CORRELATION OF ECHO CARDIAC CALCIFICATION SCORE WITH CORONARY CALCIUM SCORE AT MULTI-DETECTOR COMPUTED TOMOGRAPHY

By

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ABSTRACT

Background: Echocardiography-derived calcium score (ECS) was able to predict the presence of extensive coronary calcium and obstructive Coronary artery disease(CAD), assessed using Multi slice CT (MSCT) coronary angiography. Furthermore, significant linear trends were observed between ECS and extent and severity of coronary atherosclerosis and number of calcified coronary artery lesions.

Objective: To correlate an echocardiography-derived calcium score (ECS), obtained using coronary artery calcium Score (CACS) and the presence of obstructive CAD.

Patients and Methods: The study comprised 100 patients (males and females) presented with symptoms suspected of stable CAD. All cases were recruited from the outpatient clinic in Agouza police Hospital in Cairo and Islamic center of Al-Azhar University during a period of fourteen months from 1/11/2018 to 30/12/2019.

Results: Linear regression analysis identified that the most independent variables that can predict AVC were CAC score, dyslipidemia, and the most independent variable that can predict obstructive coronary artery disease was the presence of coronary artery calcification and higher CAC score. ROC curve analysis was used to test the predictive value of aortic valve calcification (AVC), Mitral annulus calcification (MAC) and CAC scores for the presence or absence of obstructive CAD. This analysis showed that AVC and MAC scores were inferior to CAC score which was found to have the highest predictive value evidenced by an area under the curve of 0.763 (95%CI: 0.781, 0.913). MAC score was inferior to AVC score which was found to have the highest predictive value evidenced by an area under the curve of 0.815 (95%CI: 0.758, 0.879).

Conclusion: The echocardiographic calcium scores specifically the MVC and AVC was correlated to be CAC. ECS can predict the CAC score. ECS can predict the presence or absence CAD.

Keywords: Multi-detector computed tomography, coronary artery calcium score.

INTRODUCTION

In the last 2 decades, the clinical relevance of vascular calcific deposits has emerged. The amount of calcium in both coronary arteries and the aorta correlates with atherosclerotic plaque burden in each vascular bed *(Thompson and Towler, 2012)* and is associated with increased risk of cardiovascular events *(Salmoirago-Blotcher et al., 2011)*. Severe coronary calcific deposits are associated with the presence of myocardial ischemia, and

extent of calcium in the aorta is related to coronary, carotid, and peripheral artery disease *(Tousoulis et al., 2012).*

Mitral annular calcium and aortic valve sclerosis appears to be the result of similar pathologic processes. Both are not simple passive degenerative disorders influenced by mechanical stress, but active inflammatory processes with histopathologic features similar to atherosclerosis *(Rajamannan et al., 2011).* Previous clinical studies have shown significant associations between mitral annular calcium and aortic valve sclerosis with cardiovascular risk factors, *(Linefsky et al., 2011)* impaired coronary microvascular function, *(Marciano et al., 2012)* subclinical systemic calcified atherosclerosis, *(Al Rifai et al., 2015)* inducible myocardial ischemia, *(Panza et al., 2013)* and obstructive CAD at conventional coronary angiography *(Abdulla et al., 2011).*

Large population cohort studies showed that aortic valve sclerosis and mitral annular calcium are associated with increased cardiovascular morbidity and mortality *(Thanassoulis et al., 2013).* Because it is unlikely that aortic valve sclerosis and mitral annular calcium directly lead to adverse cardiovascular outcomes, their relation with coronary atherosclerosis most likely explains these observations. Calcific deposits of the papillary muscles are less commonly observed in the general population and usually limited to their apical portion. Similarly to mitral annular calcium and aortic valve sclerosis, papillary muscle calcium is associated with the presence of CAD despite potentially different underlining mechanisms, *(Weiss et al.,*

2013) more likely a consequence of necrosis or fibrosis caused by narrowing of the coronary arterial lumen by atherosclerosis *(Yahagi et al., 2016).*

