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MULTISLICE SPIRAL CT IN DIAGNOSTICS OF CORONARY ARTERY DISEASE

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Abstract

The aim of this study is to rewiev the contribution of multislice computed tomography (MSCT) as a screening tool for coronary artery disease by measuring quantity of coronary calcium. During the period of one year, 59 patients with clinical symptoms of cardiac disease were examined in our Institute of Radiology.

The average age of the examined patients was 62 years. The youngest patient was 18 and the oldest 82 years old. 41 patients (69.5%) were male with average age of 62.7 years and 18 patients (30.5%) female with average age of 63 years.

The CT examinations were performed with ECG gating MSCT "Somatom Volume Zoom" Siemens native and with intravenous contrast medium administration (140 ml Omnipaque with 50 ml physiological solution) and with 3 mm slice thicknes.Special attention was paid to the coronary vessel calcification according to Agatston's total calcium score(TCS) for account coronary calcification.

Calcifications of coronary arteries were found in 52 patients and TCS was made according to Agatston's method. Among these patients were12 (20,3%) with mild coronary atherosclerosis (total calcium scor -TCS 10-100), 11 (18,6%) with moderate coronary atherosclerosis (TCS 100-400), and 29 (49,1%) with severe coronary atherosclerosis (TCS > 400).

42 (71,2%) of these patients were smokers, 22 (37,3%) had hypertension, 9 (15,2%) diabetes, 6 (10,2%) hypercholesterolemia and 5 (6.8%) triglyceridemia, everybody with coronary calcifications.

Only 24(40,7%) of these patients had symptoms of angina pectoris.

Infarctus myocardii was found in 7 (11.9%) patients, among them 6(85,7%) with severe coronary atherosclerosis (TCS > 400).

Calcifications of the coronary arteries are always connected with atherosclerosis.

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For this reason an early detection and quantification of coronary calcifications play an important role in the diagnosis and prognosis in patients with coronary artery disease.

MSCT has shown to be the most sensitive modality for this purpose and enables, safe and non-invasive screening investigation of coronary arteries.

Key words: *Multislice CT (MSCT), coronary atherosclerosis (CA),total calcium score(TCS)*

Introduction

Coronary atherosclerosis is a progressive pathological process, which can stay non-symptomatic for many years or even for whole life. In the first stage of coronary artery disease it could be spread over the large number of the population. It can be compared with ice-berg. Angina pectoris can develop in these patients or sudden coronary attack can happen.

That is the main cause of death in the west countries, and includes 5-10% male population (1). About 30% heart attacks appear in people who have not usual risk factors (increased cholesterol level, high blood pressure or diabetes) (2). 60% men and 42% women who come with acute myocardial infarct or sudden death didn't have disease in anamnesis before (3).

Every year over 300 persons per 100.000 inhabitants get myocardial infarct (IM), often as the first symptom of their cardiovascular disease. Patient dies in over 35% cases (4). There were 500.000 persons in USA in 1956 and 600.000 ones in Europe in 1998 who died for these reasons (5,6).

Coronary disease is manifestation of atherosclerosis in coronary arteries. It is a multifactor process, which leads to myocardial ischemia and can be showed as angina pectoris, myocardial infarct, and heart disrhythmia, congestive heart disease or sudden death. Half of the patients with ventricular dysfunction are aware of their condition or they have no adequate conditions for medical treatment, while only half of them with recognised symptoms get appropriate treatment. This statistical set is called "rule of the half" (7).

Great efforts have been put into early identification of persons with cardiovascular risk factors.Any reliable remedy wasn't found for examination of atherosclerosis progress or retreating.

In this moment, there are different ways of heart visualization: radiography, fluoroscopy, echocardiography, Doppler, Multislice CT (MSCT), Electron Beam CT (EBCT), A single photon emission tomography (SPECT), Proton emission tomography (PET), Magnetic resonance imaging (MRI) and intravascular ultrasound (US). Diagnostic tests, which were used, for screening of normal population for detecting

of obstructive lesions that disturb the coronary circulation, are treadmill test of loading, echo stress test, talium scintigraphy and so on. But, all these tests can not discover non-obstructive coronary plaques, which carry rupture risk and can provoke unstable angina, acute myocardial infarcts or sudden death without any warning signals. Angiography is gold standard for all these methods, while PET is that for quantitative measuring of myocardial blood circulation and getting metabolism information (8).

