

Quand et comment évaluer une revascularisation coronaire?

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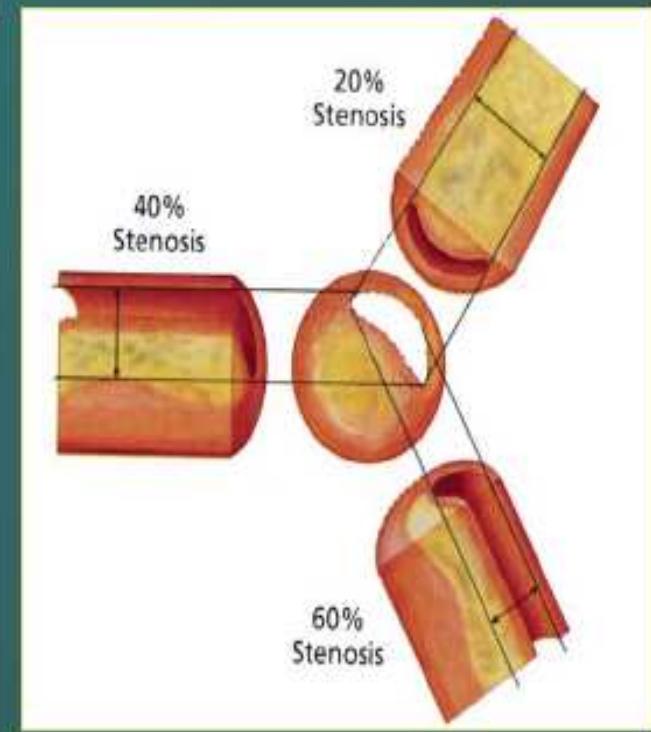
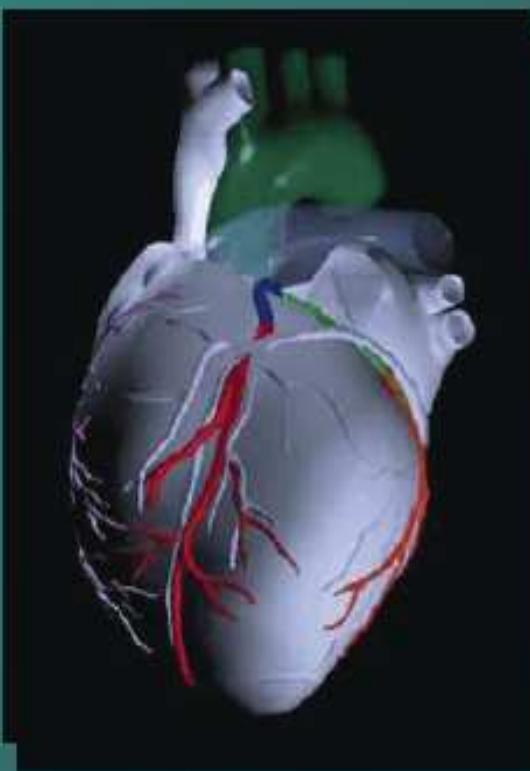
Aucune indication

Merci!

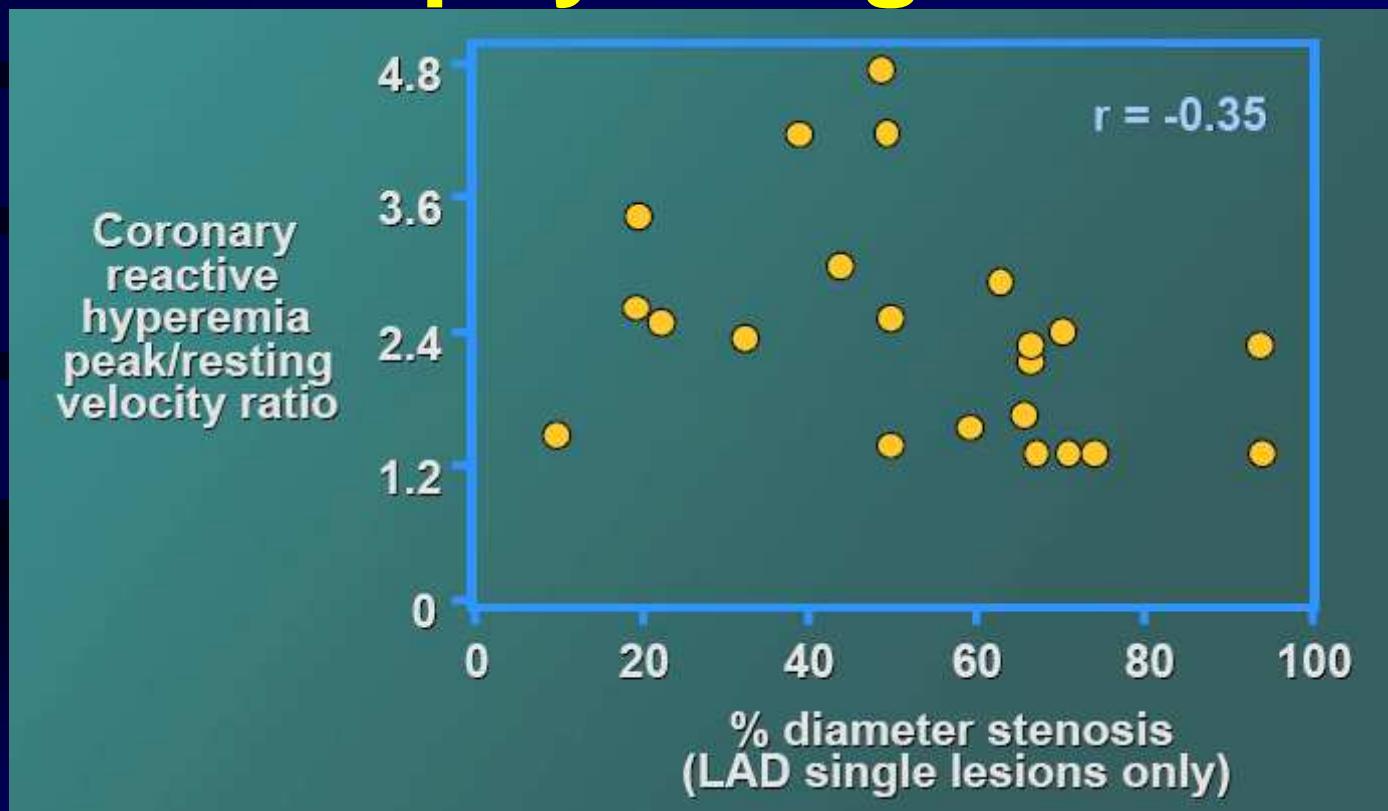
Comment évaluer la sévérité d'une sténose coronaire

