

**Sudan University of Science and Technology**  
**College of Graduate Studies**

**Study of Pulmonary Embolism by using Spiral  
Computed Tomography Angiography**

دراسة الجلطة الرئوية باستخدام الأشعة المقطعية للأوعية الدموية

A thesis Submitted for Partial Fulfillment of the Requirements of M.Sc.  
Degree in Diagnostic Radiologic Technology

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# الاية

بسم الله الرحمن الرحيم

(قَالَ رَبِّ اشْرَحْ لِي صَدْرِي (25) وَيَسِّرْ لِي أَمْرِي (26)

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صدق الله العظيم

سورة طه الآيات (25-28)

# Dedication

To My mother

To My father

To my brothers

To my sister

To my friends

# Acknowledgement

Grateful thanks and grace to Allah, the Almighty for guiding and helping me to finish this research.

I would like also to express sincere thanks and gratitude to my supervisor **Dr. Asma Ibraheem Ahmed Elamin** for her supervision, guidance and valuable comments and support from the idea of this research until finishing.

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### List of the Abbreviations

ABG	Arterial blood gas
BCE	Basal Cell Epithelium
CAT	Computed Axial Tomography
CBC	Complete Blood Count
CCF	Congestive Cardiac Failure
CHF	Chronic Heart Failure
CT	Computed Tomography
CTA	Computed Tomography Angiography
CTPA	CT Pulmonary Angiography
CUS	Common User System
DVT	Deep Vein thrombosis
ECG	Electrocardiography
EKG	Electrocardiogram
HF	Heart failure
HIV	Human Immunodeficiency
INR	International Normalized Ratio
MDCT	Multi Detector Computed Tomography
MRI	Magnetic Resonance Imaging
NSCLC	Non-Small Cell Lung Carcinoma
PE	Pulmonary Embolism
PIOED	Prospective Investigation of Pulmonary Embolism Diagnosis

SCLC	Small Cell Lung Carcinoma
SSA	Seronegative SpondyloArthropathy
TB	Tuberculosis
TST	Tuberculin Skin Test
UPET	Urokinase-Pulmonary Embolism Trial
V-P	Ventilation-Perfusion
V/Q	Ventilation-Perfusion
VTE	Venous thromboembolism

## **Abstract**

This was a descriptive study; the main objective of this study was to study of pulmonary embolism by using computed tomography angiography types, site and affected group of age.

The study was carried out at the Clinic Doctors and Elsaha Specialized Hospital during the period from June 2019 to September 2019, and the data were collected from these two hospitals. for CT machine used 64-slice scanner ( Neusoft) .

This study included random fifty patients 15 males and 35 females with clinically diagnosed of pulmonary embolism.

The study has come out with many results including that the pulmonary embolism is higher in female (70 %) than in male (30 %). The most effected age group were the ages between (60-80) years and pulmonary embolism most commonly seen in the both side of pulmonary artery (80 %) , right side (12 %) and left side (8%) and most common tayepe of Pulmonary Embolism acute massive (70 %) than acute minor (30%). Also the most common clinically indication of Pulmonary Embolism is Short of breath (72%).

According to this result Pulmonary Embolism is rare in young patients and is more common in elder patients .

The results also showed that CT is the best modality to identifying and localizing pulmonary embolism .

The Spiral Computed Tomography Angiography is a diagnostic tool with a high sensitivity and specificity for the detection of Pulmonary Embolism .

It recommended that Spiral Computed Tomography technique should be the primary investigation performed for patient who suspected to have Pulmonary Embolism .

## المستخلص

تعتبر هذه الدراسة وصفية و كان الهدف الأساسي منها هو دراسة الجلطة الرئوية بواسطة الأشعة المقطعية للشرابين والأوردة من حيث النوع و الموقع و الفئة العمرية المتأثرة.

وتم تنفيذ هذه الدراسة و قد جمعت البيانات مستشفى الاطباء و مستشفى الساحة التخصصي في الفترة من يونيو 2019 إلي سبتمبر 2019 وقد تم جمع البيانات في هذين المستشفيات بواسطة جهاز الأشعة المقطعية ( نيوسوفت نيو و نوع الشريحة 64, و قد شملت هذه الدراسة عينة عشوائية بعدد خمسين مريضا , منهم 15 ذكور و 35 إناث ,تم تشخيصهم سريريا بالجلطة الرئوية.

خرجت الدراسة بنتائج مفادها أن حدوث الجلطة الرئوية شائع أكثر في الإناث(70%) منه في الذكور(30 %) وكانت أكثر الأعمار إصابة هي في الفئة العمرية (60-80) سنة , و كانت أكثر منطقة للإصابة بالجلطة الرئوية هي الجهتين اليمنى و اليسرى معا(80%) تليها الجهة اليمنى (12%) ثم الجهة اليسرى(8%) . و اكثر الانواع حدوثا الجلطة الرئوية الحادة (70%). و اكثر الاعراض السريرية لهذا المرض هو قصور في التنفس (72%).

وفقا لهذه النتائج اتضح أن الجلطة الرئوية أمر نادر الحدوث في المرضى الصغار و أكثر شيوعا في المرضى كبار السن.

و قد أظهرت هذه الدراسة أن الأشعة المقطعية هي أفضل طريقة لتشخيص الجلطة الرئوية لأن لها درجة عالية من الدقة والكفاءة في التشخيص الآمن.

و وصت هذه الدراسة أن الأشعة المقطعية للشرابين و الأوردة ضرورية لجميع المرضى الذين يشتبهون بأن لديهم جلطة رئوية.

# **Chapter One**

## **Introduction**

## Chapter one

### 1.1 Introduction:

Pulmonary embolism (PE) is a blockage of the main artery of the lung or one of its branches by a substance that has travelled from elsewhere in the body through the bloodstream (embolism). PE most commonly results from deep vein thrombosis (a blood clot in the deep veins of the legs or pelvis) that breaks off and migrates to the lung, a process termed venous thromboembolism (VTE). A small proportion of cases are caused by the embolization of air, fat, or talc in drugs of intravenous drug abusers or amniotic fluid. The obstruction of the blood flow through the lungs and the resultant pressure on the right ventricle of the heart lead to the symptoms and signs of PE. The risk of PE is increased in various situations, such as cancer or prolonged bed rest.(Stein PD (2008))

Symptoms of pulmonary embolism include difficulty breathing, chest pain on inspiration, and palpitations. Clinical signs include low blood oxygen saturation and cyanosis, rapid breathing, and a rapid heart rate. Severe cases of PE can lead to collapse, abnormally low blood pressure, and sudden death.(Stein PD 2008)

Several imaging techniques are used for detection of the PE. Each has advantages and disadvantages. Convenience and cost-effectiveness are also factors.(Stein PD 2008)The latest advances in imaging technology help clinicians get information about the possibility of PE, the segment of the Lungs affected by thromboembolism and gives features about the lung parenchymal changes and help to determine how far the disease has progressed.Diagnosing pulmonary embolism is complicated since clinical signs and symptoms of PE are nonspecific. Patient groups usually affected by PE are patients with infection ; cancer, pregnant and post-operative patients.diagnostic testing is there for mandatory. Objective



testing for pulmonary embolism is crucial, because clinical assessment alone is unreliable and the consequences of misdiagnosis are serious. Failure to diagnose pulmonary embolism is associated with high mortality and incorrect diagnosis of the condition unnecessarily exposes patients to the risks of anticoagulant therapy. This review will outline approaches to the diagnosis of pulmonary embolism and doctors will perform one or more tests to help find the cause of symptoms, so diagnostic algorithms have been developed to rationalize the use of imaging tests in patients with clinical suspicion of PE. (Wells PS 2001) To diagnose pulmonary embolism, medical societies recommend a review of clinical criteria to determine the need for testing, followed by testing to determine a likelihood of being able to confirm a diagnosis by imaging, followed by imaging if other tests have shown that there is a likelihood of a PE diagnosis. (Wells PS 2001).

The diagnosis of PE is based primarily on validated clinical criteria combined with selective testing because the typical clinical presentation (shortness of breath, chest pain) cannot be definitively differentiated from other causes of chest pain and shortness of breath. The decision to do medical imaging is usually based on clinical grounds, i.e. the medical history, symptoms and findings on physical examination, followed by an assessment of clinical probability. The most commonly used method to predict clinical probability, the Wells score, is a clinical prediction rule, whose use is complicated by multiple versions being available. In 1995, Wells et al. initially developed a prediction rule (based on a literature search) to predict the likelihood of PE, based on clinical criteria. The prediction rule was revised in 1998. This prediction rule was further revised when simplified during a validation by Wells et al. in 2000. In the 2000 publication, Wells proposed two different scoring systems using cutoffs of 2 or 4 with the same prediction rule. In 2001, Wells published results using the more conservative cutoff of 2 to create three categories. An additional

version, the "modified extended version", using the more recent cutoff of 2 but including findings from Wells's initial studies were proposed. Most recently, a further study reverted to Wells's earlier use of a cutoff of 4 points to create only two categories. (Wells PS 2001)

## **1.2 Statement of problem**

In typical people who are not known to be at high risk of PE, imaging is helpful to confirm or exclude a diagnosis of PE after simpler first-line tests are used.

CT pulmonary angiography is the recommended first line diagnostic imaging test in most people.

Historically, the gold standard for diagnosis was pulmonary angiography. Other radiological modalities are failed to detect and give accurate the classification of pulmonary embolism.

## **1.3 Objective of study**

### **1.3.1 The general objectives:**

To Study of Pulmonary embolism by using computed tomography angiography.

### **1.3.2 Specific objectives were:**

- To evaluate the accuracy of spiral computed tomography (CT) in the noninvasive diagnosis of pulmonary embolism (PE).
- To identify the key imaging features of PE at CT pulmonary angiography.
- To discuss the current role of CT angiography imaging in evaluation of patients with clinical signs of PE.

## **1.5 Overview of the study:**

Chapter One: Introduction.

Chapter Two: Literature Review.

Chapter Three: Material and methods.

Chapter Four: Results.

Chapter Five: Discussion, conclusion and recommendation.

References

Appendices

# **Chapter Two**

## **Literature Review**

## Chapter Two

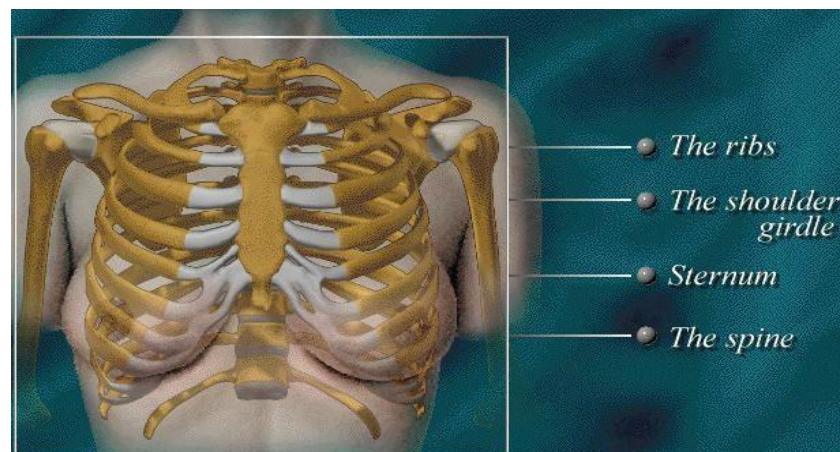
### Literature Review

#### 2.1 Anatomy

##### 2.1.1 chest wall

The chest wall is made up of bones and muscles, the bones, primarily ribs, sternum and vertebrae, form a protective cage for the internal structures of the thorax. (Dean and West1991).

