Sudan University of Science and Technology

Collage of Graduate Studies

Measurement of Main Bronchi Longitudinal Diameter in Sudanese Population Using Computed Tomography

قياس عرض الشعبتين الهوائيتين الرئيستين لدى السودانيين باستخدام الأشعة المقطعية

A thesis submitted for partial fulfillment of MSc degree in Medical Diagnostic Radiological Technology

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الايه-:

قال تعالى

] وَإِذَا رَأَوْكَ إِنْ يَتَّخِذُونَكَ إِلَّا هُزُوًا أَهَذَا الَّذِي بَعَثَ اللهُ رَسُولًا (41) إِنْ كَادَ لَيُضِلُّنَا عَنْ آَلِهَتِنَا لَوْلَا أَنْ صَبَرْنَا عَلَيْهَا وَسَوْفَ يَعْلَمُونَ حِينَ يَرَوْنَ العَذَابَ مَنْ أَضَلُّ سَبِيلًا (42) أَرَأَيْتَ مَنِاتَّخَذَ إِلَهَهُ هَوَاهُ أَفَأَنْتَ تَكُونُ عَلَيْهِ وَكِيلًا (43) أَمْ تَحْسَبُ أَنَّ أَكْثَرَهُمْ يَسْمَعُونَ أَوْ يَعْقِلُونَ إِنْ هُمْ إِلَّا كَالأَنْعَامِ بَلْ هُمْ أَضَلُّ سَبِيلًا (44. [

سوره الفرقان الايات) (41- 44

Dedication

- **To my dear and beloved mother**

- **To my father and my sisters**

- **To my family**

- **And to my friends**

Acknowledgment

I would like to thank my friends and colleague Auis bashir Mohammad, Ahmed Mohamed Osman and Omer Ali Omer who help me in this research.

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And all thanks to my family and my teachers who guided me in my study.

And in the first and last all thanks to Allah.

ملخص البحث :-

اجريت هذه الدراسة التحليلية من سبتمبر الى نوفمبر 2015 داخل ولاية الخرطوم)مستشفى الرباط الجامعي , مركز الامل التشخيصي ومركز انطاليا الطبي (

الهدف من الدراسة قياس عرض الشعبتين الهوائيتين الرئيستين لدى الاشخاص السودانيين بواسطه اجهزه الأشعةالمقطعية.

اجريت القياسات على خمسين شخصا خضعوا جميعا لفحص الاشعةالمقطعية للصدر وتتراوح اعمارهم بين 20 الى 90 عاما اخذت القياسات من الاشخاص الطبيعيين وليست لديهم اي امراض صدرية

من الخمسين حاله هناك 23 ذكر و 27 انثى استبعدت الدراسه جميع الحالات التي لديها اي امراض صدريه او التواء خلقي في العمود الفقري او اي نمو غير طبيعي والذي من شأنه ان يؤثر على الرئه او الشعب الهوائيه . ايضا استبعدت الحالات التي لديها امراض عدويه مثل الدرن او مرض توسع القصبات او اي حاله اجريت لها انبوب فموي .

من صوره الاشعه المقطعيه قام الباحث بقياس عرض الشعبتين الهوائيتين وجمع عمر الحالات .

تم تحليل البيانات بواسطه برنامج تحليل البيانات الاحصائي لايجاد الوسط الحسابي والانحراف المعياري ومدى الاختلاف بين البيانات

اجريت القياسات بواسطه اجهزه نيو سوفت 16 مقطع وتوشيبا 8 و 64 مقطع.

هذه الدراسة وجدت ان متوسط عرض الشعبة الهوائية الرئيسية اليمنى هو 12.37±1.7ملمتر ومتوسط عرض الشعبة الهوائية اليسرى هو 11.92±1.4ملمتر.

ولتحديد مدى القياسات الطبيعية اجريت قياسات اخرى على 10 مرضى لديهم امراض صدرية ووجدت الدراسة ان متوسط القياسات الطبيعية ضيق جدا وذلك بقرب القياسات الطبيعية مع القياسات الغير طبيعية.

الدراسه وجدت ان مرض الازمه يقلل من عرض الشعب الهوئيه ومرض النفاخ الرئوي يزيد من عرض الشعب الهوائيه

ايضا وجدت الدراسة ان التقدم في العمر ربما يزيد من توسع الشعبتين الهوائيتين.

وجدت هذه الدراسه ان قياسات الشعبتين الهوائيتين لدى السودانيين قريبه من متوسط الشعبتين الهوائيتين لدى الفرس والاوربيين .

توصي هذه الدراسه بدراسات مستقبليه بعدد اكبر من العينات.

توصي بدراسه مستقبليه تبحث في العلاقة بين زياده عرض الشعب الهوائيه والتقدم في العمر .

Abstract:-

This study was carried out from September to November 2015 in Khartoum state (Elribat University Hospital, Alamal Diagnostic Center and Antalya Medical Center).

The aim of this study to measure main bronchi longitudinal diameter in Sudanese population by using CT

The measurement was done from 50 cases there age ranged between 20 to 90 years all these patients under go CT chest scan and there chest was normal from any disease. From 50 cases there are 23 males and 27 females, and study exclude any case with Any musculoskeletal deformity. Kyphoscoliosis, Destructive lung pathologies including fibrosis, bullas, retractions, Meditational and/or extra-bronchial masses compressing large Tracheoomegaly, Tracheomalacia, Bronchiectasis Chronic tuberculosis, Any history of laryngo-tracheal intubation for more than 3 days.

The measurement was done by TOSHIBA 64 - 8 slices and NeuViz 16-slice machines.

From CT image the author measure the two main bronchi longitudinal diameter and collect the age of cases.

The data analysis was done by SPSS program to find out the mean, stander deviation and variance.

This study concludes the mean diameter of right main bronchus in Sudanese population is 12.37 ± 1.7 mm and the mean diameter for left main bronchus 11.92 ± 1.4 mm.

And to find out the range of normal measurement other 10 patients with pathology in their chest were measured and the study found the range of normality is very narrow because the normal measure is close to abnormal.

The study found the asthma narrowing the air way tree. The Atelectasis dilates the two main bronchus; The Emphysema dilates the two main bronchus.

The study found the increase of age my increase of diameter of two main bronchi.

The study concludes that the Sudanese people have diameter for right and left main bronchus close to Persian.

This study recommends further study in measurements of main bronchi and air tree with large sample of population.

Study recommends further study done to prove if there was relation between increase of diameter of two main bronchi and age.

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List of Abbreviations:-

CT: Computed tomography

DSA: Digital Subtraction Angiography

µm: Nano Meter

COPD: Chronic Obstructive Pulmonary Disease

CAT: Computed Axial Tomography

MRI: Magnetic Resonance Imaging

MAS: Milli Ampere Second

Kvp: kilo voltage peak

mm: Millie Meter

Cm: Centy Meter

IV: Intra Venous

HRCT: High Resolution Computed Tomography

FOV: field of view

HU: Hounsfield unit

MSCT: multi slice computed tomography

DLT: double lumen tube

LMB: left main bronchus

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Chapter One

Introduction: -

The trachea connects the upper respiratory tract to the lower respiratory tract. It is about (9-15) cm in length. It is located in front of the esophagus and behind the thyroid gland in the neck; the trachea bifurcates into the right and left main stem bronchus at a location called the carina, which is located at the level of the sternal angle (T4-T5). (Snell 2012)

Right Principal Bronchus is wider, shorter, and more vertical than the left, is about 1 in. (2.5 cm) long before entering the hilum of the right lung, it gives off the superior lobar bronchus. On entering the hilum, it divides into middle and an inferior lobar bronchus, Left Principal 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 oesophagus. (Snell 2012)

On entering the hilum of the left lung, the principal bronchus divides into a superior and an inferior lobar bronchus. (Snell 2012)

The bronchi and the connective tissue of the lung receive their blood supply from the bronchia

l arteries, which are branches of the descending aorta The bronchial veins communicate with the pulmonary veins and drain into the azygos and hemiazygos (Snell 2012)

It acts as air passages from upper respiratory tract to lung.

The trachea and main bronchi are affected by several pathologies which includes: (COPD) chronic obstructive pulmonary disease, Restrictive lung disease (interstitial lung disease), and Respiratory tract infection, like Pneumonia and Lung cancer.

GN Hounsfield, a senior research scientist in Middlesex, England announced the invention of a revolutionary imaging technique. In the year 1972, that he called computed axial transverse scanning (tomos— meaning section, graphy—picture in Greek). (Chegu 2005)

He presented a cross-sectional image of the head that revealed the internal structures of the brain in a manner previously only seen at surgery or autopsy and for the first time pathologic processes such as blood clots, tumors, and strokes could be easily seen noninvasively. (Chegu 2005)

In this study we measure the diameter of two main bronchus using CT chest high resolution images.