- Quantitative Coronary Angiography +/-
- Doppler Flow (Vélocité): viabilité +++
- Mesure de la Pression +++
- IVUS +++

Limitations de l'angiographie: sous-estimation des lésions



Limitations de l'angiographie: faible corrélation avec la physiologie



White, CW et al., Does visual interpretation of arteriogram predict the physiological importance of a coronary stenosis, NEJM, 1984; 310: 819-24

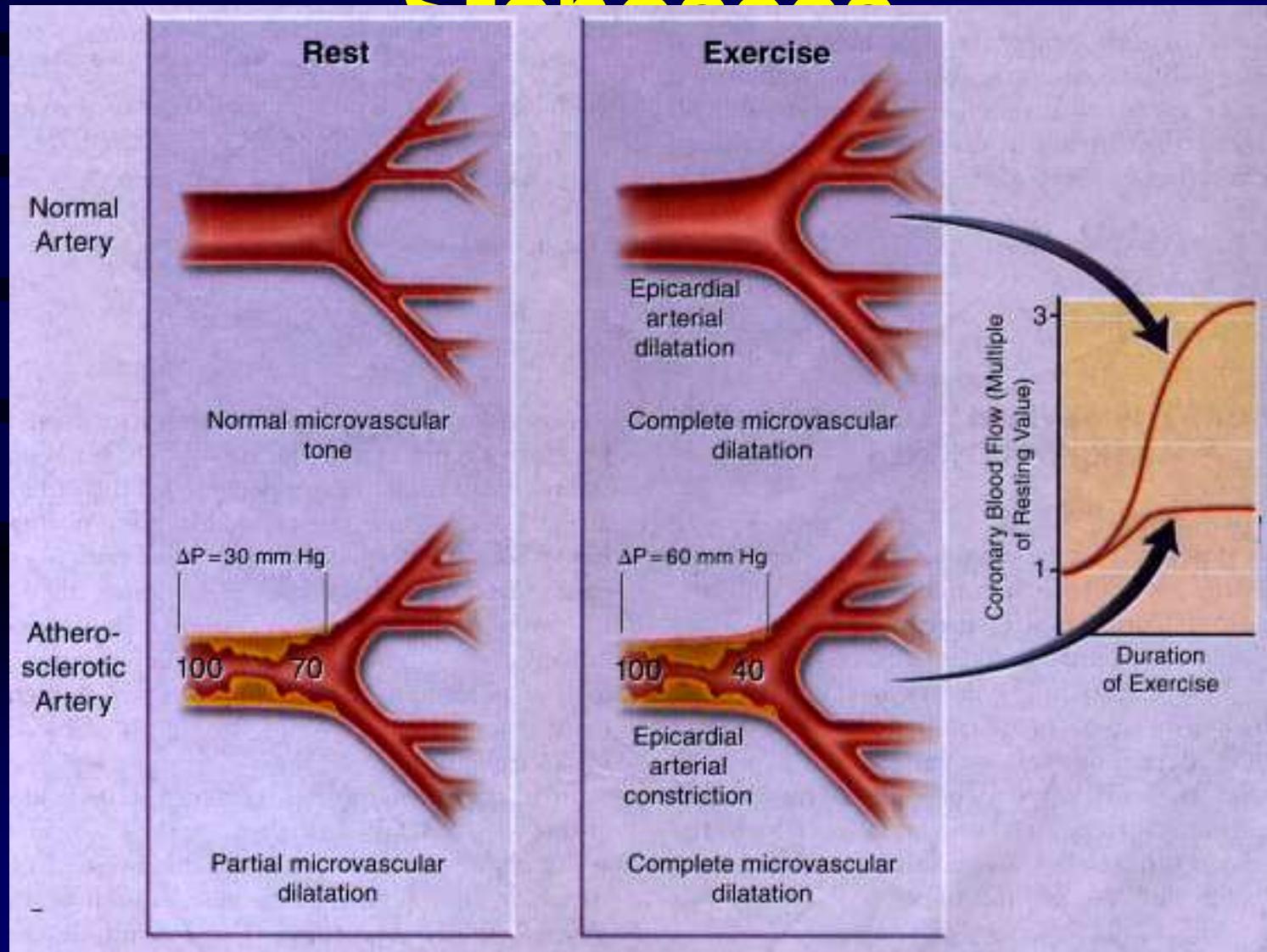
La Physiologie , Pourquoi ?

