

The diagnostic value of multislice computed tomography in evaluation of coronary artery disease in patients with left bundle branch block

Sol dal bloklü hastalarda koroner arter hastalığını belirlemede multidetektörlü bilgisayarlı tomografinin değeri

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ABSTRACT

Objective: Noninvasive diagnostic methods do not supply sufficient data for patients with left bundle branch block (LBBB) accompanied with coronary artery diseases (CAD). Therefore, generally coronary angiography is required for these patients. Our aim was to evaluate the diagnostic value of multislice spiral computed tomographic (MSCT) coronary angiography to detect CAD in patients with LBBB.

Methods: Sixty one patients (31 males, 30 females, mean age: 56±13 years) with LBBB who have determined stenosis higher than 50% in quantitative coronary angiography were included in the cross-sectional study. The MSCT coronary angiography was applied to the patients with a 16-detector MSCT scanner that has an electrocardiographic synchronization unit. Each coronary artery was evaluated segmentally in the images acquired from MSCT coronary angiographies and any detected stenosis higher than 50% was recorded.

Results: The data of 793 coronary artery segments achieved from MSCT coronary angiographies of 61 patients (13 segments for each patient) were compared with the results of conventional coronary angiographies of the same patients. When all the segments evaluated were included in this comparison, the diagnostic accuracy, sensitivity, specificity, positive and negative predictive values of MSCT coronary angiography to detect stenosis higher than 50% were 91%, 67%, 97%, 85% and 92%, respectively. Also, it was observed that, MSCT coronary angiography has 80% sensitivity and 90% specificity to detect, at least, one segment coronary artery stenosis.

Conclusion: The MSCT coronary angiography can be utilized as a noninvasive diagnostic method for patients with LBBB, in order to evaluate coronary artery disease. (*Anadolu Kardiyol Derg 2008; 8: 128-33*)

Key words: Left bundle branch block, coronary angiography, multislice computed tomography, specificity, sensitivity, diagnostic accuracy

ÖZET

Amaç: Koroner arter hastalığına eşlik eden sol dal bloklü (LBBB) hastalarda noninvazif tanı yöntemleri yeterli veri sağlamamaktadır. Bu yüzden, bu hastalarda genellikle koroner anjiyografiye gerek duyulmaktadır. Bizim amacımız, multidetektörlü bilgisayarlı tomografik (MSCT) koroner anjiyografinin, LBBB'li hastalarda koroner arter hastalığını tespit etmede kullanılabilirliğini değerlendirmektir.

Yöntemler: Kesitsel çalışmaya kantitatif koroner anjiyografide %50'nin üzerinde darlık saptanan LBBB'li 61 hasta (31 erkek, 30 kadın, yaş ortalaması 56±13) alındı. Hastalara EKG senkronizasyon ünitesi olan 16-detektörlü MSCT scanner cihazı ile MSCT koroner anjiyografi yapıldı. Elde edilen MSCT koroner anjiyografi görüntülerinde her koroner arter segmental olarak değerlendirildi ve koroner arterlerde %50'nin üzerindeki darlıklar belirlendi.

Bulgular: Çalışmaya katılan 61 hastada, MSCT koroner anjiyografi ile elde edilen 793 koroner arter segmentinin (her hasta için 13 segment) verileri, konvansiyonel koroner anjiyografi sonuçları ile karşılaştırıldı. Tüm segmentler dahil edildiğinde MSCT koroner anjiyografinin %50'nin üzerinde anlamlı darlıkları saptamadaki, tanı doğruluğu, sensitivite, spesifisite, pozitif ve negatif prediktif değerleri sırasıyla %91, %67, %97, %85 ve %92 olarak bulundu. Ayrıca, MSCT koroner anjiyografinin hastalarda en az bir koroner arter segment darlığını saptamadaki sensitivitesinin %80, spesifisitesinin %90 olduğu gözlemlendi.

