

Chapter one

1-1-Introduction

The diagnosis of pulmonary embolism (PE) remains a major clinical problem. Because of variable and non specific symptoms, imaging is required to establish the diagnosis. Selective pulmonary arteriography may provide a definitive diagnosis. However, this procedure is invasive, with morbidity and mortality rates of 4% and 0.2%, respectively (Mills, 1980, Stein, 1992) moreover, it is costly and time-consuming.

Several minimally invasive modalities have been used to detect PE. Ventilation-perfusion (V-P) scanning is the most widely used because of its general availability and lower cost (Alderson, 1987). Unfortunately, V-P scanning is of limited diagnostic value in approximately 75% of patients who have an intermediate or indeterminate probability of having PE (Goodman, 1995).

Furthermore, in 66% of patients, a definitive diagnosis could not be made by using V-P scanning and clinical data only (Kelly, 1991,). Recently, magnetic resonance imaging (Meaney, 1997), electronbeam computed tomography (CT) (Teigen, 1993), and helical CT have demonstrated superiority over V-P scanning as screening tools for acute PE.

Investigators in recent studies have reported sensitivities and specificities of 53%–100% and 81%–100%, respectively, for helical CT in the detection of PE. In parallel, several investigators (Garg, 1998) have pointed out the

limitations of helical CT in the detection of PE in segmental and subsegmental vessels. The poorer efficiency of helical CT

The diagnostic value of helical CT in the detection of PE has been reported by several authors in experimental and clinical studies (Drucker, 1998), with variable sensitivity and specificity values. However, to our knowledge, no large series of consecutive patients in which helical CT and selective pulmonary arteriography (the reference standard) were compared have been reported.

1-2 Problem of the study:

High incidence of Pulmonary Embolism with wrong diagnoses .

1-2 Objectives :

- To evaluate the role of spiral CT in the detection of pulmonary embolism practically .

-To establish the suitable protocol that used to demonstrate the pulmonary embolism in spiral CT .

1-3 Overview of the study:

Chapter one:

Is a general introduction, which consists of:

An introduction, the objectives of the research, methodology of the research, machine used & then concluded with the scope of the study

Chapter two:

It is a literature review, which consists of the following:

Anatomy of the respiratory system

Physiology of the respiratory system

Pathology of the respiratory system

Computed tomography (CT)

Previous study

Chapter three:

It deal with the material & methods

Chapter four:

It included result presentation

Chapter five:

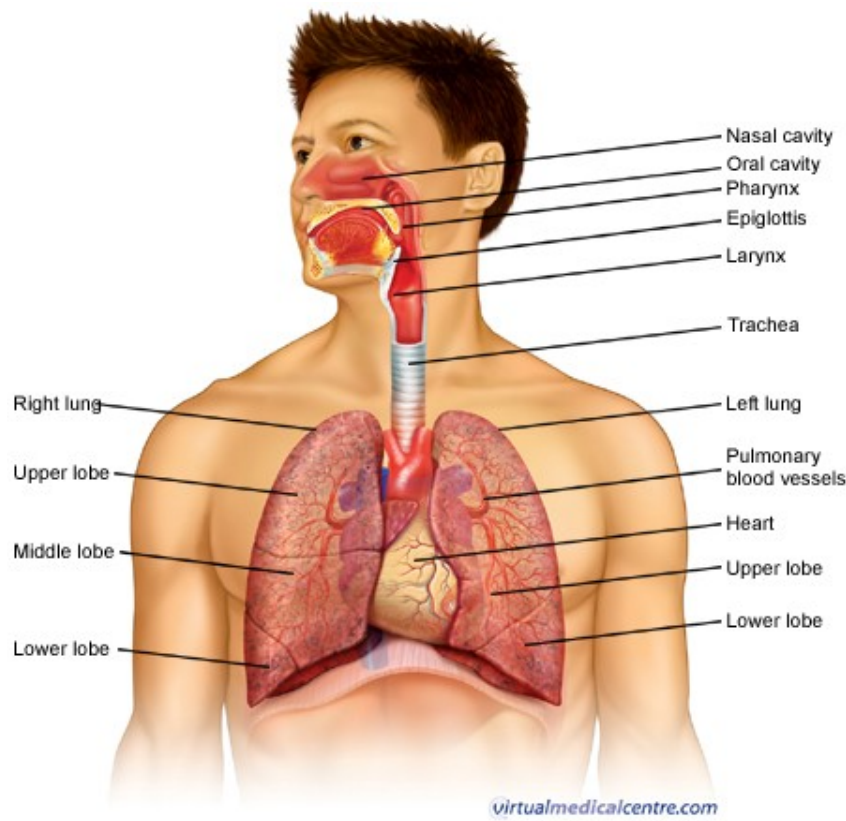
Deal with the discussion, conclusion & recommendation.

Chapter two

Back ground

2- The anatomy and physiology of the respiratory tract

Each anatomic segment performs in concert with the others and is accountable for a wide variety of physiological responsibilities. These responsibilities vary with rest or exercise, disease or health. Throughout this studies , the reader will discover that the respiratory tract is a delicate and complicated system that can be involved in a number of disease processes. An understanding of the anatomy and physiology of the respiratory tract is critical to understanding this elaborate system to maintain respiratory health and treat respiratory diseases.



Figure(2-1) shows anatomy of respiratory system

2-1Upper and Lower Anatomy Structures and Functions

2-1-1Upper Respiratory Structures

The upper respiratory structures include the nose and pharynx. The space inside the nose is known as the nasal cavity and is divided into right and left sides by the nasal septum (Tortora & Grabowski, 2000). When air first enters the nose, it is filtered, warmed, and humidified by the nasal turbinates in the internal nares. The pharynx starts at the internal nares and extends to the cricoid cartilage. The pharynx is usually subdivided into the nasopharynx, oropharynx, and laryngopharynx. The nasopharynx humidifies and filters the air they breathe. Additionally, it helps equalize ear pressure and maintains balance by exchanging air with our eustachian tubes. The oropharynx and laryngopharynx has both digestive and respiratory functions (Tortora & Grabowski, 2000). All olfactory receptors are also located within the nose and are responsible for our sense of smell.

2-1-2Lower Respiratory Structures

The lower respiratory structures include the larynx, trachea, bronchi, and lungs. The larynx lies just at the upper end of the trachea and the lower end of the laryngopharynx. The larynx, or voice box, is made of nine cartilages. Three of the largest cartilages of the larynx are the thyroid cartilage (Adam's apple), the epiglottis (prevents food and liquid from entering the trachea), and the cricoid cartilage (Thibodeau & Patton, 1999). The trachea, or windpipe, extends from the larynx to the primary bronchi (Thibodeau & Patton, 1999).

The trachea is the first in a series of tubes that furnish air to the lungs. At the lower end of the trachea, there are two primary bronchi. The right is slightly larger than the left. These bronchi enter their corresponding lung, where they branch into secondary and then tertiary bronchi. The tertiary bronchi branch into even smaller airways, the bronchioles. Because the primary bronchi and their respective branches resemble an upside down tree, they are known as the bronchial tree. The bronchioles keep dividing into smaller and smaller tubes that eventually become microscopic. Once the tubes become microscopic, they are known as the alveoli ducts. These ducts enter into alveolar sacs. Diffusion of gases occurs in the alveoli (Thibodeau & Patton, 1999).

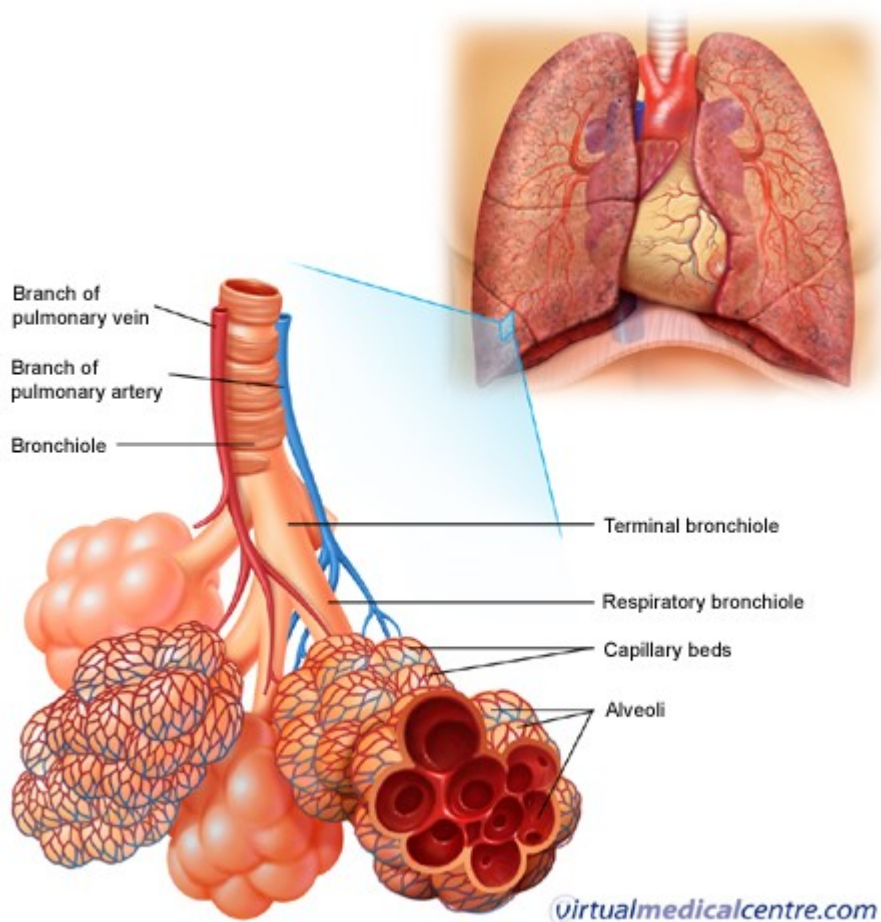
Because the alveoli are truly the functional gas exchanging units of the lungs, they deserve to be described in more detail. There are approximately 300 million alveoli in the lungs. This is equivalent to approximately 85 square meters if opened up and laid out flat (Thibodeau & Patton, 1999). The walls of the alveoli are very thin and lie right next to a bed of capillaries. This barrier between the incoming air and the blood is known as the respiratory membrane. Oxygen travels across this membrane into the bloodstream and carbon dioxide travels from the bloodstream, across the membrane and into the alveoli, where it can be exhaled. Within the alveoli is a substance known as surfactant. Surfactant is responsible for keeping the alveoli open during exhalation, so they do not collapse completely (Thibodeau & Patton, 1999; Tortora and Grabowski, 2000).

2-1-3 Structures within the Thoracic Cage

2-2-1 The Lungs

The lungs extend from the diaphragm (base) to slightly above the clavicles (apex) and expand through the entire rib cage. The right lung has three lobes and is responsible for about 55% of lung activity.

The left lung has two lobes and is responsible for about 45% of lung activity. The lungs perform two main functions: ventilation and diffusion. Ventilation is the function of both the upper and lower airways. Diffusion is the function of the alveoli and the capillary bed surrounding them.



Figure(2-1) shows anatomy of the lungs

2-2-2The Pleura

The pleura is a two-layered protective membrane which surrounds the lungs. The parietal pleura lines the thoracic cavity and the visceral pleura lines the lungs. The space in between the two pleura is known as the pleural space. This space contains a thin layer of lubricating fluid that allows the lungs to expand smoothly and fully.

2-2-3The Diaphragm

Another structure within the thoracic cage is the diaphragm. The diaphragm is the major muscle of inspiration and is responsible for about 70% of the tidal volume. Most of the time, other muscles of respiration are not used for gas exchange. When your patient needs more than normal lung volumes or has a respiratory disease process, these muscles, the external and internal intercostals, abdominals, and accessory muscles in the neck, may assist in ventilation (Sherwood, 1997).

2-3 Pulmonary & Bronchial Circulation

The lungs receive their blood supply from the pulmonary arteries from the heart and the bronchial arteries that are direct branches off of the aorta (Tortora, 1989; Tortora & Grabowski, 2000). Oxygenated blood exits the lungs via the pulmonary veins that terminate in the left atrium. The lungs have the unique capability of diverting blood away from low demand areas of the lungs during hypoxia. This increases the amount of blood flow to the areas of the lungs that take part in gas exchange, thus increasing the oxygen

carrying capacity of the blood during times of extreme demand or hypoxia (Tortora & Grabowski, 2000).

2-3-1 Physiology of Gas Exchange

The pulmonary circulation carries the blood to and from the lungs. In the heart, the blood flows from the right atrium into the right ventricle; the tricuspid valve prevents backflow from ventricles to atria. The right ventricle contracts to force blood into the lungs through the pulmonary arteries. In the lungs oxygen is picked up and carbon dioxide eliminated, and the oxygenated blood returns to the heart via the pulmonary veins, thus completing the circuit. In pulmonary circulation, the arteries carry oxygen-poor blood, and the veins bear oxygen-rich blood.

