Spiral CT Scan for Detecting Coronary Artery Stenosis

A. Soltani Shirazi MD[1].
N. Nasehi MD[2].
M. Sametzadah MD[1].
H. Saberi MD[3].
M.A. Shabani MD[3].

1. Assistant professor, Department of Radiology, Golestan Hospital, Ahvaz Jondishapour University of Medical Science, Ahvaz, Iran.
2. Department of Radiology, Golestan Hospital, Ahvaz Jondishapour University of Medical Science, Ahvaz, Iran.
3. Assistant professor, Department of Radiology, Medical Imaging Center., Imam Khomeini Hospital, Tehran University of Medical Science, Tehran, Iran.

Corresponding Author:
Ahmad Soltani Shirazi
Address:
MRI Section, Department of Radiology, Golestan Hospital, Ahvaz Jondishapour University of Medical Science, Ahvaz, Iran.
PO Box: 173-6135
Tel: 0098611-3349298
Fax: 0098611-3349298
Email: ahmadjak@yahoo.com

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Background/ Objective: Coronary vessel calcification is an obvious sign of atherosclerotic disease of coronary arteries. Electron beam CT scan is currently the imaging modality of choice for assessing coronary artery calcifications. However, its high cost makes it unavailable to a large number of medical centers. We carried out this study to compare the diagnostic yield of spiral CT scans as an alternative, to coronary angiography.

Patients and Methods: A hundred patients suspicious of having coronary artery disease (CAD) underwent angiography as well as spiral CT scan of the heart. On CT scan, calcification of >90 Hounsfield on a surface area of >0.5 mm^2, anatomically superimposed on coronary arteries were highlighted as calcified areas using the volumetric feature of the scanner. The findings were compared to angiographic results.

Results: Of 100 patients enrolled (62 males), 69 had coronary artery obstruction (>50% stenosis on angiography). Angiography was normal in the rest. Spiral CT scan had a sensitivity of 94% and a specificity of 61% for the diagnosis of coronary artery disease. The PPV and NPV were 84% and 79%, respectively. Among the coronary arteries, LAD findings had the highest sensitivity (92%) and the lowest specificity (65%) in the diagnosis of CAD. With age, spiral CT scan had more sensitivity and less specificity for CAD.

Conclusion: Detecting calcification by spiral CT scanning could be a useful non-invasive method for diagnosis and evaluation of coronary artery stenosis.

Keywords: calcium, scoring, atherosclerosis, coronary artery disease, angiography, spiral CT scan

Introduction

Coronary artery disease (CAD) results mainly from atherosclerosis of epicardial coronary arteries and is a major cause of mortality and morbidity worldwide.[1] Appearance of calcified plaques in the coronary arteries is a telltale sign of atherosclerosis.[1] Autopsy studies have evidently shown that there is a tandem relationship between coronary artery calcification and the extent of vascular stenosis, and subsequently the risk of myocardial infarction.[1]

A variety of imaging modalities has been used for detecting coronary artery calcifications of which, plain chest radiography and fluoroscopy have the lowest sensitivity.[2] Several studies have reported a sensitivity of 40-79% and a specificity of 52-95% for fluoroscopic detection of coronary artery calcifications.[2] Conventional CT scan despite its superiority over fluoroscopy in detecting coronary calcifications has certain limitations such as the slow pace of scanning and hence motion artifacts, volume averaging, problems due to patient's respiration, and inability to quantify the atherosclerotic findings.[2]A more recent imaging method is intravascular sonography, which can measure the vascular thickness and examine the mural histology.[2] Calcifications appear as hyperechoic areas with acoustic shadow; the non-calcified fibrotic plaques present as hyperechoic areas without acoustic shadow.[2] This method, however, is an invasive procedure anmainly during elective coronary angiography.[2]

Electron beam CT scan used to be the imaging technique of choice for coronary calcification,[3] however, multislice CT scans are used more commonly. The axial sections of the heart are obtained in less than 0.1 second, thus the motion artifacts due to heart beat are eliminated.[3] Unfortunately this method is inaccessible to many centers due to its high costs; therefore, spiral CT scan which is more available can be a suitable alternative in the assessments of coronary artery calcifications.

