

심근 분획 혈류 예비력과 혈관내초음파를 이용한 관상동맥 협착정도의 비교

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Fractional Flow Reserve in Coronary Artery Disease : Comparison with Intravascular Ultrasound

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ABSTRACT

Background and Objective : Precise assessment of lesion severity is fundamental for the clinical decision making in the patients with coronary artery disease. Coronary angiography has limitation to projection imaging techniques. Intravascular ultrasound (IVUS) has been known to be a gold standard of morphological severity of coronary stenosis. Fractional flow reserve (FFR) is known to be a lesion specific functional index of epicardial stenosis that can be derived from intracoronary pressure assessed during maximal vasodilation. The objective of this study was to investigate the validity of fractional flow reserve for stenosis severity in comparison with IVUS. **Methods :** The study population consisted of 24 patients with angina pectoris (M : F = 19 : 5, age : 58 ± 12 yrs). The IVUS and intracoronary pressure wire performed at 26 lesions after diagnostic coronary angiography. We measured angiographical diameter stenosis (DST), minimal luminal diameter (MLD), minimal luminal area (MLA) and reference area stenosis (r-AST). FFR was defined by the ratio of distal mean coronary pressure (Pd) to aortic mean pressure (Pa). **Results :** FFR showed significant correlation with both r-AST ($r = -0.93$, $p < 0.00001$) than DST ($r = -0.79$, $p < 0.0001$). When the lesions with MLD less than 1.1 mm were excluded, considering the limitation of IVUS for the thickness of its catheter, FFR showed excellent correlation with r-AST with higher correlation coefficient ($r = -0.96$, $p < 0.00001$). FFR showed significant correlation with MLA ($r = 0.87$, $p = 0.0001$) or MLD ($r = 0.83$, $p = 0.0005$). **Conclusion :** FFR with excellent correlation with r-AST measured by IVUS seems to be a useful lesion specific functional index for the assessment of coronary stenosis in angina patients. (**Korean Circulation J 1999;29(8):773-780**)

KEY WORDS : Fractional flow reserve (FFR) · Intravascular ultrasonography · Angina.

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서 론

가 (functional index)¹⁾²⁾ 가 (fractional flow reserve, FFR)³⁻⁷⁾ (lesion - specific functional index)⁸⁾ Pijls⁹⁾ SPECT FFR cutoff value 0.75 FFR (gold standard) FFR parameter, FFR 가 RLA) (minimal luminal diameter, MLD), (minimal luminal area, MLA)

재료 및 방법

대상환자 1997 10 1998 10 (wall motion abnormalities) 가 CK - MB 가가 24 26 관동맥조영 검사 Seldinger Judkins Targano projector (reference artery diameter) (minimal luminal diameter, MLD) (percent diameter stenosis,

DST)

혈관내초음파 검사

(30 MHz, 3.5 F, mon - orail type, Boston Scientific Co.) 0.014 inch

200 µg nitroglycerine motor - drive pull back system 0.5 mm S - VHS

Computer as - sisted planimetry 10 mm 가 Fig. 1 (reference luminal area, RLA) (minimal luminal diameter, MLD), (minimal luminal area, MLA)

(percent area stenosis, r - AST)

심근 분획 혈류예비력(Fractional flow reserve)의 측정 (0.014 inch fiberoptic pressure monitoring wire, Radi Medical System,

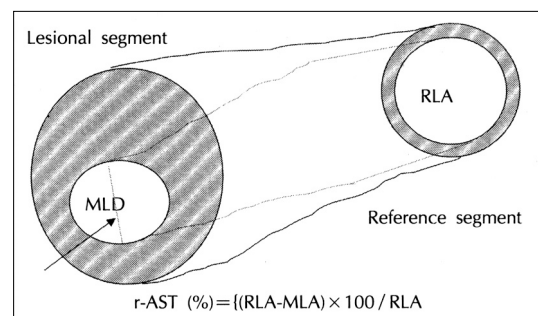


Fig. 1. Parameters of intravascular ultrasound. MLA : minimal luminal area (mm²), MLD : minimal luminal diameter (mm), RLA : reference luminal area (mm²), r - AST : reference area stenosis (%).