- Simplifier le déroulement des procédures
- Optimiser le choix des décisions cliniques et thérapeutiques
- Confirmer les stratégies thérapeutiques et les résultats

La Physiologie , Pourquoi ?

- Fournit des informations supplémentaires :
 - Avant , pendant et après l'intervention
 - Pour évaluer des lésions intermédiaires
 - Lorsque les patients n'ont pas effectué d'épreuve d'effort (?)
 - Test fonctionnel direct
 - Instruments faciles à utiliser

Régulation du Flux Sanguin dans les Artères Normales et Sténosées

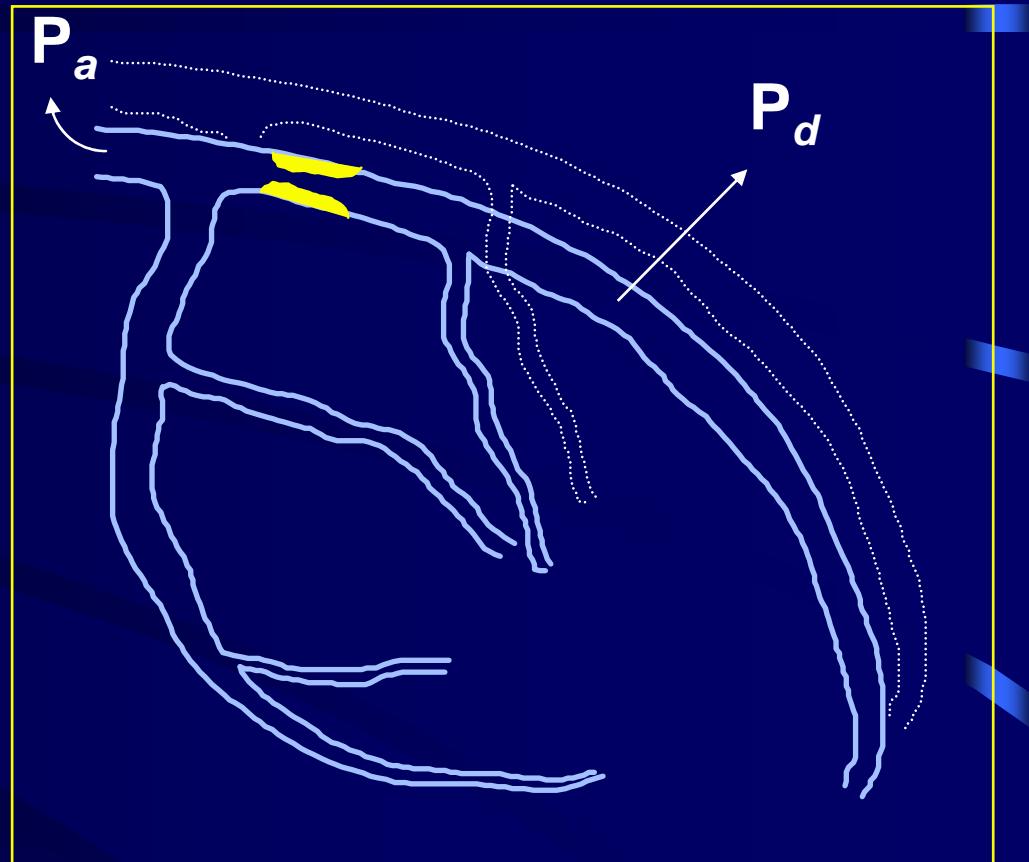


Qu'est ce que la FFR ?

