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**Marwa Hesham Ellaboudy**
Department of Radiology, Faculty of Medicine, Tanta University, Tanta, Egypt

**Mohamed Ahmed Youssef**
Department of Radiology, Faculty of Medicine, Tanta University, Tanta, Egypt

**Rasha Mahmoud Dawoud**
Department of Radiology, Faculty of Medicine, Tanta University, Tanta, Egypt

**Ekhlas Abdelmonem Shaban**
Department of Radiology, Faculty of Medicine, Tanta University, Tanta, Egypt

**Corresponding Author:**
**Marwa Hesham Ellaboudy**
Department of Radiology, Faculty of Medicine, Tanta University, Tanta, Egypt

# Cardiac multi-slice computed tomography in evaluation of chest pain in hypertensive patients

**Marwa Hesham Ellaboudy, Mohamed Ahmed Youssef, Rasha Mahmoud Dawoud and Ekhlas Abdelmonem Shaban**

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**Abstract**
**Background:** Hypertension (HTN) is a major risk factor for coronary heart diseases (CHDs) and stroke. Coronary computed tomography (CT) enables physicians to visualize the coronary vascular system with high specificity and sensitivity.
**Aim of the work:** To evaluate the role of CT coronary angiography as a diagnostic tool in the assessment of chest pain in patients suffering from HTN.
**Patients and Methods:** This prospective study was carried out on 30 patients with HTN presented with acute chest pain. Heart rate should be < 70 beat/min bpm spontaneously or beta-blocker induced then the patients subjected to multi slice CT angiography of coronary arteries.
**Results:** 17 patients presented with typical chest pain (56.7%). The rest of were suffering from atypical chest pain (43.3%). The distribution of coronary lesions was: the most affected artery is the left anterior descending coronary artery followed by the right coronary artery. Sixty percent of patients had left anterior descending coronary lesion while 35 % had right coronary lesion. The left main coronary was affected in 20 % of patients. The left circumflex coronary was affected in 15 % of these patients. The ramus, D1, and D2 were the least affected. The non-coronary lesions were: aortic aneurysm (1 patient), pulmonary embolism (1 patient), and aortic dissection (1 patient).
**Conclusions:** Computed tomography angiography (CTA) is a good fast reliable non-invasive diagnostic aid for hypertensive patients with acute chest pain.

**Keywords:** Cardiac, multi-slice computed tomography, chest pain, hypertensive

## Introduction

Ischemia from coronary heart diseases is the leading cause of death according to recent data from the World Health Organization [1]. The prevalence of ischemic heart diseases is increasing globally due to many factors, such as the increasing prevalence of obesity and diabetes [2].

The ever-increasing rate of cardiac diseases leads to crowding at emergency departments, which might delay the diagnosis and effective intervention [3]. Therefore, it is clear that health care facilities need safe and rapid diagnostic tools to assess and manage patients presenting with acute chest pain [4].

There exists a range of diagnostic tools that are commonly used to assess cardiac pain [5]. There is a large body of literature that examine the role of non-invasive CT angiography as a diagnostic technique in the assessment of acute chest pain [6-8].

Coronary CT enables physicians to visualize the coronary vascular system with high specificity and sensitivity, yielding details about various anatomical abnormalities [9]. It is natural to ask whether non-invasive CT coronary angiography can provide an alternative to invasive cardiac catheterization, an uncomfortable procedure with more adverse effects [9, 10].

According to established guidelines, high-risk patients with high serum troponin, electrocardiogram (ECG) evidence of ischemia, or ST- segment elevation should not be assessed with non-invasive coronary computed tomography angiography (CCTA) [11].

The aim of this work was to evaluate the role of CT coronary angiography as a diagnostic tool in the assessment of chest pain in patients suffering from HTN.

## Patients and Methods

This prospective study was carried out on 30 patients which are 18 males and 12 females with HTN presented with acute chest pain and heart rate (HR) < 70 beat/min bpm spontaneously or beta-blocker induced and subjected to multi slice CT angiography of coronary arteries between July 2020 and January 2022 at diagnostic radiology and medical imaging department.