Sonuç: Multidetektörlü bilgisayarlı tomografik koroner anjiyografi, sol dal bloklü hastalarda koroner arter hastalığını belirlemede noninvazif bir tanı yöntemi olarak kullanılabilir. (*Anadolu Kardiyol Derg 2008; 8: 128-33*)

Anahtar kelimeler: Sol dal bloğu, koroner anjiyografi, multidetektörlü bilgisayarlı tomografi, sensitivite, spesifisite, tanı doğruluğu

Introduction

Patients with left bundle branch block (LBBB) associated with coronary artery diseases have higher mortality rates compared to patients who have solely coronary artery diseases (1-3). In the Framingham Study, 45% of patients with LBBB were reported to have coronary artery disease, and 10-year follow-up of these patients revealed mortality rates up to 50% (1). Since the presence and extension of coronary artery disease in patients with LBBB has a direct impact on the evaluation and a treatment method, diagnosis is very important.

The noninvasive diagnoses of associated coronary artery diseases in patients with LBBB are still far from being excellent and have many flaws. Resting and stress electrocardiograms have considerably low sensitivity and specificity values in these specific patient groups (4, 5). In perfusion studies with single photon emission computed tomography (SPECT), a very wide range of sensitivity and specificity rates were reported (6-8). Therefore, generally conventional invasive coronary angiography is required due to insufficient data gathered from electrocardiographic, echocardiographic and scintigraphic studies in these patients (9-12). On the other hand, MSCT coronary angiography is a new and rapidly developing coronary artery imaging technique, which is readily accepted by patients with its unique noninvasive properties.

In this study, we aimed to evaluate the diagnostic value of MSCT coronary angiography in detection of the associated coronary artery disease, in patients with LBBB.

Methods

Patient population: In this cross-sectional study, 103 patients with LBBB who have determined stenosis higher than 50% in quantitative coronary angiography between January 2005 and May 2006 were included. Later, 32 patients with pacemakers, heart failure, atrial fibrillation, and malignant ventricular arrhythmias, incomplete and intermittent LBBB were excluded.

In patients with heart rates higher than 70 beats/min, 50 mg p.o metoprolol was administered 60 minutes prior to MSCT coronary angiography. Seven patients, whose heart rate persisted over 70 beats/min after metoprolol administration, and 3 patients who refused the MSCT coronary angiography were also excluded from the study. Finally, 61 patients with permanent and complete LBBB (QRS duration ≥ 0.12 sec) on their electrocardiogram (ECG) were included for further study analyses.

The study was conducted according to Helsinki declaration principles and informed consent was achieved from all the patients included in the study.

MSCT coronary angiography examinations: MSCT coronary angiographic studies were performed with a 16-MSCT scanner, which has an ECG synchronization unit (Aquilion 16 system, Toshiba Medical Systems Corporation, Japan). Examination parameters were as follows: collimation, 16x1mm; reconstruction interval, 0.5mm; tube rotation period, 0.4 sec, 120 kV, 350 mAs. Scanning area was defined as the space between tracheal bifurcation and diaphragm. Patients were laid on the examination tables in supine position, 18-20 G catheters were introduced to antecubital veins. Non-ionic, iodine containing contrast media

were administered with an automated injector pump (Ulrich Medizintechnik Missori) at a rate of 4 ml/sec, to a total volume of 120ml's. After the completion of contrast media injection, 40 ml's of saline were infused and scanning was initiated. With this application, artifacts resulting from the presence of contrast media in vena cava superior, right atrium and right ventricle were avoided and better image qualities were achieved.

From the axial images, new images were reconstructed with retrospective ECG gated method, applied to achieve 1mm cut slices with 0.5 mm slice interval between the 20-80% of diastolic period for better coronary artery evaluation. To minimize misinterpretation, complete reconstructions of images were performed, at least, at two diastolic phases (generally at 50% and 75%). These new images were transferred to workstation (Vitrea 2) for examination and with three-dimensional volume-rendering technique (3DVRT), maximum intensity projections (MIP), multiplane reconstructions (MPR) were formed.

