

Prevalence of Incidental Extracardiac Findings on Multidetector Computed Tomographic Coronary Angiography

Çok Kesitli Bilgisayarlı Tomografik Koroner Anjiyografideki Rastlantısal Ekstrakardiyak Bulguların Prevalansı

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ABSTRACT Objective: To determine the prevalence, spectrum, and significance of incidental extracardiac findings in patients undergoing multidetector computed tomographic (MDCT) coronary angiography. **Material and Methods:** We performed a retrospective review of 375 consecutive patients referred for MDCT coronary angiography. All MDCT angiography examinations were performed by a 16-slice MDCT scanner. Extracardiac findings were classified as clinically insignificant or significant. Insignificant findings were those considered to be of minor clinical significance with no immediate follow-up or treatment required. Clinically significant findings were classified as moderately or highly significant. Moderately significant findings were those considered to be of potential clinical importance, requiring correlation with patient history or a follow-up examination. Highly significant findings were those considered to be of definite clinical importance requiring immediate workup and treatment. **Results:** A total of 242 extracardiac findings were found in 155 (41.3%) patients. Eighty-three (22.1%) patients had insignificant findings and 72 (19.2%) had significant findings. We found 13 highly significant findings including pulmonary embolism, aortic aneurysm, aortic dissection, lung cancer, esophageal carcinoma and hepatic metastasis distributed among 12 patients (3.2%), and 8 patients who eventually had therapeutic consequences. **Conclusion:** Because extracardiac structures such as lungs, mediastinum and upper abdomen are appropriate for assessment in MDCT coronary angiography and extracardiac findings are frequent, the reporting radiologist should be aware of the likelihood and frequency of these findings and their probable significance.

Key Words: Coronary artery disease; thoracic diseases; multidetector computed tomography; angiography

ÖZET Amaç: Bu çalışmanın amacı çok kesitli bilgisayarlı tomografik (ÇKBT) koroner anjiyografi geçiren hastalardaki rastlantısal ekstrakardiyak bulguların prevalansı, spektrumu ve öneminin belirlenmesidir. **Gereç ve Yöntemler:** ÇKBT koroner anjiyografiye gönderilen ardışık 375 hastanın raporları geriye dönük olarak tekrar gözden geçirildi. Tüm ÇKBT anjiyografi incelemeleri 16-kesitli ÇKBT cihazı kullanılarak gerçekleştirildi. Ekstrakardiyak bulgular; klinik açıdan önemsiz veya önemli olarak sınıflandırıldı. Yakın bir takip veya tedavi gerekliliği olmayan klinik yönden önemi az olan bulgular önemsiz bulgular olarak kabul edildi. Klinik yönden önemli bulgular orta dereceli önemli ve ciddi olarak sınıflandırıldı. Hastanın öyküsüyle korele edilmesi gereken veya takip incelemeyi gerektiren potansiyel klinik önemi olan bulgular orta derecede önemli bulgular olarak kabul edildi. En kısa zamanda ileri bir inceleme ve tedavi gerektiren klinik önemi kesin olan bulgular ise ciddi derecede önemli bulgular olarak kabul edildi. **Bulgular:** 155 (%41.3) hastada toplam 242 ekstrakardiyak bulgu saptandı. 83 (%22.1) hastanın önemsiz, 72 (%19.2) hastanın önemli bulguları vardı. 12 (%3.2) hastada, pulmoner emboli, aort anevrizması, aort diseksiyonu, akciğer kanseri, özofagus karsinomu ve hepatik metastazı içeren toplam 13 adet ciddi derecede önemli bulgu saptandı ve neticede 8 hasta tedavi edildi. **Sonuç:** Akciğer, mediastinum ve üst abdomen gibi ekstrakardiyak yapılar ÇKBT anjiyografi ile değerlendirmeye uygun olduğu ve ekstrakardiyak bulgular sık olduğu için, bu tetkikleri raporlayan radyolog bu bulguların olabirliğinin, sıklığının ve olası önemlerinin farkında olmalıdır.