We select fifty patients randomly which undergone CT chest examination and they have normal chest imaging

Also we measure other 10 patients with pathology to find out the range of normality by compare the normal measure with abnormal measure

1-2 General objectives: -

To measurement of the main bronchi diameter in Sudanese population CT

1-3 Specific Objectives: -

1-3-1 To find out the average of normal diameter of the bronchi in the Sudanese people

1-3-2 To compare the results with reference values

1-4 Problems of the

The diameter of the bronchi is varying from subject to other this variation may due to pathology condition

Chapter Two

Theoretical background and previous study

2-1 Anatomy of the trachea and bronchi: -

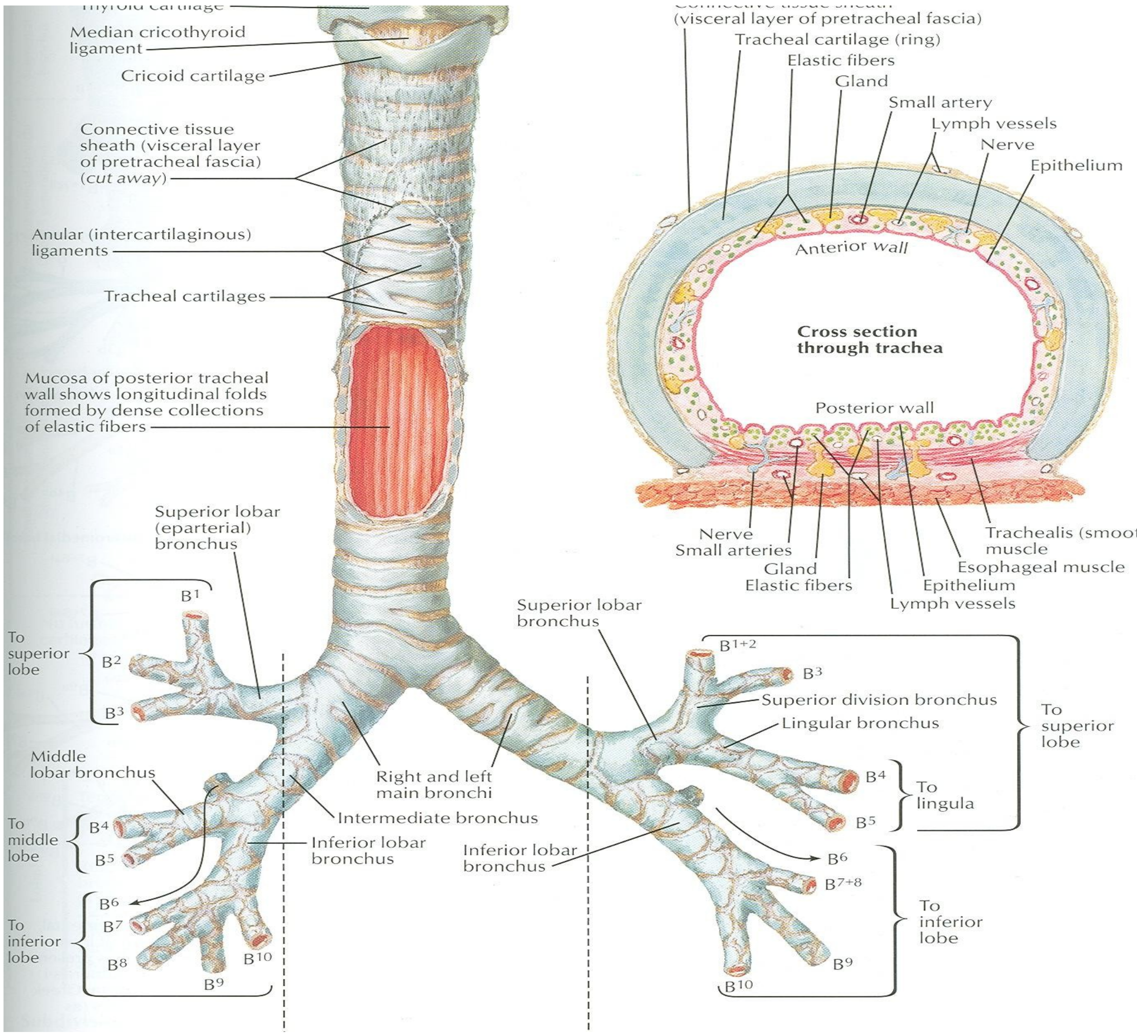

Figure (2-1): show the anatomy of air way

The trachea connects the larynx with main bronchi. It is located on the midline of the body, with its distal part usually displaced to the right side. The upper border of trachea is placed higher in children as compared to adults. In a newborn it lies at the level of second cervical vertebra. (Snell 2012)

As the descent of the larynx occurs its upper border reaches fifth cervical vertebra in a five-year-old child and finally comes to lie at the level of sixth vertebra in fifteenth year of life. (Snell 2012)

Similarly, the tracheal bifurcation is situated at the level of third or fourth cervical vertebra in new-born infants and at the fifth thoracic vertebra in adults. In an individual with a narrow thoracic cage the tracheal bifurcation may be situated at a higher level. (Snell 2012)

The cranial end of trachea is attached to the lower border of cricoids with the help of Crisco tracheal ligament. This attachment makes the larynx move up and down along with the larynx during respiration and swallowing.

The trachea is divided into cervical and meditational parts, by a line along the superior thoracic aperture when the neck is held in vertical position. In children the thoracic part is a little shorter than the cervical part, while in adults the thoracic part constitutes two-third of its entire length. From the operative surgical considerations, it is expedient to divide the thoracic portion of trachea in too three approximately equal parts, superior, mid and inferior. (Snell 2012

The trachea bifurcates into two main or primary bronchi. Within the tracheal bifurcation is a keel-shaped cartilage known as the carina.

The right main bronchus is wider, shorter, and runs more vertically than the left main bronchus. The left main bronchus is longer and passes inferior to the arch of the aorta and anterior to the esophagus and thoracic aorta.

The main bronchi later divide into segmental bronchi. A characteristic component that allows us to identify bronchi is the presence of cartilage that appear as chips and not semi-circular as in the trachea. (Snell 2012

Bronchi are lined with the pseudo tratified ciliated columnar epithelium (respiratory epithelium) with glands within the sub mucosa. (Snell 2012

Note the presence of bronchial arteries, which are distinc from pulmonary arteries and veins.

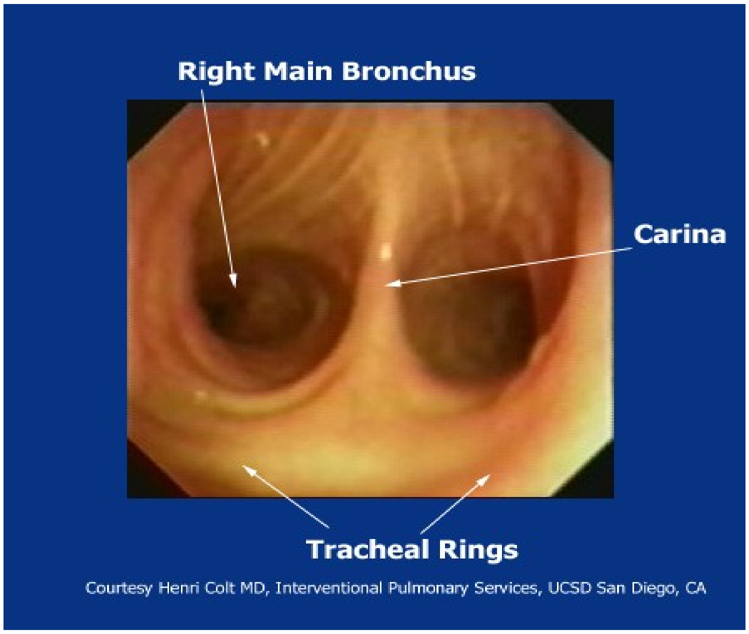

Figure (2-2). Show endoscopic imagining for two main bronchia

2-1-1 Right Principal Bronchus: -

Is wider, shorter, and more vertical than the left

Is about 1 in. (2.5 cm) long before entering the hilum of the right lung, it gives off the superior lobar bronchus, on entering the hilum, it divides into middle and an inferior lobar bronchus (Snell 2012

2-1-2 Left Principal 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 oesophagus, on entering the hilum of the left lung, the principal bronchus divides into a superior and an inferior lobar bronchus (Snell 2012

2-1-3 Blood Supply: -

The bronchi and the connective tissue of the lung receive their blood supply from the bronchial arteries, which are branches of the descending aorta
The bronchial veins communicate with the pulmonary veins and drain into the azygos and hemiazygos veins (Snell 2012)

2-2 Physiology: -

Physiology of the Tracheobronchial Tree and Lung Airways

The tracheobronchial tree conducts the inspired air to and from the alveoli. During inhalation the distal end and bifurcation of the trachea are displaced downwards, which is important for facilitating inspiration. The epithelial changes in the bronchi reflect the physiological functions of the airway. For example, the ciliated columnar epithelium in the early branch generations allow for both heating and conditioning of the air as well as filtering through mucociliary action to remove mucous secretions in an upward motion towards the esophagus. In the distal branches, the epithelium becomes cubical to allow for gas exchange. The cartilage support around the trachea and early branches also changes, progressively diminishing in order to maintain patency of the smaller airways. During gas exchange oxygen is brought into the body and is exchanged with carbon dioxide that is produced from cell metabolism. (Snell 2012

