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Difference between Proximal and Distal Right Coronary Flow Velocity Pattern in Humans

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ABSTRACT

The purpose of this study is to clarify the difference between proximal and distal right coronary artery flow velocity pattern in humans. Each portion of the coronary artery in thirteen patients with chest pain syndrome was measured by means of Doppler guide wire. The systolic / diastolic peak velocity ratio and velocity integral ratio at the proximal portion of the right coronary artery were significantly higher than those at distal portion of the right coronary artery (0.97 ± 0.27, 0.61 ± 0.20, 0.66 ± 0.19, 0.44 ± 0.13, respectively). In the right ventricular branch, coronary flow velocity pattern showed systolic dominancy. Systolic / diastolic peak velocity ratio and integral ratio showed 1.69 ± 0.62 and 1.00 ± 0.62 in the right ventricular branch, respectively. It is speculated that the less marked diastolic predominant pattern in the proximal right coronary artery flow velocity may be due to the fact that the proximal right coronary artery supplies both the right and left ventricle but that the distal right coronary artery supplies only the left ventricular inferior wall.

Key words*: Doppler guidewire, Coronary flow, Coronary artery*

Coronary stenosis, coronary flow reserve, or coronary collateral flow have recently been assessed by Doppler guide wire[3-10]. However, the characteristics of each coronary artery flow pattern have not yet been fully clarified in humans. Experimentally, it has been found that the right coronary artery flow pattern in dogs is different from the left one[2]. The right coronary artery of dogs supplies only the right ventricle, while the human right coronary artery usually supplies not only the right ventricle but also the left ventricle. Therefore, there is a possibility that human coronary flow pattern is different from dog coronary flow pattern. Moreover, the difference between proximal and distal coronary artery flow velocity pattern has not been fully elucidated, because distal coronary flow could not be measured by Doppler catheter or electromagnetic flowmeter which is the conventional method for determining coronary flow. The purpose of this study is to examine the difference between proximal and distal coronary artery flow velocity pattern in the right coronary artery.

METHODS

Patients

The study population consisted of 13 patients (5 men and 8 women) who underwent coronary angiography for the evaluation of chest pain and had no significant coronary artery stenosis (less than 25 %). The age of patients ranged from 50 to 81 years (mean 67.8). In all patients, every distal portion of the right coronary artery (#3 or #4 in AHA classification) and proximal portion of the right coronary artery (#1 in AHA classification) could be measured (Fig. 1). No patients were receiving drugs and all showed normal chest X-ray, ECG, and echocardiograms. All patients gave written informed consent, and the study protocol was approved by the Human Studies Committee of Hiroshima Prefectural Hiroshima Hospital.

Doppler guide wire

All flow velocity measurements were performed with Doppler guide wire (Cardiometrics, Inc. CA). This guide wire is constructed of a 175-cm long, 0.018-in. (0.046-cm) flexible, steerable, "floppy" guide wire with a 0.016-in. (0.041-cm), 12-MHz piezoelectric transducer mounted on its tip. The

