

# The Role of Triple Rule-out CT in an Indian Emergency Setting

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## ABSTRACT

**Background:** Emergency physicians are acutely aware of the consequences of missing fatal diagnoses for acute non-traumatic chest pain and subjecting patients to over-testing. In the large arsenal of tests that are available to us, a triple rule-out computed tomography (TRO-CT) Angiography is often less pursued, due to concerns about their efficacy and safety or because of nescience. We aim to find the yield of the test in an Indian emergency setting and impart some knowledge about it along the way.

**Materials and methods:** Twenty-six patients who presented to the emergency department of our institute with acute chest pain, with non-specific electrocardiogram (ECG) findings and negative serial troponin I, underwent TRO-CT. HEART scores of all patients, calculated at their presentation, were correlated with TRO-CT findings.

**Results:** Triple rule-out computed tomography angiography was positive in 5 patients (20%), of which 4 cases (16%) were diagnosed to have significant coronary artery disease and one had an acute pulmonary embolism. All 4 patients who had significant coronary artery disease (CAD) diagnosed by TRO-CT had a HEART score of intermediate risk. The mean effective radiation dose of the entire TRO study was  $19.024 \pm 3.319$  mSv (range = 13.89–25.95 mSv).

**Conclusion:** Triple rule-out CT angiography is a useful tool in the evaluation of patients presenting with acute chest pain in the emergency and can be an important adjunct in ruling out significant CAD in intermediate-risk patients. Emergency physicians and young residents need to know about this tool in their armamentarium to tackle doubtful cases.

**Keywords:** Coronary artery disease, Computerized tomography angiography, Emergency medicine.

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## HIGHLIGHTS

- Rationality for the use of TRO-CT in Indian emergency settings.
- Triple rule-out CT, its significance and safety concerns, and what to know for emergency residents and physicians.

## INTRODUCTION

Emergency departments provide time-sensitive and life-saving care to patients in need. There is a significantly high emergency disease burden in India and correspondingly high associated mortality and disability-adjusted life years (DALY).<sup>1</sup> Non-communicable diseases, mainly cardiovascular diseases remain one of the most common entities that add to this burden.<sup>2</sup> It was noted that about 80% of the Indian study population had two or more risk factors for cardiovascular diseases in urban areas and unlike high-income countries, they are more likely to be a cause of death among our younger population.<sup>3</sup> Acute non-traumatic chest pain is one of the common causes of emergency visits in India and has become a cause of concern among patients and physicians.<sup>4</sup>

The differential diagnosis of acute non-traumatic chest pain is a challenge to emergency physicians, as they can include life-threatening conditions like acute coronary syndrome, pulmonary embolism, and aortic dissection. Emergency physicians will have to be able to pick these fatal differentials early and exclude other nefarious and minor differentials. Missing these differentials can result in catastrophic outcomes for the patient and consequently for emergency physicians. Diagnosis of about 2% of cases of ACS

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are missed in emergency departments and subsequently, patients are discharged home.<sup>5</sup> This leads to significant malpractice liability for physicians.<sup>6</sup> The ever-vigilant physicians, wary of missing the diagnosis and in fear of malpractice liability, thus sometimes subject even low-risk chest pain patients to an increased number of tests, which are often invasive. There needs to be a balance between the two, particularly in India, where there is a high out-pocket health expenditure and patients leaving emergency departments against medical advice due to fear of increased financial burden.<sup>7</sup>

Triple rule-out CT angiography is a cost-effective modality to evaluate coronary arteries, aorta and pulmonary arteries, and other adjacent intrathoracic structures of a patient presenting with acute chest pain.<sup>8</sup> Triple rule-out CT has been a helpful and effective tool in the arsenal of emergency physicians in diagnosing cases of concern and determining the patient population which can be sent home without further cardiac testing.<sup>9–13</sup> The present study aims to quantify the diagnostic yield of TRO-CT in evaluating acute chest pain in patients presenting to the emergency department of a tertiary care hospital and revive and impart the knowledge on TRO-CT to our fellow emergency physicians and residents in India.

## MATERIALS AND METHODS

### Study Population

Twenty-six patients who presented to the emergency department of our institute with acute chest pain, with non-specific ECG findings and negative serial troponin I, underwent triple rule-out CT angiography (TRO-CT), after written and informed consent. Patients with hemodynamic instability were excluded from the study. One patient suffered contrast extravasation and was removed from the study. HEART scores of all patients were calculated at the time of their presentation and were correlated with TRO-CT findings. HEART scores can predict the risk of major adverse cardiac events (MACE) and risk-stratify patients.<sup>14–16</sup> No patients with a HEART score of 7–10 (high risk) were recruited, as they were referred for urgent cardiac interventions.