This occurs in the alveolar-capillary network which consists of a dense mesh-like network of the respiratory bronchioles, the alveolar ducts, the alveoli, and the pulmonary capillary bed. At the gas exchange surface of the alveoli is a lining that is 1–2 μm thick where O_2 and CO_2 passively diffuse across and in to plasma and red blood cells. (Snell 2012)

The diffusion occurs between the alveolar gas and blood in the pulmonary capillaries within less than one second (Snell 2012

2-3 Pathology:

Disease of the Tracheobronchial Tree and Lung Airways: -

The cross-section of the trachea typically has a coronal-to-sagittal diameter ratio of 0.6:1.0, and narrowing of the coronal diameter producing a coronal/sagittal ratio of < 0.6 is then termed a sabre sheath trachea and is seen in patients with chronic obstructive pulmonary disease (Brant and Helms 2007). A slight tracheal deviation to the right after entering the thorax can be a normal radiographic finding and in some instances, the presence of the aortic arch can lead to the left lateral wall of the distal trachea being indented by the transverse portion of the aortic arch. In younger individuals the trachea is elastic and extensible, while in older people it is more rigid or even sometimes ossified, so that it is less distensible. (Snell 2012)

There are many reported diseases of the lung airways (pulmonary disease) ranging from the common cold to life-threatening examples such as bacterial pneumonia or cancer, and include:

2-3-1 Chronic Obstructive Pulmonary Disease (COPD): -

One of the most common pulmonary diseases (e.g. bronchitis, emphysema and asthma), resulting in the inflammation of the airways which in turn causes narrowing and obstruction of the airways, seriously affecting the capacity for normal respiratory function. (Snell. 2012)

2-3-2 Restrictive lung disease (interstitial lung disease): -

Is a disease of the lung parenchyma (covering layer of the lungs), and the connective tissue that hold the air sacs together. This results in a decreased ability to breathe in because of incomplete lung expansion and increased lung stiffness. (Snell 2012

2-3-3 Respiratory tract infection: -

Any infections that can affect any part of the respiratory system such as viral or bacterial. This is normally categorized as an upper respiratory tract infection (nose, sinus, pharynx, and larynx) or a lower respiratory tract infection. The most common lower respiratory tract infection is pneumonia. (Snell 2012)

2-3-4 Lung cancer: -

is a disease of uncontrolled cell growth in tissues of the lung. The collection of these cells forms a tumor which is either malignant or benign. The spread of the disease to other tissues in the lung and even other body organs has serious health

effects and from a respiratory perspective results in a decline in all aspects of respiratory function. (Snell 2012)

2-4 Investigations done to chest:

2-4-1 Laboratory Investigation:

Total White Blood Cells:

This used in case of inflammation Normal count 4000-11000/mm^3 (Snell 2012)

2-4-2 **Radiological investigations:**

2-4-2-1 Chest x ray:

Chest x ray demonstrate most of chest disease such as infection tuberculosis and other disease (Karthikeyan et al 2005)

2-4-2-2 Computed Tomography:

It is a radiological imaging modality, usually used with contrast in cases of pulmonary disease and with different protocol, because of its higher sensitivity of detecting air way diseases (Karthikeyan et al 2005)

2-4-2-3 Ultrasound: -

Echo cardiography demonstrate the heart anatomy

2-5 Computed tomography (CT): -

In conventional X-ray imaging, the entire thickness of the body is projected on a film: structures overlap and are difficult to distinguish

One of the problems is the loss of information about depth. Suppose a small lung carcinoma can be seen at a front-to-back chest photograph. The radiologist cannot determine the exact location of this carcinoma This became possible when Geoffrey N. Hounsfield presented the first CT scanner in 1972. (Karthikeyan et al 2005)

This new technique of computed tomography (CT) reconstructs a cross-sectional image of the body from a ‘virtual pile of X-ray photographs’. A tomographic image is an image of a slice through the body. The word ‘tomography’ comes from the Greek: tomos means slice, graphe in stands for ‘to write’. So, tomography literally means ‘writing slices’. Structures and lesions previously impossible to visualize can now be seen with remarkable clarity. (Karthikeyan et al 2005)

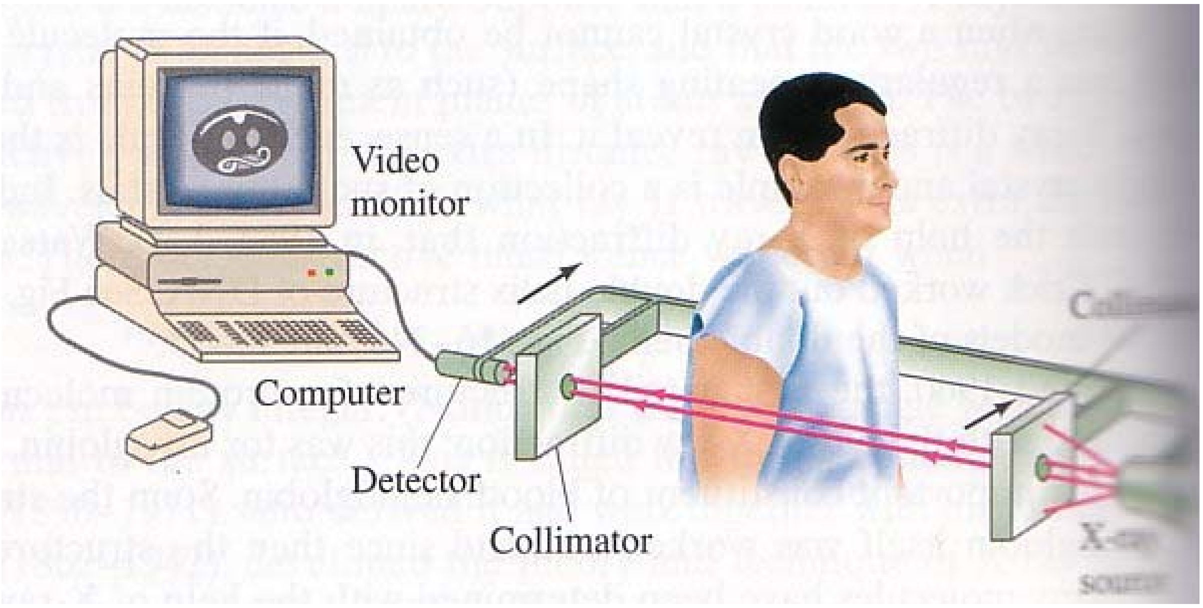

Figure 2-3. Show the basic principle of CT

A thin collimated beam of X-rays passes through the body to a detector that measures the transmitted intensity. The collimator is a set of narrow lead tubes or an array of small holes in a lead plate, resulting in a thin straight beam of X-rays. Measurements are made at a large number of points as the source and detector are moved past the body together. The apparatus is then rotated slightly about the body axis and again scanned. This is repeated at, for example, 1° intervals for 180°.(Karthikeyan et al 2005)

The intensity of the transmitted beam for the many points of each scan, and for each angle, is sent to a computer that reconstructs the image of the slice. The image is presented on a computer monitor. (Karthikeyan et al 2005)

Note that the imaged slice is perpendicular to the long axis of the body. For this reason, CT is sometimes called computed axial tomography (CAT), (Karthikeyan et al 2005)

Although the abbreviation CAT, as in CAT scan, can also be read as computer-assisted tomography. (Karthikeyan et al 2005)

The slice to be imaged as being divided into many tiny picture elements or pixels.

For CT, the width of each pixel is chosen according to the width of the detectors and/or the width of the X-ray beams. This determines the resolution of the image, which is typically about 2 mm. (Karthikeyan et al 2005)

An X-ray detector measures the intensity of the transmitted beam after it has passed through the body. (Karthikeyan et al 2005)

Subtracting this value from the intensity of the beam at the source, we get the total absorption. Note that only the total absorption along each beam line can be measured: the absorption by all the pixels in a line. To form an image, we need to determine how much radiation is absorbed at each pixel (Karthikeyan et al 2005)

We can then assign a ‘grayness value’ to each pixel according to how much radiation was absorbed. The image, then, is made up of tiny spots (pixels) of varying shades of grey, as is a black-and-white television picture. Often the amount of absorption is cooler-coded. The colours in the resulting ‘false colour’ image have nothing to do, however, with the actual colour of the object. (Karthikeyan et al 2005)

Finally, we must discuss how the ‘grayness’ of each pixel can be determined even thoug hall we can measure is the total absorption along each beam line in the slice. It can be done only by using the many beam scans made at a great many different angles.

Suppose the image is to be an array of 100 × 100 elements for a total of 104 pixels. If we have 100detectors and measure the absorption projections at 100 different angles, then we get 104pieces of information. From this information, an image can be reconstructed, but not precisely. If more angles are measured, the reconstruction of the image can be done more accurately. (Karthikeyan et al 2005)

There are a number of mathematical reconstruction techniques, all of which are complicated and require the use of a computer.