The exchange of the air between the lungs and blood are through the arterial and venous system. Arteries and veins both carry and move blood throughout the body, but the process for each is very different.

(Arteries carry blood from the heart to the body, Veins return blood from the body to the heart and the heart is a two-sided pump)

Oxygen-carrying blood travels from the left side of the heart to all the tissues of the body. The oxygen is extracted by the tissue, and carbon dioxide (a waste product) is delivered back into the blood.

The blood, now deoxygenated and with higher levels of carbon dioxide, is returned via the veins to the right side of the heart.

The blood is then pumped out of the right side of the heart to the lungs, where the carbon dioxide is removed and oxygen is returned to the blood from the air we breathe in, which fills the lungs.

Now the blood, high in oxygen and low in carbon dioxide, is returned to the left side of the heart where the process starts all over again.

The blood travels in a circle and is therefore referred to as circulation.

2-3-2 Blood clot formation

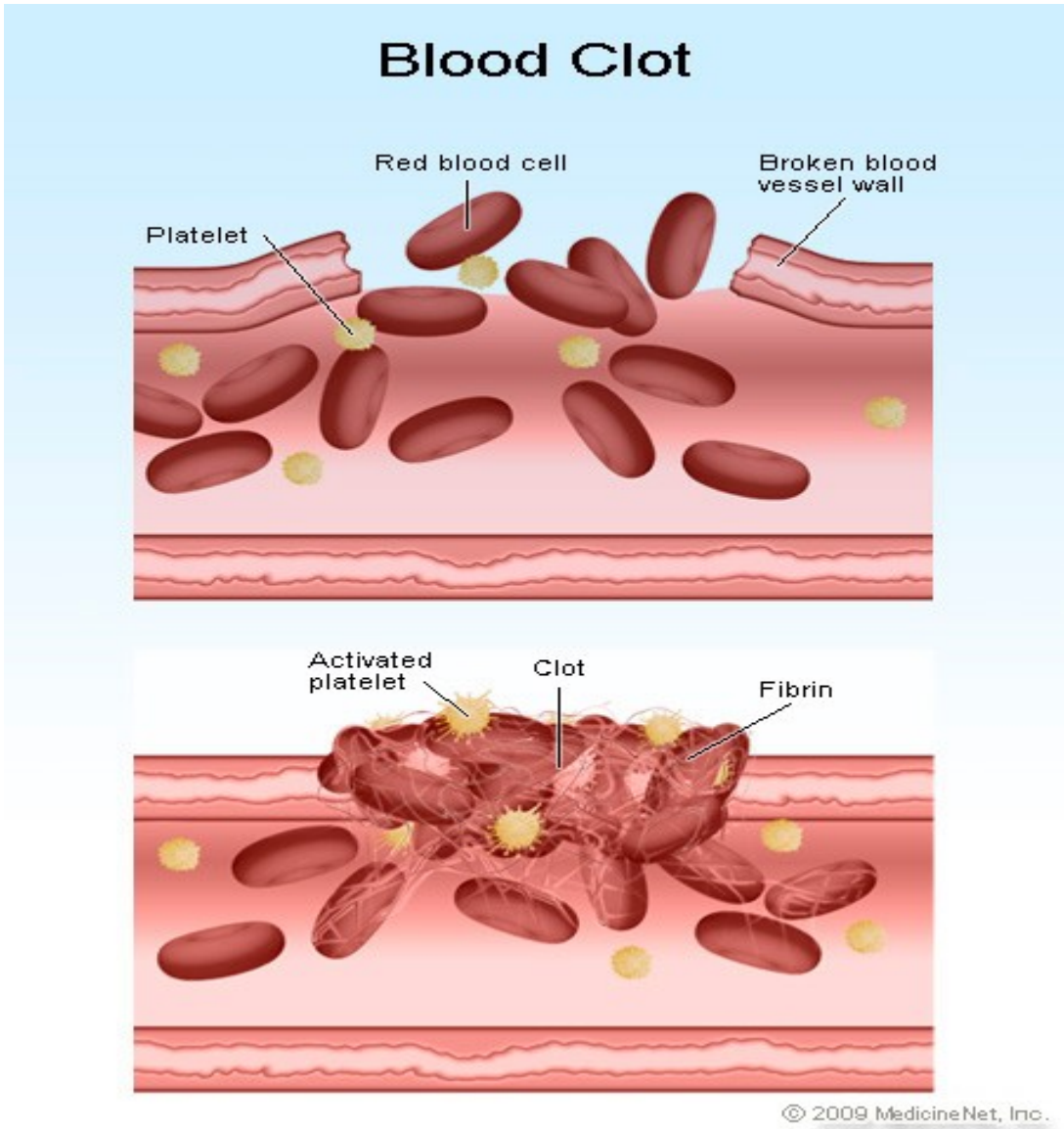
If a blood clot (thrombus) forms in the one of the body's veins **deep vein thrombosis**(DVT) , it has the potential to break off and enter the circulatory system and travel through the heart and become lodged in the one of the branches of the pulmonary artery of the lung. A clot that travels through the circulatory system to another location is known as an embolus (plural emboli).

A pulmonary embolus clogs the artery that provides blood supply to part of the lung. The embolus not only prevents the exchange of oxygen and carbon dioxide, but it also decreases blood supply to the lung tissue itself, potentially causing lung tissue to die (infarct). A pulmonary embolus is one of the life-threatening causes of **chest pain** and should always be considered ,when a patient presents to a healthcare provider with complaints of chest pain and **shortness of breath**.

Non-thrombus causes of pulmonary embolus are rare but include:

- fat emboli from a broken femur,
- an amniotic fluid embolus in **pregnancy**, and
- in some cases, tumor tissue from **cancer**.

The presentation is the same as that of a blood clot, caused by blockage of part of the arterial tree of the lung.



Figure(2-3-1) show blood clot formation

which is the ventilation, diffusion, and transport of gases – primarily oxygen and carbon dioxide. Ventilation is the exchange of air between the atmosphere and the alveoli. Diffusion is the actual exchange of oxygen and carbon dioxide across the respiratory membrane. Transport refers to the carrying of oxygen and carbon dioxide throughout the circulatory system.

2-4 Ventilation - Lung Volumes and Capacities

The following table summarizes lung volumes and capacities. Deviations from these normal values usually result in a deviation in the lungs ability to ventilate.

2-5 ventilation - Total Lung Ventilation

Total lung ventilation is the sum the alveolar and dead space ventilation. Alveolar ventilation (VA) is the portion of total ventilation that reaches the alveoli and takes part in gas exchange. The PaCO₂ value in your arterial blood gas is the best indicator of alveolar ventilation. If your PaCO₂ is normal (35-45 mm Hg), alveolar ventilation is normal or adequate. If your PaCO₂ is low (< 35 mm Hg) alveolar ventilation is increased – CO₂ is “blown off”. If your PaCO₂ is high (>45 mmHg) alveolar ventilation is decreased – CO₂ is retained.

Dead space ventilation (VD) is the volume of inspired air that does not participate in gas exchange. Dead space ventilation consists of anatomic dead space and alveolar dead space. There is typically about 2 ml/kg of anatomic dead space. This is the air that fills the conducting airways.

Alveolar dead space is the volume of air that reaches the alveoli and has little or no blood flow.

2-6 Ventilation - Lung Elasticity and Compliance

Lung elasticity and compliance affect ventilation. Elasticity refers to the lungs ability to “snap” back to their original shape during the process of ventilation and compliance is a measure of this elasticity (Thibodeau and Patton, 1999). Lungs that are overly elastic have a high compliance and are more easily distended. Patients with emphysema have highly compliant lungs. Lungs that are not very elastic have a low compliance and are less easily distended or “stiff”. Patients with pneumonia, pulmonary edema, fibrosis, atelectasis, obesity, or abdominal distention have low compliance lungs.

2-3-2 Ventilation - Lung Mechanics

Normally, when the diaphragm contracts, it moves downward, increasing the diameter of the chest and elevating the lower ribs. This furthers decreases the amount of negative pressure within the pleural space, decreasing the amount negative pressure within the alveoli. This change in pressure results in air being pulled into the lungs.

When the lungs are filled with air, the pressures within the lungs are greater than the pressure in the atmosphere, and air is exhaled (Sherwood, 1997).

Any condition that alters normal lung mechanics will alter the ventilation ability of the lungs. Examples include COPD, emphysema, pneumonia, flail chest, hemo or pneumothorax, Guillian Barre syndrome, spinal cord injury, and many others.

2-7 Diffusion

Diffusion is the second step in the process of respiration. Diffusion refers to the exchange of carbon dioxide and oxygen across the respiratory membrane. Diffusion occurs down a concentration gradient from an area of higher to lower concentration. There are several factors that influence a gases ability to diffuse across this membrane. If the integrity of the alveolar capillary membrane is impaired by either fluid or fibrosis, diffusion or gas exchange will be decreased. During atelectasis or pneumonia, when the alveolar capillary membrane's surface area decreased, diffusion, or gas exchange, is also decreased. If the amount of hemoglobin is reduced, it is more difficult for oxygen to cross the respiratory membrane and become bound to this molecule, and diffusion or gas exchange is decreased. Finally, there are some other gases are more soluble than oxygen. For example, carbon dioxide is about twenty times more diffusible across this membrane than oxygen (Sherwood, 1997).

2-8 Transport

The transport of oxygen and carbon dioxide to the cells is the final step in respiration. Oxygen is transported in the blood in two ways: bound to hemoglobin on the red blood cell and dissolved in the plasma. Hemoglobin binds to dissolved oxygen in the blood, until the molecule is fully saturated (measured by your pulse oximetry - SaO₂). The remaining oxygen is dissolved in the plasma measured by arterial blood gas sampling (PaO₂) (Normal PaO₂ 80-100mm Hg).

The oxyhemoglobin dissociation curve shows the relationship between oxygen saturation (pulse oximetry value) and your dissolved oxygen in the blood (PaO₂). This is an “S” shaped curve. Using this curve, we can predict the arterial PaO₂, if we know the oxygen saturation or (pulse oximetry value) at normal temperature and pH. If temperature or pH values change, this curve will either “shift to the left” or “shift to the right”. Shifts in the curve allow oxygen to be released to the cells more easily or held onto more tightly by the hemoglobin molecule (Sherwood, 1997). This is important in maintaining cellular oxygenation during times of high or low temperatures or acidemia or alkalosis. Carbon dioxide is a product of cellular waste. It is transported in the blood in three ways. It can be dissolved in the plasma and is reflected in the arterial blood gas as the PaCO₂ (normal values are 35-45 mm Hg). It can be combined with the hemoglobin molecule. Finally, it is carried in the form of bicarbonate. Eventually it reaches the alveolar-capillary bed, where it is released from the hemoglobin molecule, diffused across the respiratory membrane into the alveoli and finally exhaled.

2-3- Pathology of the lung;

2-3-1 Congenital and hereditary disease;

This includes Cystic fibrosis.

2-3-2 Inflammatory disease;

Pneumonia is the most frequent type of lung infection , resulting in an inflammation of the lung and compromised pulmonary function . The main causes of pneumonia are bacteria , viruses and myoplasm

2-3-3 Bronchiectasis ;

Bronchiectasis is permanent , abnormal dilatation of one or more large bronchi as result of destruction of the elastic and muscular component of the bronchial wall.

The basic pathogenesis is either congenital or an acquired weakness, typically following inflammation of the bronchial wall because of a viral or bacterial infection .

2-3-4 Tuberculosis;

Tuberculosis is an infection caused by inhalation of *Mycobacterium tuberculosis* .Although it generally affects the lung , it may also affect the lung , it may also affect other organs of the body .

2-3-5 Chronic obstructive pulmonary disease;

Chronic obstructive pulmonary disease refers to a group of disorders that causes chronic airway obstruction .The most common forms are chronic bronchitis and emphysema , with frequently and may be associated with varying degrees of asthma and bronchiectasis tow other causes of airway obstruction .

Pulmonary embolism (PE) is a relatively common cardiovascular emergency. By occluding the pulmonary arterial bed it may lead to acute life-threatening but potentially reversible right ventricular failure. PE is a difficult diagnosis that may be missed because of non-specific clinical presentation. However, early diagnosis is fundamental, since immediate treatment is highly effective. Depending

on the clinical presentation, initial therapy is primarily aimed either at life-saving restoration of flow through occluded pulmonary arteries (PA) or at the prevention of potentially fatal early recurrences.

