Original Research Article

Role of lung perfusion analysis with dual energy CT in patients with suspected pulmonary embolism: Perfusion defects are correlated with pulmonary ct angiogram and clinical parameters

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Abstract

Introduction: Pulmonary embolism is one amongst the most common causes for cardiovascular death, but this potential fatal condition is treatable if diagnosed on time. Despite various diagnostic modalities and introduction of various new tests diagnosing pulmonary thromboembolism still remains a challenge. Pulmonary Thromboembolism occurs in wide variety of settings. Pulmonary embolism refers to embolic occlusion of pulmonary arterial system. **Materials and Methods:** This was hospital based prospective study done over a period of July 2015th September 2017 .Clinically suspected patients with pulmonary emboli underwent DECT pulmonary angiography after taking informed consent. Based on inclusion and exclusion criteria patients were selected. DE CTPA finding were reported by separate radiologist, pulmonary perfusion iodine mapping is then evaluated, perfusion defects caused by pulmonary emboli is identified .this is correlated with CTPA findings and clinical parameters if present. **Results:** Total of 51 patients were included in our study .Youngest patients in our study was 22 year old and eldest was 82 year old. In our study total of 33 were male and 18 female with suspected PE .Out of these people 11.8% were below 30, 33.3% were between 31-50 years, 37.3% were between 51 to 70 years, 17.6% were above 70. Sensitivity and specificity of DECT BFI with reference to CTPA in detecting acute pulmonary embolism was 91.3% and 95.4% respectively Out of 6 cases of chronic emboli only one case showed perfusion defect in DECT BFI suggesting resolution of thrombus /non ochronic emboli. 2 cases of the normal given by CTPA showed perfusion defect in BFI could possibly indicate Sub segmental PE **Conclusion:** DECT provides both anatomical and perfusion status of the both the lungs .By doing so it has More capacity to improve the accuracy in diagnosis of pulmonary embolism. BFI and CTPA obtained during a single contrast enhanced chest CT scan in dual energy mode with no extra radiation has potential to improve the detection of acute emboli and also the follow up, effectiveness of the treatment and effects of chronic embolism.

Keywords: Pulmonary Thromboembolism, CTPA, CT, DECT.

Introduction

Pulmonary embolism is one amongst the most common causes for cardiovascular death, but this potential fatal condition is treatable if diagnosed on time.

Despite various diagnostic modalities and introduction of various new tests diagnosing pulmonary thromboembolism still remains a challenge.

Pulmonary Thromboembolism occurs in wide variety of settings. Pulmonary embolism refers to embolic occlusion of pulmonary arterial system.

Majority of the cases results from thrombus occlusion hence it's also called as pulmonary thromboembolism. Other embolic source's include tumor cells, bone marrow, fat, injected foreign material and air in pulmonary arterioles.

Clinical features of pulmonary emboli includes dyspnea, chest pain, hemoptysis syncope, vascular collapse and sudden death Sudden occurrence of dyspnea, common symptom of pulmonary emboli while pleural friction rub are present when pulmonary infarction occurs.

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Since symptoms are not very specific for pulmonary emboli it's important to not rely only on clinical features, specific investigation and imaging plays a crucial role in timely diagnosis of PTE.

Deep vein thrombosis (DVT) is one of the most common causes for pulmonary thromboembolism .Diagnosis of pulmonary embolism relies upon utilization of available tests under clinical settings of PTE ,as accuracy of the results of the investigations depends upon pretest clinical probability .

Simple tests like chest radiography, D dimer, and arterial blood gas helps in clinical probability, Ventilator perfusion scan, Computed tomographic and pulmonary angiography are regarded as main screening tests for pulmonary embolism.

Introduction of multidetector CT has brought considerable modification in diagnostic approach to PTE. It has now been firmly established that anticoagulation can be withheld safely in patient who have negative CT pulmonary angiography examination.**[1]**

Aims & objectives

- To evaluate usefulness of dual energy pulmonary perfusion study under the settings of pulmonary embolism.
- CT pulmonary angiography findings in subjects with suspected pulmonary thromboembolism undergoing CTPA is correlated DECT perfusion study.

Sensitivity and specificity of DECT perfusion study in detecting pulmonary emboli perfusion defects is determined.

Materials and methods

This was a hospital based prospective study done over a period of two years from 15th July 2015 to 01 September 2017. Clinically suspected patients with pulmonary embolism were investigated using DECT after taking an informed consent.

Place-DECT Scan was done at Department of Radio-Diagnosis, A. J. Institute of Medical Sciences, Mangalore - 575004

Subjects: Based on inclusion and exclusion criteria 50 patients coming to radio diagnosis department with clinical history of pulmonary embolism were selected . Most common clinical symptoms of pulmonary embolism include, breathlessness and chest pain .

CTPA and DECT perfusion study was assessed and compared to evaluate for pulmonary embolism and corresponding perfusion defect and vice versa.