Fractional Flow Reserve =

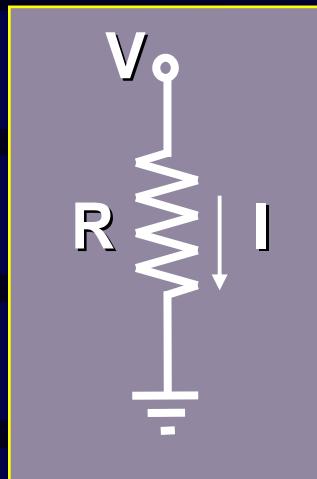
Rapport de la pression moyenne distale coronaire sur la pression aortique proximale moyenne en état d'hyperémie (vasodilatation)

Elle représente la fraction du flux sanguin préservée malgré la présence d'une sténose



$$FFR = P_d / P_a$$

Le concept de FFR



Loi d'Ohm

$$V = I \times R$$

Voltage = Intensité x Résistance



Equation hydraulique

$$\Delta P = Q \times R$$

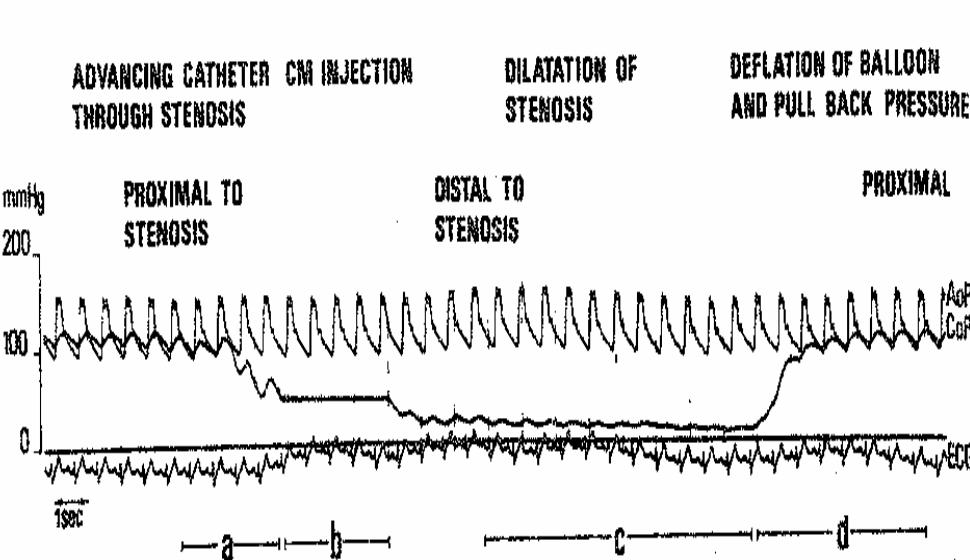
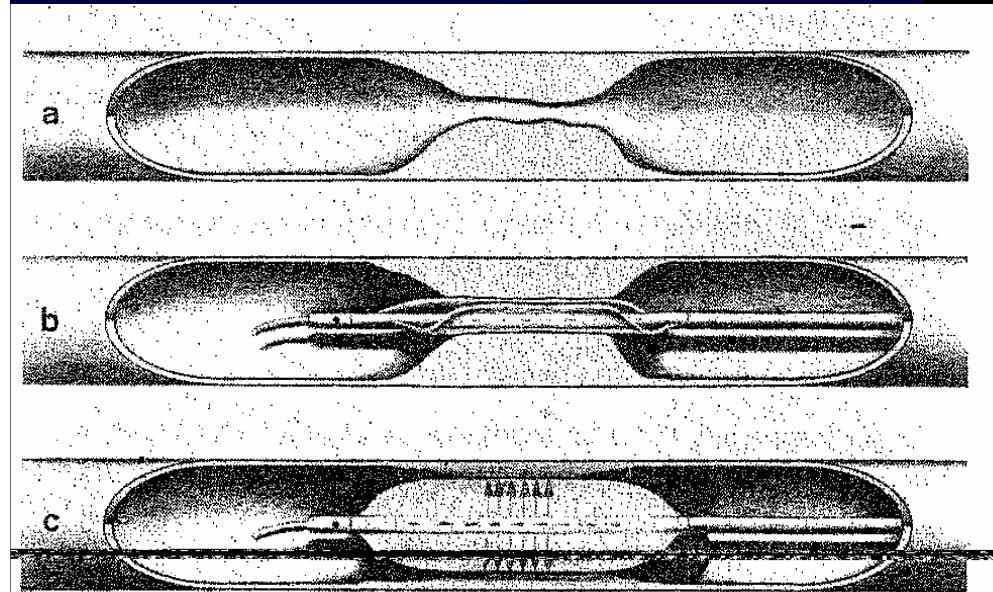
gradient
pression = flux sanguin x Résistance

La Pression , Pourquoi ?