Anahtar Kelimeler: Koroner arter hastalığı; torasik hastalıklar; bilgisayarlı tomografi; anjiyografi

Conventional coronary angiography (CCA) is the accepted reference standard for the evaluation of coronary artery stenoses due to its unprecedented temporal and spatial resolution and the ability to allow therapeutic interventions in the same session. However, it is expensive and has small but serious and potentially life-threatening complications including arrhythmia, stroke, coronary artery or graft dissection, embolic events, and myocardial infarction.¹ During the past decade, considerable progress has been achieved in the field of noninvasive coronary imaging with magnetic resonance imaging, electron beam computed tomography and most recently, MDCT. Progress with the MDCT scanner technology, which led to improved spatial resolution through thinner slice collimation and increased temporal resolution through faster gantry rotation, has made MDCT scanning a robust technology for coronary imaging. Studies comparing the MDCT coronary angiography with CCA for the evaluation of coronary artery stenosis have shown promising results and MDCT coronary angiography is rapidly becoming a major part of clinical practices worldwide.^{2,3} MDCT coronary angiography is now considered a useful modality to detect coronary artery plaques and stenoses to evaluate remodeling of coronary atherosclerotic lesions and the size and function of the ventricles.³ In addition to the heart and coronary vessels, MDCT coronary angiography examination may also provide important information on portions of the lungs, chest wall, mediastinum, great vessels, spine and upper abdomen. Some of the incidental extracardiac findings may account for the patient's clinical symptoms, while other incidental findings may indicate underlying malignant disease or even remain uncertain without further investigations or follow up.

In this study, we retrospectively examined the prevalence, spectrum, and significance of extracardiac findings in a series of patients undergoing MDCT coronary angiography.

MATERIAL AND METHODS

STUDY GROUP

The study group consisted of 375 consecutive patients (237 male, 138 female; mean age 55.7 years; range 20-88 years) with suspected or known coro-

nary artery disease who underwent MDCT coronary angiography between February 2007 and October 2008 in our institution. The medical of the patients were retrieved from our department's radiology information system. The incidental extracardiac findings and additional investigations performed due to highly significant findings were recorded. This study was approved by the local ethics committee and informed consent was obtained from all patients.

MDCT SCANNING PROTOCOL

All MDCT examinations were performed by a 16-row MDCT scanner (GE Lightspeed Ultra 16, General Electrical Medical Systems, Milwaukee, Wisc.; USA) with the same protocol. Patients were positioned supine on the CT table and connected to the with ECG monitoring. In all patients, 130 mL of iodinated contrast agent (Iodixanol, Visipaque® 320 mgI/mL, GE Healthcare Bio-[Sciences], Milwaukee, Wisc.; USA) was injected at a flow rate of 4 mL/sec. The main acquisition parameters were the use of retrospective ECG gating, craniocaudal scan direction, detector collimation of 16 x 0.625 mm, tube voltage of 120 kv, tube current of 320-460 mA, table feed of 2.75-3.0 mm/rotation and gantry speed of 0.5 sec/rotation. In all patients, the data sets were reconstructed (with a slice thickness of 0.625 mm and 0.4 mm increments) during the mid-to-end diastolic phase 65%-75 of the R-R interval.

DATA ANALYSIS

All data were transferred to a separate computer workstation (Advanced workstation 4.2, GE Healthcare, Milwaukee, Wisc.; USA) equipped with cardIQ software (GE Medical Systems). Two radiologists reviewed each study by consensus. All images were reviewed in the axial plane using all of the following settings: mediastinal windows (width= 400, level= 40), lung windows (width= 1500, level= -500), vascular windows (width= 700, level= 200), and bone windows (width= 2500, level= 500). Extracardiac MDCT findings were classified as clinically insignificant or significant. Insignificant findings were those considered to be of minor clinical significance with no immediate follow-up or treatment required. Insignificant fin-

dings such as vascular calcifications and degenerative skeletal changes were not recorded. Clinically significant findings were classified as moderately or highly significant. Moderately significant findings were those considered to be of potential clinical importance, requiring correlation with patient history or a follow-up examination. Highly significant findings were those considered to be of definite clinical importance requiring immediate workup and treatment.

For the classification of the significance of pulmonary nodules, the current Fleischner criteria were used as guideline and based only on the size they were assigned to one of the categories based only on size. Pulmonary nodules smaller than 8 mm were considered clinically insignificant. However, if smaller than 8 mm, but with other imaging characteristics to suggest malignancy, they were classified as highly significant findings. Pulmonary nodules larger than 8 mm were considered moderately significant findings. But other imaging characteristics to suggest malignancy they were classified as highly significant findings.

