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Research Article

Role of HRCT Chest and Pulmonary Angiography in Assessment of Chest Pain in Oncologic Patients

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Abstract

Background: HRCT is a non-invasive imaging technique that provides detailed images of the thoracic structures, enabling the evaluation of potential malignancies, lung metastases, and pulmonary embolism. In addition, CTPA is an effective tool in diagnosing pulmonary embolism by visualizing the pulmonary arteries. These imaging modalities aid in the early detection and characterization of chest pain-related pathologies in oncology patients, facilitating timely intervention and treatment. By assisting in the diagnosis and decision-making process, HRCT and CTPA contribute significantly to improving patient outcomes. **Methods**: This study was conducted in Minya oncology center - Radiology department during the period from July 2022 to September 2023. One Hundred and Twenty (120) oncology patients, suffered from chest pain, were referred from outpatient clinics and inpatient departments in our hospital, to be recruited in the study. All patients underwent HRCT and CT pulmonary angiography. **Results**: A total of 120 oncology patients was identified, of which 20 (16.7%) developed PE. The incidence of PE was highest in colorectal cancer (CNS) (30%; 95% CI, 13.6-51.7), followed by breast cancer (25%; 95% CI, 10.2-46.4), female genital tract malignancies (15%; 95% CI, 4.4-34.9), and hematolymphoid malignancies (15%; 95% CI, 4.4-34.9). The lowest incidence of PE was found in central nervous system (CNS) malignancies (5%; 95% CI, 0.5-21.1). The most common cause of chest pain was pleural effusion followed by pneumonia, pulmonary embolism, the least common cause was bony chest wall lesion. **Conclusion**: In our study we found that the most common causes of chest pain were pleural effusion, then pneumonia and pulmonary embolism. We concluded that HRCT and CTPA were helpful tools of choice in evaluating the cause of chest pain in oncologic patients.

Keywords: High resolution computed tomography (HRCT), CT pulmonary angiography (CTPA), chest pain, dyspnea, cancer.

Introduction

Pleuritic chest pain is characterized by sudden and intense sharp, stabbing, or burning pain in the chest when inhaling and exhaling. Pulmonary embolism is a common serious cause, found in 5% to 21% of patients who present to an emergency department with pleuritic chest pain. A validated clinical decision rule for pulmonary embolism should be employed to guide the use of additional tests such as d-dimer assays, ventilation-perfusion scans, or computed tomography angiography [(1).] Oncology patients have a fourfold higher risk for developing pulmonary embolism than that of the general population, that increases to six-fold if the patient is receiving chemotherapy. [(2)]

In patients with cancer undergoing computed tomography (CT) imaging for reasons other than for PE detection, unsuspected PE has been

found in up to 4% of overall cases and in up to 9% of inpatients. Diagnosis of unsuspected PE is important to prevent embolic recurrence that is associated with substantial morbidity and mortality. [3,4]

CT pulmonary angiography (CTPA) represents now the diagnostic test of choice for the diagnosis of PE and is widely available in most hospitals. The increasing availability of newer generations of multi-detector CT scanners (64- and 160 slice) with rapid rotation speeds has made it possible to acquire thin collimation images through large volumes of imaged tissue, allowing high quality reconstructions using isometric voxels. In patients undergoing routine contrast-enhanced CT imaging of the thorax for indications other than PE detection, it is now possible to reconstruct the acquired data to provide thin slice images of the pulmonary arteries equivalent to those in a CTPA study, provided that the contrast delivery has been timed to optimize opacification of the pulmonary arteries. [5].

In oncology patients undergoing routine staging or restaging CT scans, It is postulated that such an imaging protocol would improve detection of incidental PE, which may help to identify patients at risk for a subsequent major embolic event. [6]

Aim of the work

The objective of this study is to evaluate the role of HRCT chest and pulmonary angiography to demonstrate different causes of chest pain in oncology patients.

Patients and Methods

A. Technical design

Study type and region:

This analytical observational study was conducted in the department of Diagnostic Radiology, Minya oncology center, during the period from July 2022 through August 2023 after being ethically approved by the local Medical Ethics Committee.

Study population:

One Hundred and Twenty (120) oncologic patients, suffered from chest pain, were referred from outpatient clinics and inpatient departments in our hospital, to be recruited in the study. All patients underwent HRCT and CT pulmonary angiography.

Informed written consent was obtained from all patients prior to participating in the study.

Inclusion criteria:

1- Any stage oncology patients on regular follow up presented with acute chest pain.
2- Oncology patients receiving treatment who develop acute chest pain regardless the clinical suspicion about PE.

Exclusion criteria:

1- Patients with renal impairment.
2- Patients with history of severe allergic reaction to iodinated contrast medium.
3- Cardiac causes of chest pain.

Operational design:

Informed written consent was obtained from all patients prior to participating in the study.

