

Role of Multidetector CT in Evaluation of Acute Chest Pain: Non-Cardiac Vascular and Pulmonary Causes

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Abstract:

Background: Triage of patients with acute chest pain is one of the most important issues currently facing physicians in the emergency department. Acute chest pain may be a symptom of a number of serious conditions and is generally considered a medical emergency. The causes of acute chest pain range from non-serious to life threatening. A rapid, accurate and cost-effective approach for the evaluation of emergency department patients with chest pain is needed.

Aim of the work: This work aims to emphasize the role of multidetector CT in assessment of non-cardiac vascular and pulmonary causes of acute chest pain.

Method: The studied group included 89 patients (59 men and 30 women) presented by acute chest pain. All patients were subjected to MDCT and/or MDCT angiography using a Toshiba 64 detectors CT scanner.

Results: The high spatial resolution and relatively non-invasive nature make MSCT angiography a strong and serious competitor to established vascular imaging techniques. Having the additional ability to simultaneously acquire information on other organs, which enables the early diagnosis of complications.

Conclusion: Continued technical improvements in acquisition speed and spatial resolution of computed tomography images, and development of more efficient image reconstruction algorithms which reduce patient exposure to radiation and contrast result in increased popularity of MDCT.

Keywords: Acute chest pain, Aortic dissection, Pulmonary embolism, Pneumothorax, Computed tomography angiography.

Introduction

Chest pain is one of the most common presenting symptoms for patients coming to the emergency department (ED)⁽¹⁾.

As the spectrum of acute chest pain causes is broad and not all life threatening causes are of cardiac origin. Our study concerned with non-cardiac vascular and pulmonary causes. Pulmonary causes of chest pain include: pulmonary embolism, pneumonia, pneumothorax, tension pneumothorax and pleurisy while vascular causes include acute aortic syndrome⁽²⁾.

The proper diagnosis of the cause of chest pain in ED patient is further complicated by the often difficult challenge of recognizing patients who have an acute aortic syndrome (AAS), or pulmonary embolus (PE), which, while less frequent than acute coronary syndrome (ACS), necessitate rapid diagnosis for institution of

potentially life saving treatment that is markedly different than treatment for ACS⁽³⁾.

The consequences of diagnostic failure are extremely serious and have resulted in expensive, time consuming strategies to categorize patients presenting to the ED with acute chest pain. There is a clear need for an accurate, rapid and economical way to reduce unnecessary admissions without compromising the care of patients in need^(4,5).

Patients & Methods

The studies were performed with 64 slice, multidetector CT scanner (Toshiba, Aquilion) over a period of two years on 89 patients with acute chest pain, 59 men and 30 women. The mean age of patients was 47 years, with a maximum of 77 years and minimum of 13 years.

Patients were referred from emergency room, CCU and ICU in Nasr City Health Insurance Hospital.

After taking consents from all patients or their first degree relatives in unconscious and emergency cases, patients usually fast 4-8 hours before the procedure.

In certain situations, we acquire the images with ECG cardiac gating in order to reduce the movements caused by the cardiac cycle.

Initial Assessment

Triage of acute chest pain is based on a detailed history, a focused physical examination, an initial 12-lead electrocardiogram (ECG), and measurement of serum biochemical markers for myocardial necrosis (Troponin) or coagulation (D-dimer). Careful attention to this initial assessment guides appropriate selection of further testing and/or urgent treatment for higher risk patients and can help avoid unnecessary testing in low-risk patients^(6,7).

The clinician also must consider other causes of chest pain that may mimic ACS, such as PE and AAS, which are less common than ACS, but can be immediately life-threatening. Women, older patients, and those with a history of venous thromboembolism, immobilization, estrogen treatment, cancer, or clotting disorders are at increased risk for PE. Older men and patients with connective tissue disorders such as Marfan syndrome, bicuspid aortic valve, coarctation of the aorta, inflammatory diseases such as Takayasu arteritis, cocaine use, trauma such as coronary artery bypass grafting from the aorta, intra-arterial catheterization or blunt chest injuries, including automobile accident, are more likely to have aortic dissection. AAS and PE often present with subtle manifestations, making an early diagnosis notoriously difficult. Clinicians should maintain a high clinical index of suspicion based on detailed history and physical examination. Normal D-dimer levels, which are breakdown products of fibrin, are most helpful in excluding the presence of PE and aortic dissection. However, D-dimer is nonspecific, and may be elevated in many other conditions

besides PE and aortic dissection, When positive, further testing is necessary to make a definitive diagnosis⁽⁸⁻¹⁰⁾.