Conventional coronary angiography: Conventional coronary angiography was performed with Judkins technique at routine standard projections using digital quantitative Siemens® 777 system.

Morphology of coronary artery stenosis: Segments of coronary arteries were defined according to modified American Heart Association classification (13): right coronary artery - 1 = proximal, 2 = middle, 3 = distal, 4 = posterior descending and posterolateral branches; 5 = left main coronary artery; left anterior descending artery - 6 = proximal, 7 = middle, 8 = distal, 9 = 1st diagonal, 10 = 2nd diagonal; circumflex artery - 11 = proximal, 12 = obtuse marginal, 13 = distal. All the segments of arteries were examined with the evaluation of MPR, MIP, 3DVRT and axial images. Evaluations were recorded with the agreement of two radiologists. Image qualities were classified as follows: good, no motion artifacts, contrast media filling is good and contours are sharp; fair, there is some motion artifact, but the lumen can still be evaluated; poor, even though the contrast media can be seen, the motion artifact is blurring the image and do not allow the stenosis to be evaluated.

Conventional coronary angiographies of the patients were evaluated visually by two experienced cardiologists and one cardiovascular surgeon. Both evaluations were recorded as stenosis over 50% of the coronary artery diameter, stenosis less than 50% of the coronary artery diameter and no stenosis (normal coronary artery). Coronary artery stenoses over 50% of the artery diameter were considered significant. Evaluations for stenosis and image quality were made separately for every coronary artery segment.

Statistical analysis

Diagnostic accuracy, sensitivity, specificity, positive and negative predictive value of MSCT coronary angiography to detect coronary stenosis over 50% were calculated with the assumption of conventional invasive coronary angiography as the gold standard. Statistical evaluations were both made for the detection of stenosis according to coronary artery segments and detection of any stenosis in any given patient. The interobserver variability for the detection of significant coronary artery stenosis on MSCT and conventional invasive coronary angiography images was tested with a kappa test.

Results

All the MSCT coronary angiographies and conventional coronary angiographies were performed in all the patients without any complication. Of the 61 patients who were included in the study analysis, 31 were males and 30 were females. Age range was between 38 and 79 years and the mean age was 56±13 years. Clinical characteristics of the patients are listed in Table 1.

Totally 793 coronary artery segments (13 segments per patient) were evaluated in the 61 patients included in the study. Visual quality of MSCT coronary angiographies were good in 395 coronary artery segments, fair in 338 segments and poor in 60 segments. There were respiratory and pulsation artifacts in 40 of 60 poorly visualized segments (60%) and artifacts that caused by excessive coronary calcifications in another 20 segments (40%). Ninety percent of the segments had qualities actually (733/793) allowing examination. The poorly visualized segments were mainly in 3rd (n=10), 4th (n=12), 8th (n=15), 10th (n=13) and 12th (n=10) segments.

The segments which have poor quality images and the segments that have 50% or lesser stenosis were recorded as normal. In any of these segments, significant stenosis detected by conventional coronary angiography was taken as a false negative result. In conventional coronary angiography, significant stenosis was detected in 156 of 793 coronary artery segments (Table 2). According to these results, with MSCT coronary angiography, significant coronary artery stenosis was truly detected in 104 (67%) segments (Fig. 1). In the 52 (33%) segments stenosis could not be detected or confirmed with MSCT angiography, 27 of them were related to poor images and 25 - were recorded as stenosis less than 50%. Interobserver agreement was good (k=0.69) for MDCT detection of significant coronary artery stenosis. This analysis revealed that sensitivity of

MSCT coronary angiography to detect significant coronary artery stenosis is 67% (95% CI, 59.3% - 74.1%), specificity is 97% (95% CI, 95.9% - 98.5%), leading to positive and negative predictive values of 85% (95% CI, 79% - 91.5%) and 92% (95% CI, 90.2% - 94.2%), respectively (Table 3). But if these 60 poor-quality image