Methods:

1. Full medical history taking with analysis of symptoms.
2. Thorough physical examination of the chest.
3. Laboratory tests.
4. Chest X-ray.
5. HRCT chest.
6. Ct pulmonary angiography.

Imaging technique:

- **HRCT scan:**
  - **HRCT protocol:**

- The patient lied supine.
- The CT systems used in this study included: MDCT, Canon Aquilion prime SP 64 slice scanner.
- Conventional examination:
- FOV=350mm.
- Slice thickness=2 mm.
- 120 KV and 30 mA.

  - **Post processing:**

True thin reconstruction axial images were obtained according to patient position. Then reformatted images were obtained as follow:

- Coronal reformatted images (Standard 2mm x 2mm) were obtained.
- Sagittal reformatted images (Standard 2mm x 2mm) were obtained.

The volumetric data was further subjected to various post-processing on workstations such as:

- Multiplanar reconstructions (MPRs).
- Maximum Intensity Projection (MIP).
- Minimum Intensity Projection (minIP).

➢ **CT pulmonary angiography (CTPA):**

- Patient position: supine with their hands above their head.
- Scout: apices to diaphragm.
- Scan direction: caudocranial.
- Contrast injection considerations:

✓ Bolus tracking:

Monitoring slice (region of interest)

- Below the carina, at the level of pulmonary trunk with ROI on the pulmonary artery.

Threshold

- 100 HU

Contrast volume

- 60 mL of non-ionic contrast with a 100 mL saline chaser at 4.5/5 mL/s.

- Scan delay: minimal scan delay.
- Respiration phase: inspiration.

✓ Test bolus:

Monitoring slice (region of interest)

- Below the carina, at the level of pulmonary trunk with ROI on the pulmonary artery.
- Monitor contrast enhancement peak over a time-enhancement curve.

Contrast volume

- (Test scan) 20 mL of non-ionic contrast with a 10 mL saline chaser at 4.5/5 mL/s.
- (Diagnostic scan) 60 mL of non-ionic contrast with a 100 mL saline chaser at 4.5/5 mL/s.

- Calculating scan delay:
  as the time enhancement curve will only begin recording after the scan delay. A widely accepted formula for calculating the scan delay is 1.
  Peak contrast enhancement (time-enhancement curve) with scanner's diagnostic curve.
- Respiration phase: inspiration.

Sample result of imaging:

Case (1)

Clinical history:

- 56-year-old female patient.
- Non-smoker.
- Complain: known HCC patient with chest pain and dyspnea.

Laboratory tests:

- CBC, inflammatory markers (ESR & CRP) and D-dimer were done.
- D- dimer was (2100 ng/ml)

CT findings:

- **CTPA findings:**
  hypo dense thrombus occluding the lumen of the main pulmonary artery and the proximal parts of the right & left pulmonary arteries (saddle-shaped embolism).
- **HRCT findings:**
  - Bilateral basal atelectatic bands.

Diagnosis:

Saddle shaped pulmonary embolism.

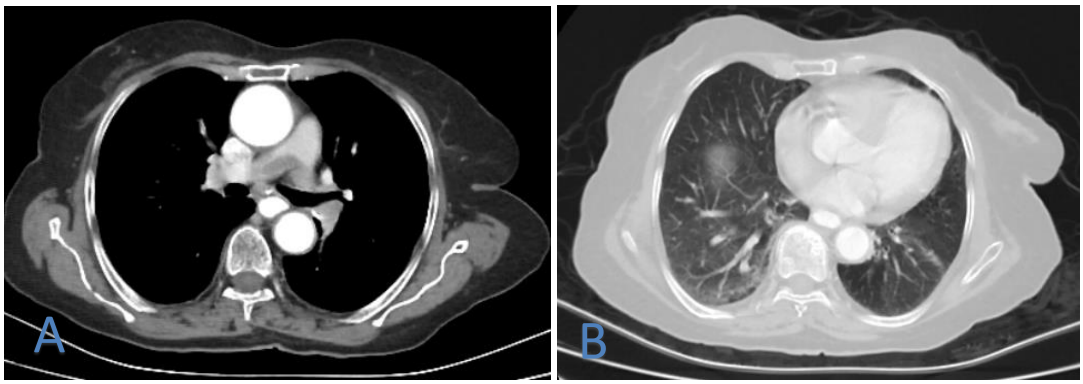

Figure (1): (A) CTPA axial image showing saddle shaped pulmonary embolism. (B) axial lung window HRCT image showing bilateral basal few atelectatic bands.

Case (2)

Clinical history:

- 34-year-old male patient.
- Non-smoker.
- Complain: known rectal cancer with chest pain and dyspnea.

Laboratory tests:

CBC, inflammatory markers (ESR & CRP) and D-dimer were done.
D- dimer was (1860 ng/ml)

CT findings:

- **CTPA findings:**
  - Small hypo dense thrombus is noted at the left lower lobe branch extending to segmental branches.
- **HRCT findings:**
  - Mild amount of right pleural effusion as well as fissural effusion associated with left lower lobe consolidation opacity.

