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RESEARCH ARTICLE

Correlations Between Regional Accumulation of Calcium in the Culprit Arteries and Plaque Burden in Acute Coronary Syndromes

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Introduction: The association between a high calcium score at the level of the unstable coronary lesions and the different characteristic of culprit lesions which result in an acute coronary syndrome (ACS) has not been described yet. We aimed to study the correlation between the accumulation of calcium within the vessel wall of a coronary artery and the plaque burden of culprit lesions that develop an acute coronary event.
Material and methods: A total of 45 patients with ACS (22 unstable angina, 23 nonST elevation myocardial infarction) underwent 64-slice CCTA. In all patients a complex CT analysis of the culprit plaques was performed and the calcium score for each coronary artery was computed.
Results: We found a significant correlation between a calcium score higher than 100 and the plaque volume ($r = 0.85$. $p = 0.01$). Selecting a cut-off value of 100 HU for regional calcium score at the level of the coronary artery, we found that those arteries with Ca score higher than 100 presented significantly larger plaque volumes than the ones with calcium score below 100 (110.8 ml vs 82.4 ml, $p < 0.0001$ for left anterior descending artery, 111.09 ml vs 82.5 ml, $p = 0.0005$ for circumflex artery, and 132.78 ml vs 76.23 ml for right coronary artery).
Conclusion: Our data shows that in ACS, the severity of the culprit lesions correlates with regional accumulation of calcium within the vessel wall.

Keywords: plaque burden, calcium scoring, cardiovascular risk score

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Introduction

The pathophysiologic substrate of an acute coronary syndrome is the atherosclerotic process developed within the coronary arteries, which includes development of atherosclerotic calcification. The ability to detect and quantify coronary artery calcium using non-invasive imaging technique like: fluoroscopy, electron beam, and computed tomographyhas increased in a certain extent the interest for developing appropriate applications in various clinical settings, especially in diagnosis, cardiovascular risk calculation, cardiac event prognostic survey or epidemiological studies.

Previous studies demonstrated that 64 slice Multidetector computed tomography (MDCT) has an excellent diagnostic accuracy for calculation of coronary artery calcium score, or evaluation of culprit lesion as compared with other imaging techniques such as conventional coronary angiography orintravascular ultrasound associated with virtual histology. However, all these features describe mainly the global coronary tree, while the association between a local calcium score at the level of the unstable coronary lesions and the different characteristic of culprit lesions resulting in an acute coronary syndrome (ACS) has not been described yet. This would represent a measure of the individual plaque vulnerability rather than of the entire patient, thus providing additional information for risk stratification according to plaque instability.

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However, the incremental values of local calcium score or different plaque characteristics defined by MDSCT such as plaque volume still needs to be investigated in patients with acute coronary syndrome.

We aimed to study the correlation between the accumulation of calcium within the vessel wall of a coronary artery and the plaque burden of culprit lesions that develop an acute coronary event.

Material and methods

Patients

From January 2011 to December 2012 we performed a contrast-enhanced 64-slice MDCT investigation in 45 patients with acute coronary syndrome. The patients were grouped in group A - 22 unstable angina and group B 23 non-ST-segments elevation myocardial infarction. All patients underwent also quantitative coronary angiography followed by PCI in the following one or two days after MDCT. The patients inclusion criteria were the presence of chest pain and ST depression associated with elevation of troponin value or if they presented a new ischaemic discomfort with ECG changes suggestive of ischaemia. The exclusion criteria's for study population were: atrial fibrillation, unstable clinical status, contraindication for the administration of contrast agent, inadequate image quality.