RESULTS

Coronary artery MDCT was performed successfully and without complications in all 375 patients. All scans were included in the analysis for extracardiac findings. Extracardiac findings were found in 155 of the 375 (41.3%) patients by MDCT. Eighty-three (22.1%) patients had insignificant findings and 72 (19.2%) had significant findings. Sixty (16%) patients had moderately significant findings and 12 (3.2%) had highly significant findings. A total of 242 extracardiac findings were found in 155 patients (97 male and 58 female, with mean age; 59.0 years, range 27 to 88). One hundred and two (66%) patients had only one extracardiac finding, 29 had 2, 16 had 3, 6 had 4 and 2 had 5. Of the 242 extracardiac findings, 136 (56.2%) were considered insignificant findings and 106 (43.8%) were considered significant findings. Among the 106 significant extracardiac findings, 93 (38.4%) were moderately significant and 13 (5.4%) severe. The 13 highly significant extracardiac findings were distributed in 12 patients; 4 females and 8 males,

with a mean age of 66.7 years (range 48-83 years). Insignificant extracardiac findings on MDCT were more frequent than significant findings. The most common insignificant extracardiac findings were emphysema and bullae (10%) (Figure 1), noncalcified pulmonary nodules smaller than 8 mm (9%), calcified lymph nodes (8%) and calcified pulmonary nodules (5%). The most common moderately significant extracardiac findings were mediastinal lymphadenopathy (7%), ascending aortic aneurysm smaller than 50 mm (5%), and noncalcified pulmonary nodules larger than 8 mm (4%). 10 patients (3 female, 7 male; age range 45-77 years) with noncalcified pulmonary nodules larger than 8 mm were recommended for radiological follow-up examination.

Twelve patients who had 13 highly significant extracardiac findings underwent further evaluation or intervention immediately. One patient with type 2 dissection and ascending aorta aneurysm were investigated by transthoracic echocardiography as well as thoracic MDCT angiography and he underwent ascending aortic surgery (Figure 2). Three patients with ascending aortic aneurysm between 50 and 70 mm were additionally examined by transthoracic echocardiography and thoracic MDCT angiography. Two of these patients were operated and the other was referred to follow-up in order to control progressi-

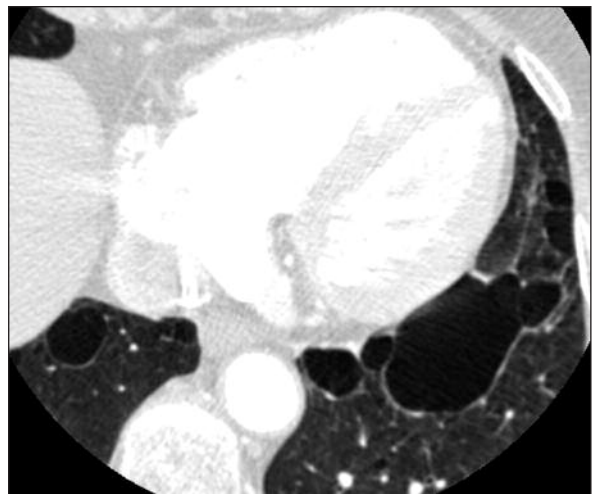


FIGURE 1: Axial MDCT image of a 67-year-old woman shows multiple lung cysts and bulla in the bilateral lower lobe segments.

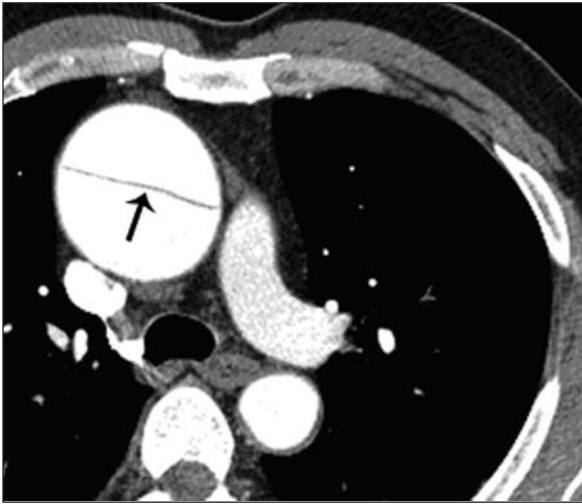


FIGURE 2: Axial MDCT image of a 52-year-old man shows type 2 dissection (arrow) and aneurysm of the ascending aorta with a diameter of 6.2 cm.