Diagnosis:

Right pulmonary embolism involving the lower segmental branches.
Right pleural effusion & pneumonia.

Image gallery:

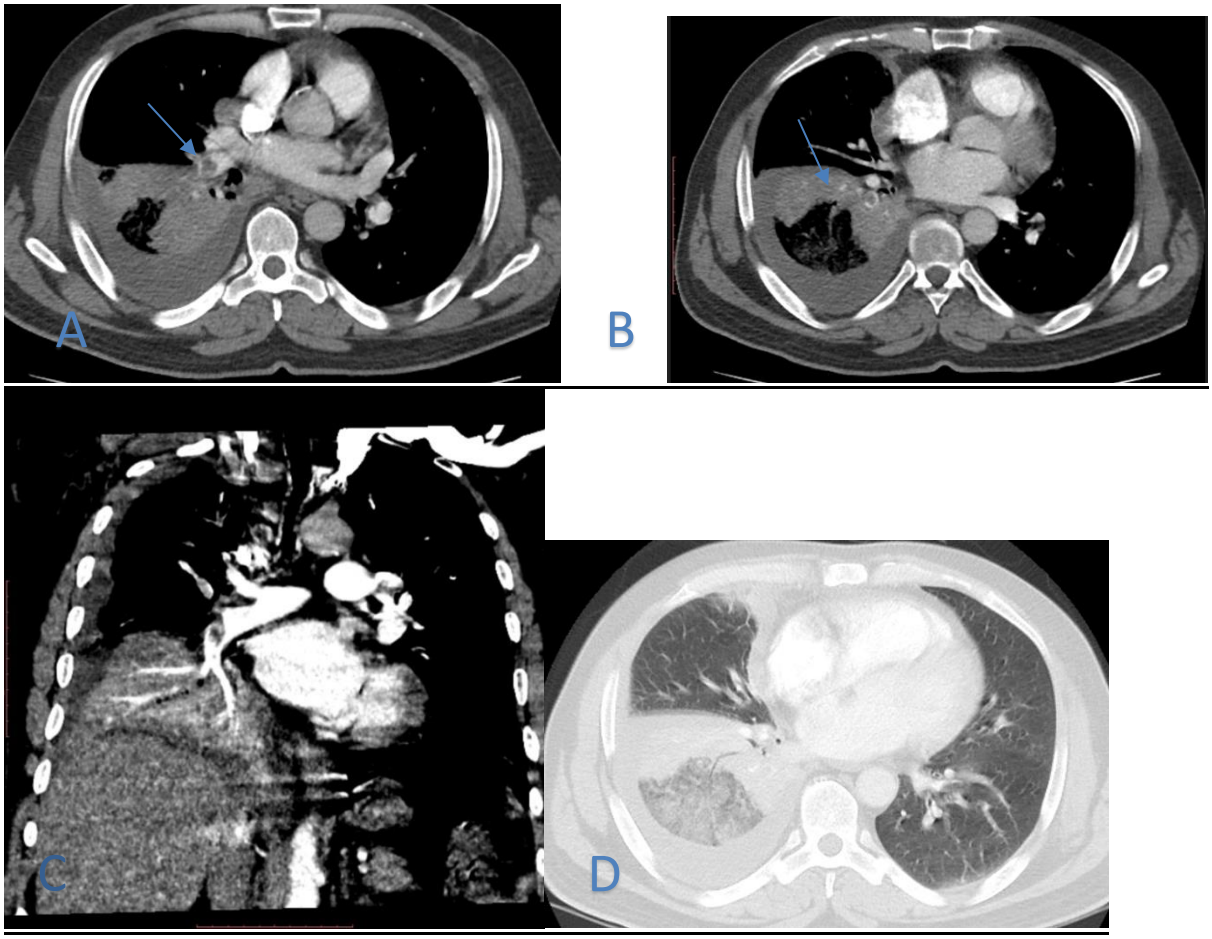

Figure (3): (A), (B) and (C) axial and coronal images of CTPA, showing small hypo dense thrombus involving the right lower branch of the right pulmonary artery that is seen extending one of its segmental branches. (D) axial lung window of HRCT showing mild pleural effusion & fissural effusion associated with consolidation opacity involving the right lower lung lobe.

Case (3)

Clinical history:

- 45-year-old female patient.
- Non-smoker.
- Complain: known uterine cancer with chest pain and dyspnea.
  Laboratory tests:
  CBC, inflammatory markers (ESR & CRP) and D-dimer were done.
  D- dimer was (470 ng/ml)

CT findings:

- **CTPA findings:**
  Normal
- **HRCT findings:**
  Multiple bilateral variable sized pulmonary nodules.

Diagnosis:

Metastatic pulmonary nodules.