In this study we aimed at comparing spiral CT scan with coronary angiography regarding sensitivity, specificity, and positive and negative predictive values (PPV and NPV) in the diagnosis of coronary artery disease.

Patients and Methods

Spiral CT scanning of the heart was performed preferably 24 hours prior to coronary angiography on 100 patients suspected of coronary artery disease (62 men, 38 women) who had a positive history of myocardial infarction, typical angina, or a positive stress test with or without thallium scintigraphy. The patients with a prior coronary artery bypass surgery (CABG) and patients with artificial valves, stents, or pacemakers were excluded for the probability of producing imaging artifacts.

All patients were examined with a spiral CT scanner (Siemens Somatom Balance) and 3-mm axial sections with 120 Kv and 300 mA, were taken from carina downwards to the heart. Broderick method was used for calcium scoring. Calcification was defined as Hounsfield of more than 90 over an area of more than 0.5 mm^2. Using the volumetric feature of the scanner, the calcifications that were anatomically superimposed on the coronary arteries were highlighted and the volume and average Hounsfield at each axial section was calculated for each coronary artery (left anterior descending artery, LAD; right coronary artery, RCA; and left circumflex artery, LCX).(Figure 1a-1d)

We categorized the patients into two groups: with calcification and without it (i.e. test positive and test negative respectively).

Based on angiographic findings, we adopted a stenosis >50% in LAD, RCA, and LCX as the angiographic evidence of CAD. Then, patients were grouped in the following four groups: no coronary involvement, 1-vessel CAD, 2-vessel CAD, and 3-vessel CAD.

The sensitivity and specificity of spiral CT scan were calculated for involved LAD, RCA, or LCX by patients' gender and age.

It should be mentioned that at the time calcification scores were calculated, we were blind to the angiographic findings of the patients.

Results

Based on the stated angiographic criterion of significant stenosis (>50%), 69 out of 100 patients were diagnosed with CAD.

Of 69 patients with coronary artery disease, 46 (66%) were men; while of patients without CAD, only 16 (52%) were men. The distribution of the involved coronary arteries is depicted in Table 1.

The mean age was 57 years and the majority of the patients (n=36) were between 40-49 years of age.

The main objective of the study was to assess the diagnostic ability of the spiral CT scan in coronary artery disease. It must be explained that the criterion for the presence of coronary artery disease on spiral CT scan was detecting calcification according to the criteria described in the patients and methods section above. Table 2 summarizes spiral CT scan and coronary angiographic findings along with the sensitivity, specificity, PPV and NPV of the spiral CT scan in detecting coronary artery disease.

In 24 patients, no calcification was detected on CT scan, from which 19 did not have CAD on angiography. On the other hand, 5 patients turned out to have coronary artery disease on angiography despite no calcification on spiral CT scan (3 patients had 1-vessel disease and two had 2-vessel disease). Hence, an NPV of 79% was calculated.

It is noteworthy that of 69 patients with coronary artery disease on angiography, 64 patients had calcification, which shows a high sensitivity of the spiral CT scan (93%).

Table 1. Patterns of coronary artery disease

Coronary artery involvement	Men	Women	Total
No coronary artery disease	16	15	31
1-vessel disease	13	8	21
2-vessel disease	17	8	25
3-vessel disease	16	7	23
Total	62	38	100

The diagnostic ability of spiral CT scan was assessed for each artery separately. LAD had the highest sensitivity (92%) and the lowest specificity (65%).

Tables 3 and 4 summarize the diagnostic ability of spiral CT scan for CAD of each vessel, by gender.

Twelve people were 30-39 years of age, 36 aged 40-49 years, 27 aged 50-59 years, 19 aged 60-69 years, and 6 aged over 70 years of age. Table 5 depicts the diagnostic ability of spiral CT scan in different age groups.

Out of 19 patients at 60-69 years of age, 15 had coronary artery disease on angiography and a calcification score of >0 (i.e. sensitivity of 100%). Among the remaining 4 patients who did not have angiographic evidence of coronary disease, only 1 patient had the calcification score of 0, which yields a specificity of 25% for this age range.

Table 2. Comparison of the spiral CT scan and angiographic findings for detecting coronary artery disease (CAD).