64-slice MDCT investigation

The MDCT angiography was performed using a Somatom

Table I. Demographic Characteristics (UA: Unstable Angina, NSTEMI: non-ST-segment Myocardial infarction)

	UA n = 22 (48.9%)	NSTEMI n = 23 (51.1%)	p value
Age, years	62.13 ± 10.49	65.82 ± 10.96	0.25
Gender, male	18 (81.8%)	17 (73.9%)	0.72
Diabetes	2 (9.1%)	5 (21.7%)	0.41
Hypertension	15 (68.18%)	19 (82.6%)	0.31
Hyperlipidemia	11 (50.0%)	9 (39.1%)	0.55
Obesity (BMI >25 kg/m^2)	12 (54.5%)	8 (34.7%)	0.23
Smoker	14 (63.6%)	16 (69.5%)	0.75
Peripheral arterial disease	2 (9.5%)	0 (0%)	0.22
Previous stroke	2 (9.1%)	1 (4.3%)	0.6

Sensation multisclice 64, Siemens. Before examination in patients with heart rate greater than 70 b.p.m. 50 or 100 mg Metoprolol, per oral was given. As contrast agent was used iopromide 370 mg/ml, at a rate of 4.8 ml/sec. All the scans were retrospectively analyzed by an experienced radiologist and interventional cardiologist.

The coronary arteries tree was segmented according to 17-segments American Heart Association classification, as well were assessed: left main, left anterior descending, left circumflex and right coronary artery, including 1.5mm side branches. Then all the segments were evaluated for the presence of any atherosclerotic plaque, presence of significant coronary stenosis and plaque characterization based on regional coronary calcium accumulation (quantified based on Agatston score), plaque volume and markers of instability like presence of spotty calcification,positive remodeling index, orburden with low density (below 30 HU) plaque.

Quantitative coronary angiography

The quantitative coronary angiography was performed next day after MDCT investigation, using Siemens Artis Zee Floor angiography system. The coronary arteries tree was analyzed in multiple projection. Any luminal stenosis >50% in any major coronary artery was classified as significant coronary stenosis

Statistical analysis

Statistical analysis was performed using Graph InStat Pad softwares. Continuous values are expressed as the mean and standard deviation, and statistical significance was determined using the Mann-Whitney test. Categorical variables are expressed as percentages and were compared using Fisher's exact test. Statistical significance was considered for a p value <0.05, and all p values were 2-sided.

To determine the correlation of plaque volume and calcium score Pearson correlation coefficient was calculated.

Results

There were no significant differences in any demographic variables between the study groups (Table I).

Culprit lesions were located mainly in the left anterior descending (LAD) (40.9% in UA group and 39.1% in group NSTEMI) and right coronary artery (RCA) (31.8% vs. 39.1%), without any major differences between groups.

Analyzing the culprit lesion's plaque volume and the regional calcium score (calcium score localized on left anterior descending, left circumflex, right coronary artery and total) we noted a relatively homogenous distribution between group A and group B (Table II).

Further analysis showed that independent of culprit lesion localization, those located in the LAD, followed by those located in the left main, presented higher calcium score as compared to the other segments. Also we observed a higher calcium score accumulation on arteries at the level where we have identified the culprit lesion (Table III, Figure 1).

Selecting a cut-off value of 100 HU for regional calcium score at the level of the coronary artery, we found that those arteries with Ca score higher than 100 presented significantly larger plaque volumes than the ones with calcium score below 100 (110.8 ml vs 82.4 ml, p <0.0001 for left anterior descending artery, 111.09 ml vs 82.5 ml, p = 0.0005 for circumflex artery, and 132.78 ml vs 76.23 ml for right coronary artery).