More than a million angiographies have been done in the USA every year, but the method is invasive and expensive and requires short hospitalisation at least (6). Heart catheterisation with diagnostic complex costs between 1500 – 3000$ in Europe. The cost prise in acute myocardial infarct if a patient survived is 3800$, but if he died 1770$ (7). Because of that it's desirable to replace angiography with non-invasive screening investigation which can enable to see marshy part of the berg of coronary artery disease before appearance of fatal result.

Research have established close link between stratums of coronary artery calcifications and atherosclerosis plaque in post-mortem studies of coronary victims, such as tight correlation between coronary artery calcifications and coronary artery stenosis (1).

From there is an idea that calcium deposits can serve as markers of early coronary artery disease. Detecting of coronary calcifications shows early atherosclerosis forms before clinical symptoms. Because of that estimation of coronary calcium has been suggested for detecting coronary artery disease in patients with pain in their chests. Severe calcifications of coronary arteries are very suggestive on significant stenosis of coronary arteries. It was suggested that coronary vessel calcification in patients over 50 years old can refer to bad prognosis. The patients with severe coronary vessel calcifications had on increase of myocardial infarct frequency during autopsy (5). Radiography and fluoroscopy can detect coronary calcifications, but these methods are of small sensitivity, especially for mild forms of calcifications.In 1982. it was detected that CT is very sensitive method for detecting coronary calcifications, and a little bit later thanks to development of fast CTs, Agatston and all. developed quantification system of calcium contents in coronary arteries known as Agatston's method (fig.1). Identification and quantification of coronary calcifications are improved by development of ultra fast scanner types EBCT and MSCT (fig.2).

Quantitative determination of coronary calcifications point to presence of coronary atherosclerosis as first indicator of heart disease. This research can be positive when all other non-invasive screening methods are negative. But number of the false negative tests is not known yet.

Whatsoever, coronary calcifications of atherosclerosis plaques happen in early stage of disease. MSCT makes possible non-invasive detection of atherosclerosis plaque (10). Reliability of coronary calcium quantification, especially for soft plaques has been improved by using retrospective ECG "gating" at MSCT, which make possible to predict if changes in coronary artery calcifications have predictive value for future coronary strokes.

Investigations have shown that the absence of coronary calcium in old people highly correlated with normal coronary arteries, so that MSCT can eliminate need for coronary angiography. MSCT can be used not only in detecting of coronary calcifications as marker for total coronary atherosclerosis, but also for estimation of preventive therapy effects. In that way modern screening techniques made possible heart to be returned in Radiology.

The aim of this investigation is a review of the contribution of MSCT as screening method in detecting coronary artery disease on the base of coronary calcium quantification.

Figure 1. *"Calcium Window" for identification of calcified plaques*

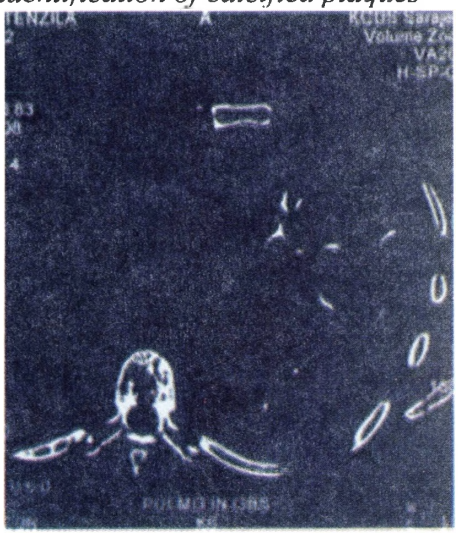
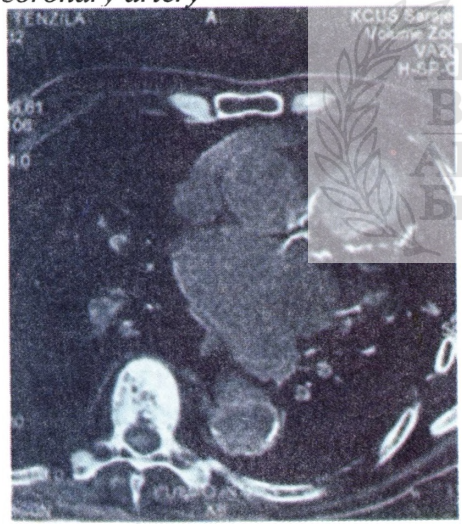