The study was approved by our institutional review board and ethics committee (IECPG-558/20.12.2017, RT-33/28.02.2018, OT-07/26.09.2019).

### Imaging

Triple rule-out CT protocol was performed using a 256 or 384-slice dual-source multidetector row computed tomography (MDCT) (Siemens, SOMATOM Definition Flash, Germany), based on scanner availability at the time of patient presentation, with prospective ECG gating. All images were reviewed by a cardio-radiology fellow and findings were confirmed by consultants in the departments of radiology and cardio-radiology. A significant coronary artery disease was defined as stenosis of 50% or greater in any coronary artery. A cut-off of 50% was chosen because this threshold usually requires further evaluation, either with non-invasive testing to determine the functional significance or with catheter angiography, depending on lesion severity.

## RESULTS

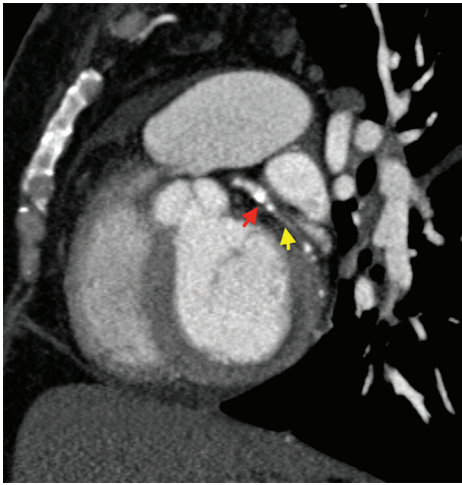
Out of 25 cases, 22 were males (88%) and 3 were females (12%). The mean age of patients was  $47.04 \pm 10.19$  years. The majority of patients had left-sided or retrosternal chest pain. Major risk factors for cardiovascular diseases in our study were smoking, diabetes, hypertension, and positive family history (Table 1).

Triple rule-out CT angiography was positive in 5 patients (20%), of which 4 cases (16%) were diagnosed to have significant coronary artery disease and one had an acute pulmonary embolism. No patient was diagnosed to have aortic dissection (Figs 1 to 4).

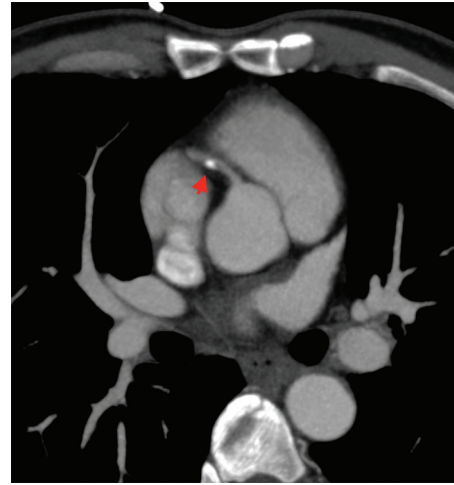
Out of 4 significant CAD patients, one had single vessel disease (25%). Two of them had double vessel disease (50%) and one had triple vessel disease (25%). Other significant findings have been summarized in Table 2.

**Table 1:** Basic characteristics

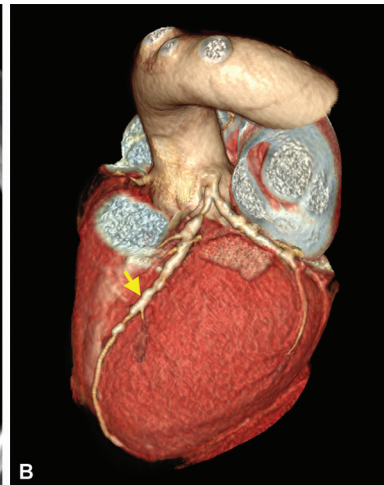
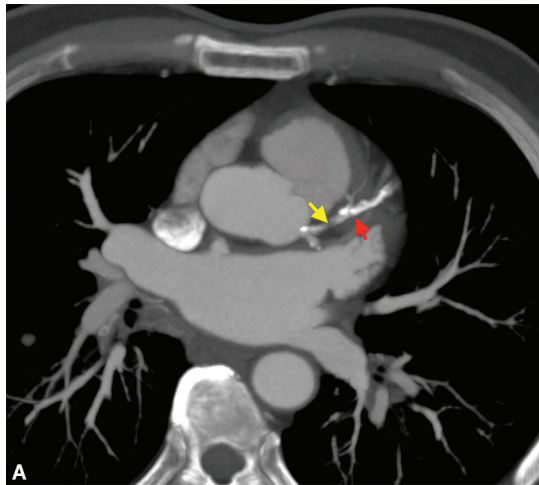
Variable	n (%)
Gender	
Male	22 (88%)
Female	3 (12%)
Age	
31–40 years	7 (28%)
41–50 years	9 (36%)
51–60 years	5 (20%)
>60 years	4 (16%)
Risk factors	
Smoking	12 (48%)
Hypertension	11 (44%)
Diabetes mellitus	10 (40%)
Family history	6 (24%)
Dyslipidemia	2 (8%)
Obesity	1 (4%)
Site of Chest pain	
Right sided	2 (8%)
Left sided	13 (52%)
Retrosternal	10 (40%)
Character	
Heaviness	15 (60%)
Squeezing	7 (28%)
Tearing	1 (4%)
Other	2 (8%)
Radiation	
To left arm	10 (40%)
To right arm	4 (16%)
To back	4 (16%)
To other areas	1 (4%)
No radiation	7 (28%)
Severity	
Mild	5 (20%)
Moderate	15 (60%)
Severe	5 (20%)
Associated symptoms	
Sweating	13 (52%)
Nausea/vomiting	13 (52%)
Shortness of breath	5 (20%)
Palpitations	4 (16%)
Cough	1 (4%)
Syncope	1 (4%)
Aggravating/relieving factors	
Aggravated on exertion	18 (72%)
Relieved on rest	13 (52%)
Relieved on medication	5 (20%)
Relieved on position change	1 (4%)
Heart score	
Low risk (1–3)	18 (72%)
Intermediate risk (4–6)	7 (28%)



