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ORIGINAL RESEARCH

The Prevalence of Extracardiac Abnormalities Identified in Negative Coronary Computed Tomography Angiography and Its Association with Clinical Symptoms

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ABSTRACT

Coronary computed tomography angiography (CCTA) is valuable for assessing both coronary and incidental extracardiac findings. Recognizing non-cardiac causes of chest pain and dyspnea can improve diagnostic efficiency. This study aimed to assess the prevalence of extracardiac findings in patients with normal or non-obstructive CCTA and to determine whether these findings could account for their presenting symptoms, such as chest pain or exertional dyspnea. We retrospectively analyzed 358 patients who underwent coronary computed tomography angiography between January 2021 and December 2024 due to chest pain or dyspnea. Patients with obstructive coronary artery disease, congenital coronary anomalies, valvular disease, or acute coronary syndrome were excluded. Two experienced radiologists reviewed all scans for extracardiac abnormalities and evaluated their potential relationship with patient symptoms. Extracardiac findings were identified in 236 patients (65.9%), with vertebral degenerative changes (39.1%) being the most frequent, followed by atelectasis (14.8%) and emphysema (10.6%). Findings potentially explaining chest pain were noted in 56% of patients with this symptom, while 64% of those with exertional dyspnea had relevant extracardiac abnormalities. Female sex and older age were significantly associated with higher prevalence of extracardiac findings ($p<0.05$ and $p<0.001$, respectively). A substantial proportion of patients undergoing CCTA for chest pain or exertional dyspnea harbor extracardiac abnormalities that may explain their complaints. Careful evaluation of all structures visible on CCTA can improve diagnostic efficiency and patient management. Further studies are warranted to explore the role of these findings in non-cardiac chest pain and dyspnea.

Key Words: Extracardiac findings. Coronary CT angiography. CCTA. Non-cardiac chest pain. Exertional dyspnea.

Negatif Koroner Bilgisayarlı Tomografi Anjiyografide Saptanan Ekstrakardiyak Anormalliklerin Sıklığı ve Klinik Semptomlarla İlişkisi

ÖZET

Koroner bilgisayarlı tomografi anjiyografi (koroner BTA), hem koroner arterleri hem de ekstrakardiyak bulguları değerlendirmede kullanılan değerli bir görüntüleme yöntemidir. Göğüs ağrısı ve dispne gibi semptomların kardiyak olmayan nedenlerinin tanınması, tanısal etkinliği artırabilir. Bu çalışmanın amacı, normal veya non-obstrüktif koroner BTA bulguları olan hastalarda ekstrakardiyak bulguların prevalansını değerlendirmek ve bu bulguların hastaların başvuru semptomlarını (örneğin göğüs ağrısı veya efor dispnesi) açıklayıp açıklayamayacağını belirlemektir. Ocak 2021 ile Aralık 2024 tarihleri arasında göğüs ağrısı veya dispne şikayetleri nedeniyle koroner BTA yapılan 358 hastanın retrospektif analizi gerçekleştirildi. Obstrüktif koroner arter hastalığı, konjenital koroner anomaliler, kapak hastalığı veya akut koroner sendrom tanısı olan hastalar çalışma dışı bırakıldı. Tüm koroner BTA görüntüleri, iki deneyimli radyolog tarafından ekstrakardiyak anormallikler açısından değerlendirildi ve bu bulguların hastanın semptomları ile olası ilişkisi incelendi. Ekstrakardiyak bulgular 236 hastada (%65,9) saptandı. En sık görülen bulgu vertebral dejeneratif değişikliklerdi (%39,1), bunu atelektazi (%14,8) ve amfizem (%10,6) izledi. Göğüs ağrısı olan hastaların %56'sında, efor dispnesi olan hastaların ise %64'ünde semptomlarla ilişkili olabilecek ekstrakardiyak bulgular tespit edildi. Kadın cinsiyet ($p<0,05$) ve ileri yaş ($p<0,001$), ekstrakardiyak bulguların daha yüksek prevalansı ile anlamlı şekilde ilişkili bulundu. Göğüs ağrısı ya da efor dispnesi nedeniyle koroner BTA uygulanan hastaların önemli bir kısmında, şikayetleri açıklayabilecek ekstrakardiyak anormallikler mevcuttur. Koroner BTA sırasında görülebilen tüm anatomik yapıların dikkatli bir şekilde değerlendirilmesi, tanısal etkinliği ve hasta yönetimini artırabilir. Kardiyak olmayan göğüs ağrısı ve dispne değerlendirmesinde bu bulguların rolünü araştırmak için ileri çalışmalara ihtiyaç vardır.

