Prevalence of extracardiac findings in the evaluation of ischemic heart disease by multidetector computed tomography

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Abstract

Objective  Multidetector computed tomography (MDCT) is now commonly used for the evaluation of coronary artery disease. Because MDCT images include many non-cardiac organs and the patient population evaluated is highly susceptible to extracardiac diseases, this study was designed to evaluate the prevalence of extracardiac findings in the MDCT evaluation of ischemic heart disease. Methods  From March 2007 to March 2008, a total of six-hundred twenty patients, who underwent 64-slice MDCT evaluations for chest pain, or dyspnea, were enrolled in this study. Cardiac and non-cardiac findings were comprehensively evaluated by a radiologist. Results  Enrolled patients included 306 men (49.4%), with a mean age of 66 years. Significant coronary artery stenosis was found in 41.6% of the patients. A total of 158 extracardiac findings were observed in 110 (17.7%) patients. Commonly involved extracardiac organs were lung (36.7%), hepatobiliary system (21.5%), thyroid (19.6%), kidney (10.8%), spine (9.7%) and breast (0.6%). Of those 110 patients, 50 (45.5%) patients underwent further diagnostic investigations. Malignant disease was detected in three (2.7%) patients (lung cancer, pancreatic cancer, and thyroid cancer). Conclusions  Extracardiac findings are frequently present and should be a concern in the MDCT evaluation of chest pain syndrome.

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1 Introduction

Invasive coronary angiography is the gold standard method for the detection of coronary artery stenosis.[1] Recent advances including the introduction of multidetector computed tomography (MDCT), a submillimeter scan with high spatial and temporal resolution, have allowed substantial progress in the non-invasive diagnosis of coronary artery disease. Several studies about the role of 64-slice CT in the diagnosis of coronary artery disease (CAD) showed that their sensitivities and specificities were more than 90% and 96%.[2-5] In the latter context, MDCT images include portions of the lung, mediastinum, chest wall, spine and bones and upper abdomen,[6] in addition to the heart, coronary arteries and great vessels. With the ever-increasing rate of coronary CT investigations, extracardiac findings may be more frequently encountered in patients with suspected coronary artery disease.

Chest pain can be of cardiovascular or noncardiovascular origin. Because in 14% of patients with unstable angina, coronary angiography revealed no significant stenosis in the epicardial coronary artery,[7] confirming that diagnostic methods evaluating myocardial ischemia, or coronary obstructions, are insufficient for a complete evaluation of the chest. This study was, therefore, designed to evaluate the prevalence of extracardiac findings during the MDCT evaluation of ischemic heart disease.

2 Methods

2.1 Study patients

This study included 620 consecutive patients who underwent MDCT from March 2007 to March 2008 at our institution for the evaluation of coronary artery disease. All patients were in stable condition; individuals who were admitted with acute coronary syndrome were excluded from this study.
2.2 Multidetector CT scan

Coronary CT angiography was performed with a 64-detector row MDCT scanner (Discover DVCT, GE Healthcare, USA). The CT scanning was performed with a detector collimation of 0.625 mm at 120 kV, using 650 mAs and rotation speed of 0.35 s. Slice thicknesses were 0.625 mm and the reconstruction interval was 0.625 mm. A single oral dose of 25–100 mg metoprolol (Yuhan Pharma, Inc, Korea) was administered two hours before the MDCT scan, if the heart rate was > 60 beats/min. The contrast enhanced scan area was set from upper neck proximally to upper abdominal area distally. A scan delay time was calculated to the maximal opacification of the proximal ascending aorta after bolus injection of contrast medium. A total of 40–60 mL of low-osmolar, non-ionic contrast medium (Bono-rex™ 350mg I/mL; Dai Han Pharm, Seoul, Korea) was injected via the antecubital vein at a rate of 4 mL/s.

