Multislice Computed Tomography Findings of Patients with Suspected Pulmonary Embolism in the Emergency Department: Incidence of Pulmonary Embolism and Non-Thromboembolic Findings

B Ergönül[1], C Ayrık[2], A Köse[2], S Bozkurt[2], E Zöhre[3], İ Çevik[2], H Narcı[2], MNass Duce[4]

ABSTRACT

Objective: This study aimed to evaluate the incidence of pulmonary embolism (PE) and tomographic findings in patients who underwent multislice computed tomography (MSCT) for suspected PE in the emergency department.

Methods: We assessed the radiologic and medical records of 212 cases undergoing MSCT for suspected PE in the emergency department for a period of 16 months. A total of 201 cases were included in the final analysis. Age, sex, admission symptoms, risk factors, and MSCT findings were recorded. The final diagnosis assigned to each patient was determined.

Results: The PE incidence was found to be 24,4%. Forty-nine (24,4%) of the cases were diagnosed with PE, while 152 (75,6%) had non-thromboembolic pathologies. There was no statistically significant difference between the patients with and without PE with respect to mean age, symptom status and gender ($p>0.05$). Among the risk factors for PE, only presence of previous surgical operation was statistically significant. Forty-three (87,7%) of the cases with PE and 118 (77,6%) of those without PE had additional parenchymal abnormalities. Linear atelectasis was the only significant difference in MSCT between patients with PE and those without PE ($p<0.001$).

Key Words: Multislice computed tomography, pleural and parenchymal findings, pulmonary embolism

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From: [1]Haseki Education and Reaserch Hospital, Emergency Medicine, [2]Mersin University, Faculty of Medicine, Department of Emergency Medicine, [3]Tarsus State Hospital, Emergency Medicine, and [4]Mersin University, Faculty of Medicine, Department of Radiology Mersin, Turkey.

Correspondence: Dr A Kose, Mersin University, Faculty of Medicine, Department of Emergency Medicine, Mersin, Turkey. E-mail: ataberk76@yahoo.com.tr
Phone : +90 0 324 337 43 00 / 2010

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A thrombus was detected in the main pulmonary artery (PA) in 15 (30.6%) patients and in right main PA in 12 (24.4%) patients.

Conclusion: Although PE is not diagnosed in the majority of cases undergoing MSCT for suspected PE, many miscellaneous information, either relevant to patient's clinical signs and symptoms or incidental, may obtained.

RESUMEN

Objetivo: Este estudio tuvo como objetivo evaluar la incidencia de la embolia pulmonar (EP) y tomográficos hallazgos en pacientes que se sometieron a la tomografía computarizada multicorte (TCMC) por sospecha de TEP en urgencias

Métodos: Se evaluaron la radiología y los registros médicos de 212 casos sometidos a la TCMC para sospecha de EP en el departamento de emergencia por un período de 16 meses. Un total de 201 casos fueron incluidos en el análisis final. Edad, sexo, síntomas de admisión, los factores de riesgo, y los resultados de TCMC se registraron. El diagnóstico final asignado a cada paciente se determinó.

Resultados: La incidencia PE se encontró que era 24,4%. Cuarenta y nueve (24,4%) de los casos fueron diagnosticados de PE, mientras que 152 (75,6%) tenían patologías no tromboembólicos. No hubo diferencias estadísticamente significativas entre los pacientes con y sin PE con respecto a la media edad, estado de los síntomas y el sexo (p> 0,05). Entre los factores de riesgo para PE, única presencia de la operación quirúrgica anterior fue estadísticamente significativa. Cuarenta y tres (87,7%) de los casos con PE y 118 (77,6%) de los que no tienen PE tenían anormalidades del parénquima adicionales. Atelectasia lineal fue la única diferencia significativa en TCMC entre los pacientes con EP y

los que no tienen educación física (p <0,001). Un trombo se detectó en la principal arteria pulmonar (AP) en 15 (30,6%) pacientes y en derecho PA principal en 12 (24,4%) pacientes.