Anahtar Kelimeler: Ekstrakardiyak bulgular. Kardiyak olmayan göğüs ağrısı. Efor dispnesi. Koroner BTA.

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The role of computed tomography (CT) in coronary artery disease (CAD) assessment has expanded considerably in recent times[1]. Coronary CT angiography (CCTA) provides precise visualization of atherosclerotic plaque distribution, extent, and severity, as well as clearly demonstrating congenital variations of the coronary arteries[2,3]. While CCTA primarily evaluates coronary anatomy, it also detects extracardiac structures, where clinically relevant findings may originate[1,2,4–10]. With rising CCTA use, the impact of such incidental results on patient management requires attention[6,8].

Retrosternal chest pain and exertional dyspnea represent the most frequent clinical manifestations of CAD[11]. Angina-like retrosternal chest pain and dyspnea may originate from either cardiac etiologies or extra-cardiac causes, including pulmonary pathologies, hiatal hernias, and esophageal disorders. Patients with these symptoms are predominantly triaged to cardiologists, establishing a diagnostic pathway where other specialties are consulted only after cardiac causes are excluded—a process that often prolongs symptoms for months[1,12–14].

The primary objective of this study was to investigate the frequency of extracardiac findings in patients who demonstrated either normal coronary arteries or non-obstructive disease on CTCA, and to determine whether any of these findings could potentially explain their initial symptoms.

Material and Method

Study Population

A retrospective analysis was performed on all patients who underwent CCTA at our department between January 2021 and December 2024. Electronic medical records were then examined to select appropriate cases. The study population included individuals aged over 18 years who underwent CCTA in the context of clinical symptomatology (chest pain or effort dyspnea). Patients with a known history of CAD, valvular heart disease, congenital coronary malformation, findings suggestive of flow-limiting or obstructive CAD were excluded from the study. In addition, patients presenting with acute chest pain who were directly referred to the Emergency Department were excluded.

CCTA Protocol

Coronary CT angiography was performed using a 128-slice MDCT (GE Revolution EVO, 128-slice, GE Healthcare, Chicago, IL, USA) with retrospective electrocardiographic (ECG) gating. The imaging parameters were as follows: 128 × 0.6 collimation, 0.3 sec rotation time, 0.32 pitch, 120 kV tube voltage, and 185 reference mAs. A pre-contrast calcium score was obtained using standard imaging parameters. The rate and volume of contrast medium administration were adjusted according to the patient's body composition. A non-ionic contrast agent was administered via an 18-G intravenous antecubital catheter at a rate of 5 ml/sec. The entire CT data was imported to a dedicated processing workstation. The images were reconstructed with an effective slice thickness of 0.6 mm, using retrospective ECG gating at 10% intervals across the cardiac cycle. The optimal mid-to-late diastolic dataset (50-70% of the RR interval) was selected for final image analysis. All scans were evaluated in axial, coronal, and sagittal planes using standard window settings: mediastinal (width 450, level 35), lung (width 1500, level -700), and bone (width 1500, level 450).

Image Interpretation

Two cardiothoracic radiologists, with 15 and 9 years of experience in cardiac CCTA evaluated all CT scans for the presence of extracardiac findings. Image reconstruction was performed using standard soft tissue and lung kernels. The observers utilized standard soft tissue, lung, and bone windowing settings for image evaluation, with additional manual adjustments made as needed. All findings were determined through consensus of the two radiologists. Extracardiac findings were classified according to their anatomical location, including the upper abdomen, pulmonary structures, aorta, breast, thyroid and vertebrae. Diagnostic criteria for various extracardiac findings were formulated from both the existing literature and the expertise of the observers. The relationship between extracardiac findings and patients' presenting symptoms was assessed using a three-point subjective scale determined by consensus of the two radiologists: 0 = no association, 1 = weak association (possible but uncertain correlation), and 2 = strong association (a plausible anatomical or physiological explanation based on location and nature of the finding).

Statistical Analysis

Continuous variables were presented as mean ± standard deviation (SD), while categorical variables were reported as percentages. Associations between gender, age, and the presence of extracardiac findings were assessed using the χ^2 test or Fisher's exact test, as appropriate. All statistical analyses were conducted using SPSS version 21.0 (SPSS Inc., Chicago, IL, USA), and a p-value of <0.05 was considered statistically significant.

The study was performed in accordance with the ethical guidelines of the Helsinki Declaration and approved by the local ethics review committee

(approval number: E-67961857-050.04-2500015767, dated March 14, 2025).