Figure 2. *Calcification of left coronary artery*



Material and method

During the period of one year, 59 patients with clinical presentation of cardiac disease were examined in our Institute and they were kept under different diagnosis, from angina pectoris, hypertension, different kinds of heart ischemia and disrhythmia, to myocardial infarct.

The average age of the examined patients was 62 years. The youngest patient was 18 and the oldest one, 82 years old.

Among those patients 41 (69,5%) were male, with average age of 62, 7 years, and 18 (30,5%) female, with average age of 63 years.

The CT examination was performed with multisection CT device "Somatom Volume Zoom" SIEMENS, with special program for heart examination, 4x2,5mm colimation, 500msec. rotation time, pitch 1,5 and FOV 200. The examination was performed first native, than with contrast bolus, 140ml non-ionic contrast medium administration (370mg/1ml) which was given in anthecubital vein with flow rate 3-4ml/sec, followed by 50ml physiological solution. Retrospective gating, 35-450msec before next R wave has done the reconstruction of the image.

Special attention was paid to detecting of coronary artery calcifications as sign of coronary atherosclerosis (CS), in keeping with Agatston's method where the product of total zone of calcified plaque for each stratum was determined, and counted so called total calcium score (TSC), for each patient. The patients were divided in three groups, one with soft (TSC 10-100), mild (TSC 100-400) and one with severe coronary calcifications (TSC>400). At the end correlation between clinical findings and real condition shawn through TSC Agatston. The attention was paid to establishing frequencies of coronary calcification in smokers.

Results

Calcifications in coronary arteries as a sign of coronary atherosclerosis were detected at 52 (88,1%) of the patients. Among these patients, there were 38 (73,1%) male (M) and 14 (26,9%) female (F). Relation between male and female patients was 2,7:1 in male benefit.

Although they had some symptoms of heart disease, there were 7 (11,9%) patients without severe calcifications in coronary arteries, 3 (5,1%) male in the average age of 45 years and 4 (6,8%) female in the average age of 48,3 years.

Table 1. *Frequency of coronary sclerosis (CS) according to clinical diagnosis, risk factors and smoking*

Clinical diagnosis	Soft CS	Mild CS	Severe CS
Angina pectoris 24 (40,7%)	5 patients	4 patients	15 patients
Myocardial infarct 7(11,9%)	1	0	6
Hypertension 22(37,3%)	5	8	9
Diabetes 9(15,2%)	2	2	5
Hypercholesterolemia 6(10,2%)	2	1	3
Tryglyceridemia 5(6,8%)	3	0	2
Smokers 42(71,2%)	8	7	24

Table 2. *Frequency of coronary sclerosis (SC) at patients according to total calcium score (TSC) and age and sex.*

Level of CS	Number of patients	Sex	Age	Sex	Age	TSC
Soft CS	12(20,3%)	8(13,6%)M	64,5 years	4(6,8%)F	49 years	10-100
Mild CS	11(18,6%)	7(11,9%)M	69,6	4(6,8%)F	66,3	100-400
Severe CS	29(49,1%)	23(39%)M	64,2	6(10,1%)F	71,8	>400

Table 3. *Frequency of coronary sclerosis (CS) at myocardial infarct, TCS and smoking*

Diagnosis	Number of patients	Sex	Age	Smoking	TSC
M. infarct	7(11,9%)	6(85,7%)M	69,2	(85,7%)smokers >30 years	>400
		1(14,3%)F	71		>400
Recent MI		M	48	Non-smoker	10 (soft CS)

A patient with recent myocardial infarct had diabetes and hypertension with positive family history and raised tryglicerides.