The study was done after approval from the local Ethical Committee. Signed consent was obtained from all patients included.

Exclusion criteria were hypersensitivity to the contrast media, renal impairment (Creatinine > 1.5), difficulties in performing CT like inadequate breath holding and heart failure, any documented arrhythmia and pregnant females.

All patients were subjected to chest X-Ray and echocardiography before CT examination, full history taking, vital signs monitoring before, during CT examination.

**Instructions:** Fasting 4-6 h before scan. Encourage water intake till one hour before scan, avoid caffeine products and smoking and exercise one day before scan, stop taking phosphodiesterase inhibitors used to treat erectile dysfunction or pulmonary HTN.

**Patient preparation:** Explanation of procedure with reassurance to relief anxiety, heart rate control (optimum HR below 65 bpm no medication given), patients with higher HR were given oral B-blockers one hour before the scan. At scanner room, patients were given gown to put on and then instructed to lie supine on scanner table with arms raised above their heads, ECG electrodes were applied to chest wall after skin preparation with alcohol and ECG trace was monitored, intra-venous (IV) cannula (16-22) in right antecubital vein was connected and test injection with saline was done.

**Contrast media injection:** Non-ionic contrast media "Iopromide" (Ultravist 370 mgI/ml; Bayer Healthcare, Berlin, Germany) was injected through the peripherally inserted, IV cannula using dual-head powered automatic injector (Stellant D, Medrad, Indianola, PA, USA) followed by 50 cc saline flushing. The amount of contrast material and injection flow rate was adapted according to patient body habitus and scan time as follows: contrast volume (in ml) = (scan time+ 10) x injection flow rate. The injection flow rates were adapted according to kV used; 100 kV: 4.0 ml/s, 120 kV: 5.0 ml/s & 135 kV: 6.0 ml/s.

**CT scan protocol:** All patients were scanned with 320-row multidetector CT scanner (Aquilion One, Toshiba Medical Systems, Otawara, Japan) installed at Tanta University Educational Hospital through these steps: Initial scanogram AP and lateral projection for automatic radiation dose calculation and for planning scan range from carina down to the apex of the heart, automatic bolus tracking technique was used to detect the arrival of contrast material at descending aorta. The ROI was placed at descending aorta at mid heart level with trigger threshold set at 230 HU. Repetitive low-dose monitoring examinations (120 kV, 50 mAs, 0.5-s scanning time) were performed 10 seconds after contrast medium injection began. When trigger threshold was reached, scan started immediately after breath holding command.

**Image acquisition:** Acquisition parameters: 0.35 s gantry rotation time, variable mA according to patient body habitus (range: 250-580 mA), variable kv according to patient body habitus (range: 80–135 kv). Prospective ECG gating was used with volume scanning method. Single heartbeat acquisition was routinely performed in those with heart rate below 65 bpm and the scan window was set at 70-80% of R-R interval. In those with heart rate ranged from 65 to 70 bpm, the scanning window was set to 30-80% of R-R interval to include end systolic phase.

Heart rate remained above 70 bpm at four (16.7%) patients due to suboptimal response to oral medications used and anxiety. In those patients, CT acquisition was done using multiple heart beats to improve temporal resolution with scanning window set manually to cover 30-80% of the R-R interval.

**Image-reconstruction:** Images were reconstructed at 0.5 mm slice thickness and 0.5 mm interval with smooth and sharp reconstruction kernels (FC03 and FC05 respectively) at 75% of R-R interval and at the best diastolic phase. The scan field of view was set to as small as possible for better spatial resolution.

**Post processing:** The reconstructed images were transferred to workstation (Vitrea Fx, Vital Images, USA) to form multiplanar reformatted images in axial, sagittal and coronal planes. Also, maximum intensity projection, 3D volume rendered images and curved planar reformations were obtained.