To suggest how it is done, we consider a very simple case using the so-called **iterative technique**. The verb ‘to iterate’ is derived from the Latin expression for ‘to repeat’. Although this technique is less used now than the more direct ‘Fourier transform’ and ‘back projection’ techniques, it is the simplest to explain. Suppose our sample slice is divided into the simple 2 × 2 pixels. (Karthikeyan et al 2005)

The number in each pixel represents the amount of absorption by the material in that are that is, 4 represents twice as much absorption as 2. But we cannot directly measure these values – they are the unknowns we want to solve for. (Karthikeyan et al 2005)

All we can measure are the projections – the total absorption along each beam line – and these are shown in the diagram as the sum of the absorptions for the pixels along each line at four different angles. These projections (given at the tip of each arrow) are what we can measure, and we now want to work back from them to see how close we can get to the true absorption value for each pixel. We start our analysis with each pixel being assigned a zero value (Karthikeyan et al 2005)

It is generally agreed that CT scanning has revolutionized some areas of medicine by providing much less invasive, and/or more accurate diagnosis.

Computed tomography can also be applied to ultrasound imaging, magnetic resonance imaging (MRI) and to emissions from radioisotopes in nuclear medicine. (Karthikeyan et al 2005)

2-5-1 The CT scanner:-

Computed tomography is an imaging technique that produces cross-sectional images, representing in each pixel the local X-ray attenuation properties of the body.

The first experimental set-up of Hounsfield in 1970 worked with the so-called translation/rotation principle. A thin beam of X-rays was generated through the use of a collimator and a singled detector element was used to measure the attenuated intensity. By translating this set-up, different positions were measured. After an entire set of parallel measurements had been acquired, the set-up was rotated to acquire the next parallel projection. (Karthikeyan et al 2005)

This principle was used in what is now called the 1st generation of CT scanners.

The **2nd generation** CT scanners differed only slightly from that initial design in that a small number of measurement values could be obtained simultaneously. In Hounsfield's first commercially available scanner a total of 180 projections were obtained in steps of 1° with160 measurement values each. The acquisition of those 28.800 measurement values took five minutes. (Karthikeyan et al 2005)

From that data an image of 80 × 80 pixels was reconstructed. With such a scanner, a head examination requiring six slices took about half an hour. Therefore ,physicists were aiming at shortening the examination times. (Karthikeyan et al 2005)

This was achieved with the introduction of the **3rd generation** CT scanners: a 1D array of detector elements positioned on an arc covers the entire measurement field and acquires a complete 'fan-beam 'projection. This not only avoided the slow translation movements, but also improved the efficiency of using the output of the X-ray tube.

Figure (2-4). Show 3rd generation of CT scanner

As figure shows, a modern3rd generation CT scanner is a machine consisting of a donut-shaped gantry with a big hole. (Karthikeyan et al 2005)

Head, body, arms or legs have to be in the middle of the scanner to make a cross-sectional image. The patient is moved in and out on a motor-controlled table. [4]

The slice thickness is usually 0.5 to several mm and the spatial resolution (in the cross section) is roughly 1 mm at 512 × 512 pixels per slice. (Karthikeyan et al 2005)

Within the ring of the CT scanner an X-ray tube is placed opposite a detector array with up to 1200 detecting elements, which receive the photons that went through the patient.

If one measurement has been done this way, the source and detector rotate over a small angle(roughly 1°) and a new measurement is taken. (Karthikeyan et al 2005)

The scanner repeats this procedure until a rotation of 180° has been reached. Then all thousands of measurements for reconstructing one slice have been done. The table on which the patient lies can then move a little further through the ring for measuring a new slice. (Karthikeyan et al 2005)

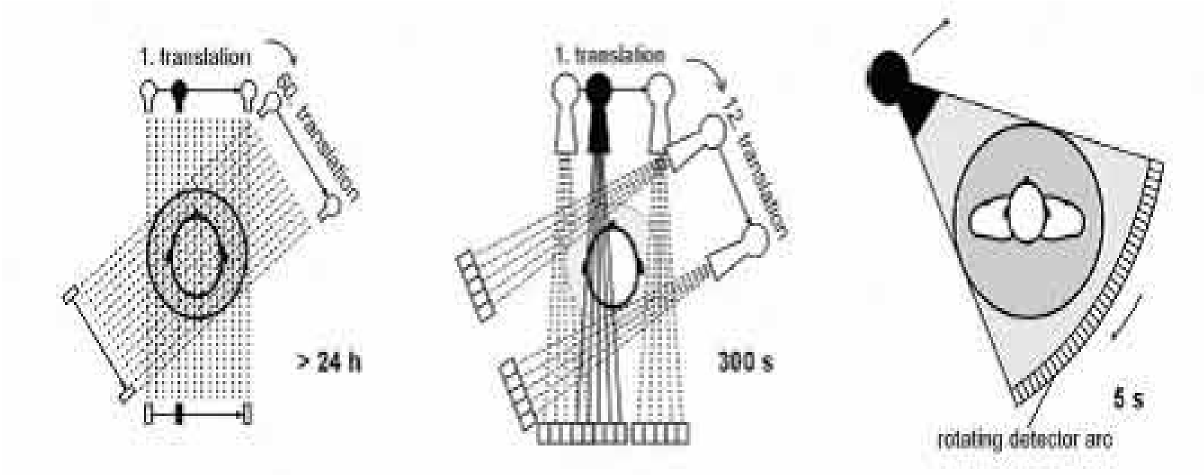

Figure (2-5)CT scanner generations. Left: 1st generation – pencil beam (1970). Centre: 2nd generation – partial fan beam (1972). Right: 3rd generation – fan beam(1978).

Spiral CT – In 1987 continuously rotating gantries were introduced to shorten examination times even more: spiral or helical CT. Up to that time, power supply to the rotating gantry and data transmission out of the gantry was performed via cables. (4)

Therefore, the direction of rotation had to be reversed after each scan, substantially slowing down the acquisition of a series of images and making the system rather vulnerable for mechanical cable damages. (Karthikeyan et al 2005)

These drawbacks were overcome with the introduction of slip ring technology for the power supply and optical transfer for data transmission. The patient is moving slowly (1-3mm/s) and continuously while the scanner rotates constantly at about 1-3 rotations/s. Spiral

CT has the important advantage to be fast: modern scanners can collect and reconstruct a high-resolution slice of 512 × 512 pixels within half a second. (Karthikeyan et al 2005)

Multi-slice CT – In 1998, several manufacturers introduced multi-slice CT (MSCT) systems. This new technique allows the simultaneous acquisition of multiple images by using 2 to 16 detector arrays next to each other.

With the simultaneous acquisition of several slices, imaging times are shortened significantly. A four-slice system with a 0.5 s rotation makes it possible to take a CT of the lungs in a few seconds while the patient holds his breath. (Karthikeyan et al 2005)

Other motion artifacts 'disturbing' the image, like the beating of the heart, become less too. Short scan times also avoid the need to wait for tube cooling between scans.

2-5-2 System details:

2-5-2-1 CT scanner X-ray tube:

Proper reconstruction of the CT scans is only possible if a very large number of photons are available for the detectors. (Karthikeyan et al 2005)

If the acquired projections are not statistically well-determined, the reading from a detector will be noisy and the reconstruction algorithm will propagate this noise, leading to unacceptable high noise in the final image. Thus, normally, the CT scan is done with a high output from the CT tube corresponding to large kilovolts and milli ampere settings. As the scans are normally extended for many slices and many revolutions, the final dose can be as high as 50 to 100 milli 17emodel. As the number of CT scans has been increasing with the wide spread installation of potent multi-slice and/or spiral scanners, the total collective radiation dose from CT scans to the entire medical irradiation constitutes a major part. (Karthikeyan et al 2005)

The high current and voltage and the extended exposure time, deposits very large amounts of primary electron beam energy in the anode of the X-ray tube. Special tubes have been developed for these X-ray scanners, with large, fast rotating anodes of high melting point materials. Special problems are related to the technology of bringing electricity of high voltage forward to the X-ray tube, rotating at an orbital diameter of more than one meter with the speed of more than two revolutions per minute. [5]

The rapid revolution of X-ray tube and perhaps detector chain also puts a large mechanical strain on the entire X-ray gantry, which must be of extraordinary sturdy construction. (Karthikeyan et al 2005)

2-5-2-2 Detector chain technology

Today, at least three types of detectors are used. These detectors can be classified according to the type of material stopping the X-rays:

- Gas (Xenon).
- Scintillator (transforms the X-ray energy into visible light, detected by a photo diode)
- Solid state semiconductor

The gas detectors are less efficient than the other two types of detectors, but by using high pressure, and extended radial dimensions efficiencies as high as 40 % can be achieved. This “deep” detector has the important property of being most sensitive to radically incoming X-rays thus providing inherence protection against too much scattered radiation. With the other two detectors, which are more like surface detectors, the scattered radiation cannot be separated, and must be removed by the mathematical reconstruction algorithm. This is possible, because the scattered radiation has little spatial structure, and can thus be detected and subtracted as a uniform blanket in the image matrix. (Karthikeyan et al 2005)

With many detectors in each chain and many slices the total data sampling rate of a modern CT scanner is extremely high.

At present, it is exactly this data sampling rate which limits the performance of state-of-the-art CT scanner technology. (Karthikeyan et al 2005)

2-5-3 Image reconstruction:-

Imagine splitting up a piece of different tissues into many mini cubes and sending X-ray beams through them at different angles. Detector elements receive signals depending on the different attenuation coefficients μ in each cube along the distance they have to travel. The line of cubes consists of different tissues with different atomic densities.