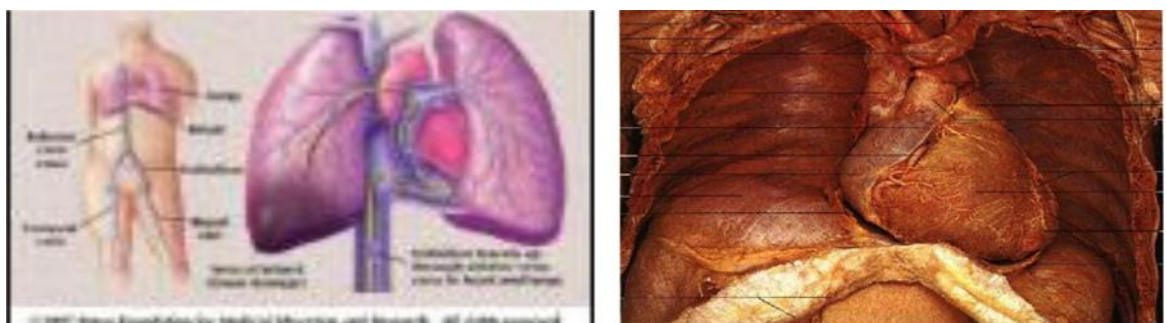
The main muscles of the chest wall, the external and internal intercostals, extend from one rib.



**Figure (2. 1)** bones of the chest (Overton 1988)

##### 2.1.2 Mediastinum

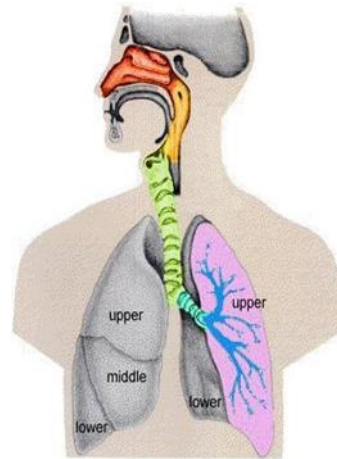
The Mediastinum is located between the lungs. This contains the heart, the great vessels, parts of the trachea and esophagus, and other structures.(Dean and West 1991).



**Figure (2. 2)** mediastinal(Overton 1988)

### 2.1.3 Respiratory system:

The respiratory system is made up of the organs consists of the: Nose, Pharynx, Larynx, Trachea, Bronchi and Lungs



**Figure (2. 3)**respiratory system(Overton 1988)

### 2.1.4 Lungs:

The lungs consist of airways (trachea and bronchi).

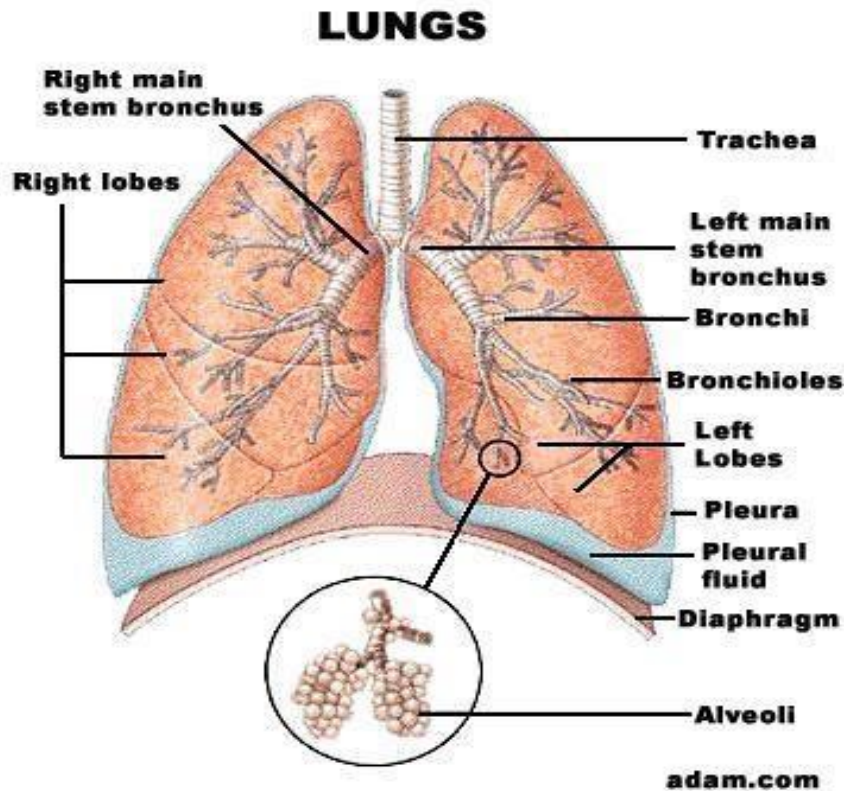
That divide into smaller and smaller branches until.

They reach that air sacs, called alveoli. The airways conduct air down to due alveoli where gas exchange takes place. (Dean and West 1991)



**Figure (2. 4)** out shape of lungs (Overton 1988)

The lung itself is covered with a membrane called the visceral (or pulmonary) pleura. The visceral pleura are adjacent to the lining of the thoracic cavity which is called the parietal pleura.



**Figure (2. 5)**inner shape of lung (Overton 1988)

### **2.1.5 Blood Supply of the Lungs:**

The bronchi, the connective tissue of the lung, and the visceral pleura receive their blood supply from the bronchial arteries, which are branches of the descending aorta. The bronchial veins (which communicate with the pulmonary veins) drain in to the azygos and hemiazygos veins. (Overton 1988)

The alveoli receive deoxygenated blood from the terminal branches of the pulmonary arteries.the oxygenated blood leaving the alveolar capillaries drains into the tributaries of the pulmonary veins which follow the inter segmental connective tissue septa to the lung root Two pulmonary veins leave each lung root to empty into the left atrium of the heart.(Overton 1988)

## **2-2 Pathology**

### **2.2.1 Pleural effusion**

Pleural effusion is excess fluid that accumulates in the pleural cavity, the fluid filled space that surrounds the lungs. This excess can impair breathing by limiting the expansion of the lungs. Various kinds of pleural effusion, depending on the nature of the fluid and what caused its entry into the pleural space, are hydrothorax (serous fluid), hemothorax (blood), urinothorax (urine), chylothorax (chyle), or pyothorax (pus). Pneumothorax is the accumulation of air in the pleural space.

(Harsh Mohan 2005)

### **2.2.2 Pneumonia**

Pneumonia is an inflammatory condition of the lung affecting primarily the microscopic air sacs known as alveoli. It is usually caused by infection with viruses or bacteria and less commonly other microorganisms, certain drugs and other conditions such as autoimmune diseases.

Typical signs and symptoms include a cough, chest pain, fever, and difficulty breathing. Diagnostic tools include x-rays and culture of the sputum. Vaccines to prevent certain types of pneumonia are available. Treatment depends on the underlying cause. Pneumonia presumed to be bacterial is treated with antibiotics. If the pneumonia is severe, the affected person is generally hospitalized. (Harsh Mohan 2005)

Pneumonia affects approximately 450 million people globally per year (7% of the population) and results in about 4 million deaths. Although pneumonia was regarded by William Osler in the 19th century as "the captain of the men of death," the advent of antibiotic therapy and vaccines in the 20th century has seen improvements in survival. Nevertheless, in developing countries, and among the very old, the very young, and the chronically ill, pneumonia remains a leading cause of death. In the terminally ill and elderly, especially those with other conditions, pneumonia is often the immediate cause of



death. In such cases, particularly when it cuts short the suffering associated with lingering illness, pneumonia has often been called "the old man's friend." (Harsh Mohan 2005)

### **2.2.3 Bronchopneumonia**

Bronchopneumonia or bronchial pneumonia or Bronchogenic pneumonia (not to be confused with lobar pneumonia) is the acute inflammation of the walls of the bronchioles. It is a type of pneumonia characterized by multiple foci of isolated, acute consolidation, affecting one or more pulmonary lobules. (www.wikipedia.org NHLBI.1 March (2011))

It is one of two types of bacterial pneumonia as classified by gross anatomic distribution of consolidation (solidification), the other being lobar pneumonia. (www.wikipedia.org NHLBI.1 March (2011))

The bronchopneumonia pattern has been associated with hospital-acquired pneumonia, and with specific organisms such as *Staphylococcus aureus*, *Klebsiella*, *E. coli*, and *Pseudomonas*.

In bacterial pneumonia, invasion of the lung parenchyma by bacteria produces an inflammatory immune response. This response leads to a filling of the alveolar sacs with exudate. The loss of air space and its replacement with fluid is called consolidation. In bronchopneumonia, or lobular pneumonia, there are multiple foci of isolated, acute consolidation, affecting one or more pulmonary lobes. www.wikipedia.org

Although these two patterns of pneumonia, lobar and lobular, are the classic anatomic categories of bacterial pneumonia, in clinical practice the types are difficult to apply, as the patterns usually overlap. Bronchopneumonia (lobular) often leads to lobar pneumonia as the infection progresses. The same organism may cause one type of pneumonia in one patient, and another in a different patient. From the clinical standpoint, far more important than distinguishing the anatomical subtype of pneumonia, is identifying its

causative agent and accurately assessing the extent of the disease.  
[www.wikipedia.org](http://www.wikipedia.org)

#### **2.2.4 Tuberculosis**

Tuberculosis, MTB, or TB (short for tubercle bacillus), in the past also called phthisis, phthisis pulmonalis, or consumption, is a widespread, and in many cases fatal, infectious disease caused by various strains of mycobacteria, usually *Mycobacterium tuberculosis*. Tuberculosis typically attacks the lungs, but can also affect other parts of the body. It is spread through the air when people who have an active TB infection cough, sneeze, or otherwise transmit respiratory fluids through the air. Most infections do not have symptoms, known as latent tuberculosis. About one in ten latent infections eventually progresses to active disease which, if left untreated, kills more than 50% of those so infected. (Harsh Mohan 2005)

The classic symptoms of active TB infection are a chronic cough with bloodtinged sputum, fever, night sweats, and weight loss (the latter giving rise to the formerly common term for the disease, "consumption"). Infection of other organs causes a wide range of symptoms. Diagnosis of active TB relies on radiology (commonly chest X-rays), as well as microscopic examination and microbiological culture of body fluids. Diagnosis of latent TB relies on the tuberculin skin test (TST) and/or blood tests. Treatment is difficult and requires administration of multiple antibiotics over a long period of time. Social contacts are also screened and treated if necessary. Antibiotic resistance is a growing problem in multiple drug-resistant tuberculosis (MDR-TB) infections. Prevention relies on screening programs and vaccination with the bacillus Calmette-Guérin vaccine. (Harsh Mohan 2005)