The imaging reports and patient charts, including clinical history, examination findings, biochemistry and pathology reports whatever available, were utilized for each case to establish a final diagnosis.

Study Design -Prospective study

Sample size-50

Sample-Patients attending AJ Institute of Medical Sciences

Sample & Duration-The study will be done over a period of 2 years from September2015 to September 2017 and data will be collected during this period from all the patients who undergo dual energy CT in whom pulmonary emboli are suspected.

Place

Department of radio diagnosis A J Institute of Medical Sciences, Mangalore

Equipment used

Somatome definition DECT

Inclusion criteria

1. Patients of clinically suspicion of PULMONARY THROMBOEMBOLI.
2. Subjects with Risk factors for pulmonary emboli

Exclusion criteria

1. Poor compliance of patient.
2. Known case of emphysema and fibrotic lung disease and ILD.

DECT image analysis

All suspected cases of pulmonary embolism in our hospital underwent CTPA using dual source CT scanner (Somatom Definition, Siemens Healthcare) in dual energy mode.

These scanners have two separate X ray tubes , one tube at 100 KVp and another at 140KVp

Images were acquired after injection of bolus of iodine contrast via 18 gauge catheter into the antecubital vein.

ROI is placed at the aorta for automatic triggering, when ROI reaches trigger threshold ,CT scan was performed.

The acquired images are reconstructed to 3 separate image sets : 100 kvp ,140 kvp, and mixed 100:140 kVp at 4:6 ratio (40% image information from 100 kVp image and 60% information from 140 kVp image)Reconstruction of pulmonary CT angiography iodine perfusion CT scans are generated using lung perfusion blood volume (PBV)using dedicated software (Syngovia, Siemens Medical Solutions).

Iodine mapping reveals blood flow imaging that reveals perfusion defect.

PBV can be fused as an overlay on weighted average images which allows grey scale evaluation of the enhances central vasculature and color coded PBV (lung parenchyma) evaluation.

Iodine perfusion map in PBV can be generated by material decomposition only in range between -960 HU and -600 HU.

Any areas with attenuation outside this range are displayed as perfusion defects hence areas of emphysema, consolidation, lung masses etc. are also demonstrated as perfusion defect.

Lung parenchyma PBV excludes chest wall, media stinum and central large vessels.

Image interpretation

On the color- coded iodine perfusion (PBV) maps, lung parenchyma with normal perfusion is presented in red-orange. Focal iodine defects are presented as black-cultured areas

PBV imaging can be used to identify contrast defects resulting from emboli.

Normal PBV images were defined as showing homogeneous contrast enhancement in the normal range (color-coded red-orange) with dependent symmetric lung iodine distribution

Perfusion defects caused by PE are peripherally located, wedge shaped and is in segmental / lobar distribution.

Rest of perfusion defects such as band etc. which are not in segmental distribution are caused by consolidation, atelectasis and other non PE related conditions.

Contrast enhanced defects caused by chronic PE.

Pulmonary arterial hypertension can be idiopathic or arise in association with chronic pulmonary thromboembolism.

CT features of chronic pulmonary arterial hypertension (PHT) are dilatation of the pulmonary artery trunk, the diameter of which frequently exceeds that of the ascending aorta; dilatation of the right and left main arteries; abrupt narrowing and tapering of the peripheral pulmonary vessels; right ventricular hypertrophy; and right ventricular and atrial enlargement[2,3]