The attenuated intensity I of the X-ray beams at the detector depends on the intensity I0 at the source, the attenuation coefficients μ of the different tissues and the path length d.

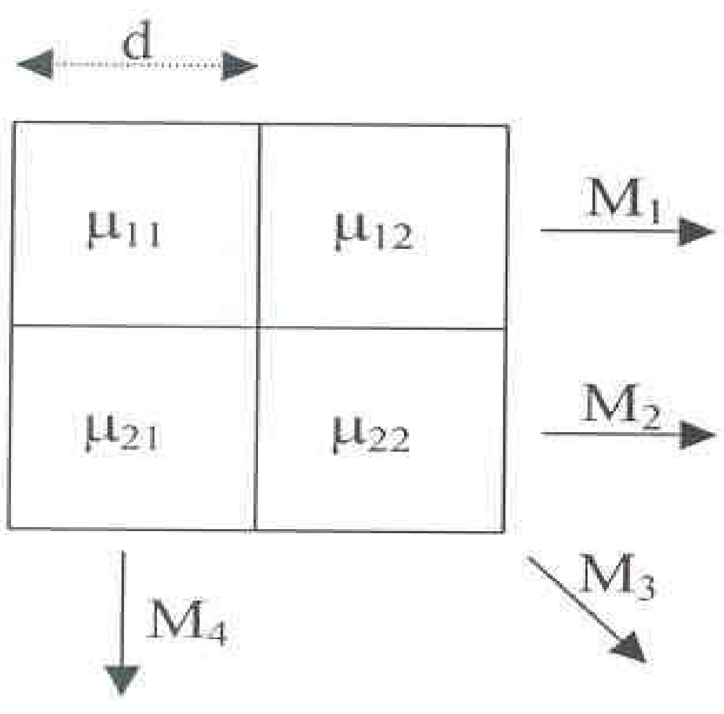

Figure (2-6) shows a very simplified example to explain how image reconstruction works.

Suppose our patient slice contains only four pixels. In such a case we are dealing with four unknown attenuation coefficients ($\mu 11$ to $\mu 22$). Of this four-pixel object four transmission intensities (I1 to I4) are measured. Assume that every pixel has a uniformly distributed absorption coefficient. The size of the pixels is given by d.

To calculate the absorption coefficients of the four pixels, we have four equations with four unknowns:

$I1 = I0 \cdot e{-}(\mu 11d + \mu 12d)$

$I2 = I0 \cdot e{-}(\mu 21d + \mu 22d)$

$I3 = I0 \cdot e{-}(\mu 11d\sqrt{2} + \mu 22d\sqrt{2})$

$I4 = I0 \cdot e{-}(\mu 11d + \mu 21d)$

This simple problem of four equations with four unknowns can easily be solved, but one can imagine that larger images as used in daily clinical routine (512 × 512 pixels = 262144unknown μ values) need highly sophisticated algorithms to solve so many equations. The most widely used algorithm is the filtered back-projection method, using Fourier transform. (Karthikeyan et al 2005)

Scientists are still searching for better algorithms nowadays.

Hounsfield units – To honour Hounsfield for his work the mean X-ray attenuation within one pixel (also known as CT number) is expressed in Hounsfield units (HU). Measured values of attenuation are transformed into CT numbers using the international Hounsfield scale

$CT\ number = 1000 \cdot (\mu - \mu water)/\mu water$

In this expression μ is the effective linear attenuation coefficient for the X-ray beam.

This scale is so defined that air and water respectively have the following CT numbers: –1000and 0 HU.

2-5-4 Clinical use:-

Compared to the projection images in conventional X-ray photography, the slice images give a much better contrast between different tissues.

This is one of the main advantages of CT. This imaging technique is applied to obtain anatomical images of all parts of the human body. CT is often used to detect cancer or follow the growing of tumors over time. (Karthikeyan et al 2005)

As tumors are often well supplied with blood vessels (as they need much supply due to their fast growth), the use of contrast agents can make them visible. Timing is therefore important in CT imaging too. A dynamical serial measurement can be studied to detect the changes in blood vessel filling after the contrast agent is applied.

Also measuring the size of the bladder or detecting water in lungs is usually done with CT scanners. As CT is based on X-ray attenuation, a contrast agent with iodine (in blood vessels) or barium (in the intestines) is often used, like in conventional X-ray imaging and Digital Subtraction Angiography (DSA) (Karthikeyan et al 2005)

Because CT is more sensitive to small intensity differences, small diffused concentrations outside blood vessels or cavities can also be detected. (Karthikeyan et al 2005)

3D images – From a whole stack of CT scans one can make a real 3D reconstruction,

. One can even make a ‘virtual endoscopy’. In such a case the intestines in the patient are emptied and slightly filled with air. (Karthikeyan et al 2005)

Then a large series of high resolution CT scans is made. The radiologist can make a virtual flight through the intestine canal to search for polyps in the full nine meters of intestines.

Another way of visualizing the intestine canal is the ‘unfolded cube view’, in which all six viewing directions are projected in one cubical view.

Real 3D CT images are also often used in radiotherapy clinics, where patients with cancer are treated by high intensity radiation at the tumors location. To make a treatment plan for the patient one can calculate by image processing on the CT slices which radiation dose will be delivered where. Clinical physicists play an important role in the dose calculations and radiotherapy treatment planning, avoiding radiation of vital organs as much as possible. (Karthikeyan et al 2005)

2-5-5 Radiation safety:-

Radiation doses in CT are relatively high. For example, the effective dose of a head scan is2 mSv, of the thorax 10 mSv and of the abdomen 15 mSv. This is a factor 10 to 100 higher than radiographic images of the same region,

But the diagnostic content of the CT images is typically much higher. Some scanners use a lower tube current and a higher voltage to reduce the dose. However, there is still some risk to a developing fetus. CT scans are therefore not recommended during pregnancy (Karthikeyan et al 2005)

2.6 Previous studies:

Study done by Nejad,etal . At 2011 they measure the Normal dimensions of trachea and two main bronchi in the Iranian population.

They found that Coronal and sagittal diameters of tracheas in the upper part were as follows: 1.8±0.24 and 2.06±0.27cm for men, and 1.48±0.20 and 1.49±0.24 for women, respectively. For the lower part that was: 1.8±0.23, 1.86±0.27, 1.51±0.18, and 1.46±0.23, respectively. For the right and left main-stem bronchi the values were as follows: 1.16±0.17 and 1.02±0.22 for men and 0.93±0.13 and 0.81±0.13 for women, respectively.

Nejad,et al . 2011

Study done by Lee et al 2014 they measured the lengths of the right and left main bronchi from the carina to the first of their branches and the AP and TR diameters at the mid-portion of the right main bronchus and 2 cm below the carina in the left main bronchus.

They determined the size of the left-sided double-lumen tube (DLT) based on the measured AP diameter of the left main bronchus from the 3D and 2D images, respectively they found the moderate correlation between the lengths of both main bronchi obtained from the 3D images and the 2D images, and between the AP diameter of the left main bronchus obtained from the 3D images and the 2D images. Same sized DLTs were estimated in 69% of the men and 34% of the women. (Lee et al 2014)

Study done by Bakker et al at 2011 they assess the influence of respiration on bronchial lumen area (defined as distensibility) in different segmental bronchi and to explore the correlations between distensibility and both lung function and emphysema severity, they found the Lumen area of third generation bronchi is dependent on inspiration level and this distensibility is different between bronchi in the upper and lower lobes. Therefore, changes in lumen area over time should be studied whilst accounting for the lung volume changes, in order to estimate the progression of bronchial disease while excluding the effects of hyperinflation. (Bakker et al 2011)

Study done by Grobbelaar et al at 2010 they determine if there was a significant difference between the measurements of compressed airway diameter in the axial plane compared with measurements of diameter using MPR for determining longitudinal axis of the airway; and to evaluate how measurements on lung window settings compare with soft tissue window settings.

They found that the degree of central airway 24emodeli is accurately assessed on axial images, obviating the need to perform MPR to obtain a true axial diameter of the airways in children. Measurements taken on soft tissue window consistently underestimate 24emodeli. (Grobbelaar et al at 2010)

Study done by Shimizu et al at 2011 they compare the airway 24emodeling assessed by computed tomography in asthma and COPD they found FEV1% predicted and FEV1 /FVC was similar between asthma and COPD (82.3 _ 3.3% vs. 77.6 _ 1.8% and 57.7 _ 1.6% vs. 57.9 _ 1.4%). At any generation, WA% was larger and was Ai smaller in asthma, both followed by COPD and then controls.

Significant differences were observed between asthma and controls in WA% of the 3rd to 5th generation and Ai of any generation, while no differences were seen between COPD and controls. There were significant differences in Ai of any generation between asthma and COPD. (Shimizu et al 2011)

Study done by Hampton et al at 2000 they measure the Diameter of the Left Main Bronchus in chest x ray they found The mean diameter of the left main bronchus (LMB) was 12.6±1.9 mm. The mean diameter of the 92 male LMB was 13.0±2.6, and for females 11.8±1.6. These data correspond closely to that reported by others. The correlation between the diameter of the LMB and that of the trachea was 0.74 but was not precise enough to be useful as an estimate for clinical use. Similarly there was good correlation between the diameter of the right main bronchus and that of the left (r=0.75) but not precise enough to be clinically useful.

