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ORIGINAL ARTICLE

Value of "large FOV" calcium score as a screening method for detection of extracardiac incidental findings

Ahmed S. Ibrahim *, **Aya Y.El. Shokeiry**, **Wahid H. Tantawy**

Radiology Department, Faculty of Medicine, Ain Shams University, Cairo, Egypt

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KEYWORDS

FOV;
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Abstract *Purpose:* The purpose of this study was to emphasize the value of calcium scoring (Ca score) using a large field of view ("large FOV") as a screening method for detection of extracardiac incidental findings.

Materials and methods: 64-Multislice CT angiography using a "large FOV" in the preliminary calcium score followed by the post-contrast routine "small FOV" examination was performed for 382 consecutive patients between January 2011 and December 2012.

Results: 375 Patients (203 men and 172 women) with age range between 40 and 80 years (mean, 60 years), were studied, using a "large FOV" technique. Among whole incidental extracardiac findings, "significant" extracardiac abnormalities (emergent and intermediate findings) were detected in 24.8% of cases, among which 13.6% would have been missed if only using a "small FOV" technique.

Conclusion: Results showed that using Ca score with a "large FOV" is favorable for better, accurate and more frequent detection of extracardiac incidental findings. With usage of low dose technique, the difference in dose between "small FOV" and "large FOV" techniques is justified for detection of supplementary "significant" extra-cardiac findings including serious findings such as lung cancer or metastatic deposits.

1. Introduction

Calcium score (Ca score) is usually a standard part of the coronary CT angiography (CCTA) examination and is highly predictive for coronary heart disease (CHD) events. A twofold increase in calcium score is associated with a 34% increase in the risk of a hard CHD event and a 52% increase in the risk of any CHD event (1).

Non-cardiac findings are considered "incidental" if an abnormality is identified without antecedent clinical suspicion or previously known disease. Incidental findings are common in radiology practice, so it is not surprising that lesions are found incidentally during cardiac imaging examinations (2).

* Corresponding author.
E-mail addresses: asibrahima@gmail.com (A.S. Ibrahim), ayassin@hotmail.com (A.Y.El. Shokeiry), tantawyw@yahoo.com (W.H. Tantawy).
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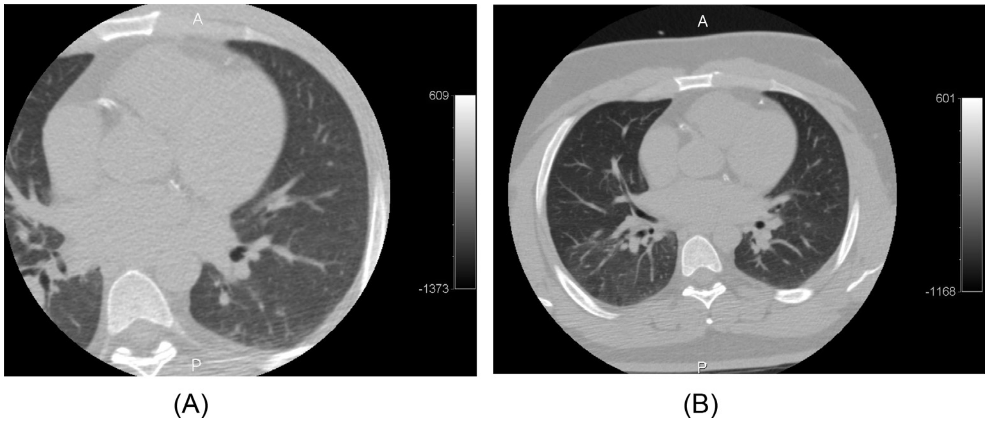

Fig. 1 MDCT Ca score [noncontrast CT chest examination] using a “small FOV” (A) and a “large FOV” (B) for same patient. Dose calculation and analysis of our cases, on a 64 MDCT scanner, showed an increase of ±1.2–1.9 mSv in dose, comparing Ca score with a “large FOV” technique dose versus that of a “small FOV” technique.