Image gallery:

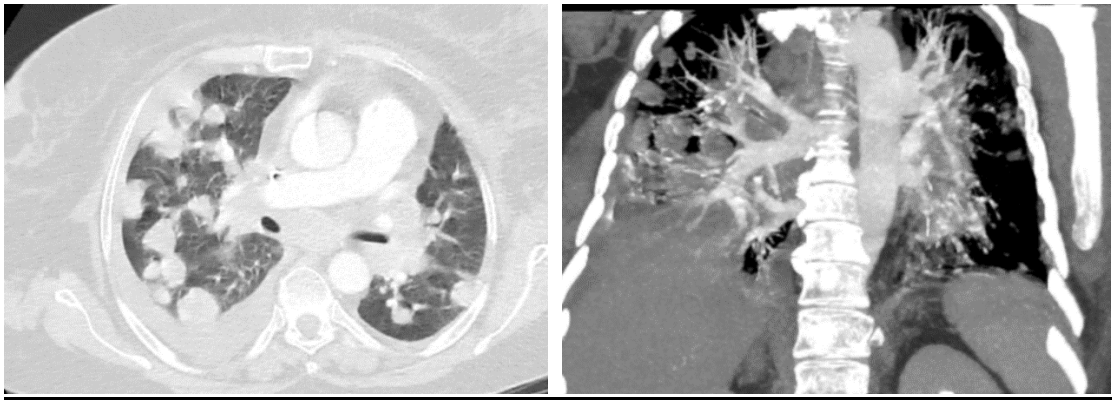

Figure (5): (A) shows axial image lung window of HRCT, multiple variable sized pulmonary nodules seen scattered at both lungs, associated with mild amount of right pleural effusion. (B) shows normal coronal MIP image of CTPA.

Results

Statistical analysis of data was carried out using the IBM SPSS 27.0 statistical package software (IBM; Armonk, New York, USA). Data were expressed as mean ± standard deviation (SD), minimum and maximum of range for quantitative parametric measures, in addition to both number and percentage for categorized data.

The student t-test was used for comparison between two independent groups for quantitative data, and the Chi-square test or Fisher's exact test were used to compare categorical variables.

A total of 120 oncologic patients were included in the study, consisting of 54 (45%) males and 66 (55%) females with a mean age of 50 years (range, 23-77 years). With 59 non- smoker patients (49.20%), 15 ex-smokers (12.50%), and 45 current smokers (38.30%).

Among different cancer types included in our study, breast cancer had the greatest number of cases of 28 patients (23.3%), followed by male genital tract malignancies 15 patients (12.5%), metastatic of unknown origin 13 patients (10.8%), hematolymphoid malignancies 12 patients (10.0%), colorectal cancer 11 patients (9.2%), urinary tract malignancies 9 patients (7.5%), upper gastrointestinal malignancies 6 patients (5.0%), hepatobiliary malignancies 5 patients (4.2%), then papillary thyroid cancer 4 patients (3.3%), and pancreatic cancer 4 (3.3%), the least is central nervous system malignancies 2 patients (1.7%). **Figure (1).**

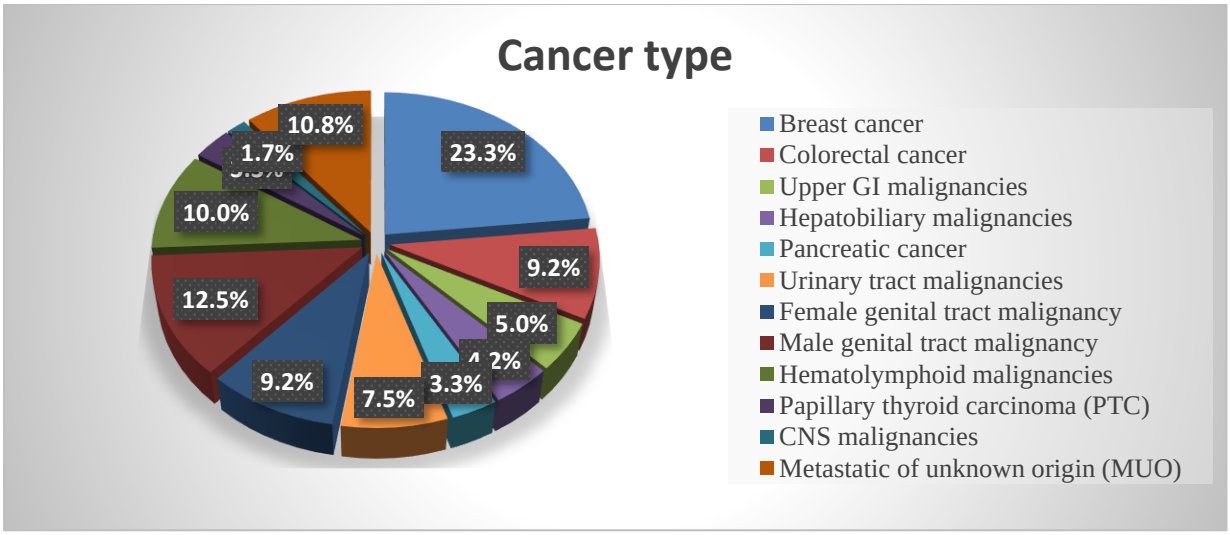

Figure (1): Classification of the studied patients according to cancer type.

