smoked ≥ 20 cigarettes per day as in table & figure (4-3).

This research shows that most of the patients were presented with recurrent respiratory infection (97%) which is due to cigarettes smoking. This matches with (Miller M et al. 2011), they found that ex-smokers with COPD had persistent increased levels of mediators of inflammation in sputum which was associated with significant progression of COPD on chest CT scan. This was demonstrated in table & figure (4-4).

This research shows that all patients were presented with dyspnea and chest pain. This is due to developed airways obstruction. This matches with literature review (most of the patients develop airway obstruction that may lead to dyspnea and chest pain). Out of 100 cases, (16%) had hemoptysis, (13%) had cough with sputum, and (10%) had cyanosis as in table & figure (4-5), which is due to COPD. This matches with literature review (the symptoms have insidious onset, with morning smoker's cough with sputum, worsening exertional dyspnea leading to hypoxemia, increase number of chest infection which can lead to fever). (David Alvesion, 2008)

Out of 100 cases, (37%) had chronic bronchitis, (32%) had emphysema and (19%) had emphysema plus chronic bronchitis, and (12%) had lung cancer, as in table & figure (4-6), which is due to cigarettes smoking. This matches

with literature review (cigarettes - induce disease, such as myocardial infarction or lung cancer). (David Alvesion, 2008)

This research shows the relation between CT findings and age group. In the age group of (40-59), out of 54 cases had emphysema (65%), emphysema plus chronic bronchitis (38%) and lung cancer(6%) as in table (4-7) & figures (4-7), (4-8), (4-9) & (4-10). This matches with (Yasunaga k et al. 2013) (current smokers had higher percentage of emphysema) and (smoking causes many diseases, including chronic obstructive disease and lung cancer). (David Alvesion, 2008)

This research shows the relation between CT findings and duration of smoking. In the duration of smoking of (15-24) years, out of 49 cases had chronic bronchitis (16%), emphysema (51%), emphysema plus chronic bronchitis (26%) and lung cancer (6%), as in table (4-8) & figures (4-11), (4-12), (4-13) & (4-14). This matches with (Yasunaga k et al. 2013) (current smokers had higher percentage of emphysema).

This research shows the relation between CT finding and amount of cigarette smoked per day. Out of 100 cases, (41%) smoked (10-14) cigarette daily, (39%) had chronic bronchitis, (41%) had emphysema, (17%) had emphysema plus chronic bronchitis and (1%) had lung ca as in table (4-9) & figures (4-15), (4-16), (4-17) & (4-18). This matches with (Yasunaga k et al. 2013) (Correlations were found between the percentage of emphysema and (a) cigarette consumption).

5.2 Conclusion

Repeated attack of respiratory infection in chronic smokers could be prognostic unfavorable sign pointing towards a developing chronic obstructive pulmonary disease.

Our study shows that maximum number of patients belong to the (40-59) years age group, (25-39) years then ($\geq$ 60) years.

Most of patients with COPD were developed recurrent respiratory infection.

All patients were presented with dyspnea and chest pain.

Chronic bronchitis was presented in (37%) of patients, chronic bronchitis plus emphysema were presented in (19%) of patients, emphysema and lung cancer were presented in (32%, 12%) respectively.

As complication of the long term- heavy tobacco smoking are COPD and lung cancer.

Significant difference (p=0.0001) was found between CT findings and patients age.

Duration of smoking showed significant difference (p=0.003) compared with CT findings.

5.3 Recommendations

- Establishing lung diagnosing centers for smokers with modern CT machines and others lungs examinations.

- Patients with COPD should be check-up regularly by respiratory specialist to monitor the lungs.

- The best way to prevent COPD is to never start smoking.

- Trained health professionals and stop smoking services can provide advice on how to reduce the amount smoked, or how to stop smoking temporarily.

- We recommended that health care systems should raise the medical awareness about the risks of smoking, methods of cessation and the health effect issues to all Sudanese population generally and smokers specially.

- We recommend researching this topic with higher CT machines with 128 slices or more for more detailed.

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Appendices

Appendix A. Data sheet

The role of CT in diagnosing lungs diseases for smokers in Sudan

Data collection sheet

Date:

Case number: ( )

Personal data:

▪age…….

Clinical and history data:

▪duration of smoking in years……..

▪amount of cigarettes per day……...