Noninvasive modalities for the diagnosis of CAD are important for both screening of asymptomatic subjects and risk stratification of symptomatic patients to identify those who could benefit from invasive coronary angiography. Recently, MSCT coronary angiography has emerged as a feasible and accurate technique allowing detection of coronary atherosclerosis by assessing the coronary artery calcium burden and performing noninvasive angiography. However, it is expensive and not widely available. Moreover, it still carries high radiation exposure, which limits its widespread use in asymptomatic patients, and a potential associated risk of allergic reactions and nephrotoxicity related to the use of iodinated contrast agents *(Youssef, et al., 2013).*

A semi-quantitative calcium score was devised to assess overall (non-coronary) cardiac calcification. This score proved easy to apply to clinically indicated echocardiograms of varying technical quality. When compared with CT as a gold standard, the new score performed reasonably well. Importantly the echo score, when dichotomized at a value of 5 or greater, can serve as a marker of severe coronary disease. From a practical standpoint the simplified version (dichotomized at a value of 3 or greater) performed equally well in predicting high CAC scores. It is easily applied in routine clinical practice and can alert the ordering physician to the likely presence of a high burden of coronary atherosclerosis. This

potentially increases the prognostic information provided by echocardiography *(Pressman et al., 2011)*.

The present work aimed to correlate echocardio calcium cation score with coronary calcium score at multi-detection competed tomography.

PATIENTS AND METHODS

The study comprised 100 patients were recruited from the outpatient clinic in Agouza police Hospital in Cairo and Islamic center of Al-Azhar University during a period from 1/11/2018 to 30/12/2019 divided into two groups Patient with obstructive CAD=44 patients and Patient with Non obstructive CAD=56 patients who presented with symptoms of intermediate likelihood stable CAD and indicated for coronary CT angiography according to ESC guideline.

Patients with aortic valve stenosis, rheumatic valvular disease, prosthetic valves, a history of MI, PCI, CABG, cardiomyopathy, rhythm other than sinus rhythm, contraindications for multi-slice computed tomography or poor transthoracic acoustic were excluded.

All patients underwent informed consent, history taking of risk factors of CAD as hypertension, diabetes, dyslipidemia and smoking. Full clinical examination included blood pressure, fasting blood sugar, heart rate. Laboratory investigations included fasting blood sugar, serum glycated hemoglobin (HbA1c), lipid profile including high density lipoprotein (HDL), low density lipoprotein (LDL), total cholesterol (TC) and triglycerides (TG), and serum creatinine.

Transthoracic echocardiography was performed in all patients within 1 month of MSCT coronary angiography All selected patients underwent a standard rest transthoracic echocardiography using vivid E9 and Philips ie33 system equipped with S5 probe, aortic valve sclerosis was defined as focal areas of increased echogenicity and thickening of the aortic valve leaflets with velocity 2.5 m/s across the aortic valve. Each aortic valve leaflet was graded on a scale of 0 (normal) to 3 (severe) according to leaflet thickening and calcific deposits. The highest score for a given cusp was assigned as the overall degree of aortic valve sclerosis. Mitral annular calcium was defined as an intense and bright echo-producing structure located at the junction of the atrioventricular groove and posterior mitral valve leaflet and was measured from the leading anterior to the trailing posterior edge and judged on a scale of 0 (normal) to 3 (severe). Papillary muscle calcium was defined as a bright echo involving the head of 1 or both papillary muscles. Ascending aorta calcium was defined as a focal or diffuse area of increased echo reflectance and thickening in the aortic root on the parasternal long-axis view

MSCT coronary angiography was performed using a 64-slice MSCT scanner (Aquilion 64; Toshiba Medical Systems, Tokyo, Japan). Heart rate and blood pressure were monitored before the examination in each patient. In the absence of contraindications, patients with a heart rate 65 beats/min were administered oral blockers (Atenolol 50 or 100 mg, single dose, 1 hour before the examination). First, a prospective coronary calcium scan without contrast

enhancement was performed, followed by MSCT coronary angiography performed according to the protocol described elsewhere *(Schuijf et al., 2006)*.