One-third of the world's population is thought to have been infected with *M. tuberculosis*, and new infections occur in about 1% of the population each year. In 2007, an estimated 13.7 million chronic cases were active globally, while in 2013, an estimated 9 million new cases occurred. In 2013

there were between 1.3 and 1.5 million associated deaths, most of which occurred in developing countries. The total number of tuberculosis cases has been decreasing since 2006, and new cases have decreased since 2002. The rate of tuberculosis in different areas varies across the globe; about 80% of the population in many Asian and African countries tests positive in tuberculin tests, while only 5–10% of the United States population tests positive. More people in the developing world contract tuberculosis because of a poor immune system, largely due to high rates of HIV infection and the corresponding development of AIDS. (Harsh Mohan 2005)

### **2.2.5 Pneumothorax**

A pneumothorax (pneumo- +thorax; plural pneumothoraces) is an abnormal collection of air or gas in the pleural space that causes an uncoupling of the lung from the chest wall. Like pleuraleffusion (liquid buildup in that space), pneumothorax may interfere with normal breathing. It is often called collapsed lung, although that term may also refer to atelectasis.(Harsh Mohan 2005)

A primary pneumothorax is one that occurs without an apparent cause and in the absence of significant lung disease, while a secondary pneumothorax occurs in the presence of existing lung pathology. In a minority of cases, the amount of air in the chest increases markedly when a one-way valve is formed by an area of damaged tissue, leading to a tension pneumothorax. This condition is a medical emergency that can cause steadily worsening oxygen shortage and low bloodness reversed by effective treatment, these sequelae can progress and cause death.(Harsh Mohan 2005)

Pneumothoraces can be caused by physical trauma to the chest (including blast injury), or as a complication of medical or surgical intervention. Symptoms typically include chest pain and shortness of breath. Diagnosis of a pneumothorax by physical examination alone can be difficult or inconclusive (particularly in smaller pneumothoraces), so a chest radiograph

or computed tomography (CT) scan is usually used to confirm its presence.(Harsh Mohan 2005)

Small spontaneous pneumothoraces typically resolve without treatment and require only monitoring. This approach may be most appropriate in subjects who have no significant underlying lung disease. In larger pneumothoraces, or when there are marked symptoms, the air may be extracted with a syringe or a chest tube connected to a one-way valve system. Occasionally, surgical interventions may be required when tube drainage is unsuccessful, or as a preventive measure, if there have been repeated episodes. The surgical treatments usually involve pleurodesis (in which the layers of pleura are induced to stick together) or pleurectomy (the surgical removal of pleural membranes). (Harsh Mohan 2005)

### **2.2.6 Pulmonary hypertension**

is an increase of blood pressure in the pulmonary artery, pulmonary vein, or pulmonary capillaries, together known as the lungvasculature, leading to shortness of breath, dizziness, fainting, leg swelling and other symptoms. Pulmonary hypertension can be a severe disease with a markedly decreased exercise tolerance such as heart failure. (www.wikipedia.org NORD.(2015)

Because pulmonary hypertension can be of five major types, a series of tests must be performed to distinguish pulmonary arterial hypertension from venous, hypoxic, thromboembolic, or miscellaneous varieties. www.wikipedia.org

Further procedures are required to confirm the presence of pulmonary hypertension and exclude other possible diagnoses. These generally include pulmonary function tests; blood tests to exclude HIV, autoimmune diseases, and liver disease; electrocardiography (ECG); arterial bloodgas measurements; X-rays of the chest (followed by high-resolution CT scanning if interstitial lung disease is suspected); and ventilation-perfusion or V/Q scanning to exclude chronic thromboembolic pulmonary hypertension.

Biopsy of the lung is usually not indicated unless the pulmonary hypertension is thought to be due to an underlying interstitial lung disease; further, lung biopsies are fraught with risks of bleeding due to the high intrapulmonary blood pressure. Clinical improvement is often measured by a "sixminute walk test", i.e. the distance a patient can walk in six minutes. Stability and improvement in this measurement correlate with better survival.  
[www.wikipedia.org](http://www.wikipedia.org)

### **2.2.7 Pulmonary oedema**

Pulmonary edema (American English), or oedema (British English; both words from the Greek οἴδημα), is fluid accumulation in the air spaces and parenchyma of the lungs. It leads to impaired gas exchange and may cause respiratory failure. It is due to either failure of the leftventricle of the heart to adequately remove blood from the pulmonary circulation ("cardiogenic pulmonary edema"), or an injury to the lung parenchyma or vasculature of the lung ("noncardiogenic pulmonary edema"). Treatment is focused on three aspects: firstly improving respiratory function, secondly, treating the underlying cause, and thirdly avoiding further damage to the lung. Pulmonary edema, especially acute, can lead to fatal respiratory distress or cardiac arrest due to hypoxia. ( [www.wikipedia.org](http://www.wikipedia.org) Dorlands Medical Dictionary)

#### **2.2.7.1 Causes**

Pulmonary edema is an accumulation of fluid within the parenchyma and air spaces of the lungs. Classically it is cardiogenic (left ventricular) but fluid may also accumulate due to damage to the lung. This damage may be direct injury or injury mediated by high pressures within the pulmonary circulation. When directly or indirectly caused by increased left ventricular pressure pulmonary edema may form when mean pulmonary pressure rises from the normal of 15 mmHg to above 25 mmHg. Broadly, the causes of pulmonary

edema can be divided into cardiogenic and non-cardiogenic. By convention cardiogenic refers to left ventricular.

### **2.2.8 Mitral stenosis**

Is a valvular heart disease characterized by the narrowing of the orifice of the mitral valve of the heart. (www.wikipedia.org carabello,B.A.(2005))

#### **2.2.8.1 Causes**

Almost all cases of mitral stenosis are due to disease in the heart secondary to rheumatic fever and the consequent rheumatic heart disease. Uncommon causes of mitral stenosis are calcification of the mitral valve leaflets, and as a form of congenital heart disease. However, there are primary causes of mitral stenosis that emanate from a cleft mitral valve. It is the most common valvular heart disease in pregnancy. (www.wikipedia.org Agabegi,Steven S.(2008))

Other causes include infective endocarditis where the vegetations may favor increase risk of stenosis. Other rare causes are including mitral annular calcification, endomyocardial fibroelastosis, malignant carcinoid syndrome, systemic lupus erythematosus, whipple disease, fabry disease, and rheumatoid arthritis. (www.wikipedia.org Peter Libby M.D.(2012))

### **2.2.9 Heart failure**

Heart failure (HF) often referred to as chronic heart failure (CHF), occurs when the heart is unable to pump sufficiently to maintain blood flow to meet the body's needs. The terms congestive heart failure (CHF) or congestive cardiac failure (CCF) are often used interchangeably with chronic heart failure. Signs and symptoms commonly include shortness of breath, excessive tiredness, and leg swelling. The shortness of breath is usually worse with exercise, while lying down, and may wake the person at night. A limited ability to exercise is also a common feature. (Harsh Mohan 2005)

### **2.2.9.1 Causes**

Common causes of heart failure include coronary artery disease including a previous myocardial infarction (heart attack), high blood pressure, atrial fibrillation, valvular heart disease, excess alcohol use, infection, and cardiomyopathy of an unknown cause. These cause heart failure by changing either the structure or the functioning of the heart. There are two main types of heart failure: heart failure due to left ventricular dysfunction and heart failure with normal ejection fraction depending on if the ability of the left ventricle to contract is affected, or the heart's ability to relax. The severity of disease is usually graded by the degree of problems with exercise. Heart failure is not the same as myocardial infarction (in which part of the heart muscle dies) or cardiac arrest (in which blood flow stops altogether). Other diseases that may have symptoms similar to heart failure include obesity, kidney failure, liver problems, anemia and thyroid disease. (Harsh Mohan 2005)

The condition is diagnosed based on the history of the symptoms and a physical examination with confirmation by echocardiography. Blood tests, electrocardiography, and chest radiography may be useful to determine the underlying cause. Treatment depends on the severity and cause of the disease. In people with chronic stable mild heart failure, treatment commonly consists of lifestyle modifications such as stopping smoking, physical exercise, and dietary changes, as well as medications. In those with heart failure due to left ventricular dysfunction, angiotensin converting enzyme inhibitors or angiotensin receptor blockers along with beta blockers are recommended. For those with severe disease, aldosterone antagonists, or hydralazine plus a nitrate may be used. Diuretics are useful for preventing fluid retention. Sometimes, depending on the cause, an implanted device such as a pacemaker or an implantable cardiac defibrillator may be recommended. In some moderate or severe cases cardiac resynchronization therapy (CRT)

may be suggested or cardiac contractility modulation may be of benefit. A ventricular assist device or occasionally a heart transplant may be recommended in those with severe disease despite all other measures. (Harsh Mohan 2005)

Heart failure is a common, costly, and potentially fatal condition. In developed countries, around 2% of adults have heart failure and in those over the age of 65, this increases to 6–10%. In the year after diagnosis the risk of death is about 35% after which it decreases to below 10% each year. This is similar to the risks with a number of types of cancer. In the United Kingdom the disease is the reason for 5% of emergency hospital admissions. Heart failure has been known since ancient times with the Ebers papyrus commenting on it around 1550 BCE.

#### **2.2.10 Aneurysm**

An aneurysm is a localized abnormal dilation of a blood vessel or the heart. When a bulging aneurysm is bounded by arterial wall components or the attenuated wall of the heart, it is called a "true" aneurysm.

A false aneurysm (also called pseudoaneurysm) is a breach in the vascular wall leading to an extravascular hematoma that freely communicates with the intravascular space

As the age increases, arteries become stiffer, wider (aneurysm) and longer (tortuosity)

#### **2.2.11 Coronary artery disease**

Coronary artery disease is one of the most common and serious effects of aging.

Fatty deposits build up in blood vessel walls and narrow the passageway for the movement of blood.

The resulting condition, called atherosclerosis often leads to eventual blockage of the coronary arteries and a "heart attack".



Atherosclerosis can, and does, occur in almost any artery in the body. But in the heart its effects can be crucial.(Harsh Mohan 2005)

### **2.2.12 Lung abscess**

Lung abscess is a type of liquefactive necrosis of the lung tissue and formation of cavities (more than 2 cm) containing necrotic debris or fluid caused by microbial infection.( Overton 1988)

This pus-filled cavity is often caused by aspiration, which may occur during altered consciousness. Alcoholism is the most common condition predisposing to lung abscesses.