Table 1. Clinical characteristics of Patients

Age (yrs)	58 ± 12
Diagnosis	
Stable angina	6 (25%)
Unstable angina	18 (75%)
Risk factor	
DM	4 (17%)
Hypertension	18 (75%)
Smoking	14 (58%)
T.cholesterol (mg/dl)	193 ± 40
Triglyceride (mg/dl)	182 ± 90
HDL (mg/dl)	40 ± 9
Target lesion	
LAD	20 (78%)
LCX	2 (7%)
RCA	4 (15%)

DM : Diabetes mellitus

HDL : high-density lipoprotein cholesterol

LAD : left anterior descending artery

LCX : left circumflex artery

RCA : right coronary artery

Table 2. FFR, parameters of IVUS and angiography
mean ± SD

FFR	0.72 ± 0.14
DST (%)	70 ± 22
MLA (mm ²)	3.06 ± 2.34
MLD (mm)	1.67 ± 0.65
r-AST (%)	65 ± 25

FFR : fractional flow reserve, DST : diameter stenosis

MLA : minimal luminal area

LD : minimal luminal diameter

r-AST : reference area stenosis

Uppsala, Sweden)

adenosine 18~20 µg

(P_d)

(P_a)

(P_d / P_a) FFR

. FFR

FFR

통계적 처리

±

FFR

parameter

curvilinear(quadratic) regression analysis

p

0.01

결 과

대상 환자

19 : 5,

58 ± 12

6 ,

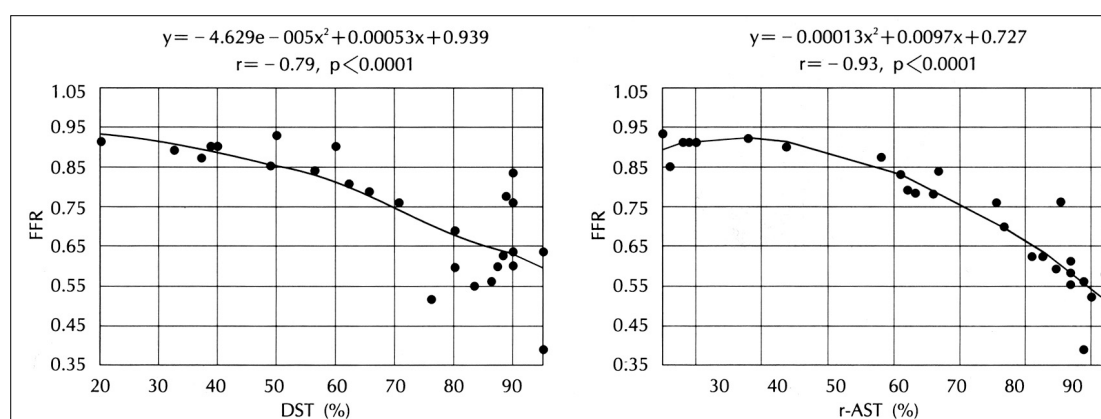


Fig. 2. Quadratic correlation of FFR with angiographical diameter stenosis (left) and reference area stenosis measured by IVUS (right). IVUS ; intravascular ultrasound, FFR : fractional flow reserve, DST : diameter stenosis, r-AST ; reference area stenosis.

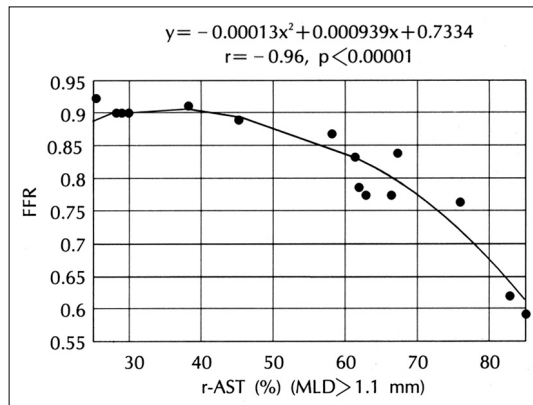


Fig. 3. Quadratic correlation between FFR and r-AST excluding the lesions with MLD > 1.1 mm. FFR : fractional flow reserve, r-AST : reference area stenosis, MLD : minimal luminal diameter.