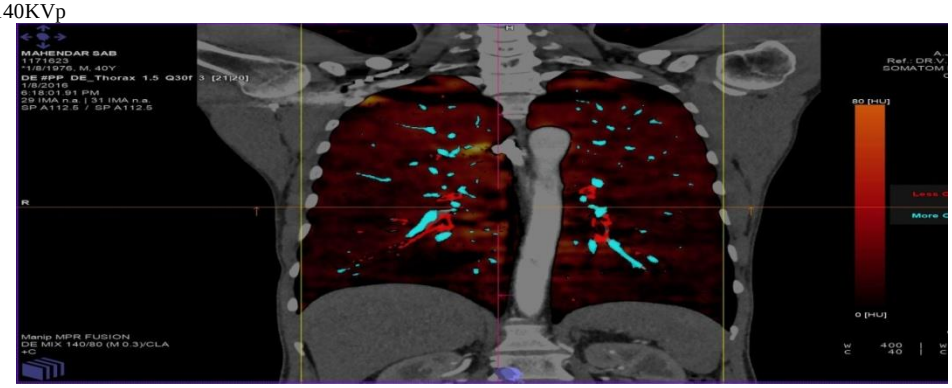

Fig 1: Normal perfusion of lung color red in absence of pulmonary embolism

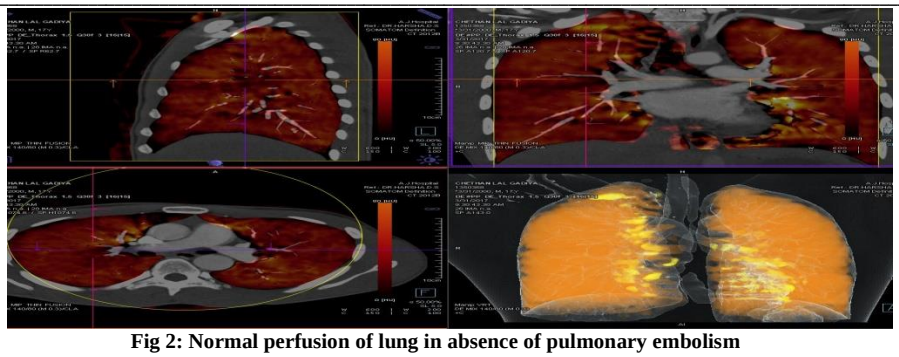

Fig 2: Normal perfusion of lung in absence of pulmonary embolism

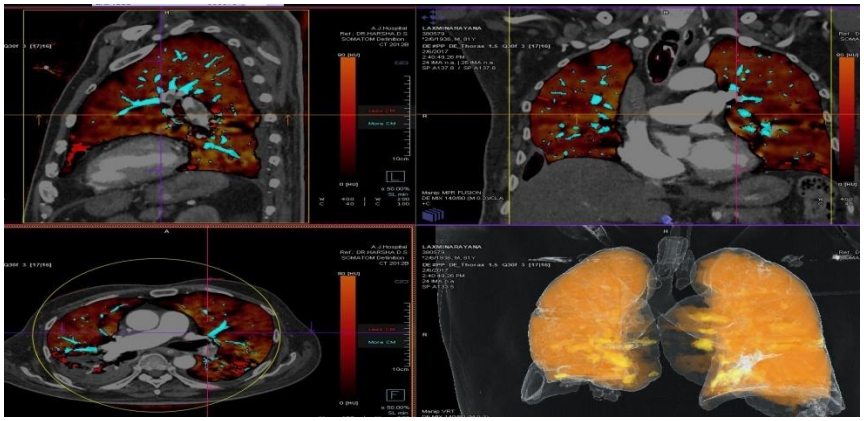

Fig 3: Case of acute pulmonary embolism

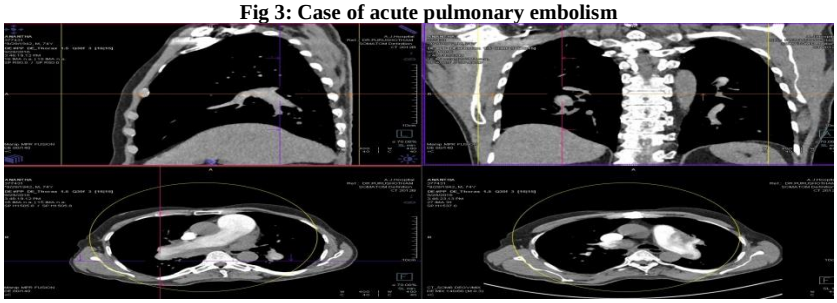

Fig 4: Case of chronic pulmonary embolism

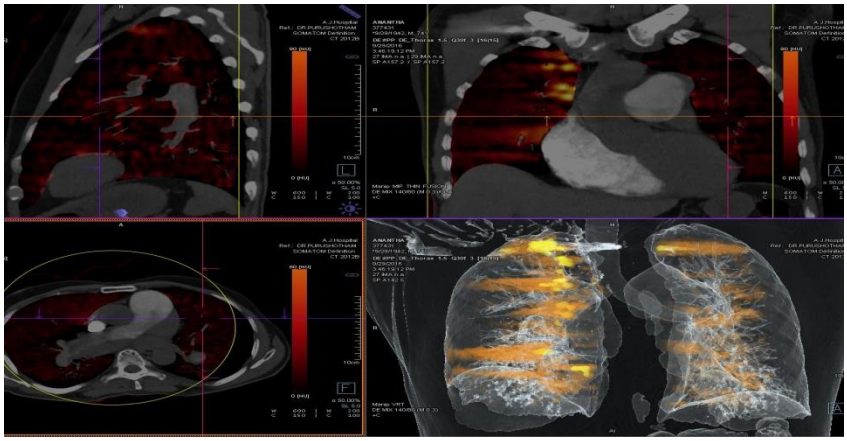

Fig 5: No perfusion defect corresponding chronic embolism