Both initial treatment and the long-term anticoagulation that is required for secondary prevention must be justified in each patient by the results of an appropriately validated diagnostic strategy.(Roy, 2006)

Epidemiology, predisposing factors, natural history, and the pathophysiology of PE have been described more extensively elsewhere. This document focuses on currently available and validated methods of diagnosis, prognostic evaluation and therapy of PE. In contrast to previous guidelines, we decided to grade also the level of evidence of diagnostic procedures. The most robust data come from large-scale accuracy or outcome studies. Accuracy studies are designed to establish the characteristics of a diagnostic test (sensitivity and specificity) by comparing test results with a reference diagnostic criterion (the so-called gold standard).

Outcome studies evaluate patient outcomes when a given diagnostic test or strategy is used for clinical decision-making. In the field of PE, the outcome measurement is the rate of thromboembolic events [deep vein thrombosis (DVT) or PE]

during a 3-month follow-up period in patients left untreated by anticoagulants. The reference for comparison is the rate of DVT or PE in patients left untreated after a negative conventional pulmonary angiogram, which is around 1–2%, with an upper limit of the 95% confidence interval (CI) of 3% during a 3-month follow-up. The advantage of outcome studies is that they are easily carried out under normal clinical circumstances and their results are therefore generalizable. However, they do not yield any information on false positives and potential overtreatment.

2-3-5 -1-Causes of pulmonary embolism ;

The most common causes of embolism are proximal leg deep venous thrombosis (DVT) pelvic vein thrombosis .

2-3-5-2-Risk factor of pulmonary empolism:

Risk factor which are included for pulmonary embolism are prolonged bed rest, surgery, child birth, heart attack , stroke , congestive heart failure , cancer , obesity, oral contraceptive , sickle cell anemia , congenital coagulation disorder , chest trauma, certain congenital heart defects and angina.

2-3-5-3 complication of pulmonary embolism:

Complication that can occur during or after of embolism are palpitation, heart failure or stroke , respiratory distress (severe breathing difficulties), sudden death , hemorrhage (usually are complication of thrombolytic or anti coagulant therapy) , and pulmonary hypertension with recurrent pulmonary embolism.

2-3-5-4-Epidemiology

PE and DVT are two clinical presentations of venous thromboembolism (VTE) and share the same predisposing factors. In most cases PE is a consequence of DVT. Among patients with proximal DVT, about 50% have an associated, usually clinically asymptomatic PE at lung scan.⁸ In about 70% of patients with PE, DVT can be found in the lower limbs if sensitive diagnostic methods are used.(Dalen, 2002)

2-3-5-4-Predisposing factors

Although PE can occur in patients without any identifiable predisposing factors, one or more of these factors are usually identified (secondary PE). The proportion of patients with idiopathic or unprovoked PE was about 20% in the International Cooperative Pulmonary Embolism Registry (ICOPER) (Goldhaber, 1999)

VTE is currently regarded as the result of the interaction between patient-related and setting-related risk factors. Patient-related predisposing factors

are usually permanent, whereas setting-related predisposing factors are more often temporary .

2-3-5-6-Natural history

Since PE in most cases is a consequence of DVT, the natural history of VTE should be considered as a whole instead of looking at DVT and PE separately.

The initial studies on the natural history of VTE were carried out in the setting of orthopaedic surgery during the 1960s.(Kakkar, 1969) A landmark report showed that VTE started during surgery with DVT of the calf in about 30% of patients. DVT resolved spontaneously after a few days in about one-third and did not extend in about 40%, but in 25% it developed into proximal DVT and PE. Since this initial report, knowledge about natural history chronotropic stimulation may not suffice to maintain RV function in the long term even in the absence of new embolic episodes.

This might be attributable to a potentially detrimental combination of increased RV myocardial oxygen demand and decreased RV coronary perfusion gradient. Both elements contribute to RV ischaemia and dysfunction, and may initiate a vicious circle leading to a fatal outcome. Pre-existing cardiovascular disease may influence the efficacy of compensatory mechanisms and consequently affect the prognosis.

The severity of PE should be understood as an individual estimate of PE-related early mortality risk rather than the anatomical burden and the shape and distribution of intrapulmonary emboli. Therefore, current guidelines

suggest replacing potentially misleading terms such as ‘massive’, ‘submassive’ and ‘non-massive’ with the estimated level of the risk of PE-related early death. PE can be stratified into several levels of risk of early death (understood as in-hospital or 30-day mortality) based on the presence of risk markers. For practical purposes, risk markers useful for risk stratification in PE can be classified into three groups .

Immediate bedside clinical assessment for the presence or absence of clinical markers allows stratification into high-risk and non-high-risk PE. This classification should also be applied to patients with suspected PE, as it helps in the choice of the optimal diagnostic strategy and initial management.

2-3-5-7-Diagnosis

Throughout these guidelines and for the purpose of clinical management, ‘confirmed PE’ is understood as a probability of PE high enough to indicate the need for PE-specific treatment and ‘excluded PE’ as a probability of PE low enough to justify withholding specific PE-treatment with an acceptably low risk despite a clinical suspicion of PE. These terms are not meant to indicate absolute certainty regarding the presence or absence of emboli in the pulmonary arterial bed.

2-3-5-4-1 .Clinical presentation

Evaluating the likelihood of PE in an individual patient according to the clinical presentation is of utmost importance in the interpretation of diagnostic test results and selection of an appropriate diagnostic strategy. In 90% of cases, suspicion of PE is raised by clinical symptoms such as dyspnoea, chest pain and syncope, either singly or in combination. In several

series, dyspnoea, tachypnoea, or chest pain were present in more than 90% of patients with PE. (Wells, 1998)

Syncope is a rare but important presentation of PE since it may indicate a severely reduced haemodynamic reserve. In the most severe cases, shock and arterial hypotension may be present.

Pleuritic chest pain, whether or not combined with dyspnoea, is one of the most frequent presentations of PE . The pain is usually caused by pleural irritation due to distal emboli causing a so-called pulmonary infarction, an alveolar haemorrhage, sometimes accompanied by haemoptysis. Isolated dyspnoea of rapid onset is usually due to more central PE causing more prominent haemodynamic consequences than the pulmonary infarction syndrome. It may be associated with retrosternal angina-like chest pain, which may reflect right ventricular ischaemia. Occasionally, the onset of dyspnoea may be very progressive over several weeks, and the diagnosis of PE is evoked by the absence of other classic causes of progressive dyspnoea. In patients with preexisting heart failure or pulmonary disease, worsening dyspnea may be the only symptom indicative of PE.

Knowledge of which predisposing factors for VTE are present is essential in the evaluation of the likelihood of PE, which increases with the number of predisposing factors present. However, in around 30% of cases PE occurs in the absence of any predisposing factors (unprovoked or idiopathic PE). Individual clinical signs and symptoms are not very helpful, as they are neither sensitive nor specific . The chest X-ray is usually abnormal, and the most frequently encountered findings (plate-like atelectasis, pleural effusion or elevation of a hemidiaphragm) are nonspecific. (Elliott, 2000) However, the chest X-ray is very useful in excluding other causes of dyspnoea and chest pain. PE is generally associated with hypoxaemia, but up to 20% of patients

with PE have a normal arterial oxygen pressure (PaO₂) and a normal alveolar-arterial oxygen gradient [D(A-a)O₂]. Electrocardiographic (ECG) signs of RV strain, such as inversion of T waves in leads V1–V4, a QR pattern in lead V1, the classic S1Q3T3 type and incomplete or complete right bundle-branch block, may be helpful, particularly when of new onset. Nevertheless, such changes are generally associated with the more severe forms of PE and may be found in right ventricular strain of any cause.

In summary, clinical signs, symptoms and routine laboratory tests do not allow the exclusion or confirmation of acute PE but increase the index of its suspicion.

Compression ultrasonography and computed tomographic venography

In 90% of patients, PE originates from DVT in a lower limb. (Sevitt, 1961) In a classic study using venography, DVT was found in 70% of patients with proven PE. Nowadays, lower limb compression venous ultrasonography (CUS) has largely replaced venography for diagnosing DVT. CUS has a sensitivity over 90% for proximal DVT and a specificity of about 95%. (Perrier, 1998) CUS shows a DVT in 30–50% of patients with PE, and finding a proximal DVT in patients suspected of PE is sufficient to warrant anticoagulant treatment without further testing. In the setting of suspected PE, CUS can be limited to a simple four-point examination (groin and popliteal fossa). The only validated diagnostic criterion for DVT is incomplete compressibility of the vein, which indicates the presence of a clot, whereas flow criteria are unreliable. The diagnostic yield of CUS in suspected PE might be raised by performing complete ultrasonography, including the distal veins. In a recent study, the proportion of patients with PE in whom a DVT could be detected increased from 22% when performing proximal CUS only to 43% using complete CUS, but the specificity

decreased accordingly from 96–84%.The high specificity of a positive proximal CUS result for PE is confirmed by data from a large prospective outcome study in which 524 patients underwent both multidetector computed tomography (MDCT) and CUS. The sensitivity of CUS for the presence of PE on MSCT was 39% and its specificity was 99%. The probability of a positive proximal CUS in suspected PE is higher in patients with leg signs and symptoms than in asymptomatic patients. (Perrier, 1998)

More recently, computed tomography (CT) venography has been advocated as a simple way to diagnose DVT in patients with suspected PE as it can be combined with chest CT angiography as a single procedure using only one intravenous injection of contrast dye. In the recent PIOPED II study, combining CT venography with CT angiography increased sensitivity for PE from 70% to 90% and had a similar specificity (around 95%).However, the corresponding increase in NPV was not clinically significant.

Therefore, CT venography increases the overall detection rate only marginally in patients with suspected PE and adds a significant amount of irradiation, which may be a concern, especially in younger women.(Brenner, 2007)

Ventilation–perfusion scintigraphy Ventilation–perfusion scintigraphy (V/Q scan) is a robust and well-established diagnostic test for suspected PE. The test has been proved extremely safe to apply and few allergic reactions have been described. The basic principle of the test is based on an macroaggregated albumin particles, which block a small fraction of pulmonary capillaries and thereby enable scintigraphic assessment of lung perfusion at the tissue level. Where there is occlusion of pulmonary arterial branches, the peripheral capillary bed will not receive particles, rendering the area ‘cold’ on subsequent images.

Perfusion scans are combined with ventilation studies, for which multiple tracers, such as xenon (Xe)-133 gas, Tc-99 m labeled aerosols or Tc-99 m-labelled carbon microparticles (Technegas), can be used. The purpose of the additional ventilation scan is to increase specificity by the identification of hypoventilation as a non-embolic cause of hypoperfusion due to reactive vasoconstriction (perfusion–ventilation match). On the contrary, in the case of PE, ventilation is expected to be normal in hypoperfused segments (perfusion–ventilation mismatch). Miller , 1992)Traditionally, planar perfusion and ventilation images in at least six projections are acquired. Tc-99 m-labelled ventilation tracers, which (in contrast to the situation in the United States) are approved for clinical use in Europe, are considered preferable to radioactive gases for ventilation imaging because they are deposited in the bronchoalveolar system with little washout, and thus allow the acquisition of multiple projections and more accurate regional matching of perfusion and ventilation. (Trujillo , 1997)The radiation exposure from a lung scan with 100 MBq of Tc-99 m macroaggregated albumin particles is 1.1 mSv for an average sized adult according to the International Commission on Radiological Protection (ICRP), and thus significantly lower than that of a spiral CT (2–6 mSv). In comparison, a plain chest X-ray delivers a dose of approximately 0.05 mSv.

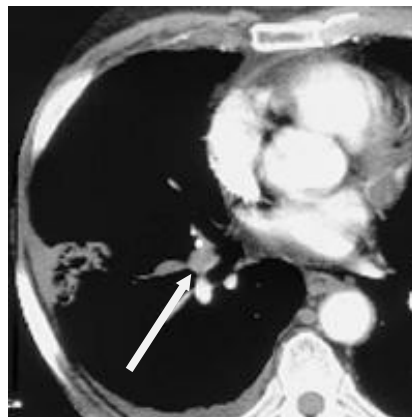
Lung scan results are frequently classified according to criteria established in the North American PIOPED trial⁶⁰ into four categories:

normal or near-normal, low, intermediate (non-diagnostic) and high probability of PE. The criteria for classification have been a matter of debate and revision. Nevertheless, the validity of a normal perfusion lung scan has been evaluated in several prospective clinical outcome studies, which

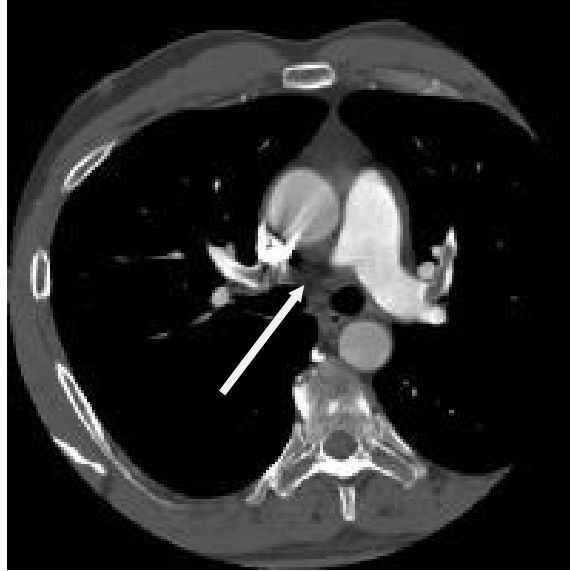
observed low event rates, (Wolde , 2004)suggesting that it is a safe practice to withhold anticoagulant therapy in patients with a normal perfusion scan. This has been confirmed recently in a randomized trial comparing the V/Q scan and CT.