on. Two patients with pulmonary embolism were treated with anticoagulant therapy (Figure 3). One patient who had 28 x 32 mm spiculated pulmonary mass in the left upper lobe underwent lung biopsy with a histological diagnosis of adenocarcinoma (Figure 4). One patient who had 22 mm suspicious pulmonary nodule investigated by positron emission tomography and biopsy, histologically proved adenocarcinoma. Another patient with a 15 mm suspicious pulmonary nodule had a prior thoracic CT examination performed two years ago, and the final decision was that the nodule was most likely benign due to its stability during this period. One patient with esophageal wall thickening underwent esophagoscopy and biopsy with a histological diagnosis of esophageal carcinoma. Two patients with indeterminate liver lesions that did not meet the criterion of a cyst were additionally examined by ultrasound and triphasic MDCT. One of these patients had a 16 mm hypodense lesion in segment 8 of the liver. Triphasic MDCT revealed that this lesion had enhancement characteristics of a hemangioma. Another patient with a prior history of pancreatic adenocarcinoma had a 24 mm hypodense lesion in segment 4. Ultrasound and triphasic MDCT revealed additional four lesions in the liver. The patient underwent a liver biopsy with a histological diagnosis of metastasis of adenocarcinoma. A de-

tailed list of all extracardiac findings with percentages is given in Table 1.

DISCUSSION

MDCT coronary angiography is performed with increasing frequency as a non-invasive method for evaluation of coronary artery disease in symptomatic and asymptomatic patients. The detection of extracardiac findings on MDCT coronary angi-



FIGURE 3: Axial MDCT image of a 58-year-old woman shows bilateral pulmonary embolism (arrows).



FIGURE 4: Axial MDCT image of a 75-year-old man shows a spiculated mass (arrow) in the left upper lobe with a diameter of 3.2 cm. Histology confirmed diagnosis of adenocarcinoma.

TABLE 1: Summary of 242 Incidental Extracardiac Findings on MDCT in 155 patients.

Extracardiac Findings	No (%)
Insignificant findings	136 (56.2%)
Emphysema, bulla	26
Atelectasis	12
Calcified pulmonary nodule	14
Noncalcified pulmonary nodule (<8 mm)	22
Bronchiectasis	8
Lung cysts	3
Calcified pleural plaque	5
Calcified lymph nodes	21
Hiatal hernia	5
Liver cyst	9
Fatty liver	5
Splenic cyst	2
Splenic calcification	3
Vertebral hemangioma	1
Significant findings	106 (43.8%)
Moderate	93 (38.4%)
Consolidation, ground glass opacity	5
Noncalcified pulmonary nodule (8-30 mm)	10
Interstitial lung disease	5
Pleural effusion	8
Pleural thickening	5
Pericardial effusion	8
Pericardial thickening	4
Pericardial calcification	2
Mediastinal lymphadenopathy (>10 mm)	18
Ascending aortic aneurysm (40-50 mm)	13
Descending aortic aneurysm (30-40 mm)	6
Pulmonary artery ectasia	8
Sclerotic bone lesions	1
Severe	13 (5.4%)
Ascending aortic aneurysm (>50 mm)	4
Aortic dissection	1
Pulmonary embolism	2
Pulmonary mass (>30 mm)	1
Suspicious pulmonary nodule	2
Esophageal wall thickening	1
Indeterminate liver lesion	2

raphy examination is important because they may account for the patient's clinical symptoms, indicate underlying malignant disease or require immediate workup and treatment. In this study, 41.3% of the patients referred for MDCT coronary angiography had extracardiac findings, 3.2% had highly significant extracardiac pathology requiring immediate workup and treatment, and 8 patients eventually had therapeutic consequences.

So far, several studies have been published evaluating the prevalence of incidental extracardiac findings using electron-beam-computed tomography (EBCT) and 16-slice or 64-slice MDCT.⁴⁻¹⁴ Depending on the patient population, incidental extracardiac findings are detected on 10-60% of cardiac CT scans.⁴⁻¹⁴ Hunold et al reviewed 1812 consecutive patients who underwent non-contrast EBCT for calcium scoring.⁴ They found that 53% of the study subjects had incidental extracardiac findings and 11% had significant findings requiring further diagnostic investigations. They included a large number of minor abnormalities, such as pulmonary scarring, atelectasis, degenerative arthritis and rib fractures. In a similar study of 1326 EBCT examinations for calcium scoring, Horton et al.⁵ found that 7.8% of the patients had significant extracardiac findings requiring additional work-up and 5% of patients had noncalcified pulmonary nodules. No pulmonary emboli were reported, which may be ascribed to the fact that no contrast agent was administered in those patients. In our study with contrast-enhanced MDCT coronary angiography, pulmonary emboli were detected in 0.5% of patients, which is similar to the results of Haller et al. They reviewed 166 consecutive patients who underwent 16-slice MDCT coronary angiography and found significant extracardiac findings in 4.8% and incidental pulmonary emboli in 0.6% of patients. Onuma et al reviewed 503 patients who underwent 16-slice or 64-slice MDCT coronary angiography examinations.⁸ Cardiologists evaluated the heart, while radiologists reviewed the other organs, and found that 22.7% of patients with clinically significant extracardiac findings required further work-up, and 3.6% who eventually had therapeutic consequences. Dewey et al reported an incidence of 5% for clinically significant findings and only 10% for nonsignificant findings, in a cohort of 108 patients scanned with a 16-slice MDCT.⁹ However, Gil et al reported a 56.2% rate of extracardiac findings in their study, without classifying them by severity, in a cohort of 258 patients also scanned with 16-slice MDCT.¹⁰ The differences in the incidence of extracardiac find-