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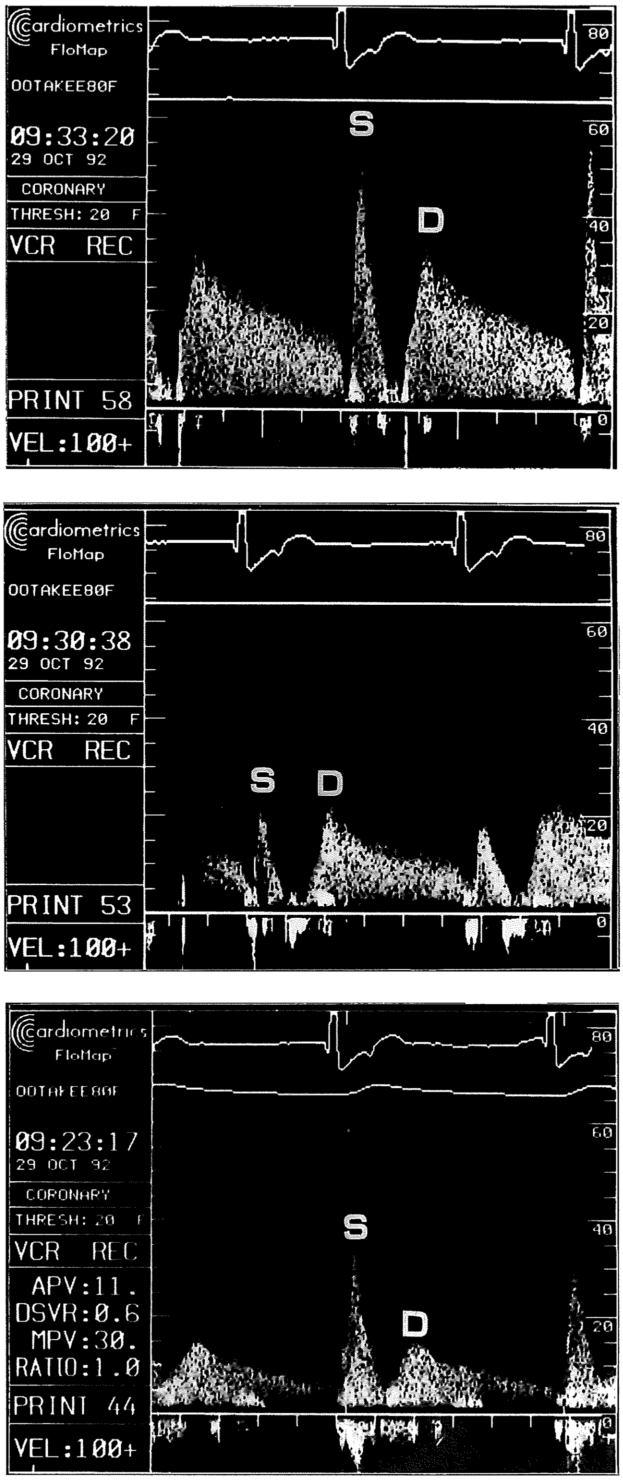

Fig. 1. Typical data recording.
Upper panel: Doppler flow velocity tracing at the proximal portion of the right coronary artery.
Middle panel: Doppler flow velocity tracing in the right ventricular branch.
Lower panel: Doppler flow velocity tracing at the distal portion of the right coronary artery.

transducer produces a relatively broad beam (20° divergence angle) ultrasound signal, with an estimated sample volume size of 2.25 mm (diameter) at a range depth of 5 mm.

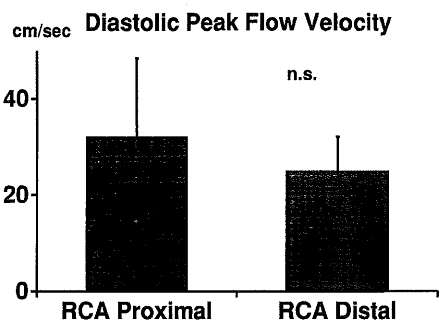

Fig. 2–1. Comparison of mean peak diastolic coronary flow velocity between proximal and distal portion of the right coronary artery.

Coronary artery flow velocity measurements

After routine quantitative coronary angiography was completed, all patients received 5,000 U of intravenous heparin. A Doppler guide wire was inserted into the right and left coronary arteries via 6F Judkins coronary angiography catheter with a small side hole.

Coronary flow velocity analysis

Doppler velocity spectra were analyzed off-line by a customized computer program and computer bit pad with manual tracing of video prints to determine spectral diastolic peak velocity, spectral systolic peak velocity, diastolic peak velocity integral (area under the peak velocity curve from the aortic dicrotic notch to the systolic aortic upstroke), and systolic peak velocity integral (area under the peak velocity curve from the systolic aortic upstroke to the aortic dicrotic notch). Systolic / diastolic peak velocity ratio and systolic / diastolic peak velocity integral ratio were also calculated.

