The Evaluation of Calcium Score Validity in the Diagnosis of Patients with Coronary Artery Disease by Using CT Angiography

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Abstract

Background: Coronary artery disease is one of important diseases as in many cases ends up with death. Among many types of coronary artery disease is the lipoprotein plaque deposition on the artery wall. Many reports appeared in the literature concerning the causes, investigation, and treatment of the coronary artery disease. As computed tomography scanners were developed, a new non-invasive procedure was introduced using the calcium present in the plaque as an indicator for the amount of plaque in the coronary artery.

Objective: To investigate the validity of the calcium score in the diagnosis of coronary artery disease, and also to find the relation between calcium score with calcification and plaque.

Patients and methods: Sixty one patients 40 were men and 21 were women evaluated for calcium score. They had symptoms of chest pain and were subjected to electro cardio gram examination to determine their eligibility for computed tomography angiography to investigate the coronary calcification as a marker of atherosclerosis.

The history of diseases including hypertension and diabetes were recorded and check renal function test. Anthropometric measurements and the level of fasting lipid profile for patients and normal subjects were tasted.

Patients were advised to come fasting prior to the examination. They have been given Beta blocker to reduce the heart rate in the range of 55-65 beats/min. Contrast medium was injected IV by means of injector immediately before scanning.

Results: Results revel that not all patients suffering from chest pain with electro cardio gram changes show high calcium score; on the other hand patients with high calcium score they have an increased plaque in their coronary artery. At low calcium score calcium score (0-100), cholesterol, triglyceride and high density lipoprotein are generally inversely proportional with calcium score with the exception of LDL remains virtually unchanged throughout the whole range of calcium score (0 > 300) as appear in the figures . While at high calcium score concentration (>300) lipoproteins are directly proportional with calcium score in contrast with high density lipoprotein which is inversely proportional with calcium Score.

Key word: calcium score, computed tomography angiography, plaque, and atherosclerosis.

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Introduction

One of the prime causes of mortality is coronary artery disease (CAD) [1] [2]. To protect people from the progression of such diseases early diagnosis is needed. One of these among many procedures for diagnosis is the evaluation of calcium in the plaque of coronary artery, the procedure is known as calcium score (CS) [3]. It is the measurement of calcium content via the use of CT scanner. CT scanner can easily detect Calcium, because calcium atomic number is higher than the soft tissue and plaque which makes it a better absorber for X-ray and consequently better vision.

There is considerable evidence that high blood cholesterol is associated with an increasing risk of atherosclerosis [4]. Vascular calcification occurs as part of atherosclerosis [5].

The high blood cholesterol can be produced by a diet rich in cholesterol and saturated fat, or it may be the result of an inherited condition known as familial hypercholesteremia. This condition is inherited as a signal dominant gene; individuals who inherit two of these genes have extremely high cholesterol concentration and usually suffer heart attack in his early life [6]. Since oxidized LDL seems to be important in the progression of atherosclerosis, it would appear that antioxidant compounds could be used to treat this condition or help to prevent it [7].

Excessive cholesterol may be released from cells and travel in the blood as high-density lipoproteins (HDL), which are removed by the liver [8].The cholesterol in HDL is not taken into the artery wall because these cells lack the membrane receptor required for endocytosis of the HDL particles. For this reason cholesterol does not contribute to atherosclerosis [9]. Women in general have higher HDL-cholesterol concentrations and lower risk of atherosclerosis than men [10].

Lipids are the fats are present in the body. The major lipids in the bloodstream are cholesterol and triglycerides. Cholesterol is an essential part of every cell in the body. It is necessary for new cells formation and for older cells to repair themselves after injury. Cholesterol is also used by the adrenal glands to form hormones such as cortisol, by the testicles to form testosterone, and by the ovaries to form estrogen and progesterone. Triglycerides supply energy for the body; they either meet immediate energy needs in muscles or stored as fat for future energy requirements [11].