Discussion

Analyzing the distribution of culprit lesion in patients with Acute Coronary Syndromes, our data shows that the proximal part of left anterior descending (LAD) (40.9% in UA group and 39.1% in group NSTEMI) and the right coronary artery (31.8% vs. 39.1%) are most frequently involved. Similar results were described by Pavan KCh et al, who demonstrated that the ruptured plaque mainly occurs

Table II. Regional calcium score and plaque volume (LAD: left anterior descending, LCX: circumflex artery, RCA: right coronary artery, LM: left main)

	Plaque volume	CaS LM	CaS LAD	CaS LCX	CaS RCA	CaS total		
LAD	205.28	239.33	362.85	238.62	335.75	1176.56	UA	p=0,0938
	127	116.07	433.86	179.71	199.73	929.38	NSTEMI	
LCX	99.7	352.2	536.14	373.92	412.28	1674.54	UA	p=0,0625
	118.5	8.25	390.67	133.3	214.35	746.57	NSTEMI	
RCA	90.47	273.71	372.74	257.4	319.05	1222.91	UA	p=0,06875
	146.91	324.66	388.85	94.72	277.88	1086.13	NSTEMI	
LM	62.1	28.7	5.4	2.4	1.2	37.7	UA	p=0,0735
	92	687.5	354.5	256	78	1376	NSTEMI	

Table III. Correlation between culprit lesion plaque volume and regional calcium score (LAD: left anterior descending, LCX: circumflex artery, RCA: right coronary artery, LM: left main)

	Plaque volume	Pearson r	CaS LM	CaS LAD	CaS LCX	CaS RCA	CaS total
LAD	106.66	r	0.6243	0.3409	0.497	0.4092	0.4424
		p	0.098	0.1662	0.084	0.165	0.066
LCX	107.91	r	0.2504	0.7915	(-0.19202)	0.6928	0.6645
		p	0.6845	0.011	0.7181	0.0386	0.0509
RCA	122.18	r	0.3998	0.4203	0.4432	0.4537	0.6055
		p	0.3742	0.1188	0.1499	0.0894	0.0129

in the proximal portions of the left anterior descending and left circumflex coronary arteries (90% within the first 33 mm) while in the right coronary arteries shows more uniformly distribution [1,2].

Same researches noted that MDSCT overestimate the severity of coronary stenosis on LAD compared to the other coronary segments, but further analysis showed that discordance is prevalent only in the stable angina pectoris group [3]. Our data revealed that this limitation was not observed in the unstable angina and NSTEMI groups, because we observed a good fits between severity of culprit lesion defined by quantitative coronarography and MDSCT [4,7].

Comparing the culprit lesion's plaque volume, the total and the regional calcium score on left anterior descending, circumflex artery,right coronary artery and the left main, we did not find any statistical significant differences between the unstable angina group and the NSTEMI group.

Previous reports showed that a high coronary calcium score as a benchmark of the atherosclerosis process potentially predicts the presence of significant coronary arteries disease [5,6]. In addition our finding revealed that the total calcium score was closely correlated with the one corresponding to the location of the culprit lesion (regional calcium score), suggesting that a significant target lesion calcification can simply be predicted by a high total calcium score [6,9]. While recent studies have found a moderate correlation between coronary calcium score and the incidence of atherosclerotic disease on vessel-based analysis [7,8] our results showed that the correlations particularly were observed on circumflex artery and right coronary artery [10]. The clinical importance of this information can be defined in establishing the invasive treatment strategy [11].

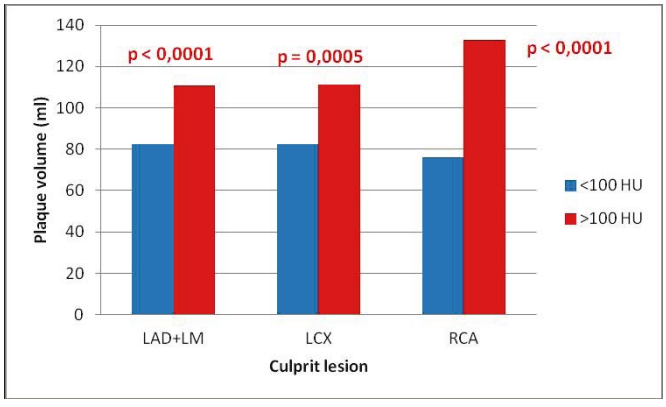

Fig. 1. Correlation between culprit lesion plaque volume and regional calcium score

We found a significant correlation between a calcium score higher than 100 and the plaque volume (r = 0.85, p = 0.01). Selecting a cut-off value of 100 HU for regional calcium score at the level of the coronary artery, we found that those arteries with Ca score higher than 100 presented significantly larger plaque volumes than the ones with calcium score below. As a conclusion we observed that the severity of the culprit lesions correlates with regional accumulation of calcium within the vessel wall.