ings in these studies are related to the technique used, as EBCT will use thicker slices than MDCT, and will be performed without the administration of a contrast agent that might specifically demonstrate some otherwise hidden findings, and to the predetermined criteria to include and/or classify the findings.

Various incidental extracardiac findings have been reported, with a common one being the pulmonary nodule. The frequency of the incidental finding of pulmonary nodules in MDCT coronary angiography was reported to range from 5% to 20%.^{5-8,10,11} The Fleischner Society's recommendations for follow-up and management of pulmonary nodules detected incidentally on screening CT do not suggest follow-up of nodules smaller than 4 mm in non-smokers and patients with low risk of lung cancer.¹⁵ Larger nodules greater than 8 mm or with suspicious radiographic features such as spiculation or irregular margins may benefit from formal thoracic CT for characterization and detection of probable concurrent nodules, evaluation of lymphadenopathy or other pulmonary diseases.¹⁵ A recent review on solitary pulmonary nodules by Winer-Muram showed that more than 90% of nodules smaller than 2 cm were benign.¹⁶ Stability of size over a 2-year follow-up period will be reassuring. In our study, 34 pulmonary nodules were detected in 24 patients. The frequency of pulmonary nodules in our study population was 6.4% (24/375); most (64%) were smaller than 8 mm and their imaging characteristics did not suggest malignancy. We considered that two nodules had suspicious radiographic features; one of the nodules was diagnosed as lung adenocarcinoma by follow-up evaluation with positron emission tomography and lung biopsy.

For cardiac imaging, to maximize spatial resolution and anatomic detail, it is necessary to use a field of view (FOV) that contains only the heart, called coned-down or limited FOV. However, this FOV includes only one third of the chest volume and excludes a large portion of the lung parenchyma. The limited scan FOV, which does not cover the entire chest, is a limiting factor for the application of MDCT coronary angiography to detect in-

cidental extracardiac findings. In a recently published study, Northam et al found that during MDCT coronary angiography, if only limited FOV images were viewed, more than 67% of lung nodules larger than 10 mm and more than 80% of nodules smaller than 10 mm would be missed.¹⁴ Combining their findings with those of Onuma et al showed that fewer than one third of pulmonary neoplasms would be diagnosed with use of only a limited FOV.⁸

In a study reported by Budoff et al, reviewing the literature to determine the potential benefits and harms of specifically overreading MDCT coronary angiography for extracardiac findings, they suggested that specifically reanalyzing the data set for noncardiac disease would almost certainly cause additional costs and anxiety to the patient, without proven benefit.¹⁷ We believe that this suggestion is not good enough, especially given the many types of incidental findings, many of which are not benign. A favored approach should be to detect the incidental extracardiac findings and report their clinical significance. There is a major benefit for the individual patient in identifying potentially life-threatening extracardiac findings such as aortic dissection or pulmonary embolism. In our study, one patient had type 2 aortic dissection and two patients had pulmonary embolism. These findings led to an immediate aortic surgery and anticoagulant therapy, respectively. In our study, 3 cases of malignancies consisting of 1 esophagus and 2 lung cancers were detected during the asymptomatic and surgically treatable stage.

Our study is limited by the lack of follow-up to evaluate the validity of our classification system on patients with moderately significant findings. However, the primary aim of our study was to determine the prevalence of significant extracardiac findings requiring additional clinical or radiological follow-up but it was not to follow the outcome of the abnormalities detected.

CONCLUSION

Today, MDCT scanner is increasingly used as a method to evaluate coronary arteries. Because extracardiac structures such as lungs, mediastinum

and upper abdomen are readily appropriate for assessment in MDCT coronary angiography, and extracardiac findings are frequent, the reporting

radiologist should be aware of the likelihood and frequency of these findings and their probable significance.

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