2.3 CT image analysis

All image processing and analyses were performed on a GE Advantage Windows Workstation (GE Healthcare, USA). A comprehensive image analysis, including cardiac structures, bone, lung and soft tissues, was performed by a radiologist. Significant coronary artery stenosis was defined as > 50% of arterial diameter stenosis on a maximal intensity projection image. Extracardiac findings were regarded as abnormal when these studies required additional imaging, invasive study or a further follow-up by an experienced radiology doctor who had read more than 1000 cases of MDCT. Patients were classified into two groups, namely those with extracardiac findings (Group A) and without extracardiac findings (Group B). Clinical data were obtained from the medical records and compared the two groups.

2.4 Statistical analysis

All numerical variables were expressed as mean ± SD. Categorical variables were expressed as frequencies. The Student’s t-test or non-parametric analysis with the Mann-Whitney U test was used to analyze continuous variables for comparisons between groups. The Chi-square test or the Fisher’s exact test was used for comparisons of categorical variables expressed as frequencies. Multivariate logistic regression analysis was used to evaluate predictors for the presence of extracardiac findings. SPSS version 17.0 (SPSS Inc., Chicago, Illinois) was used for data analysis. A value of $P < 0.05$ was considered statistically significant.

3 Results

The 620 patients included 306 males (49.4%) with a mean age of 66.3 ± 8.7 years. Of these patients, 24.7% were current smokers, and hypertension was the most frequent risk factor for atherosclerotic ischemic heart disease (32.6%). Significant coronary artery stenosis was found in 41.6% of patients, and a total number of 468 lesions was found in those patients (Table 1).

Table 1. Baseline characteristics of the study population.

| Variables | Value ($n = 620$) |
|-----------|-------------------|
| Male gender | 306 (49.4%) |
| Age (yrs) | 66.3 ± 8.7 |
| Smoking | 153 (24.7%) |
| Diabetes mellitus | 117 (18.9%) |
| Hypertension | 202 (32.6%) |
| Cerebrovascular accident | 44 (7.1%) |
| Body mass index > 25% | 125 (20.2%) |
| LDL cholesterol level, mg/dL | 115.3 ± 38.8 |
| hsCRP level, mg/dL | 1.7 ± 11.8 |
| Coronary lesion location |  |
| Left anterior descending artery | 198 (42.3%) |
| Left circumflex artery | 121 (25.9%) |
| Right coronary artery | 126 (26.9%) |
| Left main trunk | 23 (4.9%) |

Data are presented as $n$ (%) or mean ± SD. LDL-C: Low density lipoprotein cholesterol; hsCRP: high sensitivity C-reactive protein.

There were some differences in clinical characteristics between Group A and Group B. Table 2 shows the results of univariate analysis of the differences of clinical features and characteristics of chest discomfort between the two groups. Mean age was higher, chest pain duration was shorter and less typical, dyspnea complaint frequency was higher, and significant coronary artery stenosis was less common in Group A than in Group B. Multivariate analysis including, age, symptom duration, presence of typical chest pain and dyspnea, showed that there were no significant predictors for the presence of extracardiac findings (Table 3).

A total of 158 extracardiac findings were observed in 110 (17.7%) of the 620 patients (Table 4). Lung (36.7%), hepatobiliary system (21.5%), thyroid (19.6%) and kidney (10.8%) were common extracardiac organs with abnormal findings. Among lung abnormalities, follow-up studies were recommended for 31 pulmonary nodules measuring < 15 mm. Four patients with lung nodules ≥ 15 mm underwent lung biopsy to rule out malignancy. Lung cancer, which was
Table 2. Differences in clinical characteristics between groups.