Data were subsequently transferred to dedicated workstations for post processing and evaluation (Advantage; GE Healthcare, Milwaukee, Wisconsin, and Vitrea 2; Vital Images, Minnetonka, Minnesota). MSCT data analysis was performed by 2 experienced observers who had no knowledge of the patient's medical history and symptom status. Disagreement was solved by consensus or evaluation by a third observer. Coronary artery calcium was identified as a dense area in the coronary artery 130 Hounsfield units. A total CACS was recorded for each patient. According to the total CACS, patients were subsequently categorized as having no calcium (total score 0) or low (total score 1 to 100), moderate (total score 101 to 400), and severe (total score 400) coronary artery calcium *(Agatston et al., 1990)*.

MSCT coronary angiograms were evaluated for the presence of CAD on patient, vessel, and segment levels. For this purpose, both the original axial data set and curved multiplanar reconstructions were used. Coronary arteries were divided into 17 segments according to the modified American Heart Association classification *(Austen et al., 1975)*.

Each segment was evaluated for the presence of atherosclerotic plaque, and 1 coronary plaque was assigned per coronary segment. Subsequently, type of plaque was determined as (1) non calcified plaques, plaques with a lower density compared with the contrast-enhanced vessel lumen; (2) calcified plaques, plaques with high density; and (3) mixed plaques, plaques with non-calcified and calcified elements within a single plaque. Finally, plaques were classified as obstructive (50% luminal narrowing) or non-obstructive.

Statistical analysis of data:

Data were entered on the computer using "Microsoft Office Excel Software" program (2010) for windows, then transferred to the Statistical Package for Social Sciences Software program, version 21 (SPSS) to be statistically analyzed. Quantitative data were statistically described in terms of mean ± standard deviation (± SD), while qualitative data were statistically described in terms of frequencies (number of cases) and percentages when appropriate. Student T-Test: was used for independent samples for Comparison between two groups with quantitative data and normally distributed. Chi-Square test: was used for Comparison between groups with qualitative data.

Receiver operator characteristic (ROC) analysis was created to determine the sensitivity and specificity of the CCS scores for obstructive and Severe CAD as a function of the minimum score required defining a positive study. We added AVC and MAC calcification to the model to demonstrate the incremental values of these. The area under each curve represented the ability to detect patients with obstructive angiographic disease. P ≤ 0.05 was considered statistically significant.

RESULTS

54% population had HTN, 62% had DM, 59% had dyslipidemia and 46% of them were smoker. Regarding chest pain 81% of them had typical chest pain, and 19% of them had a typical chest pain **(Table 1)**.

Table (1): Clinical characteristics of studied group

Patient baseline characteristics	Number (%)
Hypertension	**54 (54%)**
HR	**66.1± 4.2**
DM	**62 (62%)**
Dyslipidemia	**59 (59%)**
Smoker	**46 (46%)**
Chest pain	
• **Typical**	**81 (81%)**
• **Atypical**	**19(19%)**

Distribution of coronary artery calcium score among total studies people 54%had CAC score of (0-10) 36% had CAC score of (11-100) 10% had CAC score(101- 400), and no patients had CAC score>400, Mean CAC scores of studied patients was 39.3±73.1 **(Table 2)**.