▪Is the patient complaining of any of the following:

Dyspnea☐ Chest pain☐

Hemoptysis☐ Cough with sputum☐

Fever ☐ Cyanosis☐

▪ Is there any history of recurrent respiratory disease? (Y☐/N☐)

……

▪ Is there any history of heart disease?(Y☐/N☐)

……

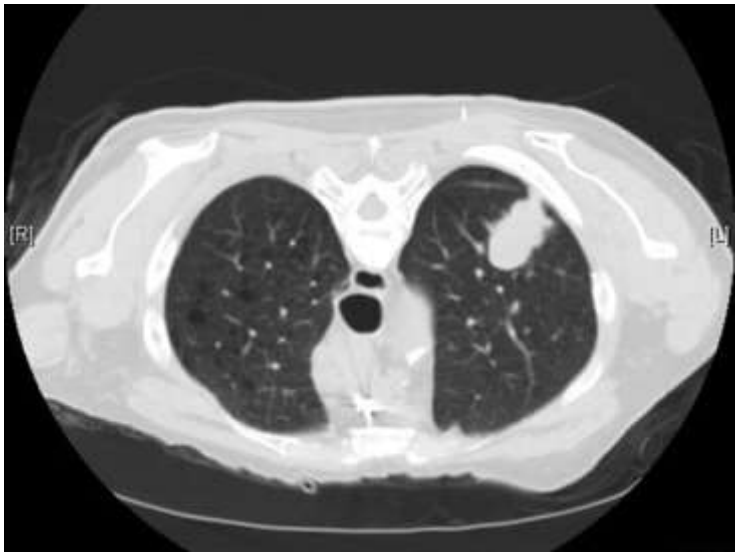
▪ CT findings:

-…….

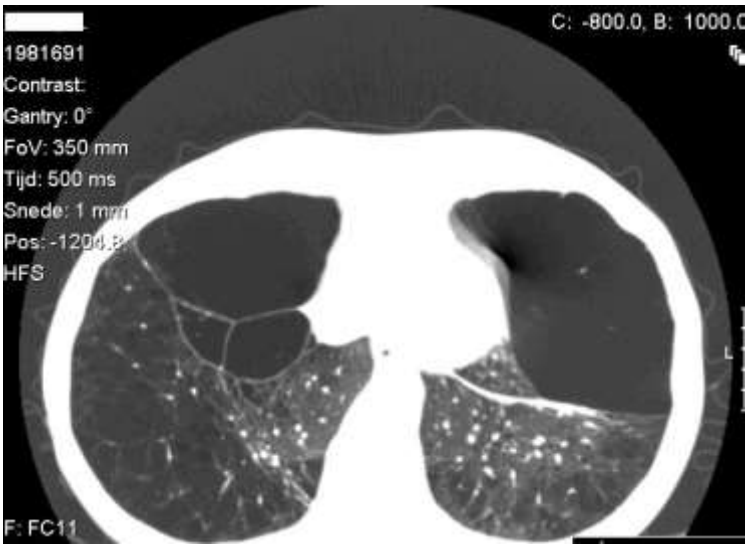
-…….

-…….