Spiral CT scan \ Coronary angiography	Pts. with CAD	Pts. without CAD
+	64	12
-	5	19

Sensitivity=64×100/ 69= 94%; Specificity=19×100/ 31= 61%; PPV (positive predictive value) = 64×100/ 76= 84%; NPV (negative predictive value) = 19×100/ 24= 79%

Discussion

Presence of intimal calcification in coronary arteries is associated with coronary stenosis and a high risk of myocardial infarction, as evidenced in post mortem studies. Early diagnosis of atherosclerosis is therefore highly important in predicting and preventing myocardial infarction.[1,4] Imaging modalities especially CT scan have been proved quite helpful.

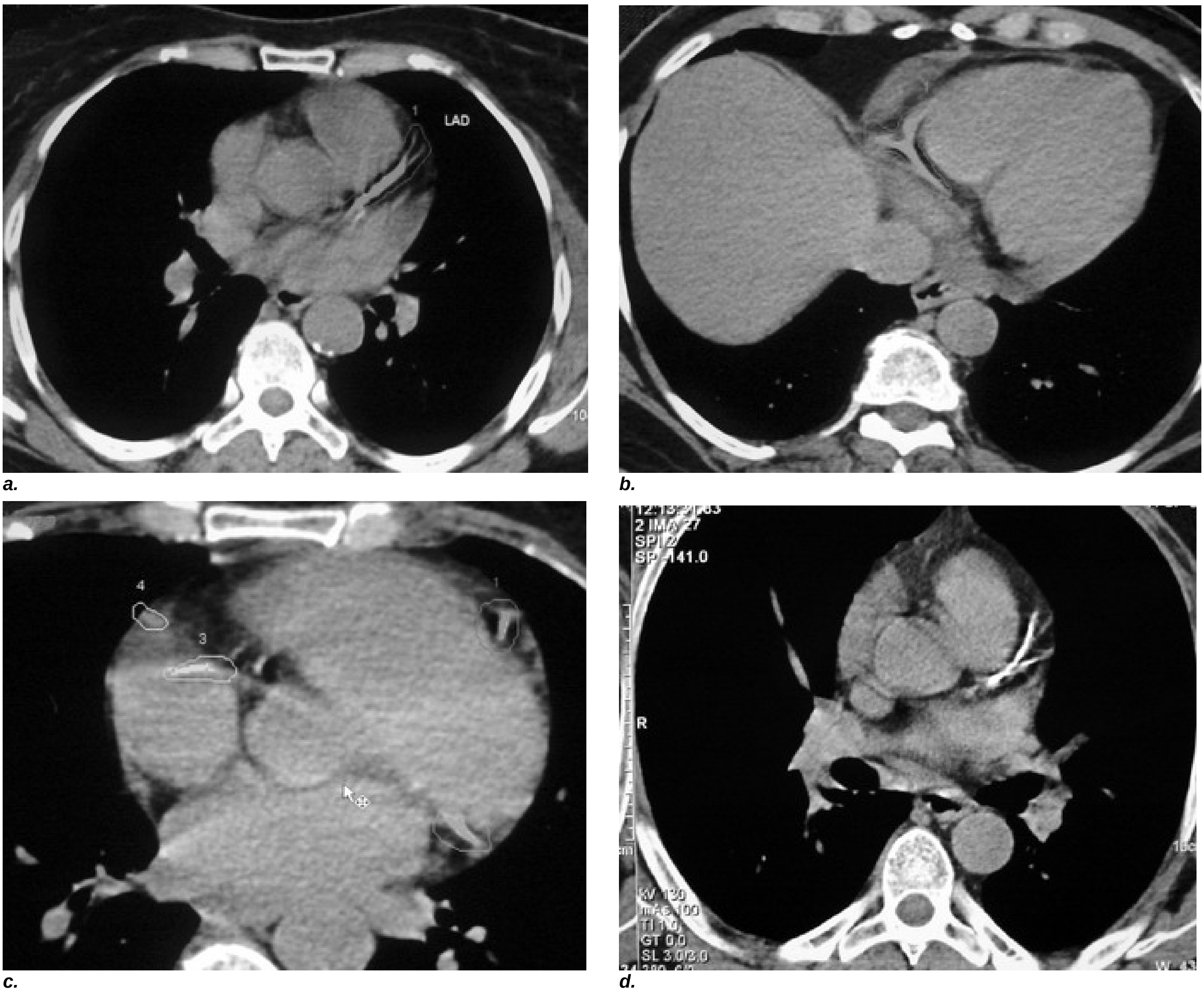

Fig 1. How to measure coronary artery calcification.