MDCT in the ED

After initial triage, several diagnostic techniques may be helpful in assessing patients who have acute chest pain of indeterminate cause.

Cardiac gating and rapid image acquisition are advantageous in imaging the pulmonary arteries and aorta, as artifacts caused by breathing and motion of the great vessels during the cardiac cycle can be avoided. As CT has many robust non-cardiovascular applications for evaluation of ED patients, MDCT scanners are now found in or near the ED in many hospitals. The immediate availability of MDCT has heightened the attractiveness of CTA using MDCT to evaluate acute chest pain⁽¹¹⁾.

MDCT also provide insight into non-coronary causes of chest pain, with the ability to simultaneously image the other part of the thorax and upper abdomen. MDCT has very high accuracy in demonstrating pneumothorax, pneumonia, malignancies, pulmonary airspace disease, and hiatal hernia. CTA is the imaging modality of choice for suspected PE and aortic pathology such as dissection or aneurysm⁽¹²⁻¹⁴⁾.

Clinical Applications:

Acute Aortic Syndrome:

Including aortic dissection, intramural hematoma, penetrating aortic ulcer and dissecting aneurysm.

Dissection:

Dissection is characterized by a tear in the intima layer, which lets the blood flow enter the middle layer, causing double lumen of the vessels.

The main predisposing factor is hypertension; other associated conditions include connective tissue disorders, congenital valve defects, aneurysms, coarctation⁽¹⁵⁻¹⁷⁾. It is considered acute when the development of the process takes less than two weeks⁽¹⁸⁾.

Regarding the anatomical extent, the Stanford classification is the most widely used nowadays:

© **Type A:** It involves the ascending aorta irrespective of the site of the

primary intimal tear; it represents about 60% of the cases and requires surgical repair because of its potential fatal complications.

- ⊙ **Type B:** Its origin is located distal to the emergence of the left subclavian artery⁽¹⁹⁾.

The key and typical image of dissection is the presence of a tear or intimal flap dividing the vascular lumen into two; true and false lumina. CT features that generally indicate the true lumen are outer wall calcification, eccentric flap calcification, and continuity to a non-dissected portion of the aorta⁽²⁰⁾.

Intramural Hematoma:

Basically, it is an acute hemorrhage in the middle layer of the aortic wall, and its pathogenesis is still unclear.

The major pathophysiological mechanism is the spontaneous rupture of the vasa vasorum that feeds the middle layer. Another proposed theory is that of the thrombus in the false lumen of a classical dissection which does not show intima involvement⁽²¹⁾.

In MDCT, the typical finding is observed in the non contrast phase, in which crescent shaped hyperdensity of the aortic wall is visualized. A common finding is the medial displacement of intimal calcifications. When the angiographic phase is acquired, no intimal tear is demonstrated⁽²²⁾.

Penetrating Aortic Ulcer:

It is defined as an atherosclerotic lesion characterized by the erosion of the inner layer, with extended flow toward the media. It is important because it predisposes to intramural hematomas, dissection and even rupture⁽²³⁾.

The CT angiography shows a contrast collection outside the aortic lumen in an area that typically presents atheromatous wall thickening⁽²⁴⁾.

Aneurysms:

Aneurysms are defined as permanent focal (saccular) or diffuse (fusiform) dilatation in any aortic segment by 50% or more of the normal vessel diameter. True aneurysms involve the three layers of the aortic wall (intima, media and adventitia)⁽²⁵⁾.

At present, MDCT angiography is considered the reference standard for the evaluation of aneurysms, because it can accurately determine their extension, maximum diameters, wall features, presence of thrombus, wall calcifications and aspect of effective lumen⁽²⁶⁾.

Pulmonary Embolism:

Patient related predisposing factors include age, history of previous venous thromboembolism (VTE), active cancer, neurological disease with extremity paresis, medical disorders causing prolonged bed rest, such as heart or acute respiratory failure and congenital or acquired thrombophilia, hormone replacement therapy and oral contraceptive therapy⁽²⁷⁾.

Pulmonary embolism symptoms can vary greatly, depending on how much of lung is involved, the size of the clot and overall health especially the presence or absence of underlying lung disease or heart disease⁽²⁸⁾.

On CTPA, acute PE manifests either as arterial occlusion with failure to enhance the entire lumen due to a large filling defect, with the affected artery often being enlarged, or as centrally located partial filling defects⁽²⁹⁾.