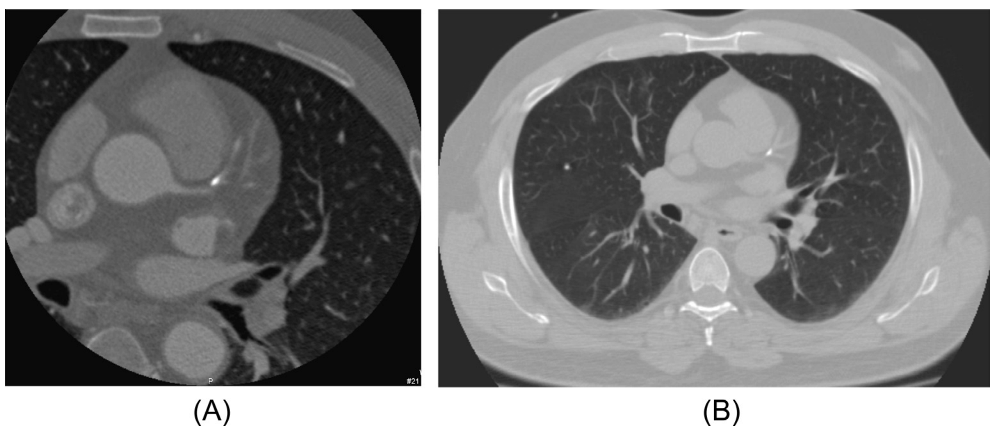

Fig. 2 MDCT; (A) angiography for coronary assessment using the standard “small FOV”. (B) Ca score for same patient using a “large FOV” revealing a right sided pulmonary nodule, classic example for an incidental extracardiac finding that would not have been detected using a “small FOV” technique in Ca score.

Because extra cardiac findings are frequent (3), the reporting radiologist should be aware of the likelihood and frequency of these findings and their clinical significance (4). Some of the incidental extra-cardiac findings may account for the patient’s clinical symptoms, while other incidental findings may indicate underlying malignant disease or even remain uncertain.

Cardiac CT angiography examinations are usually acquired with a small field of view (small FOV) focused on the heart (5). By acquiring a larger field of view [noncontrast CT chest examination], greater variety and numbers of innocent and significant lesions can be detected (6) (Figs. 1–3).

1.1. Aim of this work

The purpose of this study was to show how the systematic usage of “large Field Of View (FOV)” Ca score [noncontrast CT chest examination] technique in multidetector CT (MDCT) coronary cases instead of the “small FOV” technique, may allow for the detection of potentially “significant” extracardiac incidental findings without a great increase of the exposure dose.

2. Materials and methods

2.1. Patients

The institutional review board approved this study and informed consent was obtained. Between January 2011 and December 2012, 382 patients clinically indicated for coronary MDCT examination were included in the study and scanned starting by a calcium score examination covering whole chest – using a “large FOV” – followed by a routine “small FOV” coronary CT angiography examination. Patients were excluded if they declined to enter this study or did not have an accessible large intravenous line.

2.2. Image acquisition

All the examinations were performed using a MDCT scanner (Toshiba® Aquilion 64 CT Scanner) at Misr scan Radiology

