Detection of perfusion abnormalities on coronary angiograms in hypertension by myocardium selective densitometric perfusion assessments

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Structural and functional vascular alterations could be observed in arterial hypertension [1]. Several sophisticated methods are available to assess reserve capacity of coronary circulation and myocardial perfusion including videodensitometric analysis on coronary angiograms [2–6]. The present study was aimed to evaluate regional myocardial perfusion abnormalities by a novel computerized videodensitometric method in patients with arterial hypertension and negative coronary angiograms.

The study comprised 31 non-diabetic patients with hypertension and normal epicardial coronary arteries (<40% intraluminal diameter stenosis). Their results were compared to 18 age-, gender- and risk factor-matched controls without significant coronary artery disease (CAD). Typical angina and positive stress result indicated coronary angiography in all cases. Patients with acute coronary syndrome were excluded from this study. Informed consent was obtained from each patient and the study protocol conformed to the ethical guidelines of the 1975 Declaration of Helsinki, as reflected in a prior approval by the institution's Human Research Committee.

During coronary angiography the following criteria were used for later perfusion assessments:

1) motion of the patient or the table was avoided,
2) patients hold their breath during the period of the recording,
3) one contrast-free heart cycle was recorded before injection of contrast material,
4) field of view was to be set to contain the whole supplied area of the vessel of interest.

Projections were chosen to minimize the possible superpositioning myocardium supplied by different arteries and the edge of the diaphragm which usually gives motion artifacts on digital subtraction angiography (DSA) images. Left anterior descending (LAD) and left circumflex coronary arteries (CX) were recorded in lateral (LAO 90°), while right coronary artery (RC) was recorded in antero-posterior projection. For all coronary angiograms, contrast material was injected by a manual injector. Innova 2000™ system (GE Healthcare, Chalfont St. Giles, Buckinghamshire, United Kingdom) was used for recording coronary angiograms, images were stored in 512×512 size 8-bit, grayscale, uncompressed format.

Constant contrast, brightness and stabilized acquisition parameters of the X-ray imaging system were used in recording phase-matched DSA angiograms. The computerized method for myocardial perfusion assessment was performed on the base of the analysis of time-density curves (TDC) measured over the myocardial region of interest (ROI). Polygonal shaped ROIs were selected by an experienced interventional cardiologist and covered the whole myocardial area supplied by the investigated vessel. The maximal density of TDC (G_{max}) and the time to reach maximal density (T_{max}) were measured on the filtered curve. Arteries were masked out from regions of measurement improving sensitivity of measurements [7]. Cardiologists were blinded to all other clinical data.

Data analyses were performed with statistical software Medcalc (Mariakerke, Belgium). Data are reported as means ± SD and $p<0.05$ was considered to be statistically significant. Unpaired *t* test and Fisher's exact test were used during statistical evaluations.

Reduction in Gmax/Tmax values was found in hypertensive patients as compared to normotensive subjects with normal epicardial coronary artery in LAD- and CX-related coronary artery territories (see Table 1).

The result of the present study could suggest myocardial perfusion abnormalities assessed on coronary angiograms by the recently developed computerized videodensitometric method in hypertensive patients with normal epicardial coronary arteries. Several methods have been demonstrated to be feasible to detect coronary circulation and perfusion abnormalities including echocardiography [2,3], scintigraphy [4], magnetic resonance imaging [5] and positron emission tomography [6]. It would be optimal to find a tool with which coronary perfusion or microvasculature could be assessed during invasive procedures at the same time in patients with normal epicardial coronary arteries. Recently, a novel computerized videodensitometric method to assess regional myocardial perfusion abnormalities has been introduced by our working group [7–9]. It has been demonstrated that vessel masking could improve densitometric myocardial perfusion assessments [8]. Moreover, correlation was found between corrected TIMI frame count (TFC), as a simple method to evaluate epicardial flow and videodensitometric myocardial perfusion parameters (Gmax/Tmax) in stable patients free of coronary artery disease [9].

Based on literature, further studies are warranted to compare the above mentioned videodensitometric perfusion parameters with other

Table 1
Clinical and videodensitometric data in all subjects.

	Hypertension	Normotension	P value
Clinical data			
No of patients	31	18	–
Age (years)	60.0 ± 10.5	55.4 ± 10.6	0.56
Male (%)	19 (61)	11 (61)	0.99
Hypertension (%)	31 (100)	0 (0)	0.01
Hypercholesterolaemia (%)	24 (77)	14 (78)	0.98
Smoking (%)	10 (32)	5 (28)	0.82
Family history of CAD (%)	7 (23)	4 (22)	0.98
Videodensitometric data			
Gmax/Tmax — LAD	2.62 ± 1.56	3.81 ± 2.09	0.03
Gmax/Tmax — LCX	2.62 ± 1.47	3.21 ± 2.21	0.03
Gmax/Tmax — RC	2.53 ± 1.00	2.57 ± 0.90	0.88

Abbreviations: CAD: coronary artery disease, LAD: left anterior descending coronary artery, LCX: left circumflex coronary artery, RC: right coronary artery.

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imaging methods and to demonstrate abnormalities in other patient populations, and their relationship with other clinical characteristics.

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The authors of this manuscript certify that they comply with the Principles of Ethical Publishing in the International Journal of Cardiology [10].