The diagnostic criteria for acute PE include, first, complete arterial occlusion with failure to opacify the entire lumen and the artery may be enlarged in comparison with pulmonary arteries of the same order of branching; second, a central arterial filling defect surrounded by IV contrast material; and third, a peripheral intraluminal filling defect that makes an acute angle with the arterial wall.

The diagnostic criteria for chronic PE include complete occlusion of a vessel that is permanently smaller than the pulmonary arteries of the same order of branching, a peripheral eccentric filling defect that makes an obtuse angle with the vessel wall, contrast material flowing through apparently thick walled arteries that are smaller due to recanalization, and a band or web in a contrast filled artery⁽³⁰⁾.

Pneumothorax:

The term pneumothorax denotes air in the pleural space. This is a potential space and not an actual space, because the

visceral and parietal layers of the pleura are held in contact by the surface tension of their moist surfaces⁽³¹⁾.

If air is present in the pleural space, one of three events must have occurred: 1) communication between alveolar spaces and pleura; (2) direct or indirect communication between the atmosphere and the pleural space; or (3) presence of gas producing organisms in the pleural space⁽³²⁾.

Pneumothorax is classified according to aetiology into spontaneous, traumatic and iatrogenic pneumothorax.

A pneumothorax is classically seen as an area of absent lung markings between the bony thoracic cage and the edge of the lung.

In a major collapse, the lung appears as a globular mass at the hilum, the density proportional to the degree of collapse, and there may be mediastinal shift to the opposite side. A tension pneumothorax usually displaces the mediastinum to the opposite side. A major degree of collapse of one lung usually results in increased blood flow and congestion in the other with appearances which may simulate lobular pneumonia⁽³¹⁻³²⁾.

Early recognition of tension pneumothorax is very important because an emergency thoracocentesis is the only treatment and is life saving. The presence of subcutaneous emphysema and pulmonary contusions highly predicts for the presence of an underlying pneumothorax⁽³³⁾.

Pleurisy:

Pleuritis, the classic condition causing pleuritic chest pain, results from acute pleural inflammation. Pleuritis usually is caused by lower respiratory infections, although other causes, such as autoimmune disease, are possible.

Pleurisy can develop many ways, including: pleural effusion, lung infection, pulmonary embolism, pleural cancer, lung cancer, rheumatic fever and connective tissue disorders.

Pleurisy typically causes a sharp chest pain (pleuritic chest pain) that worsens with breathing in or coughing. The pain may start and remain in one specific area of the chest wall, or it may spread to

the shoulder or back. Depending on its cause, pleurisy can be associated with an accumulation of fluid in the space between the lungs and chest wall called a pleural effusion, or it can be dry pleurisy, which has no fluid accumulation⁽³⁴⁾.

Mesothelioma:

CT is the primary imaging modality used for the evaluation of malignant pleural mesothelioma (MPM). Key CT findings that suggest MPM include unilateral pleural effusion, nodular pleural thickening, and interlobar fissure thickening. Growth typically leads to tumoral encasement of the lung with a rindlike appearance. Calcified pleural plaques are found at CT in approximately 20% of patients with MPM and may become engulfed by the primary tumor, causing the tumor to mimic calcified MPM.

The tumor can rigidly encase the lung, causing compression of lung parenchyma, diaphragm elevation, intercostal space narrowing, and mediastinal shift toward the tumor.

The tumor extent along the pleural surfaces and into the mediastinum, diaphragm, or chest wall can be evaluated much better with CT scanning than plain radiography. Chest wall invasion manifests as obliteration of fat planes or chest wall nodules⁽³⁵⁾.

Pneumonia:

Pneumonia is an inflammatory condition of the lung affecting primarily the microscopic air sacs known as alveoli. Pneumonia fills the lung's alveoli with fluid, hindering oxygenation. It is usually caused by infection with viruses or bacteria and less commonly other microorganisms, certain drugs and other conditions such as autoimmune diseases⁽³⁶⁾.

Typical symptoms include a cough, chest pain, fever and difficulty breathing.

Confident diagnosis is based on the presence of ground glass opacities, areas of air-space consolidation, areas of consolidation and nodules. High resolution CT is of limited value in the differential diagnosis of the various types of infective pneumonia⁽³⁷⁾.

Discussion

Acute chest pain is pain of (1) recent onset, typically < 24 hours, which causes the patient to seek prompt medical attention; (2) with location on the anterior thorax; and (3) with a sensation distressing to the patient⁽³⁸⁾.

Chest pain is one of the most common presenting symptoms for patients coming to the emergency department (ED)⁽³⁹⁾.