Because the heart muscle requires a continuous supply of oxygen and nutrients to survive, obstruction of a coronary artery rapidly leads to significant problems [12]. The calcified plaques are relatively stable and are often referred to as hard plaques. If the plaque became large enough to narrow the coronary artery lumen, angina may result; if not, the plaque may only be detected by imaging studies. In other instances, the plaque does not undergo a healing response, and instead the internal portion of the plaque remains soft and fatty, and the outer portion of the plaque, in contact with the blood flowing within the coronary artery, consists of a fibrous covering often referred to as soft plaque. Soft plaque may remain stable, enlarge, or may rupture. When rupture occurs, the outer fibrous cap is torn, and blood flow gains access to the internal fatty portion of the atherosclerotic plaque [13].

In the present study we were aiming to investigate the validity of the calcium score in the diagnosis of coronary artery disease, and also to find the relation between calcium score with calcification and plaque

Patient and Methods

A total number of sixty-one patients (40 male and 21 were female) from Ibn Al Bitar Hospital for Cardiac Surgery were included in this study. Their age ranged between 37 and 72 years.

Patients complain from chest pain were physically examined by consultant cardiologist the Blood pressure was measured at sitting position and show ECG changes were considered eligible for CT Angiography and referred to the coronary computerized tomography CT scan (type brilliance 64-silice CT by Philips) for CTA to evaluate the status of coronary artery plaque and to determine the calcium score. Patients were asked to get blood analysis including (serums. cholesterol, serum. triglyceride, serum HDL, serum LDL).

Anthropometric measurements including weight and height were also measured. The history of diseases including hypertension and diabetes were recorded.

Laboratory test for lipid profile was carried out for each patient. Renal function test was also performed for patient safety in order to take contrast medium. The data of serum lipids and lipoproteins, cholesterol, triglycerides, and high density lipoprotein-cholesterol HDL and Very low density lipoprotein (VLDL) were all measured in (mmol/L).

Low density lipoprotein (LDL) calculated by using Friedewald equation:
LDL = cholesterol – (HDL + VLDL) (mmol/L)

Patients were examined by CT scanner. Each patient prepared to have a heart rate between 55 and 65 beats per minutes at the time of examination by using Beta-adrenoceptor blocking agent (40 mg propranolol or other drags) used to control the heart rate within the desirable range.

Patients are positioned for CTA examination table in the supine position. Three ECG leads are attached to obtain an adequate ECG tracing. A noise-free ECG signal is important to synchronize the ECG signal to the raw image data. Intravenous access via a large intravenous line (vein) is necessary to ensure easy injection of the viscos contrast agent at a flow rate of 5(ml/s). Except in very obese patients, a flow rate of 4 (ml/s) usually renders diagnostic image quality as well. It is important to prepare the patient for sensations experienced from injection of the contrast material, and to perform repeated test breath holds. We recommend the breath hold during inspiration preceded by a cycle of inspiration and expiration. The approach improves the length and stability of the breath hold during the scan and leads to the reduction of the movements during the scan, in turn, resulting in better image quality. During the test breath holds, a decision regarding whether more β Blocker is needed.

Results

To recognize the effect of the increased calcium in the plaque we have divided the calcium score into three groups. In this case we will be able to detect the effect of the increase in the calcium score with the change of other factors which influence the CS, and to investigate its quantity on the calcium score measured by the CT angiography. The first category includes data ranging from zero calcium score to one hundred (0-100 agatston) the second group includes calcium score range from (100-300 agatston). And the third group calcium score (>300 agatston).

Figure (1-a) shows a negative slope of the curve plotted between cholesterol and CS for the range (0-100Agatston) CS which indicates an inverse proportionality

between cholesterol and CS at this low CS level. While at higher CS level range (100-300) and (> 300 Agatston) the slope of the curve is positive indicate direct proportionality of cholesterol with CS (Figure 1-b and c).