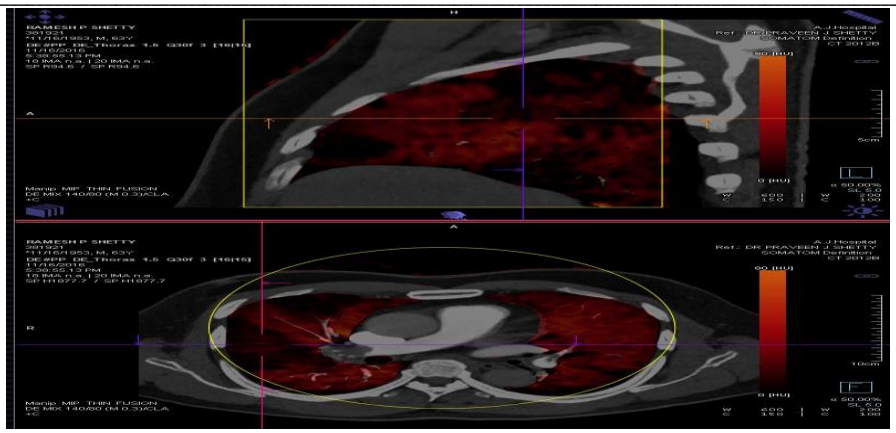

Fig 6: Perfusion defect corresponding to PE

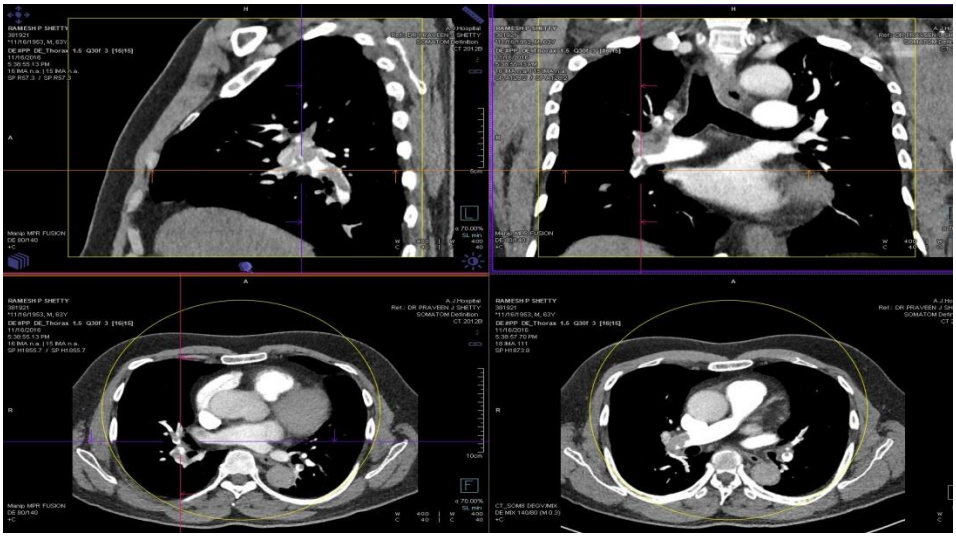

Fig 7: Corresponding CTPA showing PE

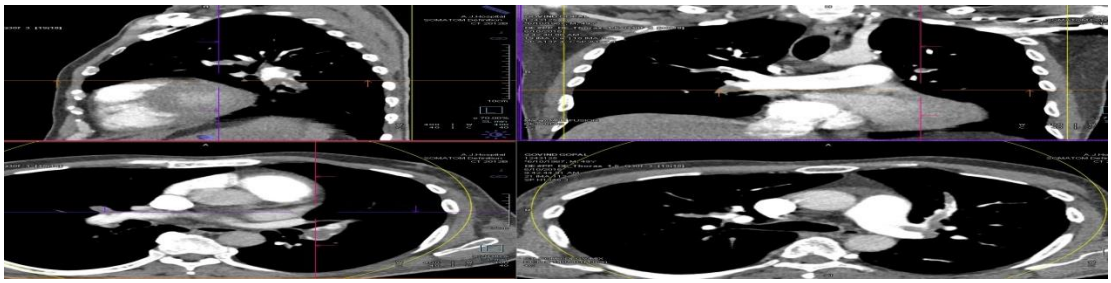

Fig 8: CTPA corresponding to PE

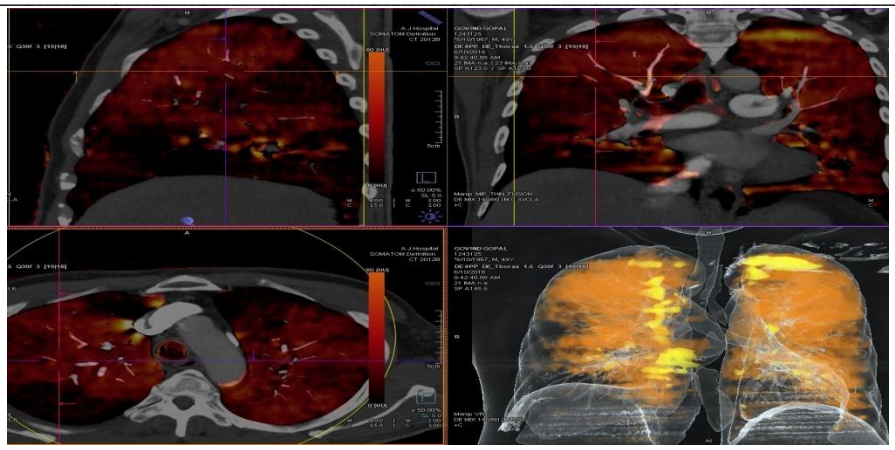

Fig 9: DECT showing perfusion defects corresponding to PE

Results

Table: 1 Age wise distribution of the patients studied

Age	Frequency	Percent
30 and below	6	11.8
31 – 50	17	33.3
51 – 70	19	37.3
Above 70	9	17.6
Total	51	100.0