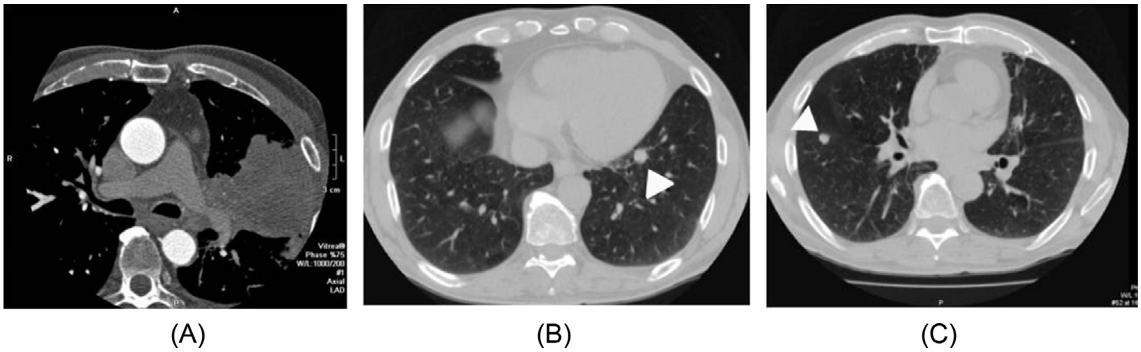

Fig. 3 MDCT; (A) angiography for coronary assessment using the standard “small FOV” revealing a left sided bronchogenic carcinoma. (B and C) “Large FOV” Ca score for same patient revealing bilateral highly suspicious pulmonary metastatic deposits, and only one of them would have been detected with the “small FOV” technique (white arrow) (B); while the other would only have been seen with the “large FOV” technique (white arrow) (C).

center, east Cairo, Egypt. As a preparatory phase, non-contrast calcium score covering whole chest from the root of the neck to the diaphragm, was done using a “large FOV” of 32–50 cm, interval 5 mm and slice thickness 5 mm. Other CT technical parameters included mA: 250–300 and kV: 120. Then, coronary CT angiography examination was performed via IV administration, in an antecubital vein through an 18- to 20-gauge IV catheter. We injected 65–85 mL of nonionic iodinated contrast material (Ultravist 370 [iopromide], Bayer HealthCare [formerly Schering]) at an injection rate of 5–5.5 mL/s with a power injector (double syringe pump), sure start 160, “small FOV”: 18–24 cm; mA: 300–400; kV: 120; and section thickness, 0.5 mm × 64 detectors.

Dose calculation, in mSv, was performed for 5 patients, comparing Ca score noncontrast CT chest examination using “Small FOV” and “Large FOV” techniques.

2.3. Data analysis and interpretation

Two blinded experienced cardiovascular radiologists (5 and 15 years), independently reviewed all cases on Vitrea® Workstation. The reviewers surveyed each examination, both