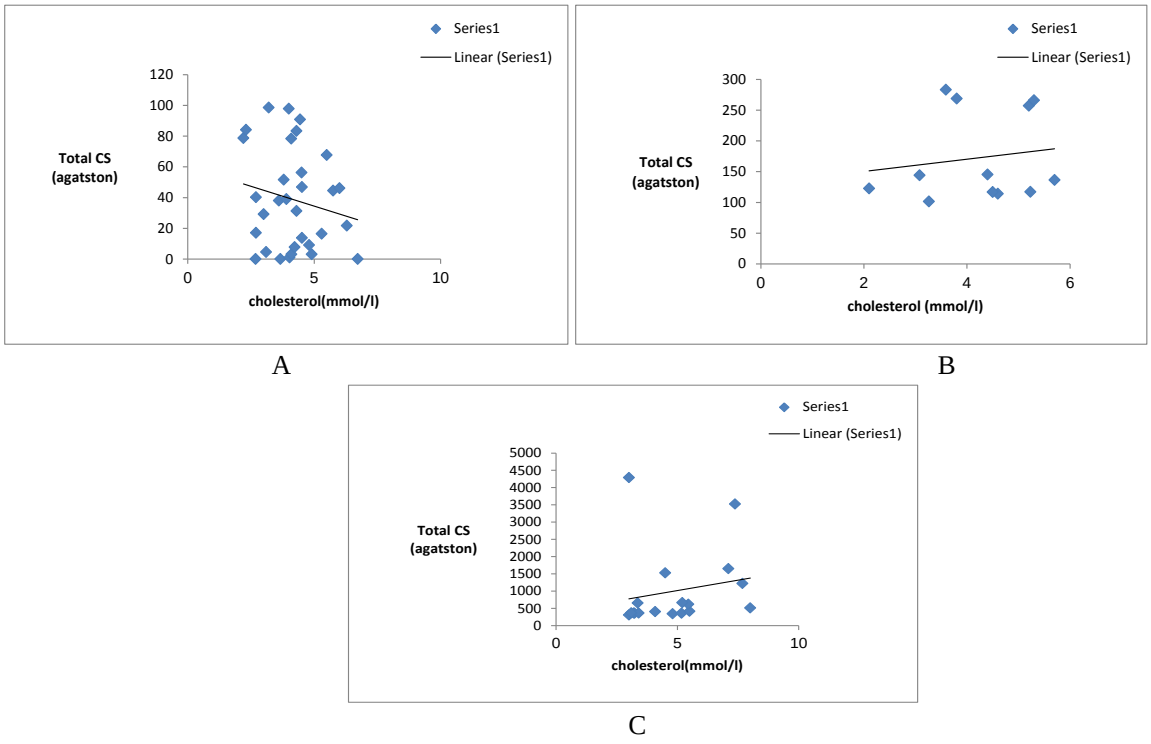
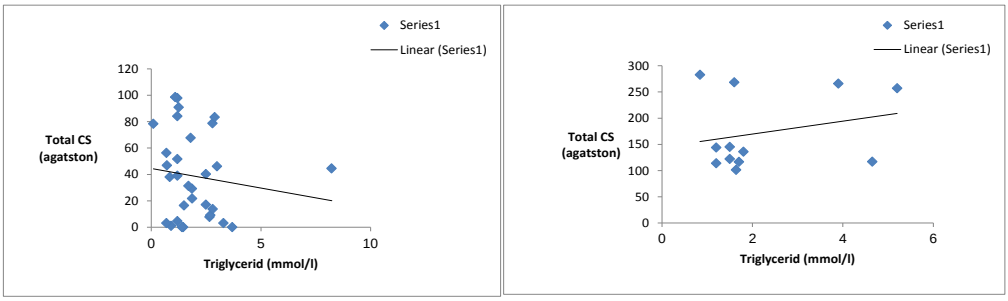
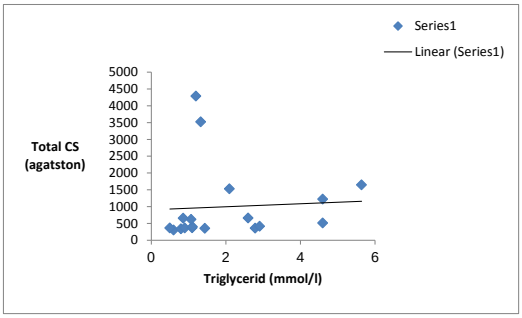


Figure (1): The relation between cholesterol VS calcium score in rang (0-100) (a), (100-300) (b) and (>300) (c).

