THE PATTERN OF FINDINGS ON MULTIDETECTOR COMPUTED TOMOGRAPHIC PULMONARY ANGIOGRAPHY FOR SUSPECTED PULMONARY EMBOLISM IN NAIROBI.

A DESCRIPTIVE CROSS-SECTIONAL STUDY CARRIED OUT AT KENYATTA NATIONAL HOSPITAL AND M.P SHAH HOSPITAL.

A DISSERTATION SUBMITTED IN PART FULFILLMENT FOR THE AWARD OF THE DEGREE OF MASTER OF MEDICINE IN DIAGNOSTIC IMAGING AND RADIATION MEDICINE UNIVERSITY OF NAIROBI.

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DECLARATION

I, **Dr.Wainaina Anne Nduta** declare that the work contained herein is my original work and has not been presented in any other university to the best of my knowledge.

Signature _____ Date _____

APPROVAL BY UNIVERSITY SUPERVISORS

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DEDICATION

This dissertation is dedicated to my spouse Francis and my children Arnold and Angela for their unwavering support and perseverance through it all.

TABLE 0F CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

PE	Pulmonary Embolism
DVT	Deep Venous Thrombosis
VTE	Venous thrombo-embolism
PIOPED	Prospective Investigation on Pulmonary Embolism Diagnosis
MDCT-PA	Multidetector Computed Tomographic Pulmonary Angiography
CTV	Computed Tomographic Venography
V/Q	Ventilation Perfusion radionuclide scanning
ST	Slice Thickness
HU	Hounsfield Units
MPA	Main Pulmonary Artery
RPA	Right pulmonary artery
LPA	Left pulmonary artery
AO	Ascending Aorta
RV	Right ventricle
RA	Right atrium
IVC	Inferior vena cava
CI	Confidence Interval
SD	Standard Deviation
SPSS	Statistical package for social sciences
KNH	Kenyatta National Hospital

DEFINITIONS OF TERMS

Pulmonary embolism (PE)

It is the total or partial obstruction of one or more pulmonary arteries by a single or multiple thrombotic or non-thrombotic emboli.

Embolus

It is a blood clot that dislodges and circulates through the blood stream.

Deep venous thrombosis (DVT)

Presence of blood clots in the deep veins as most commonly occurs in the lower limbs.

Venous thromboembolism (VTE)

It comprises both DVT and PE which are distinct manifestations of the same disease process.

Computed Tomographic Angiography (CTA)

This is a non-invasive radiological method of studying the vascular structures by injecting radio-opaque water soluble contrast media into the arteries and taking X- ray images by a CT machine. X- Ray beams from many angles are used to create a series of detailed body cross-sectional images.

ABSTRACT

Introduction:

Pulmonary embolism is a common condition with considerable morbidity and mortality. Prompt and accurate diagnosis is important because the mortality of untreated PE is high and complications can occur with its treatment of long-term anticoagulation. As there are no specific signs or symptoms of this condition, the diagnosis relies heavily on imaging tests. Since the introduction of MDCT technology with high spatial and temporal resolution, MDCT-PA has become the current imaging method of choice for imaging pulmonary vessels when PE is suspected.

Objective:

The main objective of this study was to assess the clinical utility of MDCTPA for suspected PE and determine the pattern of imaging findings. Additionally to identify shortcomings in PE services at KNH and MP Shah hospital in Nairobi Kenya with recommendations.

Methods:

This was a cross-sectional descriptive study carried out at the Radiology departments over a period of 7 months between April and October 2011 for 110 consecutive patients referred by clinicians with clinically suspected PE for MDCT-PA. The patients were included in the study once ascertained they did not have history of allergy to iodinated contrast media and after signing an informed consent. The study was performed on 16 slice MDCT. Each CTPA was reviewed by the researcher and a consultant radiologist. The findings were recorded in the data collection form. Data entry preceded analysis using SPSS 17.0. The results were presented in form of tables, graphs and charts followed by a discussion of the results.

Results:

A total of 110 consecutive patients were recruited into the study. The age distribution ranged between 20 and 92 years with a mean age of 52.6 and a median age of 55years. The male to female ratio of patients with clinically suspected PE was 1:2.1. Dyspnea [100%](n=110) was the commonest presenting complaint. There was radiologic evidence of PE in 30 patients (27.3%). There was no evidence of PE in 80 patients (72.7%). PE male to female ratio was 1:2. PE was

also found to be more common with increasing age greater than 60 years comprising 16 patients (53.3%). Anatomically PE was found more commonly in the sub-segmental arteries followed by segmental, lobar and finally MPA. Additional diagnosis was found in 21 out of 30 patients with PE (70%) whereas alternative diagnosis was made in 37 out of 80 patients (46.3%) found to have no evidence of PE.

Conclusion:

MDCT-PA was found to be a useful diagnostic tool in the work-up of patients suspected of having PE. In patients without a contraindication for iodinated intravenous contrast medium, this readily available, rapid and minimally invasive study is well tolerated. It allows direct demonstration of endoluminal clots in the thorax and also reveals significant additional diagnosis which is imperative for appropriate patient management.

The patient selection in Kenya for CTPA demonstrated comparable yield for a positive diagnosis of PE (27.3%) to that published in literature [8,44].

The management of patients with suspected PE requires a multidisciplinary approach which will ensure that only relevant examinations are performed and reduce unnecessary medical radiation exposure.

INTRODUCTION AND BACKGROUND TO PE AND CTPA

Pulmonary embolism is the partial or total occlusion of one or more central or peripheral pulmonary arteries by thrombi that originate typically in the large veins of the lower extremities or pelvis. Due to its mostly unspecific clinical presentation, PE is often referred to as the “great masquerader” and remains a diagnostic challenge to both the clinicians and radiologists. Diagnostic algorithms are needed to assist clinical assessment and optimize the use of diagnostic tests especially in an emergency setting [1].

The most striking advantage of MDCT technology is the fast data acquisition and 3D reconstruction which allows for a distinct examination protocol. The shorter scan time reduces cardiac and respiratory motion artifacts, making vessels adjacent to the heart easier to visualize. Thin collimation improves the depiction of sub-segmental arteries. Faster scans require less intravenous contrast, a factor beneficial to patients with cardiac and renal failure. The increased use of CT has improved patient care by minimizing diagnostic delays that may be incurred when alternative imaging tests are used [2].

CTPA has now been recognized as the golden reference standard in a large multi-centric study on PE (PIOPED) [3].
It has become established as the first imaging test due to its high negative predictive value for clinically relevant PE. Despite the direct visualization of clot material, depiction of cardiac and pulmonary function in combination with the quantification of pulmonary obstruction helps to grade the severity of PE for further risk stratification. Additional diagnoses add to the usefulness of this method [4].

In particular, MDCT equipment with 16–64 detector rows or more with the use of IV contrast can properly display pulmonary arteries down to the sub-segmental level, quickly providing images with voxel isotropy and maximizing the efficiency of the IV bolus of iodinated contrast medium [5].

PE whether acute or chronic form, causes either partial or complete intraluminal filling defects, which should have a sharp interface with intravascular contrast material. In acute PE that manifests as complete arterial occlusion and the affected artery may be enlarged. Partial filling defects due to acute PE are often centrally located, but when eccentrically located they form

acute angles with the vessel wall. Chronic PE can manifest as complete occlusive disease in vessels that are smaller than adjacent patent vessels. Other findings may include evidence of recanalization, webs or flaps, and partial filling defects that form obtuse angles with the vessel wall [6,7].

Despite the fact that CTPA has been found to be cost effective and widely available some of the limitations include the use of ionizing radiation with a relatively high radiation dose. It is also contraindicated in patients with allergy to iodinated contrast media and reduced renal function. The possibility of the development of contrast induced nephropathy which may lead to renal failure has also been documented [15, 38, 39, 40].

LITERATURE REVIEW

Epidemiology of Pulmonary embolism

PE is a common condition in adults with a reported annual incidence of 23–69 per 100, 000 population [8]. PE has also been reported to occur in some 600,000–630,000 patients per year in the United States [9]. Not only is it ranked as the third most common acute cardiovascular disease after myocardial infarction and stroke but also results in thousands of deaths each year because it often goes undetected [10]. Moreover untreated PE is associated with a high mortality of 15–30% [11]. The long term anticoagulation therapy always carries the risk of bleeding. Hence to avoid unnecessary anticoagulant therapy, it is important to promptly confirm or exclude PE accurately.

The incidence of PE rises with age increasing dramatically after the age of 60 years and approaching approximately 1 in 100 in the very old. In the absence of risk factors PE is rare in children under 15 years of age (<5 per 100,000) [12].

Natural history of pulmonary embolism

PE usually arises from deep vein thrombosis of the lower extremities. Usually, deep vein hrombosis originates in the calf veins and propagates to the proximal leg veins. Patients with DVT involving the proximal leg veins are considered at greatest risk for developing PE as opposed to those with isolated calf vein thrombosis [1].

Less commonly DVT originates in the iliac veins and with time may spread distally in a cephalad direction. Ilio- femoral or pelvic DVT tends to occur in certain settings such as pregnancy or in the presence of pelvic masses and post-surgery in gynecological, urological or abdominal procedures. The thrombus dislodges from the deep veins, travelling through the inferior vena cava and the right heart to finally lodge in the pulmonary arterial system. PE may less commonly originate from other venous sources. With the chronic use of upper extremity indwelling catheters, PE may arise from the veins in the upper extremities. The denovo development of PE is thought to be uncommon. Other rare causes of PE include amniotic fluid, placenta, air, fat, tumor, parasites such as schistosomes and septic emboli from endocarditis affecting the pulmonary or tricuspid valves [1].

Pathophysiology of Pulmonary embolism

Risk factors that predispose a patient to thrombus formation are described as the Virchow's triad [13] that encompasses conditions that impair venous return, endothelial injury and underlying hypercoagulable states which include inherited conditions; Antithrombin III deficiency, Protein C or S deficiency, Factor V Leiden mutation, Prothrombin gene mutation, Plasminogen deficiency and Dysfibrinogenemia [1,13].

Among the acquired factors include long distance flights, obesity, smoking, oral contraceptives, postmenopausal hormone replacement, pregnancy, surgery, trauma and medical conditions such as antiphospholipid antibody syndrome, malignancy, systemic arterial hypertension and chronic obstructive pulmonary disease [12]

Another risk factor for VTE is ethnicity, with a significantly higher incidence among Caucasians and African Americans than among Hispanic persons and Asian-Pacific Islanders. Approximately 25% to 50% of patient with first-time VTE have an idiopathic condition without a readily identifiable risk factor [11].

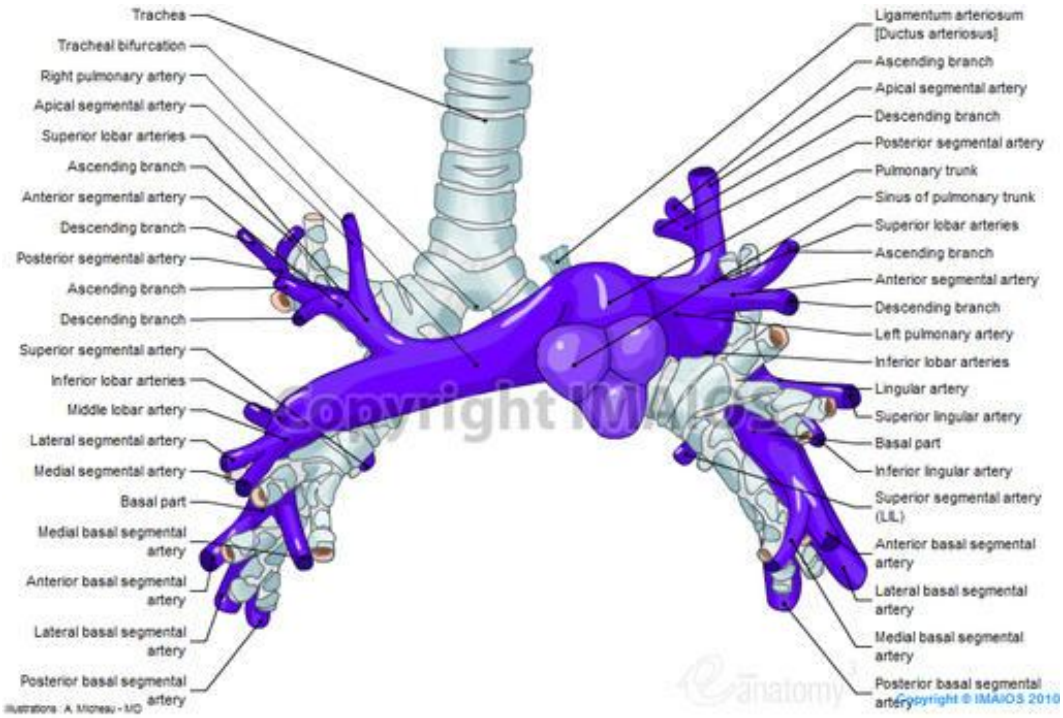
There are no other unique risk factors particular to the Kenyan population reported in literature.