### Statistical analysis

Statistical analysis of the present study was conducted by SPSS V.20. Qualitative data was presented using number and percentage. Quantitative data was presented as mean and standard deviation (SD). For categorical variables, Chi-square test was used for analysis and when it was found inappropriate, it was replaced by Monte Carlo or Fisher exact test. The level of significance was adopted at $p<0.05$.

## Results

This prospective study was carried out on 30 hypertensive patients presented with acute chest pain (18 males and 12 females). Demographic data of the studied patients listed in Table 1. Associated co-morbidities were DM and hyperlipidaemia (Figure 1. A), CT was abnormal in 23/30 patients (Figure 1.B).

As regard to type of chest pain: 17/30 patients (56.7%) presented with typical chest pain and 43.3% of patients suffered from atypical chest pain. Coronary lesions were found in 20 patients out of 30 subjects. Some presented with more than one coronary lesion. The most affected artery was the left anterior descending coronary artery followed by the right coronary artery. 60 % of patients had left anterior descending coronary lesion while 35 % had right coronary lesion. The left main coronary was affected in 20 % of patients. The left circumflex coronary was affected in 15 % of these patients. The ramus, D1, and D2 were the least affected. The non-coronary lesions in the study sample, out of our 30 patients' sample, were only 3 patients who had non coronary diseases representing 9.9% of total cases. The non-coronary lesions were: aortic aneurysm (1 patient (3.3 %)), pulmonary embolism (1 patient (3.3 %)), and aortic dissection (1 patient (3.3 %)). The degree of stenosis in

coronary artery lesions varied in patients (Table 2).

There is a strong correlation between age, non-controlled clinical HTN, abnormal CT finding and typical chest pain ($p$<0.05). There was no significant correlation between gender, diabetes mellitus (DM), hyperlipidemia, smoking and typical chest pain. Table 3

There is a stronger correlation between HTN, DM, hyperlipidemia and coronary disorder ($p$<0.05). There was no significant correlation between age, gender, smoking and coronary disorder. Table 4

A 44 year-old male patient, hypertensive, diabetic presented with typical chest pain, palpitstions and exertional shortness of breath. MSCT angiography shows (A) CR image shows mixed calcified atherosclerotic plaque extends from the proximal to the middle LAD with focal area of at least 70% stenosis. (B) CR image shows small non-dependent, mild atherosclerotic disease in RCA. Figure 2 A 64 year-old female patient hypertensive, diabetic presented with atyoical chest pain, nausea and vomiting. MDCT shows (A) CR image shows RCA with mild atherosclerotic disease with focal area of stenosis at the origin of PDA. (B) CR image shows LAD with extensive calcified atherosclerotic plaques at proximal part 70-80% stenosis. (C) Axial image shows extensive calcification in LAD and LCx.Figure 3

47 year-old patient, hypertensive, diabetic, previous pulmonary TB treated more than 2 years ago, active smoker presented with acute typical chest pain MDCT shows (A) CR image RCA shows extensive atherosclerotic disease. Focal circumferential calcified plaque noted at RCA causing artefacts obscuring the lumen (B)Axial image shows extensive calcified and non-calcified plaques with a large plaque in the LAD (C) CR image shows extensive atherosclerotic plaques are noted. Significant stenosis at LCx. Figure 4