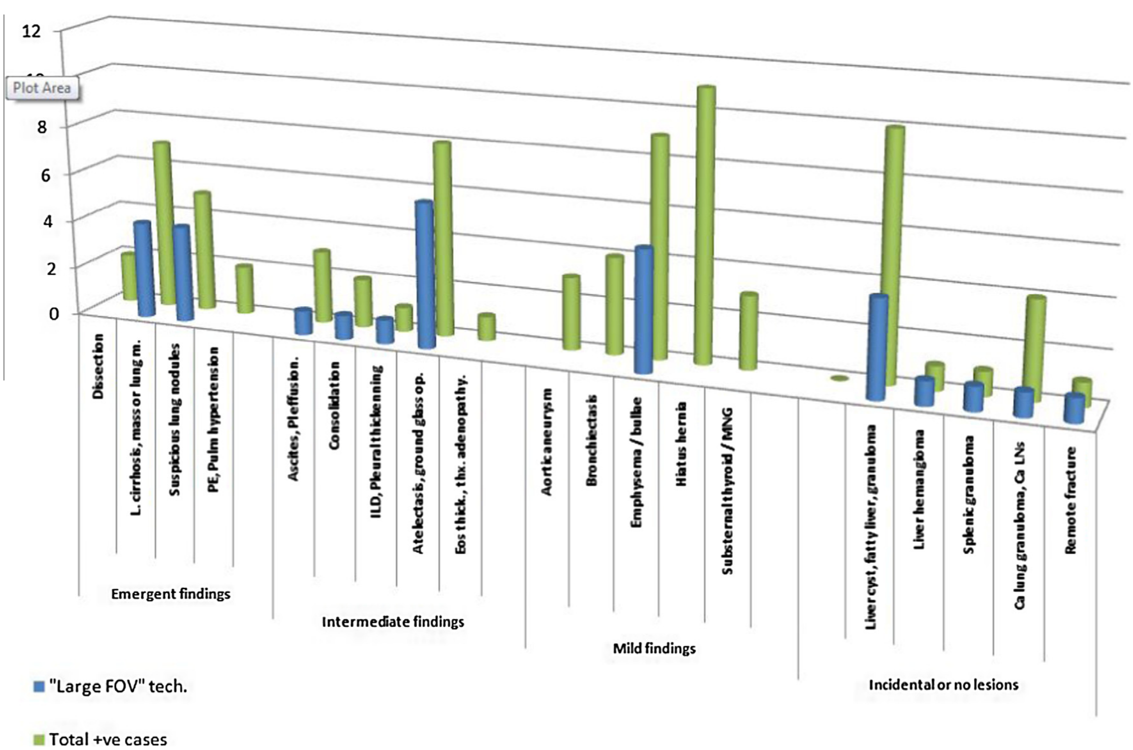

Fig. 4 Distribution of extra cardiac findings detected via “large FOV” Ca score among 375 consecutive patients for coronary MDCT between January 2011 and December 2012. Results were classified into four groups: (1) Emergent findings where therapy is often needed, (2) intermediate findings where timely workup is often needed with medical treatment, (3) mild findings where later follow-up is often needed and (4) incidental lesions where follow-up is often not needed. Among whole incidental extracardiac findings, “significant” extracardiac abnormalities (emergent and intermediate findings) were detected in 24.8%, among which 13.6% would have been missed if only using a “small FOV” technique.

the small FOV and large FOV, using axial source images for evaluation of extracardiac findings.

They reviewed all images in the axial plane using manually and independently adjusted settings for mediastinal windows and lung windows, vascular and bone windows. The window level settings were quite large, progressing to very wide settings in the cases of dense calcifications.

Results were classified into four groups: (1) Emergent findings where surgical intervention is needed, (2) intermediate findings where medical intervention is enough, (3) mild findings where later follow-up is needed and (4) incidental lesions where follow-up is not needed (Fig. 4). Finally, the two radiologists reviewed the findings together and reached a consensus about the findings.

The emergent group included complicated aortic dissection, liver mass, lung mass, pulmonary embolism and pulmonary hypertension. The intermediate findings were ascites and lung inflammatory diseases as consolidation, effusion, pleural thickening and interstitial lung disease. The mild findings were: non-complicated aortic aneurysm, multinodular goiter, bronchiectasis, hiatus hernia and emphysema. The incidental findings were liver hemangioma, fatty changes of liver, splenic granuloma, calcified lymph nodes or nodules and remote fracture.

The findings were recorded according to their presence in both fields: the large and small fields. We analyzed the numbers to outline the incidence of extracardiac lesions and the percentage missed lesions on small FOV.

Table 1 Distribution of emergent and intermediate significant findings. Extra cardiac findings detected using "large FOV" compared to "small FOV" technique.

	Findings	Large "FOV"	Small "FOV"
Emergent F.	Dissection	6	6
	Liver cirrhosis, mass or lung mass	21	9
	Suspicious pulmonary nodules	15	3
	PE, Pulm hypertension	6	6
Intermediate F.	Ascites, Pl effusion	9	6
	Consolidation	6	3
	ILD, Pleural thickening	3	3
	Atelectasis, ground glass opacities	24	3
	Eos thickening, thoracic adenopathy	3	3
Mild findings	Aortic aneurysm	9	9
	Bronchiectasis	12	12
	Emphysema/bullae	27	12
	Hiatus hernia	33	33
	Substernal thyroid/MNG	9	9
Incidental F.	Liver cyst, fatty liver changes, granuloma	30	18
	Liver hemangioma	3	
	Splenic granuloma	3	
	Ca lung granuloma, Ca LNs	12	9
	Remote fracture	3	
	No findings	141	
	Total	375	

Table 2 Distribution of all extracardiac incidental abnormalities.