Statistical analysis

All parameters were compared by using Wilcoxon signed-rank test. Statistical significance was defined as $p < 0.05$. All data were expressed as mean value ± SD.

RESULTS

(1) Peak diastolic flow velocity was 31.9 ± 16.6 in the proximal right coronary artery and 24.8 ± 7.3 cm/sec in the distal right coronary artery (Fig. 2–1). Peak systolic flow velocities in the proximal right coronary artery were significantly higher than those in the distal right coronary artery (29.1 ± 12.4, 16.2 ± 5.8 cm/sec, respectively, $p<0.002$) (Fig. 2–2). Systolic / diastolic peak flow velocity ratio in the proximal right coronary artery was significantly higher than those in the proximal right coronary artery ($p<0.002$). Systolic

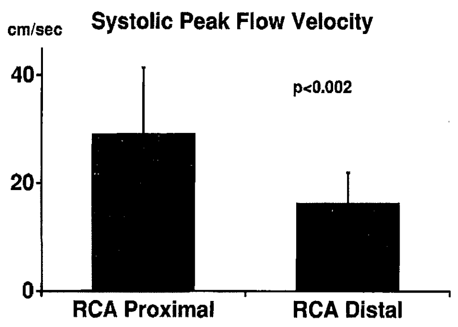

Fig. 2–2. Comparison of mean peak systolic coronary flow velocity.

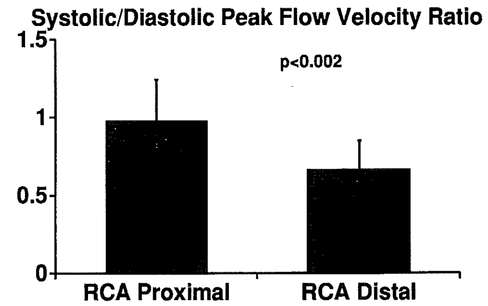

Fig. 2–3. Comparison of mean peak diastolic / systolic coronary flow velocity ratio in each coronary segment.

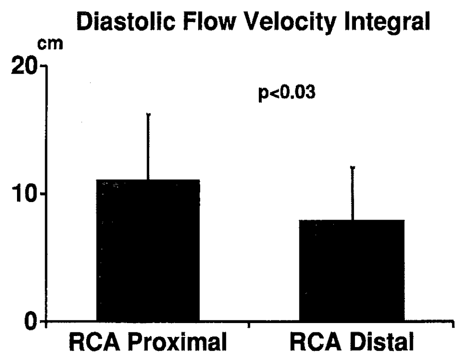

Fig. 3–1. Comparison of mean diastolic coronary flow velocity integral in each coronary segment.

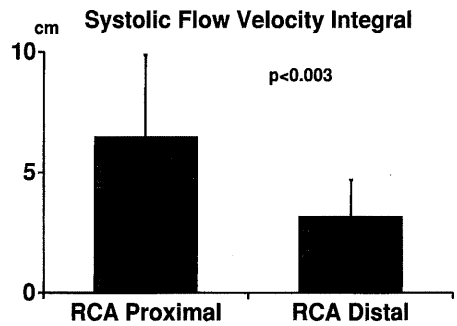

Fig. 3–2. Comparison of mean systolic coronary flow velocity integral in each coronary segment.

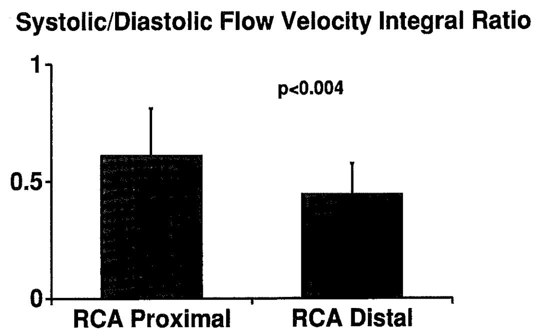

Fig. 3–3. Comparison of mean systolic / diastolic coronary flow velocity integral ratio in each coronary segment.