Table (2): Calcium scoring distribution among the studied patients

Calcium Scoring	Total (N=100)	Mean± SD
Calcium score (0-10)	54 (54%)	
Calcium score (11-100)	36(36%)	
Calcium score (101-400)	10 (10%)	
Calcium score (>400)	0 (0%)	
Range	0-392	39.3±73.1
Degree of CAD	**Number (%)**	
Non obstructive CAD	56 (56%)	
obstructive CAD	44 (44%)	

Distribution of atherosclerotic coronary arterial localization among total studies population showed that 23 patients (52.3%) had LAD obstruction, while 21 patients (47.7%) had LCX obstruction,9 patients (20.5%) had RCA obstruction, and 8 patients (18.2%) had LMT obstruction. Thirty patients (53.6%) had LAD non obstruction, while 28 patients (50%) had LCX non obstruction. Ten patients (17.9%) had RCA non obstruction, while 7 patients (12.5%) had LMT non obstruction **(Table 3)**.

Table (3): Distribution of atherosclerotic CAD

Parameters \ Groups	Non- Obstruction N (56) (%)	Obstruction N (44) (%)
LAD	30 (53.6%)	23 (52.3%)
LCX	28 (50%)	21 (47.7%)
RCA	10 (17.9%)	9 (20.5%)
LMT	7 (12.5%)	8(18.2%)

Semi quantitative score of cardiac calcification on the total studies population showed that no patient had papillary muscle or arch calcification.

Mild MAC was present in 4 patients vs moderate MAC was present in one patient, and mild AVC was present in 26 patients **(Table 4)**.

Table (4): **Semi quantitative score of cardiac calcification on the echocardiographic examination**

Calcifications / Grades	Papillary muscle calcium	Mitral annulus calcium	Aortic valve sclerosis/ calcification	Ascending aorta wall calcium
• **0**	absent 100	absent 95	absent 74	absent 100
• **1**	present 0	mild 4	mild 26	present 0
• **2**	0	moderate 1	moderate 0	0
• **3**	0	Severe0	Severe0	0

There was an insignificant difference between calcium score distribution and risk factors, i.e. DM, HTN, dyslipidemia, and smoking **(Table 5)**.

Table (5): **Relation between severity of calcium scoring and risk factors**

Calcium Scoring / Risk Factors	Calcium score (0-10) (N=54)		Calcium score (11-100) (N=36)		Calcium score (101-400) (N=10)		Chi-square test	
	No. 23	%	No.	%	No.	%	χ^2	P-value
Diabetes mellitus	29	42.6%	11	30.6%	4	40%	2.372	**0.668***
Hypertension	22	53.7%	18	50%	7	70%	1.264	0.531
Dyslipidemia	26	40.7%	12	33.3%	7	70%	2.133	0.545
Smoking							0.28	0.869

Linear regression analysis was performed in order to identify the most independent variable that can predict CAD. The independent predictors for CAD category were MAC, AVC, HTN, smoking and CAC score **(Table 6)**.

Table (6): **Linear regression analysis to identify predictors of CAD**

Regression / Variables	R	R^2	P value
AVC and/or MAC	**0.701**	**0.421**	**<0.002**
HTN	**0.651**	**0.442**	**<0.005**
Smoking	**0.721**	**0.513**	**0.012**
CAC score	**0.574**	**0.268**	**<0.001**

ROC curve analysis showed that AVC and MAC scores were inferior to CAC score which was found to have the highest predictive value evidenced by an area under the curve of 0.763 (95% CI: 0.781, 0.913) MAC score was inferior to AVC

score which was found to have the highest predictive value evidenced by an area under the curve of 0.815(95%CI: 0.758, 0.879 **(Table 7)**.

Table (7): ROC curve analysis curve for the presence or absence of any obstructive/non obstructive CAD

Analysis / Parameters	AUC	Sensitivity	Specificity	95% CI
AVC score	0.741	65%	60%	(0.645-0. 781)
MAC score	0.581	45%	43%	(0.419-0.619)
CAC score	0.763	82%	80%	(0.814-0.913)
Total echo CAC score	0.735	78%	75%	(0.765-0.965)

DISCUSSION

Coronary artery calcifications are strongly correlated with atherosclerosis and the coronary artery calcium score (CACS) by coronary computed tomography angiography (CCTA) can be used to make better prediction regarding the individual risk of future coronary events *(Silverman et al., 2013)*.