Table (1): Incidence of pulmonary embolism (PE) and the risk of PE across different cancer types

Incidence of PE					Risk of PE across cancer types		
Tumor type	**Total No. of patients**	**No. of patients with PE**	**%**	**95% CI**	**P**	**OR**	**95% CI**
Breast cancer	28	5	25%	10.2-46.4	0.847	1.11	0.4-3.4
Colorectal cancer	11	6	30%	13.6-51.7	<0.001*	8.14	2.2-30.3
Upper GI malignancies	6	0	0%				
Hepatobiliary malignancies	5	0	0%				
Pancreatic cancer	4	0	0%				
Urinary tract malignancies	9	2	10%	2.1-28.4	0.642	1.48	0.3-7.7
Female genital tract malignancy	11	3	15%	4.4-34.9	0.322	2.03	0.5-8.4
Male genital tract malignancy	15	0	0%				
Hematolymphoid malignancies	12	3	15%	4.4-34.9	0.414	1.78	0.4-7.3
Papillary thyroid carcinoma (PTC)	4	0	0%				
CNS malignancies	2	1	5%	0.5-21.1	0.307	5.21	0.3-87
Metastatic of unknown origin (MUO)	13	0	0%				

Table (1) shows the incidence of pulmonary embolism across different cancer types. A total of 20 patients developed PE, with an incidence of 16.7%. The incidence of PE was highest in colorectal cancer, followed by breast cancer, female genital tract malignancies and hematolymphoid malignancies. The lowest incidence of PE was found in central nervous system (CNS) malignancies

After we applied statistical correction, the risk for PE was found to be significantly higher for colorectal cancer (P < .0001; OR, 8.14) than other cancers. Breast cancer, female genital tract malignancies and hematolymphoid malignancies have high incidence of PE; however, it did not meet statistical significance after we applied the Bonferroni correction. A non-significantly lower risk of PE was noted for central nervous system malignancies.

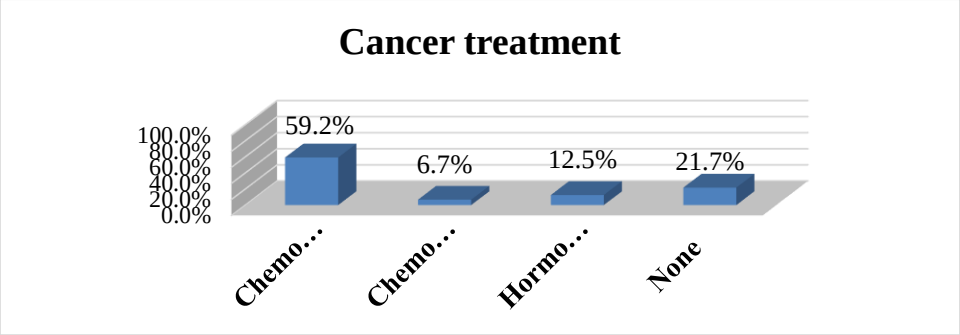

Figure (2): Number & percentage of studied patients receiving cancer treatment.

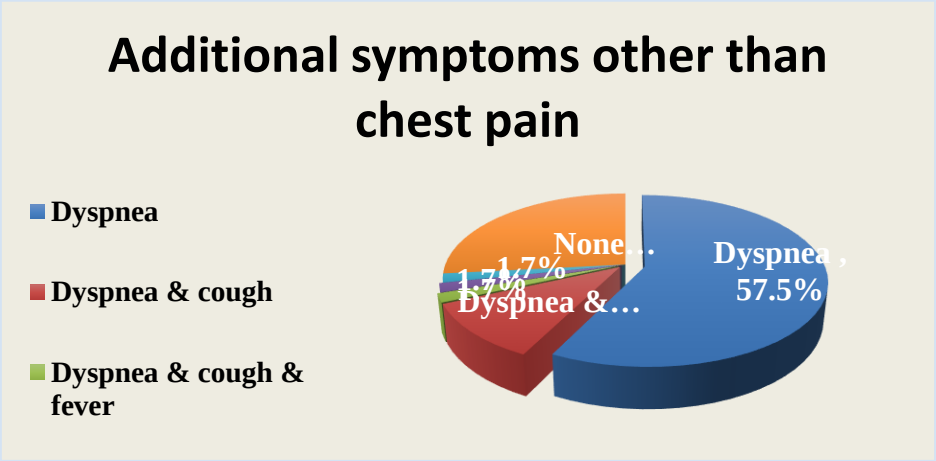

Figure (3): Represents additional symptoms of the studied patients other than chest pain.