A similar observation to cholesterol has also seen for the relation between triglyceride and CS. (Figure 2-a) show an inverse relation between triglyceride and CS at low CS range (0-100 Agatston). At higher score (100-300) and (> 300 Agatston) there is a direct proportionality between CS and the triglyceride with a less steep curve in comparison with cholesterol (Figure 2-b, c).

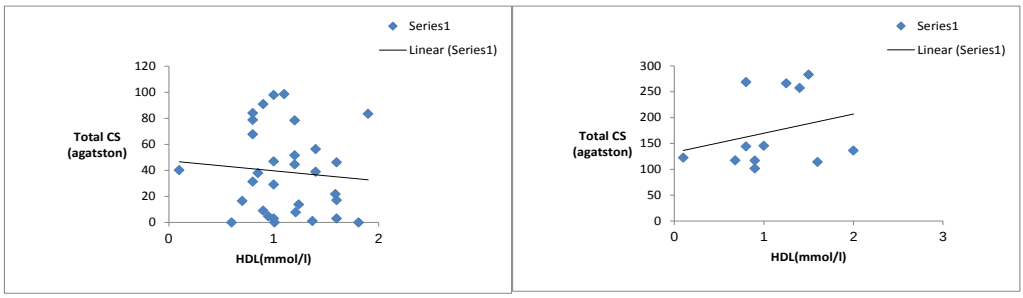




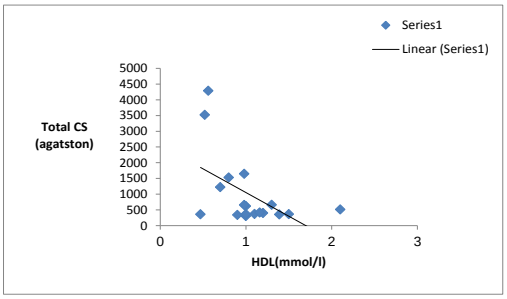
C

Figure (2): The relation between Triglyceride VS calcium score in rang (0-100) (a) , (100-300) (b)and (>300)(c).

High density lipoprotein HDL. (figure 3-a) the situation is different for HDL at the region of higher CS. The graph is also descending at low CS level (0-100 Agatston) but at higher CS (100-300) the curve is ascending indicating a direct proportionality of HDL with CS (Figure 3-b), the situation is reversed again at higher CS levels (> 300 Agatston) the slope of the graph is much steeper than what we observed at low CS (0-100) indicating a strong invers proportionality between CS and HDL (Figure 3-c).



a b



c

Figure (3): The relation between HDL VS calcium score in rang (0-100) (a), (100-300) (b) and (>300)(c).

It can be seen from (Figure 4-a) that show there is almost no change in the slope of LDL with respect to CS as the slope of the graph is very small for the three categories of the CS. (0-100 Agatston), (100-300 Agatston) and (> 300 Agatston) (Figure 4-b, c) this indicates no correlation between LDL with the increase in CS.