2-3-5-4-2 Acute Pulmonary Embolism (Helical CT)

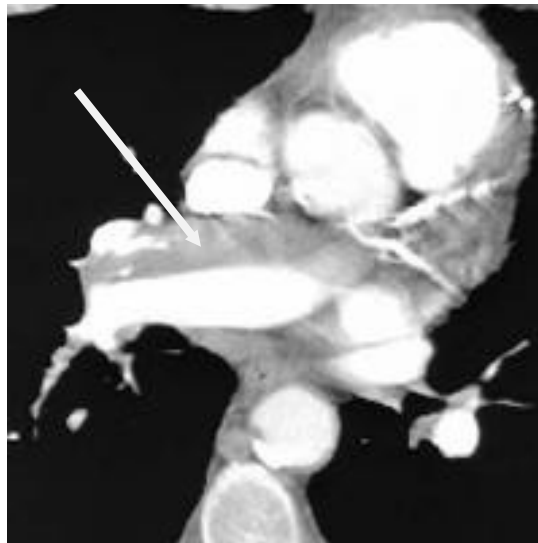
Pulmonary embolism (PE) was clinically described in the early 1800s, and von Virchow first described the connection between venous thrombosis and PE. In 1922, Wharton and Pierson reported the first radiographic description of PE. Images depicting clots in the pulmonary arterial system are provided below.(Wharton, 1922)



Figure(2-3) shows Computed tomography angiogram in a 53-year-old man with acute pulmonary embolism. This image shows an intraluminal filling defect that occludes the anterior basal segmental artery of the right lower lobe. Also present is an infarction of the corresponding lung, which is indicated by a triangular, pleura-based consolidation (Hampton hump).



Figure(2-4) shows Computed tomography angiography in a young man who experienced acute chest pain and shortness of breath after a transcontinental flight. This image demonstrates a clot in the anterior segmental artery in the left upper lung (LA2) and a clot in the anterior segmental artery in the right upper lung (RA2).



Figure(2-5) shows Computed tomography angiogram in a 69-year-old man with known pulmonary arterial hypertension and a history of chronic pulmonary embolism. This image shows an eccentric mural thrombus with punctate calcification along the anterior wall of the right lower interlobar artery.

Imaging has played an important role in the diagnosis of PE. For many years, ventilation-perfusion (V/Q) scintigraphy has been the main imaging modality for the evaluation of patients with suspected PE. However, with the advent of and the widespread availability of faster computed tomography (CT) scanners, CT scanning has emerged as another important diagnostic test for the evaluation of not only PE, but also of deep venous thrombosis (DVT) in select patients.

Three primary influences predispose a patient to thrombus formation; these form the so-called Virchow triad: (1) endothelial injury, (2) stasis or turbulence of blood flow, and (3) blood hypercoagulability. (Jardin, 2007)

More than 90% of all PEs arise from thrombi within the large deep veins of the legs, typically the popliteal vein and the larger veins above it. The pathophysiologic consequences of thromboembolism in the lung largely depend on the cardiopulmonary status of the patient and on the size of the embolus, which, in turn, dictates the size of the occluded pulmonary artery.

2-3-5-4-3 Preferred examination

In patients with possible PE, chest radiographic findings may indicate if lung scanning (V/Q) or helical CT scanning should be the next method of evaluation. If the chest radiograph is normal, V/Q findings may be diagnostic; if the chest radiograph is abnormal, helical CT should be performed. (Stein, 2007)

A quantitative D-dimer assay is reported to have high negative predictive value and may be effective for excluding the need for pulmonary CT angiography (CTA) in selected cases.^[7] Another study shows that using a

clinical decision rule with D-dimer level improved pulmonary CTA and better identified positives for pulmonary embolisms.([Hoo,2011](#))

Conventional pulmonary angiography is invasive, time consuming, and more expensive than other tests. The role of conventional angiography is limited to patients in whom other results are nondiagnostic or the clinical suspicion is high.([Silverstein ,1998](#))In patients with suspected DVT, the workup should start with leg ultrasonography.

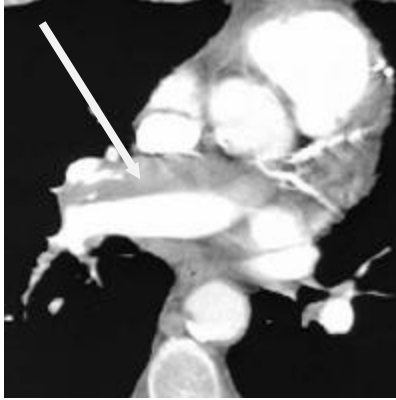
2-3-5-4-4 Limitations of techniques

Iodinated contrast agents are needed for helical CT pulmonary angiography, and their use may not be possible in patients with impaired renal function or a severe allergy to the contrast material.

Small (subsegmental) emboli may be missed with CT angiography.

Compared with CT scanning, conventional pulmonary angiography requires more expertise and support staff. Conventional angiography is also invasive, time consuming, more expensive, and less available. In addition, a chronic central mural thrombus that is easily seen with CT scanning may be missed at pulmonary angiography.([Oser , 1996](#)).

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.^[13] 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. (See the image below.)



Figure(2-6) shows Computed tomography angiogram in a 69-year-old man with known pulmonary arterial hypertension and a history of chronic pulmonary embolism. This image shows an eccentric mural thrombus with punctate calcification along the anterior wall of the right lower interlobar artery.

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.

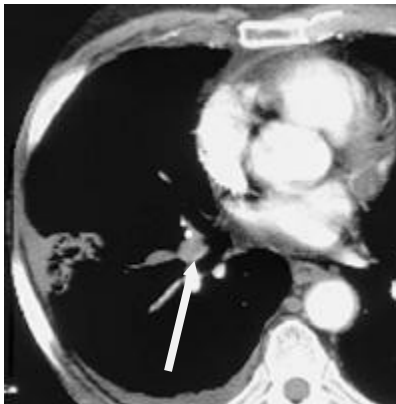
Because DVT and PE are part of the same disease process, CT venography can easily be performed after CT pulmonary angiography, without the administration of additional contrast material.(Loud , 2000)This study requires only a few extra minutes and allows "one-stop imaging" for PE and DVT.

The technique for CT pulmonary angiography with single-section helical CT involves the following parameters: 3-mm collimation, 2-mm reconstruction interval, pitch of 2, and an average acquisition time of 24 seconds. Iodinated contrast medium is administered as a bolus with an automated injector.

Generally, a large volume (100-150 mL) of contrast material is administered at a high flow rate (4 mL/s) for good-quality diagnostic opacification of

vessels.(Schoepf ,2004) CT venograms can be acquired 3-4 minutes after the start of the administration of contrast material. The new multidetector-row CT (MDCT) scanners are considerably faster, allowing the performance of thin-section (1.25-mm) helical CT pulmonary angiography during a shorter breath hold (15-17 seconds). With introduction of dual-source CT technology, ECG-gated CTA of the chest may become practical and help provide clinicians with cardiac functional information. Efforts should be made to minimize the radiation dose by using all available equipment-specific dose reduction techniques.

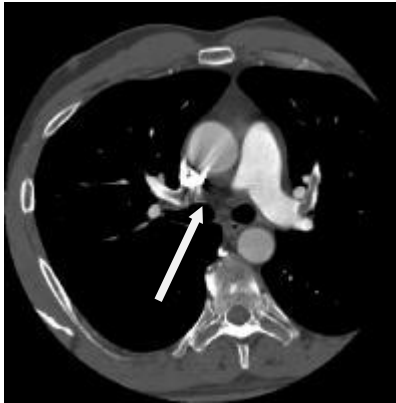
When a PE is identified, it is characterized as acute or chronic. An embolus is acute if it is situated centrally within the vascular lumen or if it occludes a vessel (vessel cutoff sign; see the image below). Acute PE commonly causes distention of the involved vessel.



Figure(2-7) shows Computed tomography angiogram in a 53-year-old man with acute pulmonary embolism. This image shows an intraluminal filling defect that occludes the anterior basal segmental artery of the right lower lobe. Also present is an infarction of the corresponding lung, which is indicated by a triangular, pleura-based consolidation (Hampton hump).

An embolus is chronic if (1) it is eccentric and contiguous with the vessel wall (see the image below), (2) it reduces the arterial diameter by more than 50%, (3)

evidence of recanalization within the thrombus is present, and (4) an arterial web is present.



Figure(2-8) shows Computed tomography angiography in a young man who experienced acute chest pain and shortness of breath after a transcontinental flight. This image demonstrates a clot in the anterior segmental artery in the left upper lung (LA2) and a clot in the anterior segmental artery in the right upper lung (RA2).

PE is further characterized as central or peripheral, depending on the location of the arterial branch involved. Central vascular zones include the following:

Main pulmonary artery , the left and right main pulmonary arteries , the anterior trunk , the right and left interlobar arteries , the left upper lobe trunk ,the right middle lobe artery the right and left lower lobe arteries

Peripheral vascular zones include the following:

The segmental and subsegmental arteries of the right upper lobe , the right middle lobe , the right lower lobe , the left upper lobe , the lingula , the left lower lobe

There is ongoing research in the field of post processing of CT scan data for acute PE, one dealing with the detection of perfusion defects as an adjunct to transverse CT scans for detection of small peripheral PE and another focusing on the automatic computer-aided detection of endoluminal clots.

2-3-5-4-5 Echocardiography

Right ventricular dilatation is found in at least 25% of patients with PE, and its detection, either by echocardiography or CT, is useful in risk stratification. Echocardiographic criteria used for the diagnosis of PE were different across trials, though usually based on tricuspid insufficiency jet velocity and right ventricular dimensions.

Because of the reported sensitivity of around 60–70%, a negative result cannot exclude PE. (Perrier, 1998) On the other hand, signs of RV overload or dysfunction may also be due to concomitant cardiac or respiratory disease, in the absence of acute PE. Data suggesting that some echocardiographic signs may be more specific are limited. Three different sets of echocardiographic criteria potentially useful for diagnosing acute PE were compared in a series in which 100 symptomatic patients were enrolled, of whom 62% were referred from the intensive care unit. The criteria which were based either on disturbed RV ejection pattern (the 60–60 sign) or on depressed contractility of the RV free wall compared with its apex (the McConnell sign) seemed to have a higher PPV despite pre-existing cardiorespiratory diseases.

However, concomitant echocardiographic signs of pressure overload are required to prevent the false diagnosis of acute PE in patients with RV free-wall hypo/akinesis due to RV infarction, which may mimic the McConnell sign. Tissue Doppler imaging was used to obtain various indices of myocardial performance, which were reported to have a sensitivity of 85–92% and a specificity of 78–92% for PE, but the data are still limited.

Hence, echocardiographic examination is not recommended as an element of elective diagnostic strategy in haemodynamically stable, normotensive patients with suspected PE.

In patients with suspected high-risk PE presenting with shock or hypotension, the absence of echocardiographic signs of RV overload or dysfunction practically excludes PE as a cause of haemodynamic instability. Furthermore, echocardiography may help in the differential diagnosis of the cause of shock, by detecting cardiac tamponade, acute valvular dysfunction, acute myocardial infarction or hypovolaemia. Conversely, unequivocal signs of RV pressure overload and dysfunction in a haemodynamically compromised patient with suspected PE are highly evocative and may justify aggressive treatment for PE if bedside diagnostic tools must suffice because of the patient's critical condition. In one series, such treatment was introduced in the joint presence of high clinical probability, a shock index ≥ 1 (defined as heart rate divided by systolic blood pressure) and RVD on echocardiography, and resulted in an acceptable 30-day outcome.