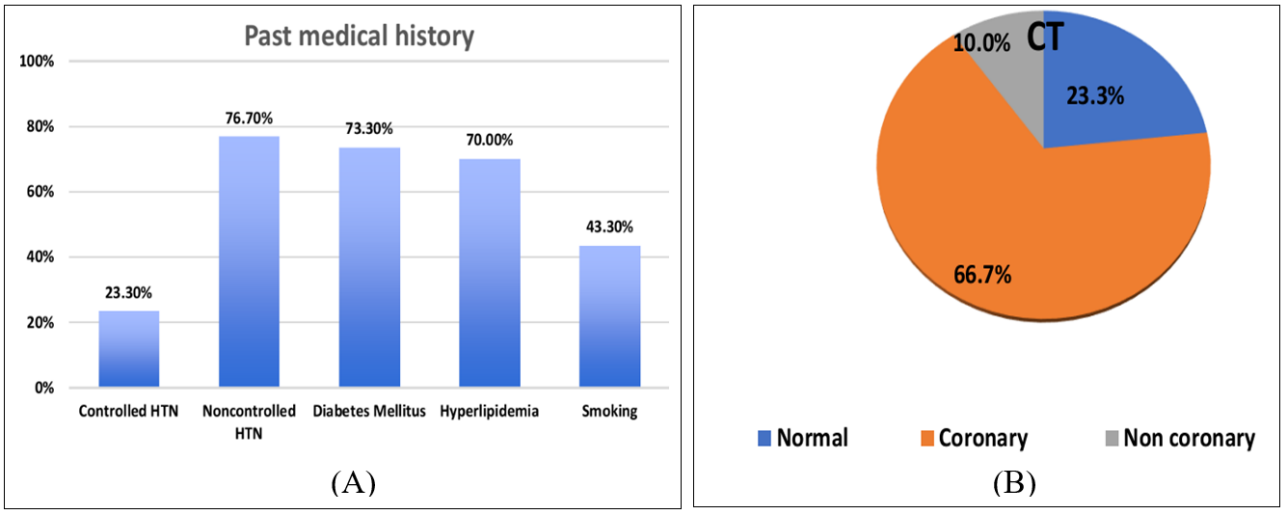


**Fig 1:** A) Past medical history, (B) CT findings among study patients.

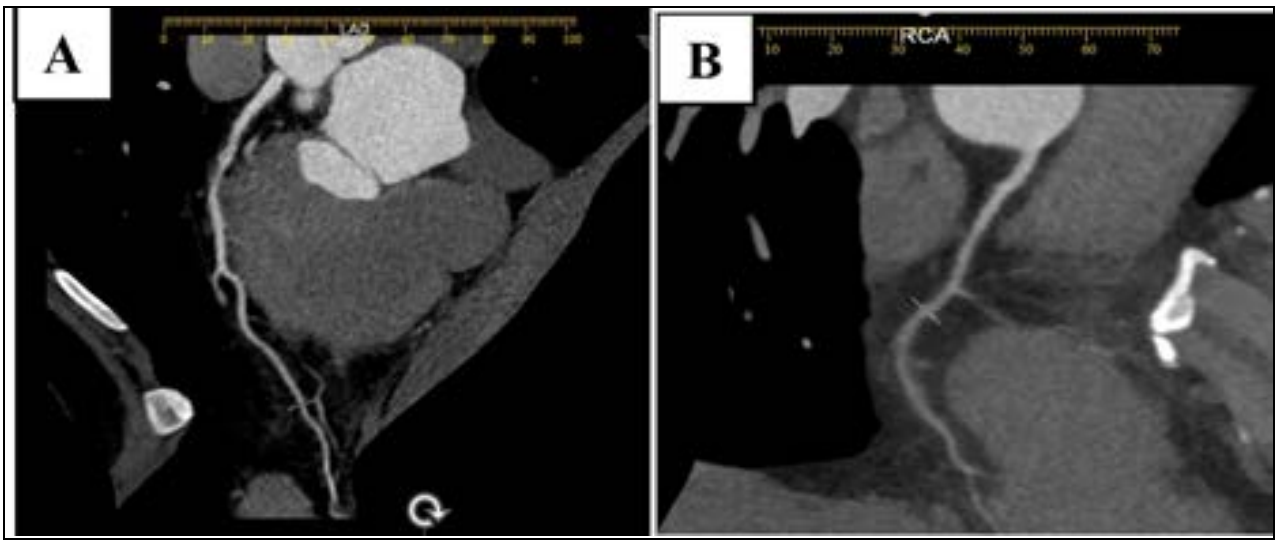


**Fig 2:** (A) CR image shows mixed calcified atherosclerotic plaque extends from the proximal to the middle LAD with focal area of at least 70% stenosis. (B) CR images shows small non-dependent, mild atherosclerotic disease in RCA.