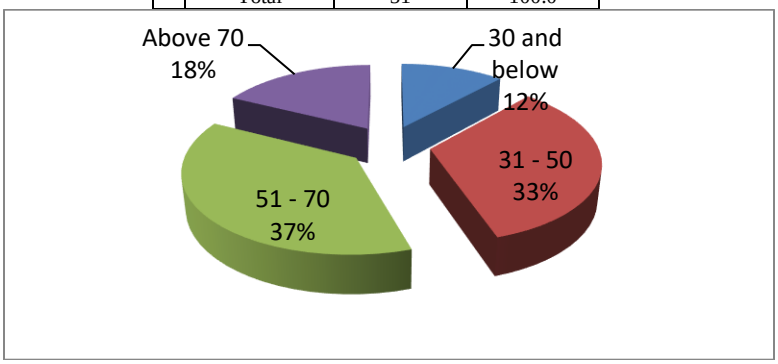

Fig-1 Age wise distribution of the patients studied

Table: 2 Gender wise distribution of the patients studied

Sex	Frequency	Percent
Female	18	35.3
Male	33	64.7
Total	51	100.0

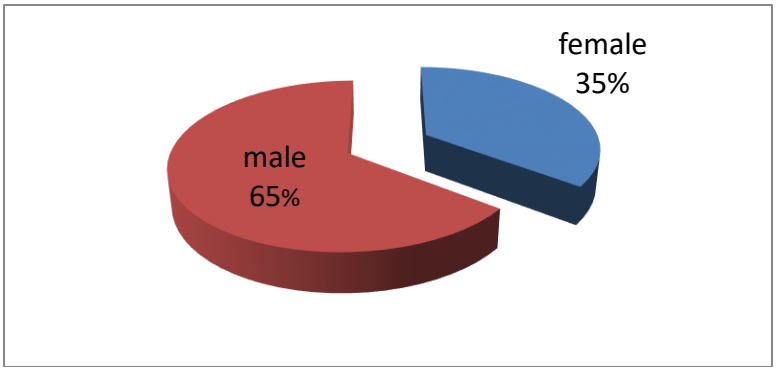

Fig 2 gender wise distribution of the patient studies

Table: 3 Distribution of patients based on presence and absence of risk factors.

Risk factors	Frequency	Percent
Present	38	74.5
Absent	13	25.5
Total	51	100.0

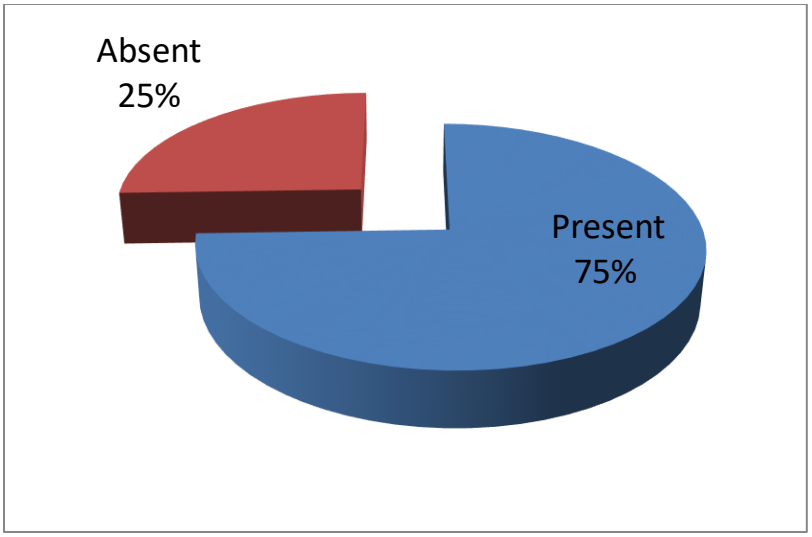

Fig 3: Distribution of patients based on presence and absence of risk factors

Table: 4 Distribution of patients based on presence and absence of chest x-ray findings correlating to PE.