Concomitant exploration of proximal veins in search of venous clots with compression ultrasound¹⁵² and searching for emboli in main pulmonary arteries by transoesophageal echocardiography may be considered in specific clinical situations. Indeed, because of the high prevalence of bilateral central pulmonary thromboemboli in patients with haemodynamically significant PE, transoesophageal echocardiography may confirm the diagnosis in most cases. Also, right heart thrombi, which can be found with transthoracic echocardiography in 4–18% patients with acute PE, justify treatment. (Torbicki, 2003)

2-3-6 Diagnostic strategies

Suspected high-risk and non-high-risk PE are two distinct situations that must be distinguished because the diagnostic strategies differ.

Overall, with adequate clinical awareness the prevalence of PE in patients in whom the disease is suspected is low (10–35% in recent large series). Pulmonary angiography, the definitive standard criterion, is invasive, costly and sometimes difficult to interpret. Hence, non-invasive diagnostic approaches are warranted, and various combinations of clinical evaluation, plasma D-dimer measurement, lower limb CUS, V/Q lung scintigraphy and, more recently, CT have been evaluated to obviate the requirement for pulmonary angiography. These strategies were applied to patients presenting with suspected PE in the emergency ward, during a hospital stay, or both. In a recent survey, failure to comply with evidence-based diagnostic strategies when withholding anticoagulation despite the clinical suspicion of PE was related to a significant increase in the number of VTE episodes and in sudden death in the 3 months of follow-up.¹ It should be recognized that the approach to suspected PE may legitimately vary according to the local availability of tests in specific clinical settings.

Suspected high-risk pulmonary embolism Although the greatest body of evidence concerns suspected haemodynamically stable, non-high-risk PE, we have chosen to deal with suspected high-risk PE first because it is an immediately life-threatening situation and patients presenting with shock or hypotension present a distinct clinical problem. The clinical probability is usually high and the differential diagnosis includes cardiogenic shock, acute valvular dysfunction, tamponade and aortic dissection. Hence, the most useful initial test in this situation is echocardiography, which will usually show indirect signs of acute pulmonary hypertension and right ventricular overload if acute PE is the cause of the haemodynamic consequences. Right

heart thrombi in transit can be sometimes found on transthoracic echocardiography. (Torbicki, 2003) When available, transoesophageal echocardiography may allow direct visualization of a thrombus in the pulmonary artery.^{153,155,163} However, in a highly unstable patient, or if other tests are not available, the diagnosis of PE may be accepted on the basis of compatible indirect echocardiographic findings alone (Figure 1). If the patient is stabilized by supportive treatment, a definite diagnosis should be sought. Because of the high thrombus load in the pulmonary circulation, CT is usually able to confirm the diagnosis.

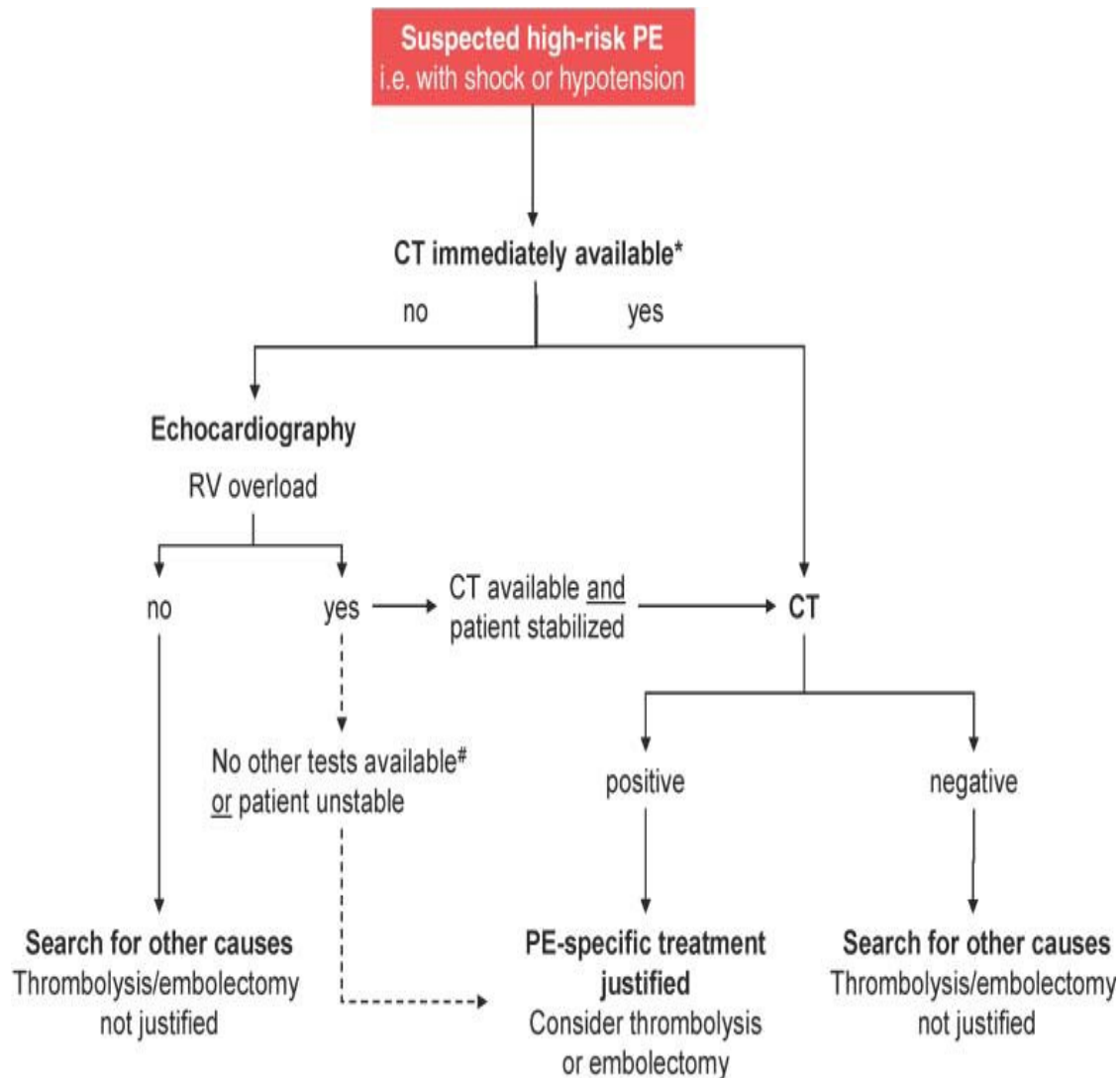
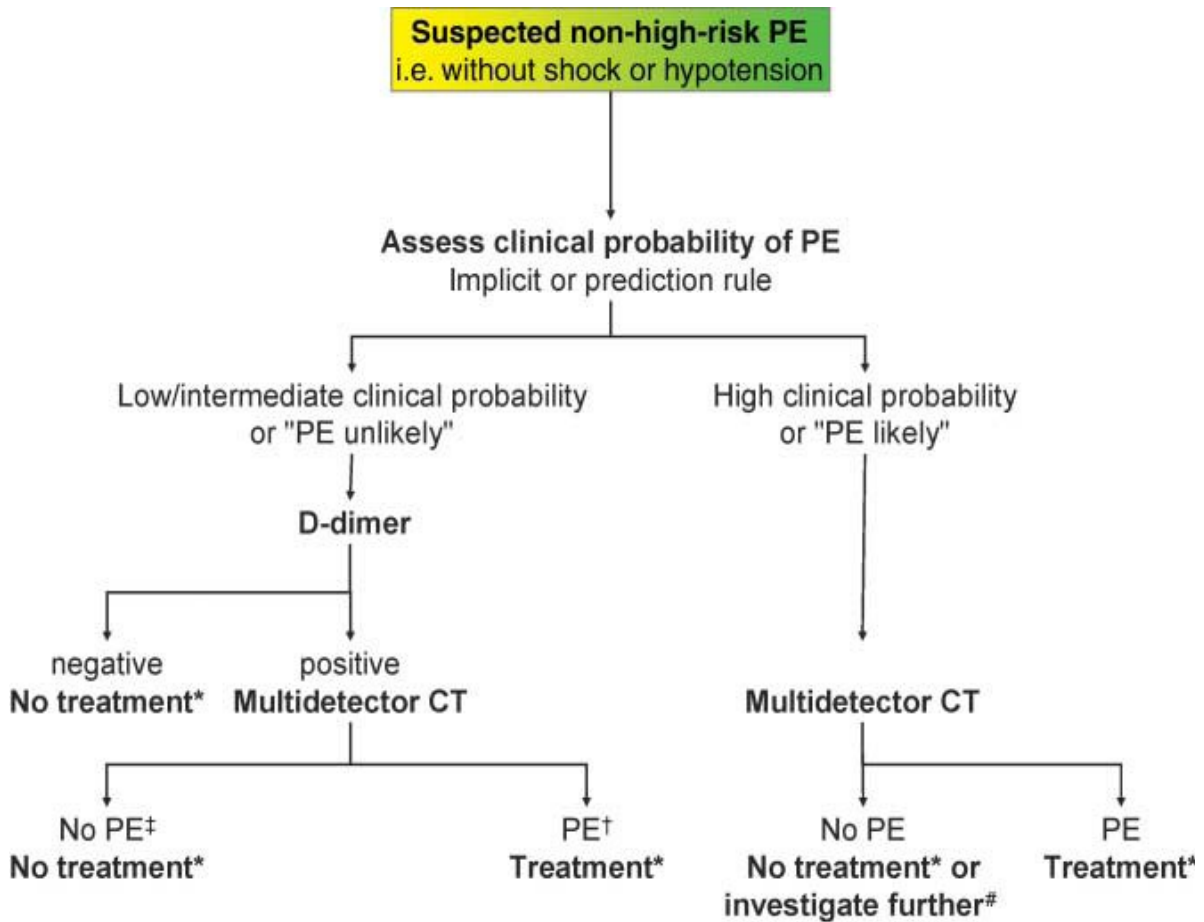


Figure (2-9) Proposed diagnostic algorithm for patients with suspected high-risk PE, i.e. presenting with shock or hypotension. CT is considered not immediately available also if the critical condition of a patient allows only bedside diagnostic tests. Transoesophageal echocardiography may detect thrombi in the pulmonary arteries in a significant proportion of patients with RV overload and PE that is ultimately confirmed by spiral CT; confirmation of DVT with bedside CUS might also help in decision-making.



Figure(2-10) Proposed diagnostic algorithm for patients with suspected non-high-risk PE (i.e. without shock and hypotension). Two alternative classification schemes may be used to assess clinical probability: a three-level scheme (clinical probability low, intermediate or high) or a two-level scheme (PE unlikely or PE likely). When using a moderately sensitive assay, D-dimer measurement should be restricted to patients with a low clinical probability or a 'PE unlikely' classification, while highly sensitive assays may be used in patients with a low or intermediate clinical probability of PE.

2-Previous studies

Qanadli et al(2000) studied Pulmonary Embolism Detection: Prospective Evaluation of Dual-Section Helical CT versus Selective Pulmonary Arteriography in 157 Patients , To evaluate the accuracy of dual-section helical computed tomography (CT) in acute pulmonary embolism (PE) diagnosis , using 204 consecutive patients with clinically suspected acute PE (mean age, 58 years 6 14 [SD]), 158 were enrolled. All patients underwent dual-section helical CT (2.7-mm effective section thickness) and selective pulmonary arteriography within 12 hours of each other. Each image was analyzed independently by two observers, who determined image quality and presence of PE among arterial segments, including at the subsegmental level. The final diagnosis was made with consensus.

They found that Selective pulmonary arteriography was considered optimal in 147 (93%), suboptimal in 10 (6%), and inconclusive in one (0.6%) of 158 patients. Dual-section helical CT findings were considered technically optimal in 140 (89%), suboptimal in 11 (7%), and inconclusive in six (4%). Selective pulmonary arteriography demonstrated PE in 62 patients. Four (6%) of 62 patients had isolated subsegmental PE.

The sensitivity of dual-section helical CT was 90%, and the specificity was 94%. The positive and negative predictive values were 90% and 94%, respectively

Goodman et al (6) compared helical CT with arteriography in 20 patients with an unresolved clinical (abnormal V-P scanning results that were discordant with the level of clinical suspicion) and scintigraphic (intermediate- probability V-P scanning results) diagnosis. Four (36%) of 11 patients who had positive pulmonary arteriograms had isolated subsegmental

clots. Only two of these PE were depicted at helical CT, with a sensitivity and specificity of 63% and 89%, respectively. Remy-Jardin et al (14) found four (10%) isolated subsegmental emboli on 39 positive pulmonary arteriograms. Only two of the four emboli were identified on CT scans. van Rossum et al (15) reported three (2%) isolated subsegmental emboli in their 149 patients. However, in that series, 56 patients underwent pulmonary arteriography, and only 15 arteriograms were positive.