관동맥조영 검사 및 혈관내초음파 검사와 심근 분획 혈류 예비력간의 비교

parameter

FFR Table 2

r - AST FFR
($r = -0.79$, $p < 0.0001$ vs $r = -0.93$, $p < 0.00001$)(Fig. 2).

1.1 mm

FFR r - AST

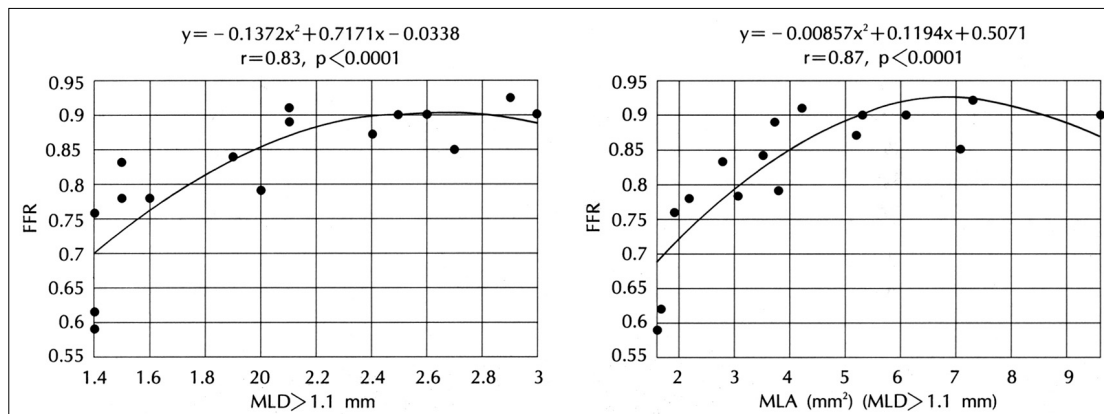


Fig. 4. Quadratic correlation of FFR with MLD and MLA excluding the lesions with MLD > 1.1 mm. FFR : fractional flow reserve, MLD : minimal luminal diameter, MLA : minimal luminal diameter.

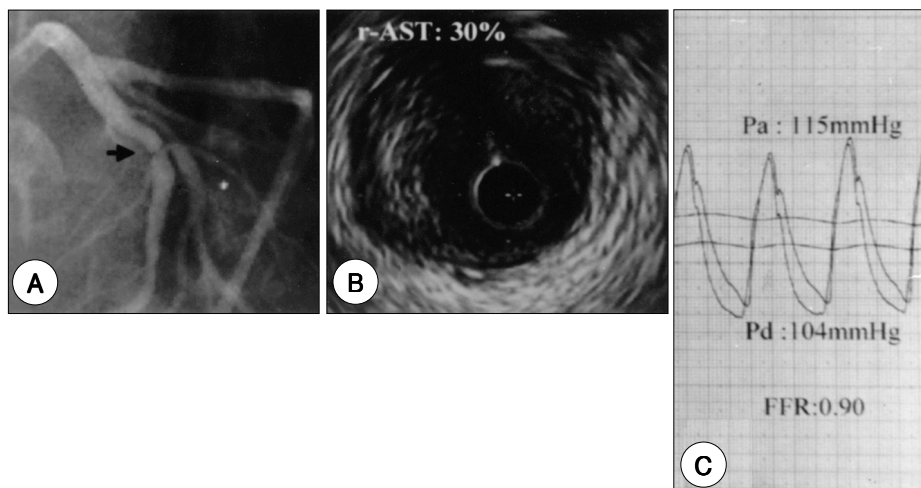


Fig. 5. Angiographical overestimation of coronary stenosis. A : The coronary angiography showed significant membrane like stenosis in mid-LAD (arrow). B : Intravascular ultrasonography of the lesion showed mild stenosis with r-AST of 30%. C : Pressure tracing revealed FFR of 0.83 compatible with r-AST.