Conclusión: A pesar de PE no se diagnostica en la mayoría de los casos sometidos a la TCMC para sospecha de TEP, muchos de información diversa, ya sea relevante a los signos y síntomas o incidental clínicos del paciente, puede obtenidos.

INTRODUCTION

Pulmonary embolism (PE) has a high morbidity and mortality, especially in elderly patients with comorbid conditions that are not diagnosis and treatment. In contrast, mortality can be reduced in cases accurately diagnosed and treated with appropriate prophylactic and therapeutic agents (1, 2). Signs and symptoms of PE are not disease-specific, but rather they can mimic a wide spectrum of disorders (3). The risk stratifying tools, D-dimer, chest radiography, electrocardiography, and arterial blood gases are helpful for the assessment of patients with suspected PE in emergency departments (EDs). However, they are also not sufficient for a definitive diagnosis (4, 5).

Multislice computed tomography (MSCT) is a minimally invasive, rapid diagnostic tool that can provide unexpected alternative diagnoses in patients with respiratory symptoms (6, 7). In many EDs, contrast enhanced MSCT is mostly used as the radiologic procedure in the diagnosis of PE. Many studies have shown that MSCT has a high diagnostic performance for PE, having a sensitivity of 83-100% and a specificity of 89-97% (1-3,8,9). Currently, MSCT devices enable scanning large areas in a very short period of time with quite thin slice thickness, and high quality multiplanar reconstruction of images, thus allow the detection of smaller filling defects even in the segmental and subsegmental pulmonary arteries (PAs) (9,10). It has been reported that compared to other imaging modalities used in PE, MSCT

can also show parenchymal, mediastinal, cardiac, pleural, thoracic wall, and upper abdominal organ pathologies in addition to pulmonary vascular abnormalities. This provides an important advantage in the differential diagnoses (6,11,12).

Contrast enhanced MSCT has recently become the most widely employed imaging method in patients presenting to the ED with suspected PE. However, there is little literature on PE incidence by MSCT imaging in our country. This study was conducted to analyze the incidence of PE and of other findings detected in patients who underwent MSCT for suspected PE in the ED.

MATERIALS AND METHOD

In this study, we evaluated the patients who had suspicion of PE with contrast enhanced CT scanning. We aimed to determine the frequency of patients with PE and without PE, identify and compare the findings of MSCT in patients with PE and without PE, evaluate the frequency and alternative last diagnoses in patients without PE, and indicate the frequency and anatomical localization of clot in patients with PE.

Study Design and data collection

At our institution, contrast enhanced MSCT is currently the imaging modality of choice for clinically suspected PE in ED. Our study was a retrospective, descriptive study that assessed the radiologic and clinical data of patients undergoing MSCT for suspected PE on the basis of clinical presentation in the ED. Between October 2010 and March 2012, medical records of 212 cases undergoing MSCT for suspected PE were assessed using Hospital Information System (HIS) (Nucleus v9.8.52, Monad Software and Counseling, Turkey). There are a few exclusion criteria for our study. We did not included other PE cases who were detected with different imaging or evaluation (clinical, scintigraphy, echocardiography or Doppler USG, etc.) but did not undergo a MSCT. The patients who had allergy to contrast media, renal failure or increased serum creatinine, high body mass index and

pregnancy were excluded from the study. In addition, eleven patients who had missing data and inadequate image quality were not included in the analysis for the study. Two hundred and one cases who were 18 years old or older were included for the final analysis.

Institutional Ethics Committee approval was obtained for the study. First admission of the patients over a period of 16 months was taken into account. Age, sex, admission symptoms, risk factors (surgical operation within last 45-90 days, immobilization, previous thromboembolism, active malignancy, etc.), and MSCT results (findings) were recorded. The last diagnosis assigned to each patient was determined. At the end of the entire diagnostic work up, the alternative and last diagnoses in cases without PE were achieved by a combination of clinical, laboratory analysis, other diagnostic tests. After adequate imaging and clinical consultation to other divisions, according to the findings of MSCT we found the last diagnosis.