Lung abscess is considered primary (60%) when it results from existing lung parenchymal process and is termed secondary when it complicates another process e.g. vascular emboli or follows rupture of extrapulmonary abscess into lung.(Harsh Mohan 2005)

### **2.2.13 Lung cancer**

Lung cancer, also known as carcinoma of the lung or pulmonary carcinoma, is a malignant lung tumor characterized by uncontrolled cell growth in tissues of the lung. If left untreated, this growth can spread beyond the lung by process of metastasis into nearby tissue or other parts of the body. Most cancers that start in the lung, known as primary lung cancers, are carcinomas that derive from epithelial cells. The main primary types are small-cell lung carcinoma (SCLC) and non-small-cell lung carcinoma (NSCLC). The most common symptoms are coughing (including coughing up blood), weight loss, shortness of breath, and chest pains.(Harsh Mohan 2005)

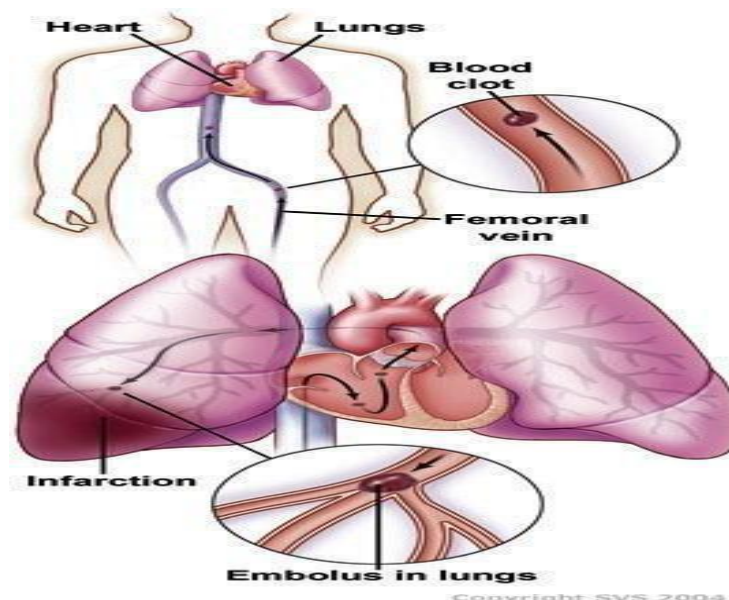
The vast majority (80–90%) of cases of lung cancer are due to long-term exposure to tobacco smoke. About 10–15% of cases occur in people who have never smoked. These cases are often caused by a combination of genetic factors and exposure to radon gas, asbestos, or other forms of air pollution, including secondhand smoke. Lung cancer may be seen on chest radiographs

and computed tomography (CT) scans. The diagnosis is confirmed by biopsy which is usually performed by bronchoscopy or CT-guidance.(Harsh Mohan 2005)

Treatment and long-term outcomes depend on the type of cancer, the stage (degree of spread), and the person's overall health, measured by performance status. Common treatments include surgery, chemotherapy, and radiotherapy. NSCLC is sometimes treated with surgery, whereas SCLC usually responds better to chemotherapy and radiotherapy. Overall, 16.8% of people in the United States diagnosed with lung cancer survive five years after the diagnosis, while outcomes on average are worse in the developing world. Worldwide, lung cancer is the most common cause of cancer-related death in men and women, and was responsible for 1.56 million deaths annually, as of 2012. (Harsh Mohan 2005)

#### **2.2.14 pulmonary embolism:-**

A pulmonary embolism is blockage of an artery in the lungs usually caused by fat, blood clot, air, and tumor cells.



**Figure (2. 6)** emboli in right lung (Overton 1988)

### **2.2.14.1 Types of PE:-**

#### **2.2.14.1.1 Acute massive pulmonary embolism:-**

The pathophysiology is due to acute obstruction of more than 50% of either the main or the proximal pulmonary artery leading to an acute reduction of cardiac output and right ventricular dilatation. (Overton 1988)

To compare multi-detector row computed tomography (CT) and ventilation-perfusion (V-P) scintigraphy in the diagnosis of acute pulmonary embolism (PE) in outpatients who were cared for in the emergency department. (Overton 1988)

#### **2.2.14.1.2 acute minor pulmonary embolism:**

The majority of patient will present with so called pulmonary infarction syndrome with shortness of breath and haemoptysis, clinically there may be pleural effusion the chest radiography may show wedge-shaped opacity due to hemorrhage, pleural effusion or an elevated diaphragm. (Overton 1988)

### **2.2.14.2 Pathophysiology**

Most episodes of PE result from embolisation of thrombi in the leg or pelvic veins. Very large emboli may lodge at the bifurcation of the pulmonary arteries ("saddle embolus"), leading to rapid circulatory failure or sudden death. However, most lodge in lower-order pulmonary vessels. (Carol Mahson Rorth 2008)

Because the lung has no pain fibres, PE only causes chest pain if there is involvement of parietal pleura. Fever is common. (Carol Mahson Rorth 2008)

### **2.2.14.3 Causes:**

Deep venous thrombosis, Having a close family member who has had a pulmonary embolism, Inherited blood clotting abnormalities, Major surgery, Hip or leg fractures, Standing or sitting still for long periods of time, such as on along plane trip or car ride, Cancer, Obesity, Smoking, Having a history

of a heart attack or stroke and Pregnancy, taking birth control pills, or taking estrogen replacement therapy.

#### **2.2.14.4 Signs and symptoms:**

Symptoms can depend on the location and size of blood clot.

Symptoms can depend on the location and size of blood clot, Short of breath (common symptom), Chest pain, extended to shoulder, arm and neck, Coughing with blood stained sputum and Rapid heartbeat (Tachycardia).

#### **2.2.14.5 Complications:**

Abnormal Heart rhythm, Heart failure or shock, Hemorrhage, usually a complication, Thrombolytic and With recurrent pulmonary embolism.

#### **2.2.14.6 Diagnosis modalities**

##### **2.2.13.6.1 Electrocardiogram:**

The electrocardiogram (ECG) is not a specific test for PE. It may be useful in suggesting alternative diagnoses in the patient with signs and symptoms suggestive of PE such as cardiac ischemia, pericarditis, or rhythm disturbances. The ECG is abnormal in the great majority of patients presenting with PE. (Yap KS 2007)

According to the Urokinase-Pulmonary Embolism Trial (UPET), 87 percent of patients with PE have an abnormal ECG. The most frequent findings were sinus tachycardia or non-specific T-wave inversions, each occurring in as many as 40 percent of patients with some patients having both. Other ECG findings include changes reflecting right sided heart strain such as peaked P waves in lead II suggesting right atrial enlargement, right axis deviation or right bundle branch block. Atrial fibrillation or an S<sub>1</sub>Q<sub>3</sub>T<sub>3</sub> (S wave in lead I and Q wave with T wave) inversion in lead III) pattern can also occur. The 'characteristic' S<sub>1</sub>Q<sub>3</sub>T<sub>3</sub> abnormality occurs in only 11 percent of patients with PE

#### **2.2.14.6.2 Chest x-ray:**

This noninvasive test shows images of your heart and lungs on film although xray cant diagnosis pulmonary embolism and my even appear normal in pulmonary embolism exists, they can rule out condition that mimic disease. Chest x-ray findings, although usually abnormal, are most often nonspecific, and the role of chest radiography is largely to guide performance and interpretation of the V/Q scan. Nuclear scanning is highly sensitive for PE (98%) when anything other than a normal perfusion scan is considered.

The chest x-ray is helpful for two important reasons: it is necessary to interpret a subsequent ventilation-perfusion scan, and it could suggest other disease processes that might be causing a patient's symptoms such as pneumothorax, pneumonia, or lung mass. The CXR is rarely normal in PE. In the PIOPED study, the CXR was abnormal 88 percent of the time, and this finding is fairly consistent with most other studies, although the percentage of a given abnormality varies. The timing of the CXR might be a factor in the particular abnormality noted, and this might explain some of these variations. For example, it has been shown that infiltrates usually occur several days after the PE. Results of CXR findings from several studies are presented in Table 6. It should be noted that Westermark's sign and Hampton's hump are very uncommon findings on the CXR.

#### **2.2.14.6.2.1 Embolism with Infarction**

Consolidation, Cavitation, Pleural effusion (bloody in 65%), SSA, No air bronchograms, “Melting” sign of healing and Heals with linear scar



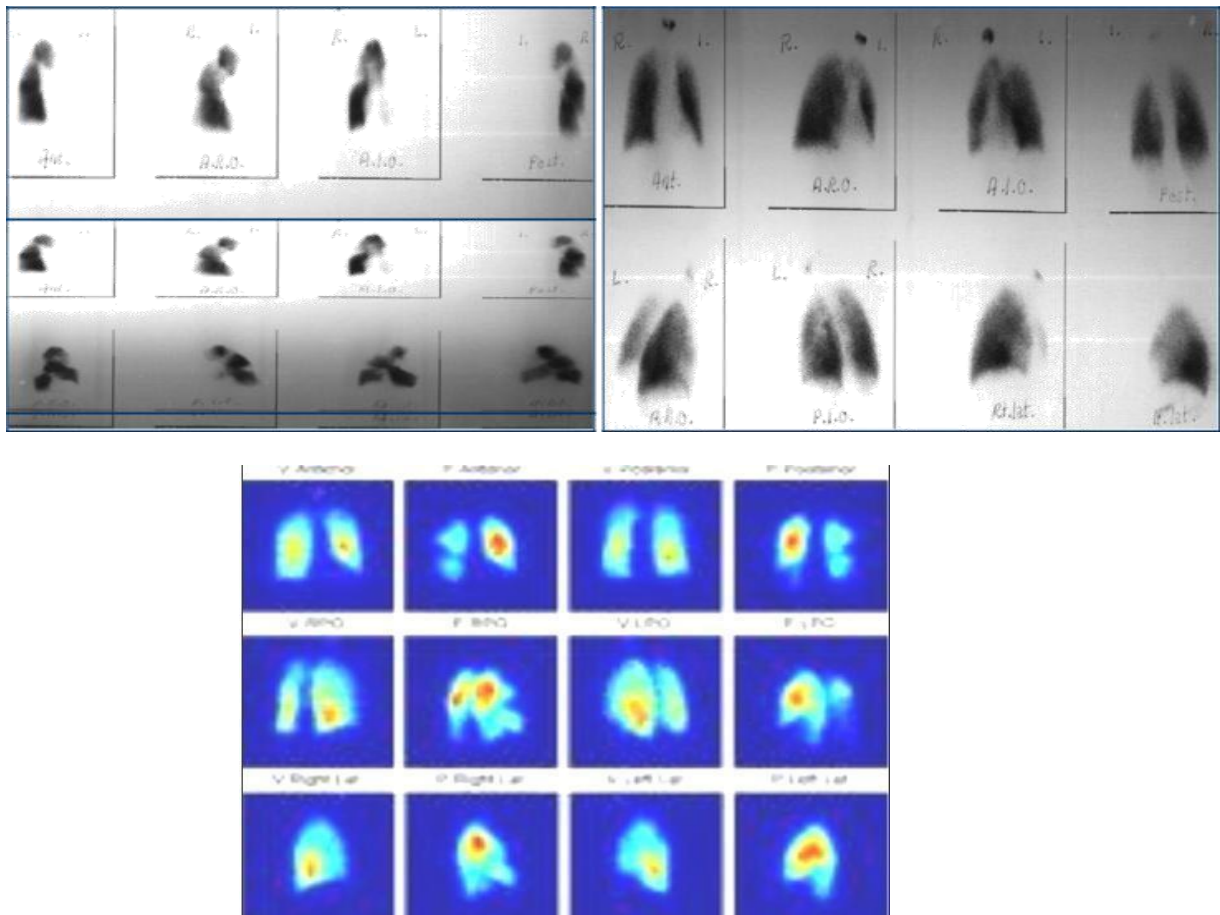
**Figure (2. 7)** showing embolus with infarction (black row) (Overton 1988)

### **2.2.13.6.3 Lung scan**

Perfusion / ventilation scintigraphy is one of the method of choice since abnormal perfusion scan virtually rules out PE This test, also called a ventilation –perfusion scan (V/Q scan). Uses small amount of radioactive tracers (radioisotopes) to study airflow (ventilation) and blood flow (perfusion) in your lungs.