| Variable                    | Group A    | Group B    | P-Value |
|-----------------------------|------------|------------|---------|
| Male                        | 60 (54.1%) | 246 (48.3%)| 0.274   |
| Age, yrs                    | 67.9 ± 9.1 | 66.0 ± 8.6 | 0.042   |
| Smoking                     | 24 (33.3%) | 129 (38.2%)| 0.441   |
| Diabetes mellitus           | 17 (23.6%) | 100 (28.4%)| 0.407   |
| Hypertension                | 35 (47.9%) | 167 (47.3%)| 0.921   |
| Cerebrovascular accident    | 5 (6.9%)   | 39 (11.0%) | 0.298   |
| Body mass index > 25%       | 26 (39.4%) | 99 (32.5%) | 0.280   |
| LDL cholesterol level, mg/dL| 114.7 ± 34.6| 115.41 ± 39.7| 0.892  |
| hsCRP level, mg/dL          | 1.9 ± 5.4  | 1.7 ± 12.8 | 0.883   |

Symptoms

- Chest pain duration, day: 19.7 ± 49.9 vs. 46.5 ± 143.9, 0.011
- Typical chest pain: 23 (31.5%) vs. 152 (45.2%), 0.032
- Atypical chest pain: 32 (43.8%) vs. 139 (41.2%), 0.684
- Dyspnea: 35 (47.9%) vs. 114 (33.4%), 0.019
- Absence of significant coronary artery stenosis: 72 (64.9%) vs. 290 (57.0%), 0.049

Table 3. Multivariate logistic analysis for predictors of the presence of extracardiac findings.

| Variant                      | RR (confident interval) | P-value |
|------------------------------|-------------------------|---------|
| Age (vs. > 80 yrs)           |                         |         |
| 50–59                        | 1.396 (0.431–4.517)     | 0.578   |
| 60–69                        | 1.499 (0.508–4.423)     | 0.463   |
| 70–79                        | 1.504 (0.511–4.428)     | 0.458   |
| Symptom duration (vs. > 56 days) |                       |         |
| 0–14                         | 1.420 (0.574–3.508)     | 0.448   |
| 15–28                        | 0.425 (0.047–3.820)     | 0.445   |
| 29–56                        | 1.257 (0.433–3.648)     | 0.674   |
| Typical chest pain (vs. Non-typical chest pain) | 0.567 (0.304–1.057) | 0.074   |
| Dyspnea (vs. no dyspnea)     | 1.530 (0.848–2.763)     | 0.158   |

Table 4. Prevalence of extracardiac findings by organ.

| Findings by organ              | Number of lesions | Number of follow-up investigations |
|-------------------------------|-------------------|-----------------------------------|
| Lung                          | 58 (36.7%)        | 33                                |
| Pulmonary nodule (< 15 mm)    | 31 (19.6%)        | 17                                |
| Pulmonary mass (≥ 15 mm)      | 4 (2.5%)          | 3                                 |
| Pleural effusion              | 11 (7.0%)         | 7                                 |
| Pneumonia                     | 10 (6.3%)         | 5                                 |
| Pulmonary thromboembolism     | 2 (1.3%)          | 1                                 |
| Hepatobiliary system & Pancreas| 34 (21.5%)      | 14                                |
| Gallbladder stone             | 21 (13.3%)        | 7                                 |
| Biliary stone                 | 3 (2.0%)          | 1                                 |
| Liver cyst                    | 4 (2.5%)          | 2                                 |
| Liver mass                    | 4 (2.5%)          | 2                                 |
| Pancreatic cyst               | 2 (1.3%)          | 2                                 |
| Kidney                        | 17 (10.8%)        | 8                                 |
| Renal cyst                    | 12 (7.6%)         | 5                                 |
| Renal mass                    | 2 (1.3%)          | 2                                 |
| Renal stone                   | 2 (1.3%)          | 1                                 |
| Hydronephrosis                | 1 (0.6%)          | 0                                 |
| Adrenal gland mass            | 2 (1.3%)          | 0                                 |
| Thyroid nodule                | 31 (19.6%)        | 14                                |
| Spinal fracture               | 11 (9.7%)         | 4                                 |
| Others                        | 5 (3.1%)          | 3                                 |
| Breast mass                   | 1 (0.6%)          | 0                                 |
| Abdominal aortic aneurysm     | 1 (0.6%)          | 1                                 |
| Hiatal hernia                 | 2 (1.3%)          | 2                                 |
| Ascites                       | 1 (0.6%)          | 0                                 |
| Total                         | 158 (100%)        | 76 (48.1%)                        |