CT imaging protocol and interpretation

MSCT was performed with a 64-detector CT device (Aquillion, Toshiba, Japan) during a single breath-hold. Contrast material was administered automatically with an automatic CT injector (Medtron, Medtron AG, Germany). Bolus-tracking software of the equipment with a trigger threshold of 150 HU at the level of main PA was used to determine the scan delay. The contrast protocol was standardized in all patients. All patients were administered 100 ml of nonionic contrast material at a rate of 4-5 ml/sec via forearm veins.

The radiologists evaluated all MSCT images in standard window and level settings. CT images and examination reports were retrospectively assessed on Picture Archiving and Communication System (PACS) Workstations and HIS, respectively. For MSCT findings undergoing in the ED during the study periods, we documented all findings noted in the final radiology reports that were entered into the medical record and signed by an attending radiologist. PA and its branches were evaluated in the arterial phase for the presence of PE

and the findings were interpreted by radiologists. For the diagnosis PE, the following criteria were utilized, based on published methods when analyzing the imaging data:

1. A filling defect that completely fills and dilates the artery
2. Intraluminal hypodense filling defect with peripheral contrast
3. A peripherally located intraluminal hypodense filling defect forming a narrow angle with the arterial wall (9,13,14).

Presence of vascular signs in the main PA, right and left PA, lobar, segmental, and, if visible, subsegmental branches were assessed in cases diagnosed with PE. In addition, pulmonary parenchymal, pleural, mediastinal, and cardiovascular, thoracic wall/musculoskeletal, and upper abdominal findings were also looked for and recorded on the basis of the radiological report in all cases (with PE and without PE).

Statistical Analysis

Shapiro Wilk test was used to test normality of age distribution in patients with and without PE, and the age distribution was found to be normal. Categorical variables were expressed as frequency and percentage and continuous variables as mean±standard deviation, and minimum-maximum. Significance of the difference between means of two groups was analyzed with Student's t test depending on the normality of data distribution. Categorical variables were analyzed with Chi Square test and comparisons of two ratios were performed with z test. Statistical analyses were completed with SPSS v. 11.5.0 and MedCalc®v11.0.1 software packages. A p value less than 0.05 was considered statistically significant for all statistical calculations.

RESULTS

Clinical datas of study and incidence of PE

Among 201 patients enrolled in our study, 97 were male and 104 were female. The age range was 18-98 years and the mean age was 62.5±17.9 years. Forty-nine (24.4%) cases had PE, while 152 (75.6%) patients did not have PE. Of those with PE, 27 (55.3%) were male and 22 (44.7%) were female. The most common symptoms were dyspnea and chest pain. There was no significant difference between PE and without PE group with respect to mean age, sex and presenting symptoms ($p>0.05$). In patients with PE, the most common risk factor was immobilization (n=56, 27.8%). The other risk factors in descending order were malignancy (n=38, 19%), previous thromboembolism (n=20, 10%) and recent major surgery (n=19, 10%). Among the risk factors, only recent major surgery was found to be significantly different between PE and without PE groups (odds ratio, 3.195; 95% confidence interval, 1.215-8.399). A previous surgery constituted three times more risk for an episode of PE ($p=0.021$) (Table 1).

Distribution of thrombus location in the PA system

Based on the radiology reports, a thrombus (filling defect) was detected in the main PA in 15 (30.6%) cases and in the right PA in 12 (24.4%) cases. The distribution of thrombus location in the pulmonary arterial system is shown in Figure 1. Figure 2 and 3 show examples of the left and right PA, lobar, and/or segmental emboli in the MSCT.