ANATOMY OF THE PULMONARY VASCULATURE

The lungs are the essential organs of respiration located on either side of the heart and other mediastinal contents. There are two functionally distinct circulatory pathways. These are pulmonary vessels which convey deoxygenated blood to the alveolar walls and drain oxygenated blood to the left side of the heart and the bronchial vessels which are derived from the systemic circulation and supply oxygenated blood to the lung interstitium.

The pulmonary arteries can be categorized by the standard anatomical descriptions which labels pulmonary arteries as main, lobar, segmental and sub-segmental branches, corresponding to first-order, second-order, third-order and fourth-order pulmonary arteries, respectively. The commonly used term ‘central pulmonary arteries’ refers to the arteries from the main pulmonary trunk to the lobar branches. The main pulmonary artery bifurcates at the level of fifth thoracic vertebra into the left and right pulmonary artery which further subdivide into the lobar, segmental and subsegmental arteries [14].

ANATOMY OF THE PULMONARY VASCULATURE



Clinical presentation of pulmonary embolism

Symptoms and signs depend upon the size of embolism and co-morbidity and encompass a wide spectrum from cardiovascular collapse to small emboli with few or no hemodynamic consequence. Dyspnea is the most frequent symptom of PE. Whereas dyspnea, syncope and hypotension indicates massive PE, pleuritic chest pain, cough, or hemoptysis suggests smaller, more peripheral emboli which occur in patients with pulmonary infarction**.** Tachypnea is the most frequent sign. Other signs include fever, tachycardia, decreased breath sounds, wheezing, pleural rub, rales, jugular venous distention and accentuated pulmonic component of second heart sound [1].

Stein et al. analyzed the data from the prospective investigation of pulmonary embolism diagnosis study II (PIOPED II) which was a multicenter prospective trial on PE [15]. They reported that the onset of dyspnea is usually but not always rapid. At least one of the syndromes typical of the condition (hemoptysis/pleuritic pain syndrome, uncomplicated dyspnea syndrome or circulatory collapse syndrome) was present in 94% of the patients with PE in proximal arteries, but in only 72% of those with segmental PE [21]. In patients with PE in the main or lobar pulmonary arteries, dyspnea or tachypnea occurred in 92%. The largest PE was in the segmental arteries in only 65%. In general, signs and symptoms were similar in the elderly and younger patients, but dyspnea or tachypnea was less frequent in elderly patients with no history of cardiopulmonary disease. Dyspnea may be absent, even in patients with circulatory collapse. Patients with a low-probability objective clinical assessment may sometimes have PE, even in proximal vessels. The authors concluded that symptoms may be mild and generally recognized typical symptoms may even be absent, particularly in patients with PE only in the segmental pulmonary branches, although they can also be absent in those with severe PE. While a high- or intermediate-probability objective clinical assessment suggests that diagnostic studies are warranted, a low-probability objective clinical assessment does not exclude the diagnosis. Therefore maintenance of a high level of index of suspicion and vigilance is very critical [16].

Diagnosis of pulmonary embolism

Diagnostic tests for PE include the plasma D-dimer enzyme-linked immunosorbent assay which rises in the presence of PE because of plasmin's breakdown of fibrin. D-dimer is a fibrin degradation product whose main use is to exclude thrombo-embolic disease where the clinical probability is low. However the high sensitivity of the test at 96.8% is associated with a low specificity at 45.1% [17, 18]. Levels increase in patients with concomitant systemic illness like pneumonia, myocardial infarction, cancer, sepsis, second or third trimester of pregnancy and also in the postoperative state [1]. A negative D-dimer result does not exclude PE in more than 15% of patients with a high probability clinical assessment [19].

A chest radiograph is usually the first imaging study performed in patients with suspected PE [20]. Common radiographic abnormalities include atelectasis, pleural effusion, parenchymal opacities, cardiomegally and elevation of a hemidiaphragm. The classic radiographic findings of pulmonary infarction are focal oligemia (Westermark's sign), peripheral wedged-shaped triangular opacity (Hampton's hump) or an enlarged right descending pulmonary artery (Palla's sign) [1]. It is however not a very reliable test. The accuracy of diagnosing PE on chest radiography alone was shown to be only 33% in one study [21]. The purpose of chest radiography is mainly for excluding other differential diagnosis which may mimic PE which includes: pneumothorax, rib fracture, chronic obstructive airway disease, congestive heart failure and costochondritis [1].

Nuclear medicine ventilation perfusion (V/Q) scintigraphy has for long been the clinical mainstay for the evaluation of suspected PE. In a study undertaken by Sostman et al they reported that with the exclusion of patients with intermediate or low probability, the sensitivity of a high probability (PE present) scan finding was 77.4%(95% confidence interval [CI]: 69.7%, 85.0%), while the specificity of very low probability or normal (PE absent) scan finding was 97.7%(95%CI:96.4%, 98.9%)[22]. However a disadvantage of V/Q scan is that PE is not directly visualized but rather its effects on perfusion and ventilation. These problems cause the need for probability criteria, categorized as high, intermediate, low, or very low probability and normal [23].The main practical problem is evident in the large group of patients with intermediate or indeterminate probability when the classic PIOPED criteria are applied as

they present diagnostic uncertainty and would require additional diagnostic techniques such as CTPA or conventional angiography [24].

Anderson et al. conducted a randomized, single-blinded non-inferiority multicenter clinical trial to determine whether CTPA may be relied upon as a safe alternative to V/Q scanning as the initial pulmonary imaging procedure for excluding PE in acutely symptomatic patients. Significantly more patients were diagnosed with PE using the CTPA approach as 133 patients (19.2%) in the CTPA group vs 101 (14.2%) in the V/Q scanning group were diagnosed with PE (difference 5.0%; 95% CI 1.1–8.9%). The authors concluded that CTPA was not inferior to V/Q scanning in ruling out PE and that CTPA is more sensitive than V/Q scanning [25].

Although pulmonary angiography established itself as the gold standard diagnostic criterion for PE, it rapidly showed its limits. It is costly, invasive, time consuming, labor intensive and not widely available . It also has mortality risk of 0.2–0.5%. [26]. Furthermore inter-observer agreement is only 92% for including and 83% for excluding PE, which is a potential source for both false-negative and false-positive results [24].

The European Multicenter Trial was a prospective study that compared single detector spiral CT with conventional pulmonary angiography. The study demonstrated sensitivity of spiral CT to vary between 75% to 92%. Sensitivity of V/Q scans in this study ranged from 36% to 65%. Spiral CT had the advantage of performing fewer non-diagnostic exams than V/Q scanning, since the lung parenchyma, mediastinum and chest wall structures were also assessed resulting in alternative diagnoses for patient's symptoms. The inter-observer agreement between readers was greater for CT than for V/Q scanning (*72% versus *39%) and even better than conventional pulmonary angiography (46%). The trial also showed inter-observer agreement for CT to be dependent on the quality of the study. For V/Q scans, inter-observer agreement was neither due to study quality nor the use of PIOPED criteria [27].

The first study evaluating PE with spiral CT came from Remy-Jardin et al. in 1992. Diagnosis of pulmonary embolism with spiral volumetric CT was based on the direct visualization of intraluminal clots: partial filling defects (n = 41; 37%), complete filling defects (n = 51; 46%), "railway track" signs (n = 6; 5%), and mural defects (n = 14; 12%). All 23 patients with normal

findings on spiral volumetric CT had normal findings on conventional pulmonary angiography. With spiral volumetric CT, the finding of 112 central emboli (eight main, 28 lobar, and 76 segmental) corresponded exactly to the angiographic findings. The study demonstrated 100% sensitivity and 96% specificity [28].

The advent of MDCT has allowed refinement of the technique, such that the whole lung may be examined during a single breath-hold. Indeed, in one recent prospective study conducted by Winer-Muram et al. found the sensitivity, specificity and accuracy of MDCT were 100%, 93% and 95%, respectively, whereas for conventional pulmonary angiography these calculations were 86%, 100% and 97%, respectively [29].

MDCT has led to increased observation of segmental and sub-segmental emboli as reported by Schoepf et al who evaluated patients with PE by MDCT and assessed inter-observer agreement in 1mm, 2 mm, and 3 mm-thick reconstructions. They determined that the use of 1-mm section widths resulted in higher detection rates and greater inter-observer agreement than thicker sections [30].

According to the updated guidelines of the British Thoracic Society, no further examination or treatment is needed for patients with a high-quality negative MDCT-PA [31].

Although there are variations for reformatted images for MDCT-PA studies between institutions, the minimum reconstruction interval should be 2 mm contiguous axial images preferably for viewing on a CT workstation. In a study undertaken by Heuschmid et al. comparing the different image reconstruction parameters for detecting PE with a 16-slice MDCT, there was no difference in detection of main and lobar PE in 0.75, 2 and 6 mm slice thickness axial data sets. For segmental and sub-segmental PE, axial 2 mm slice thickness (ST) had higher sensitivity and specificity (segmental 0.99 sensitivity/1.0 specificity, sub-segmental 0.94/1.0) compared with 4 mm ST (segmental 0.95/0.99, sub-segmental 0.67/0.99) Maximum intensity projections(MIP) reformations and coronal images did not improve the diagnostic accuracy of peripheral PE compared with thin-slice axial images [32].

The value of associated pleural and parenchymal findings that aid in the diagnosis of PE was reported by Coche et al. Ancillary signs such as wedge-shaped pleural based hyper-attenuation

areas of consolidation, linear bands, and dilated central or segmental pulmonary arteries can be associated with the diagnosis of PE and are statistically significant findings. Hence the detection of these findings may direct further investigation particularly if a study is "suboptimal" for assessment of central or segmental vessels. However, these radiologic features are not specific for PE [33].

After experiencing an initial embolic event, a patient may be at risk for circulatory collapse secondary to right-sided heart failure, and a subsequent embolism may be fatal. Early detection of acute right ventricular failure allows implementation of the most appropriate therapeutic strategy. Some morphologic abnormalities that suggest right ventricular failure on CT include right ventricular dilatation in which the right ventricular cavity is wider than the left ventricular cavity in the short axis with or without contrast material reflux into the hepatic veins and deviation of the inter ventricular septum towards the left ventricle [34].

Ancillary findings in chronic pulmonary embolism may include CT changes caused by pulmonary arterial hypertension which is either a main pulmonary artery diameter greater than 33 mm or a ratio of main pulmonary artery to ascending aorta of greater than 1 [35,36].

In 1998, Loud et al first reported a combined technique of CT venography of lower limbs performed at the time of CTPA that required neither additional intravenous contrast medium nor additional venipuncture and that permitted evaluation of the deep veins of the abdomen, pelvis, thighs, and calves. The rationale for this is that both pulmonary emboli and venous thrombus are part of the same process and that detection of either is important. This comprehensive examination for PE and DVT added only a few minutes (3-5) and images, yet revealed additional relevant pathologic findings in the abdomen, pelvis, and legs in a minority of patients. Unlike ultrasound, CTV routinely evaluates the pelvic veins. With the introduction of this technique, CT has become a single practical test for both DVT and PE [37].

A study by Van Erkel et al. reported that Helical CT reduced mortality and improved cost-effectiveness in the diagnostic workup of suspected PE [38].

Unfortunately, the use of iodinated contrast media in CTPA can provoke the development of contrast-induced nephropathy (CIN) which is a known complication associated with an increased

risk of renal failure. Therefore caution in using contrast agent is imperative and clinicians should only order CTPA only when it is clinically indicated [39].

The increasingly frequent use of CT has raised concerns about the overall radiation exposure to the population scanned hence there is a need to optimize scanning protocols. Imaging should follow the ALARA principle (As Low as Reasonably Achievable). The effective radiation dose for CTPA protocols is generally between 2.2 and 5 millisievert(mSv). Assuming a background dose of 2.5 mSv per year, the risk from CTPA is 1 to 2 times that from background radiation exposure [40]. However it is important to weigh the risk versus benefits of imaging.

Radiation dose can be reduced by lowering the peak kilovoltage or the tube current. Hurwitz et al reported a reduction from 140 to120 peak kilovoltage reduced the average breast dose by 28%. The average reduction in lung dose was 47% [41].

JUSTIFICATION OF THE STUDY

1. Various studies have been done elsewhere in different settings. However no similar study has been recorded locally. It was therefore imperative to undertake this study to evaluate the diagnostic role of MDCT-PA in managing patients with suspected PE so as to provide a current baseline database as a learning curve upon which further studies can be based on. This would greatly facilitate improvement on our patient management.

2. In the local set up, Kaguthi JN conducted a generalized study in 2008 on the pattern of vascular pathology on Multi-detector Computed Tomography Angiography as seen in KNH. The study population consisted of 73 patients who underwent various CTA according to clinical indications including peripheral, renal, abdominal aorta, thoracic aorta, carotid and 4 vessel CTA. 6 patients underwent MDCTPA and 5 patients(83.3%) were found to have pulmonary embolism [42].

A recommendation was made that further extensive studies in the individual regions should be done in the local setup focussing on specific pathologies as this would give more comprehensive findings and reduce the error index. This prompted my decision to evaluate a larger cohort.