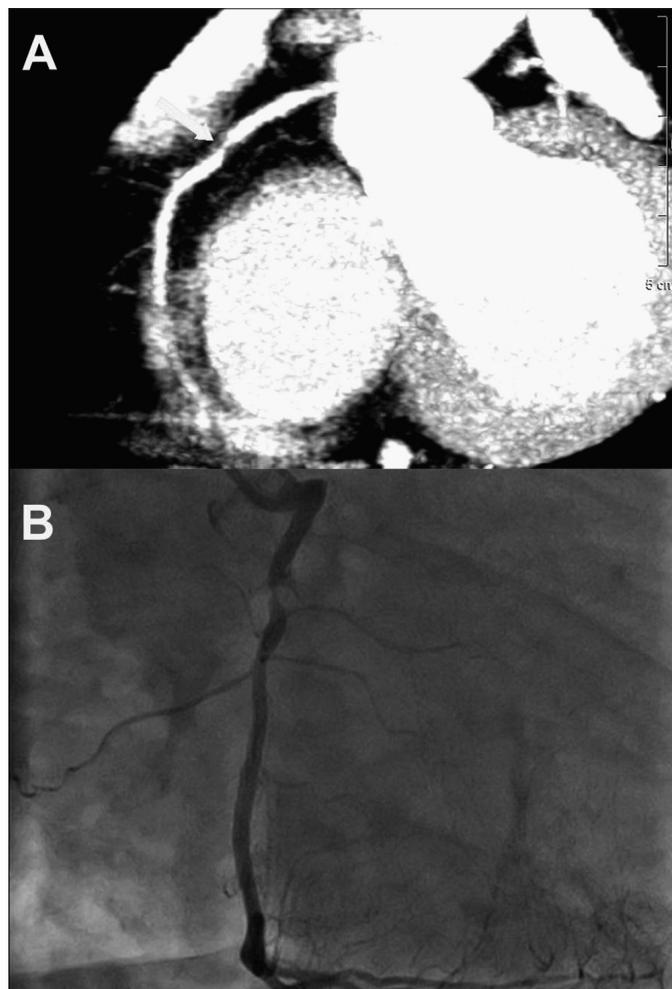


Figure 1. Severe stenosis of right coronary artery in MSCT. Curved multiplanar reformation (A) images shows stenosis (arrow) in the proximal portion of right coronary artery. B. Conventional coronary angiography demonstrates significant stenosis in the right coronary artery

MSCT- multislice computed tomography

Table 1. Clinical characteristics of the patients

Clinical data	
Age, years	56±13
Male / Female, n (%)	31 / 30 (51 / 49)
Hypertension, n (%)	18 (29)
Hyperlipidemia, n (%)	21 (34)
Smoking, n (%)	17 (28)
Diabetes mellitus, n (%)	5 (8)
Family history of coronary artery disease, n (%)	24 (39)

Table 2. Comparison of MSCT-A and invasive coronary angiography

Invasive coronary angiography				
MSCT-A		Stenosis >50%	Normal or stenosis < 50%	Total
	stenosis >50%	104	18	122
	Normal or stenosis < 50%	52	619	671
	Total	156	637	793

Data are given as number of segments
MSCT-A- multislice computed tomography-angiography

Table 3. Diagnostic accuracy of MSCT in detection of stenosis >50%

	All Segments
Patients, n	61
Segments, n	793
Lesions by invasive coronary angiography, n	156
Correct positive lesions by MSCT-A, n	104
Diagnostic accuracy, %	91
Sensitivity, %	67
Specificity, %	97
Positive predictive value, %	85
Negative predictive value, %	92

MSCT-A- multislice computed tomography-angiography

segments are excluded (remaining segments; 733), it can be said that MSCT revealed 104 significant stenosis of the 129 stenosis seen with conventional coronary angiography. Accordingly, the new sensitivity, specificity, positive and negative predictive values were 80%, 97%, 85% and 96% respectively.

Fifty patients had at least one stenosed coronary artery segment recorded after MSCT coronary angiographic examination, leaving 11 patients without any detected coronary artery stenosis. This sums to 80% sensitivity and 90% specificity for MSCT coronary angiography's ability to detect at least one significantly stenosed coronary artery in these patients.