**Fig. 1:** Triple rule-out CT scan of a 48-year-old female who presented to emergency with chest pain showing near total obstruction of the left circumflex coronary artery (yellow arrow) and calcifications (red arrow)



**Fig. 2:** Triple rule-out CT scan in a 54-year-old male who presented to emergency with chest pain showing calcifications of the right coronary artery



**Figs 3A and B:** (A) Triple rule-out CT scan of a 61-year-old male who presented to emergency with chest pain shows proximal left anterior descending artery stenosis (yellow arrow). Diffuse calcifications (red arrow) are also noted; (B) Virtual reality (VR) image of the same patient shows stenosis in the left anterior descending artery (yellow arrow)

All 4 patients who had significant CAD diagnosed by TRO-CT had a heart score of intermediate risk (score 4–6, a 16.6% risk of MACE over the next 6 weeks). Among the 21 patients who did not have CAD by TRO-CT, 18 had HEART scores in the range 1–3 (low risk, a 1.7% risk of MACE over the next 6 weeks), and 3 had HEART scores of 4–6 (intermediate risk).

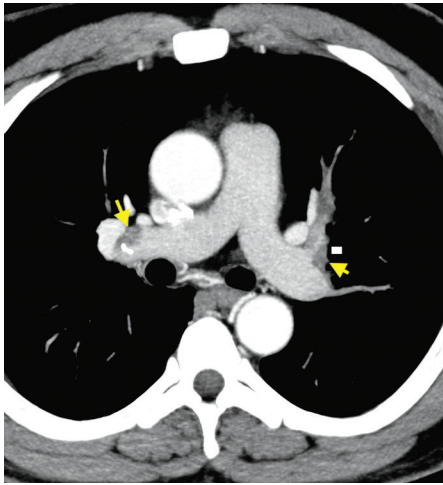
The mean effective radiation dose was calculated by multiplying the dose length product (DLP) with the normalization factor for the adult chest. The mean effective radiation dose of the entire TRO study was  $19.024 \pm 3.319$  mSv (range = 13.89–25.95 mSv).

## DISCUSSION

Patients presenting to emergency departments with acute chest pain warrant a time-sensitive approach for early diagnosis of fatal etiologies and safe disposal if serious underlying causes are excluded. The current study was undertaken to study the utility and diagnostic yield of TRO-CT in evaluating patients with acute chest pain presenting to an emergency department in India. The diagnostic yield of TRO-CT for cardiovascular etiology was found

to be 20%. All such patients were admitted and referred to the department of cardiology for further evaluation and management. Scans also revealed significant other non-cardiac etiologies of chest pain (76%). There was no aortic dissection reported in our study.

Missed cases of significant CAD and acute coronary syndrome are of significant concern, both emotional and financial, to emergency physicians in India. In low and intermediate-risk individuals, physicians have to balance the need for further invasive and costly testing for accurate diagnosis, with the possibility of over-testing and the financial burden associated with them. Resources are limited in our country and there is a need for wise allocation of them even among patients presenting with risk factors. Usual protocols of serial ECG and troponin I to rule out significant diseases and subsequent disposal of negative patients often result in the discharge of patients with significant coronary disease. Further non-invasive modalities are needed at emergency physicians' disposal that won't require them to have cardiology department referrals, as they are also very often burdened with caseloads.