OBJECTIVES OF THE STUDY

BROAD OBJECTIVE

To assess the clinical utility and the pattern of imaging findings on Multi-detector Computed Tomographic Pulmonary Angiography for patients with suspected pulmonary embolism at KNH and MP Shah hospital in Nairobi.

SPECIFIC OBJECTIVES

1. To determine the common clinical presentations of patients with suspected pulmonary embolism referred for MDCT-PA .
2. To determine the socio-demographic factors of patients with suspected pulmonary embolism referred for MDCT-PA.
3. To determine the prevalence rate, age and gender distribution of pulmonary embolism on MDCT- PA
4. To determine the radiological findings on MDCT-PA in clinically suspected pulmonary embolism.

DESIGN AND METHODOLOGY

Study Area

The study was conducted at the Radiology departments in the following centers: Kenyatta National Hospital which is the main teaching and referral hospital in Kenya and MP Shah Hospital both situated in the Nairobi County. KNH is equipped with a 16 slice MDCT scanner, Brilliance model, serial no.729 manufactured by Phillips in January 2007 in Netherlands. MP Shah hospital is equipped with a 16 slice Siemens Somatom model manufactured in Germany in 2000.

Study Population

This included 110 consecutive patients referred by clinicians with a clinical suspicion of PE who presented to the Radiology departments for MDCTPA, were able to afford the service and had no history of contrast allergy. Data was not captured for the patients who did not qualify for the service. Moreover it was not also possible to get the exact number of patients who had a suspicion of PE across the hospitals but never presented for CTPA for varied reasons due to lack of a central communication system.

Study design

It was a prospective cross-sectional study that was conducted from April to October 2011. Upon obtaining an informed consent the patients' clinical summary was obtained from the request form and filled into the data collection form. In case some of the information was missing from the request form, this was inquired directly from the patient or guardian by the principal researcher or assistant data collectors. Further scrutiny of the patients' files was done manually for relevant information by the principal researcher. The MDCT-PA findings was then reviewed on a workstation by the researcher and a consultant Radiologist on duty and recorded in the data collection forms. A total of 7 Radiologists were involved and their working experience ranged from 5 to 20 years. The studies carried out during the day were reviewed immediately. However the ones done at night would be reviewed later on during the day.

Materials

This prospective study was conducted in Nairobi at the following centers: Kenyatta National Hospital and MP Shah Hospital. The study was conducted on 16 slice MDCT scanners available in both hospitals which ensured standardization of the technique in all the patients.

Methodology

Once the request form for CTPA was presented to the Radiology reception it would be counter-signed by a Radiologist on duty after which booking and payment would be made. The patient would then be wheeled in for the CTPA. It is at this point that the patient would be recruited into the study upon informed consent. Diagnosis of PE was based on the direct visualization of intraluminal clots either as complete filling defects, mural defects or partial filling defects as railway track and polo mint signs. The ratio of the main pulmonary trunk to ascending aorta diameter was determined at the level of MPA bifurcation. A ratio > 1 is a marker of pulmonary hypertension attributable to PE. The ratio of the right to left ventricular diameter was determined midway at the axial level depicting the full length of the inter-ventricular septum. A ratio >1 is a marker of right ventricular strain attributable to PE.

Inclusion criteria

1. This included 110 consecutive patients with suspected PE referred by clinicians who presented to the Radiology departments with request forms for MDCT-PA within the study period and were able to afford for the service. The cost at MP Shah was 12,000Ksh while at KNH was 7000Kshs.

2. No known history of allergy to Iodinated contrast media.

The clinical criteria used by the clinicians to refer patients for MDCTPA was as per their discretion. None of the clinicians provided an objective clinical score for the probability of PE.

Exclusion criteria

1. Non-consenting patients.

2. CTPA not obtained during the 7 month study period as this was a prospective study.

Diagnostic Criteria of Acute PE:

1. Complete arterial occlusion with failure to opacify vessel lumen(vessel cut-off sign). Artery may be enlarged as compared to others of the same order.
2. Central filling defect surrounded by contrast.
3. Peripheral intraluminal filling defect that makes an acute angle with the arterial wall.

Diagnostic criteria of Chronic PE:

1. Complete occlusion of vessel that is smaller than others of same order of branching
2. Peripheral filling defect that makes obtuse angles with the vessel wall

MDCT-PA SCANNING TECHNIQUE

For intravenous access, introduction of an 18 or 20 gauge catheter into an antecubital vein was done. The patient was positioned supine within the CT gantry with both arms extended and resting comfortably below the head.

The chest field of view is the widest rib to rib distance acquired during breath hold after suspended inspiration and from the lowest pleural recess to the apices of the lungs. Images of the thorax were acquired in a cranial caudal direction with a standard algorithm at 120 peak kilovoltage (kVp), tube current 350 (mAs) and slice thickness of 2 millimetres. A scanogram of the entire thorax was first obtained after which serial axial pre-contrast scans were acquired. The syringe pump with contrast was then fixed to the intravenous cannula after which100 ml of iodine concentration water soluble contrast media(Ultravist 370) was infused at 4 ml/second by use of a power injector with a 20 second delay to scan start after which post contrast images were acquired.

From each dataset multi-planar reconstructions were generated as 2.5 mm thick slices with 1mm spacing on the standard three orthogonal planes—axial, coronal and sagittal. Images were displayed and viewed on the workstation (KNH-Extended brilliance, MP Shah- Navigator) with a computer software in 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) which aids in differentiating between a sharp margined embolus and an ill-defined artifact. The lung algorithm is a high spatial frequency reconstruction used to improve the quality of images of the pulmonary vessels, bronchi, and interstitium.

Combined CTPA and CT venography (CTV) of the pelvic and lower extremities was done for only 73 patients attended at MP Shah Hospital in the same sitting as this is the routine protocol that has already been established. None of the 37 patients attended at KNH had combined CTPA/CTV as the protocol has not yet been established.

CT Venography Technique- It is performed after CTPA with the patient supine. After a scan delay of 4 min after the start of the injection bolus for CTPA, scans are obtained from the iliac crests to the tibial plateaus in the cranial-to-caudal direction at 120 kVp and 200 mAs. Images of the iliac, femoral, and popliteal veins were obtained, processed and interpretated on the workstation in conjunction with CTPA.

Table represents number of patients studied in the 2 hospitals and the protocols they received.

	KNH		MP SHAH	
	N	%	N	%
CTPA	37	33.6%	73	66.4%
COMBINED CTPA/CTV	0	0	73	66.4%

Sample size determination

The sample size included the patients who presented at KNH and MP Shah Radiology departments with suspected PE in whom MDCTPA was done within the study period. The sample size was determined by the following formula by Fisher et al (1998) [44].

$$n = \frac{z^2 \, p \, (1-p)}{d^2}$$

n = desired sample size.

z = Standard normal variance corresponding to 1.96

p = known prevalence rate of pulmonary embolism. In this study 69/100,000*100 = 0.069

d= the level of significance desired.

When this formula is applied at d = 0.05, z = 1.96, and p = 0.069

$$n = \frac{(1.96)^2 \times 0.069 \, (\, 1-0.069)}{(0.05)^2}$$

n = 98.7122 Therefore n = 99

The expected minimum sample size was 99 patients.

A Total of 110 patients were studied for the 7 month study period

Data collection

A well formatted data collection sheet was used to get the information relevant to the study.

Data analysis

Data was cleaned and entered into the computer programme; (SPSS 17.0) which is made by IBM. Univariate analysis was used which included descriptive statistics for mean, median and standard deviation, chi-square test and independent T-test. A p value < 0.05 was considered significant. The results were presented in figures, tables, frequency graphs and pie charts. Representative diagnostic images with demonstrable pathology were sampled and presented.

Ethical Considerations

1. Approval of the research proposal was sought from the Ethical and Research Committee of KNH following approval by the supervisors at the departmental level.
2. The patients who met the sampling criteria were requested to fill in an informed consent.
3. The patients who declined to fill in the consent were not coerced to do so.
4. Confidentiality was maintained throughout the study.
5. The patient's name was not included on the data collections sheet; a code was used instead.
6. No added cost was met by the patient apart from that of the requested imaging procedure; CTPA.
7. The copies of the study will be given to the University of Nairobi/KNH for future reference and to facilitate possible improvement in patient management.

RESULTS

During the 7 months study period, a total of 110 consecutive patients with a clinical suspicion of PE and referred for MDCTPA were identified and recruited into the study after having met the inclusion criteria. All the patients had MDCTPA done at the participating study sites: KNH and MP Shah Hospital. A review of these cases is done and the results are presented in form of tables and graphs to fulfill the objectives of the study.

AGE

The mean age was of the study participants was 52.6 years and the median age was 55 years (interquartile range (36-70). The youngest patient was aged 20 years and the oldest was 92 years old.

Table 1: Socio-demographic characteristics (n = 110)

	Pulmonary Embolism		
Characteristics	**+ve, n (%)**	**-ve, n (%)**	**p-value**
Gender			
Male	10 (27.8)	26 (72.2)	
Female	20 (27.0)	54 (73.0)	0.934
Race			
African	30 (33.3)	60 (66.7)	
Caucasian	0	3 (100.0)	0.013
Asian	0	17 (100.0)	
Age			
< 30	3 (20.0)	12 (80.0)	
30 – 39	5 (23.8)	16 (76.2)	
40 - 49	4 (36.4)	7 (63.6)	0.649
50 – 59	2 (15.4)	11 (84.6)	
60+	16 (32.0)	34 (68.0)	

Table 2: Number of patients studied by hospital (n=110)

		HOSPITAL			
		KNH		MP SHAH	
		N	%	N	%
CTPA STATUS	+VE	9	24.3%	21	28.8%
	-VE	28	75.7%	52	71.2%
		37	100.0	73	100.0

There were a total of 37 patients studied at KNH out of whom 9 patients (24.3%) were found to have evidence of PE while 28(75.7%) did not have PE on CTPA. There were a total of 73 patients studied at MP Shah Hospital out of whom 21(28.8%) had PE and 52(71.2) had no PE.

Figure 1: Number of patients studied by hospital (n=110)

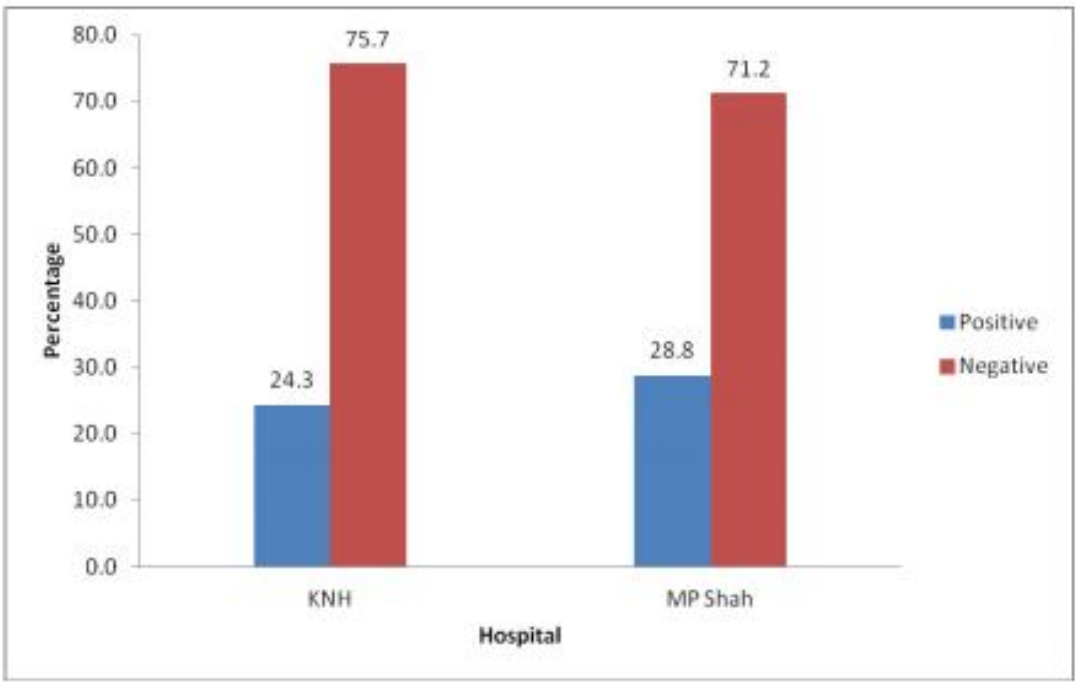
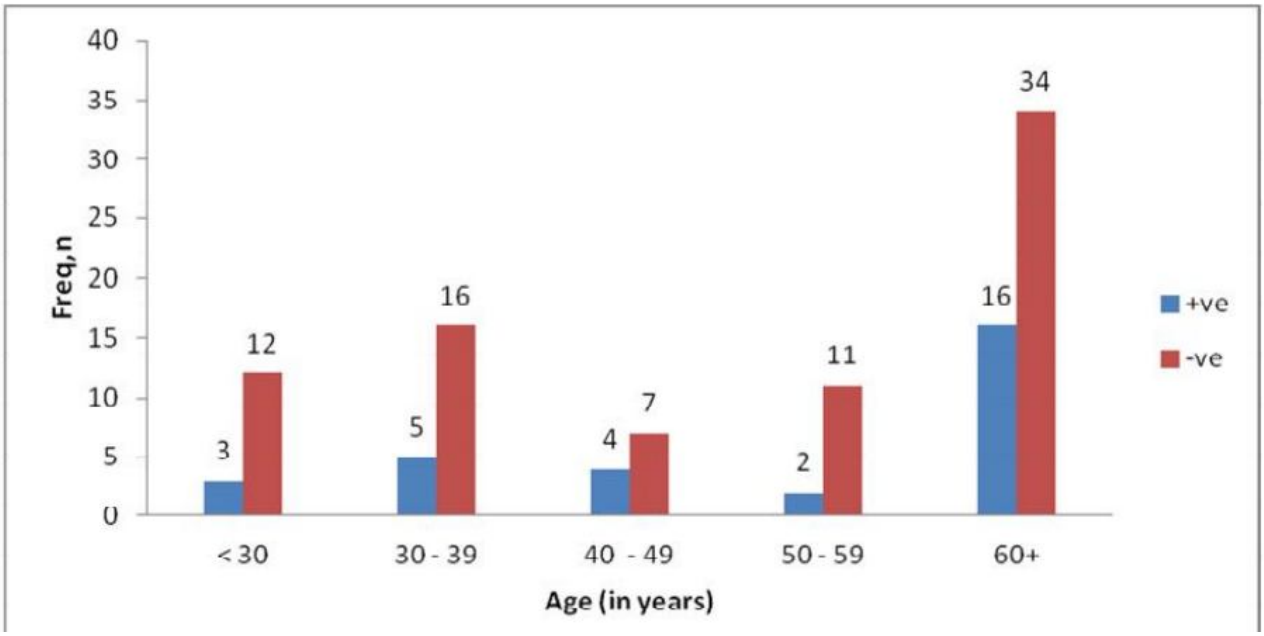