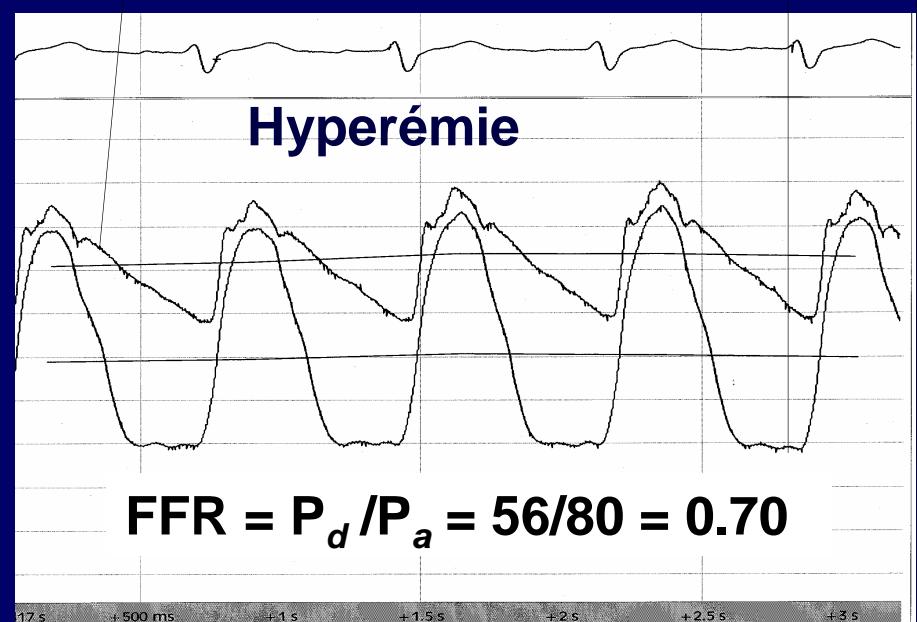
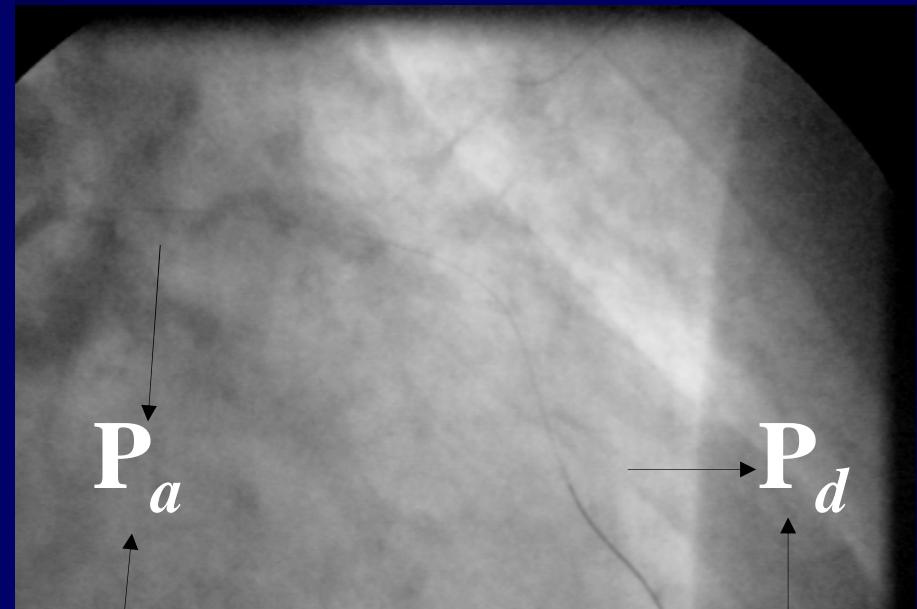
- Index lésionnel spécifique d'une sténose
- Facilité d'utilisation
- Indépendance vis à vis de la fréquence cardiaque , de la pression sanguine et de la contractilité
- **Valeur sans équivoque** pour le myocarde normal : FFR = 0,75