Table 3. Sensitivity, specificity, positive predictive value and negative predictive value for the spiral CT scan based on the involved coronary vessel.

Coronary artery involved	Sensitivity	Specificity	PPV	NPV
LAD	(53/57) 93%	(28/43) 65%	(53/68) 78%	(28/32) 87%
LCX	(33/42) 78%	(42/58) 72%	(33/49) 67%	(42/51) 82%
RCA	(29/40) 72%	(42/60) 70%	(42/60) 61%	(42/53) 79%

(LAD: left anterior descending artery; LCX: left circumflex artery; RCA: right coronary artery)

Table 4. Sensitivity, specificity, PPV and NPV of the spiral CT scan by gender

Coronary artery involvement	Sensitivity	Specificity	PPV	NPV
Men	(43/46) 93%	(10/16) 62%	(43/49) 88%	(10/13) 77%
Women	(21/23) 91%	(9/15) 60%	(21/27) 78%	(9/11) 82%

Medical literature states a sensitivity of 85-100% for CT scan in significant coronary artery stenosis.[4-10] Our study reports a sensitivity of 93% for spiral CT scan in coronary stenosis of >50% that is a very favorable result. Also, the specificity of spiral CT scan has been reported to be 41-62%, and our results yielded a specificity of 61%.

Reported PPV and NPV were 55-81% and 70-100% respectively [4-10] as compared to the respective values of 84% and 79% in our study. The NPV for spiral CT scan, in ruling out significant coronary artery stenosis was lower in our study (79%) than elsewhere (94-100%) which we believe it to be probably attributable to the composition of our study population. All our patients were clinically highly suspicious of having coronary artery disease as evidenced by ECG changes, therefore the probability of atherosclerosis and >50% stenosis was higher than the general population.

Regarding the diagnostic ability of spiral CT scan in detecting significant stenosis of each of the three main coronary arteries, we found that it had the highest sensitivity (93%) and the lowest specificity (65%) for LAD as compared with RCA and LCX. In a similar study from an Indian university hospital in 1995, LAD had the highest sensitivity (86%) and the lowest specificity (46%) among other main coronary arteries.[5] In our study, the lowest sensitivity belonged to RCA (72%); LAD had the lowest specificity (65%) on spiral CT scan.

As the results showed, the sensitivity of spiral CT in detecting significant coronary stenosis increased with age, so that the sensitivity was 100% in patients over 60 years of age. On the other hand, the specificity dropped with age. We can therefore conclude that at an older age, a negative CT scan result for coronary artery disease is more accurate.

In this regard, an important limitation was the small sample size of the age groups; for example only 19 patients were older than 60, of which only 4 patients had not CAD on angiography; computing test indicators (such as sensitivity and specificity) in this groups based on such small sample sizes could be associated with unreliable results. Computing the highest sensitivity equal to 100% and a low specificity equal to 25% could be due to this limitation. Assessing the results in groups with larger samples can yield more reliable results.

Finally, it is recommended to perform a similar study using spiral CT scan on asymptomatic population to better determine the sensitivity, specificity, PPV and NPV of this imaging modality for diagnosing coronary heart disease. Such a study would help with the interpretation of the signs of incidentally found calcifications on chest CT scans of the patients,

Table 5. Sensitivity, specificity, PPV and NPV for the spiral CT scan by age group

Age group (years)	Sensitivity	Specificity	PPV	NPV
30-39	85%	80%	85%	80%
40-49	86%	64%	79%	75%
50-59	95%	62%	86%	83%
60-69	100%	25%	83%	100%

Scoring of CAC by volume and HU density

VOI	1	2	3
Volume [cmm]	36.69	55.03	42.27
Depth [cm]	0.67	0.77	0.31
Mean [hu]	236.8	167.8	111.4
SD	98.9	69.2	16.9
L Eval Limit [hu]	90	90	90
U Eval Limit [hu]	1000	1000	1000

and in early detection and prevention of at risk individuals.

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