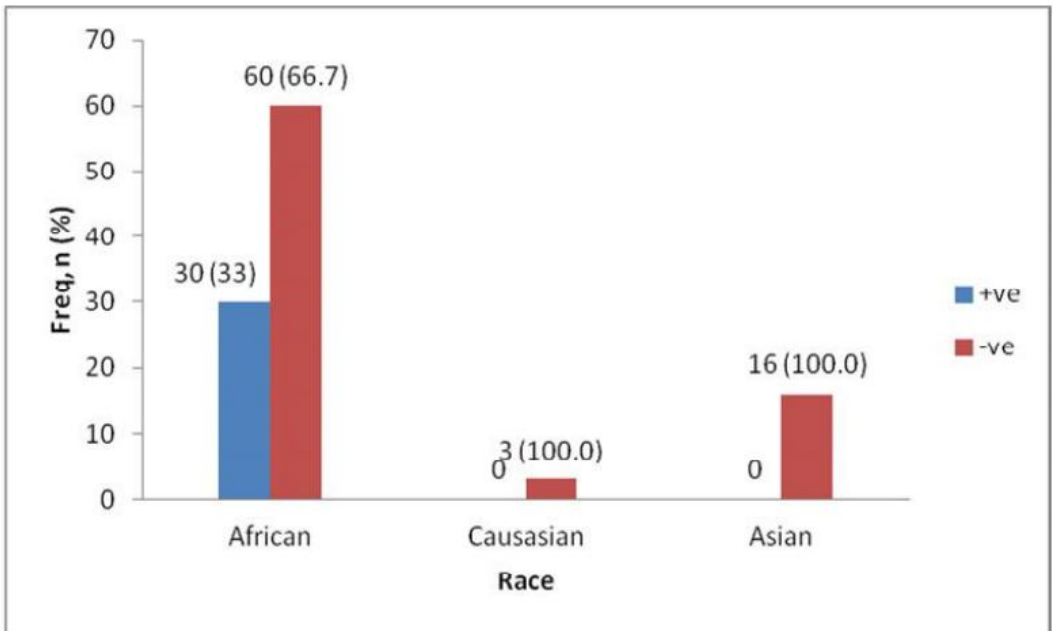
Figure 2: Age distribution



As shown in figure 2, majority of the patients with suspected PE 50(45.5%) and also confirmed to have PE 16(53.3%) on CTPA were aged 60 years and above.

Figure 3: Distribution of race (n=110)

Majority of patients with suspected PE were of African descent 90 (82%) as depicted by figure 3 Out of the 110 patients studied, 30 patients (100%) all of African descent were found to have evidence of PE on CTPA.



GENDER

Figure 4 presents the gender of patients recruited into the study. More female patients had clinically suspected PE as compared to the males. Females represented 74 (67.3%) of all participants while the males were 36 (32.7%.) The male to female ratio of patients with clinically suspected PE was 1:2.1.

Figure 4: Gender distribution of patients with suspected pulmonary embolism (n=110)

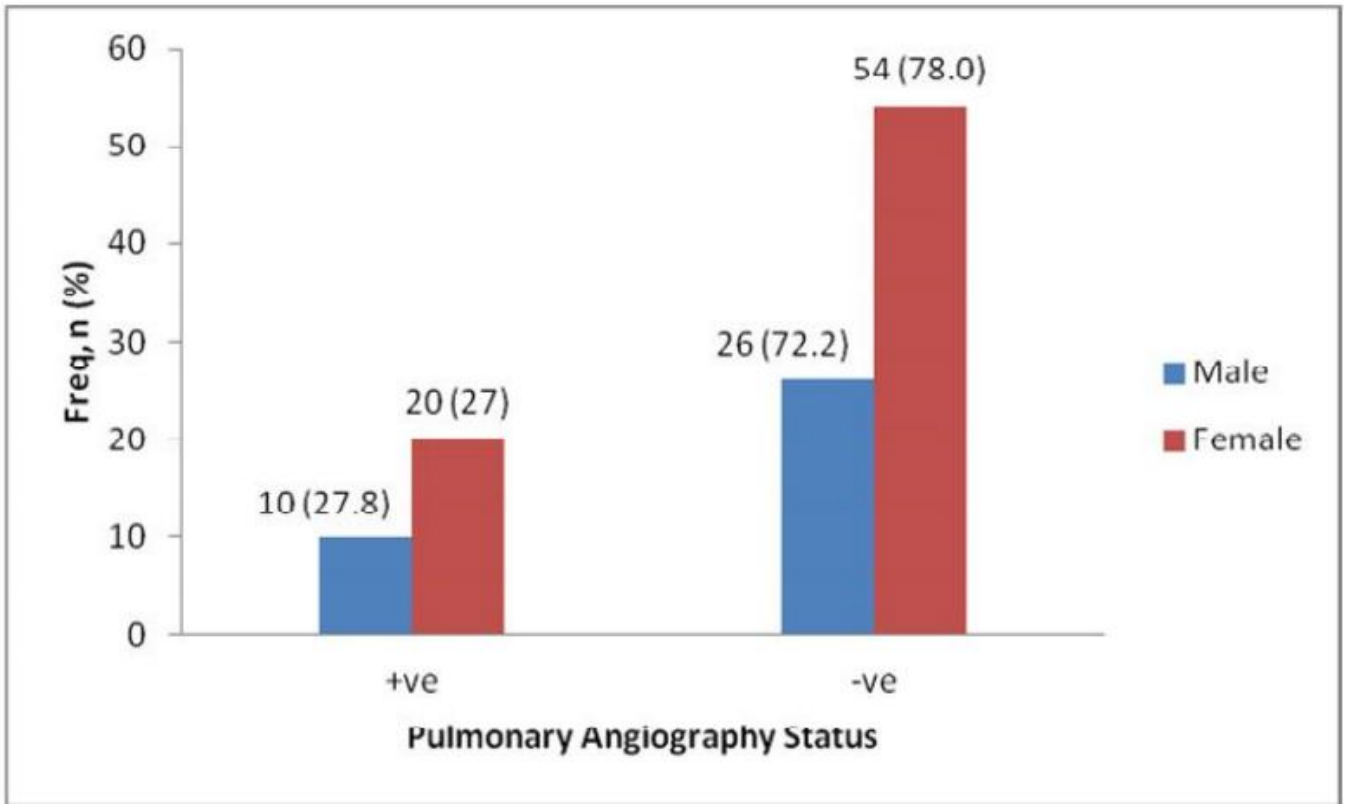


TABLE 3: CLINICAL HISTORY (n = 110)

	Pulmonary Embolism			
Clinical History	**+ve, n (%)**	**-ve, n (%)**	**Total, n (%)**	**p-value**
Dyspnea	30 (27.3)	80 (72.7)	110 (100.0)	-
Chest Pain	8 (26.7)	22 (73.3)	30 (27.3)	0.930
Cough	5 (33.3)	10 (66.7)	15 (13.6)	0.571
Hemoptysis	3 (50.0)	3 (50.0)	6 (5.5)	0.199

All the patients presented with dyspnea 110(100%). The proportion of patients presenting with difficulty in breathing was significantly higher than that presenting with either chest pain (difference in proportions=72.7%), cough (difference in proportions = 86.4%) or hemoptysis (difference in proportions=94.5%). However there was no significant association between the clinical history and the status of the CTPA (p-value>0.05).

FIGURE 5: CLINICAL HISTORY

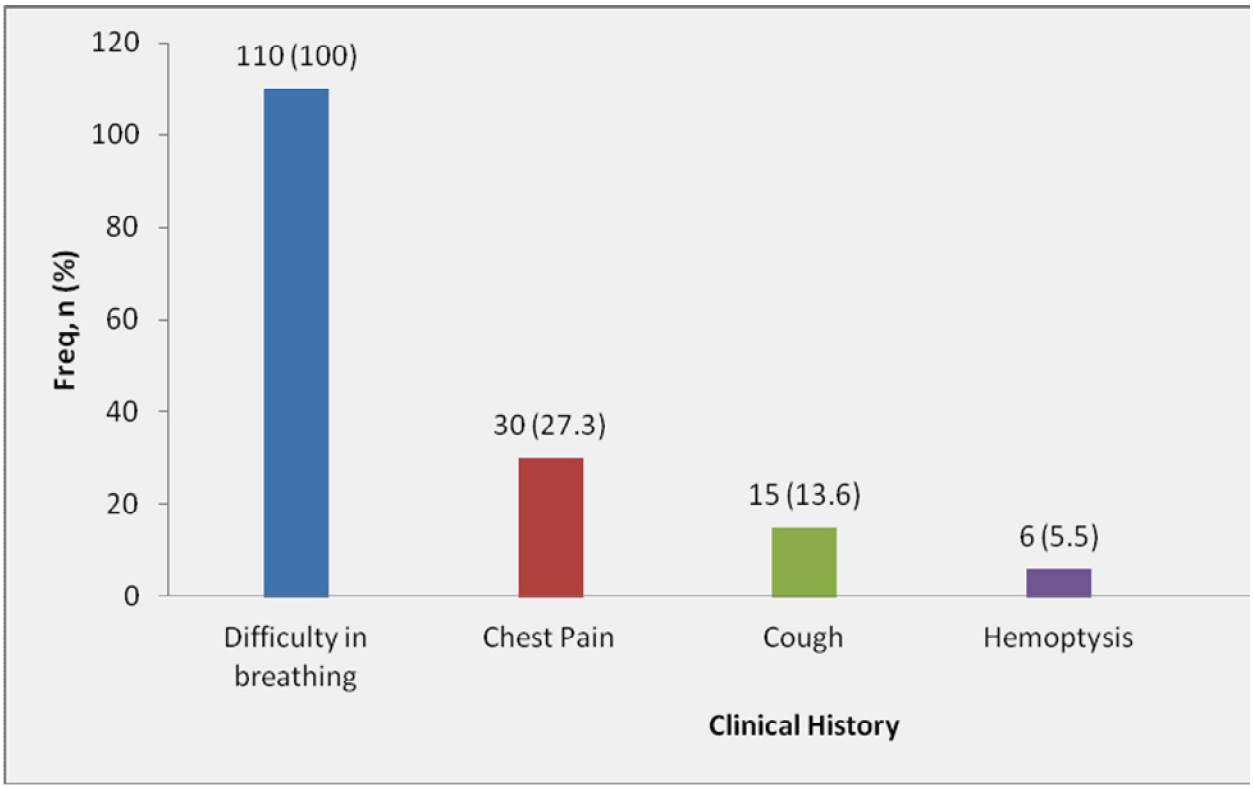


TABLE 4: Risk factors in patients with suspected pulmonary embolism (n=110)

	Pulmonary Embolism			
	+ve, n (%)	**-ve, n (%)**	**OR (95% CI)**	**p-value**
Risk Factor				
Deep Venous Thrombosis(DVT)	11 (57.9)	8 (42.1)	5.2 (1.8 - 14.8)	***0.001***
Previous venous thromboembolism	3 (75.0)	1 (25.0)	8.8 (0.9 - 89.9)	***0.028***
Surgery	-	-	-	-
Trauma	-	-	-	-
Immobilization > 3days	2 (66.7)	1 (33.3)	5.6 (0.5 - 64.7)	0.121
Malignancy	2 (100.0)	0	-	***0.020***
Coagulation Disorder	-	-	-	-
Contraception	1 (50.0)	1 (50.0)	2.7 (0.2 - 45.0)	0.466
None	15 (16.1)	78(83.9)	0.03 (0.0 - 0.14)	<0.001
Other	1 (100.0)	-	-	0.101

DVT as a risk factor was not part of inclusion criteria in the methods but formed part of the history and presentation of patients with suspected PE. The number of patients with history of DVT was 19 (17.3%). Patients with history of DVT and also found to have PE on CTPA were 11(58%). Patients with DVT were 5.2 times more likely to have PE on CTPA. DVT history was found to be statistically significant (p-value 0.001).