Table (2): Causes of chest pain

Cause of chest pain	Cancer patients (N=120)	
	N	%
Pulmonary embolism (PE)	20	16.7%
PE degree		
Massive	15	75.0%
Sub massive	5	25.0%
PE type		
Acute	14	70.0%
Chronic	6	30.0%
Pleural effusion	32	26.70%
Pneumonia	29	24.20%
Radiation pneumonitis	11	9.20%
Metastatic pulmonary nodules	13	10.80%
Chest wall lesion	4	3.3%
Consolidation collapse	3	2.50%
Bony deposits	3	2.50%
Unrelated causes	17	14.20%

N.B. The percentage of patients having chest pain do not sum to 100%, as patients are able to have more than one cause of chest pain
Massive PE: involvement of main pulmonary artery, Rt or Lt main pulmonary arteries.
Sub massive PE: involvement of Rt or Lt segmental or subsegmental branches.

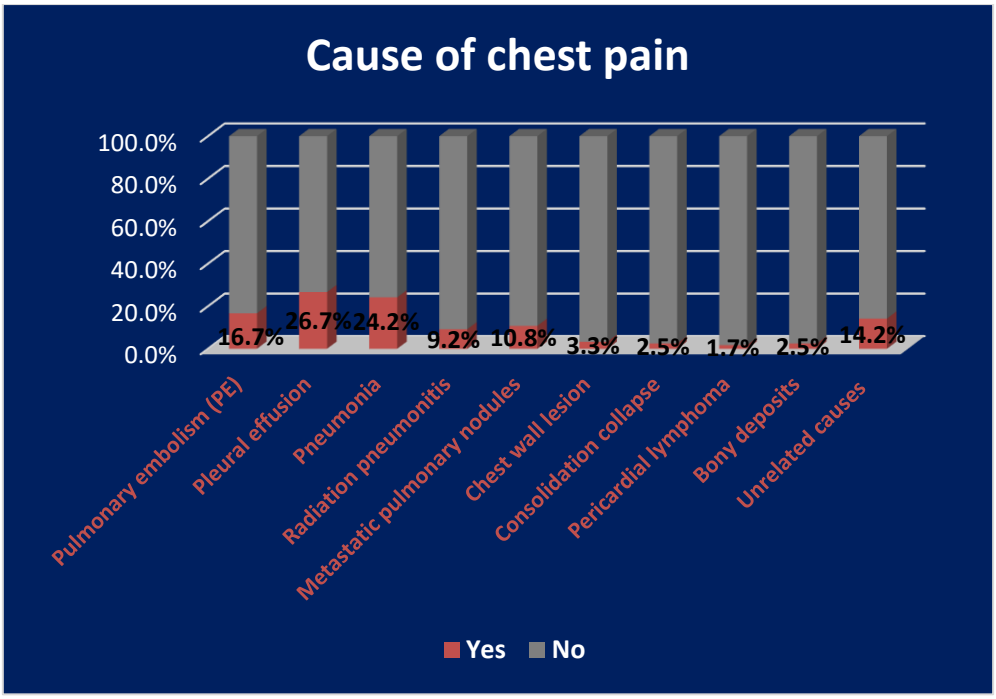

Figure (4): Causes of chest pain among the studied patients.

Table 4: Types and degree of PE

	Cancer patients (N=120)	
	N	**%**
Pulmonary embolism (PE)	20	16.7%
PE degree		
Massive	15	75.0%
Sub massive	5	25.0%
PE type		
Acute	14	70.0%
Chronic	6	30.0%

Massive PE: involvement of main pulmonary artery, Rt or Lt main pulmonary arteries.
Sub massive PE: involvement of Rt or Lt segmental or subsegmental branches.

Table (4): Association between treatment modality and pulmonary embolism among studied cancer patients (n=120), and it shows statistical significance between patients with PE and patients without PE.

	Patients with PE (N=20)	**Patient without PE (N=100)**	**P value**
Chemotherapy	15 (75.0%)	56 (56%)	0.013*
Chemotherapy & Radiotherapy	0 (0.0%)	8 (8%)	
Hormonal	5 (25.0%)	10 (10%)	
None	0 (0.0%)	26 (26%)	

Table 5: Association between treatment modality and pulmonary embolism among breast cancer patients (n=28), and it shows no statistical significance between the two groups.