Chest x-ray finding	Frequency	Percent
Absent	12	23.5
Present	39	76.5
Total	51	100.0

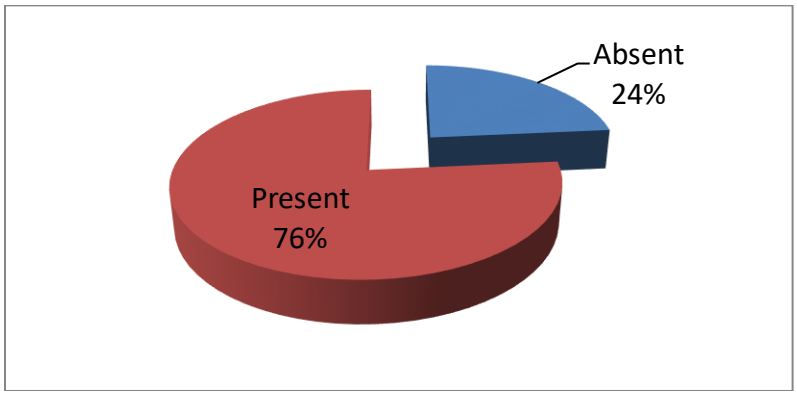

Fig 4: Distribution of patients based on presence and absence of chest x-ray findings correlating to PE.

Table: 5 Distribution of patients on presence and absence of lower limb deep venous thrombus based on Doppler findings in suspected cases of PE

DVT	Frequency	Percent
Absent	21	63.3
Present	12	33.3
Total	33	100

Table: 6 Distribution of patients on presence and absence of lower limb deep venous thrombus based on Doppler findings in suspected cases of PE

		Frequency	Percent
1	Normal	21	63.3
2	Unilateral DVT	3	8.8
3	Bilateral DVT	9	26.5
4	Thrombophlebitis	1	2.9

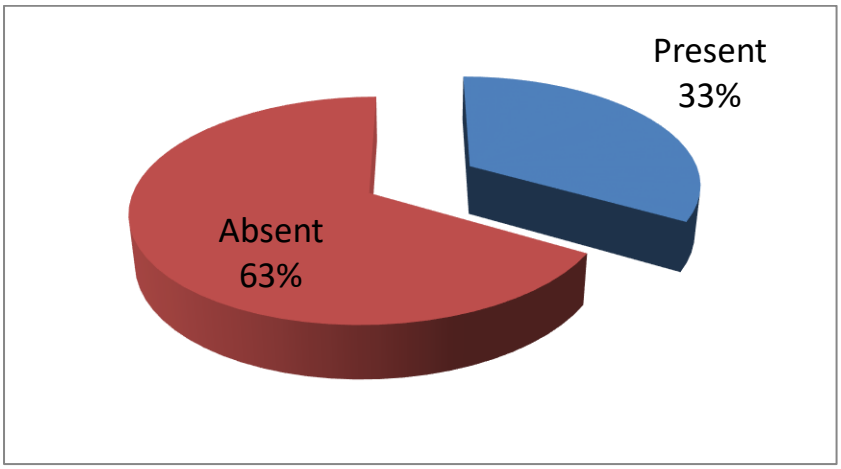

Fig: 5 Distribution of patients on presence and absence of lower limb deep venous thrombus based on Doppler findings in suspected cases of PE

Table 7: Distribution of patients with acute pulmonary emboli on presence and absence of lower limb DVT based on Doppler findings

	Frequency	Percent
No evidence of DVT	7	38%
Presence of DVT	11	61%
Total	18	100%

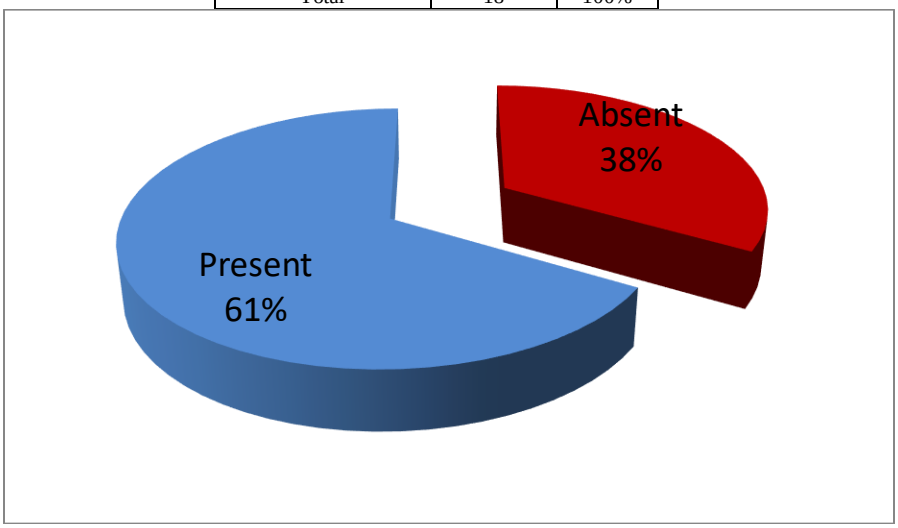

Fig 6: Distribution of patients with acute pulmonary emboli on presence and absence of lower limb DVT based on Doppler findings

Table 8 : Distribution of patients on presence and absence of pulmonary emboli based on CTPA in suspected cases of PE