Patients with intermediate-probability V/Q (and low-probability V/Q in the presence of continued clinical suspicion) require further imaging, such as lower extremity Doppler ultrasound or pulmonary angiography The advantages and shortcomings of conventional imaging for thromboembolic disease (chest x-ray, ventilation/ perfusion [V/Q] scan, lower extremity Doppler ultrasound, and pulmonary angiography) are well known. Data from the

Prospective Investigation of Pulmonary Embolism Diagnosis (PIOPED) study shows that almost all patients with PE had abnormal ventilation/perfusion (V/Q) scans of high, intermediate, or low probability, but so did most without PE. If the V/Q scan was interpreted as high probability, it carried a sensitivity of 41 and a specificity of 97 percent. If all scans interpreted as high or intermediate probabilities are included, the sensitivity is 82 percent and the specificity drops to 52 percent. If all non-normal V/Q scans (high, intermediate, and low probability) are included, the sensitivity goes to 98 percent but the specificity drops further to 10 percent. (Worsley DF 1991)



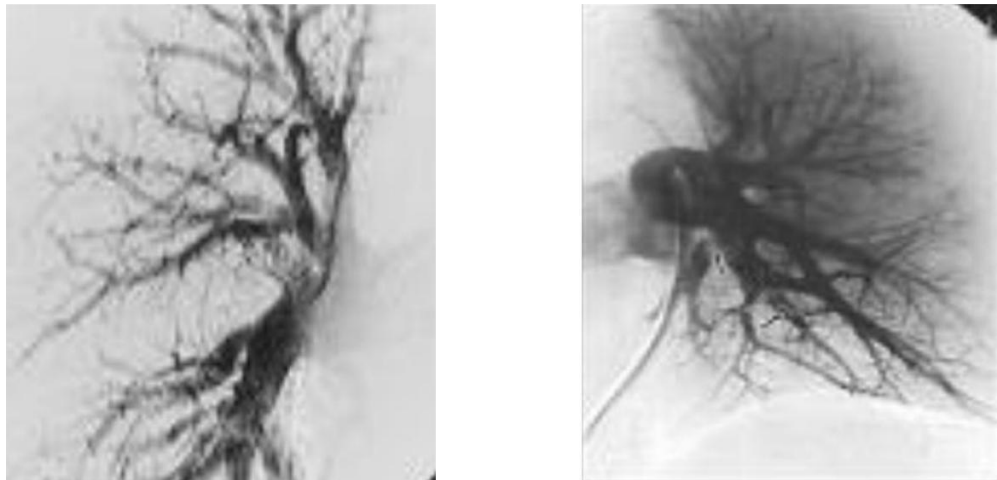
**Figure (2. 8)**a, b, & lung scan by V/Q scans done in the PIOPED study (Overton 1988).

#### **2.2.13.6.4 Pulmonary angiogram**

This test provides a clear picture of the blood flow in the arteries of your lungs. It's the most accurate way to diagnose PE, but because it requires a high degree of skill to administer and carries potentially serious risk, it's usually performed when other tests fail to provide definitive diagnosis.

In a pulmonary angiogram, a flexible tube (catheter) is inserted into a large vein usually in your groin and threaded through your heart into the pulmonary arteries. A special dye is then injected into the catheter, and X-rays are taken as the dye travels along the arteries in your lungs.

Pulmonary angiography, with a sensitivity of at least 95%, is still the gold standard but is used in only 15% of patients with an unresolved question of PE. The risks of inappropriately treating-or not treating-thromboembolic disease are substantial. (Yap KS 2007)

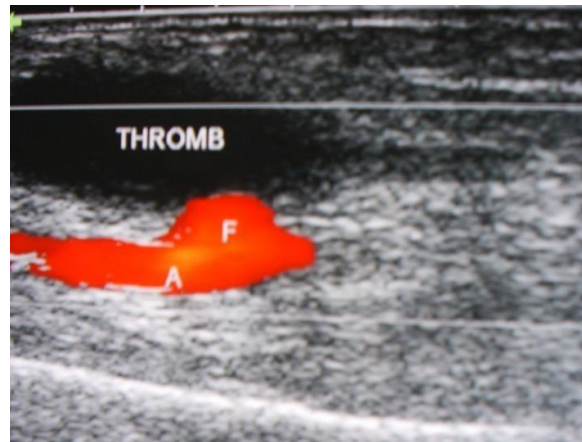


**Figure (2. 9) pulmonary angiogram (Overton 1988)**

It is believed that deep venous thrombosis of the lower extremities and pelvis is responsible for more than 90% of pulmonary emboli, but lower extremity ultrasound is positive in no more than half of patients with proven PE. The utility of compression U/S (CUS) OF the leg veins as a first test is the controversial due to the insensitivity of CUS for diagnosing DVT in pt without leg complaints. (Worsley DF 1991)



However the recent Doppler U/S is increase the sensivity for detection of the lower limbs DVT.



**Figure (2. 10)** Doppler U/S for detection of the lower limbs DVT (Overton 1988).

#### **2.2.13.6.5 Venography**

A more complex and invasive procedure called venography can help reveal blockages caused by blood clots at any point in your arms or legs. During the test, a catheter is inserted into a vein in your foot or ankle. Because blood vessels aren't normally seen on X-rays, a contrast dye is injected into the vein to make it visible just before the X-rays are taken. (Overton 1988)

Although venography generally takes less than an hour, you'll need to keep your leg straight for six hours after the procedure. There are some risks, including an allergic reaction to the dye and a chance that the catheter may damage blood vessels or dislodge part of a clot. Although venography can accurately detect DVT, it's been replaced in large part by duplex ultrasonography. (Overton 1988)

#### **2.2.13.6.6 Blood Tests**

The measurement of D-dimer (a degradation product after plasmin lysis of cross-linked fib-rin) can be an extremely useful screening test in the workup of suspected PE. The quantitative ELISA assay is the D-dimer test we will discuss here, since it has proved to be the most reliable evaluation of D-

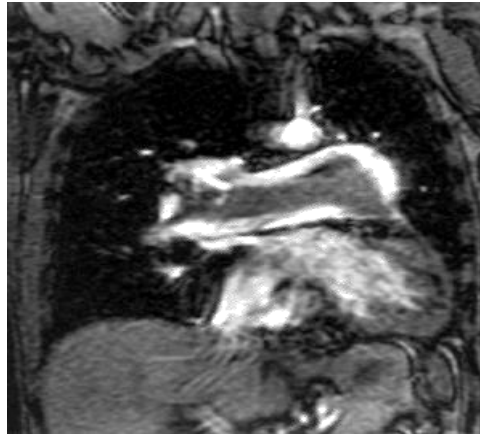
dimer. Available rapid quantitative D-dimer assays have a sensitivity and negative predictive value of 95-99 percent. Therefore, when coupled with a low pretest probability, a normal D-dimer allows the clinician to rule out PE early in the workup and focus on other competing diagnoses. Unfortunately, D-dimer assays are not very specific. In fact, the specificity has been reported as low as 9 percent. Therefore, if the result is positive further testing is required to establish the diagnosis of PE. (Stein PD 2009)

Arterial blood gas (ABG) analysis can confirm hypoxemia, which is one of the possible clinical indicators for the evaluation of the pretest probability of PE. It is important to note that PaO<sub>2</sub> can be greater than 80 mmHg in as many as 12 percent of patients with PE. However, 86 percent of patients with proven PE were found to have an alveolar-arterial oxygen gradient of greater than 20 mmHg. Of course many other disease processes can give abnormal ABG values as well. (Stein PD 2009)

Other blood tests such as CBC, serum chemistries, liver and pancreatic function tests are not particularly helpful in diagnosing PE; however they may lend evidence for other diagnoses that may have signs and symptoms that overlap those of PE. (Stein PD 2009)

#### **2.2.13.6.7 Magnetic resonance imaging (MRI)**

This test uses no X-rays. Instead, a computer creates tissue "slices" from data generated by a powerful magnetic field and radio waves. Because MRI is expensive, it's usually reserved for pregnant women and people whose kidneys may be harmed by dyes used in other tests.



**Figure (2. 11)**MRI for pulmonary embolism (Overton 1988).

#### **2.2.13.6.8 Diagnosis by CT scan:**

Contrast-enhanced thin collimation spiral computed tomography of the thorax with 1 to 2 mm image reconstruction (also known as CT angiography or CTA) has been recognized as a potential test in the diagnosis of PE since 1992, where the sensitivity and specificity was initially reported as 99 percent and 96 percent, respectively. A clinical policy statement from the American College of Emergency Physicians has reviewed the more recent literature, and when subsegmental PE are included, the overall sensitivity of CTA drops to 77 percent, with 89 percent specificity. However, outcome data from CTA studies are much more encouraging, with reported incidence of only 1 percent of subsequent PE in patients with a negative CTA in one trial and a three month incidence of fatal PE of only 0.3 percent reported in a retrospective study of 1510 patients. These outcomes compare favorably with the 0 percent subsequent PE for a normal V/Q and 3 percent subsequent PE for a low probability V/Q reported by Goodman et al.

Is fast becoming the first- line test for diagnosing suspected pulmonary embolism. Is nearly as sensitive in detecting most cases of PE as pulmonary angiogramCT is sensitive to large emboli. (Stein PD 2009)

Single slice technology may miss smaller sub segmental PE and outcome studies using a combination of normal single slice helical CT and normal CUS.

The multi-slides computerized tomography studies of the pulmonary vessels can provide higher-quality images than those obtained at single and dual slice CT. The greater overall data acquisition can be manipulated to make scanning more comfortable and decrease motion artefact, as scan times can be half as long. And much more sensitive than a lung scan but spiral CT exposes you to more radiation than standard X-rays, as to the risk of an allergic to the contrast medium. (Stein PD 2009)

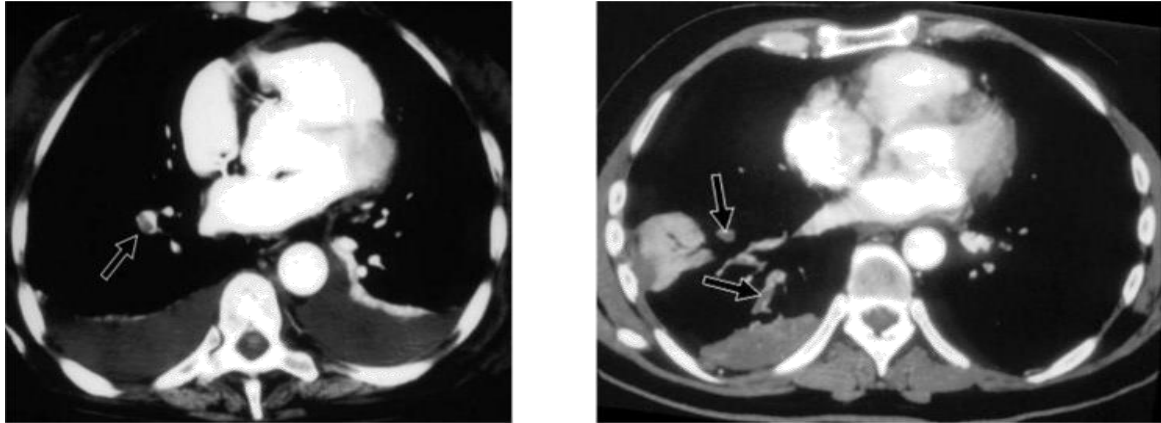
Technical advances in CT scanning, including the development of multidetector-array scanners, have led to the emergence of CT scanning as an important diagnostic technique in suspected PE. Contrast-enhanced CT scanning is increasingly used as the initial radiologic study in the diagnosis of PE, especially in patients with abnormal chest radiographs in whom scintigraphic results are more likely to be nondiagnostic. (Stein PD 2009)

CT scanning shows emboli directly, as does pulmonary angiography, and it is also noninvasive, cheaper, and widely available. CT scanning is the only test that can provide significant additional information related to alternate diagnoses; this is a clear advantage of CT scanning compared with either pulmonary angiography or scintigraphy. (Stein PD 2009)

The addition of venous studies of the legs improves the overall sensitivity, because diagnosis of venous thrombosis in a patient with signs and symptoms of PE strongly supports the diagnosis. Since IV contrast is utilized in CTA, patients with an allergy to IV contrast dye or those with impaired renal function may not be candidates for this test.