Results

Between January 2021 and December 2024, a total of 535 CCTA examinations were performed at the Bandırma Onyedi Eylül University Research and Training Hospital. Of these, 29 patients were excluded due to the absence of any history of any initial symptoms. Among the remaining patients, 63 were excluded due to the presence of flow-limiting CAD on CCTA, 46 were excluded on account of a known history of CAD, 39 were excluded due to valvular heart disease or congenital coronary malformations, and 3 were excluded due to a diagnosis of acute coronary syndrome. The final cohort comprised 358 patients: 196 men (54.7%) and 162 women (45.3%), with a mean age of 51.3 ± 11.8 years, and an age range of 21 to 85 years. Patient demographics are presented in Table I.

Table I. Patient characteristics

	No extra-cardiac finding	Extra-cardiac finding present	p value
Number of patients (%)	122 (34.1)	236 (65.9)	
Age±SD	41.9±7.1	56.2±10.8	p<0.001
Sex			p<0.05
Male (%)	75 (38.3)	121 (61.7)	
Female (%)	47 (29.1)	115 (70.9)	

SD, standard deviation.

Extracardiac findings were detected in 236 patients (65.9 %); 121 males (mean age of 57.6 years) and 115 females (mean age of 58.3 years). In 187 patients (52.2%), more than one extracardiac finding was depicted. A total of 440 extracardiac findings were detected in 236 of the 358 patients evaluated. The extracardiac findings detected in our patient population are presented in Table II. The most frequently observed finding was degenerative changes in the vertebrae, detected in 140 patients (39.1%). Other notable extracardiac findings were atelectasis (53 patients, 14.8%), emphysema (38 patients, 10.6%), ascending aortic aneurysm (30 patients, 8.4%), and hiatal hernia (22 patients, 6.1%). Among all extracardiac findings, 46% (204/440) were considered potential causes of chest pain, while 19% (86/440) were thought to be related to exertional dyspnea. Since our study also investigated the relationship between extracardiac findings and patient symptoms, the study group consisted of patients who underwent imaging due to specific initial symptoms. Accordingly, 341 patients presented with non-acute chest pain, 74 patients with exertional dyspnea, and 57 patients exhibited both symptoms. In 56% of patients with chest pain (194/341), at least one extracardiac finding potentially accounting for chest pain was identified, whereas in 64% of patients (48/74), an extracardiac finding that could explain exertional dyspnea was detected. Figure 1 and Figure 2 present two representative cases from our patient cohort with clinically significant extracardiac findings.

Table II. Prevalence of extracardiac findings detected on computed tomography coronary angiography.

Anatomic Location	Extracardiac finding	No. of patients (%)	Relationship with chest pain	Relationship with effort dyspnea
Lung	Linear or segmental atelectasis	53 (14.8)	0	0
	Bronchiectasis	6 (1.6)	0	1
	Emphysema	38 (10.6)	0	2
	Nodule	22 (6.1)	0	0
	0.5-30 mm (non-spiculated)	21 (5.8)		
	spiculated nodule in any size	1 (0.2)		
	Calcified granuloma	4 (1.1)	0	0
	Focal fibrosis	15 (4.2)	0	0
	GGO	2 (0.5)	0	1
	Consolidation	7 (2)	2	2
	ILD	5 (1.4)	1	1
	Pleural effusion	4 (1.1)	2	1
	Pleural thickening or plaque	11 (3.1)	1	0
Abdomen	Hiatus hernia	22 (6.1)	1	1
	Liver simple cyst	13 (3.6)	0	0
	Liver mass	2 (0.6)	0	0
	Cholelithiasis	2 (0.6)	1	0
	Adrenal mass	6 (1.7)	0	0
	Adenoma	5 (1.3)		
	non-adenoma	1 (0.2)		
	Adrenal hypertrophy	1 (0.2)	0	0
	Renal cyst	9 (2.5)	0	0
	Renal suspicious mass	1 (0.2)	0	0
	Nephrolithiasis	6 (1.7)	1	0
Miscellaneous	Vertebral degenerative changes	140 (39.1)	1	0
	Scoliosis	2 (0.5)	1	1
	Breast mass	5 (1.4)	1	0
	Mediastinal LAP	12 (3.4)	0	0
	Mediastinal calcified lymph node	11 (3.1)	0	0
	Thyroid nodule	9 (2.5)	0	0
	Pectus excavatum	2 (0.6)	1	1
	Ascending aortic aneurysm	30 (8.4)	0	0

GGO, ground glass opacity. ILD, interstitial lung disease.