Storto et al(2005) studied , Incidental Detection of Pulmonary Emboli on Routine MDCT of the Chest to assess the prevalence of pulmonary embolism incidentally detected on routine MDCT of the chest and to determine whether the use of wide window settings can improve detection of unsuspected pulmonary embolism. using 589 patients. CT angiograms obtained for suspected pulmonary embolism or thoracic aorta disease were not considered. Image evaluation was performed on a dedicated workstation during two separate review sessions using different window settings: standard, with a width of 400 H and level of 40 H; and wide, with a width of 600 H and level of 100–150 H. The quality of vascular enhancement was recorded. Eight examinations were excluded because of poor quality. Unsuspected pulmonary embolism was present in 20 (3.4%) of 581 patients with an inpatient prevalence of 4.0% (19/474) and outpatient prevalence of 0.9% (1/107). Fourteen patients (70.0%) with unsuspected pulmonary embolism had cancer. The proximal extent of pulmonary embolism involved the main pulmonary artery in five patients, a lobar artery in five, and a segmental artery in 10; isolated subsegmental thrombi were never found. The use of wide window settings allowed detection of pulmonary embolism in two more patients than did the standard settings.

Hayashino et al (2005) studied Ventilation-Perfusion Scanning and Helical CT in Suspected Pulmonary Embolism: Meta-Analysis of Diagnostic Performance to perform meta-analysis of literature about the role of helical computed tomography (CT) and ventilation-perfusion (V-P) scanning in detection of acute pulmonary embolism (PE) by using summary receiver operating characteristic (ROC) curve analysis. V-P scanning articles published from January 1985 to March 2003 and helical CT articles published from January 1990 to March 2003 in MEDLINE and EMBASE databases were included if (a) tests were performed for evaluation of acute PE, (b) conventional angiography was the reference standard, and (c) absolute numbers of true-positive, false-negative, true-negative, and false-positive results were available. Sensitivity analysis was conducted by excluding articles published before 1995. They found that A total of 12 articles discussing helical CT and/or V-P scanning were included. With a random-effects model, pooled sensitivity for helical CT was 86.0% (95% confidence interval [CI]: 80.2%, 92.1%), and specificity was 93.7% (95% CI: 91.1%, 96.3%). V-P scanning yielded low sensitivity of 39.0% (95% CI: 37.3%, 40.8%) but high specificity of 97.1% (95% CI: 96.0%, 98.3%) with high probability threshold. V-P scanning yielded high sensitivity of 98.3% (95% CI: 97.2%, 99.5%) and low specificity of 4.8% (95% CI: 4.7%, 4.9%) with normal threshold. Regression coefficients for helical CT angiography were 0.588 (95% CI: -1.55, 2.74) and 4.14 (95% CI: -0.002, 8.28) versus V-P scanning with high and normal thresholds, respectively. Regression coefficients for helical CT angiography were 0.588

(95% CI: -1.55, 2.74) and 4.14 (95% CI: -0.002, 8.28) versus V-P scanning with high and normal thresholds, respectively.

Kim et al (2010) Detection of Pulmonary Embolism in the Postoperative Orthopedic Patient Using Spiral CT Scans , to compare the clinical presentations of a suspected versus a documented PE/DVT and to determine the actual incidence of PE/DVT in the post-operative orthopedic patient in whom CT was ordered. All 695 patients at our institution who had a postoperative spiral CT to rule out PE/DVT from March 2004 to February 2006 were evaluated and information regarding their surgical procedure, risk factors, presenting symptoms, location of PE/DVT, and anticoagulation were assessed. Statistical analysis was performed using an independent samples *t* test with a two-tailed *p* value to examine significant associations between the patient variables and CT scans positive for PE. Logistic regression models were used to determine which variables appeared to be significant predictors of a positive chest CT. Of 32,854 patients admitted for same day surgery across all services, 695 (2.1%) had a postoperative spiral CT based on specific clinical guidelines. The incidence of a positive scan was 27.8% (193/695). Of these, 155 (22.3%) scans were positive for PE only, 24 (3.5%) for PE and DVT, and 14 (2.0%) for DVT only. The most common presenting symptoms were tachycardia (56%, 393/695), low oxygen saturation (48%, 336/695), and shortness of breath (19.6%, 136/695). Symptoms significantly associated with DVT were syncope and chest pain. A past medical history of PE/DVT was the only significant predictor of a positive scan. Patients who have a history of thromboembolic disease should be carefully monitored in the postoperative setting.

Edward et al(2010) Unsuspected Pulmonary Emboli in Pediatric Oncology Patients: Detection With MDCT to determine the prevalence, distribution, risk factors, and clinical outcome associated with the detection of unsuspected pulmonary emboli (PE) in routine thoracic MDCT examinations of pediatric oncology patients. They used hospital information system to retrospectively identify all consecutively registered pediatric oncology patients 18 years old and younger who underwent contrast-enhanced thoracic MDCT for indications other than PE from July 2004 to May 2008. Two pediatric radiologists in consensus reviewed diagnostic-quality images from consecutive routine thoracic MDCT examinations for the presence and anatomic distribution of PE. The distribution of PE was assessed according to pulmonary arterial level and lobe. Clinical and radiology reports were reviewed for demographic data, type of underlying neoplasm, prospective embolus detection, risk factors, treatment, and outcome. Subgroups of patients with and without PE were compared with respect to type of neoplasm and risk factors.

They found that sample consisted of 468 children (249 boys, 219 girls; mean age, 9.5 ± 5.7 years) who underwent a total of 1,002 thoracic MDCT examinations. Nine of the 468 children (1.9%) had PE, including seven with venous thromboembolism and two with tumor emboli. In these nine patients, the pulmonary arterial locations of 17 emboli were nine (53%) segmental, five (29%) lobar, two (12%) central, and one (6%) subsegmental. Classified by lobar location, six of 11 PE (55%) were in the left lower lobe, four (36%) were in the right lower lobe, and one (9%) was in the right upper lobe. PE were not detected prospectively in five of the nine patients (56%). All PE in this subgroup were solitary and located either within the segmental pulmonary arteries (four PE) or a lobar pulmonary artery (one PE).

Underlying coagulation disorder ($p < 0.001$) and history of deep venous thrombosis or PE ($p < 0.01$) were risk factors for unsuspected PE. Two of nine patients (22%) with unsuspected PE died of causes not directly related to PE. The other seven patients survived, four of whom were not treated for PE.

Chapter Three

Materials & Methods

3-1-Place & time of the study:

This study was done in ROYAL CARE HOSPITAL , FIESAL SPECIALIZ HOSPITAL , FEDAIL CENTER and EL-NELEIN DIAGNOSABUL CENTER radiographic departments, Data were collected in the period from (10.8.2011) to (30.11.2011).

3-2-Patient's population:Of 50 cpatients with clinically suspected acute PE will be enrolled. All patients were examined by using CT

This study is a practical study, included random samples of 50 patients in different genders & different ages. Those were refer CT examination 34 patients were females while the 16 were males and their ages are ranged from 20 to 70 years old.

3-3 Instrumentation:

Toshiba (64 multi slice detector) and semience(4 multi slice detector) Spiral CT scanners are not different in external appearance from conventional CT scanner . However , there are significant differences in several major equipment components,.

3-3 -1 Equipment Components;

The rotating part of the system consists of the X-ray tube , high voltage generator , detectors and detector electronics (DAS). The stationary part consists of the front –end memory and computer and the first stage high voltage component .

The X-ray tube and detector rotate continuously during data collecting because the cable wraparound problem has been eliminated by slip ring technology . Because large amount of projection data are collected very quickly , increased storage is needed . This accommodated by the front -end memory fast solid state , and magnetic disk storage .

In spirals CT scanner the X-ray tube is energized for longer period of time compared with conventional CT tubes .This character requires X-ray tube that are physically larger than conventional X-ray tubes and have heat units capacities greater than 3 million heat unit (MHU)and anode cooling rates of 1MHU per minute

X-ray detector for single slice spiral CT scanning are one dimensional (ID) array and should be solid state because their overall efficiency is greater than gas ionization detectors.

The high voltage generator for spiral CT scanner is a high frequency generator with high power output . The high voltage generator is mounted on the rotating from of CT gentry and positioned close to the X-ray tube operate are high voltages (about 80 to 140 kvp)to produce X-ray with the intensity needed for CT scanning . At such high voltages , arcing between the brushes and rings of the gantry may occur during scanning . To solve this problem one approach (high voltage SR)is to divide the power supply into a first stage on the stationary part of the scanner , where the voltage is increased to an intermediate level and a second stage on the rotating part of the scanner , where the voltage is increased to the requirement high voltages needed for X-ray production and finally rectified to direct current potential .

Another approach passes a low voltage across the brushes to the slip ring, the high voltage generator and then the X-ray tube. In both designs, only a low to intermediate voltage is applied to the brush-slip ring interface, thus decreasing the chances of arcing.



Figures3-1(a,b,c) shows CT Equipment



3-3-2 Slip ring technology ;

One of the major factor that contribute to the success of spiral CT scanning is slip ring technology .The purpose of the slip ring is to allow the X-ray tube and detectors (in third generation CT system) rotated continuously so that a volume of slices , rather than one slice , can be scanned very quickly in a single breath hold. The slip ring also eliminate the long high tension cables to the X-ray tube used in conventional start stop CT scanners . As the X-ray tube rotates continuously , the patient also moves continuously through the aperture of the gentry so that data can be acquired from a volume of tissue .

These include the design and high voltage slip ring CT scanners in terms of the high voltage supplied to the X-ray tube .

3-3 -3 Basic scan parameters;

Several scan parameters for spiral CT are the same as for conventional CT , however , there are a few parameter as well as set of terms associated only with spiral pitch is of particular significance because it affects image quality and patient dose and also play role in the overall outcome of the clinical examination .

Other parameters that affect the performance of spiral CT and demand effective communication between the radiologist and technologist are collimation , table speed , duration of the scan and the reconstruction increment.

3-4-1- Patient preparation ;

A successful CTA examination depend on careful preparation of the patient before the examination .Such preparation requires that both the technologist and radiologist work together to obtain the appropriate and correct information from the patient and to ensure that the patient understand the procedure , particularly breath- hold technique . Preceding the CTA a patient history was obtained to identify patients with histories of iodine allergy , renal dysfunction , cardiac disease and asthma . Steroid pre-medication was administrated to those patient with a history of iodine allergy or previous reaction to iodinated contrast agents. Patient with a history of renal dysfunction were further evaluated with creatinine

level and blood urea nitrogen level assessed before the procedure patient were instructed on breath –holding technique and practicing with the patient , before the examination ,helped in providing a successful motion free examination . Hyperventilation was performed immediately before the examination facilitates patient breath-holding ability .

3-4-2- Technique;

A significant advantage of spiral CT data acquisition is application to 3D imaging of vascular structures with an intravenous injection of contrast medium . This application CT angiography (CTA) is defined as ‘any CT imaging of a blood vessels that has been opacities by a contrast medium .

During spiral data acquisition , the entire area of interest can be scanned during the injection of contrast . Images can be captured when vessels are

fully opacities to demonstrate either arterial or venous phase enhancement through the acquisition of both data sets (arterials and venous)

CTA was been applied successfully to number of examination investigation vascular anatomy, problems and disease .In particular , CTA techniques have proved useful in imaging the abdominal and thoracic aorta (Renal and pulmonary arteries)

1-Volume of contrast medium 100-150 ml or when dual phase injector availability 80-100ml of contrast midume flowed by slaine chase of 30-50 ml

2-Delay :

-Preset delay of approximately 15s for single slice ,22s for 16 slice scanner ,26s for 64 slice scanner

OR

-Bolus tracking using soft ware supplied with most multi detector scanner .A ROI(region of interest) is positioned over the pulmonary artery at the level of the carina . After commencing the injection a(trecker scan) monitors the hounsfield level at the ROI and the scan is the triggered when the density at the ROI reaches a preset value .

3- Rate of injection 2-4 ml s .

4-Detector width- reconstruction(mm)-0.625-1.25 .

5-Scan direction and extension-caudocranial direction helps reduce respiratory motion artifact at the lung bases ,less important with faster multi slice scanner ,scan from hemi diaphragm to the lung apex .

Imaging review and post-processing, imaging should be reviewed at three settings :

*Mediastinal window (window width-window level 400-40 HU)

*Pulmonary embolism –specific window(700-100HU)

*Lung window (1500-600HU)

Multiplanar reformatted images through the longitudinal axis of a vessel can be helpful to overcome difficulties encountered on axial section of obliquely oriented arteries, adding confidence in diagnosis or exclusion of thrombus.