In contrast to previous claims, only direct measurement of the left main bronchus has sufficient precision to define the appropriate size of left double-lumen tube to be selected for lung separation. (Hampton et al 2000)

Chapter Three

Material and Method

3-1 material:-

3-1-1 Patients:

Analytical descriptive study was carried out for (50) patient whose undergone CT Chest 23 adult male and 27 adult female in different age Following information about patient was reported; age, sex and clinical finding And that was from September 2015 until November 2015 in Elribat University Hospital, Alamal Diagnostic Center and Antalya Medical Center

3-1-1-1 Inclusion criteria:

- Age of 20 years or more.
- Any normal CT chest images

3-1-1-2 Exclusion criteria:

- Any musculoskeletal deformity.
- Kyphoscoliosis,
- Destructive lung pathologies including fibrosis, bullas, retractions,
- Meditational and/or extra-bronchial masses compressing large
- Tracheoomegaly,
- Tracheomalacia,
- Bronchiectasis,
- Chronic tuberculosis,
- Any history of laryngo-tracheal intubation for more than 3 days.

3-1-1-3 Study variables:

The variable that collected from each subject include: age, gender, mid sagittal diameter of right and left two main bronchus

3-1-2 Machines:-

Table (3-1) shows the machine used in this study

CT machine	Slice	features
Toshiba	64	Large couch capacity – 180cm long by 47cm wide 40% dose reduction compared to previous models. 256 slices in one rotation with 5mm slice thickness.
General electric	8	Sub – second scan time 70cm gantry aperture MX200 X-ray tube
NeuViz	16	•5.0 MHU tube configured with powerful 50 kW HV generator 24 mm volume coverage and 0.75 mm slice thickness enable advanced motion-sensitive applications

Figure (3-1) show NeuViz 16-slice CT machine.

Figure (3-2). Show TOSHIBA aquiline 64 slices CT scanner

3-2 Methodology:

3-2-1 CT Examinations:

3-2-1-1 CT Protocol:

Technical parameters used for CT imaging of the airways include the use of thin sections (1.25 mm or less), a fast acquisition that allows the entire lungs to be scanned during a single breath-hold, optimal spatial resolution, and the use of post processing techniques. Overlapping z axis image reconstruction of 50% is typical. (Karthikeyan et al 2005)

Neither IV nor oral contrast media are routinely required; IV contrast may be used in cases of airway tumors. (Karthikeyan et al 2005)

HRCT protocols use thin sections (1.5 mm or less), a fast acquisition to reduce motion artifact, and optimal spatial resolution.

3-2-1-2 Chest, HRCT (High resolution CT):

Indications: Detection and characterization of diffuse parenchymal lung disease including emphysema or bronchiectasis.

Patient preparation: Information about the procedure.

Scan projection radiograph: Frontal from neck to upper abdomen.

3-2-1-3 Image criteria:

Visualization of: Entire field of lung parenchyma.

Patient position: Supine, arms above the head. Volume of investigation: From lung apex to the base of the lungs (survey) or corresponding to radiographically defined abnormality (localized disease).

Nominal slice thickness: 1-2 mm.

Inter-slice distance/pitch: 10-20 mm.

FOV: Adjusted to the minimum which will demonstrate the whole lung field.

X-ray tube voltage (kV): High kV or standard.

Tube current and exposure time product (MAS): Should be as low as consistent with required image quality.

Reconstruction algorithm: High resolution.

Window width: 1000-1600 HU.

Window level: -400 to -700 HU

. 3-2-2 Descriptive data collection Sheet:

Concerned with age, sex, and sagittal (antero-posterior) diameter of right and left main bronchus.

3-2-3 Method of measurement on CT image:

The diameters of two main-stem bronchi were measured on images where they appeared the roundest. This is below the level of bifurcation (carina).

CHAPTER FOUR

Results:

Table (4-1). Shows the percentage of cases

Gender	No	Percentage
male	23	46%
female	27	54%

Table (4-2) shows the percentage of cases in age group

Age group	Percentage	Number
20-30	12%	6
30-40	12%	6
40-50	8%	4
50-60	22%	11
60-70	22%	11
70-80	8%	4
80-90	16%	8

Table (4-3). Shows the measurements of male cases

	Statistics	Lt bronchus	Rt bronchus
N	Valid	23	23

	Missing	0	0
	Mean	12.688	13.071
	Median	12.630	13.220
	Std. Deviation	1.1879	1.4869
	Variance	1.411	2.211
	Minimum	11.3	10.0
	Maximum	14.9	15.6

Table (4-4). Shows the measurements of female cases

	Statistics	Lt bronchus	Rt bronchus
N	Valid	27	27
	Missing	0	0
	Mean	11.269	11.776
	Median	11.350	11.700
	Std. Deviation	1.2474	1.8249
	Variance	1.556	3.330
	Minimum	9.1	9.1
	Maximum	14.0	17.7

Table (4-5). Shows the mean, minimum, maximum and variance for both gender related to left and right main bronchus

Bronchus	**Mean**	**Minimum**	**Maximum**	**Variance**

Left	**11.92 ±1.4**	**9.1**	**14.9**	**1.96**
Right	**12.37 ± 1.78**	**9.1**	**17.7**	**3.18**

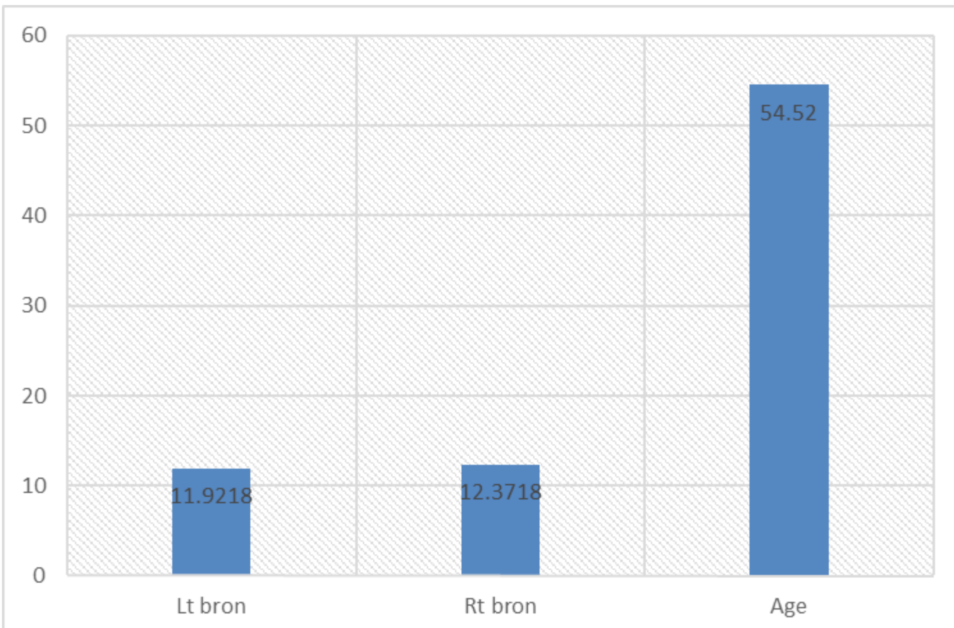

Figure (4-1). Represent the relation between both measure and age

Table (4-6) shows age mean, minimum, maximum and variance for both genders.

Gender	Mean	minimum	maximum	variance

Both	54.52 ± 17.5	21	90	307.7
Male	56.04± 16.5	25	80	274.407
Female	53.22 ± 18.5	21	90	343.949

Table (4-7) shows correlation between age grouping and the mean of RT and LT bronchus

Age group	Lf bronchus mean	Rt bronchus mean	Number
20-30	11.38	12.58	6
30-40	11.89	12.34	6
40-50	12.17	11.44	4
50-60	11.77	12.31	11
60-70	12.25	13.09	11
70-80	11.77	11.19	4
80-90	12.29	13.09	8