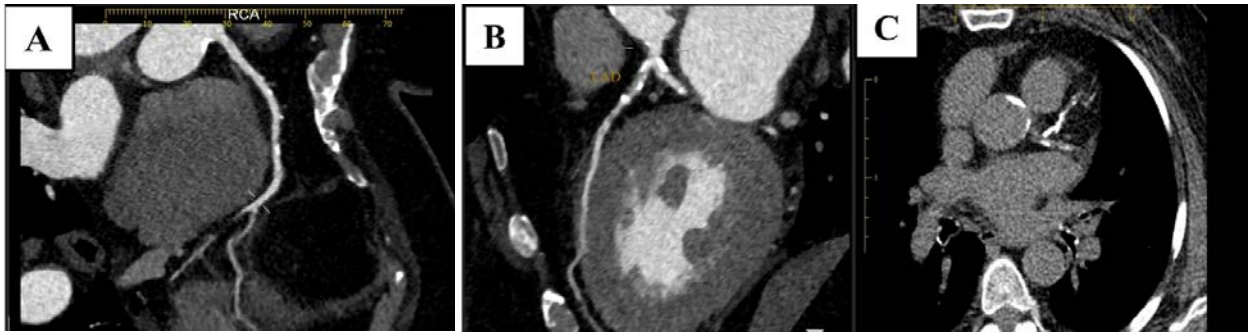


**Fig 3:** (A) CR image shows RCA with mild atherosclerotic disease with focal area of stenosis at the origin of PDA. (B) CR image shows LAD with extensive calcified atherosclerotic plaques at proximal part 70-80% stenosis. (C) Axial image shows extensive calcification in LAD and LCx.

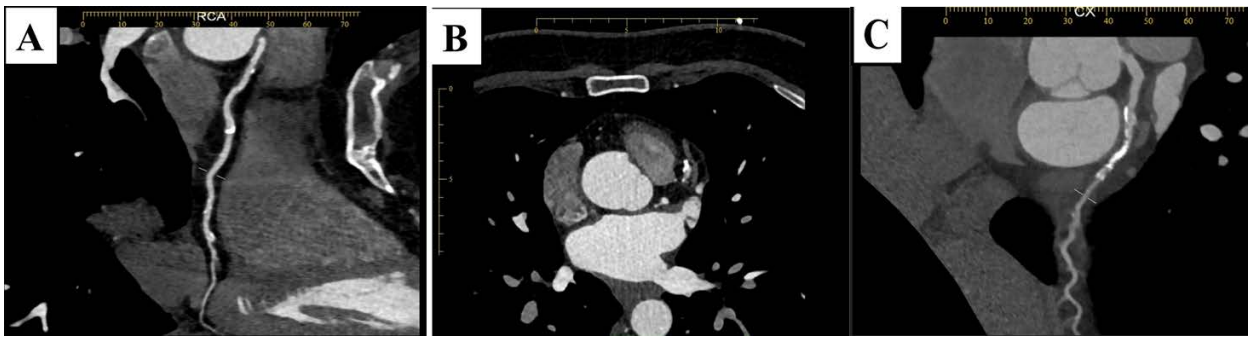


**Fig 4:** (A) CR image RCA shows extensive atherosclerotic disease. Focal circumferential calcified plaques noted at RCA causing artefacts obscuring the lumen (B). Axial image shows extensive calcified and non- calcified plaques with a large plaque in the LAD. (C). CR image shows extensive atherosclerotic plaques are noted. Significant stenosis at LCx