	Breast cancer patients with PE (N=5)	Breast cancer patient without PE (N=23)	P value
Chemotherapy & Radiotherapy	0 (0.0%)	8 (34.8%)	0.072
Hormonal	5 (100.0%)	10 (43.5%)	
None	0 (0.0%)	5 (21.7%)	

Table 6: Association between treatment modality and pulmonary embolism among studied cancer patients (n=120)

	Patients with PE (N=20)	Patient without PE (N=100)	P value
Chemotherapy	15 (75.0%)	56 (56%)	0.013*
Chemotherapy & Radiotherapy	0 (0.0%)	8 (8%)	
Hormonal	5 (25.0%)	10 (10%)	
None	0 (0.0%)	26 (26%)	

Discussion

Various types of cancer were included in the current study, the most common one was breast cancer, followed by male genital tract malignancies, metastatic cancer of unknown origin, hematolymphoid malignancies, colorectal cancer, upper gastrointestinal malignancies and pancreatic cancer. The lowest incidence was observed in central nervous system malignancies. The incidence of pulmonary embolism (PE) was highest in colorectal cancer (30%), followed by breast cancer (25%), female genital tract malignancies, and hematolymphoid malignancies (15%). The lowest incidence was found in central nervous system malignancies (5%). After applying statistical correction, the risk for PE was significantly higher for colorectal cancer compared to other cancers. The incidence of PE in breast cancer, female genital tract malignancies, and hematolymphoid maligna-ncies was high but did not reach statistical significance after correction. Central nervous system malignancies had a non-significantly lower risk of PE. In contrast, Samra et al., [7]. Who estimated the incidence of pulmonary embolism (PE) among oncology outpatients, diagnosed different types of PE, and assessed certain clinical characteristics, found that a total of 24 patients (4.45%) had PE, with 17 patients (3.14%) having symptomatic PE and 7 patients (1.3%) having incidental PE. The patients with incidental PE had lung, uterus, and pancreas cancer, while those with symptomatic PE were more common in breast, prostate, colon, seminoma, and germ cell tumor patients, with percentages of 87.5%, 100%, 80%, and 50%, respectively. In another study, Shinagare et al.,[8] who studied the incidence of PE in oncologic outpatients at a tertiary cancer center and investigated whether the risk for PE was higher in certain cancer types than in others, they found that the highest incidence of PE was observed in central nervous system (CNS) malignancies (12.90%; 95% CI, 8.45-18.59), followed by hepatobiliary, pancreatic, and upper gastrointestinal (GI) malignancies. Hematologic malignancies and breast cancer had the lowest incidence of PE. Also found that the risk of PE was significantly higher for CNS, pancreatic, upper gastrointestinal, and lung/pleural malignancies compared to other cancers. On the other hand, the risk of PE was significantly lower for hematologic malignancies and breast cancer (1.16%; 95% CI, 0.79-1.64). However, the higher incidence of PE in hepatobiliary and colorectal cancers did not reach statistical significance after applying the Bonferroni correction [7,8].

Regarding the types and degree of pulmonary embolism. The current study found that the

involvement of main pulmonary artery and/or its lobar branches was observed in 15 patients (75.0%), whereas involvement of segmental and/or subsegmental branches was found in 5 patients (25.0%). Acute pulmonary embolism was found in 14 patients (70.0%), chronic pulmonary embolism was found in 6 patients (30.0%). These findings were in agreement with Alshumrani et al.,[9].Who investigated the association between clinically suspected PE based on Wells score and CTPA results, found that scan results were negative for PE in 357 cases (66.86%) of the clinically suspected patients, and positive in 177 cases (33.14%) (P<.01%). In positive scans, 143 cases were acute (81%), and 34 cases were chronic (19%)[9]

Regarding cancer treatment, the current study found that 71 patients (59.2%) were receiving chemotherapy, 8 patients (6.7%) were receiving combined chemo and radiotherapy, 15 patients were receiving hormonal therapy (12.5%) and the rest of the patients were on follow up. This finding could be in agreement with Abdel-Razeq et al., [10] who aimed to describe the characteristics of 34 incidentally diagnosed PE in patients undergoing staging and related work-up for cancer. They found that twenty-seven patients had their PE while undergoing active treatment with chemotherapy (68%) or radiotherapy (12%) [10].

In another study, Browne et al.,[11]. reported that eighty-three (20%) patients had received chemotherapy within 1 month before their CT [11].

The current study found that 120 patients presented with chest pain. The most common additional symptom was dyspnea, 69 patients (57.5%) presented with dyspnea, 13 patients (10.8%) presented with dyspnea and cough and 2 patients additionally presented with fever or hemoptysis (1.7%). This could be in partial agreement with King V, et al., [12] who aimed to prospectively evaluate the diagnostic performance of the D-dimer assay for PE in an oncologic population by using CT pulmonary angiography as the reference standard, to assess the association between the location of the PE and the sensitivity of the assay, and to examine the association between the assay and clinical factors that raise suspicion of PE. They found that of the 201 patients, 118 (59%) were presented with chest pain; 163 (82%), with dyspnea; and nine (5%), with hemoptysis.[12]
In another study, Qanadli et al.,[13] who aimed to evaluate the accuracy of dual-section helical computed tomography (CT) in acute pulmonary embolism (PE) diagnosis. Their study included 158 patients, 109 patients had chest pain, 101 patients had dyspnea and 5 patients had hemoptysis. Furthermore, Fujieda K et al.,[14] who aimed to investigate the background of patients who presented with pulmonary embolism (PE) on contrast-enhanced chest computed tomography (CT) and to explore the risk factors for PE. They found that 74 patients had symptoms such as dyspnea, chest pain, fever, cough, hemoptysis. [13,14]