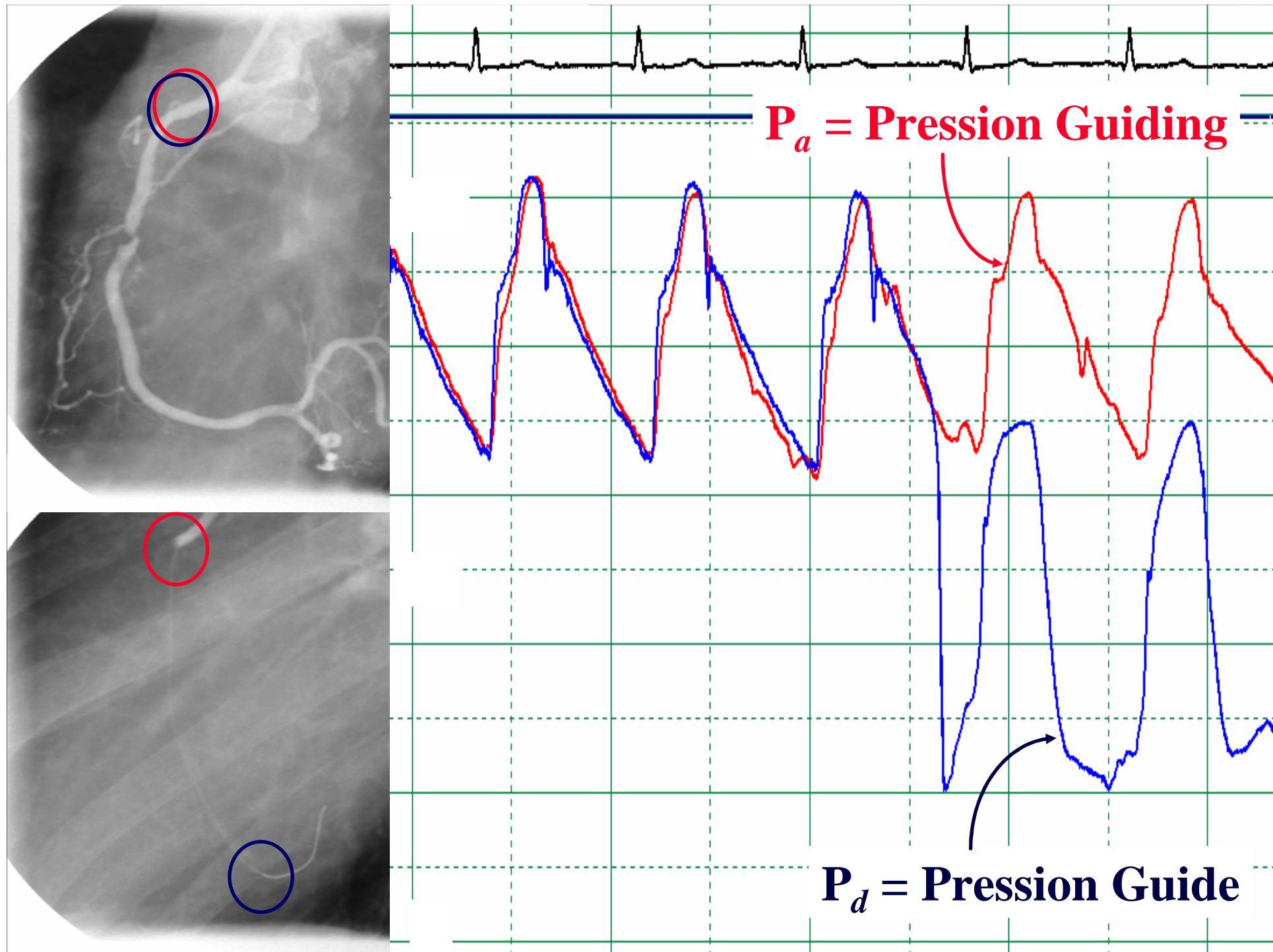
MESURES DE LA PRESSION Coronaire

1979



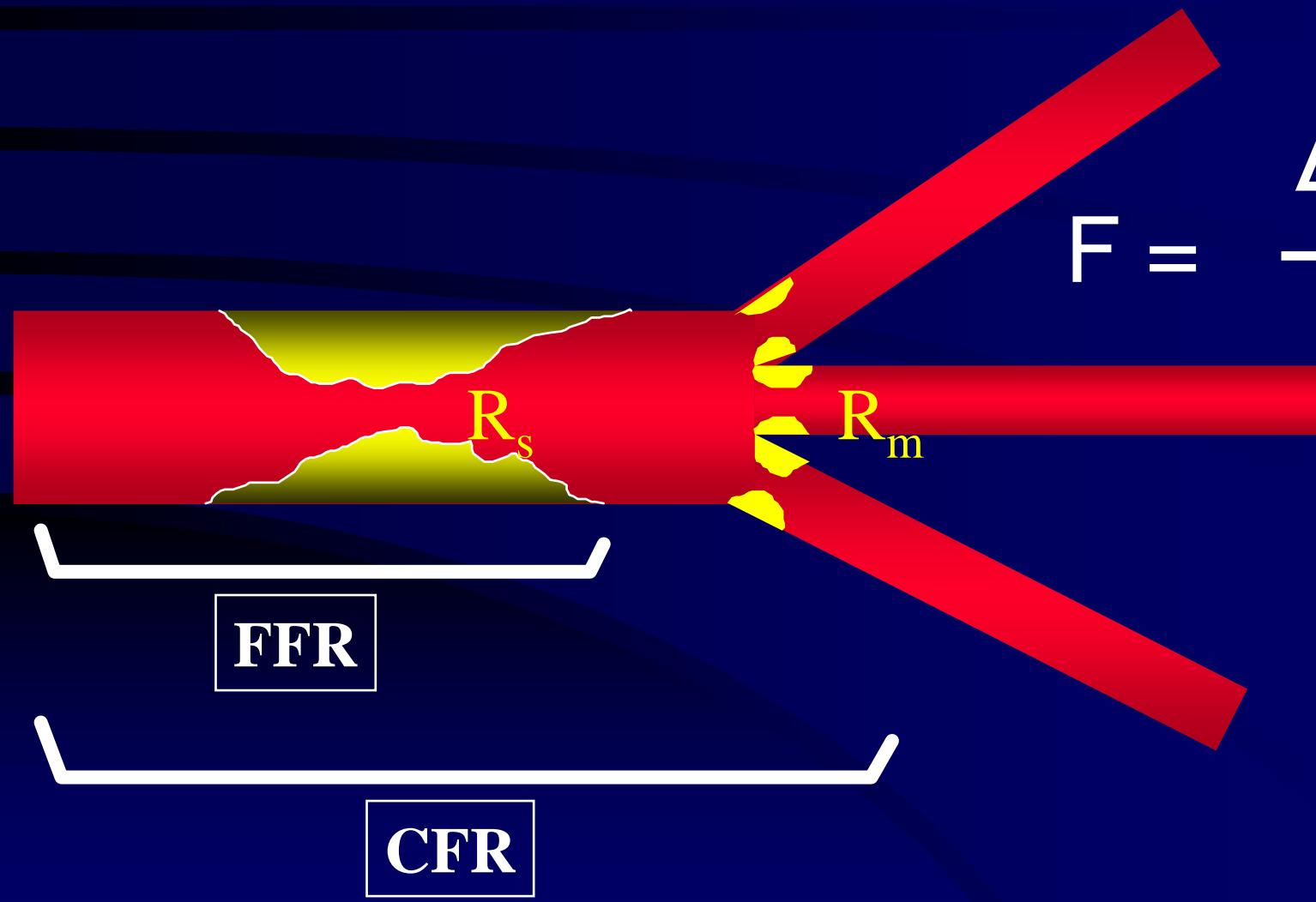