The outcome studies noted above indicate that a negative CTA can be considered essentially equivalent to a normal V/Q scan in the evaluation of suspected PE. An abnormal CXR limits the interpretability of a V/Q scan,

and so CTA may be the preferred test in these patients. Furthermore, CTA is more likely than V/Q scan to identify an alternative diagnosis. (Stein PD 2009)



**Figure (2. 12)**CTA showing embolus in Rt lung (Stein PD 2009)

### **2.2.13.7 Treatment**

#### **2.2.13.7.1 Anticoagulant therapy**

Is the mainstay of treatment. Acutely, supportive treatments, such as oxygen or analgesia, may be required. People are often admitted to hospital in the early stages of treatment, and tend to remain under inpatient care until the INR has reached therapeutic levels. Increasingly, however, low-risk cases are managed at home in a fashion already common in the treatment of DVT. Evidence to support one approach versus the other is weak. (Stein PD 2009)

#### **2.2.13.7.2 Thrombolysis**

Massive PE causing hemodynamic instability (shock and/or hypotension, defined as a systolic blood pressure <90 mmHg or a pressure drop of 40 mmHg for >15 min if not caused by new-onset arrhythmia, hypovolemia or sepsis) is an indication for thrombolysis, the enzymatic destruction of the clot with medication. In this situation it is the best available treatment in those without contraindications and is supported by clinical guidelines.

The use of thrombolysis in non-massive PEs is still debated. Some have found that the treatment decreases the risk of death and increases the risk of

bleeding including intracranial hemorrhage. Others have found no decrease in the risk of death.

#### **2.2.13.7.3 Inferior vena cava filter**

If anticoagulant therapy is contraindicated (e.g. shortly after a major operation), an inferior vena cava filter may be implanted to prevent new emboli from entering the pulmonary artery and combining with an existing blockage. It should be removed as soon as it becomes safe to start using anticoagulation. (Stein PD 2009)

#### **2.2.13.7.4 Surgery**

Surgical management of acute pulmonary embolism (pulmonary thrombectomy) is uncommon and has largely been abandoned because of poor long-term outcomes. However, recently, it has gone through resurgence with the revision of the surgical technique and is thought to benefit certain people. Chronic pulmonary embolism leading to pulmonary hypertension (known as chronic thromboembolic hypertension) is treated with a surgical procedure known as a pulmonary thromboendarterectomy.

### **2.3 Computer tomography**

The basic equipment configurations for CT are three major systems: the imaging system, computer system and image display, recording, storage and communication system. Moss-(Gamsu-Genant2015)

#### **2.3.1 The three major systems are located in separate rooms as follows:**

- I. The imaging system is located in the scanner room.
- II. The computer system is located in the computer room.
- III. The display, recording and storage system is located in the operator's room.

### **2.3.1.1 Imaging system:**

#### **2.3.1.1.1 Gantry:**

Is amounted frame work that surrounds the patient in vertical plane. It contains a rotating scan frame on to which the x- ray generator, ray tube and other component are mounted.

#### **2.3.1.1.2 Patient couch:**

The patient couch or table provides a plate from on which the patient lies during examination. The couch should be strong and rigid to support the weight of the patient, additionally it should provide for safety and comfort of the patient during examination. (Moss-Gamsu-Genant 2015)

### **2.3.1.2 The computer system:**

The computer system in CT belongs to class of minicomputers. The two most important characteristics of the CT computer system are a large strong capacity and fast and efficient processing of various kinds of data. (Moss-Gamsu-Genant 2015)

### **2.3.1.3 Imaging display, storage, recording and communication:**

#### **2.3.1.3.1 Image display:**

A display device for CT generally a black and white or color monitor, where as images are usually displayed in gray scale. The features of the image display are display matrix, pixel, size, bit depth, CT value scale image monitor and number of lines, and selectable window width and window center. (Moss-Gamsu-Genant 2015)

#### **2.3.1.3.2 Image storage:**

Data are stored in digital form to preserve the wide dynamic range of image processing and intensity transformation and to decrease the possibility of lost records and reduce the space needed for archiving. (Moss-Gamsu-Genant 2015)

### **2.3.1.3.3 Laser recording system:**

The requirements for hard copy recording of CT images are stringent because these images are used for diagnostic interpretation. (Moss-Gamsu-Genant 2015)

The steps in the laser printing film are:

- I. When the appropriate command from the operator is received; an unexposed film is transported to the exposure area of the printer.
- II. In the exposure area, the film is scanned systematically line by line. The laser receives its signal from the computer to produce a latent image.
- III. Depending on the printer, the scanned film is sent to the receiver or a chemical processor attached to the printer for development.
- IV. The result is a laser printed film ready for viewing.



**Figure (2. 13)** CT machine (64-slice) (Moss-Gamsu-Genant 2015)

### **Technique and strategies of computed tomography examination:**

The diagnostic methodology is part of diagnostic strategy and includes patient preparation, examination parameters and administration of contrast media.



### **2.3.2 Patient preparation:**

When patient presents for abdominal computed tomography the radiologist should assess the clinical problem and review previous imaging studies.

Assess medical history, including the

current indication for study, contrast allergies, renal impairment, past abdominal surgeries, radiation therapy...etc. (Moss-Gamsu-Genant 2015)

Beif physiological examination is helpful if there is agaestion of an abdominal mass. -Decision to be made to individualize the examination includes:

- Contrast, intra venous, oral or rectal.
- Area scanned, anatomic land marks.
- Scan parameter, thickness, spacing, field of view, filters, dose and angulations.

Technique, dynamic sequence, as (axial \_ spiral \_ helical \_ time \_matrix).

The radiologist should review the scan before patient leave.

### **2.3.3 Technical parameter:**

Slice thickness (5-10) mm is sufficient for most application of abdominal computed tomography.

Most scan are performed using contiguous slice (10mm-thick at 10mm interval) surgery examination may be performed at the longer interval 10mm thickness at 15-20mm.interval to sac radiation dose and time with minimal loss of information.

Sac time of 1-2 second used to adimnish motion artifact from peristalsis and pulsating blood vessels.

Contiguous section must be scanned when second image reconstruction (reformatting) to be performed.

A reduction in slice thickness will lead to increase noise if the reduction dose per slice is not increase correspondingly.

Good patient preparation (anti peristaltic agent) is also an important factor in reducing motion artifact.

The number of slices to be scanned determines the total scan time; these should be considered when intravenous contrast is administered.

Depending on the slice thickness and size of the computer matrix, the selected dose per slice determines the degree of spatial and contrast resolution. (Moss-Gamsu-Genant 2015)

Image reconstruction time during biopsy procedure 925\*256 matrices will usually suffice.

#### **2.3.4 CT imaging technique:**

If using a single-detector-row scanner, thin collimation of 2 to 3 mm with pitch 1.7 to 2 generally provides adequate resolution for detection of segmental and larger emboli. Dyspneic patients may be scanned using slightly thicker collimation to permit shorter breath-hold duration, but this will decrease detection of small emboli. Typical parameters for MDCT include a collimation of 1 to 2.5 mm and pitch 6. The volume of interest extends from the dome of the diaphragm (inferior pulmonary veins) up to the aortic arch, or approximately 10 to 12 cm along the z-axis. Patients are coached to hyperventilate two or three times before holding their breath in inspiration as the x-rays begin. (Moss-Gamsu-Genant 2015)

As most emboli go to the lower lobes, patients are scanned in a caudal-to-cranial direction, which helps ensure that dyspneic patients can hold their breath for at least the initial, lower lobe images. An injection rate of at least 3 cc/second should be used with 100 to 140 cc of full-strength nonionic contrast; many centers use higher flow rates.<sup>16</sup> At higher injection rates, more dilute contrast may be used to avoid streak artifacts in the central veins. Contrast should be injected through an antecubital or more proximal vein. (Moss-Gamsu-Genant 2015)

The use of a standard injection delay is feasible in most cases; the value depends on flow rate but is usually between 15 and 20 seconds. A timing bolus may be of value if there is known severe pulmonary hypertension or circulatory delay. Images are reconstructed using overlapping intervals of 1 to 2 mm, unless 1mm collimation is used. If cases are being filmed, those that are not clearly positive on film review must be viewed on a workstation to maximize accuracy.

(Moss-Gamsu-Genant 2015)

## **2.4 Previous Studies:**

Gillum RF (1987) in the incidence of venous thromboembolism rose markedly with increasing age for both sexes, with pulmonary embolism accounting for most of the increase. The incidence of pulmonary embolism was approximately 45% lower during the last 15 years of the study for both sexes and all age strata, while the incidence of deep vein thrombosis remained constant for males across all age strata, decreased for females younger than 55 years, and increased for women older than 60 years. There was very variation between male and female, from 60 patients with PE were found 76% females and 14% males.

Teigen CL (1993) In one of the early investigations, 42 patients were prospectively studied with spiral CT and selective pulmonary angiography for the detection of pulmonary embolism. One hundred and twelve emboli in the main, lobar, and segmental pulmonary arteries were detected at spiral CT and correlated exactly with the emboli detected on subsequent angiograms. All 23 patients with normal spiral CT had normal pulmonary angiograms, whereas of 19 patients with evidence of pulmonary embolism by spiral CT, 18 had pulmonary embolism by pulmonary angiography. The sensitivity of spiral CT for pulmonary embolism was 100% and the specificity was 96%.

Another study published 1 year later using electron beam CT found that this technique had significant potential as a noninvasive test for pulmonary embolism. In this retrospective study of 86 patients, the authors also raised the possibility that the pulmonary arteriogram gold standard may be weak as several definite clots seen at CT were not observed at angiography. They also proposed using CT to distinguish between acute and chronic emboli. In a follow-up paper, the same authors prospectively evaluated 60 patients with suspected pulmonary embolism using electron beam CT and pulmonary angiography. In addition, 38 patients had ventilation-perfusion scans. In a review of their cases, there was close to 100% sensitivity and specificity for

the diagnosis of pulmonary embolism using CT, and they also commented that CT had the capability of replacing ventilation-perfusion scanning as a screening test. This led to more excitement in the radiology community regarding the utility of CT scanning for the diagnosis of pulmonary embolism. The fact that some vessels might not be visualized by CT did not seem too important because in the studies just cited, an average of over six emboli per patient was discovered and the likelihood of missing all of them was considered negligible.