CTPA	Frequency	Percent
Abnormal	27	52.9
Normal	24	47.1
Total	51	100.0

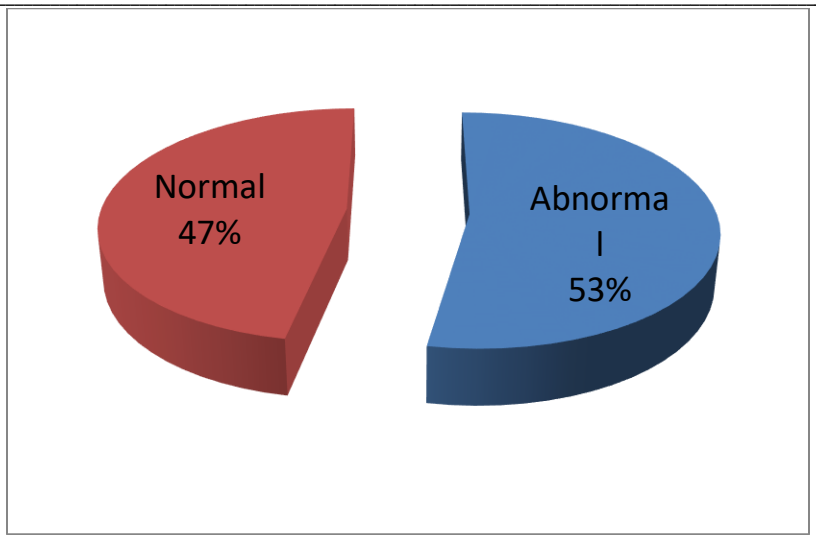

Fig 7: Distribution of patients on presence and absence of pulmonary emboli based on CTPA findings in suspected cases of PE

Table 9 : Distribution of patients on presence and absence of pulmonary emboli based on CTPA findings in suspected cases of PE

CTPA	Frequency	Percent
No evidence of PE	24	47.1
Main and segmental PE	18	35.3
Segmental PE	3	5.9
Chronic PE	6	11.8
Total	51	100.0

Table 10 : Distribution of patients on presence and absence of pulmonary perfusion defects in suspected cases of PE

DECT pulmonary perfusion	Frequency	Percent
Abnormal	23	45.1
Normal	28	54.9
Total	51	100.0

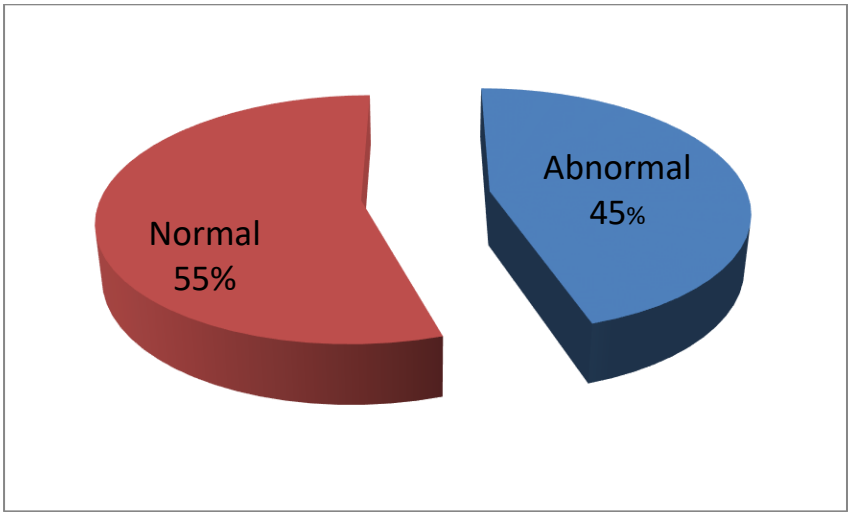

Fig 8 : Distribution of patients on presence and absence of pulmonary perfusion defects in suspected cases of PE

Table 1: distributions of subjects under study based on presence and absence of Pulmonary hypertension

Presence of pulmonary hypertension	Frequency	Percent
Present	8	15.7
Absent	43	84.3
Total	51	100.0