Discussion

The aim of this and quoted studies in introduction part is reducing of disease and mortality at coronary disease caused by atherosclerosis process. Identification of coronary artery calcifications and calcium score can be useful in detecting of early stage of coronary disease at asymptotic patients, if coronary calcification is found. The reports show that TCS could be radiology equivalent to Babinski in clinical neurology. Coronary calcium score shows close link between coronary calcifications and cardiovascular disease and tells us about difficulty of atherosclerosis process.

According to our research 88,1% of the patients with symptoms of cardiovascular disease have had coronary calcifications, and 49,1% of them refer to severe coronary calcifications with TCS>400 (table 1). Percentage of severe coronary calcifications in patients with myocardial infarct was 85,7%, with TCS>400 (table 3). Our information is in accordance with those in literature, where it is quoted that the patients with calcium score over 2000 had 8 times better chance for heart attack compering with patients whose calcium score was under 100 (11). Also, information from literature tells us that 90% hearts with myocardial infarct have at least one calcification in coronary arteries (7).

Most investigations show that quantity of calcifications found at CT has correlation with seriousness of coronary sclerosis, although absence of calcifications on specific place doesn't exclude possibility of atherosclerosis plaque in that zone. This could have significant results for primary prevention of coronary artery disease, because coronary calcium points to developed stages of atherosclerosis.

Estimation of calcium can be useful in two cases: in non-symptomatic patients with high level of risk from coronary artery disease and at patients with non-typical chest pain (12). Calcium presence suggests higher risk for appearance of infarct and sudden death. So, detecting and quantification of coronary calcium play important role in diagnostics and prognosis in patients with and without coronary disease. CT is the most sensitive method for this purpose and enables fast, safe and non-invasive screening (13). Coronary artery calcium score according to Agatston's method can be effective weapon in estimation of therapy efficiency and can play a role in planning therapy technique (1,14).

High TCS can be important in making decision about more aggressive treatment of risk factors in non-symptomatic patients and can influence the selection of treatment procedure, like angioplastic, stenting, endarterectomy or rotating ablation.

Most of our patients who were analysed and who had at least one of risk factors (hypertension, diabetes, hypercholesterolemia, trygliceridemia or were smokers), have had calcifications in coronary arteries and often high TCS. Only 49,1% of these patients had signs of angina pectoris as warning symptom. Smoking, hypertension, male sex and older age in our small series have most often been united with coronary calcifications and high TCS. 42 (71,2%) of our patients were smokers (table 1,2). Relation between male and female patients was 2,7:1. This confirms previous knowledge about larger endanger of male from artery disease.

Development of new CT devices with scanning speed under 500msec like MSCT is powerful weapon for analysing coronary artery disease. That is simple non-invasive method to examin of the patients with non-typical chest pain. It is valuable method of examination, which can become an alternative to heart catheterisation or intravascular US (2).

Our first experiences with series of 59 patients with signs of heart disease confirmed existing of coronary artery calcifications in 88,1% cardiac patients and showed high sensitivity of this non-invasive way of examination.

According to information from literature MSCT enables virtual angioscopy of coronary arteries with sensitivity of 88% and specificity of 93% for detecting chemodinamic significant stenosis in proximal

segments of coronary arteries (2,6,15). In those case it can give important information in non-invasive way, not only about luminary condition of coronary artery, but also about artery wall, and evolution of plaque after therapy can be followed (2,10).

When calcifications in coronary arteries are detected as a warning sign, the risk can be reduced by suggesting patients to change the way of living, drugs for reducing cholesterol and so on (5,7). Contribution of MSCT is simultaneous visualization of aorta ascendens and lungs, which can sometimes be priceless and is not to be done with other methods.

But, there are some investigations, which show that 20% of patients under 50, who got acute myocardial infarct, have no calcium in coronary arteries (1). The similar case was with our 48 years old patient, non-smoker man, with recent myocardial infarct, whose TCS were 10 and who had risky factors: diabetes, hypertension, tryglicerides and positive family history (table 3).

For that some authors think that calcium score 0 does not exclude presence of atherosclerosis in patients under 50, more exactly that screening of coronary calcium should not be used to exclude acute coronary attack in young people (1,5). It is shown that small stained classifying lesions mostly dominate in patients with first myocardial infarct (16).