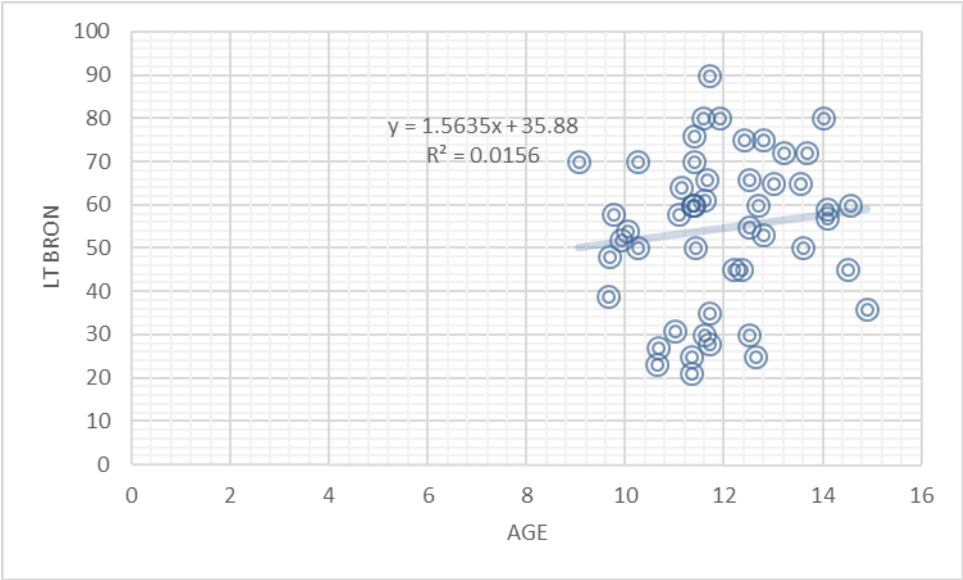

Figure (4-2). Represents the correlation between left bronchus and age

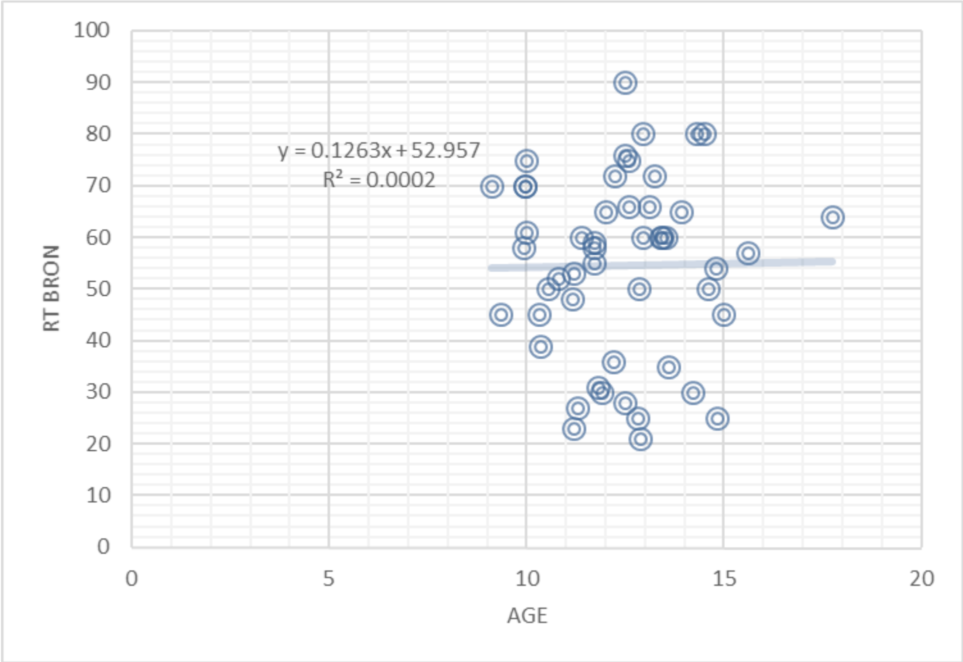

Figure (4-3). Represents the Correlation between right bronchus and age

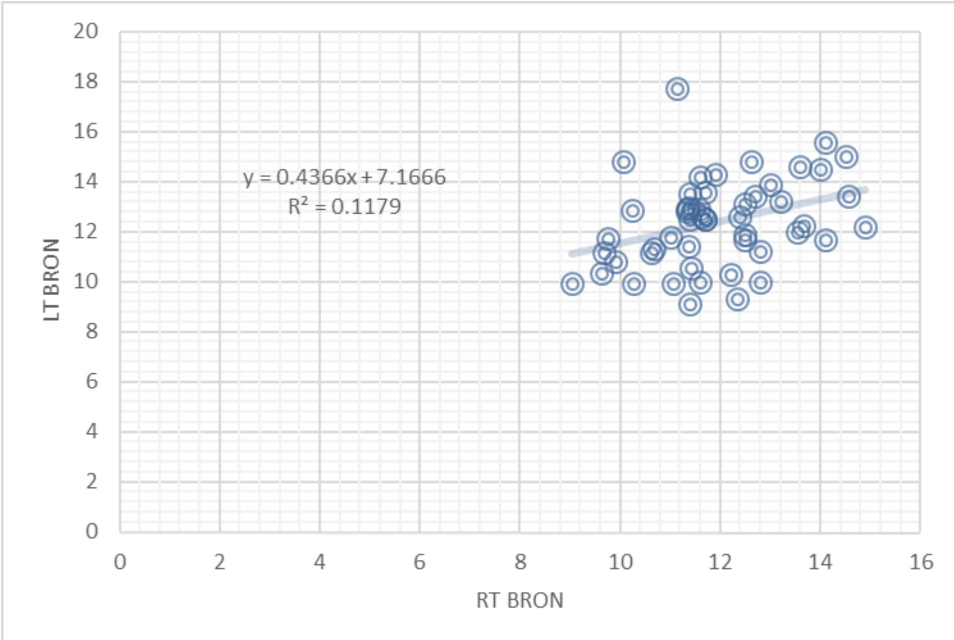

Figure (4-4). Represents the correlation between left and right bronchus

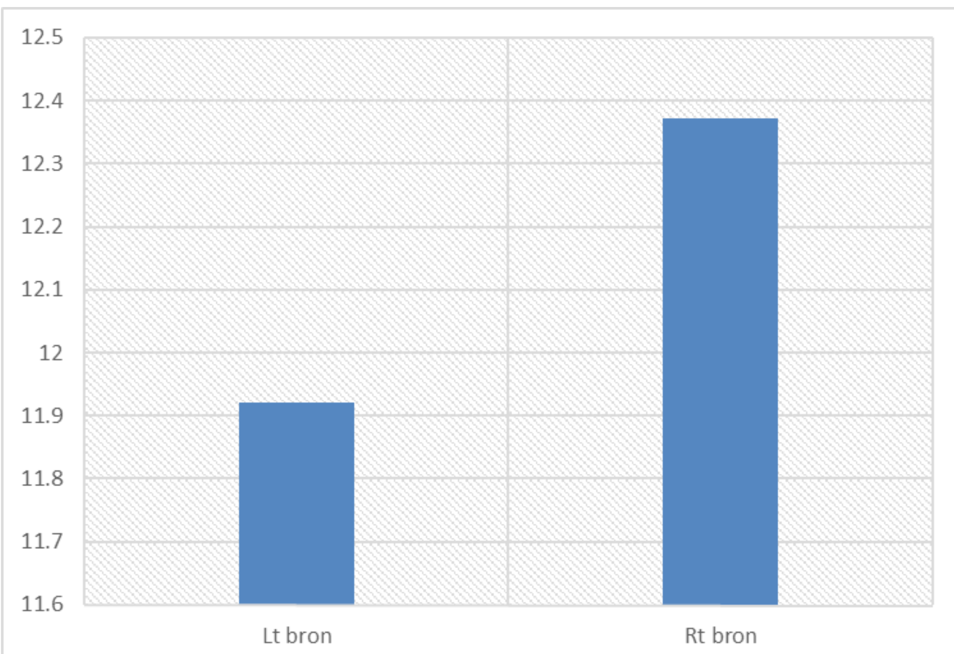

Figure (4-5). Represents the relation of measurement of right and left main bronchus

Table (4-8). Shows the correlation between the normal measurements of bronchus and pathology

Disease	Lt bronchus	Rt bronchus
normal	**11.92**	**12.37**
asthma	**8.705**	**7.608**
Atelectasis - Collapse	**12.97**	**13.15**
Emphysema	**16.37**	**16.61**

