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Original article

Coronary vasodilation by the use of sublingual nitroglycerin using 64-slice dual-source coronary computed tomography angiography

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ABSTRACT

Background: Sublingual nitroglycerin capsules or spray is routinely used to treat anginal attacks and to maximally dilate the epicardial coronary arteries during coronary angiography. These dilated coronary vessels have an advantage, but increased heart rates were disadvantageous for coronary computed tomography angiography (CTA).
Purpose: The influence of applying nitroglycerin was analyzed regarding the coronary diameter, coronary luminal attenuation, evaluable number of coronary segments, heart rate (HR), HR variability, the optimal reconstruction phase, and image scoring of CTA in the same patients using a 64-slice dual-source CT.
Methods and subjects: Fifty-two patients with atypical chest pain underwent coronary CTA before and after the administration of sublingual nitroglycerin without heart rate control. The coronary diameter and luminal attenuation were measured on short-axial images in each coronary segment. The coronary vasodilation ratios (VRs) were calculated from the coronary diameters at the same location before and after the use of nitroglycerin. The local institutional review board approved this study and written informed consent was obtained from all the patients.
Results: No significant differences were noted in the HR variability or optimal reconstruction phase, despite an increase in HR after the use of nitroglycerin. Nitroglycerin significantly enlarged the coronary artery diameter, and VRs of each coronary segment ranged from 7.54% to 22.26%. As compared with baseline coronary diameter, VRs of minor segments (16.91%) were significantly larger than those of major segments (11.35%), and the magnitude of VR correlated with the baseline coronary diameter ($r = -0.48$, $p < 0.001$). Coronary luminal attenuation significantly increased due to additional administration of contrast material after the use of nitroglycerin ($p < 0.01$), but no significant difference was noted in the image quality after the use of nitroglycerin.
Conclusion: Sublingual nitroglycerin significantly enlarged the coronary diameters, especially in peripheral small coronary arteries, and increased the evaluable number of coronary segments on coronary CTA.

Introduction

Coronary computed tomography angiography (CTA) has evolved into a reliable, noninvasive technique to detect or rule out significant coronary artery stenosis [1,2]. The current generation of multi-detector-row CT (MDCT) systems permits the cross-sectional and longitudinal imaging of the coronary arteries with a high spatial and temporal resolution. However, small vessels and side branches and the distal portions of the main coronary arteries are not always optimally visualized [3,4]. Before coronary CTA, sublingual nitroglycerin is usually used to dilate the coronary vessels. The investigators of several studies on coronary CTA using MDCT reported that the use of nitroglycerin is now a widely accepted practice to dilate the coronary

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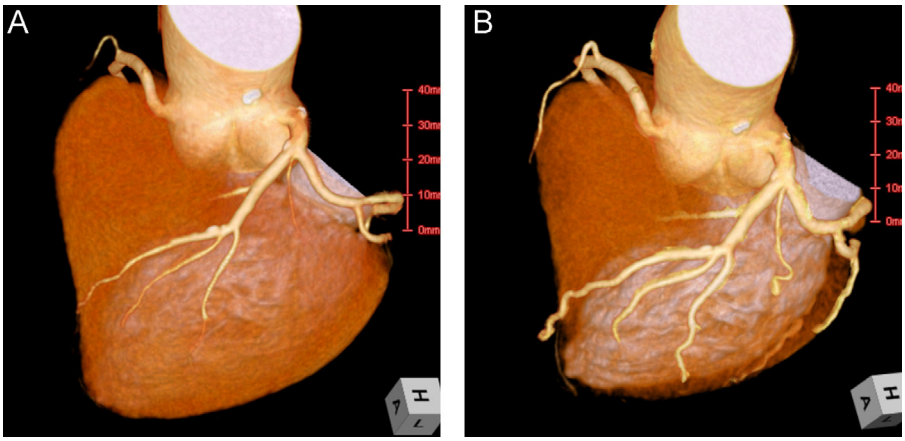

Fig. 1. Volume rendering coronary computed tomography angiography (CTA) images before and after the use of nitroglycerin. Coronary CTA images before (A) and after (B) the administration of sublingual nitroglycerin showing the more dilated septal, diagonal, high lateral, and right ventricular branches following the nitroglycerin administration.

lumen in different patient groups [5–7] as invasive X-ray coronary angiography [8], intravascular ultrasound [9], or magnetic resonance angiography [10]. Impaired coronary vasodilation in response to nitroglycerin, an endothelium-independent vasodilator, has been found in patients who have coronary risk factors [11] and has also been associated with an increased risk of future cardiac events [12].