Patients with previous deep venous thromboembolism (VTE) were 8.8 times more likely to have pulmonary embolism on CTPA. This finding was significantly associated with PE (p-value 0.028).

History of malignancy was also found to be significantly associated with PE (p value 0.020).

Immobilization > 3 days also had an added likelihood of 5.6 of having PE on CTPA although it was not statistically significant (p-value 0.121).

History of hormonal contraception was not significantly associated with PE (p value 0.466).

TABLE 5: Investigations done for patients with suspected pulmonary embolism (n = 110)

Investigations	Frequency	Percentage
Chest Radiograph	30	27.3
D-dimers	20	18.2
Doppler Ultrasonography(lower extremities)	8	7.3
Radionuclide V/Q scanning	0	0
CT venography (pelvic/lower extremities)	73	66.4
Conventional pulmonary angiography	0	0
Other Investigations	29	26.4

As depicted by table 5 the most common investigation done for patients with suspected PE was CT venography carried out in 73 patients(66.4%). This was done in combination with MDCT-PA at the same sitting for only the 73 patients attended at MP Shah radiology department as it is an already established protocol. The combined protocol has not yet been adopted at KNH hence 37 patients(33.6%) attended here only had CTPA and no CTV was done. This was followed by chest radiograph 30(27.3%), D-dimers 20(18.2%) and finally Doppler sonography 8 (7.3%). Under the category of other investigations these included electrocardiography(ECG), echocardiography and cardiac enzymes which were carried out as further work-up but unrelated to PE. These investigations were carried out at the discretion of attending physicians so standardization and analysis of results for all patients studied was impossible.

TABLE 6: MDCT-PA FINDINGS IN SUSPECTED PULMONARY EMBOLISM (n= 110)

Findings	Freq.	Percent
(i) No pulmonary embolism	80	72.7
(ii)Pulmonary Embolism	30	27.3
(iii)Additional Diagnosis to PE	21	70.0
(iv)Alternative Diagnosis to PE	37	46.3
(v)Other findings:		
(a)Pleural Effusion	35	31.8
(b)Atelectasis	16	14.5
(c)Wedge shape opacity(Infarct)	2	1.8
(d)Consolidation	10	9.1

Among the 110 patients studied 80(72.7%) did not have evidence of PE while 30(27.3%) had radiological evidence of PE. 21(70%) out of 30 patients with PE had an additional diagnosis while 37(46.3%) out of 80 patients without PE had an alternative diagnosis. 43patients (39.1%) had no abnormality detected (normal CTPA).

FIGURE 6: MDCT-PA PULMONARY EMBOLISM GENDER DISTRIBUTION (n=30)

Among the 110 patients studied 30(27.3%) were found to have PE out of whom 20 (66.7%) were females and 10 (33.3%) were males. The male to female ratio is 1:2

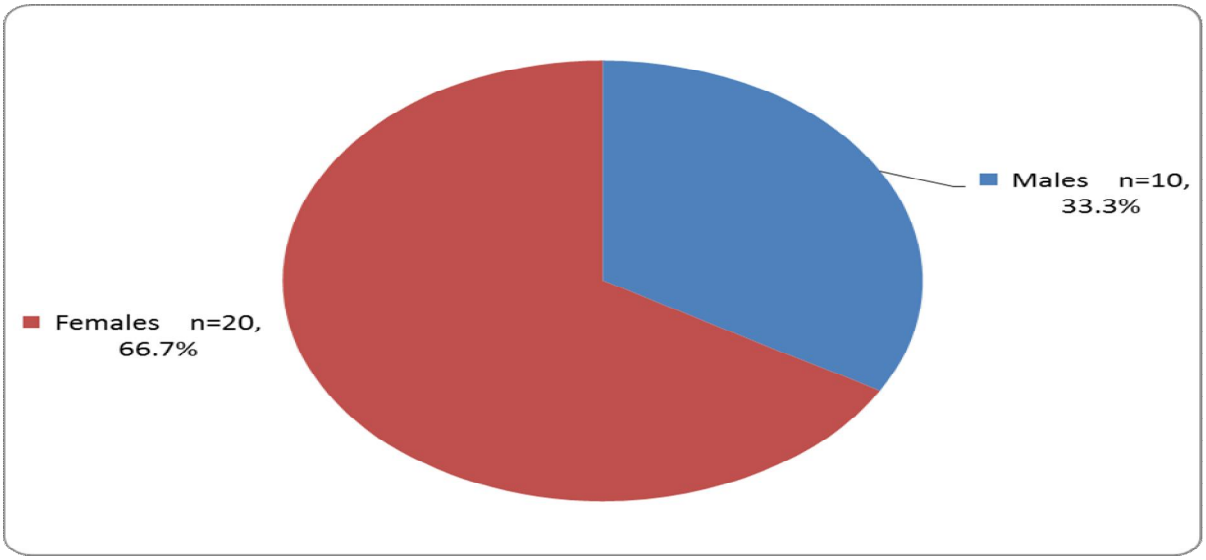


TABLE 7: PULMONARY EMBOLISM V/S. OTHER PLEURAL AND PARENCHYMAL FINDINGS ON MDCT-PA (n=110)

	Embolism					
	+VE		-VE		OR (95% CI)	p value
	Freq	Percent	Freq	Percent		
Pleural Effusion	7	23.3	28	35.0	0.7 (0.2 - 1.5)	0.242
Atelectasis	4	13.3	12	15.0	0.9 (0.3 - 2.9)	0.825
Consolidation	3	10.0	7	8.8	1.2 (0.3 - 4.8)	0.839
Infarct	2	6.7	0	0.0	0.9 (0.8 - 1.1)	***0.020***

As depicted by table 7, pleural and parenchymal abnormalities were commonly reported in 63 CTPA done (57.3%).

These findings were reported in 16 patients (53.3%) with PE and 47 (58.8%) without PE.

Pleural effusion was the commonest finding comprising 7 patients (23.3%) with PE and 28 patients (35%) without PE. This was followed by atelectasis comprising 4 patients (13.3%) with PE and 12 patients (15%) without PE.

Among the above findings only the presence of infarct (wedge shape opacity) was significantly associated with PE (p value 0.020).

Patients with consolidation were 1.2 times more likely to have an embolism. However this finding was not significantly associated with PE (p value 0.839).

TABLE 8: ANATOMICAL DISTRIBUTION OF THE LOCATION OF PULMONARY EMBOLISM ON MDCT-PA (n=30)

Location of Pulmonary Embolism (PE)	Frequency
Right Lung	30
Left Lung	21
Main Pulmonary Artery	2
Right Pulmonary Artery	16
Left Pulmonary Artery	8
Lobar	32
Segmental	33
Sub-segmental	39

SUBGROUP

	FREQUENCY	PERCENTAGE
Right lung	30	100.0
Left lung	21	70.0
	FREQUENCY	**PERCENTAGE**
MPA	2	1.54
Right pulmonary artery	16	12.31
Right- lobar arteries	20	15.38
Right- segmental arteries	19	14.62
Right sub- segmental arteries	22	16.92
Left pulmonary artery	8	6.15
Left -Lobar arteries	12	9.23
Left- segmental arteries	14	10.77
Left -sub segmental arteries	17	13.08
TOTAL	130	100.00

Anatomically PE on CTPA was found to be more common within the sub-segmental arteries 39(30%), followed by segmental 33(25.4%), lobar 32 (24.6%), right pulmonary artery 16(12.3%), left pulmonary artery 8(6.15%) and finally main pulmonary arteries 2(1.5%) as depicted by the frequency table 8. All positive patients 30(100%) had evidence of PE within the right lung while 21(70%) had PE located within the left lung.

TABLE 9: RATIO OF MAIN PULMONARY ARTERY DIAMETER TO ASCENDING AORTA DIAMETER(MPA/AO) n=110

Count

		STATUS		
		+VE	-VE	Total
Ratio grouped	>= 1	11	17	28
	< 1	19	63	82
Total		30	80	110

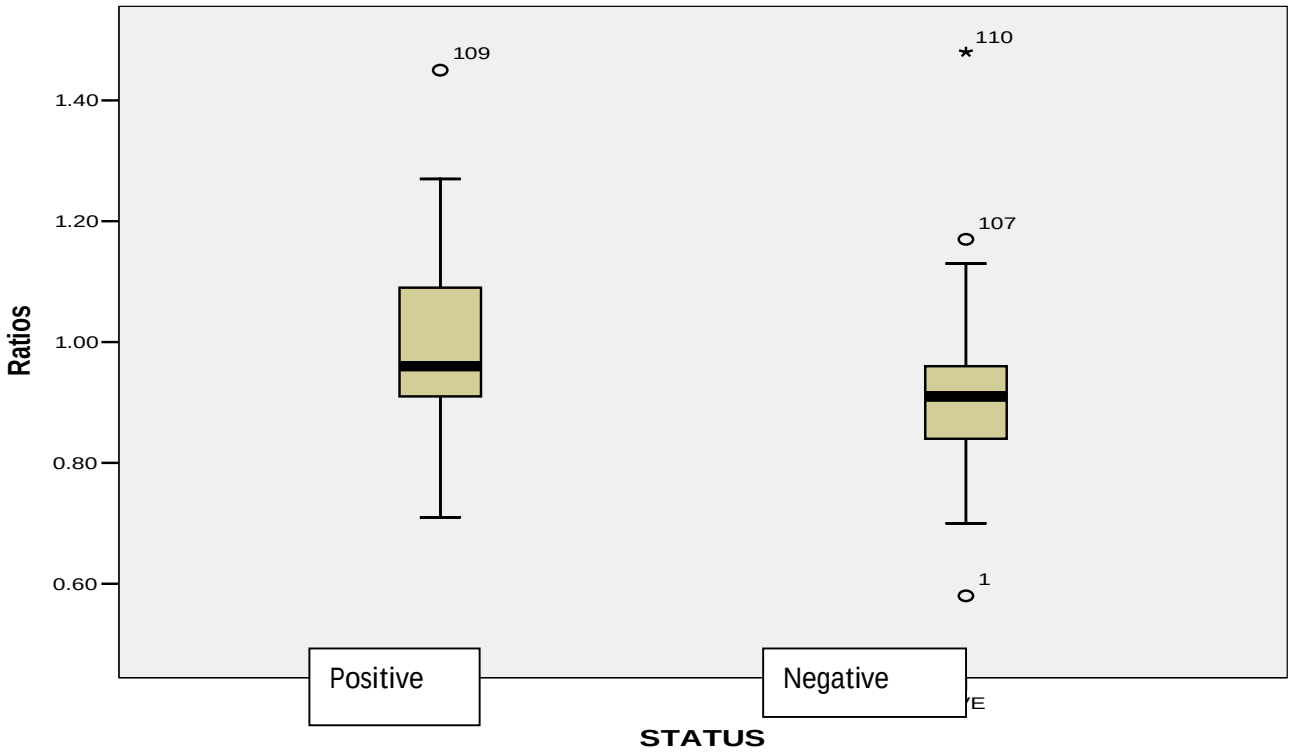
OR = 2.1 (0.9 – 5.4) p-value = 0.098

A ratio OF MPA/AO >1 is a marker of pulmonary hypertension whereby the MPA dilates due to PE. [35,36]

The Patients with MPA/AO ratio on MDCT-PA ≥ 1 were 2.1 times more likely to have PE on CTPA compared to those with a ratio < 1.

However, there was no significant association between the ratio of MPA diameter to AO diameter with the presence of pulmonary embolism (p value 0.098) in this study.

FIGURE 7: BOX PLOT DISTRIBUTION OF THE RATIO OF MAIN PULMONARY ARTERY TO THE ASCENDING AORTA DIAMETER (MPA/AO)



There was wide variation in the MPA/AO diameter ratio among patients found to have PE with the majority having a ratio equal to or greater than 1. This ratio is important as it is an indicator of pulmonary hypertension attributable to PE [35,36].

