The Non-Hyperemic Coronary Pressure Notch as an Indicator of the Physiologic Significance of Coronary Artery Stenosis

Mohammad Hasan Namazi[1], Morteza Safi[1], Hosein Vakili[1], Habibollah Saadat[1], Saeed Alipour[1], Abdulkarim Alhuthaifi[2], Shamseddin Pedari[2], and Mohammad Amin Abbasi[3]

[1] *Department of Cardiology, Cardiovascular Research center, Shahid Beheshti Univercity of Medical Sciences, Tehran, Iran*

[2] *Department of Cardiology, School of Medicine, Shahid Beheshti University of Medical Sciences, Tehran, Iran*

[3] *Department of Internal Medicine, School of Medicine, Shahid Beheshti University of Medical Sciences, Tehran, Iran*

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Abstract- Myocardial fractional flow reserve (FFR) is a new index of the functional significance of intermediate coronary stenoses that is calculated from pressure measurements made during coronary arteriography. The aim of this study was to evaluate the correlation between non-hyperemic coronary pressure dicrotic notch and fractional flow reserve (FFR). A consecutive of 114 patients (73 men and 41 women) was enrolled in this study. Data were shown as means ± SD. Statistical analyses were performed with SPSS software. The statistical significance of differences was determined by chi-square analysis with Yates correction. Significance was defined as $P < 0.05$. Positive dicrortic notch was observed in 97 patients (85%). Significant association was detected between coronary pressure notch (dicrotic notch), and FFR as loss of the dicrotic notch was detected in 93.8% (15/16) of patients with FFR less than 0.75 (P=0.001). Upon ROC curve, a cutoff FFR value of approximately 0.75 demonstrated sensivity and specifity of 93.8% and 98%, respectively for loss of the dicrotic notch. The positive predictive value for loss of the dicrotic notch was 88.2%. Our study demonstrated loss of non-hyperemic coronary pressure diacrotic notch correlates significantly with FFR and may predict an FFR < 0.75 with high accuracy. In patients with functionally significant coronary stenosis, loss of non-hyperemic diacrotic notch appears to be a useful index of the functional severity of the stenoses and the need for coronary revascularization.

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Introduction

Functional significance of coronary artery stenosis is the most important factor in patients with coronary artery disease (CAD). Although coronary angiography is the gold standard for evaluating CAD but its limitation in assessing functional severity of arterial stenosis is now well understood. Recently myocardial fractional flow reserve (FFR), is an index of epicardial coronary artery stenosis on maximal myocardial perfusion. FFR shows the correlation between myocardial ischemia and coronary lesion is used to better analyze the functional severity of the coronary lesion (1-4). Despite remarkable benefits of FFR in improving PCI treatment outcomes and decreasing the costs, the use of FFR in the interventional community at large is less than 10% (5).

One of the barriers to FFR adoption is the cumbersome requirement of adenosine with complaints about dose, route of administration, femoral venous access, and achievement of maximal hyperemia (5).

Dicrotic notch - obtained by analysis of the arterial pressure waveform- is another modality that seems to be highly associated with stenosis severity. Recently there are some studies showing that attenuation of the high-frequency components of the pulse waveform can be an indicator of the existence of significant stenosis leading to a significant ischemia (6,7). The aim of this study is to assess the relation between non-hyperemic coronary pressure notch (dicrotic notch) distal to the coronary stenosis and FFR to find out any probable correlation.

Corresponding Author: A. Alhuthaifi
Department of Cardiology, School of Medicine, Shahid Beheshti University of Medical Sciences, Tehran, Iran
Tel: +98 912 1140287, Fax: +98 21 42910703, E-mail address: kareem_1400@yahoo.com

Materials and Methods

Study patients

A consecutive of 114 patients (73 men and 41 women) was enrolled in this study. To be eligible for the study, each patient was required to have chest pain; an angiographically detectable stenosis of moderate severity (40-70%) in the coronary artery; and uncertainty about whether the chest pain was related to reversible ischemia caused by the moderate stenosis. The patients were referred for cardiac catheterization for a variety of indications that included patients with stable angina, remote myocardial infarction and asymptomatic patients with positive non-invasive stress testing. FFR measurements were made in all coronary artery locations, including lesions in the left main artery, lesions of in-stent restenosis. Patients with acute MI (less than 2 days) were excluded. This study was approved by the Ethics Committee of Shahid Beheshti University of Medical Sciences. Informed consent was obtained from all patients.

Coronary pressure measurements were performed with a 0.014 pressure guide wire (Volcano Therapeutics, Rancho Cordoba, Calif.) through 6 Fr coronary catheters as previously described.1 Heparin (40 units/kg IV) was given before guide wire insertion. In brief, the sensor guide wire is advanced to the coronary ostium, and the pressure signals of the guide wire and guide catheter are matched. The guide wire is then advanced distally beyond the coronary stenosis. Phasic and mean aortic (Pa) and distal coronary (Pd) pressure tracings are recorded for 10 seconds prior to the administration of intracoronary adenosine (18 or 24 mg in the RCA and 24-40 mg in the LCA) to induce maximal hyperemia. Simultaneous Pa and Pd were continuously recorded. FFR was calculated as the ratio of Pd/Pa during maximal hyperemia. FFR measurements were performed in duplicate. A coronary pressure notch was present if there was a distinct incisura, a horizontal line or well-defined change in the descent of the distal coronary pressure curve.