/ diastolic peak flow velocity ratio was 0.97 ± 0.27 in the proximal right coronary artery and 0.66 ± 0.19 in the distal right coronary artery, respectively (Fig. 2–3).

(2) Diastolic and systolic flow velocity integral in the proximal right coronary artery was significantly higher than those in the distal right coronary artery ($p<0.05$, $p<0.003$, respectively). Diastolic flow velocity integral was 11.0 ± 5.2 in the proximal right coronary artery and 7.8 ± 4.2 cm in the distal right coronary artery (Fig. 3–1). Systolic flow velocity integral was 6.5 ± 3.4 in the proximal right coronary artery, 3.1 ± 1.6 cm in the distal right coronary artery (Fig. 3–2). Systolic / diastolic flow velocity integral ratio was significantly higher than those in the distal right coronary artery ($p<0.004$). Systolic / diastolic flow velocity integral ratio was 0.61 ± 0.20 in the proximal right coronary artery and 0.44 ± 0.13 in the distal right coronary artery (Fig. 3–3).

(3) Right ventricular branch flow could be measured in 4 of the 13 patients. In the right ventricular branch, coronary flow velocity pattern showed systolic dominancy. Systolic / diastolic peak velocity ratio and integral ratio was 1.69 ± 0.62 and 1.00 ± 0.62 in the right ventricular branch, respectively (Fig. 1).

DISCUSSION

Until recently, coronary flow velocities in conscious humans have been measured by Doppler catheters. However, it has been difficult to measure flow velocity of the proximal and middle coronary artery, because Doppler catheter size is 3F in diameter. In closed-chest humans, coronary flow velocity has been measured by a transesophageal route, but these measurements have been limited to the very proximal coronary arteries. Moreover, in some patients it is very difficult to measure coronary flow velocity by the transesophageal route. A recent technological advance using a coronary Doppler flow guide wire has allowed measurement of even very distal coronary arterial blood flow velocity with relative ease and safety[1]. The coronary flow vasodilator reserve[8,10], changes of the coronary flow before and after coronary interventions[4], and quantitation of coronary artery stenosis[5] have been studied by using a coronary flow guide wire. However, the difference between distal and proximal coronary flow velocity in normal humans was still unknown. There are relatively few experimental studies on distal coronary arterial blood flow velocity. Hiramatsu et al reported that systolic / diastolic peak flow velocity ratio in the proximal right coronary artery of dogs was greater than that in the distal right coronary artery by using a optical fiber sensor of a laser Doppler velocimeter[2]. In the present study in humans, systolic / diastolic peak flow velocity ratio and velocity integral ratio in the proximal right coronary artery was found to be significantly higher than in the distal right coronary artery. Ofili et al reported that the right coronary artery showed significantly less diastolic predominance and this less diastolic predominance was similar both in the proximal and distal right coronary artery. This discrepancy between Ofili et al's and our results about proximal and distal right coronary flow pattern seem to depend upon the fact that Ofili et al' s data were obtained from different patients in the each coronary segment[7]. This less marked diastolic predominant pattern in proximal right coronary artery flow velocity may be due to that the proximal right coronary artery supplies mainly to both the right and left ventricle but the distal right coronary artery to the inferior wall of the left ventricle and a relatively unimpeded right coronary systolic flow as a result of the lower right ventricular contractile force, compared with the left ventricle. In the present study, the peak velocity in right ventricular branch was greater in systole than in diastole. This coronary flow pattern in the right ventricular branch is dependent upon the right ventricular branch feeding only the right ventricle. We studied the flow pattern of the proximal right coronary artery in relation to the dominancy of the right and the left coronary artery. However, we could not find a close relation between flow pattern and dominancy of the right and left coronary artery (Data not shown). In the present study, the number of patients was small. Further investigation is necessary to evaluate the coronary flow pattern of the right coronary artery that feeds only the right ventricle, for example in the right coronary artery of the patients with the super left dominant coronary artery.

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