There are some opinions that sclerosis of arteries is not something to be less afraid of than of some fatty inflamed plaque and its rupture risk and making clot (10,11). All of these point out that risk of fatal heart attack is more complex than we thought before. Because of that, we need more studies.

New variants of MSCT show that they could become non-invasive device detecting soft plaques, and make possible identification of these patients in early stage (2). For now, it gives us a chance for easy non-invasive visualisation of calcified atherosclerosis in coronary artery wall and its measuring (TCS) to determine coronary risky factor. In that way necessary coronary angiography could be avoided (7). All these have the aim to improve non-invasive diagnostic procedure, intensify understanding of heart disease and reduce getting sick and patient mortality (3,7). Tight co-operation between radiologists and cardiologists is necessary.

Conclusion

Calcifications of coronary arteries are always in close connection with coronary atherosclerosis, and with heart diseases also, especially myocardi. Because of that early detecting and quantification of coronary calcifications play an important role in diagnostics and

prognosis in patients with coronary arteries disease. According to this investigation and research of other authors MSCT has been shown as very sensitive way for this purpose, because it make possible fast, safe and non-invasive screening examination of coronary arteries. It could be used as a way of selecting patients for coronarography or more intensive conservative treatment. It is relative cheep and easy accessible method for everyone to check coronary arteries, in non-symptomatic patients or those with inexplicable chest pain.

Apstrakt

Cilj ove studije je prikaz doprinosa višeslojne kompjuterske tomografije (MSCT) kao sredstva za screening koronarne arterijske bolesti, pomoću kvantifikacije koronarnog kalcija.

U periodu od jedne godine pregledali smo na našem Institutu 59 pacijenata sa kliničkim simptomima bolesti srca. Najmladi pacijent je imao 18 godina a najstariji 82 godine. Medu ovim pacijentima 41 (69,5%) su bili muškarci, prosječne starosti 62,7 godina., a 18 (30,5%) žene, prosiječne starosti 63 godine.

CT pregled je bio učinjen, sa retrospektivnim ECG "gating"-om na višeslojnom CT-u "Somatome Volume Zoom"SIEMENS, nativno i sa intravenski datim kontrastnim sredstvom (140 ml Omnipaque sa 50ml fiziološkog rastvora) i 3mm debljinom sloja. Posebna pažnja je bila usmjerena na kalcifikacije koronarnih sudova u skladu sa Agatston-ovim ukupnim kalcijum skorom (TCS) za proračun koronarnih kalcifikacija.

Kalcifikacije koronarnih arterija nadene su kod 52 (88,1%) pacijenata, a ukupni kalcijum skor je učinjen prema metodi Agatston-a. Medu ovim pacijentima je bilo 12 (20,3%) sa blagom koronarnom aterosklerozom (ukupni kalcijum skor 10-100), 11 818,6%) sa umjerenom koronarnom aterosklerozom (TCS 100-400), i 29 (49,1%) sa ozbiljnom koronarnom arteriosklerozom (TCS>400).

42 (71,2%) od ovih pacijenata su bili pušači, 22 (37,3%) su imali hipertenziju, 9 (15,2%) diabetes, 6 (10,2%) hiperholesterolemiju i 5 (6,8%) trigliceridemiju, svi sa koronarnim kalcifikacijama. Od ovih pacijenata samo 24 (40,7%) je imalo simptome anginе pektoris. Infarkt miokarda je naden kod 7 (11,9%) pacijenata, od kojih 6 (85,7%) sa teškom koronarnom aterosklerozom (TCS>400).

Kalcifikacije koronarnih arterija su uvijek u vezi sa aterosklerozom. Iz tog razloga otkrivanje i kvantifikacija koronarnih kalcifikacija igra važnu ulogu u dijagnostici i prognozi kod pacijenata sa koronarnom arterijskom bolesti.

MSCT se pokazao da je najosjetljiviji način sa ovom namjenom i mogućnosti brzog, sigurnog i neinvazivnog screening ispitivanja koronarnih arterija.

Kljucne riječi: *Višeslojni CT (MSCT), koronarna ateroskleroza (CS), ukupni kalcijm skor (TCS).*

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