Statistical analysis

Data were shown as means ± SD. Statistical analyses were performed with SPSS software for Windows (Statistical Product and Service Solutions, version 15.0, SSPS Inc, Chicago, IL, USA) was used for statistical analysis. Comparisons between groups were made using the Student's *t*-test for continuous variables. The statistical significance of differences between proportions was determined by Fisher's exact or chi-square analysis with Yates correction.

For the physiologic lesion analysis, the minimum obtained FFR value (maximum hyperemia were used. Simple linear regression analysis was used to calculate Pearson's correlation coefficients between quantitative values. The best-fitted cutoff PTC value for predicting FFR<0.75 was determined by a receiver operating characteristic (ROC) curve analysis. Values were defined as significant when the values for P were defined as $P< 0.05$.

Results

A total of 114 patients (41 female and 73 male) were enrolled in this analytical cross-sectional study. Mean ± SD age of patients was 60.1 ± 10.7 years old (range 35–83).

Table 1. Basic characteristics of the participants

Basic characteristics		N (%)
Gender	**Male**	73(82)
	Female	41 (18)
Age (mean±SD)		60.1 ±10.7
Coronary artery	**LAD**	62(52.4)
	LCX	20 (17.5)
	LM	3(2.6)
	RCA	22(24)
	Diagonal	6(5.3)
Clinical presentation	**Stable angina**	75 (65.9)
	Unstable ungina	26 (22.8)
	MI	6 (5.3)
Risk factors for IHD	**Hypertension**	70 (61.4)
	Diabetes mellitus	35 (30.7)
	Hyperlipidemia	44 (38.6)
	Smoker	32 (28.1)
	Previous MI	21(18)
	Previous CABG	3 (2.6)
	Previous PCI	29 (25)
Dicrotic notch	**Presence**	97 (85)
	Loss	17 (15)
FFR	**Positive (FFR ≤ 0.75)**	16 (14)
	Negative (FFR > 0.75)	98 (86)

Demographic characteristics and patients clinical features were shown in table 1. Positive dicrortic notch was observed in 97 patients (85%). Our data revealed no association between gender and dicrotic notch (P>0.05). The FFR was 0.75 or higher in 98 patients, and in these patients, no revascularization procedure was performed. The FFR less than 0.75 was reported in 16 patients (14%). As shown in table 2, a significant association was detected between coronary pressure notch (dicrotic

notch) and FFR as loss of dicrotic notch was detected in 93.8% (15/16) of patients with FFR less than 0.75 (*P*=0.001).

Table 2. Age and angiogapphic parameters between two FFR groups

	FFR > 0.75 (n=98)	FFR≤ 0.75 (n=16)	*P*. value
Lesion Lenght	1.53 ± 0.50	1.87 ± 0.34	0.001
Vessel diameter	1.57 ± 0.49	1.5 ± 0.51	0.57
Dicrotic notch presence	96(98%)	15 (93.8%)	0.001
Loss	2 (2%)	1(6.2%)	
Age (mean±SD)	60.3 ± 10.5	58 ± 12.1	0.37

Angiographic data showed there was no difference in vessel diameter between the patients with an FFR below 0.75 and those with higher values (*P*>0.5). Lesion length was statistically different between groups with FFR more and less than 0.75, respectively (*P*<0.001). Upon ROC curve, a cutoff FFR value of approximately 0.75 demonstrated sensitivity and specificity of 93.8% and 98%, respectively for loss of the dicrotic notch. Low FFR indexes with a positive predictive value of 88.2%.

Discussion

In our study, we showed a significant correlation between loss of non-hyperemic coronary dicrotic pressure notch and FFR<0.75. Thus, a non-hyperemic parameter may serve as an adjunct parameter for the assessment of the physiologic significance of CAD. Because of the limitations of coronary angiography, in-lab physiological lesion assessment of indeterminate lesions is may be necessary. In many instances noninvasive stress testing may be negative, inconclusive or not performed prior to coronary angiography and the decision to proceed with coronary revascularization is not clear based on angiography above. FFR is a reliable index of the functional severity of coronary stenosis with a cutoff value of 0.75 and small zone of uncertainty (< 0.05 units) (5,7). However, although FFR is straight forward and well validated, some operators may be reluctant to employ adenosine to induce hypertension because of the time and cost (5,7).

The loss of the arterial pressure notch in the coronary artery was similar to peripheral arteries. An early study compared the loss of the peripheral arterial dicrotic notch to coronary artery disease (11,12). Patients without a peripheral arterial dichrotic notch were more likely to have angiographic and clinically significant coronary artery disease. The presence of a pressure notch in both the coronary and peripheral arteries suggested minimal disease with adequate pressure waveform transmission. In patients with mild lower extremity ischemia, the dicrotic notch was less than prominent than patients with no disease (12). Patients with severe ischemia had a dicrotic notch that was not visible in the distal arterial pressure waveforms.

Visual inspection of the pressure waveform provides a gross estimation of the preservation of the high-frequency components distal to a stenosis and may also serve as a non-hyperemic marker of lesion significance (7).

Our study demonstrated loss of diacrotic notch correlates significantly with FFR and may predict an FFR<0.75 with high accuracy. In patients with significant coronary stenosis, loss of diacrotic notch appears to be a useful index of the functional severity of the stenosis and the need for coronary revascularization.

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