In our study, 54% patients had HTN, 62% patients had DM, 59% patients had dyslipidemia and 46% patients were smokers. Regarding chest pain, 81 %patients had typical chest pain and 19% patients had a typical chest pain. *Gaibazzi et al. (2014)* found that 66% were hypertensive, 55% hypercholesterolemia, 30% were active smokers and 14% diabetics.

Our study showed distribution of coronary artery calcium score among total studied population, 54% had CAC score of 0-10, while 36% had CAC score of 11-100, while 10% had CAC score of 101-400, and no patient had CAC score > 400. Mean CAC scores of studied patients was 39.3±73.1.

According to coronary CTA result, the total population was classified into 44 patients with obstructive CAD, and 56% patients with non-obstructive CAD.

Regarding obstructive CAD, 52.3% had LAD obstruction, 47.7% had LCX obstruction, 20.5% had RCA obstruction and 18.2% had LMT obstruction. Regarding non-obstructive CAD, 53.6% had LAD non-obstruction, while 50% had LCX non-obstruction, while 17.9% had RCA non-obstruction and 12.5% had LMT non-obstruction. *Gaibazzi et al. (2014)* used a >50% diameter stenosis to define obstructive CAD at CCTA, patients with no CAD, single-vessel, 2-vessel or 3-vessel disease were 61%, 23%, 9% and 7%, respectively; accordingly, 61% had no obstructive CAD, while 39% had at least one diseased (>50% stenosis) coronary artery.

Our study showed the semi quantitative score of cardiac calcification on the total population. No patient had papillary muscle or aortic root calcification. Mild MAC was present in 4 patients versus moderate MAC in one patient. But, mild AVC was present in 26% patients. *Saha et al. (2015)* observed moderate or severe calcific deposit in the aortic valve in 29.3%, followed by the aortic root (23.8%), and the left main coronary artery (12.4%) Moderate or severe calcific deposits on the mitral annulus were seen in 10.8%.

Saha et al. (2015) found that compared with participants with a composite calcium score of 0, those with a score of > 2 were older and had a higher proportion with a history of diabetes mellitus or coronary revascularization. The proportion of participants with previous myocardial infarction, heart failure, stroke, or peripheral arterial disease did not differ significantly between groups. Participants with calcific deposits at multiple sites also had higher diastolic blood pressure, reduced renal function, and higher serum phosphorus levels. However, there were no significant differences between the groups in the fasting cholesterol profiles or C-reactive protein levels at baseline. Participants with a composite calcium score of 0 had a significantly lower incidence of CV events than participants with composite calcium score of > 2. Participants with a composite score of 0 also had significantly lower rates of death and myocardial infarction compared with participants with a composite score of > 2.

In our study, ECS and CAC score were significantly correlated. *Nucifora et al. (2011)* confirmed the relation between eCS, CAC and CAD, but found that the best predictive cutoff was eCS > 2. This confirms the presence of a grey zone, as in most scores in medicine, between eCS 1 and 2, in which results should be interpreted with clinical caution.

Koulaouzidis et al. (2013) showed that the presence of cardiac calcium outside the coronary tree may not only reflect coronary calcium burden but also the vulnerability of atherosclerotic plaques, acting like a feature of additional risk for cardiac events, independently from the presence or grade of a coronary stenosis. This would explain the robust link between cardiac calcium and prognosis, in spite of a weaker correlation with coronary artery stenosis grade. *Criqui et al. (2014)* linked coronary plaque vulnerability to calcium density in the plaque, by so doing demonstrating that the total burden of coronary calcium is only part of the cardiac risk picture.

Gaibazzi et al. (2014) showed also a significant positive correlation. When eCS was correlated with the number of diseased vessels at CCTA, there was a weak to low correlation only when the most severe definition of CAD (diameter stenosis > 70%) was applied. CACS correlated with the number of diseased vessels also (and more robustly than >70%) when the definition of milder disease, i.e. stenosis > 50%, was used. Only 12 patients had at least one >70% stenosis.