1999



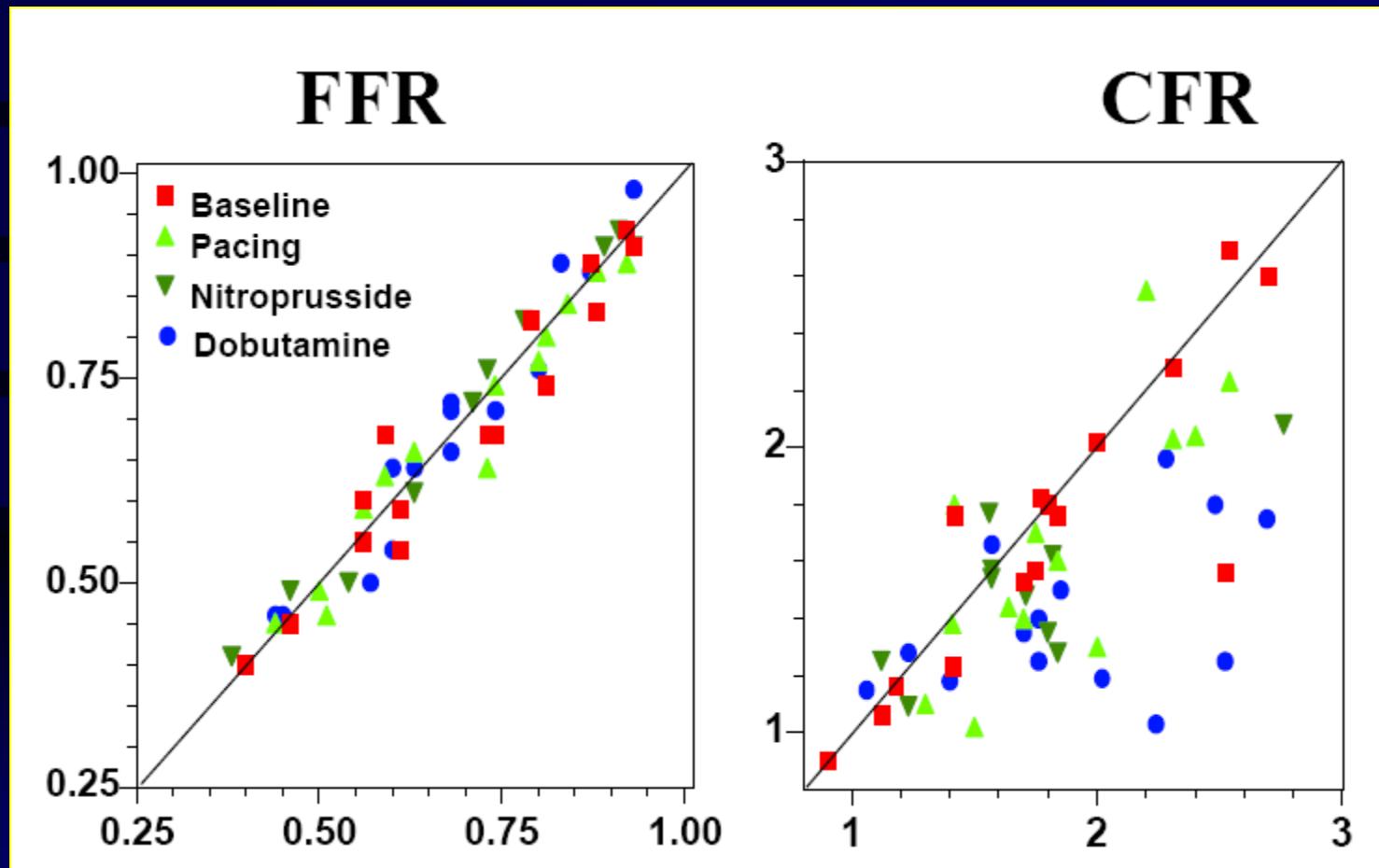


FFR versus CFR

$$F = \frac{\Delta P}{R}$$

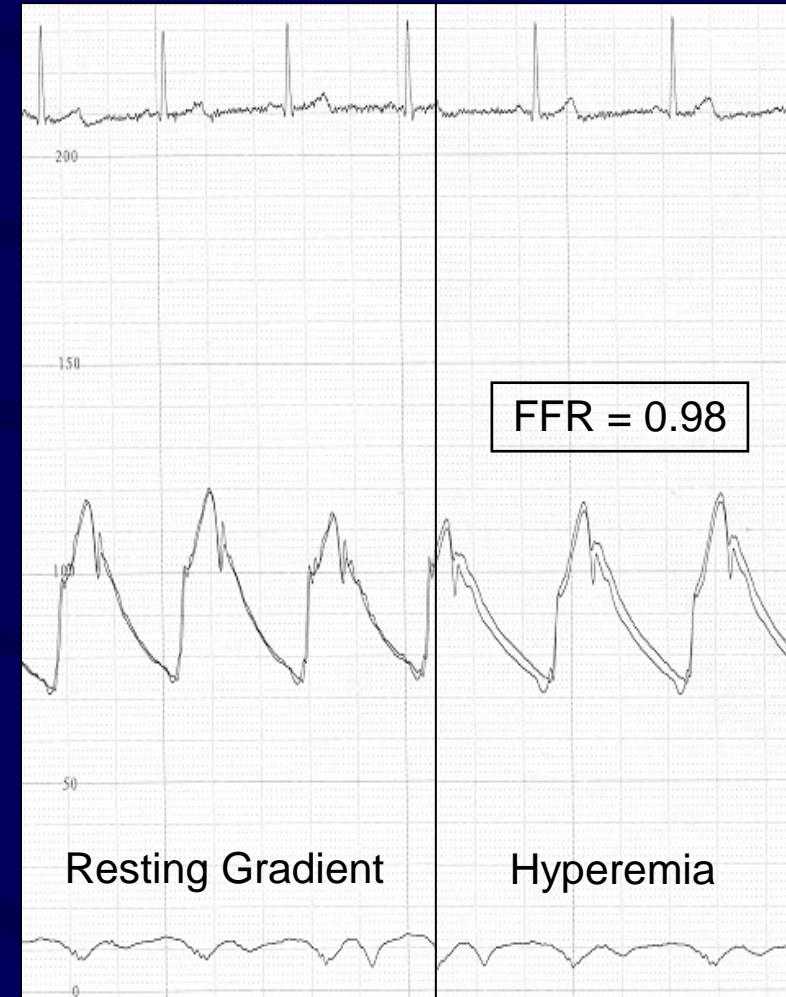