Of the poorly visualized 60 segments by MSCT coronary angiography, significant stenosis was found in 27 segments by conventional coronary angiography and these were accepted as false negative results. On the other hand, in 25 of 65 segments which were recorded as normal (stenosis less than 50%) after MSCT angiography (Fig. 2), significant stenoses were found in

conventional examination. In MSCT images of these 15 of 25 segments, intense calcifications surrounding coronary artery lumen were seen. These results (Fig. 3) were also accepted as false negative for MSCT angiography.

Discussion

The present study shows the feasibility of MSCT in the patients with LBBB. Our data reveals that MSCT coronary angiography is an effective and non-invasive method of choice in evaluating CAD in these patients with LBBB.

Coronary artery stenosis is one of the main reasons of LBBB (14). Since noninvasive techniques are not satisfactory to reveal coronary artery occlusive diseases, usually conventional coronary angiography is needed for exact diagnosis. Electrocardiography, echocardiography and Treadmill exercise tests were not found to be reliable enough (4, 5, 9, 10). Septal perfusion defects are frequently observed in myocardial perfusion studies by SPECT of the patients with LBBB who actually do not have any coronary artery disease, leading to high rates of false positive results. The LBBB-related septal reversible defects reflect the variation in phasic flow in the left anterior descending artery, and abnormal septal wall stress and metabolism (15). Since high heart rates could produce false positive defects, vasodilator imaging with adenosine or dipyridamole has been accepted as the stress modality in such patients (16, 17). Vasodilator SPECT imaging has decreased the false-positive rates (18). The addition of regional left ventricular (LV) function parameters by gated SPECT improved the diagnostic accuracy and prognostic value of perfusion imaging (19).

Although myocardial perfusion study is quite an effective diagnostic method in detection of ischemia in patients with LBBB, it can not reveal sufficient information about the anatomy or stenosis of coronary artery. On the other hand, MSCT coronary angiography, which is a new and rapidly developing coronary artery imaging technique may be proposed as an alternative method to other noninvasive stress tests in screening patients with LBBB. Furthermore, recent studies have suggested that, MSCT may provide information related to assessment of myocardial morphology, left ventricular function, myocardial perfusion and viability (20). The combination of non-invasive coronary MSCT angiography and analysis of left ventricular function offers an inclusive examination strategy for the evaluation of the heart. Our study was designed to determine only the diagnostic value of MSCT for evaluation of coronary artery disease in patients with LBBB, so further studies are needed for the assessment of cardiac functioning and myocardial viability.

In the previous studies, high sensitivity and specificity rates were reported for 16-slice MSCT coronary angiography, to detect coronary artery disease (21, 22). In the work of Nieman et al. (23), MSCT coronary angiography was found to have 95%, 86%, 80% and 97% sensitivity, specificity, positive and negative predictive values respectively to reveal any coronary artery occlusive lesions, but only main coronary arteries and branches with diameters over 2 mm were included for evaluation. The study of