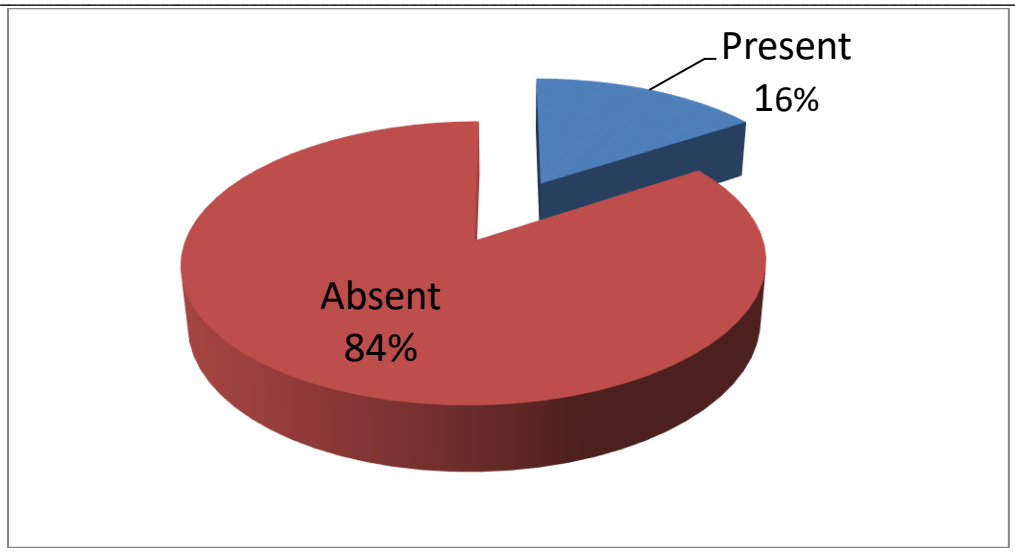

Fig 8: distributions of subjects under study based on presence and absence of Pulmonary hypertension

Table 12: correlation between DECT PA and CTPA findings

		CTPA		
		Abnormal	Normal	Total
DECT Pulmperf	Abnormal	20	3	23
		87.0%	13.0%	100.0%
		74.1%	12.5%	45.1%
	Normal	7	21	28
		25.0%	75.0%	100.0%
		25.9%	87.5%	54.9%
Total		27	24	51
		52.9%	47.1%	100.0%
		100.0%	100.0%	100.0%

Table 13: Overall sensitivity and specificity of DECT Pulmonary perfusion study

		Lower	Upper
Sensitivity	74.07	57.54	90.60
Specificity	87.50	74.27	100.73
PPV	86.96	73.19	100.72
NPV	75.00	58.96	91.04
Overall accuracy**	80.39	69.50	91.29

Discussion

We performed study at AJ Institute of medical sciences in 51 patients with suspected pulmonary Embolism. We evaluated the role of DECT pulmonary perfusion in patients with suspected PE.In our study we found that DECT pulmonary perfusion study was helpful in detecting Pulmonary Embolism by showing perfusion defects corresponding to pulmonary embolism.DECT BFI detected perfusion defects not only from acute emboli but also from chronic clots. Total of 51 patients were included in our study .Youngest patients in our study was 22 year old And eldest was 82 year old. In our study total of 33 were male and 18 female with Suspected PE .Out of these people 11.8% were below 30, 33.3% were between 31-50 years, 37.3% were between 51 to 70 years, 17.6% were above 70.According to our study male predominance was noted and majority of the patients were above 30. and 74.5 % of the patients who underwent CTPA had one or more risk factor related to PE [4-6]

Chest x-ray features in pulmonary emboli is highly variable, there are few chest x-ray findings Corresponding to Acute PE and these are Fleischner sign, Hampton hump, wester mark sign pleural effusion, knucle sign, pallasign, chang sign.

Most common chest x-ray finding is fleischner sign .12 out of 21 (57%) patients with PE had presence of this sign in our study .second most common finding was pleural effusion[7,8].

CTPA was used in our study as standard reference in 51 patients with suspected PE , out of Which CTPA detected acute PE in 21 of them and chronic PE in 6 patient's .DECT BFI showed Perfusion defects in 19 patients out of 21 corresponding to acute PE. Sensitivity and specificity of BFI in detecting acute PE in our study was 91.3% and 95.4% respectively.24 (47%) cases out of 51 were diagnosed normal on CTPA as normal. In this study 6 cases out of 51 were chronic pulmonary emboli. CTPA showed findings Corresponding to chronic pulmonary emboli. Of these cases only one case showed perfusion defect in DECT BFI corresponding to PE suggesting presence of occluding emboli causing significant perfusion defect hence requires treatment. Rest of the 5 cases showed no perfusion defect suggesting resolution of pulmonary embolism and corresponding perfusion defect and hence effectiveness of the treatment.So our study is useful to assess the perfusion changes that occur as a result of pulmonary emboli. The effectiveness of DECT BFI has been well evaluated in our study of 51 patient's .Our study has however few drawbacks like false negative at BFI (2 cases, 9%) resulting from non Occlusive emboli that have very little contrast enhanced perfusion defect, and BFI. In elderly with emphysema, patients with pleural effusion, consolidation and lung masses, in these situations BFI showed reduced perfusion defects.Nevertheless Small peripheral segmental pulmonary artery emboli can be missed even in state of ArtMDCT, which produces perfusion defects that can be still detected in perfusion BFI hence DECT CTPA and perfusion BFI should go hand in hand in diagnosis of pulmonary embolism.

Conclusion

DECT provides both anatomical and perfusion status of the both the lungs .By doing so it has More capacity to improve the accuracy in

diagnosis of pulmonary embolism. BFI and CTPA obtained during a single contrast enhanced chest CT scan in dual energy mode with no extra radiation has potential to improve the detection of acute emboli and also the follow up, effectiveness of the treatment and effects of chronic embolism.

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