MSCT findings in patients with PE and without PE

Overall, 18.9% of the patients were reported to be totally normal. Pulmonary parenchymal, pleural, mediastinal, cardiovascular, thoracic wall, musculoskeletal and upper abdominal findings in MSCT were compared between PE and without PE groups. The most prominent pathologies were atelectasis (44.9% in PE group and 29% in non-PE group), infiltration/consolidation (24.5% PE group and 27% in non-PE group) (Figure 4), and pleural

effusion (14.3% in PE group and 30.3% in non-PE group). Forty-three (87.7%) of patients with PE and 124 (81.5%) of non-PE patients had additional parenchymal abnormalities. Furthermore, incidental pathologies like pleural and pericardial effusion, consolidation, pulmonary edema, aortic aneurysm and dissection, hemopneumothorax, mass lesion, perforation, biliary stones and hepatic cyst were noted in MSCT performed for suspected PE (Table 2). Of the ancillary findings, only linear atelectasis had a statistically significantly difference between PE and without PE groups (odds ratio, 5.680; 95% confidence interval, 2.507-12.872) ($p<0.001$).

Alternative and last diagnoses identified in patients with and without PE

Thirty nine patients were diagnosed solely with PE. Along with PE, 2 patients were diagnosed with acute coronary syndrome, 7 with pneumonia, and 1 with pericarditis. Among 152 patients without PE, 114 patients were diagnosed to have different disorders, while 38 patients (25%) remained totally normal. Fifty (32.9%) patients were diagnosed with pneumonia and 23 (15.2%) with pulmonary edema. Table 3 summarizes the last diagnoses in PE and without PE groups.

DISCUSSION

We could not draw a significant relationship between PE probability, clinical signs and symptoms, sex and mean age. In some studies demonstrated that PE incidence was not affected by age or gender in patients who underwent MSCT for suspected PE (8,14). There is plenty of literature on PE risk factors (immobilization, history of thrombophlebitis, malignancy and previous surgery). Sen et al. reported that recent surgery was a major risk factor with a rate of 27.3% (15). In our study, previous surgery was found to be the only significant risk factor. A previous surgery conferred 3-times more risk for PE. This is

possibly due to inadequate intake of anticoagulant therapy. Since our study was retrospectively designed, we did not access adequate information about anticoagulant therapy. Many clinical studies have revealed that 9.4%-40% of patients undergoing MSCT for suspected PE are diagnosed to have PE, while a substantial number of patients are found to have some other pathologies (5,8,9). In two recent study, 20.2% (66/327) and 21.2% (280/1321) patients were diagnosed to have PE, respectively (14,16). PE incidence of 24.3% found in our study was concordant with the previous literature (especially European incidence of PE on CT) (5,14,16,17). This is lower in American data (%8-10) (7,12).

MSCT, which is currently accepted as the gold standard imaging modality for the diagnosis of PE, can show the thrombus and anatomic location. This has relevance to catheter directed therapies and implications for use with Interventional Radiology. The most common locations of thrombi in our patients with PE were the main PA (30.6%) and right PA (24.4%). In a 487-patient study De Monye et al. detected emboli 7.7% in the main PA, 14.6% in right and left PA, 28.5% in lobar arteries, 26.9% in segmental arteries, and 22.3% in subsegmental arteries (18). Tascı et al. reported thrombi in at least one of the PAs in 16 (43%) and in both PAs in 6 (16%) of 37 patients (19). Similar to our results, Perrier et al. (20) reported thrombus in the main PA in 32% of cases, while Sen et al. reported thrombus in the main PA 30% of 172 cases diagnosed with PE (15).