	Findings	Cases	Percentage %
Total significant F.	Emergent + intermediate	93	24.8
Total mild findings	Mild + incidental	141	37.6
No findings		141	37.6
Total[a]		375	

[a] 7 cases were excluded.

Table 3 Calculation of additional significant extracardiac abnormalities using "Large FOV" compared to "small FOV".

	Findings out of total	Percentage %
Total significant F. "Large FOV"	93/375	24.8
Significant F. "Small FOV"	42/375	11.2
Extra significant F. using "Large FOV"	51/375	13.6

3. Results

382 Patients were scanned during the study period, 5 declined enrolling in the study and 2 had no IV access. The total number was 375 patients, 203 men and 172 women, 40–80 years old (mean, 60 years), were included in this study and incidental extracardiac findings were found in 62.4% of scanned patients.

Among whole incidental extracardiac findings, "significant" extracardiac abnormalities (emergent and intermediate findings) were detected in 93 out of 375 cases (24.8%), 42 cases (11.2%) out of these 93 cases were detected by using "small FOV" technique, so 51 out of remaining 93 cases (13.6%) would have been missed if only using a "small FOV" technique (Tables 1–3). Dose calculation and analysis for 5 of our cases, on a 64 MDCT scanner, showed an increase of ±1.2–1.9 mSv in dose, comparing Ca score with a "large FOV" technique dose versus that of a "small FOV" technique.

4. Discussion

Systematic usage of "large FOV" Ca score of the whole chest region [noncontrast CT chest examination] technique instead of the "small FOV" technique, offers the possibility to detect non-cardiac abnormalities from the same image acquisition (7). This can be achieved without a significant increase of the exposure dose.

Utilization of cardiac MSCT angiography must be defined as whether it leads to the greatest benefit and whether the radiation risk may be greater than the benefit expected from the CT examinations (8). The radiologists should aim at analyzing the non-cardiac findings focusing on the lungs, upper abdomen, mediastinum, bones and breasts as meticulously as possible to ensure that important findings that might be responsible for a patient's symptoms are not missed and unnecessary follow-up examinations are avoided (9,10). Our results showed that Calcium score using an extended "Large FOV" technique could be applicable at the expense of a small increase in patient dose allowing detection of supplementary significant incidental findings. In our results, "significant" extracardiac abnormalities were detected in 24.8%, among which 13.6% would have been missed if using only a "small FOV" technique.

Extra cardiac abnormalities may be clinically significant requiring further diagnostic workup, immediate therapeutic intervention, or clinical/imaging follow-up such as; aortic dissection, thyroid malignancy, hepatic malignancy and malignant breast lesion. Clinically non-significant findings include patients not requiring any additional examinations such as pulmonary granuloma and pulmonary scarring. The most common potentially significant finding is suspicious pulmonary nodule whereas the most common insignificant finding is hepatic cysts (11). In our study, incidental extracardiac findings were found in 62.4% of scanned patients, among which 24.8% were significant extracardiac abnormalities consisting of emergent and intermediate findings requiring further management versus mild and incidental non-significant findings – representing 37.6% – where later follow-up is often or not needed. The major non-cardiac organ system that is evaluable on cardiac CT is the lung parenchyma (including the pulmonary arteries). Lung parenchyma findings accounted for 66.5% of extra-cardiac findings. The most frequently occurring extra-cardiac findings and those causing most concern were the pulmonary nodules (12). In this study lung parenchyma findings accounted for 13.6% of extra-cardiac findings. Out of them, pulmonary nodules represented 24 out of 375 cases (6.4% of cases).