In this study, the effects of sublingual administration of nitroglycerin on coronary CTA were evaluated in the same patients using 64-slice dual-source CT (DSCT) without heart rate control (Fig. 1). The coronary diameter and mean attenuation were measured in the same coronary segments before and after the administration of nitroglycerin. Vasodilation ratios (VRs) were calculated and compared with the baseline cross-sectional coronary diameters. The image quality of coronary CTA was also evaluated by two readers before and after the administration of sublingual nitroglycerin.

Materials and methods

Between August 2010 and November 2011, fifty-two patients (15 males and 37 females, mean age: 65.9 ± 9.6 years, age range: 36–77 years, mean body weight: 56.3 ± 9.3 kg, body mass index: 23.0 ± 3.4 kg/m^2) suspected to have atypical chest pain were prospectively included in this study (Table 1) and underwent electrocardiogram (ECG)-gated coronary CTA before and after the use of nitroglycerin (twice in the same examination) using 64-slice DSCT (Somatom Definition, Siemens Healthcare, Forchheim, Germany).

Table 1
The patients' characteristics.

	Mean	SD	Range
Age (years)	65.9	9.6	36–77
Gender (percentage of male)	28.9	45.8	Male = 15, female = 37
Body weight (kg)	56.3	9.3	41–78
BMI (kg/m^2)	23	3.4	14.7–33.8
Creatine (mg/dl)	0.7	0.16	0.44–1.05
BUN (mg/dl)	16.84	18.05	7–22.5
eGFR (ml/min/1.73 m^2)	73.3	16	45.5–119.5
Diastolic BP before CTA (mmHg)	78	11.6	45–108
Systolic BP before CTA (mmHg)	152.4	22.9	115–209
Diastolic BP after CTA (mmHg)	70.9	10.3	51–94
Systolic BP after CTA (mmHg)	136.4	17	112–172

The normal range of creatine (0.64–1.12 mg/dl [male], 0.48–0.81 mg/dl [female]).
BUN, blood urea nitrogen (normal range: 8–23 mg/dl); eGFR, estimated glomerular filtration rate; SD, standard deviation; BP, blood pressure; CTA, computed tomography angiography; BMI, body mass index.

To reduce the radiation exposure, unenhanced CT was omitted. However, two scans of coronary CTA even under wide ECG-dependent dose modulation (25–85%) in the same examination might lead to increased radiation exposure. Wide ECG-dependent dose modulation was applied, because there was a possibility that the optimal reconstruction windows might shift from diastolic to systolic phase as HR increased without HR control. The local institutional review board approved this study, and written informed consent was obtained from each patient. This study aimed to evaluate the difference of coronary vasodilation in the patients with atypical chest pain and as a baseline study, the coronary vasodilation was compared with its diameter in detail. The patients suspected to have typical effort angina or with a previous history of percutaneous coronary intervention or coronary artery bypass graft surgery were excluded from the study.

Scan protocol

Vasoactive medications were discontinued 24 h before the examination. An unenhanced calcium scoring scan was omitted to reduce the radiation exposure. Coronary CTA before the use of nitroglycerin was performed by using a 64-slice DSCT scanner and the scan volume was determined from the tracheal bifurcation to the base of the heart with the ECG-dependent dose modulation from 25% to 85% of the RR interval. One minute after the coronary CTA scan without nitroglycerin, nitroglycerin was sublingually atomized using a nitroglycerin pump spray (one push of 0.3 mg of atomized nitroglycerin; Myocorspray, Astellas, Tokyo, Japan). Four minutes after the administration of nitroglycerin, coronary CTA scan with nitroglycerin started at the same time after the injection of contrast material. The interval of coronary CTA before and after the administration of nitroglycerin was about 5 min. The parameters of coronary CTA were the same and as follows: number of X-ray tubes, 2; collimation, 32 detector rows of 0.6 mm each, with double sampling by using rapid alteration of the focal spot in the longitudinal direction (z flying focal spot); rotation time, 330 ms; tube voltage, 120 kV; and full tube current, 625 mA (independent of the patient size). Prior to scanning, the pitch was set automatically by the scanner software program.

A bolus of iodinated contrast material (300 mgI/ml, Ominipaque; Daiich-Sankyo, Tokyo, Japan), which varied between 40 ml and 70 ml, depending on the expected scan time × flow rate, was injected at a flow rate of 0.07 (ml/s/kg) × body weight (kg), in the right antecubital vein, followed by a saline chaser (30 ml; same flow rate as the contrast material). The region of interest (ROI) was placed at the ascending aorta and the bolus-tracking technique based on real-time monitoring of the main bolus during injection