MSCT allows detection of intraluminal thromboembolic filling defects, parenchymal infarction, vascular remodeling, pleural effusion, and oligemia (5,20,21). In a retrospective study by Groth et al. (14), additional pathologic findings detected by CTPA for suspected PE were examined in 1353 patients. The most common additional pathologic findings were pleural effusion 21.9% (296/1353), pneumonia 18.6% (251/1353) and pulmonary nodule/mass, 7.2% (110/1353). Another study reported that the most common findings in patients without PE were infiltration/consolidation (15.1%), atelectasis (13.5%), and pleural

effusion (13.1%) (22). In our study, additional parenchymal abnormalities were detected in 43 (87.7%) of PE positive cases and 124 (81.5%) of PE negative cases. While the most common findings in our overall study population were atelectasis and consolidation, pleural effusion was the most noteworthy sign among pleural findings. Coche et al. assessed parenchymal and pleural findings in 88 cases suspected for PE and reported a significant co-occurrence of pleura-based, wedge-shaped consolidation and linear atelectasis with PE (23). Shah et al. (24) reported atelectasis as the most common parenchymal abnormality in cases with and without PE [71% for PE (+) and 64% for PE (-)]. Linear opacities have been reported more often in patients with PE than those without PE. Previous single-detector CT studies have reported a rate of 46-54% of linear opacities in PE (23,24). Parenchymal findings, like linear atelectasis, may be useful for PE diagnosis especially in patients with typical clinical signs and major risk factors for PE (17). The ED physician is concerned about other significant pathologic findings which warrant further treatment. In our study, among parenchymal abnormalities the only significant difference between PE and non-PE patients was the rate of linear atelectasis which is not an emergency and specific finding. They usually represent possible discoid atelectasis or post-inflammatory changes. The interpretation of some linear opacities as linear atelectasis on MSCT may have contributed to the discrepancy between different study results. Thus, further MSCT studies will be useful in order to evaluate the importance of parenchymal and pleural findings as the indicators of PE.

One important advantage of MSCT lies in its ability to recognize conditions that clinically mimic PE, such as pneumonia, pneumomediastinum, pneumothorax, pleural and pericardial effusion, aortic dissection, or malignancy. Such conditions have been reported by radiologists in 11-70% of CT examinations performed for a suspected acute PE (5,16,21). CT findings requiring emergency care other than PE were detected in 71.8% (327/235) of their cases by Cereser et al. (16) and in 60% (387/234) of their cases by Heradia et al. (13). The

study by Heradia et al. revealed no abnormality in 131 (34%) patients (13). In a similar study, 154 (78.2%) of 197 cases found to have no PE, but had other pathologies related to lungs, mediastinal structures, thoracic wall, and upper abdominal organs. Again, that study reported findings that were both related to patient's signs and symptoms (62.5%) and were only incidental pathologies (37.5%). MSCT could not detect any abnormality in 43 (21.8%) cases (22). Richman et al. researched 1025 patients who had suspected PE and found that 104 patients had PE and 921 patients had no PE. In the diagnostic analysis of 921 patients who had no PE; 17 % of them had significant mortality and morbidity findings, 17 % of them had no specific finding, and 41 of them had no ancillary findings. In the same study, the most common life-threatening findings included infiltrate or consolidation suggesting pneumonia, aortic aneurysm/dissection, and mass (7). In our study, MSCT revealed many incidental findings and miscellaneous diagnoses other than PE were recorded. While 38 (19%) of 201 patients had no pathology, 114 (56.7%) were diagnosed with conditions that explain their symptomatology consistent with PE. Furthermore, additional pathologies concurrent with PE were also detected. Our results are in general consistent with the literature and pleural effusion and pneumonia were the most common diagnoses in PE negative cases.

Our study has several limitations. First, this was a retrospective, descriptive study and the collection of data may have caused some unintended bias in patient selection. The incidence of such findings can also be affected by study population demographics. However, we were reliant on the clinical records for our evaluation of clinical decision-making. Second, our study was performed at a single and large tertiary hospital and therefore our findings do not necessarily reflect practice elsewhere. Third, distribution of MSCT additional findings in patients with and without PE is based on the radiological reports. Nevertheless, many findings (such as effusion, atelectasis, infiltrate or consolidation, pneumothorax, nodule and masss) are diagnosed with contrast-enhanced MSCT. Lastly, only ED patients undergoing

MSCT for suspected PE were enrolled in this study. We did not included other PE cases who were detected with different imaging or evaluation (clinical, scintigraphy, echocardiography or Doppler USG, etc.) but did not undergo a MSCT.