diac findings (21.5%). Gallbladder stones were the most frequent findings, although their relation to the patient’s clinical symptoms was unclear and none required surgical intervention. Thyroid nodule was the third most common abnormality. Of 31 thyroid nodules detected, only one patient had papillary thyroid cancer and underwent total thyroidectomy. Kidney and adrenal gland diseases were found in 19 patients. Unexplained hydronephrosis was detected in one patient, but he refused follow-up investigation. One year later, he was found to have pancreatic cancer with ureteral metastasis.

Figure 1 shows different extracardiac findings by MDCT.
4 Discussion

Multidetector coronary computed tomographic angiography is now being carried out with increasing frequency as a non-invasive method for the evaluation of ischemic heart disease. Because the field of view in MDCT examinations includes the lungs, bony thoracic cage, spine and upper abdomen, it is a means for detection of potential abnormalities in them. This study investigated the potential value of MDCT to detect extracardiac findings in patients complaining of chest pain, or dyspnea. We determined that 110 (17.7%) of the 620 patients who underwent MDCT had extracardiac lesions requiring further evaluation. Although the prevalence of extracardiac findings in this study is toward the low end of the range of previous studies,\textsuperscript{[8-11]} it is very important that the reporting cardiologist or radiologist be aware of the presence and potential significance of extracardiac findings to chest pain syndromes.

The frequency of the extracardiac findings differs among studies for a variety of reasons. Several previous studies involved electron-beam CT (EBCT) examinations. Horton, et al.\textsuperscript{[9]} reviewed 1,326 consecutive patients who underwent EBCT, and found that 7.8% of patients had significant extracardiac pathology requiring additional investigation: non-calcified lung nodules in 4.9%, infiltrates in 1.8%, liver lesion in 0.5% and bone abnormalities in 0.15%. The frequency of these extracardiac findings was lower than in our study because they excluded minor findings, such as granulomas, liver cysts, pleural lesions, and rib fractures. In contrast, Hunold, et al.\textsuperscript{[9]} in a study of 1,812 consecutive patients undergoing EBCT, found that 53% of patients had extracardiac findings: in the lungs in 28% of patients, mediastinum in 4%, spine in 5% and abdomen in 2%. They included minor insignificant findings, such as scars, granulomas, atelectasis, degenerative arthritis and rib fractures.

Some recently published studies examined the frequency of significant extracardiac findings on MDCT examination. In the study by Gil, et al.\textsuperscript{[10]} a total 258 consecutive asymptomatic participants underwent 16-slice MDCT scanning and found. One hundred and forty five patients (56.2%) to have significant extracardiac findings: lung abnormalities were detected in 91 (35.3%) patients, pericardium in 10 (3.8%), liver in 12 (4.6%), adrenal gland in 8 (3.1%) and bone in 3 (1.1%). Greenberg-Wolff, et al.\textsuperscript{[11]} reviewed 134 patients who underwent 40-slice MDCT coronary angiography examinations. Extracardiac findings were observed in 76.8% of patients. Clinically significant findings were present in 39%. The most common findings were pulmonary nodules > 4 mm (13%) and enlarged mediastinal lymph nodes > 10 mm (10%); other significant findings included aortic aneurysm in 4.5%, spine in 9%, abdomen in 3%. Our study shows a lower prevalence of extracardiac findings than other MDCT studies, which is probably secondary to several causes. First, the field of the extracardiac region covered differs among studies. Second, patients included in the study have different clinical characteristics and symptoms. Third, the definition of “abnormal findings” is different among studies.