3- 4 -3 Requirements;

At least four major steps are crucial to carrying out a CT pulmonary angiography (CTA) examination careful execution of these steps will serve to optimize the examination and produce high –quality images that will aid the radiologist in making an accurate diagnosis.

These steps include patient preparation, acquisition parameter, contrast medium administration and post – processing

3-4-5-Acquisition Parameter ;

The CTA was been determined a number of parameter were carefully chosen to optimize both the quality of the imaging and the accuracy of the CTA examination. These parameter include the total spiral scan time, T(sec) the slice thickness S (mm) and the speed of the patient through the gantry with is the table speed D(mm/sec)

Also influencing the quality of the CTA examination was upon careful selection of KVP and MA values and the images reconstruction intervals 120 kvp was commonly used the MA values selected were based on the size of the patient's body section to be delaminated.

The image reconstruction interval referred to the spacing between the center of the slice . Reconstruction intervals were important because they play a role in the quality of the 3D-CTA images .

3-4-6- Contrast Medium Administration:

Imaging the contrast while it was in vascular area of interest during the CTA examination was a critical step in the acquisition of images . Contrast injection techniques took into consideration

The volume of contrast needed to opacity vascular regions ,the contrast injection rate , and the timing between the start of contrast medium injection and the start of the spiral scan .Measuring the contrast circulation times for different patient was important in CTA to ensure that imaging were recorded when flow-in of contrast was optimum in the pulmonary arteries.

3-4-7 post processing technique:

3-4-7-1 Visualization tool:

The a logarithm used to display 3D images from the axial data set was post processing technique or visualization tool with were used quite extensively in CTA currently , the following technique was common -place in CTA .

3-4-7-2 Multiplanar reconstruction (MPR)

MPR was the first visualization tool used in CTA . It was simple and faster to reconstruct than any other 3D technique and enabled visualization of the volume data set in any plane including curved planes .

Chapter four

Results

The peak incidence was among the age between 20-30 years of age presenting the percent of (50%)

Table (4. 1) :Age distribution

Age	Frequency	Percentage
20-30	25	50%
31-40	15	30%
41-60	10	20%

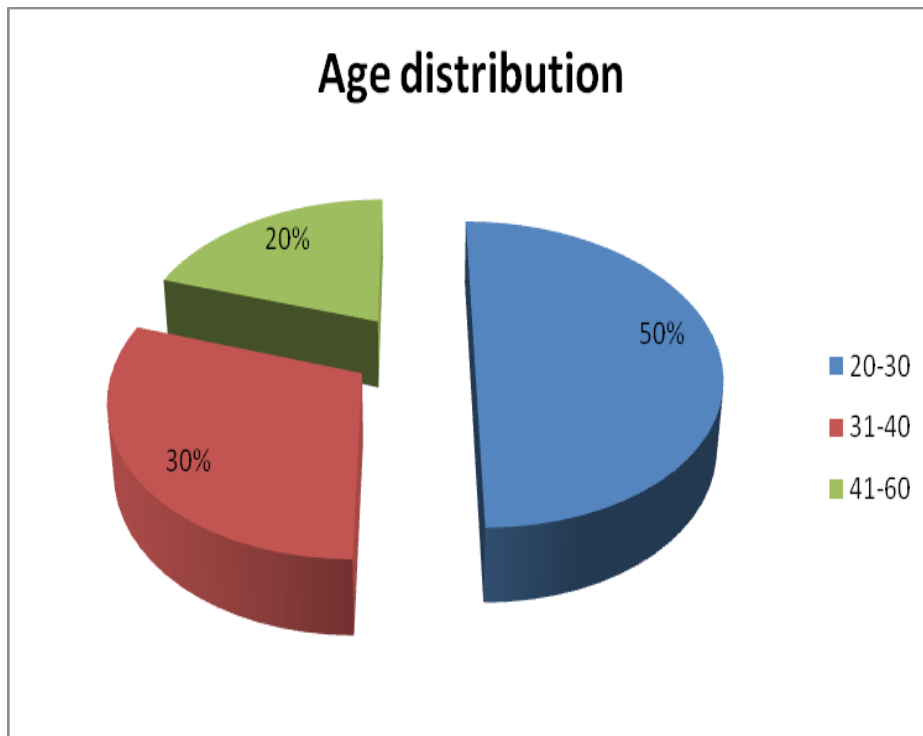


Figure (4. 1) :Age distribution

Figure and Table 4.1 show that the majority of patients studied were males (32%), while females present the percent of (68%).

Table (4.1): gender distribution

Gender	Frequency	Percentage
Male	16	32%
Female	34	68%

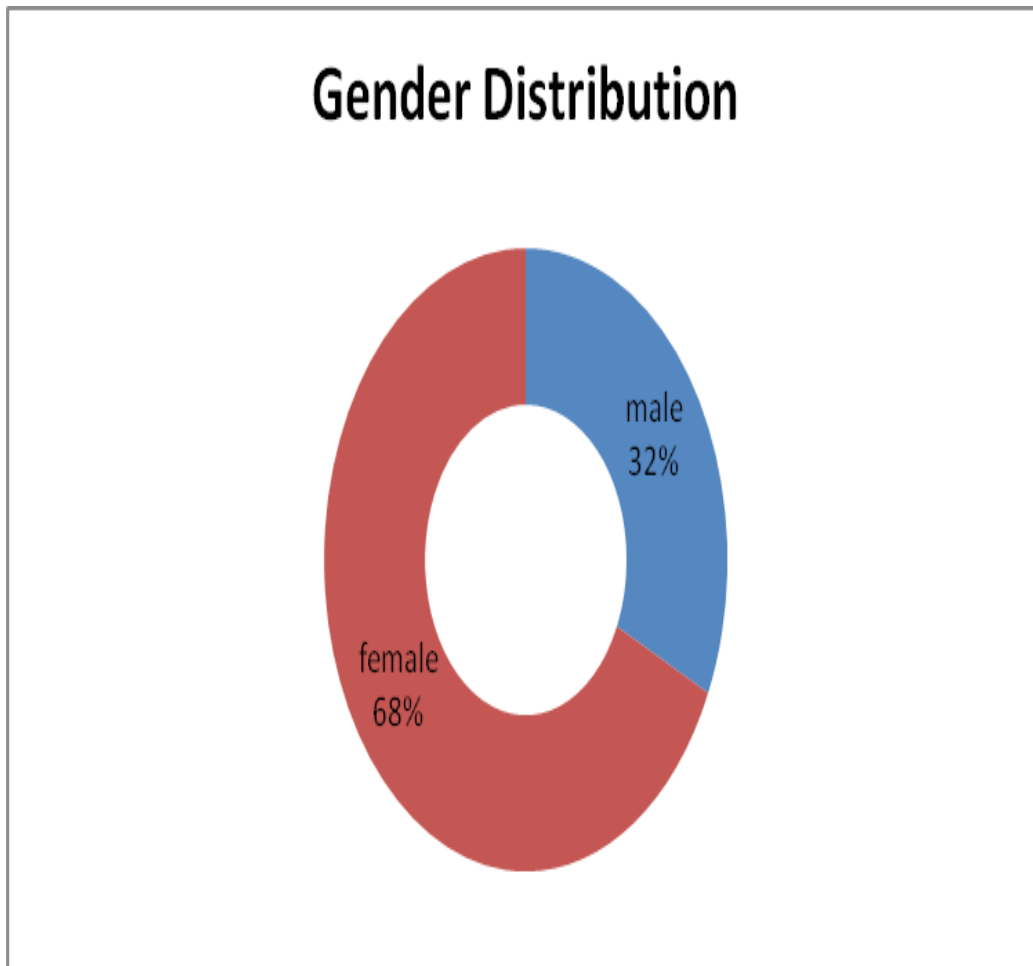


Figure (4.2): gender distribution

Shortness of breath is the most clinical indication with (54%) incidence, followed by Cyanosis (14%), Chest pain (12%), Cough (12%), and Haemoptysis

Table (4-3): shows the Clinical indication

Symptoms	Frequency	Percentage
Shortness of breath	27	54%
Cyanosis	7	14%
Chest pain	6	12%
Cough	6	12%
Haemoptysis	4	8%

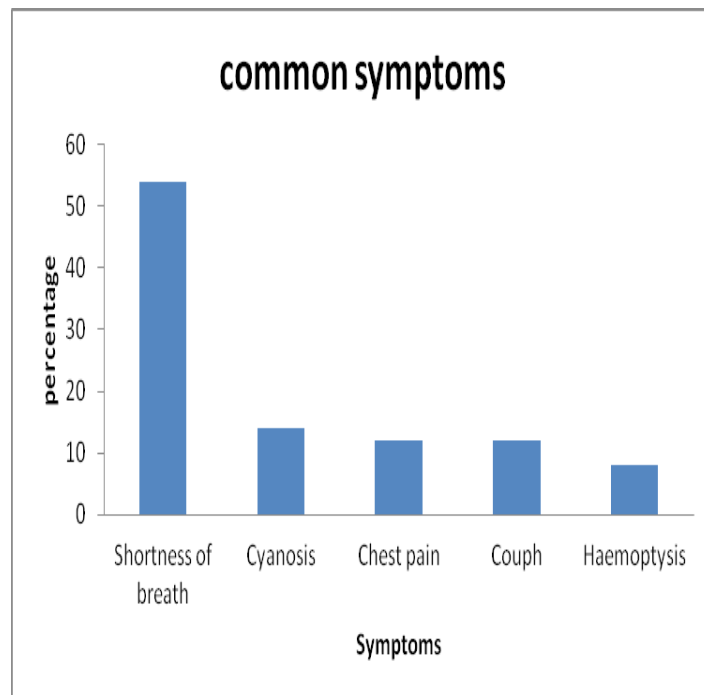


Figure (4-3): shows the Clinical indication

Table (4-4) shows the presence of DVT

DVT	Frequency	Percentage
Yes	26	52%
No	14	48%

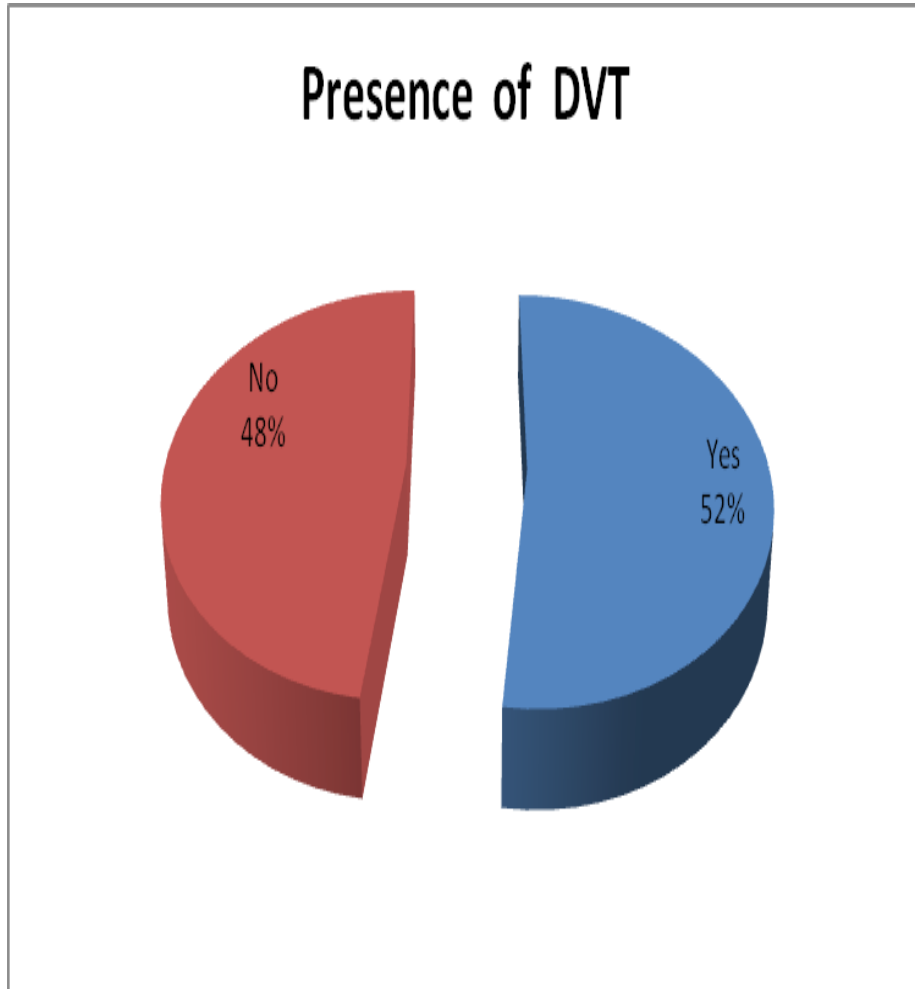


Figure (4-4) shows the presence of DVT

Table (4-4) shows the most common underlying lung disease

Lung diseases	Frequency	Percentage
Mosaic perfusion	12	24%
Plural effusion	8	16%
Infarcts	10	20%
Others	20	40%