In conclusion, our study shows the condition using 64-MSCT in patients suspected of having PE based on clinical presentation. Contrast enhanced MSCT can principally be used to confirm or exclude PE in patients presenting to the ED with suspected PE. PE incidence was 24.3% in our study. MSCT also may provide findings suggesting additional information explaining patient symptoms and signs to make an alternative diagnosis in patients who were negative for PE. In our study, although atelectasis, consolidation, and pleural effusion among parenchymal findings are most common, the only significant findings were "linear atelectasis. This finding, however, is not an emergency and specific condition. Contrast enhanced MSCT can define the anatomic location of clot in patients with PE and this may be important in the interventional direction for therapy (catheter based strategies and thrombolysis techniques). Considering the largely varied results reported in the literature, it is necessary to conduct large-scale prospective multicenter studies in future for our country.

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Table 1: Comparison of data in patients with and without pulmonary embolism

Data	**PE (+)[a] (n=49)**	**PE (-)[b] (n=152)**	***P* value**
Age (Years)[c]	61.6±16.3	62.8±18.4	0.670
Sex			
Male	27 (55.3)	71 (46.1)	0.267
Famale	22 (44.7)	82 (53.9)	0.126
Clinical signs and symptoms			0.6936
Shortness of breath	28 (57.1)	96 (63.2)	
Chest pain	9 (18.4)	26 (17.1)	
Shortness of breath/chest pain	6 (12.2)	21 (13.8)	
Cough	1 (2.0)	3 (2.0)	
Syncope	3 (6.1)	4 (2.6)	
Hemoptysis	2 (4.1)	2 (1.3)	
Risk factors			
Immobilization	19 (38.8)	37 (24.3)	0.050
Recent major surgery	9 (18.4)	10 (6.6)	0.021
Prior PE and/or DVT	8 (16.3)	12 (7.9)	0.102
Malignancy	10 (18.4)	28 (18.4)	0.757

Unless otherwise specified, given data represent number of patients and the numbers in parentheses represent percentages.
[a]Patients with PE, [b]Patients without PE
[c]Data are given in means ± standard deviations.
DVT: Deep venous thrombosis

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Table 2: MSCT findings in patients with and without pulmonary embolism

MSCT findings	**PE (+) (n=49)**	**PE (-) (n=152)**	**Total**	***P* value**
Parenchymal findings				
Normal	6 (12.3)	28 (17.8)	34	0.7280
Increased reticular density	3 (6.1)	10 (5.9)	13	0,9050
Linear atelectasis	17 (34.7)	13 (8.6)	30	<0.001*
Atelectasis	5 (10.2)	31 (20.4)	36	0,1607
Nodules	1 (2.0)	7 (4.6)	8	0,6977
Infiltration/consolidation	12 (24.5)	41 (27.0)	53	0,8744
Pulmonary oedema	0 (0)	7 (4.6)	7	0,2809
Ground glass appearance	2 (4.1)	7 (4.6)	9	0,8019
Emphysematous changes	3 (6.1)	8 (5.2)	11	0,9031
Pleural findings				
Normal	42 (85.7)	103 (67.1)	145	
Bilateral pleural effusion	4 (8.2)	34 (22.4)	38	
Unilateral pleural effusion	3 (6.1)	12 (7.9)	15	0.4741
Haemothorax	0 (0)	2 (1.3)	2	
Pneumothorax	0 (0)	1 (0.7)	1	
Mediastinal and cardiovascular findings				
Normal	29 (59.1)	72 (47.4)	101	