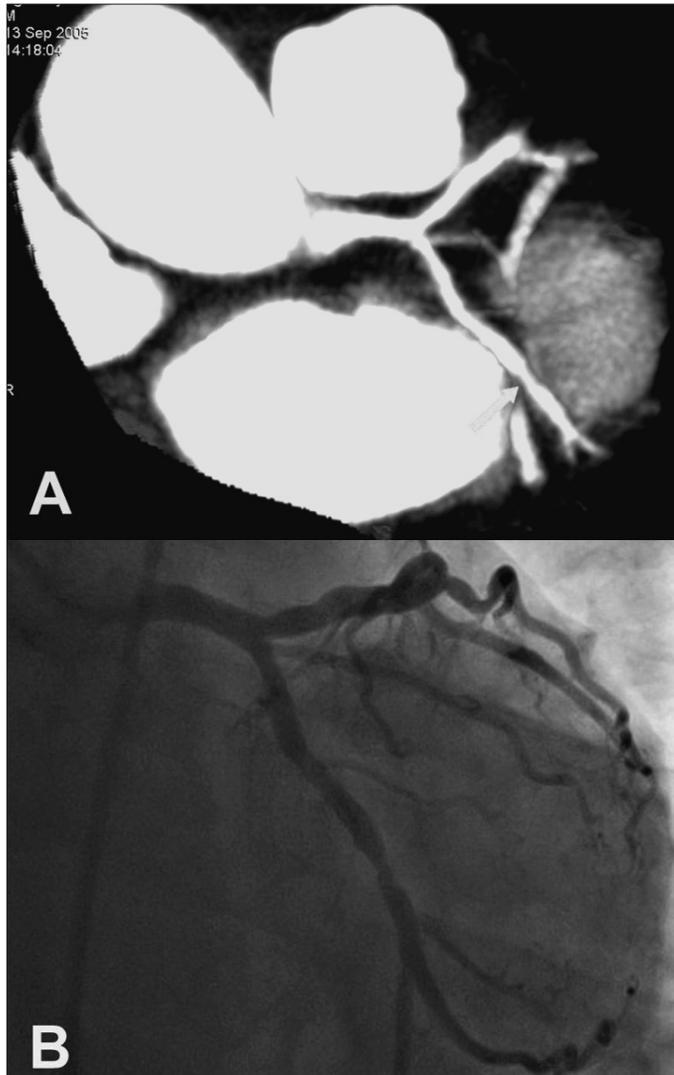


Figure 2. Stenosis of <50% of left circumflex artery in MSCT. A cross sectional multiplanar reformation (A) images shows stenosis (arrow) in the proximal portion of left circumflex artery. B. Conventional coronary angiography demonstrates <50% stenosis in the left circumflex artery

MSCT- multislice computed tomography

Kuettner et al. (24) reported 72%, 97%, 72% and 97% for the same terms, respectively. In a recent study of Andreini et al (25) revealed that 16-slice MSCT have high diagnostic accuracy in patients with and without dilated cardiomyopathy but the heart rates of patients in this study was under 65 per minute.

There is limited data in the literature with MSCT coronary angiography for patients with LBBB (26). Ghostine et al. (26) reported that accuracy, sensitivity, specificity, positive predictive value, and negative predictive value of 64-slice CT for detecting significant stenosis was 97%, 72%, 99%, 91%, and 97%, respectively. In this study, 64-slice CT was used as different from our study. Our results show that, 16-slice MSCT coronary angiography have 91% accuracy, 67% sensitivity, 97% specificity, 85% positive and 92% negative predictive value to determine the

presence of significant coronary artery stenosis in patients with LBBB. Our results with 16-slice MSCT coronary angiography has a very high sensitivity and specificity value to detect at least one significantly stenosed coronary artery segment and these results were close to the ones obtained with 64-slice MSCT. High negative predictive values suggest that, MSCT coronary angiography can be a useful noninvasive method to reveal coronary artery lesions for the patients with LBBB. On the other hand, newly developing MSCT techniques with 128 detectors could have better results.

In the evaluation of coronary arteries with MSCT coronary angiography, respiration, pulsation artifacts, arrhythmias and extensive calcifications are the main factors affecting the quality of images. Haberl and colleagues (27) reported 19% of non-diagnostic segments in patients with heart rates under 70/minute, contrasting with 39% of non-diagnostic segments in patients with heart rates over 70/minute. In the report of Heuschmid et al. (28) the sensitivity, specificity, positive and negative predictive values of MSCT coronary angiography were found to be 59%, 87%, 61% and 87% respectively in general, but when only the patients with lower calcium scores were included, these values were 93%, 94%, 68% and 99% respectively. In our study, we did not include the patients with arrhythmia and we tried to keep the pulse rate below 70/minute during the MSCT examinations. Therefore, we do not think that these factors might have affected our study negatively.