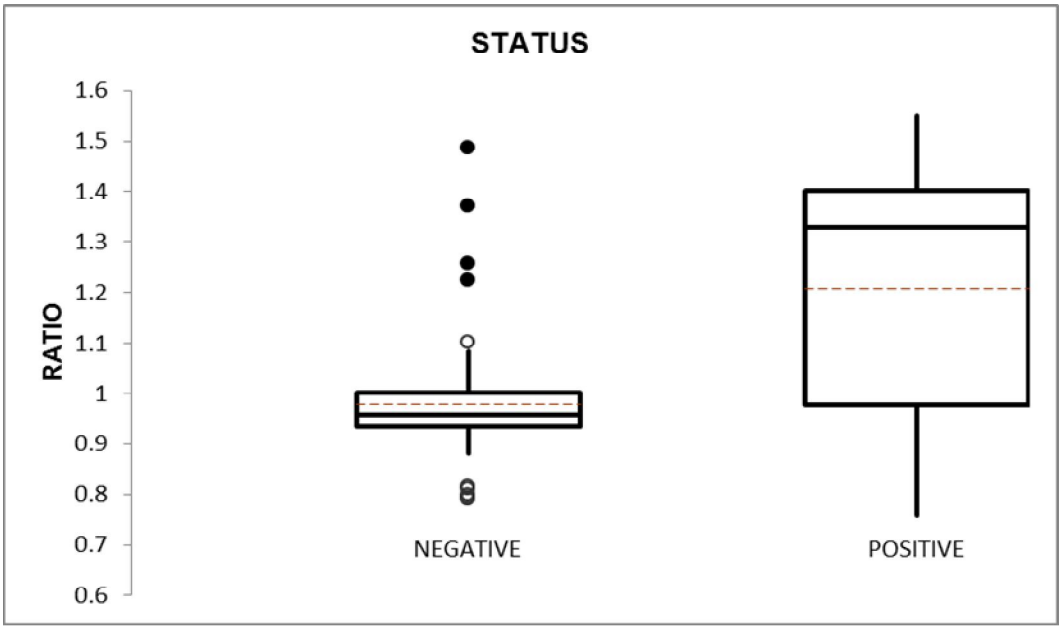
However the variation in the ratio among the PE negative patients was narrow with the majority of patients found to have a ratio less than 1.

TABLE 10: RATIO OF RIGHT VENTRICLE TO LEFT VENTRICLE DIAMETER (RV/LV)

	STATUS		
	+VE	-VE	Total
Ratio grouped			
>=1	21	24	45
<1	9	56	65
Total	30	80	110

A ratio of the right ventricle to the left ventricular diameter ≥ 1 was significantly associated with PE on MDCT-PA (p value < 0.001). This ratio is important as it is an indicator of right ventricular strain due to pulmonary hypertension attributable to PE. [34]

FIGURE 8: BOX PLOT DISTRIBUTION OF THE RATIO OF RIGHT VENTRICLE TO LEFT VENTRICLE DIAMETER (RV/LV) ON MDCT-PA



There was wide variation in the RV/LV ratio among patients found to have PE with the majority having a ratio greater than 1 and a median of 1.2

However the variation in the RV/LV ratio in the negative patients was narrow with the majority of patients found to have a ratio less than 1.

ILLUSTRATIONS

Illustration 1

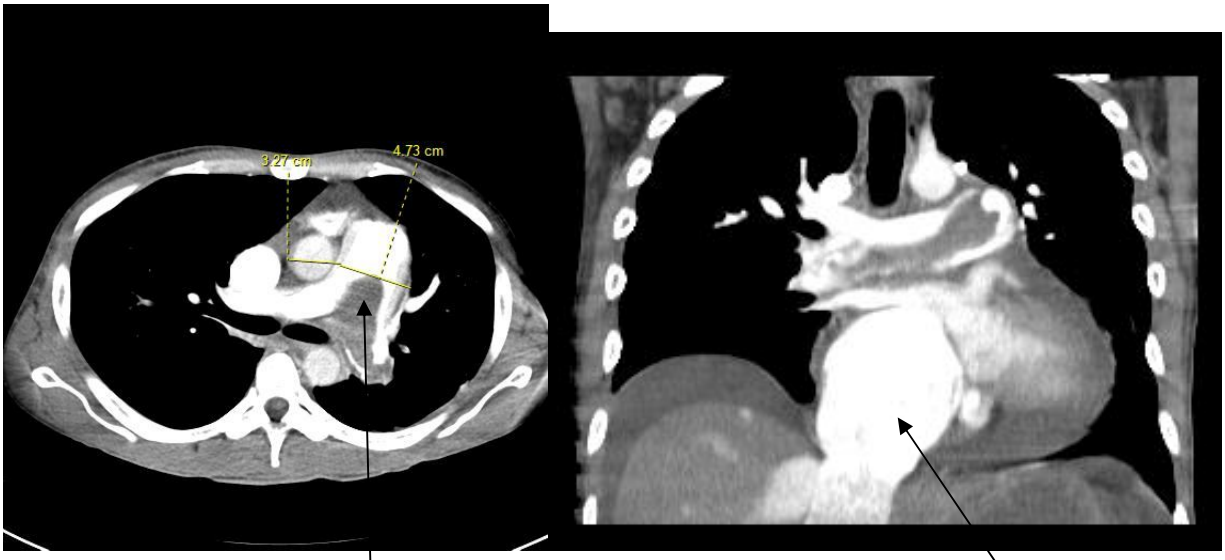
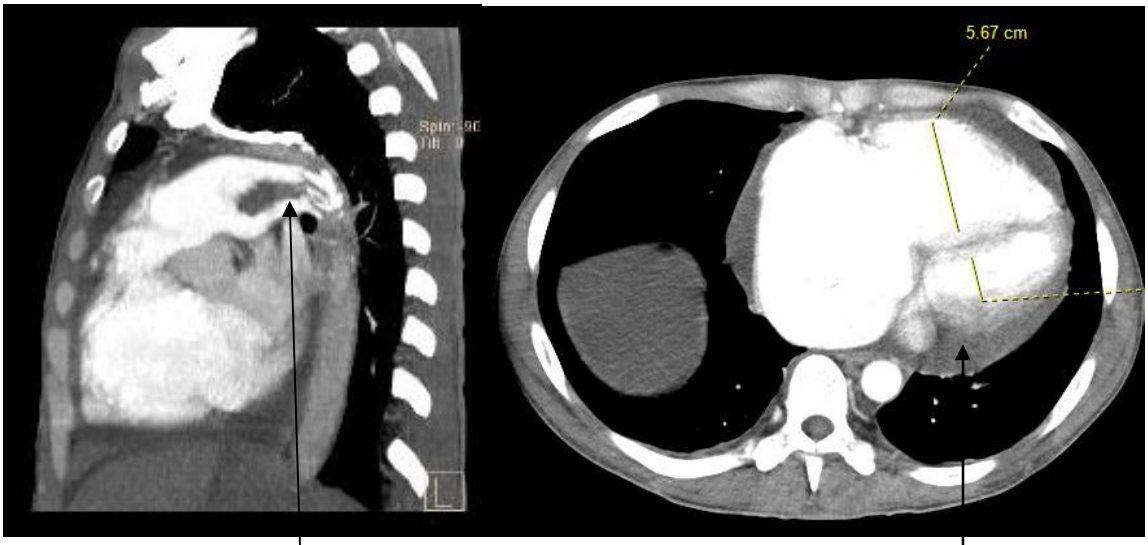


Fig 1(a)Axial CTPA –MPA saddle thrombus MPA diameter=47.3mm

Fig 1 (b) Coronal reformat- Dilated IVC with contrast reflux and ascites

MPA/AO diameter = 1.45



Railway track sign of PE in MPA

Fig 1(c) Sagittal reformat

Fig 1(d)Axial view- Pericardial effusion, dilated RV and RA

36 year old male presented with dyspnea and previous history of DVT in 2004. CTPA shows extensive thrombus within the MPA which extended bilaterally to the RPA and LPA. Additional diagnosis of right sided heart failure secondary to PE.

Illustration 2

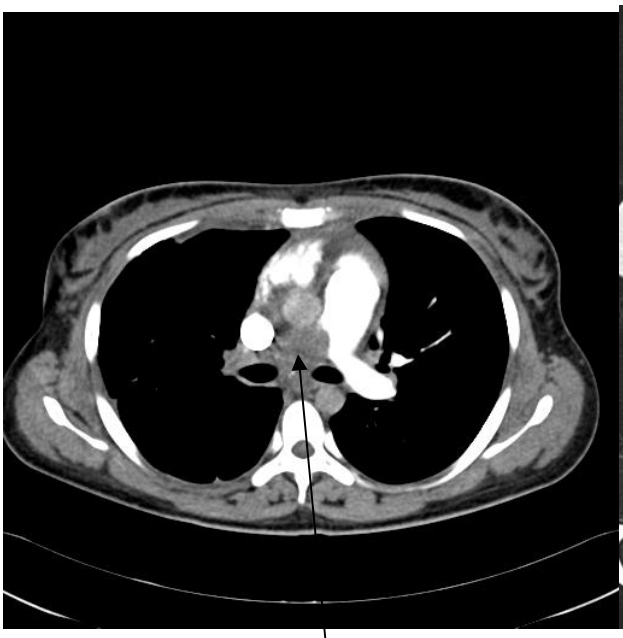


Fig 2(a) Axial CT- RPA thrombus(vessel cut-off sign)

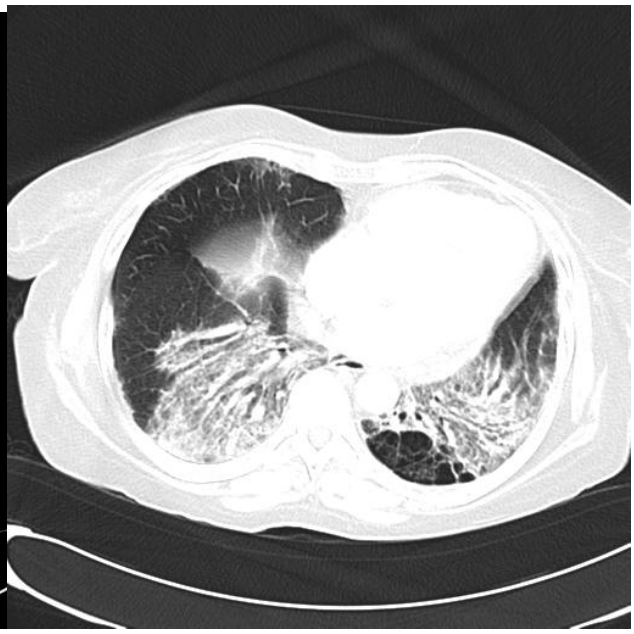


Fig 2(b) Axial lung window

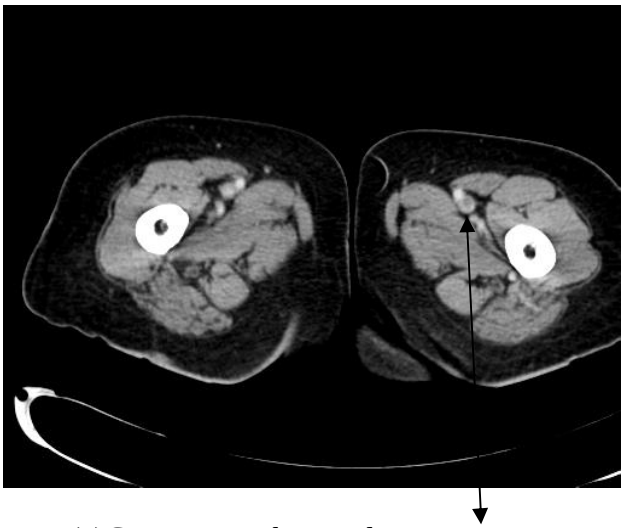
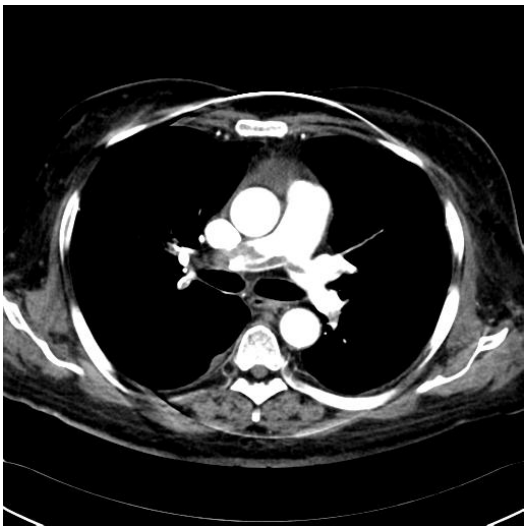


Fig 2(c)CT venography axial view- DVT seen within the left superficial femoral vein(SFV) seen as a filling defect.

60 year old female patient on treatment for SLE presented with dyspnea and chest pain. PE is seen within the right pulmonary artery. Additional diagnosis of bilateral basal NSIP(Non-specific interstitial pneumonia). CT venography showed DVT of bilateral superficial femoral veins (SFV).