Regarding the relation between treatment modality of the studied cancer patients and occurrence of pulmonary embolism. We found that 15 patients (75.0%) were treated with chemotherapy developed pulmonary embolism; 5 patients (25.0%) were treated with hormonal therapy developed pulmonary embolism. None of the patients received combined radio and chemotherapy therapy developed pulmonary embolism. And this difference was statistically significant, P value is 0.013.-Agnelli G et al., [15] reported that radiotherapy was used by 10.1 % of cases and 5.9 % of controls; no association with VTE risk was observed (OR 1.63; 95 % CI 0.84–3.16). No significant association was also observed for chemotherapy (OR = 0.95), hormonal therapy (OR 0.75).

Also, Lyman GH et al.,[16] reported that cancer treatments including chemotherapy and radiation therapy were not significantly associated with VTE. [15,16]

Conclusion

In the present study we found that the most common causes of chest pain were pleural effusion, then pneumonia and pulmonary embolism. We concluded that HRCT and CTPA were helpful tools of choice in evaluating the cause of chest pain in oncologic patients.

References

1. Reamy B V, Williams PM, Odom MR Pleuritic chest pain: sorting through the differential diagnosis. Am Fam Physician. 2017;96(5):306–12.

2. Chan J, Ho B, Ye K, Haramati LB, Jain VR. Using Routine Chest Computed Tomography to Diagnose Pulmonary Embolism. J Comput Assist Tomogr. 2022;46(6):888–93.
3. Ahuja J, Palacio D, Jo N, et al., Pitfalls in the imaging of pulmonary embolism. In: Seminars in Ultrasound, CT and MRI. Elsevier; 2022.
4. Uhrig M, Simons D, Schlemmer H-P. Incidental pulmonary emboli in stage IV melanoma patients: prevalence in CT staging examinations and improved detection with vessel reconstructions based on dual energy CT. PLoS One. 2018;13(7): e0199458.
5. Clements W, McMahon GAL, Joseph T, et al., Risk stratification of emergency department patients with acute pulmonary thromboembolism: Is chest pain a reason to investigate? J Med Imaging Radiat Oncol. 2021;65(7):864–8.
6. Li W, Chen C, Chen M, et al., Pulmonary embolism presenting with itinerant chest pain and migratory pleural effusion: A case report. Medicine (Baltimore). 2018;97(22).
7. Samra SR, Said AM, Elsayed DH, Elhamed MEA, HAbeb MA. The incidence and clinical characteristics of pulmonary embolism in oncologic patients. Egypt J Bronchol. 2022;16(1):64.
8. Shinagare AB, Guo M, Hatabu H, Krajewski KM, Andriole K, Van den Abbeele AD, et al., Incidence of pulmonary embolism in oncologic outpatients at a tertiary cancer center. Cancer. 2011;117 (16):3860–6.
9. Alshumrani G, Mousa WF. Diagnostic yield of CT pulmonary angiography for pulmonary embolism in clinically suspected patients. Medicine (Baltimore). 2021; 100(22).
10. Abdol Razak NB, Jones G, Bhandari M, Berndt MC, Metharom P. Cancer-associated thrombosis: an overview of mechanisms, risk factors, and treatment. Cancers (Basel). 2018;10(10):380.
11. Browne AM, Cronin CG, English C, NiMhuircheartaigh J, Murphy JM, Bruzzi JF. Unsuspected pulmonary emboli in oncology patients undergoing routine computed tomography imaging. J Thorac Oncol. 2010;5(6):798–803.
12. King V, Vaze AA, Moskowitz CS, Smith LJ, Ginsberg MS. D-dimer assay to exclude pulmonary embolism in high-risk oncologic population: correlation with CT pulmonary angiography in an urgent care setting. Radiology. 2008;247(3):854–61.
13. Qanadli SD, Hajjam M El, Mesurolle B, Barré O, Bruckert F, Joseph T, et al., Pulmonary embolism detection: prospective evaluation of dual-section helical CT versus selective pulmonary arteriography in 157 patients. Radiology. 2000; 217(2):447–55.
14. Fujieda K, Nozue A, Watanabe A, Shi K, Itagaki H, Hosokawa Y, et al., Malignant tumor is the greatest risk factor for pulmonary embolism in hospitalized patients: a single-center study. Thromb J. 2021;19(1):1–7.
15. Agnelli G, Verso M, Mandalà M, Gallus S, Cimminiello C, Apolone G, et al., A prospective study on survival in cancer patients with and without venous thromboembolism. Intern Emerg Med. 2014;9:559–67.
16. Lyman GH. Impact of venous thromboembolism on survival in patients with advanced cancer: an unmet clinical need. Intern Emerg Med. 2014;9:497–9.