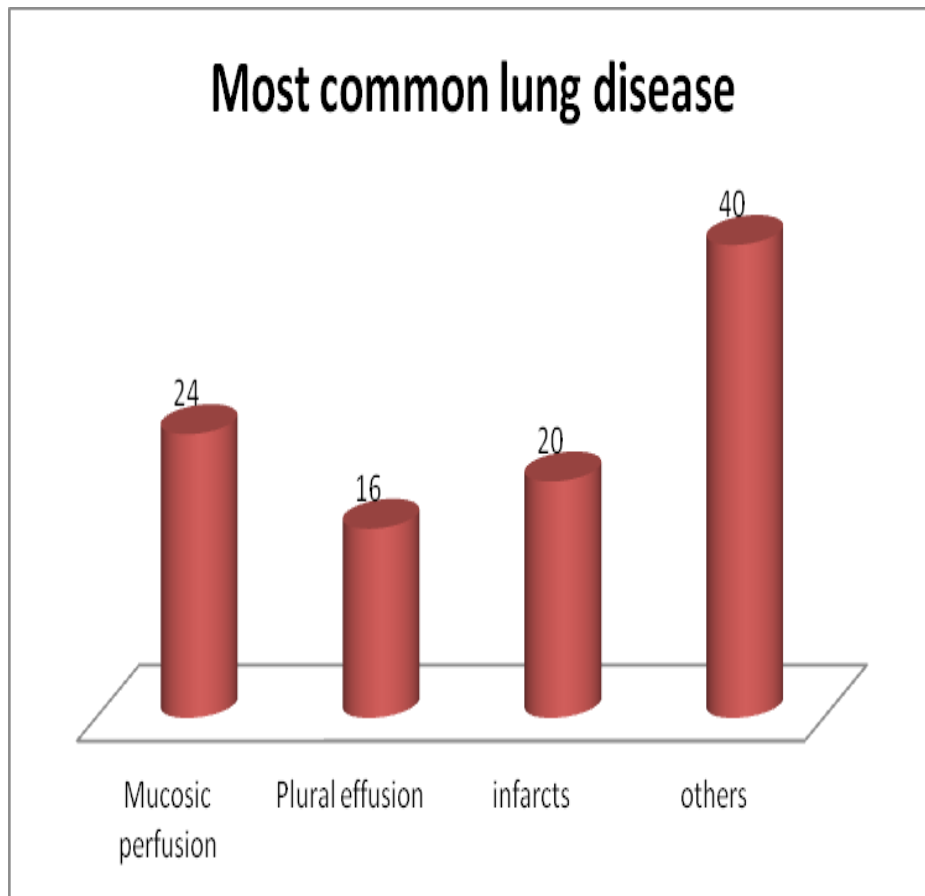


Figure (4-5) shows the most common lung disease

Table (4-6) shows the Pulmonary Embolism present within sample population

Presents	Frequency	Percentage
Yes	38	76%
No	12	24%

Pulmonary Embolism present within sample population

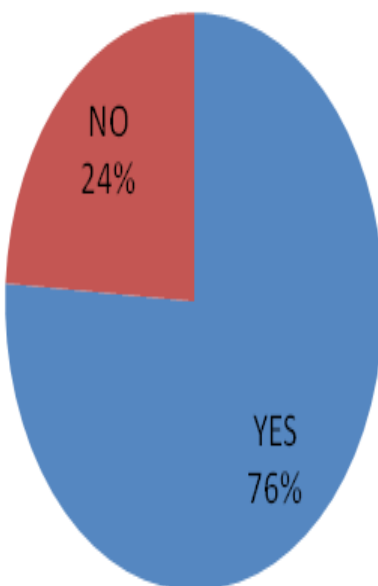


Figure (4-6) shows the Pulmonary Embolism present within sample population .

Table (4-7) Measurement of RT and LT Pulmonary arteries in PE infected

Site of embolism	Frequency	percentage
Rt pulmonary artry	30	79%
Lt pulmonary artry	8	21%

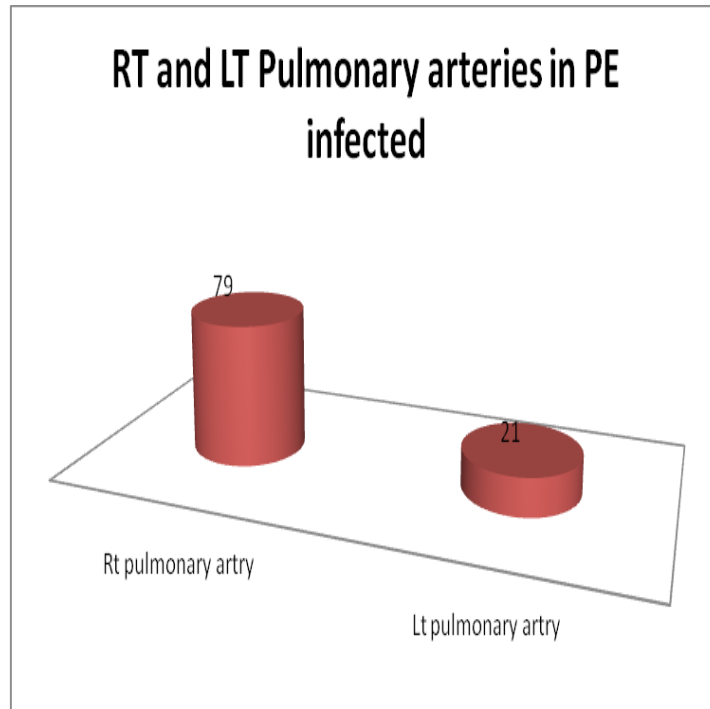


Figure (4-7) RT and LT Pulmonary arteries in PE infected

Table (4-8) Shows Location of PE in males and females ;

Location of PE	Frequency	Percentage
Male Rt pulmonary artry	6	16%
Male Lt pulmonary artry	4	10%
Female Rt pulmonary artry	24	62%

Female Lt pulmonary artery	4	10%
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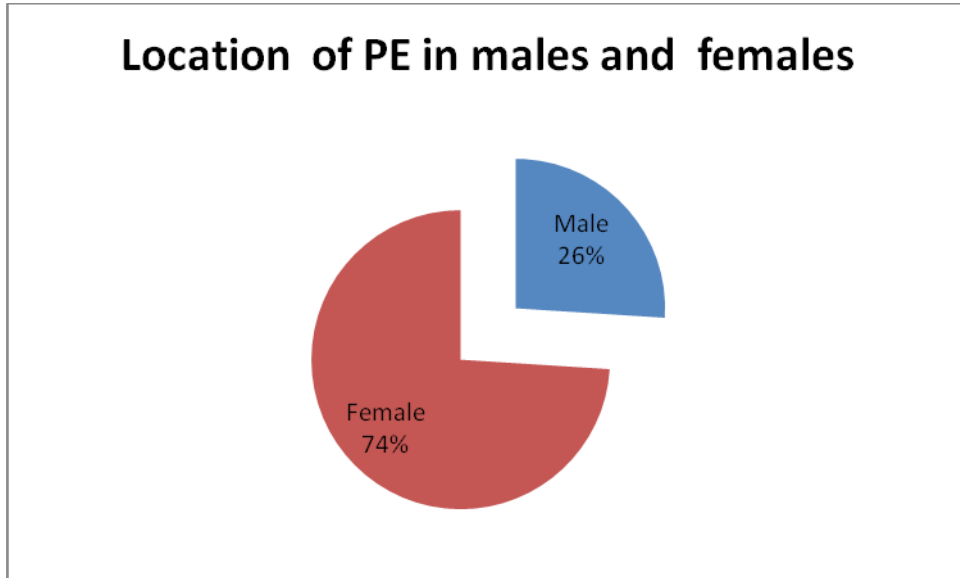


Figure (4-8) Shows Location of PE in males and females

Chapter five

Discussion , Conclusion and Recommendation

5-1 Discussion

This study was performed in 50 patients 34 patients were females while 16 were males and their ages are ranged from 20 to 60 years old they referred for CT chest.

The prevalence of PE in this study population was 76% (38 of 50 patients) during the study period.

Common presenting symptoms were shortness of breath, cyanosis , chest pain and haemoptysis .Most of those patient were presented with short duration of symptoms (less than 6 hours) From total population nearly half were presented with DVT as show in Fig &Table (4-4)

Consequently on CTA 12%of patient with PE showed plural effusion , 20%with consolidation collapse and cavities From the total sample population , only 38 where significantly positive for PE . Furthermore , the former population was distributed according to dilatation of pulmonary artery into RT pulmonary artery and LT pulmonary dilatation of pulmonary artery .Where 30 patients presented with RT pulmonary artery dilatation while only 8 patient with LT pulmonary artery . Frequency of Pulmonary Embolism was higher within females (28) than males (10) . 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 (19), with variable sensitivity and specificity values. However, to our knowledge, no large series of consecutive patients in which helical CT and selective pulmonary arteriography (the reference standard) were compared have been reported. This study findings demonstrate that CT is useful in the diagnosis of PE.

In this study, we found an overall prevalence of 76% of PE among 50 patients who underwent routine thoracic CT examinations. We believe that multiple factors contributed to a missed diagnosis of PE in our sample, including the relatively small size of affected pulmonary arteries in most cases and the limited extent of involvement. Our results emphasize the importance of a heightened awareness of PE in pediatric oncology patients, especially those with coagulation disorders and a history of deep venous thrombosis or PE.

We did not find a significant association between the presence of PE and a specific type of symptoms.

We acknowledge several limitations of our study. First, a number of CT scans were excluded from analysis, most commonly because of suboptimal contrast enhancement. Cases with suboptimal contrast enhancement have been similarly excluded in previous studies of unsuspected PE in adults (*Kyrle, 2008*).

CT is a technical improvement of helical CT and a diagnostic tool with a high sensitivity and specificity for the detection of PE. Our experience indicates 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 multisection or multiple-array detectors) with submillimeter isotropic imaging are expected to improve the evaluation of subsegmental pulmonary

vessels, with optimal spatial and temporal resolution, in the near future. In the present study, we investigated prospectively the diagnostic performance of pulmonary MDCT angiography alone in consecutive patients suspected of having PE. Our major findings were that CT had a high sensitivity. In addition, pulmonary MDCT angiography.

With regard to sensitivity, specificity, and accuracy, we found good agreement with a previous retrospective study (*Reinartz ,2004*), which found values of 86%, 98%, 93%, respectively, for MDCT. The sensitivity found for pulmonary MDCT angiography was 83% (*Stein, 2006*). We had a slightly lower sensitivity of 68% for MDCT. We have no obvious explanation for the difference in sensitivity, but the differences in study populations and algorithms for final diagnosis may have been contributing factors.

Taken together, we found that CT in diagnosis pulmonary embolism useful as a first-line routine test for PE, with excellent diagnostic performance.

At present, many centers use only pulmonary MDCT, but this might be suboptimal because of its possible lower sensitivity and higher radiation dose. Reasons for extensive use of MDCT may include its round-the-clock availability, its lower cost, its high frequency of conclusive results,

Recently proposed algorithms for imaging evaluation of patients suspected of having PE have omitted V/Q scintigraphy from the work-up, and some guidelines considered V/Q scintigraphy only as an alternative when patients cannot undergo MDCT because of severe renal insufficiency or allergy to intravenous contrast agents or when a CT-based strategy is inconclusive (*Kyrle, 2008*). A total of 46 patients (24%) were excluded from the present

study because of renal dysfunction, indicating that MDCT may not be an option in many patients. This is an important strength of a scintigraphic approach.

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. This 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 subsegmental 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 the provides 'a road map', and excellent detail is available regarding to the anatomy, pathology and early diagnosis of PE very import factor in the disease management.

CT were used ideally for full evaluation of the PE. 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. CT is now an attractive means for establishing a safe, highly accurate, and cost-effective diagnosis of PE. The lack of a clinically available reference standard for the diagnosis of PE suggests that the medical community should replace theoretical and academic discussions on the relative value of different imaging modalities with more realistic approaches based on patient outcome. Retrospective studies (16,44,53,55–59) already indicate the high negative predictive value for a normal multi-detector row CT pulmonary angiographic study. 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. Recommendation

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 .

Detection of Pulmonary Embolism with Combined Ventilation–Perfusion
SPECT and Low-Dose CT