References

[1] Mourad JJ, Laville M. Is hypertension a tissue perfusion disorder? Implications for renal and myocardial perfusion. J Hypertens Suppl 2006;24:S10–6.
[2] Cortigiani L, Rigo F, Galderisi M, et al. Diagnostic and prognostic value of Doppler echocardiographic coronary flow reserve in the left anterior descending artery in hypertensive and normotensive patients. Heart 2011;97:1758–65.
[3] Lønnebakken MT, Rieck AE, Gerdts E. Contrast stress echocardiography in hypertensive heart disease. Cardiovasc Ultrasound 2011;9:33.
[4] Iriarte M, Caso R, Murga N, et al. Microvascular angina pectoris in hypertensive patients with left ventricular hypertrophy and diagnostic value of exercise thallium-201 scintigraphy. Am J Cardiol 1995;75:335–9.
[5] Nakajima H, Onishi K, Kurita T, et al. Hypertension impairs myocardial blood perfusion reserve in subjects without regional myocardial ischemia. Hypertens Res 2010;33:1144–9.
[6] Masuda D, Nohara R, Tamaki N, et al. Evaluation of coronary blood flow reserve by 13N-NH3 positron emission computed tomography (PET) with dipyridamole in the treatment of hypertension with the ACE inhibitor (Cilazapril). Ann Nucl Med 2000;14:353–60.
[7] Ungi T, Ungi I, Jónás Z, et al. Myocardium selective densitometric perfusion assessment after acute myocardial infarction. Cardiovasc Revasc Med 2009;10:49–54.
[8] Ungi T, Zimmermann Z, Balázs E, et al. Vessel masking improves densitometric myocardial perfusion assessment. Int J Cardiovasc Imaging 2009;25:229–36.
[9] Nagy FT, Sasi V, Ungi T, et al. Correlations between myocardium selective videodensitometric perfusion parameters and corrected TIMI frame count in patients with normal epicardial coronary arteries. Int J Cardiol 2012;155:498–501.
[10] Shewan LG, Coats A. Ethics in the authorship and publishing of scientific articles. Int J Cardiol 2010;144:1–2.

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Increased dietary calcium intake is not associated with coronary artery calcification ☆

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Adequate calcium intake has long been advocated as an integral part of the prevention or treatment of osteoporosis [1–3]. Moreover, several lines of evidence have suggested that high calcium intake protects against vascular disease by lowering serum cholesterol level [4] and blood pressure [5,6]. In observational studies, women with higher calcium intake had a lower risk for deaths from cardiovascular events or for ischemic stroke than women with lower calcium intake [7]. However, recent studies demonstrated that there is a positive relationship between serum calcium level and risk for cardiovascular events [8–12]. The emerging mechanism linking calcium to cardiovascular disease is vascular calcification [13,14], which is predictive of the cardiovascular events [15–17]. There have been few studies that specifically investigated the relationship between calcium supplementation and coronary artery calcification [18,19]. We evaluated the interrelationship among dietary calcium intake, coronary artery calcification and serum calcium or phosphate levels in a healthy Korean population.

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This was a retrospective analysis of data obtained from 2710 men and 1143 women (postmenopausal women: 626) aged 30 years or older at the Healthcare System Gangnam Center of Seoul National University Hospital during the period between 2006 and 2009. Study participants had medical examinations and coronary artery CT for screening purposes. None of the subjects was taking calcium supplementation. We used a 24-hour recall diary to assess dietary

Table 1
Descriptive and biochemical characteristics of study population.

	Men (n = 2110)	Women (n = 1103)	*p*-value
	Mean ± SD or n(%)	Mean ± SD or n(%)	
Age (years)	56.5 ± 7.7	57.7 ± 7.1	<0.001
Body mass index (kg/m^2)	24.7 ± 2.6	23.2 ± 3.0	<0.001
Systolic blood pressure (mm Hg)	121.6 ± 14.5	119.3 ± 16.3	<0.001
Diastolic blood pressure (mm Hg)	80.5 ± 10.4	75.4 ± 11.0	<0.001
Serum calcium (mg/dL)	9.28 ± 0.38	9.24 ± 0.41	0.004
Serum phosphate (mg/dL)	3.43 ± 0.50	3.89 ± 0.57	<0.001
Fasting plasma glucose (mg/dL)	106.1 ± 23.9	97.4 ± 17.8	<0.001
HOMA-IR	2.73 ± 1.81	2.31 ± 1.48	<0.001
Total cholesterol (mg/dL)	197.3 ± 34.4	205.6 ± 35.3	<0.001
Triglyceride (mg/dL)	136.5 ± 84.8	107.6 ± 61.5	<0.001
HDL-cholesterol (mg/dL)	50.1 ± 12.0	58.7 ± 14.6	<0.001
LDL-cholesterol (mg/dL)	120.0 ± 32.2	125.4 ± 33.1	<0.001
Serum creatinine (mg/dL)	1.13 ± 0.14	0.88 ± 0.21	<0.001
Dietary calcium intake (mg/day)	765.7 ± 303.4	767.9 ± 301.7	0.839
Coronary artery calcium score	70.0 ± 262.6	22.7 ± 94.9	<0.001
Hypertension	450 (21.3)	171 (15.5)	0.005
Coronary artery disease	50 (2.4)	18 (1.6)	0.350
Dyslipidemia	261 (12.4)	97 (8.8)	0.071
Diabetes mellitus	176 (8.3)	47 (4.3)	<0.001
Stroke	29 (1.4)	12 (1.1)	0.781
Current smoker	487 (23.1)	23 (2.1)	<0.001
Current drinker	1096 (51.9)	148 (13.4)	<0.001

Data are mean (SD) or n (%). HOMR-IR, homeostatic model assessment of insulin resistance; HDL, high-density lipoprotein; LDL, low-density lipoprotein