**Table 1:** Demographic data of the studied patients

| | | **N=30** |
|---|---|---|
| **Age** | | 49.9 ± 11.1 |
| Gender | Males | 18 (60 %) |
| | Females | 12 (40 %) |
| Typical chest pain | | 17 (56.7 %) |
| Atypical chest pain | | 13 (43.3 %) |
| Coronary | Right coronary | 7 (35 %) |
| | Left main coronary | 4 (20 %) |
| | Left anterior descending coronary | 12 (60 %) |
| | Left circumflex coronary | 3 (15 %) |
| | D1 | 1 (5 %) |
| | D2 | 1 (5 %) |
| | Ramus | 1 (5 %) |
| Non coronary | Aortic aneurysm | 1 (3.3 %) |
| | Pulmonary embolism | 1 (3.3 %) |
| | Aortic dissection | 1 (3.3 %) |

Data are presented as mean ± SD or frequency (%).

**Table 2:** The degree of stenosis in coronary artery lesions varied in patients

| **Coronary** | **Non-significant stenosis < 50%** | **Significant stenosis ≥ 50%** |
|---|---|---|
| | **N (%)** | **N (%)** |
| Right coronary | 3 (10 %) | 4 (13.3 %) |
| Left main coronary | 2 (6.7 %) | 2 (6.7 %) |
| Left anterior descending coronary | 4 (13.3 %) | 8 (26.7 %) |
| Left circumflex coronary | 3 (10 %) | 0 (0 %) |
| D1 | 0 (0 %) | 1 (3.3 %) |
| D2 | 0 (0 %) | 1 (3.3 %) |
| Ramus | 1 (3.3 %) | 0 (0 %) |

Data are presented as frequency (%).

**Table 3:** Relation between demographic data, risk factor and typical chest pain

| | | Typical chest pain n=17 | Atypical chest pain n=13 | P |
|---|---|---|---|---|
| **Age** | | 55.5 ± 9.4 | 45.6 ± 10.7 | 0.012* |
| Gender | Males | 9 (50 %) | 9 (50 %) | 0.367 |
| | Females | 8 (66.7 %) | 4 (33.3 %) | |
| Hypertension | Controlled | 2 (6.65 %) | 5 (16.6 %) | 0.037* |
| | Not controlled | 15 (50 %) | 8 (26.6 **%)** | |
| Diabetes Mellitus | | 12 (40 %) | 10 (33.3 %) | 0.203 |
| Hyperlipidemia | | 11 (36.6 %) | 10 (33.3 %) | 0.413 |
| Smoking | | 8 (26.6 %) | 5 (16.6 %) | 0.602 |
| CT | Abnormal | 15 (50 %) | 8 (26.6 %) | 0.047* |

Data are presented as mean ± SD or frequency (%), *significant as $p<0.05$. CT: Computed Tomography.

**Table 4:** Relation between demographic data, risk factor and coronary disorder

| | | Coronary n=20 | | Non-coronary n=3 | | P |
|---|---|---|---|---|---|---|
| Age | | 49.3 ± 10.9 | | 51.6 ± 12.4 | | 0.645 |
| **Gender** | Males | 12 (85.7 %) | | 2 (14.3 %) | | 0.312 |
| | Females | 8 (88.9 %) | | 1 (11.1 %) | | |
| **Hypertension** | Controlled | 4 (17.4 %) | | 2 (8.7 %) | | 0.026* |
| | Not controlled | 16 (69.6 %) | | 1 (4.3 %) | | |
| Diabetes Mellitus | | 12 | 52.2 | 3 | 13.0 | 0.042* |
| Hyperlipidemia | | 13 | 56.6 | 1 | 4.3 | 0.044* |
| Smoking | | 10 | 43.5 | 0 | 0.0 | 0.559 |

Data are presented as mean ± SD or frequency (%), *significant as $p<0.05$. CT: Computed Tomography.

## Discussion

HTN is also one of the most common and influential risk factors of cardiovascular disease including myocardial infarction, cerebral stroke, congestive heart failure, peripheral vascular disorders, and kidney disease [12]. It has been estimated that eliminating high blood pressure would reduce the occurrence of stroke by 35% and heart attacks by 18% [13, 14].