($r = -0.96$, $p < 0.00001$) (Fig. 3)
 FFR ($r = 0.87$, $p = 0.0001$)
 ($r = 0.83$, $p = 0.0005$) (Fig. 4).

고 찰

가 가
 가 가
 10) 가 가
 가 가
 (QCA) vid -
 eodnsitometric analysis
 가 가 (projection imaging te -
 chnique)

가 11 - 13)
 clinical decision making
 가 가

가 가
 가 가
 가가 14 - 17)
 0.14 inch Doppler
 pressure wire가 가가 가
 18 - 20)
 Pijls²⁰⁾

FFR

$FFR_{myo} = \frac{\text{masimum myocardial flow in the presence of stenosis}}{\text{normal maximum flow}}$

$FFR_{myo} = \frac{Q}{Q_n} = \frac{(Pd - Pv)/R}{(Pa - Pv)/R}$ (if R is minimal and constant)

$FFR_{myo} = \frac{(Pd - Pv)}{(Pa - Pv)}$ (if Pv close to zero)

$FFR_{myo} = \frac{Pd}{Pa}$

FFR_{myo} : myocardial fractional flow reserve
 Q : maximum myocardial flow in the presence of stenosis
 Qn : normal maximum flow, Pa : mean aortic pressure at maximum hyperemia
 Pd : mean distal coronary pressure at maximum hyperemia
 Pv : mean venous pressure
 R : resistance of the myocardial vascular bed at maximum vasodilation
 (from Pijls et al. Circulation 1993 ; 87 : 1354 - 67)

FFR

가 21)

FFR 20)21)

8)
 20)21) FFR 1
 가

8)21) 23)
 (multivessel)
 (control artery) 24)

ischemia) 가 (reversible 가

cutoff 0.75 가 .⁸⁾²²⁾²⁵⁾ 가 가

²⁶⁾²⁷⁾ 가

. Bech²⁸⁾ FFR 0.7

가 5 100

(gold standard) 18 ± 13

, stent atherectomy (target coronary artery related event) 4

가³⁻⁷⁾

FFR 가 . Kaplan - Meier 84.7%

FFR (r = - 0.79, p<0.0001) FFR 0.75

r - AST (r = - 0.93, p<0.00001) 가 FFR

70

FFR , FFR

0.9 가 가 가

30% FFR (Fig. 5). 가 가

. FFR

ring -

downm phenomenon , syndom X

가²⁰⁾²⁴⁾²⁵⁾ FFR

가 .

1.1 mm

FFR r - AST

가 - 0.93 - 0.96

가

²⁹⁾ 가

FFR 3 parameter 1.1 mm

가 FFR

r - AST 가 FFR 0.75 r - AST

luminological

cutoff FFR 가

r - AST

(lesion - specific functional index)

1.1 mm

r - AST FFR
(r = - 0.95, p<0.0

요약

연구배경 및 목적 :

가

가

FFR

가

FFR

, FFR

parameter

재료 및 방법 :

24

 58 ± 12

26

20 ,

2 ,

4

, FFR

. FFR

adenosine

 (P_d)

(P_a)

$$(P_d / P_a) \quad \text{FFR}$$

결 과 :

1)

$\pm 22\%$,

 1.67 ± 0.65 mm, $3.06 \pm 2.$

34 mm²,

(reference

area stenosis, r - AST) $65 \pm 25\%$. FFR 0.72

 ± 0.14 .

2)

FR

001).

3)

001).

결론:

FFR

가

(les -

ion - specific functional index)

중심 단어 :

1998

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