Linear regression analysis was performed in order to identify the most independent variable that can predict CAD. We found that the independent predictors for CAD category were MAC&AVC, HTN, FH of IHD, and smoking.

Gaibazzi et al. (2014) demonstrated that global chi square of logistic regression models significantly increased when adding eCS to age and clinical variables and further when finally adding CACS score. *Saha et al. (2015)* indicated that the following variables were significantly associated with the composite cardiac calcium score: age, history of diabetes mellitus, previous coronary revascularization, diastolic blood

pressure, estimated glomerular filtration rate, and serum phosphorus level.

ROC curve analysis was used to test the predictive value of AVC, MAC and CAC scores for the presence or absence of obstructive CAD. This analysis showed that AVC and MAC scores were inferior to CAC score which was found to have the highest predictive value evidenced by an area under the curve of 0.763 (95%CI: 0.781, 0.913).

We also used ROC curve analysis to test the predictive value of AVC and MAC scores for the presence or absence of CAC. This analysis showed that MAC score was inferior to AVC score which was found to have the highest predictive value evidenced by an area under the curve of 0.815 (95%CI: 0.758, 0.879).

Corciu et al. (2010) estimated the correlation between the total heart calcification score index (CSI), assessed by echocardiography, left ventricle mass index (LVMI), Framingham risk score (FRS), and angiographic ally assessed coronary artery disease (CAD). They concluded that calcification score index calculated as the sum of aortic root sclerosis, aortic valve sclerosis, and mitral annulus calcification, is associated with risk factor profile, coronary atherosclerosis and left ventricle mass index. The low cost, portable, facile and radiation free nature of the ultrasound approach make CSI an attractive candidate in the ongoing search for the ideal marker of vascular and valvular calcification.

Gaibazzi et al. (2014) demonstrated that eCS or AVC + MVC had similar capability (AUC 0.77 and AUC = 0.78, respectively) to predict a high CACS

score, while AVC and MVC (AUC 0.67) alone had slightly lower AUC values. Regarding the prediction of obstructive CAD, CACS had the highest predictive power when compared with eCS. They concluded that eCS, calcium score easily obtainable during standard echocardiography, is moderately to strongly correlate with nCACS by CCTA. The full eCS score correlates with nCACS better than its single components. It correlates with CACS and predicts severe coronary calcification (CACS > 400), a known predictor of cardiovascular morbidity and mortality. The eCS also predicts obstructive CAD, incrementally to age and clinical variables; although for this purpose CACS remains the most accurate score. *Saha et al. (2015)* concluded that a simple TTE-derived composite cardiac calcium score was independently predictive of death in patients with pre-existing CAD.

CONCLUSION

The echocardiographic calcium score specifically the MVC and AVC was correlated to be CAC. Ecs can predict the CAC score, and the presence or absence CAD.

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إرتباط درجة تكلس القلب بواسطة الموجات الصوتية مع درجة الكالسيوم التاجية بواسطة الأشعة المقطعية المتعددة

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خلفيـة البحـث: يعـد تصلب الشـرايين التاجيـه واحـدة مـن أشـهر الأمـراض التـي تصيـب القلـب ويـتم تشخيصـها باسـتخدام الأشـعة المقطعيـة عـن طريـق قيـاس نسـبة الكالسيوم المتواجـده بالشـرايين التاجيـه للقلب. وبـالرغم مـن ذلـك فهـو غيـر منتشـر علـي نطـاق واسـع نظـرا لارتفـاع تكلفـة هـذا الفحـص وانبعـاث كميـة كبيـرة مـن الاشعاعات الضـارة منـه، كمـا أنــه مـن الممكـن ان يتعـرض المـريض الـي حساسـية شـديده وتسـمم كلـوي جـراء إسـتخدام الصـبغة الخاصـة بـه ممـا يحـد مـن إسـتخدامه فـي المرضـي الـذين لا يعانون من أية أعراض بالقلب.