Another study by Kim K-I (1999) further evidence of the value of spiral CT scanning as a screening test is found in the results of a European multicenter trial. In this study 401 patients were examined. It was found that spiral CT had greater sensitivity for disease than ventilation-perfusion scanning (mean values, 85% vs. 50%). CT was able to detect abnormalities not only in the lung but also in the mediastinum and elsewhere in the thorax. Interobserver agreement in interpretation of CT scans was also found to be better than with ventilation-perfusion scans (72% vs. 39%). In another study the authors prospectively evaluated the use of spiral CT in examining patients with clinically suspected pulmonary embolism. One hundred ten patients had spiral CT and at least one other imaging test. A chart review or telephone interview with the referring clinician sought the contribution of spiral CT in establishing the patient's final diagnosis. Spiral CT had 92% sensitivity in identifying patients with pulmonary embolism; in 67% of patients without pulmonary embolism, it provided additional information useful in establishing an alternative diagnosis such as pneumonia, heart disease, and pulmonary fibrosis. These results and others further strengthen the use of spiral CT as a screening test for the diagnosis of pulmonary embolism, particularly in patients likely to have indeterminate ventilation-perfusion studies such as hospitalized patients or patients with known underlying disease.

Another study by Remy-Jardin M (2007) CTPA studies using the multislice technique showed a high sensitivity (96 to 100%) and specificity (97 to 98%), and they have replaced invasive pulmonary angiography as the reference test for acute PE. Sensitivity and specificity, depending on the location of the emboli, vary from 20 to 30% for small subsegmental emboli using single-row CT up to 95% for segmental, lobar, and central emboli using multislice CTPA.

Several follow-up studies have demonstrated that it is safe to withhold anticoagulant treatment if CTPA has excluded acute PE. In only 1.3% of the patients with a high pretest probability of PE but a negative CTPA, a VTE was diagnosed during 3-month follow-up. In a meta-analysis these results were confirmed and showed a high negative predictive value of a normal CTPA result (98.8%; 95% CI 98.2 to 99.2).

By Anderson DR (2007) a study from 2007 compared diagnostic test results of CTPA with V/Q scintigraphy and revealed comparable results with a prevalence of PE of 14 to 19% and a 0.6 to 1.0 incidence of recurrent VTE after normal V/Q scan during 3-month follow-up. The most important advantage of CTPA over V/Q scintigraphy is the low number of inconclusive test results (0.9 to 3.0 vs 28 to 46%) and the possibility to achieve an alternative diagnosis that can explain the complaints of the patients, including pneumonia, malignancy, or aortic dissection. With the development of the CTPA technique, more and smaller, subsegmental emboli may become visualized. The clinical relevance of these emboli is yet uncertain. Although observational research suggests that treated as well as untreated patients have a good prognosis, the clinical relevance is not clear at this moment given the lack of good randomized outcome studies. Disadvantages of CTPA are the relative contraindications in patients with allergy to iodinated contrast material, occurring in 0.7% of patients, and in patients with impaired renal function. Contrast-induced nephropathy after

CTPA is estimated to occur in 8.9 to 12% of patients. Overuse of CTPA, without assessment of the pretest probability, may lead to a high rate of more than 90% of negative results.

# **Chapter Three**

## **Materials and Methods**



## **CHAPTER THREE**

### **Materials and Methods**

#### **3-1 Materials:**

##### **3.1.1 Machine Used:**

For CT was used 64 slice scanner (NEUSOFT).

##### **3.1.2 Patients:**

The entire populations of this study were 50 patients (15 males and 35 females) with ages range between (15-80) Years,.They referred to CT center for CT examination of chest. All patients suspected to have pulmonary embolism according to the clinical signs and symptoms.

#### **3-2 Methods:**

##### **3.2.1 Method of Data collection:**

Data collected by Questionnaire

##### **3.2.2Methods of data analysis:**

The all data analyzed through statistical method that includes frequency table percentage.

##### **3.2.3 Area and duration of the Study:**

The study has been carried out during the period from June 2019 up September 2019 in Clinic Doctors and Elsaha Specialized hospital.

##### **3.2.4 Technique Used**

Lightspeed 64-section CT scanners (NEUSOFT) are used to acquire images of the thorax in a caudocranial direction. For intravenous access, introduction of an 18- or 20-gauge catheter into an antecubital vein is preferred. The chest field of view is the widest rib-to-rib distance acquired during breath hold after inspiration. Images are acquired with a standard algorithm and viewed with it software. Images are displayed with three different gray scales for interpretation of lung window (window width/level

[HU] = 1500/600), mediastinal window (400/40), and pulmonary embolism-specific (700/100) settings. Multiplanar reformatted images through the longitudinal axis of a vessel are sometimes used to overcome various difficulties encountered with axial sections of obliquely or axially oriented arteries. Reformatted images can help differentiate between true pulmonary embolism and a variety of patient-related, technical, anatomic, and pathologic factors that can mimic pulmonary embolism.

Contrast material-enhanced spiral CT of the veins of the lower extremities is performed with the same contrast material bolus that is used for chest CT. Images of the iliac, femoral, and popliteal veins are obtained 4 minutes after the onset of enhancement from the initial contrast material injection. Multisection CT venography is simple and accurate, and when combined with lung imaging it allows fast and comprehensive evaluation for thromboembolic disease

### **3.2.5 Interpretation and results**

A radiologist, a physician specifically trained to supervise and interpret radiology examinations, will analyze the images and send assigned report to primary care or referring physician.

Data is collected from image reports that demonstrate size, site, texture and enhanced tumors

# **Chapter Four**

## **Results**

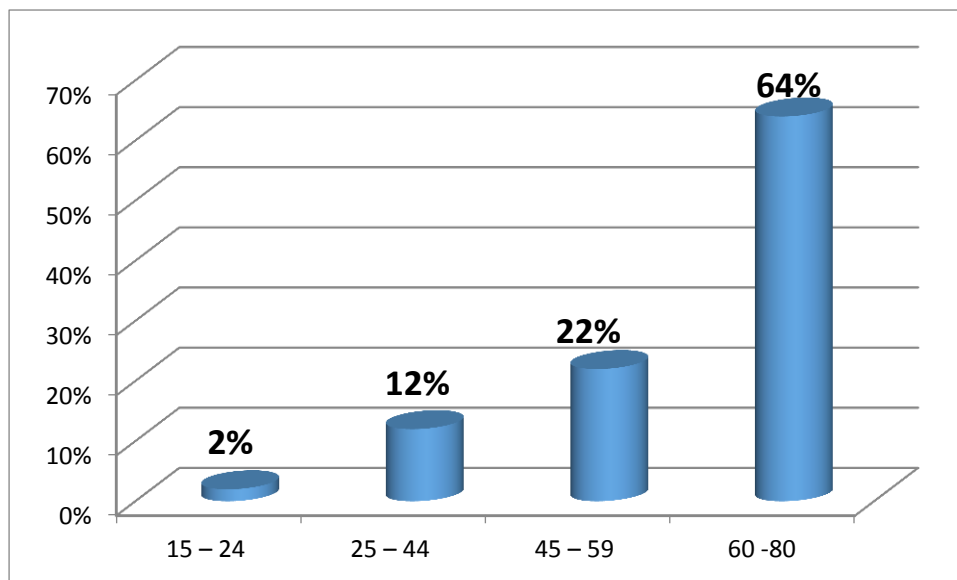
## CHAPTER FOUR

### The Results

The peak incidence was among the age between 15 - 80 years of age presenting the percent of (%)

**Table (4-1)** shows division of subject group according to the age.

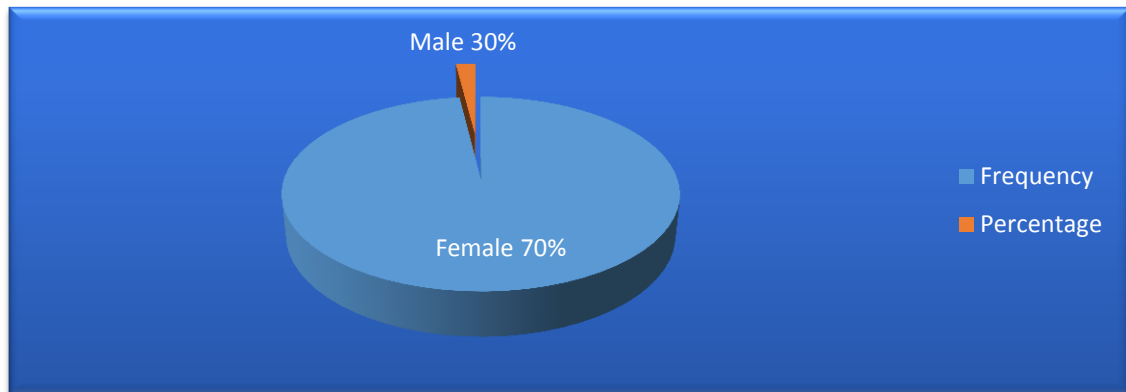
Age	Frequency	Percent
15 – 24	1	2 %
25 – 44	6	12 %
45 – 59	11	22 %
60 -80	32	64%



**Figure(4-1)** illustrates the frequency & percentage of population age.

**Table (4. 2)** shows study group according to gender

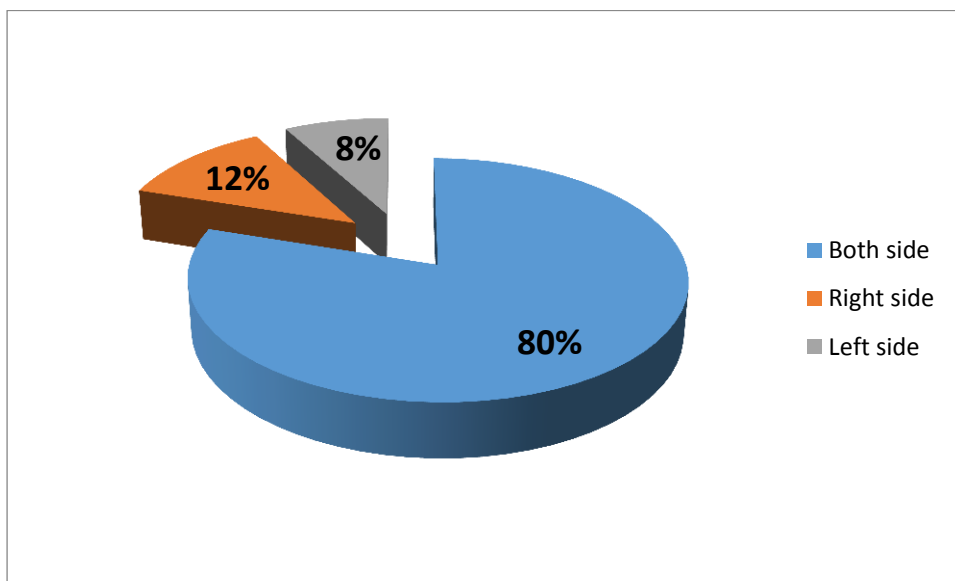
Patient sex group	Frequency	Percentage
Male	15	30%
Female	35	70%