Aortic dissection	0 (0)	1 (0.7)	1	0.6012
Aortic aneurysm	2 (4.1)	3 (2.0)	5	
Cardiomegaly	1 (2.0)	6 (3.9)	7	
Pericardial effusion	2 (4.1)	6 (3.9)	8	
Chest wall /musculoskeletal findings				
Normal	25 (51.0)	84 (55.3)	109	0.7254
Osteodejenerative changes	24 (49.0)	67 (44.1)	91	
Tracheal stenosis	0 (0)	1 (0.7)	1	
Upper abdominal findings				
Normal	44 (90)	143 (94)	185	
Adrenal mass	1 (2.2)	3 (2)	2	
Perihepatic fluid	0 (0)	2 (1.3)	2	0.3388
Subdiaphragmatic free air	0 (0)	1 (0.7)	1	
Gallstone	3 (6,6)	1 (0.7)	2	
Liver cyst	1 (2.2)	2 (1,3)	1	

Unless otherwise specified, given data represent number of patients and the numbers in parentheses represent percentages. *Statistically significant difference (odds ratio, 5,680; 95% confidence interval, 2,507-12,872)

Table 3: Frequency and types of alternative and last diagnoses identified in patients with and without pulmonary embolism

Final diagnoses	**PE (+) (n=49)**	**PE (-) (n=152)**	**Total**
No additional pathology	39 (79,5)	38 (25)	77
Coronary syndromes	2 (4.1)	6 (9)	8
Pneumonia	7 (14.3)	50 (32,9)	57
Pulmonary edema	0	27 (17,8)	27
Lung cancer	0	2 (1,3)	2
Asthma +COPD attacks	0	9 (5,9)	9
Pneumonia+pulmonary edema	0	7 (4,6)	7
Alveolar hemorrhage	0	4 (2,6)	4
Organized hematoma	0	1 (0,7)	1
Sepsis	0	3 (2)	3
Pericarditis	1 (2.0)	2 (1,3)	3
Pneumothorax	0	1 (0,7)	1
Pleural effusion	0	2 (1,3)	2

Unless otherwise specified, given data represent number of patients and the numbers in parentheses represent percentages. **COPD:** Chronic obstructive pulmonary disease.

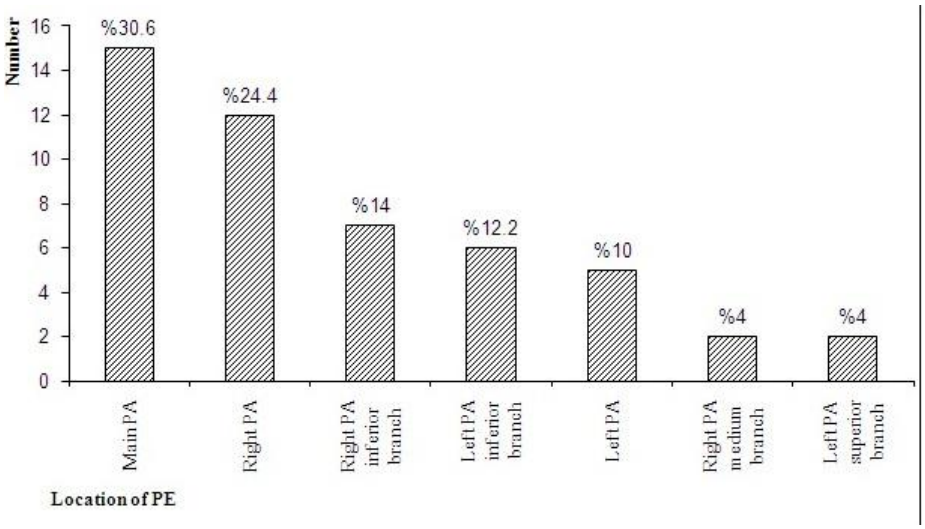

Figure 1: Distribution of thrombus location in the pulmonary arterial system (PA, Pulmonary artery)