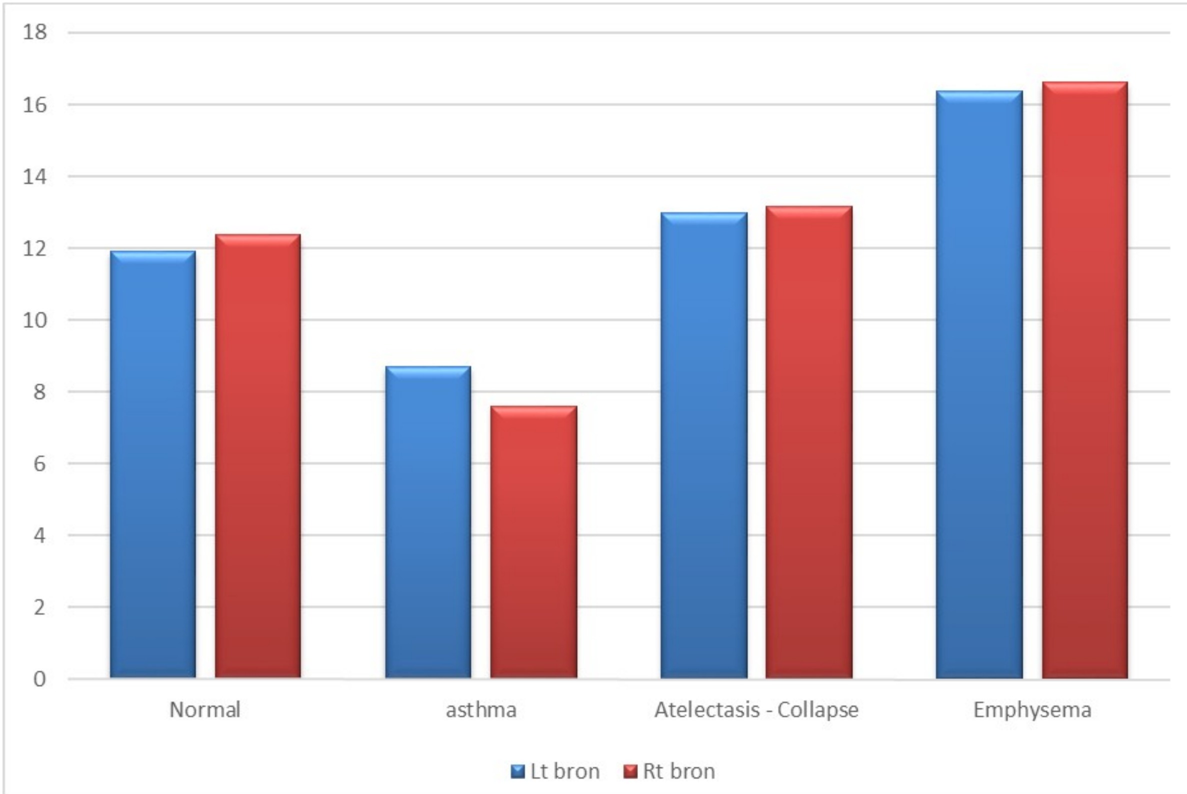

Figure (4-6). Represent the relation between normal and abnormal measurements

Chapter Five

5.1 Discussion: -

Fifty subjects were studied. Their age ranged from 20to 90 years.23 males which represent 46% and 27 females which represent 56%. With women being minimally younger than men. However, the mean age was not statistically different between the two groups. The measurements were done on axial CT chest high resolution imaging.

From table 4-5 the study found the mean of left main bronchus is 12.37±1.7 mm and mean of right main bronchus is 11.92±1.4 mm. this measure is close to measure form study of Hampton et al at 2000 whom found the left main bronchus is 12.6±1.9 mm

Table 4-5 show the mean of age, the mean age of male is 54.04± 16.5 years, and the mean age of females is 53.22±18.5 years and the mean of both genders is 54.52 years, from this result we find out the male is minimally older than females.

In table 4-5 which shows age groups of the study in relation to bronchus diameter. there were 6 cases out of 50 cases have age between 20-30 years , have mean of left main bronchus diameter 11.38 and right bronchus mean diameter 12.58 , and 6 other cases have age between 30-40 years have mean of left bronchus diameter 11.89 and right bronchus diameter 12.34 , other 4 cases have age between 40-50 years mean of left main bronchus diameter 12.17 and mean of right bronchus diameter 11.44 , other 11 cases have age between 50-60 years mean of left bronchus diameter 11.77 and mean of right bronchus 12.31 ,other 11cases have age between 60-70 mean of left bronchus diameter 12.25 and mean of right bronchus diameter 13.09 , 8 cases have age between 70-80 years and have mean of left bronchus diameter 11.77 and mean of right bronchus diameter 11.19.

And 4 cases have age between 80-90 years mean of left bronchus diameter12.29 and right bronchus diameter 13.55. This mean that increase of age may increase of diameter of two main bronchus.

Table 4-6 show the mean of normal and mean of abnormal diameter which represent in three diseases (Asthma, Atelectasis and Emphysema) and the relation between normal and abnormal is represent in figure 4-6 and we found:

To find out the range of normal measures we take another 10 patients which have pathology in their CT chest imaging and we found some diseases affect on diameter of two main bronchi which is: The asthma narrowing the air way tree, The Atelectasis dilates the two main bronchus, and the Emphysema dilates the two main bronchus.

5-2 conclusion: -

The study found the mean of right main bronchus is 11.91±1.4 mm for both gender. Also the mean of left main bronchus is 12.37±1.7 mm for both genders.

Now it is possible for us to label cases as abnormal with more certainty than before, because of our narrower range of normality.

The asthma narrowing the air way tree. The Atelectasis dilates the two main bronchus; The Emphysema dilates the two main bronchus.

Also from this study we can concludes increase of age my increase of diameter of two main bronchus.

The study concludes that the Sudanese people have diameter for right and left main bronchus close to Persian.

5-3 Recommendation: -

- Further studies in measurements of main bronchia and air tree with large sample of population.
- The author recommends that the Government should introduce the CT machines and increase the training institutes of CT for increasing the technologist skills and experiences.
- The author recommended that the government should be increasing the specialist hospitals for cardiac diseases because they increased in Sudanese now a day.
- According to the high cost of scientific research which the researcher was faced, the government should appeal universities in Sudan and companies to support the researchers in order to improve plans of treating and management of such diseases.
- Study recommend further study done to prove if there was relation between increase of diameter of two main bronchus and age
- Study recommend further study with large number of cases

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Appendices

DATA SHEET

Patient name …………. Age……………………….

Gender ………….

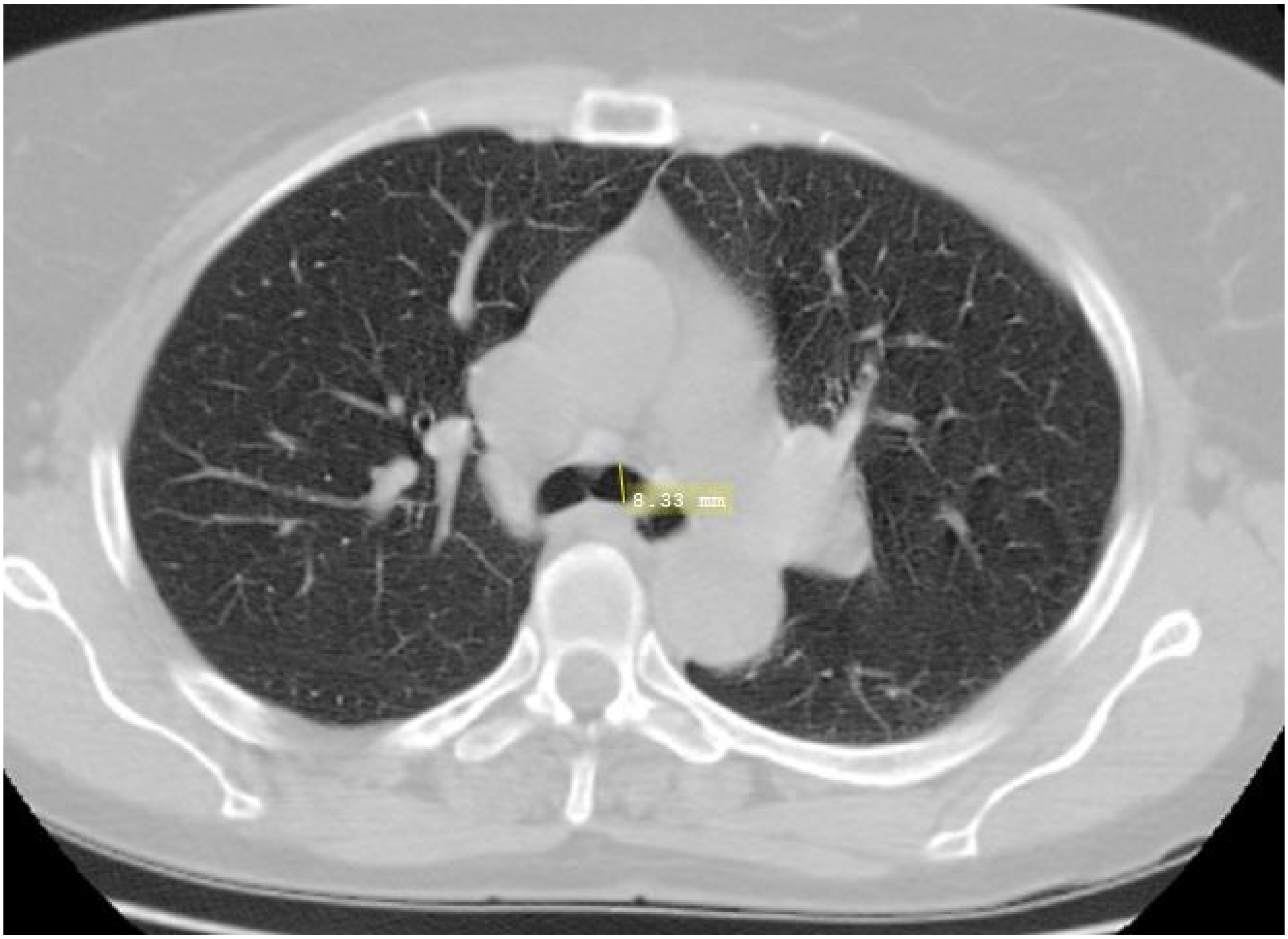
Right main bronchus measure ……………

Left main bronchus measure …………

Image finding ……………….

CT image show the measure of left main the bronchus

CT image show the measure of right main bronchus



CT image show measure of left main bronchus