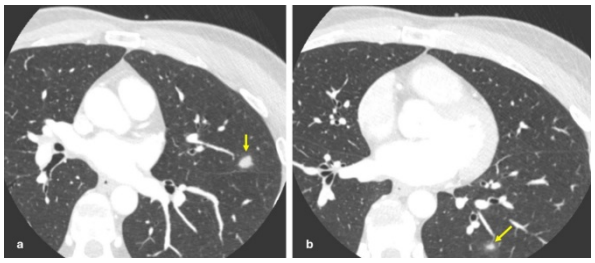

Figure 1:
Incidentally detected colon adenocarcinoma metastasis in 59-year-old male patient.

a, b. On coronary CT angiography (CCTA), multiple pulmonary nodules were identified (arrows), the largest measuring 1 cm in diameter. The radiologic appearance was suggestive of metastatic lesions from an underlying primary malignancy. Subsequent diagnostic evaluation led to the diagnosis of colonic adenocarcinoma.

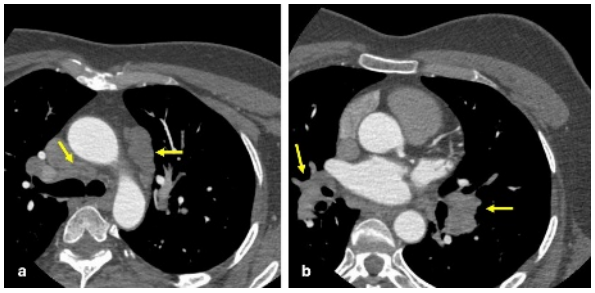

Figure 2:
a, b. In a 59-year-old female patient, incidental mediastinal and bilateral hilar lymphadenopathies were identified (arrows). Following further diagnostic evaluation, a diagnosis of sarcoidosis was established.

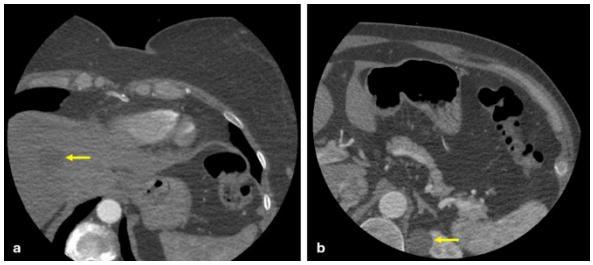

Figure 3:
a. In a 62-year-old female patient, incidental liver cyst was detected (arrow). b. 49-year-old male patient with a hypodense, simple renal cyst located in the upper pole of the left kidney (arrow).

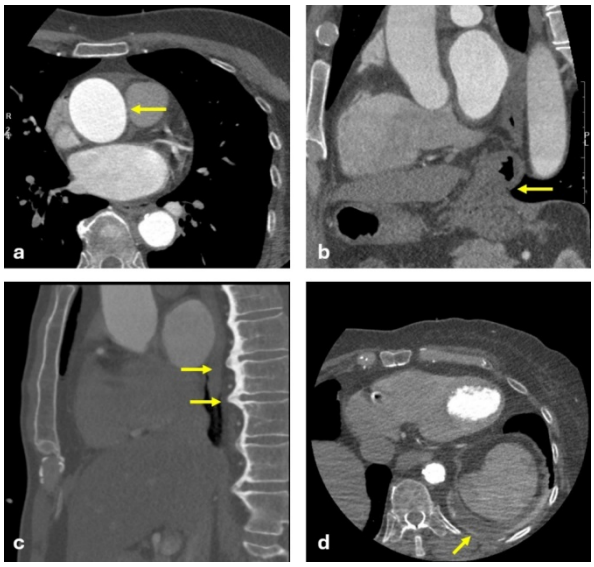

Figure 4:
a. Aortic aneurysm incidentally detected in a 67-year-old male patient (arrow). b. Hiatal hernia observed in a 59-year-old female patient (arrow). c. Bridging anterior osteophytes consistent with degenerative changes in the thoracic vertebrae of a 72-year-old male patient (arrow). d. Pleural effusion measuring 15 mm in thickness in the left pleural space of a 64-year-old female patient (arrow).

A higher percentage of female patients (70.9%, 115/162) exhibited at least one extracardiac finding, a difference that was statistically significant compared to male patients (61.7%, 121/196; $p<0.05$). The mean age of patients with at least one extracardiac finding was 56.2±10.8, which is significantly higher than the mean age of patients without any extracardiac findings with 41.9±7.1 ($p<0.001$). Vertebral degenerative changes exhibited the most significant variation in relation to age. The mean age of 140 patients with degenerative changes was 63 ± 8 years, whereas the mean age of 218 patients without such changes was 43.8 ± 6.7 years ($p < 0.001$). The mean age of patients with ascending aortic aneurysm (58.9 ± 8.2 years) was significantly higher than that of those without this finding (50.6 ± 11.9 years) ($p < 0.001$). Similarly, patients with pulmonary consolidation had a higher mean age (62.1 ± 51.1 years) compared to those without consolidation (48.3 ± 7.2 years) ($p < 0.05$). For all other extracardiac findings, no statistically significant age-related differences in their prevalence were observed.