Although acute chest pain (ACP) is frequent, the work up of those patients remains a major clinical challenge for the following two reasons: (1) Many of the pathologies leading to acute chest pain are potentially life-threatening and require instant diagnosis and treatment such as acute coronary syndrome, acute aortic syndrome, pulmonary artery embolism, pericardial tamponade, tension pneumothorax, and esophageal rupture. (2) A great number of different thoracic, abdominal, musculoskeletal, and even psychiatric disease can present as ACP, which makes the differential diagnosis difficult.

As the spectrum of acute chest pain causes is broad and not all life threatening causes are of cardiac origin, our study concerned with non cardiac vascular and pulmonary causes.

So, the major goals of the diagnostic pathway in ACP patients under emergency conditions are twofold, i.e., identifying potentially acute life threatening disease and clarify the broad spectra of differential diagnosis to direct the patient's way on the correct track immediately⁽⁴⁰⁾.

Multidetector CT has excellent accuracy in demonstrating non cardiac causes of chest pain, including pneumothorax, pneumonia, malignancies, pulmonary airspace abnormalities, and interstitial lung disease. Pericardial effusions, thickening, and calcifications are seen far more readily than with radiography alone. In the setting of undifferentiated chest pain, CT angiography (CTA) with its high sensitivity and specificity can be considered the modality of choice to diagnose suspected PE or aortic pathology such as aortic dissection or aneurysm⁽⁴¹⁾.

The majority of chest pain causes in this study was due to pulmonary etiologies detected in 71 (80%) of 89 cases while vascular causes detected in 18(20%) only.

Among life threatening causes, pulmonary embolism was the most common cause encountered through out the period of our study and was detected in 13(14.6%) of 89 cases.

Computed tomographic pulmonary angiography (CTPA) has become the standard of care for the evaluation of patients with suspected pulmonary embolism (PE) in most institutions⁽⁴²⁾.

Torbicki et al.⁽⁴³⁾, who mentioned that PE and DVT are two clinical presentations of venous thromboembolism (VTE) and share the same predisposing factors. They also, reported that in about 70% of patients with PE, DVT can be found in the lower limbs. In contrast 9 cases (69%) of 13 cases in our study were diagnosed as idiopathic PE while only 4 (31%) cases were secondary to LL DVT, these results may be due to lack of sensitive diagnostic methods were used.

Torbicki et al.⁽⁴³⁾ stated that the mean age of patients with acute PE is 62 years; about 65% of patients are aged 60 years or older, while in our study, 9 (69%) cases were below 60 years and 4 (31%) cases above.

Baptista et al.⁽⁴⁴⁾ stated a majority of females (53.8%) with dyspnea reported as the most common presentation that associated with pain (69.2%) our results are in agreement with those of **Baptista et al.** as dyspnea detected in 9 (69%) of 13 cases with predominance of female gender 7 (54%) cases.

13 (100%) of PE cases in our study were identified as acute PE which confirmed by CTPA.

As reported by **Lee et al.**⁽⁴⁵⁾, the pulmonary thrombus was demonstrated in main pulmonary arteries in 50 (48.5%) cases, lobar arteries in 24 (23.3%) cases and segmental arteries in 23 (22.35) of cases with more involvement of right lung than left and lower lobe involvement more than others. Our study showed different results as pulmonary thrombus was demonstrated in main pulmonary arteries 13 (100%) cases of PE, 8 (61.5) cases in labor and 4 (31%)

segmental arteries with equal affection of both lung side and more involvement of lower lobes, these different obtained results may be due to limited number of PE cases which delivered to our ED throughout the period of the study.

During evaluating cases with suspected PE, none of the MDCT scans were ECG gated.

In this study, the second most common life threatening cause of acute chest pain was aortic dissection and dissecting aneurysm (AD/DA) which present in 12 (13.4%) of 89 cases.

CTA imaging provides excellent diagnostic accuracy for acute Aortic diseases (AAD) and allows the full extent of the acute dissection to be visualized non invasively, also it is currently the most frequently used imaging modality for diagnosing AAD and most often the initial test to be done when ADD is suspected⁽⁴⁶⁾.

In this study, 12 (67%) cases were diagnosed as aortic dissection, 5 of which were dissection alone and the remaining 7 cases were associated with an aneurysm. In all 12 cases diagnosis was achieved after the detection of an intimal flap dividing the aortic lumen into false and true.

In 7 cases (58%) the false lumen was thrombosed. The dissection was seen extending to the branches of the arch in two cases (16.6%) and involvement of Abdominal Aorta and its branches in 7 cases (58%).