Illustration 3



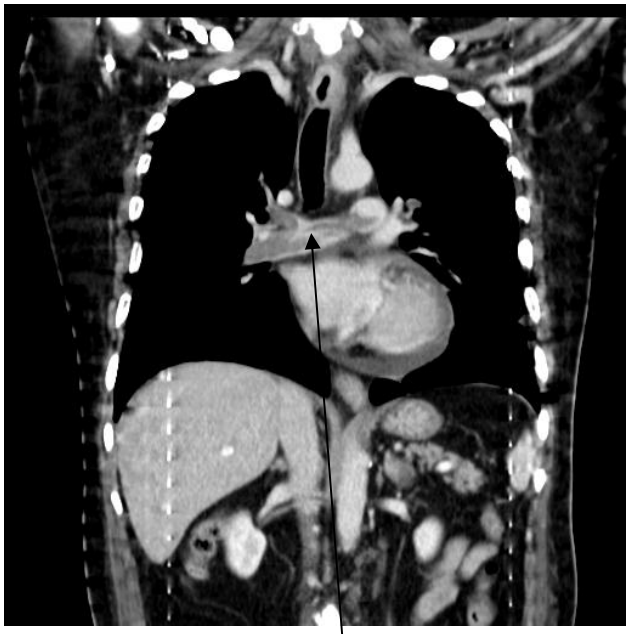
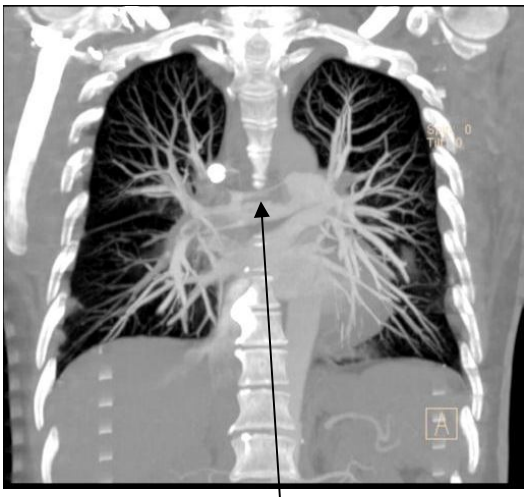


Fig 3(a)Axial CTPA –saddle thrombus in MPA

Fig 3(b)Coronal reformat- Thrombus in RPA



Filling defect-thrombus within the right pulmonary artery

Fig 3(c) MIP- maximum intensity projection

66 year male patient with CA esophagus, dyspnea and DVT right popliteal vein has saddle thrombus extending to both lungs up to the segmental arteries bilaterally

Illustration 4

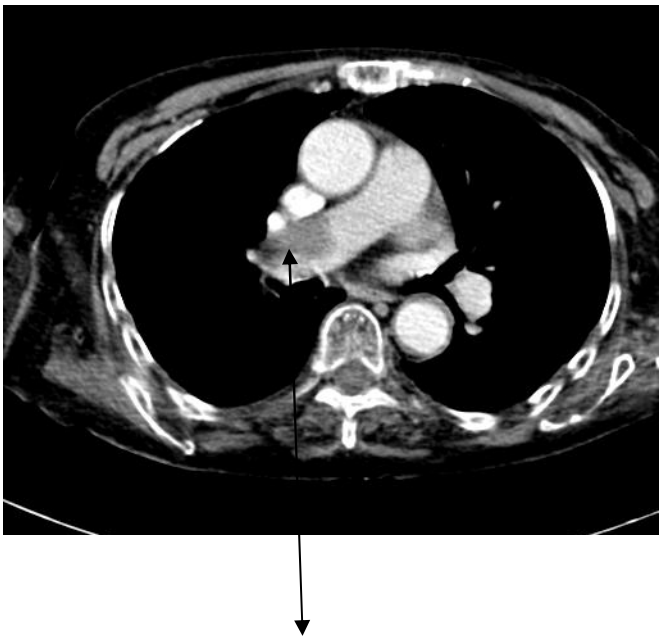


Fig 4(a)Axial CTPA- RPA thrombus

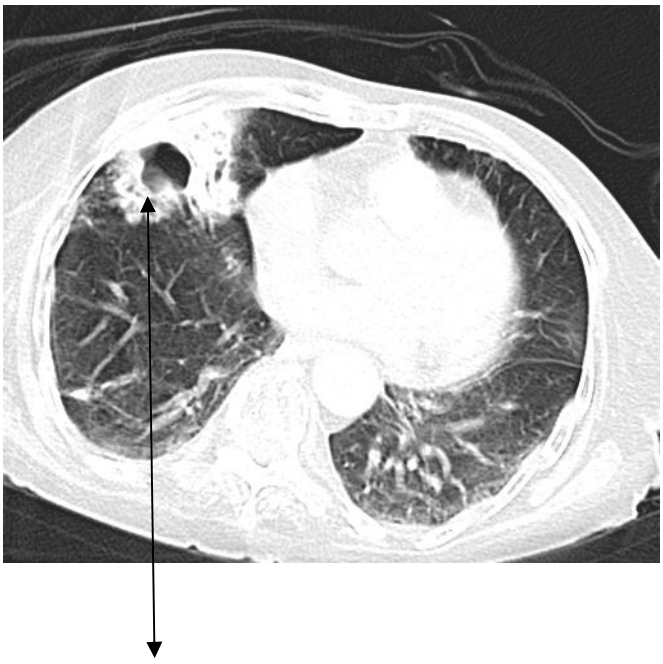


Fig 4(b) Cavitating right middle lobe infarct on lung window

84 years female with diabetes mellitus, hypertension and stroke presented with dyspnea. There is a right pulmonary artery thrombus which extended into the lobar arteries. It was associated with a cavitating right middle lobe infarct secondary to PE.

Illustration 5

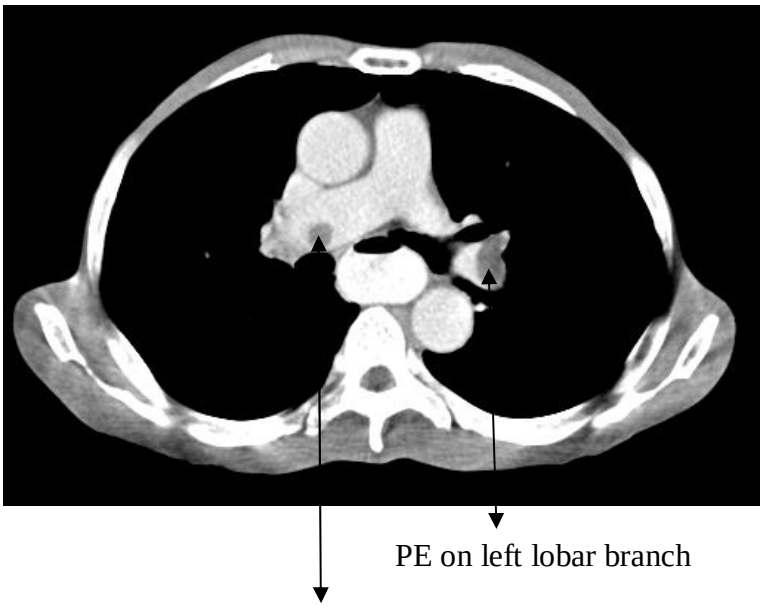


Fig 5(a) Filling defect in RPA- Polo mint sign

Axial CTPA- Right pulmonary artery thrombus demonstrated as target/polo mint sign. There is also thrombus seen within the left lobar branch.

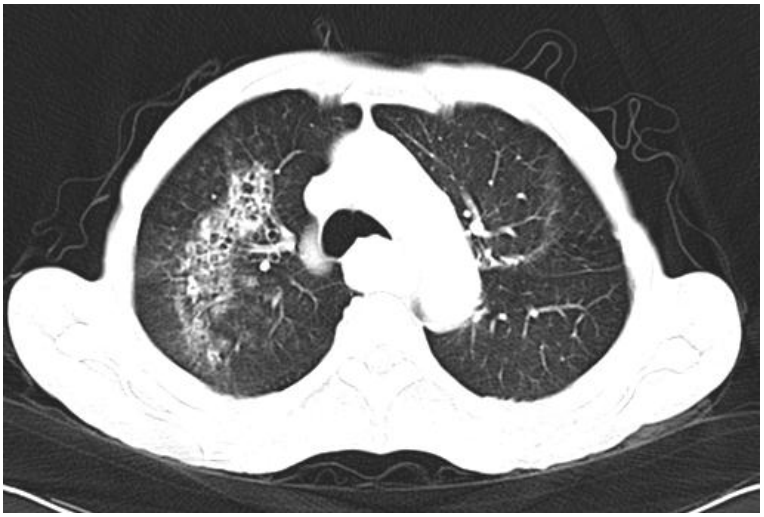


Fig 5(b)Axial CT- lung window

72 year old male with dyspnea and marked weight loss. PE with additional diagnosis of endobronchial infection.

Illustration 6

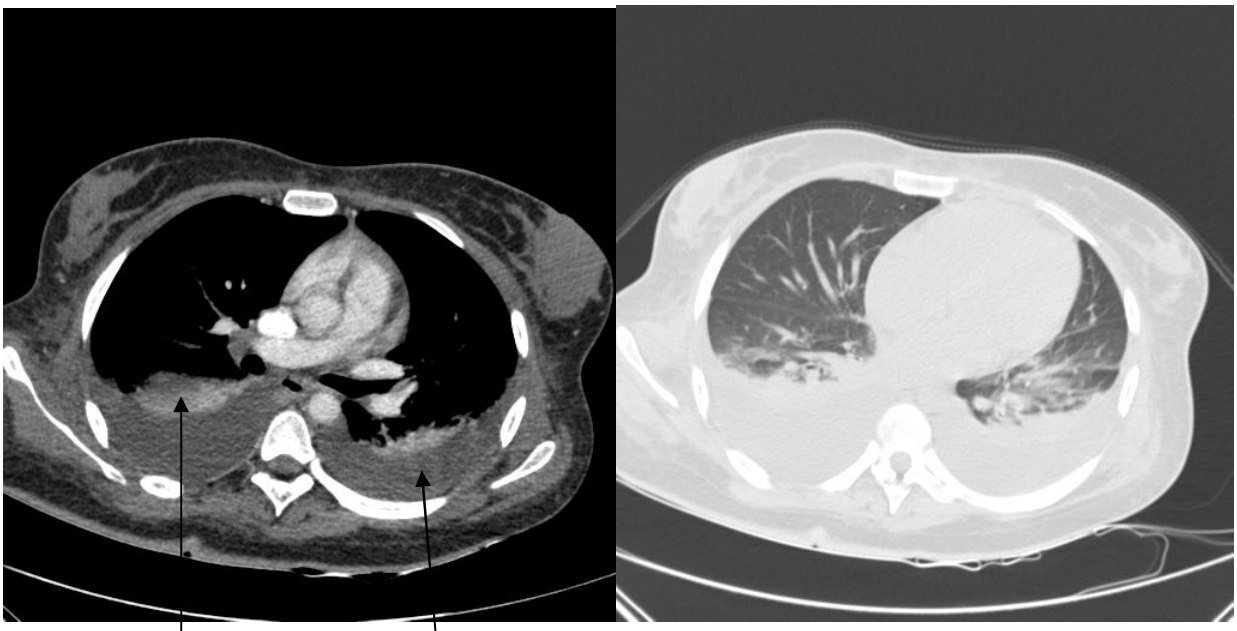


Fig 6(a) Axial CTPA

Fig 6(b) lung window

30 year old female with history of dyspnea and chest pain. CTPA was normal . Alternate diagnosis was bibasal pneumonia with bilateral pleural effusion.

DISCUSSION

A total of 110 consecutive patients with suspected PE referred for MDCT-PA within the study period after having met the inclusion criteria and able to afford paying for the service were recruited into the study. Since the study was based and conducted at the Radiology departments for patients who actually presented for CTPA it was not possible to get the exact numbers of patients across the hospitals that had presented with suspected PE, but did not get CTPA for varied reasons due to lack of a centralized computerized communication system from which such information could be extracted.

This study showed that the age range in suspected PE is wide with a mean age of 52.6 years and a median age of 55 years (interquartile range 36-70). Not only the majority of patients with suspected PE 50(45.5%) but also patients found to have PE 16(53.3%) were aged 60 years and above as shown by table 1. These findings compare with earlier studies which showed that the prevalence of PE increases with advancing age [10, 12,16]

Females represented the majority 74(67.3%) of all participants while the males were 36(32.7%.). The male to female ratio of patients with suspected PE was 1:2.1. Gender prevalence was seen in this study with more females comprising 20(66.7%) found to have PE while the males were 10(33.3%). The male to female ratio of PE at MDCT- PA was 1:2.

The commonest clinical presentation of patients reffered for MDCTPA was dyspnea that was present in 110 patients (100%) followed by chest pain 30(27.3%), cough 15(13.6%) and finally hemoptysis 6(5.5%). However there was no significant association between the clinical history and PE (p-value>0.05). This is in keeping with reported literature that have shown PE presents with non-specific symptoms [1,15]. The message to the clinicians is that not all dyspnea is equivalent to pulmonary embolism and the lack of dyspnea doesn't rule out PE.

The prevalence rate of pulmonary embolism found among 30 patients (27.3%) is comparable to other published studies which have reported approximately 25%-35 % prevalence of PE in clinically suspected cases [8,44].

Among the 110 patients studied 80(72.7%) did not have evidence of PE. 21 out of 30 patients (70%) with PE had an additional diagnosis while 37out of 80 patients(46.3%) without PE had an alternative diagnosis. 43patients (39.1%) had no abnormality detected (normal CTPA). This findings also correlates with previous studies that showed despite the presence or absence of PE, an alternate or additional diagnosis is commonly found on CTPA scans for suspected PE [45, 46, 47].