Limitations of the study

Our study had some limitations. First, the study was done with 16-slice MSCT. Due to the lower temporal resolution of 16-slice CT, compared to those of 64- or 128-slice CTs, higher incidence of artifacts may occur and this can be thought as a negative factor affecting our study. Second, in the 29 (15 segments false negative, 14 segments false positive) segments which were misdiagnosed with MSCT coronary angiography, there were extensive calcifications. This may be one of the reasons for our low sensitivity rates. The coronary calcification score is correlated with the presence and severity of atherosclerosis (29). In our study, we did not assess calcification score, because all patients had significant coronary artery stenosis documented with conventional coronary angiography. Third, in our study, we did not include the patients with arrhythmia and the patients, whose heart rate persisted over 70 beats/min. We believe that, one can overcome these problems with better software and hard-ware and non-diagnostic segment ratios can be lowered.

Conclusion

The MSCT coronary angiography can be utilized to diagnose occlusive coronary artery disease in patients with LBBB, as a noninvasive imaging method. Also, this method can be used as a preliminary evaluation technique to determine the patients who will need conventional coronary angiography and further invasive interventions. To have higher diagnostic accuracy with MSCT coronary angiography in patients with LBBB, factors that are affecting the imaging qualities should be modified and artifacts should be minimized.

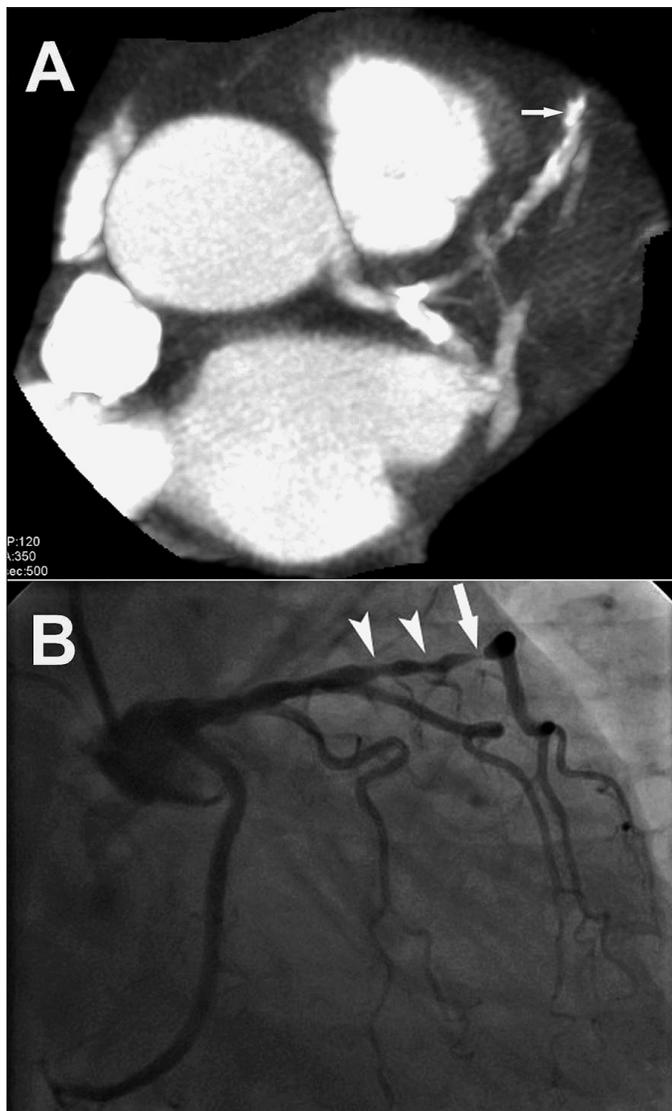


Figure 3. False negative MSCT result. Significant stenosis of left anterior descending coronary artery cannot be identified in patient because of circumferential calcification. A. A cross sectional multiplanar reformation image shows calcification (arrow) in left anterior descending coronary artery. B. Conventional coronary angiography demonstrates significant stenosis (arrow) in the left anterior descending coronary artery

MSCT- multislice computed tomography

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