Regarding complications associated with different types of AD, the diagnosing imaging results showed predominant presence of pericardial and pleural effusion (34%) with type A AAD while thrombosed false lumen and extension to abdominal aorta were more with type B AAD (75%), while equal incidence of arch vessels involvement (8%) detected in type A and type B respectively.

We didn't encountered any cases that were diagnosed as Intramural hematoma

(IMH), this possibly because non enhanced CT was not done as a preliminary investigation for our patients, in order to lower the dose of irradiation to which they were exposed. The same for penetrating aortic ulcer (PAU), no case could be detected among period of this study, which may be attributed to limited number of cases presented to ED.

In our study we encountered 5 cases (5.6%) with tension pneumothorax, coming as the third cause of life threatening causes associated with acute chest pain. One case (20%) of the 5 cases is classified as iatrogenic pneumothorax, with 2 cases (40%) classified as traumatic pneumothorax and the rest 2 cases (40%) as secondary spontaneous pneumothorax, according to aetiological classification.

Traumatic pneumothorax had the highest incidence among all pneumothorax cases as it was identified in 14 (45%) cases, there were 11 cases (34%) with iatrogenic pneumothorax, CT guided needle biopsy encountered for 82% of iatrogenic pneumothoraces and this agree with **Min et al.**⁽⁴⁷⁾, who reported that pneumothorax is the most common complication of transthoracic needle biopsy.

Spontaneous pneumothorax was detected in 6 cases (19%) with 5 (83%) cases of secondary spontaneous pneumothorax (SSP) and only one case (17%) of primary spontaneous pneumothorax (PSP), different results were detected by **Sousa et al.**⁽⁴⁸⁾ as 36% of cases diagnosed as spontaneous pneumothorax, including 80% corresponding to PSP and only 20% corresponding to SSP, other authors such as **Sharma et al.**⁽⁴⁹⁾ described 70% for SSP and 30% for PSP; these differences should explain population from different studies.

Case [1]

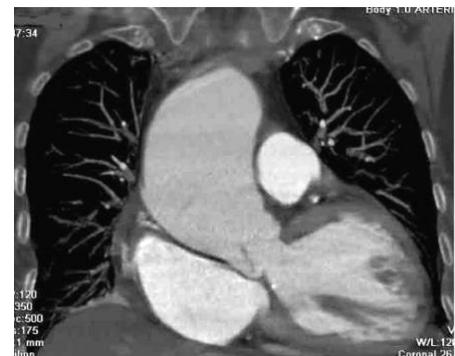
A 65 years old male patient, hypertensive, presented to the emergency room after attack of sudden severe chest and back pain followed by syncope and vomiting. CT brain and carotid duplex studies were free. CTA was recommended.

Axial CTA image showing aortic dissection of the ascending and descending aorta with thrombosed false lumen.



Case [2]

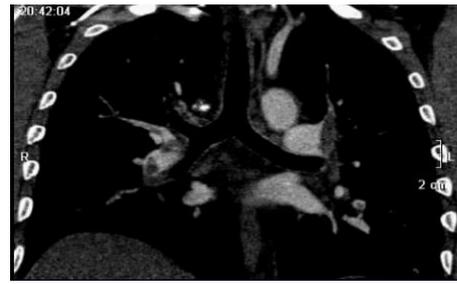
A 73 years old female patient presenting with chest pain and dyspnea on exertion. Chest X-ray revealed right sided mediastinal shadow. Further evaluation by CTA was recommended.



(a) & (b) Sagittal and coronal MPR reconstruction images demonstrating the aneurysm and its extension.

Case [3]

A 49 years old male patient with bilateral chest pain and dyspnea, CTPA was recommended as a part of diagnostic work up.



Multiple axial and coronal MPR scans showing bilateral pulmonary embolus involving both main pulmonary arteries with bilateral upper and lower main pulmonary A division and extending to segmental arteries. Normal caliber of pulmonary artery trunk, no evidence of Rt ventricular dilatation.

Case [4]

A 57 years old male patient, smoker, had not history of any chest medical condition, presented to ED with Rt sided chest pain and dyspnea of sudden onset. Non-enhanced CT chest axial cuts showed: Rt pneumothorax with underlying lung compression consolidation collapse (Tension Pneumothorax).



Conclusion

Continued technical improvement in acquisition speed and spatial resolution of computed tomography images and development of more efficient image reconstruction algorithms which reduce patient exposure to radiation and contrast result in increased popularity of MDCT.

MDCT provide insight into non-coronary causes of acute chest pain, with the ability to simultaneously image the other part of the thorax and upper abdomen.

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