PE was more commonly anatomically distributed within the sub-segmental arteries 39(30%), followed by segmental 33(25.4%), lobar 32(24.6%), RPA 16(12.3%), LPA 8(6.2%) and finally the MPA 2(1.54%) as depicted on table 8.

Other pleural and parenchymal abnormalities were commonly reported among 63 patients (57.3%) with suspected PE. Pleural effusion was the commonest comprising 7 patients (23.3%) with PE and 28 (35%) without PE. This was followed by atelectasis comprising 4 patients (13.3%) with PE and 12 (15%) without PE. Patients with consolidation on CTPA were 1.2 times more likely to have PE. However this finding was not significantly associated with PE (p value 0.839). Only the presence of infarct (wedge shape opacity) was found to be significantly associated with PE (p value 0.020). This is also in keeping with an earlier published study [33]. These findings are non-specific for PE. Undocumented other co-existent cardiac, pulmonary, or other systemic diseases may have influenced the frequency of various parenchymal and pleural findings on CTPA.

Clinical history of DVT was reported in 19 patients (17.3%) out of whom 11(57.9%) had PE. Patients with DVT history were 5.2 times more likely to have PE on MDCT-PA and DVT was found to be significantly associated with PE (p-value 0.001). This finding further reinforces the need to comprehensively evaluate suspected PE by use of combined CTPA/ CT venography of the pelvic and lower extremities in one sitting.

Moreover patients with a history of previous venous thromboembolism (VTE) were 8.8 times more likely to have PE on CTPA and this was also significantly associated with PE (p value 0.028).

History of immobilization for 3 days or more was also found to have an added likelihood of 5.6 times of having PE on CTPA although it was not statistically significant (p value 0.121).

2 patients found to have PE had history of malignancy. 1 patient had metastatic carcinoma of the cervix while the other had carcinoma of the esophagus. History of malignancy was significantly associated with PE on MDCT-PA (p value 0.020)

There was no patient found to have PE post-surgery which may be due to the wide spread practice of DVT prophylaxis and physiotherapy post-surgery in our setup.

Among other investigations carried out on the patients with suspected PE the commonest was CT venography of the pelvic and lower extremities conducted on 73 patients (66.4%) all attended at MP Shah hospital which was done in combination with CTPA at the same sitting as it is an already established protocol. 30 patients (27.3%) availed chest radiographs, 20 patients (18.2%)

had D-dimer assay and 8 patients (7.3%) had Doppler sonography of the lower extremities. The ordering of these investigations was as per the attending clinician's discretion and the researcher had no control on this factor hence standardization and analysis of these results for all recruited patients was impossible. The CTPA were interpretated independently of other investigations. This also points to a lack of adherence to a standardized clinical protocol of investigating patients with suspected PE in the local setup. This low level of algorithm use is in contradiction to the PIOPED II investigators recommendations [48].

Neither V/Q scanning nor conventional pulmonary angiography was conducted on any of the patients studied. This points out to their unpopularity as investigative tool for suspected PE among clinicians and radiologists in our setup.

The Patients with MPA/AO ratio of ≥ 1 were 2.1 times more likely to have PE as compared to those with < 1. However, there was no significant association between the ratio of MPA diameter to AO diameter and PE (p value0.098). Other undocumented, co-existent co-morbidities may have resulted in this finding.

A ratio of the right ventricle to left ventricular diameter greater than 1 which is an indication of right ventricular strain due to pulmonary hypertension attributable to PE was found to be statistically significant (p value < 0.001) and significantly associated with PE.

Study Limitations

1.The study was limited to the two named hospitals in Nairobi due to constraints of resources. Therefore the results may not be generalized to other radiology centers in or outside Nairobi.

2.This study was not designed to compare the diagnostic accuracy of CTPA as there was no comparison of findings to other imaging modalities due to limitation of resources.

3. No major comprehensive study has been undertaken locally on PE thus the local prevalence rate is unknown. Hence the prevalence rate used here may not be truly representative of the actual local scenario.

4. Collection of data was hampered by deficient clinical summary provided by clinicians on most request forms and patients' files. None of the clinicians provided an objective clinical score for the probability of PE. Hence it was not possible to correlate CTPA findings with clinical scores.

5.The clinical criteria used by clinicians to refer patients for MDCTPA was as per their discretion. This study was an audit of the current practices with regards to suspected PE so as to find out the gaps in service and offer recommendations.

6. Data was not complete for each variable studied, as the decision whether to perform an investigation (e.g. CXR, D-dimer) was entirely dependent on attending physicians. Moreover some of the investigations were reportedly done but were untraceable (11 chest radiographs) due to lack of picture archiving and communication system(PACS), poor hospital and patient record keeping. Also it was not possible to get the exact number of patients who were eligible for CTPA but did not get it for varied reasons due to lack of a central computerized communication system.

7. Since the study was carried out at the Radiology departments for the patients who actually presented and had MDCTPA, it was not possible to determine the exact numbers of patients who had presented with a clinical suspicion of PE to the clinicians but never presented for MDCTPA for various reasons. This is because there is no central communication system interlinking the various departments from which the reseacher would have been able to retrieve such information.

8. There was frequent breakdown of KNH MDCT thus patients may have been reffered elsewhere for the service. This accounted for the lower numbers of patients studied at KNH.

9. Opportunity for developing a PE protocol not realized. This is because the study mainly focussed only on patients with a suspicion of PE who presented for MDCTPA to document pattern of findings. Furthermore this would have required more resources which was not available. Hence my findings can form a platform for future studies to assist in PE protocol development in the local set-up.

10. Follow up of patients was not done due to constraints of resources. It would have been ideal to follow up patients as this would have contributed to prognosis of PE positive patients.

CONCLUSION

MDCT-PA was found to be readily available even off routine hours, fast, relatively affordable and minimally invasive imaging modality in clinically suspected PE in patients without a contraindication to CTPA.

CTPA reveals significant additional diagnoses which ensure appropriate patient management is instituted without delay.

Parenchymal abnormalities and pleural effusion are present in the majority of patients undergoing CTPA for the clinical suspicion of PE, irrespective of the presence or absence of PE.

Other than wedge-shaped opacities, parenchymal and pleural abnormalities on CTPA do not correlate with the presence of PE in this study.

Evidence of right venticular strain on CTPA as evidenced by right ventricular to left ventricular diameter ratio >1 is significantly associated with pulmonary embolism..

Not all dyspnea is due to pulmonary embolism.

The referral algorithm is suboptimal as evidenced by the lack of a standardized clinical referral criteria and investigations as preliminary work-up to MDCTPA in suspected PE hence a large number of patients may be getting unnecessary CTPA in the local setup.

RECOMMENDATIONS

It is important to evaluate for evidence of right ventricular strain on MDCTPA for suspected PE.

It is necessary to clinically stratify more precisely the population being scanned according to the likelihood of PE being present with the aim of reducing the number of unnecessary CTPA being obtained in patients who are unlikely to have PE.

Picture archiving and communication system (PACS) should be introduced in the medical facilities as it is required for efficient, accurate and timely retrieval of patient information and images which not only facilitates research but also proper patient management.

Regular maintenance of MDCT equipment so as to avoid mechanical breakdown and frequent service interruption which is detrimental to management of patients.

A long term follow up study to find out effectiveness of managing suspected PE using an algorithm combining clinical probability and CTPA. This would contribute to risk stratification and prognosis of PE.

The University and Teaching/Refferal Hospital should find ways and means to externally fund, facilitate and co-ordinate student projects across the disciplines so as to reduce the numerous limitations and challenges faced in order to come up with comprehensive outcomes.

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APPENDIX I

PATIENT'S CONSENT FORM

My name is Dr. Anne N. Wainaina.

I am pursuing Masters of Medicine degree in the department of Diagnostic Imaging and radiation medicine at the University of Nairobi.

I am doing my research study on matters related to imaging of patients with suspected pulmonary embolism who have been reffered for Multi-detector Computed Tomographic Pulmonary Angiography to either confirm or rule out pulmonary embolism.

I am requesting to use your data and findings so that the recommendations I am going to make may be used to improve management of patients with similar problems .

No name is required and your information will be treated as confidential. Only the CTPA number will be used. Your investigative imaging findings shall be utilized only for the purpose of research. There will be no other chargeable repeat investigations performed for the purpose of research.

Please note that your participation is voluntary and you have the right to decline or withdraw from the study.

Patient's signature _____

Date _____

I certify that the patient has understood and consented to participate in this study.

Dr. Anne N. Wainaina

Signature _____

Date _____

FOMU YA RIDHAA (RUHUSA) YA MGONJWA

Jina langu ni Daktari Anne N. Wainaina.

Ninasoma shahada ya uzamili katika idara ya uchunguzi wa magonjwa kwa mionzi (Radiolojia) katika chuo kikuu cha Nairobi.

Ninafanya utafiti katika eneo la shida ya kuziba kwa mishipa ya damu ya mapafu, haswa upigaji picha kutumia CTAna matatizo yanayoweza kuambatana.

Ninaomba ridhaa/ruhusa yako, niweze kupata na kutumia taarifa zako katika utafiti wangu,ili hatimaye maoni ya utafiti wangu yafaidi katika matibabu ya magonjwa ya namna hii. Tafadhali fahamu ya kuwa taarifa zako ni za siri. Nitatumia nambari ya hospitali tu ili kukutambulisha. Hakutakuwepo na malipo ya ziada wala uchunguzi zaidi kwa minaajili ya utafiti. Matumizi ya picha ni kwa minaajili ya utafiti pekee.

Uko na haki yakukubali au kukataa kushiriki au kujitoa katika zoezi zima bila kuathiri huduma nyingine zitolewazo mahali hapa.

Sahihi ……

Tarehe ……

Nathibitisha ya kwamba mhusika ameelewa na ameridhia kushiriki katika utafiti huu.

Daktari Anne N. Wainaina

Sahihi.. ……..……

Tarehe ……

APPENDIX II

WORK PLAN

ACTIVITY	ACTION BY	PERIOD
Writing research proposal	Student	June-Sept 2010
Revising and analyzing proposal	Student Supervisors	Oct-Nov 2010
Ethical approval	IREC	Dec 2010-March 2011
Data collection	Student	April -Oct 2011
Data checks and cleaning	Student Research assistant	Jan –March 2012
Data analysis and interpretation	Student Biostatistician	April-July 2012
Writing of thesis	Student Supervisors	Aug- Dec 2012
Submission of thesis	Student	Feb 2013

APPENDIX III

ESTIMATED BUDGET

No.	Requirements	Cost in (Kshs)
1.	Stationery, typing,, printing, and photocopying	30,000/=
2.	Ethics board fees	1,000/=
3.	Secretarial services	10,000/=
4.	Assistant data collectors	20,000/=
5.	Transport	25,000/=
6.	Data analysis	20,000/=
7.	Biostatistician	15,000/=
8.	Digital transfer of images	10,000/=
9.	Contingency expenses	10,000/=
	TOTAL	131,000/=

All the above overhead costs were met by the researcher.

APPENDIX IV

QUESTIONNAIRE

1. PATIENT'S BIODATA

Serial No. _____ CTPA No. _____ Age _____

Gender Male _____ Female _____

Race African_____ Caucasian_____ Asian_____

2.CLINICAL HISTORY (tick where applicable)

(a) Dyspnea

(b) Chest pain

(c) Cough

(d) Hemoptysis

(e) Others (specify)

(f) None

3**. RISK FACTORS (Tick where applicable and specify)**

(a)Deep Venous Thrombosis

(b)Previous Venous Thromboembolism

(c)Surgery

(d)Trauma

(e)Immobilization > 3 consecutive days

(f)Malignancy

(g)Coagulation disorders

(h)Contraception

(i)Other(s)

(j)None

4. OTHER INVESTIGATIONS (Tick and specify where applicable)

(a)Chest radiograph _____

(b)D-dimers _____

(c)Doppler Ultrasonography _____

(d) Radionuclide (V/Q) scanning _____

(e)CT Venography (lower limbs) _____

(f)Conventional Pulmonary angiography_____

(g)Other(s) _____

(h)None _____

4(A) MDCT-PA FINDINGS (Tick and specify)

(i)Normal – No abnormality

(ii)No pulmonary embolism

(iii)Pulmonary Embolism

(iv)Additional diagnosis

(v)Alternate diagnosis

(vi)Other findings

(a)Pleural effusion (b)Atelectasis

(c)Consolidation (d)Infarct(wedge shape opacity)

4(B) State diameter in millimeters of:

(i)Ascending aorta (AO) _____

(ii) Main pulmonary artery(MPA) _____

(iii)Right ventricular cavity _____

(iv)Left ventricular cavity _____

4(C)Ratio

(i) MPA diameter/ AO diameter _____

(ii) Right ventricle diameter/left ventricle diameter _____

4(D) MDCT-PA LOCATION OF PULMONARY EMBOLISM. (Tick and specify)

RIGHT LUNG	**RPA**	**LOBAR**	**SEGMENTAL**	**SUBSEGMENTAL**
LEFT LUNG	**LPA**			
MPA				

KEY

MPA- Main pulmonary artery.

RPA- Right pulmonary artery.

LPA-Left pulmonary artery