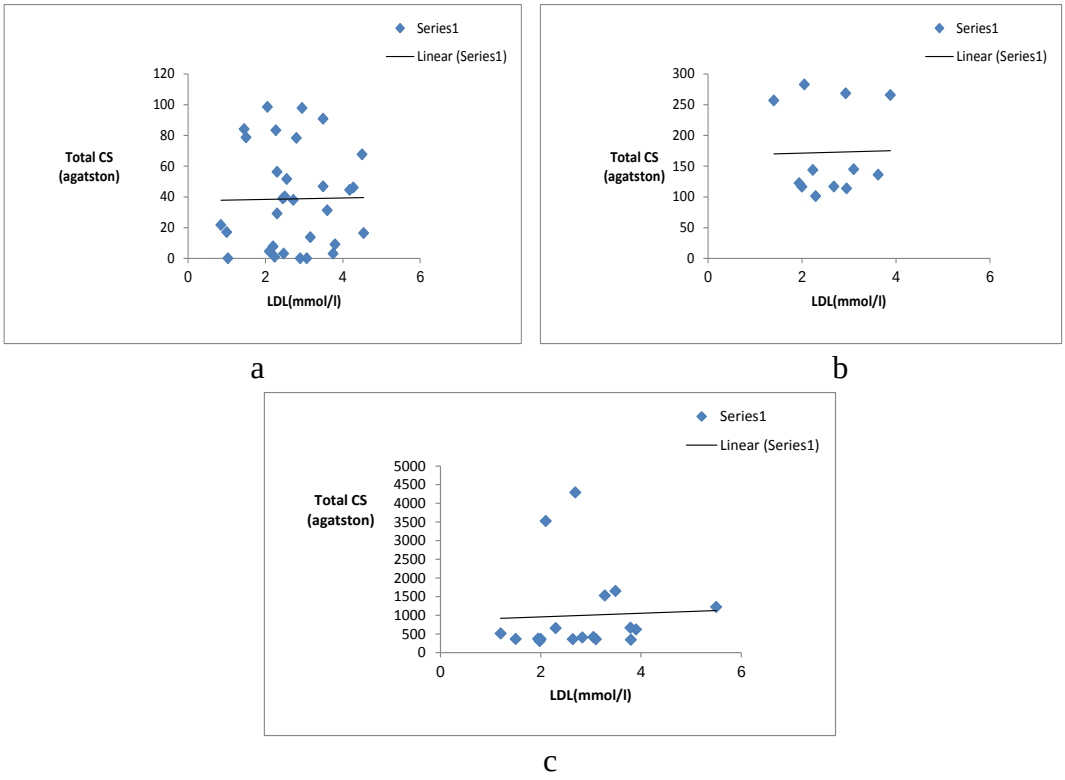


Figure (4): The relation between LDL VS calcium score in rang (0-100) (a) and (100-300) (b) and (>300) (c).

Discussion:

We have studied the factors that might impose CAD risk on patients; these are the study of lipid profile, which is the most important factor as the coronary plaque is basically lipids deposition. It has been reported that when there is cell death or tissue necrosis, the body invokes a process of calcification which can be regarded as part of the healing process [14]. Pathology studies have shown that the calcium in the coronary artery is formed in areas of healed plaque ruptures [15] [16].

The healing process of arterial calcification is similar to bone formation in the wall of the artery [17] [18] [19]. Although the data for lipid profile is scattered which gives weak correlation but still the plot can give the pattern of the change of CS with other variables. One important observation is that the change in the measured variables at lower CS (0-100 Agatston) showed that the slope of the curve is descending, in other words inversely proportional with CS. This observation is similar for all lipoproteins components apart from LDL which have very small slope. We do not have an obvious answer for this phenomenon but we may think that at higher serum lipoproteins (in the low CS region (0-100Agatston) there are probably a competitive interactions causing lipid plaque deposition more efficient than Calcium deposition so a decrease in the value of CS at higher concentrations of other related factors such as lipoproteins. Alternatively CS usually increases in places where there is a defect (rupture) in the plaque [20], so the low score may be associated with a little or no defect in the deposited lipoproteins [21] .

It can be clearly seen that LDL component does not change with increasing CS for all levels from (0 to > 300 Agatston) Figures (4-a, b and c), this indicates that (serum LDL) has no correlation with the increase in CS and it has the same deposition rate whether CS is high or low.

Because that our patient had chest pain and show ECG changes and a small percentage (14.7%) of them has shown zero or less than 10 Agatston CS we may conclude that CS does not definitely exclude CDA

The relation between the CS with cholesterol and HDL become more correlated as the calcium score is increased. For example the cholesterol, and HDL correlation with CS Is (-0.180 and-0.0903) for CS range (0-100 Agatston) and (0.1823 and -0.51504) for CS (>300 Agatston) respectively. This shows highest correlation at higher values of CS.

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