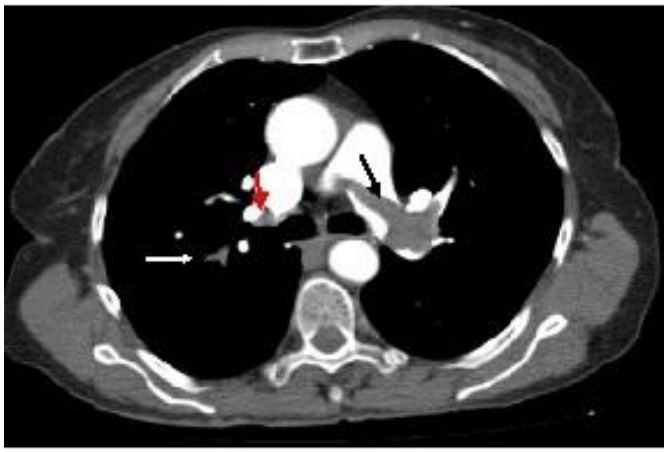

Fig.2: A 74-year-old female patient who presented to ED with chest pain. MSCT shows a filling defect that primarily extends from the main PA to the left PA (black arrows), and a filling defect in the right PA and its upper lobe branch (red and white arrows).

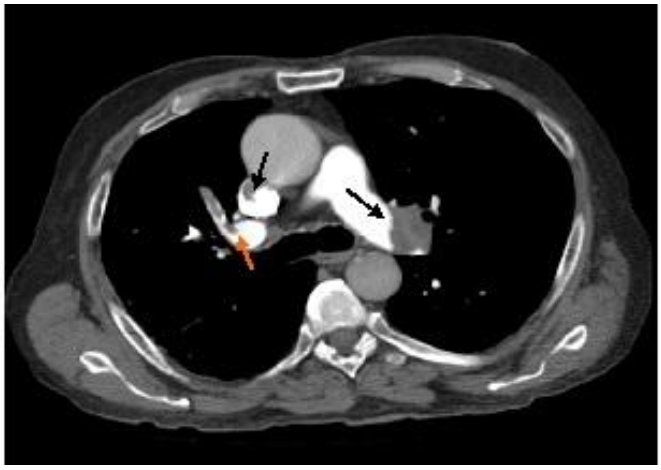

Fig.3: A 70-year-old male patient who presented with chest pain and dyspnea. MSCT shows filling defects in the left PA and in the distal right PA extending to its segmental branch to the upper lobe (arrows).

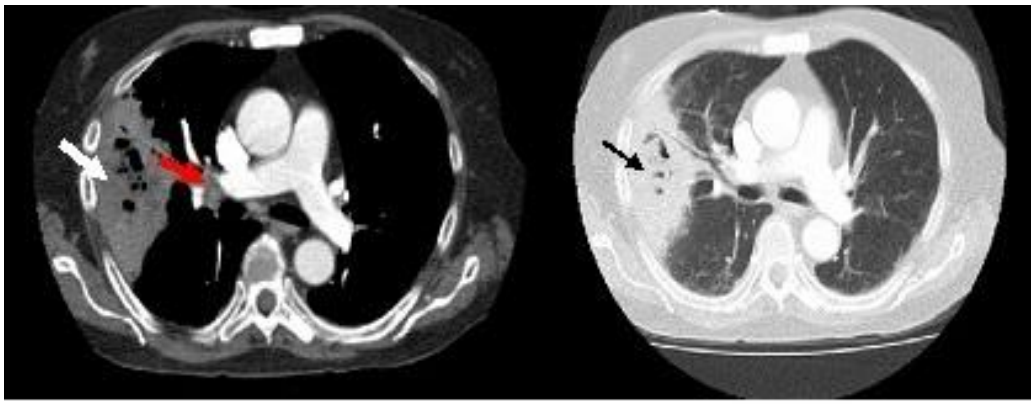

Fig.4: A 77-year-old male patient who presented with chest pain and dyspnea. MSCT shows a filling defect in the right PA (red arrow). Also note the pleural based consolidation and abscess formation within it (black and white arrows).