Some researchers have pointed out that over-reading MDCT for extracardiac findings can have untoward consequences, including additional costs and anxiety to the patients without proven benefit.\textsuperscript{[12]} Also, a recent document of the American College of Cardiology Foundation/American Heart Association (ACC/AHA) defining the examination for evaluation and interpretation of MDCT findings, was limited to the interpretation of cardiac findings, while other reports underscore that significant extracardiac findings need further evaluation and treatment, and that ignoring, or not reporting, extracardiac findings has legal and moral implications. The American College of Radiology practice guidelines stress that professionals performing MDCT should be competent in the evaluation of cardiac, as well as non-cardiac findings.\textsuperscript{[13]}

In conclusion, this study of elderly patients with common

\[\text{Figure 1. Images of extracardiac findings by multidetector computed tomography. (A): Pulmonary nodule (biopsy – adenocarcinoma); (B): Thyroid nodule (biopsy – papillary carcinoma); and (C): Hydronephrosis (pancreatic cancer with ureteral metastasis).}\]
risk factors for malignancy, especially lung cancers, and undergoing MDCT evaluation of chest pain syndrome, confirmed that the presence of extracardiac findings is frequent and should be of concern.

References
1. Lawler LP, Pannu HK, Fishman EK. MDCT evaluation of the coronary arteries, 2004: How we do it-data acquisition, post-processing, display, and interpretation. AJR Am J Roentgenol 2005; 184: 1402–1412.
2. Sun Z, Lin CH, Davidson R, et al. Diagnostic value of 64-slice CT angiography in coronary artery disease: A systematic review. Eur J Radiol 2008; 67: 78–84.
3. Abdulla J, Abildstrom Z, Gotzsche O, et al. 64-multislice detector computed tomography coronary angiography as potential alternative to conventional coronary angiography: a systematic review and meta-analysis. Eur Heart J 2007; 28: 3042–3050.
4. Mowatt G, Cook JA, Hillis GS, et al. 64-slice computed tomography angiography in the diagnosis and assessment of coronary artery disease: systematic review and meta-analysis. Heart 2008; 94: 1386–1393.
5. Vanhoenacker P, Heijenbrok-Kal M, Van Heste R, et al. Diagnostic performance of multidetector CT angiography for assessment of coronary artery disease: meta-analysis. Radiology 2007; 244: 419–428.
6. Law YM, Huang J, Chen K, et al. Prevalence of significant extracoronary findings on multislice CT coronary angiography examinations and coronary artery calcium scoring examination. J Med Imaging Radiat Oncol 2008; 52: 49–56.
7. Diver DJ, Bier JD, Ferreira PE, et al. Clinical and angiographic characterization of patients with unstable angina without critical coronary arterial narrowing (from the TIMI-IIIA Trial). AM J Cardiol 1994; 74: 531–537.
8. Horton KM, Post WS, Blumenthal RG, et al. Prevalence and clinical significance of accidental findings in electron beam tomographic scans for coronary artery calcification. Eur Heart J 2001; 22: 1748–1758.
9. Hunold P, Schmermund A, Seibel RM, et al. Prevalence and clinical significance of accidental findings in electron-beam computed tomography coronary artery calcium screening examinations. Circulation 2002; 106: 532–534.
10. Gil BN, Ran K, Tamar G, et al. Prevalence of Significant Noncardiac findings on coronary multidetector computed tomography angiography in asymptomatic patients. J Comput Assist Tomogr 2007; 31: 1–4.
11. Greenberg-Wolff I, Uliel L, Goitein O, et al. Extra-cardiac findings on coronary computed tomography scanning. Isr Med Assoc J 2008; 10: 806–808.
12. Budoff MJ, Fischer H, Gopal A. Incidental findings with cardiac CT evaluation: should we read beyond the heart? Catheter Cardiovasc Interv 2006; 68: 965–973.
13. ACCF/AHA Clinical competence statement on cardiac imaging with computed tomography and magnetic resonance. Circulation 2005; 112: 598–617.