Discussion and Conclusion

CCTA is recommended for patients presenting with chest pain or atypical symptoms who are at low to intermediate risk for suspected coronary artery

disease. In addition to coronary artery evaluation, CCTA provides the advantage of simultaneously assessing both cardiac and noncardiac etiologies of chest pain and exertional dyspnea, a feature that was a central focus of our analysis[15,16].

The prevalence of noncardiac findings in patients undergoing CCTA varies significantly, depending on the classification criteria used and the demographic characteristics of the study population[1,2,6,8–10,17,18]. Karius et al.[10] reported in their meta-analysis that the prevalence of extracardiac findings on cardiac CT ranged from 7.1% to 79.4%, with clinically significant findings observed in 1.6% to 58.5% of cases.

In the present study, extracardiac findings identified on CCTA demonstrated both similarities and notable differences compared to previous literature. Consistent with earlier reports, extracardiac abnormalities remain a common incidental observation; however, in contrast to prior studies, vertebral degenerative changes emerged as the leading extracardiac abnormality in our cohort, present in 39.1% of patients. Atelectasis was the second most common extracardiac finding, observed in 14.8% of all patients. Several studies in the literature have investigated extracardiac findings on CCTA, with varying results regarding the most frequently observed abnormalities. However, several studies in the literature focusing on extracardiac findings detected on CCTA have consistently identified pulmonary nodules as the most common abnormality[4–6,10]. In contrast, Mumtaz et al. identified hiatus hernia as the most prevalent extracardiac finding in their cohort[2]. Furthermore, Lazoura et al. highlighted emphysema as the most frequently observed extracardiac abnormality in their analysis[9]. These discrepancies across studies may be attributed to differences in study populations, inclusion criteria, or radiological interpretation protocols.

Similar to previous studies, we observed that the rate of extracardiac findings was higher in elderly patients. Consistent with the study by Mumtaz et al.[2], we also found that female patients had a higher likelihood of extracardiac findings compared to male patients. In contrast to our study, Moser et al. reported a higher prevalence of extracardiac findings in male patients[8].

The detected extracardiac findings could represent the pathological basis for the presenting symptoms that indicated the examination**.** Mumtaz et al.[2] previously reported that 22% of patients had at least one extracardiac finding providing an alternative explanation for chest pain. In our study, extracardiac findings potentially explaining chest pain were identified in 56% of patients. We attribute the higher rates observed in our study compared to Mumtaz et al.'s findings to the greater prevalence of vertebral degenerative changes -which can be a potential cause of chest pain- detected in our patient cohort. In 64% of the patients (48 out of 74), an extracardiac finding potentially explaining exertional dyspnea was identified. To the best of our knowledge, there is no study in the literature investigating the relationship between exertional dyspnea and extracardiac findings detected on CCTA. In this regard, our study is original.

Several limitations of our study should be considered when interpreting the results. First, it was conducted at a single center with a relatively small sample size, which may limit the generalizability of the findings. Second, the retrospective design of our study limited our ability to assess follow-up data and evaluate whether treatment of the extracardiac etiology led to improvement in symptoms such as chest pain or exertional dyspnea. The retrospective nature of our study also introduces potential information bias, as symptom descriptions were extracted from existing medical records without the use of standardized assessment tools. The subjective nature of symptom reporting and the lack of objective measures (e.g., standardized dyspnea or pain scores) may have influenced the association between symptoms and extracardiac findings. The final limitation is that a non-quantitative assessment method was used to evaluate the relationship and its strength between the extracardiac findings and the patients' presenting symptoms.

In conclusion, we believe that prioritizing the evaluation of extracardiac findings that are both symptom-related and clinically significant may enhance the efficiency of diagnostic and therapeutic pathways by optimizing the balance between clinical outcomes and healthcare costs. All anatomical structures visualized on CCTA should be thoroughly evaluated for clinically significant abnormalities. Further studies are needed to determine whether certain extracardiac findings are more prevalent in patients with non-cardiac chest pain compared to the general population

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The data presented in this study are available on request from the corresponding author due to privacy and ethical reasons.

Researcher Contribution Statement:

Idea and design: E.T., Ö.T.; Data collection and processing: E.T., Ö.T., E.K.; Analysis and interpretation of data: E.T., B.T.,; Writing of significant parts of the article: E.T., Ö.T., A.D.

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