Conclusion

In conclusion this study further indicates that in ACS, the severity of the culprit lesions correlates with regional accumulation of calcium within the vessel wall and suggest a possible relationship between the calcium score and the target lesion severity. In the same time we showed that an increased regional calcium score above 100 was also associated with the presence of a high volume vulnerable plaque.

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Abbreviations

ACS – Acute Coronary Syndrome
CAD – Coronary Artery Disease
CT – computed tomography
IVUS – Intravascular Ultrasound associated with Virtual Histology
MDCT – 64-slice multidetector computed tomography
NSTEMI – non-ST-segment elevation myocardial infarction
UA – unstable angina pectoris

References

1. Pavan KCh, Aloke VF, Gardner C, et al. Relationship between Coronary Artery Calcium Score by Multidetector Computed Tomography and Plaque Components by Virtual Histology Intravascular Ultrasound. J Am Coll Cardiol. 2007;50:940-9.

2. Rubinshtein R, Gaspar T, Halon DA, et al. Prevalence and extent of obstructive coronary artery disease in patients with zero or low calcium score undergoing 64-slice cardiac multidetector computed tomography for evaluation of a chest pain syndrome. Am J Cardio. 2007;99:472-475.
3. Choi YH, Hong JY, Myung H, et al. Relationship between Coronary Artery Calcium Score by Multidetector Computed Tomography and Plaque Components by Virtual Histology Intravascular Ultrasound. J Korean Med Sci. 2011;26(8):1052-1060.
4. Yang X, Gai LY, Li P, et al. Diagnostic accuracy of dual-source CT angiography and coronary risk stratification. Vasc Health Risk Manag. 2010;6:935-41.
5. Benedek Th, Bucur O, Pascanu I, Benedek I. Analysis of coronary plaque morphology by 64-multislice computed tomography coronary angiography and calcium scoring in patients with type 2 diabetes mellitus. Acta endocrinologica. 2011;7,1:59-68.
6. Liu YC, Sun Z, Tsay PK, et al. Significance of Coronary Calcification for prediction of coronary artery disease and cardiac events based on 64-slice coronary computed tomography angiography. BioMed Research International 2013, 9.
7. van Werkhoven JM, Schuijf JD, Gaemperli O, et al. Incremental prognostic value of multi-slice computed tomography coronary angiography over coronary artery calcium scoring in patients with suspected coronary artery disease. Eur Heart J. 2009;30(21):2622-9.
8. Benedek Th, Gyöngyösi M, Benedek I. Multislice Computed Tomographic Coronary Angiography for Quantitative Assessment of Culprit Lesions in Acute Coronary Syndromes. Canadian Journal of Cardiology. 2013;29(3): 364-371.
9. Shapiro E, Bush ED. Visualizing Vulnerability Toward a new cardiac score. J Am Coll Cardiol. 2013;61(22):2306-2308.
10. Takashi K, Maehara A, Mintz SB, et al. The Dynamic Nature of Coronary Artery Lesion Morphology Assessed by Serial Virtual Histology Intravascular Ultrasound Tissue Characterization. J Am Coll Cardiol. 2010;55(15):1590-1597.
11. Ho JS, Fitzgerald SJ, Stolfus LL, et al. Relation of a coronary artery calcium score higher than 400 to coronary stenoses detected using multidetector computed tomography and to traditional cardiovascular risk factors. Am J Cardiol. 2008;101(10):1444-7.