The CT findings seen in our study showed that around 23 % of the subject did not show any CT evidence of abnormal pathology, despite the fact that they had acute chest pain. The majority of abnormal CT findings had coronary origins, mostly related to stenotic lesions in the left anterior descending coronary artery. Non-coronary CT abnormalities are due to aortic dissection, aortic aneurysm, and pulmonary embolism.

Our study confirms a significant correlation between clinical HTN and positive CT findings which was more significant in non-controlled hypertensive patients with typical chest pain. This is consistent with the findings in Zeina *et al.* [15] and in Schuijf *et al.* [16]. In Zeina [15], they found that coronary artery disease (CAD) of the obstructive type was twice as common in hypertensive patients and that the severity of CAD is positively correlated with the duration of HTN. In our study, we did not investigate this relationship.

While, in Schuijf *et al.* [16], they found that non-invasive CT imaging resulted in an accurate diagnosis in 90 % of patients. It can then be concluded that CTA is better as a first line diagnostic modality because it is non-invasive and therefore is not associated with complications.

Our study showed significant correlation between DM and positive CT findings. Moreover, CT findings in those patients were significantly detected in the coronary arteries.

In agreement with us, Tomizawa *et al.* [17] found that DM is correlated with high-risk plaque accumulation. DM was also associated with obstructive and extensive CAD.

In Jiang *et al.* [18] study, they found that patients with comorbid DM and HTN showed more segmental stenosis, calcified and non-calcified plaques. Multi-vessel disease was also more prevalent in patients suffering from comorbid conditions. While in Krul *et al.* [19] they concluded that although the prevalence of CAD in patients with atypical chest pain and DM did not differ from that in non-DM, patients with DM with CAD had more advanced CAD than patients without DM which was detected by CT.

Interestingly, another parameter shows a positive correlation with CT finding is the co-existence of hyperlipidemia and HTN in patients within this study. In addition, the positive CT findings were prominent in coronary arteries rather than the non-coronary lesions.

In Tomizawa *et al.* [17] study, they found that, although the prevalence and extent of CAD was slightly higher in HTN patients than hyperlipidemic patients, low attenuation plaque was more frequent in hyperlipidemic patients than HTN patients.

The mean of age of the studied group in this context was about 55.5 in patients who had typical chest pain and about 45.5 in patients who had atypical chest pain. These results agree with several studies that considered the risk of developing CAD increases with age and includes age >45 years in men and >55 years in women [20].

No significant relation has been found between smoking and CT abnormalities. No correlations have likewise been identified between sex on one hand and CT findings on the other hand. However, a significant relation has been found between the existence of CT abnormalities and chest pain complaints, which suggests that CT is useful as a general strategy in elucidating the existence of coronary pathology in patients presenting with chest pain.

Correlations have been investigated between other parameters that do not involve CT findings as well. For example, significant correlations have been found between site of lesions (coronary or non-coronary) and HTN, DM and hyperlipidemia. In conclusion, the study reveals that there is an important association between positive CT findings and clinical HTN. It furthermore shows that CT

scanning is useful in revealing whether a coronary pathology exists in hypertensive patients presenting with acute chest pain.

Limitations: This study was performed at single centre, which makes it uncertain whether the results can be equally applied to other populations, there were male dominance in the study so the baseline characteristics contributed to the higher risk of CAD would be present. Patients with chronic kidney disease have higher risk for CAD but using ionized dye in performing MSCT carries high risk for developing contrast induced nephropathy or even renal failure, so those population was excluded from our study making us to miss a group of subjects with high prevalence of CAD. Patients with any types of arrhythmias are excluded from our study due to motion artifaction which can be due to prospective ECG- triggered CT to lower radiation exposure, those patients may be part of CAD inducing arrhythmia.

## Conclusions

CTA is a good fast reliable noninvasive diagnostic tool for patients with acute chest pain. There is a strong correlation between uncontrolled HTN and abnormal coronary CT findings in patients with acute chest pain.

## Conflict of Interest

Not available

## Financial Support

Not available

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