The "small" limited scan FOV, which does not cover the entire chest, is a limiting factor for the application of CT to identify incidental non-cardiac findings. Patient with absolutely normal coronary arteries could have a potentially life-threatening finding in the thorax accounting for chest pain, such as acute pulmonary embolism, acute aortic syndrome, or a relatively benign finding such as a large hiatal hernia (13). This applies to both inpatient or outpatient and emergency patient populations. Patients received at the emergency department in particular may present non-cardiac sources of chest pain that may be accurately detected with a cardiac CT/triple rule-out CT (7). In this work, 18 out of 375 cases (4.8%) were found to have extracardiac causes for their chest pain. A larger FOV emphasizes that many patients have benefited from the incidental discovery of malignant pulmonary nodules (14), most of which are only seen on the "large FOV" (15). Our work emphasizes that fact, with 3.2% of our cases presenting suspicious nodules (12 out of 375 cases).

The frequency of incidental findings is influenced by the scanning range. Larger scanning ranges containing more anatomic structures might reveal a greater number of incidental findings. The scanning range comprised the area between the lung apex to the base. When coronary CT angiograms were viewed in a limited, or focused way, the result was substantially reduced sensitivity to pathologic findings outside the mediastinum and serious pathologic conditions of heart were missed (6). Extracardiac upper mediastinal findings, i.e. from apex to level of carina, represented 25 out of 375 cases (6.6%) while extracardiac peripheral findings, i.e. outside confine of pericardium, represented 56 out of 375 cases (14.9%).

In a study by Johnson Kevin (16), using a "large" approach done for a total of 6920 patients who underwent consecutive contrast-enhanced MDCT examinations of the coronary arteries, 1642 of the 6920 patients (23.7%) had one or more extracardiac findings using a "small FOV". In his study, all anatomic structures were evaluated in the large field of view with standard mediastinal and lung windows. In a "focused" approach, the images were evaluated in the small field of view with mediastinal windows only. With the focused viewing approach, 51.2% necessitating follow-up were missed, while use of the broad viewing approach led to further workup of 10.2% of the findings and later follow-up of 50.6%. In our work, further more increase of 13.6% of extracardiac findings, was noted in "large FOV" technique.

These incidental lesions can often present a challenge to physicians because of both the potential benefits and the risks of identifying such lesions (17). The missing of even one cancer is clinically unacceptable. Additionally, "failure to diagnose" remains one of the most common issues in malpractice (18). Non-cardiac findings on cardiac examinations provide an opportunity to make alternative diagnoses that may account for the patient's symptoms or detect important but clinically silent problems such as early stage lung cancer. This global overview can be a mixed blessing (6). Large FOV images depict a considerably increased number of clinically important and indeterminate pathologic findings, including unsuspected lung cancers and indeterminate pulmonary nodules (19).

Radiologists should aim at analyzing the non-cardiac findings as meticulously as possible to ensure that important findings that might be responsible for a patient's symptoms are not missed and unnecessary follow-up examinations are avoided. A patient with absolutely normal coronary arteries could have a potentially life-threatening problem in the thorax accounting for chest pain, such as acute pulmonary embolism, acute aortic syndrome, or a relatively benign problem such as a large hiatal hernia. Thus, interpreters of cardiac CTA images should have adequate training and skill in differentiation between benign and potentially clinically significant lesions so as not to cause undue cost or patient anxiety and reducing additional work-up.

Recently, new advanced machines as dual MDCT with 256 and 320 detectors have enabled the radiation dose to be lowered to less than 1 mSv (sub-mSv dose) and this leads to the greatest benefit of the patient (7). "Large FOV" Ca score could be more easily and widely applicable in such conditions.

5. Conclusion

Using a "large FOV", incidental extracardiac abnormalities were detected in 62.4% of the scanned patients. Among those, incidental extracardiac findings, "significant" extracardiac abnormalities (emergent and intermediate findings) were detected in 24.8%, among which 13.6% would have been missed if only using a "small FOV" technique.

We confirmed that the frequency of incidental findings is influenced by the scanning range (20). Larger scanning ranges containing more anatomic structures would reveal a greater number of incidental findings and several serious diagnoses would be missed with the limited viewing approach. 6.6% of our cases were extracardiac upper mediastinal findings while 14.9% of our cases were extracardiac peripheral findings.

Conflict of Interest

There is no conflict of interest to declare.

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