الهـدف مـن البحـث: الوقـوف علـي مـدي قـدرة تحديـد نسـبة الكالسـيوم بالقلـب والشـريان الأورطـي باسـتخدام الموجـات الصـوتيه علـي معرفـة نسـبته بالشـرايين التاجيـه وبالتـالي انسـدادها واعـتلال عضـلة القلـب والتـي يـتم تحديـدها باسـتخدام التصـوير المقطعي المحوسب.

المرضـى وطـرق البحـث: إشـتملت تلـك الدراسـة علـي مائـة مـريض مصابون بانسـداد الشـريان التـاجي وكـان متوسـط أعمـارهم 51 عامـاً بينمـا كـان 51% مـنهم ذكـورا و 49% اناثـا. كـان ، أيضـا هنـاك 46 مـدخنا و54 مريضـا مصابين بارتفـاع ضـغط الـدم و 62 مصـابين بـداء السـكري و 59 بارتفـاع نسـبة الـدهون بالـدم مـن خـلال تحديـد نسـبة الكالسـيوم بالقلـب والشـريان الأورطـي باسـتخدام الموجـات الصـوتيه علـي معرفـة نسـبته بالشـرايين التاجيـه وبالتـالي انسـدادها واعـتلال عضـلة القلـب والتـي يـتم تحديدها باستخدام التصوير المقطعي المحوسب.

نتـائج البحـث: حـدث فـروق ذات دلالـة إحصـائية بـين توزيـع درجـات الكالسـيوم وعوامـل الخطـورة كمـرض السـكر وارتفـاع ضـغط الـدم وارتفـاع نسـبة الـدهون بالـدم والتـدخين. هنـاك علاقـة كبيـرة بـين درجـة الكالسـيوم بالشـريان التـاجي ودرجـة التـكلس بالصـمام الأورطـي. وتـم إجـراء تحليـل الانحـدار الخطـي بهـدف تحديـد أكثـر

المتغيـــرات المســتقلة التـــي يمكـــن أن تسـبب مـــرض الشـــريان التـــاجي الانســدادي ووجـد أنهـــا تكلـــس الصـــمامات اليســري، وارتفـــاع ضـــغط الـــدم والتـــاريخ المرضـــي الأســري لأمـــراض القلـــب والتـــدخين أيضـــا، وحـــدد تحليـــل الانحـــدار الخطـــي أن أكثـر المتغيـرات المســتقلة التـــي يمكـــن أن تتوقـــع تكلـــس الصـــمام الأورطـي كانـــت درجـــة تكلـس الشـــرايين التاجيـــه وارتفـــاع نســبة الـــدهون بالـــدم وكـــان المتغيـــر الأكثـــر اســتقلالية الـــذي يمكـــن أن يتنبأ بمرض الشريان التاجي الانسدادي هو وجود تكلس بالشريان التاجي.

الاســتنتاج: تحديـــد درجـــة الكالســـيوم بالقلـــب عـــن طريـــق الموجـــات الصـــوتيه قريـــب مـــن نفـس النتـــائج التـي أظهرهـــا التصـــوير المقطعـــي المحوسـب فـي حـــالات الـــتكلس الحـــاد بالشـــريان التـــاجي وإن كـــان أقـــل قـــوة مـــع مـــرض الشـــريان التـــاجي الانسدادي و مـــن الممكـــن إســتخدام تحديـــد درجـــة الكالســـيوم عـــن طريـــق الموجـــات الصـــوتيه علـــى نطـــاق واســع بتكلفـــة منخفضـــة وبـــدون التعـــرض الكثيـــف للإشـــعاع فـي ألمرضـي الـــذين لـــديهم عوامـــل خطـــورة عاليـــة، مـــن أجـــل تحســـين الصـــحة العامـــة والتنبـــوء المبكـــر بـــأمراض القلب ومن ثم تلافيها.