**Figure (4. 2)** illustrates the frequency & percentage of population gender

**Table (4.3)** shows study group according to location of PE

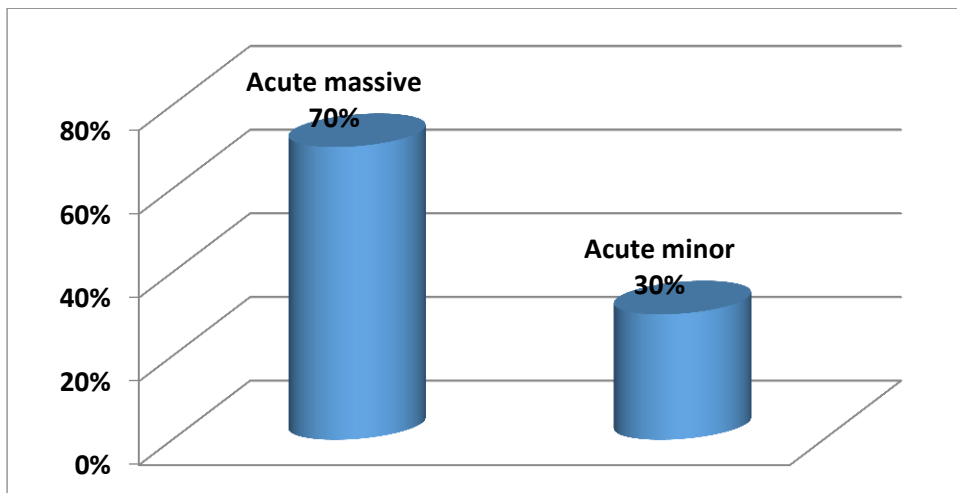
location	Frequency	Percentage
Both side	40	80%
Right side	6	12%
Left side	4	8%



**Figure (4.3)** illustrates study group according to location of PE

**Table (4. 4)** shows study group according to type of PE

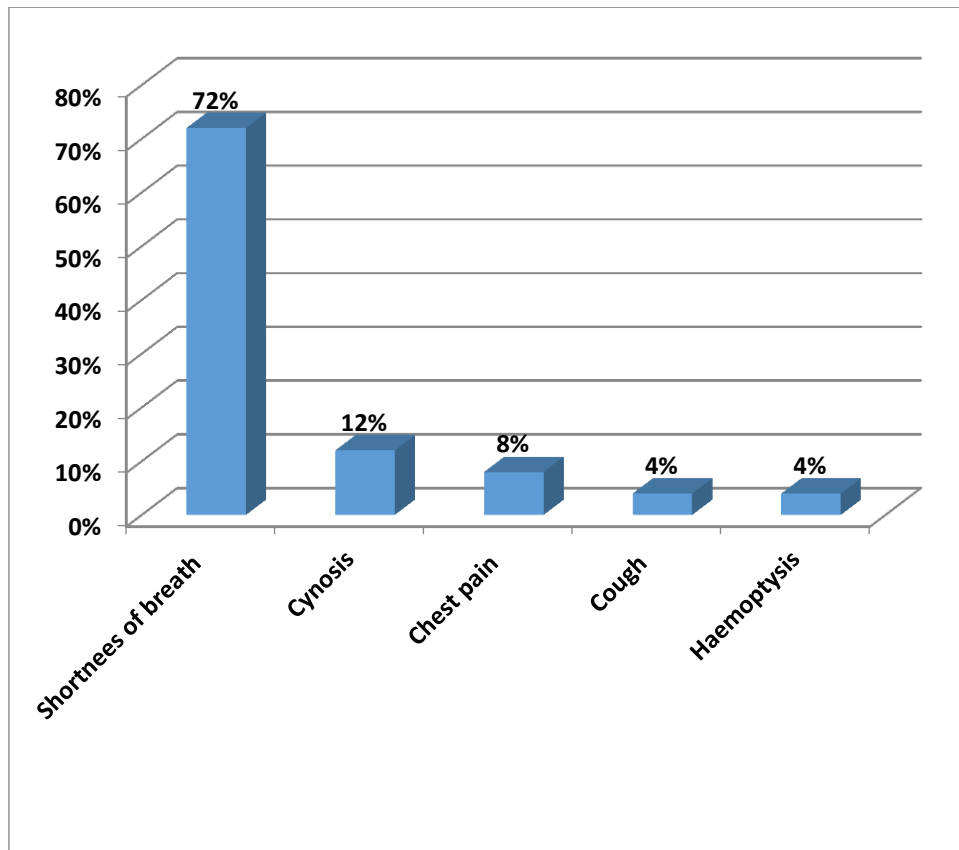
Type	Frequency	Percentage
Acute massive	35	70%
Acute minor	15	30%



**Figure (4. 4)** illustrates study group according to type of PE

**Table (4.5)** shows study group according to the Clinical indication

Symptoms	Frequency	Percentage
Shortnees of breath	36	72%
Cynosis	6	12%
Chest pain	4	8%
Cough	2	4%
Haemoptysis	2	4%



**Figure (4.5)** illustrates study group according to clinical indication .



# **Chapter Five**

**Discussion, Conclusion and  
recommendation**

## Chapter FIVE

### Discussion, conclusion and recommendation

#### 5.1 Discussion

This study carried out to evaluate the accuracy of CT in diagnosis and classification of pulmonary embolism here below we will discuss in details, the findings of the study.

Table and figure.(4.1) showed the main CT chest finding were PE in 32 patients(64%) with age range (60-80) years,11 patients (22%) with age range (45-59) years, 6 patients (12%) with range (25-44) years, 1 patient (2%) with range (15- 24) years, according to this result PE is more common in elder patients ( 60- 80) years. This result agreed with Gillum RF 1987.

There were variation in incidence of PE between male and female, in table and fig. (4.2) showed that 15 of patients out of 50 (30%) are males while 35 (70%) are females. The study showed common side for PE in both side. There were 40 patients form study group PE were found in both side (80%), the second common site was right site 6 patients (12%) and the rare side in left site 4 patients (8%), showed in table and fig.(4.3). Table and fig. (4.4) showed that types of PE were 35 patients (70%) out of 50 patient with acute massive PE ,and other 15 patients (30%) were with acute minor PE

Table and fig. (4.5) showed the most clinical indications of PE, common presenting symptoms were shortnees of breath (72%) followed by cyanosis(12%),chest pain (8%),cough (4%),and haemoptysis (4%).This result indicates that CT has a high technical success rate. The characteristic of the all variables in the sample studied were described as frequencies and percentages. CT for chest was used in this study axial and coronal to demonstrate PE found the following results; CT scanning of chest was providing great clarity and reveal high details in diagnosing of PE. The diagnostic value of CT in the detection of PE has been reported by several

authors in experimental and clinical studies, with variable sensitivity and specificity values.

## 5-2 Conclusion

- ✦ In conclusion, helical CT is a technical improvement of helical CT and a diagnostic tool with a high sensitivity and specificity for the detection of PE.
- ✦ These findings of study indicate that helical CT could replace pulmonary arteriography for the direct demonstration of endoluminal thrombi in the pulmonary arteries in a majority of patients.
- ✦ Selective pulmonary arteriography should be reserved for select patients with an unresolved diagnosis. The evaluation of small vessels, which is improved by thin sections, remains a limitation of current helical CT.
- ✦ However, the development of faster imaging systems with submillimeter isotropic imaging are expected to improve the evaluation of sub-segmental pulmonary vessels, with optimal spatial and temporal resolution, in the near future.
- ✦ This modern equipment CT has diagnosing function and resulting in good high technical properties and this powerful procedure must be one important interests of our planning to progress and develop our medical services in the Sudan. CT is the image modality of choice evaluate PE, as it provides „a road map „, and excellent detail is available regarding to the anatomy, pathology and early diagnosis of PE very important factor in the disease management.
- ✦ CT was used ideally for full evaluation of the PE and today CT scanners allow post processing reformats for further views in different planes if required. With multi-detector row CT technology, past limitations of CT for the diagnosis of PE should be effectively overcome; for all practical purposes,
- ✦ CT has become the first-line modality for imaging in patients suspected of having PE. However, prospectively acquired patient outcome studies are still needed. Once this type of investigation has confirmed that a negative CT study can be used to safely rule out PE, we believe use of CT to aid in diagnosis of PE will be Unanimously accepted.

### **5-3 Recommendations:**

- Clinical assessment should be made for patient suspected of having PE before the CT examination.
- Other investigations must be done before CTPA, as CXR, ECG, and echocardiography.
- Other quantification methods must be used to diagnose PE including blood gas values and lung attenuation.
- CT chest should be performed for any patients complain of chest pain or breathing problem.
- Spiral CT technique should be the primary investigation performed for patient suspected to have PE
- The radiologist and technologist should be well trained.
- There should be effective co operation between technologist, radiologist & Physicians to make full use of available spiral CT facilities.
- The medication for the contrast media reaction should be available before Injection.
- Technical that must be the perception of pulmonary and all branches
- Spiral CT is best to diagnoses of pulmonary embolism (PE).

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# **Appendices**



**Appendix (A) SUDAN UNIVERSITY OF SCIENCE &  
TECHNOLOGY COLLEGE OF GRADUATE STUDIES  
DATA COLLECTION**

**FORM**

- Pt Gender:
- Pt Age:
- Date of Examination:
- Clinical Sign & Symptoms:
- Clinical Diagnosis:
- CT Finding:
- Side of Embolism: Rt Side() Lt Side () Bilateral()
- Types of PE

## Appendix (B)

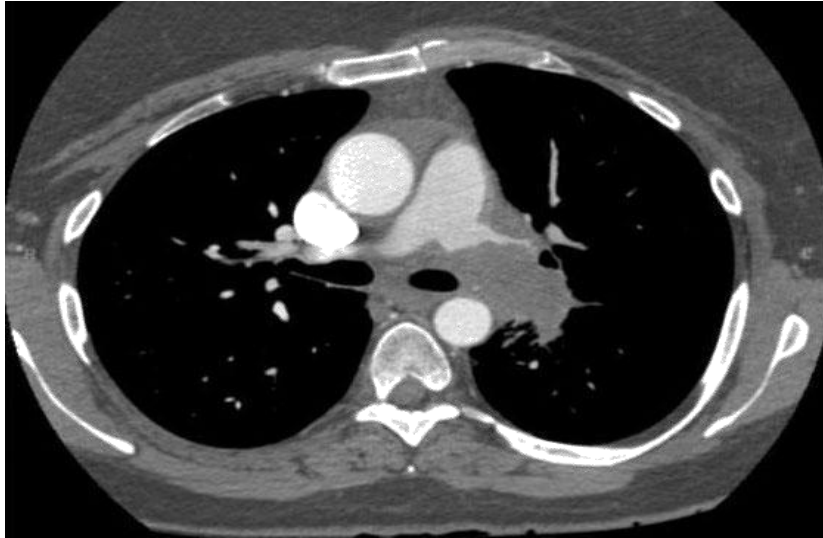


Image (1) A 47 year<sup>o</sup> s male axial CT image of the chest demonstrating chronic massive pulmonary embolism in the left main pulmonary artery and extending into all sub-branches.



Image (2) A 66 year<sup>o</sup> s female axial CT image of the chest demonstrating chronic massive pulmonary embolism in the right main pulmonary artery.



Image (3) A 63 year<sup>s</sup> female axial CT image of the chest demonstrating chronic minor pulmonary embolism in the both side of main pulmonary artery.



Image (4) A 71 year<sup>s</sup> male axial CT image of the chest demonstrating chronic massive pulmonary embolism in the both side of main pulmonary artery.