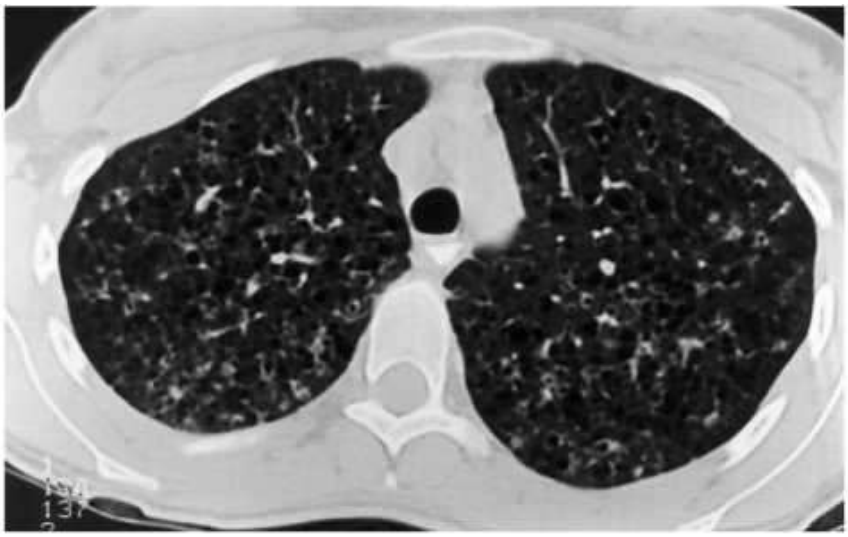
Appendix B. CT images



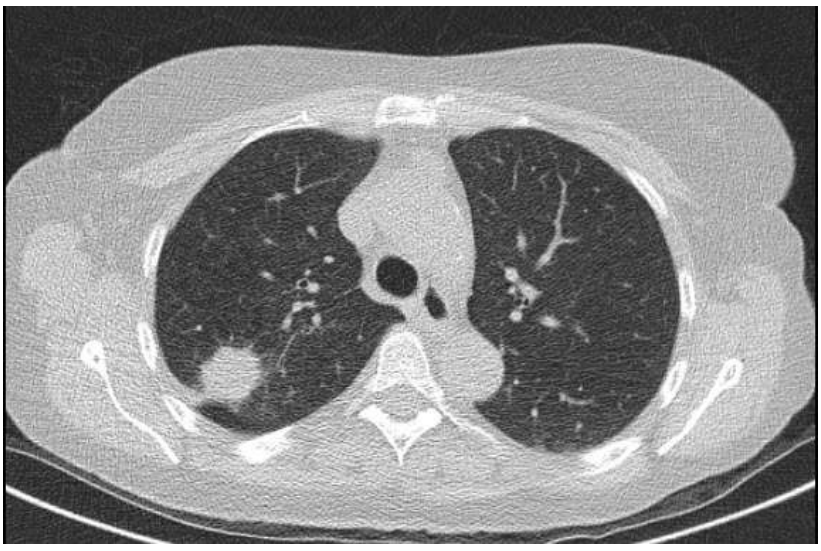
A computed tomography (CT) scan shows a large tumor in the left lung.



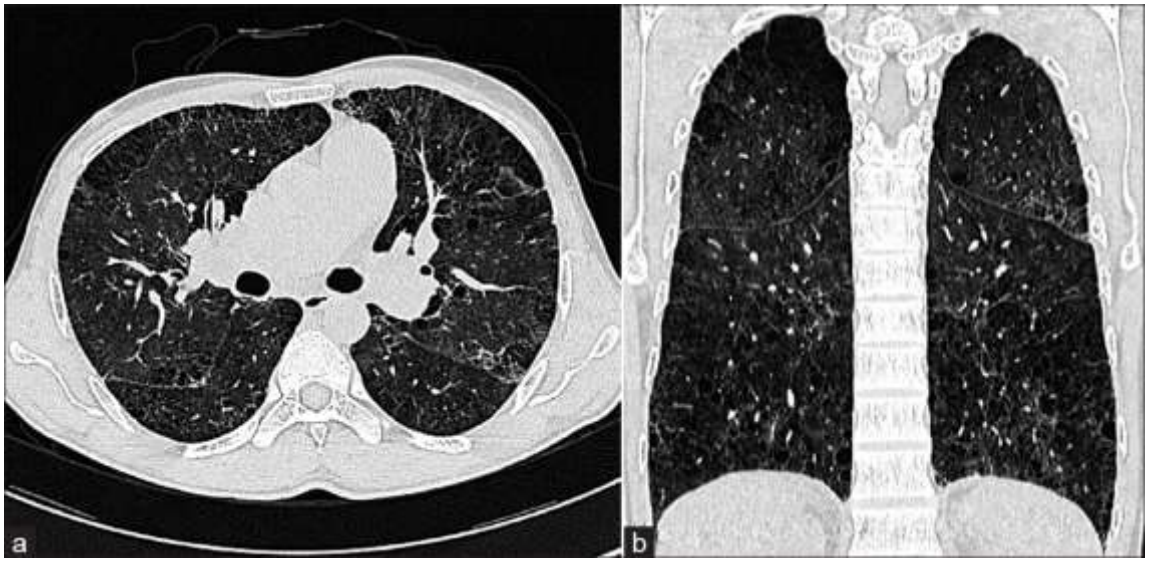
CT of the lung showing emphysema and bullae in the lower lung lobes of a subject with type ZZ alpha-1-antitrypsin deficiency. There is also increased lung density in areas with compression of lung tissue by the bullae.



HRCT in a patient with Langerhans cell histiocytosis (eosinophilic granuloma). HRCT demonstrates upper lung zone cystic changes and small nodular lesions that are characteristic of this disease.



This asymptomatic 57 year old smoker had a low-dose lung cancer screening CT. A highly suspicious spiculated mass was detected in the right upper lobe.



(a & b) High resolution computer tomography 4 years later showing centrilobular and paraseptal emphysema with associated areas of fibrosis which are not very well appreciated due to the predominance of emphysema.