**Fig. 4:** Triple rule-out CT scan of a 38-year-old male who presented with chest pain and shortness of breath. His coronaries and aorta were normal, but he was found to have extensive bilateral pulmonary emboli (yellow arrows)

**Table 2:** TRO-CT findings

Variable	n (%)
Coronary artery disease	4 (16%)
Pulmonary embolism	1 (4%)
Aortic dissection	0 (0%)
Coronary artery disease	
Number of vessels involved	
Single vessel disease	1 (4%)
Double vessel disease	2 (8%)
Triple vessel disease	1 (4%)
Territory	
Left main	1 (4%)
LAD	3 (12%)
LCX	3 (12%)
RCA	2 (8%)
Other significant findings	19 (76%)
Pneumonia	1 (4%)
Pleural effusion	2 (8%)
Pulmonary nodule	2 (8%)
Mediastinal lymphadenopathy	2 (8%)
Fibrotic changes in lung	6 (24%)
Atherosclerosis/calcifications in aorta	4 (16%)
Liver lesions	2 (8%)

LAD, left anterior descending artery; LCX, left circumflex coronary artery; RCA, right coronary artery

Multidetector computerized tomography (CT) angiographies have been studied for their efficacy in assisting diagnosis in this setting. They are non-invasive and more logistically available than invasive coronary angiography, even in a setting of a tertiary care hospital. They have been found to have a sensitivity of 87–94% and specificity of 96–97% in the establishment of causes of chest pain.<sup>17,18</sup> They have a high negative predictive value for cardiac diseases.<sup>19</sup>

The triple rule-out CT angiography provides visualization of coronary arteries, aorta, and pulmonary arteries, along with visualization of adjacent intrathoracic structures, which can be the origin of causation of acute chest pain. In a retrospective observational study comparing TRO-CT with CT angiogram and cardiac stress test, TRO-CT was found to be a feasible solution in the evaluation of chest pain, with a resultant reduced hospital stay, less cost, and reduced radiation exposure.<sup>11</sup> It was found to be particularly useful for the evaluation of elderly patients presenting with chest pain when compared to dedicated coronary CT angiography, as it can also evaluate pulmonary arteries, aorta, and adjacent structures.<sup>20</sup> The systematic review of TRO-CT similarly found its high sensitivity and positive and negative likelihood ratios in diagnosing coronary artery diseases.<sup>21</sup>

Various studies of a comparable sample size to our study had found diagnostic yield TRO-CT in detecting significant coronary diseases to be in the range of 25–57%.<sup>13,22</sup> Non-coronary causes were found in a lesser patient population than ours, which could be due to their strict patient recruitment criteria or attributed to the difference in epidemiology. We had a 76% detection of non-cardiac causes of chest pain detected in our study. There was no aortic dissection found in our study, which could be because of our low mean patient age and sample size.

The mean effective radiation dose of our TRO-CT protocol was 19.024 ± 3.319 mSv (range, 13.89–25.95 mSv). Comparable mean effective radiation dose was found in other studies.<sup>13,23</sup> One of the drawbacks of TRO-CT is high radiation exposure, which limits its use in the young patient population. However, new TRO-CT protocols are being investigated which result in substantially low radiation dose (2.0–3.3mSv) and contrast materials, but result in excellent image quality and opacification.<sup>24</sup> We could not make such an attempt in our study because of logistical issues.

Appropriate patient selection is important in the TRO-CT evaluation of chest pain. All our patients who had positive findings in TRO-CT had intermediate-risk heart scores. This could guide us in formulating new algorithms to include which patients should benefit from TRO-CT. The intermediate-risk patients who might otherwise be discharged from emergency departments shall undergo TRO-CT to rule out significant cardiovascular diseases. Given high radiation exposure, the same can be withheld for low-risk patients, after considering other patient risk factors. This will enable the safe and early disposal of patients, and more judicious utilization of hospital resources. Since we don't have the necessary follow-up data on our study patients and further studies are required to estimate the specificity and sensitivity of TRO-CT in Indian patients, we request readers to keep caution while applying this logic. Another important thing to note in the context of TRO-CTs is the necessary higher expertise that is required in reporting it. As a tertiary center, we were fortunate to have collaborated with faculties from the department of radiology and cardio-radiology, but we understand that the same may not be available everywhere.<sup>25–29</sup>

## CONCLUSION

Triple rule-out CT angiography is a useful tool in the evaluation of patients presenting with acute chest pain in the emergency. To our best knowledge, there are no studies done in the Indian population on the efficacy and cost-effectiveness of TRO-CT, hence we advise caution on its wider use in view of increased radiation exposure and higher expertise required for reporting. Nevertheless,



TRO-CT can be an important adjunct in ruling out significant coronary artery disease in intermediate-risk patients. Emergency physicians and young residents need to know about this tool in their armamentarium to tackle doubtful cases.

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