Influence des modifications de Fc, PA et contractilité sur la CFR et la FFR

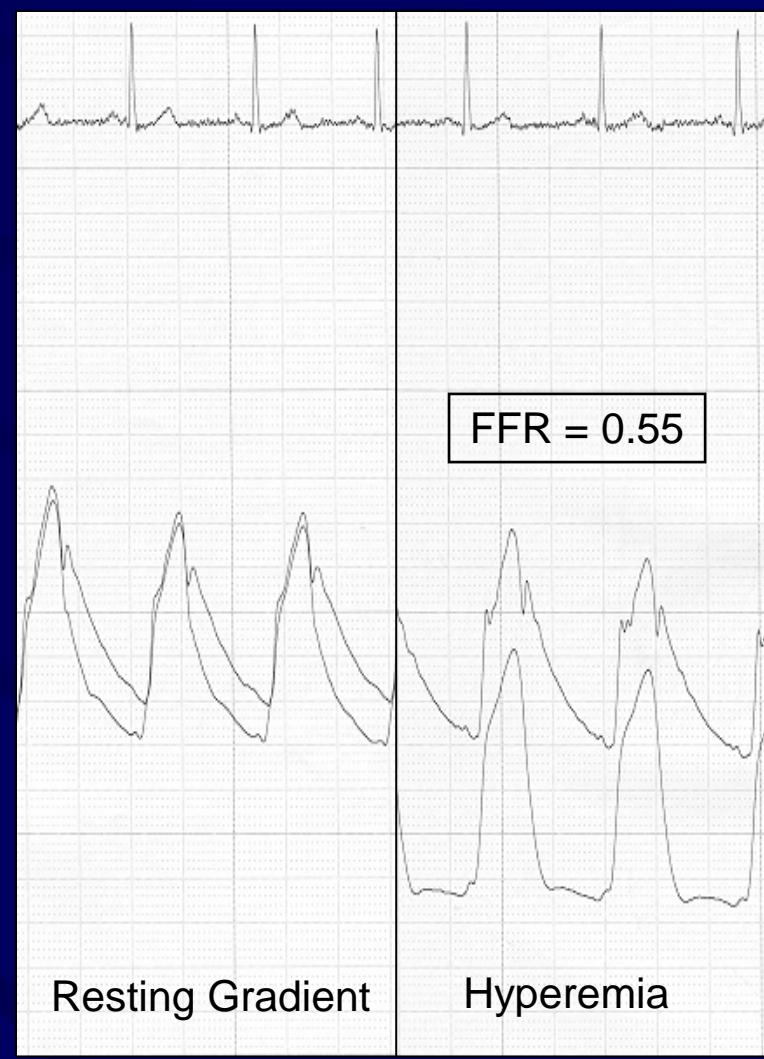
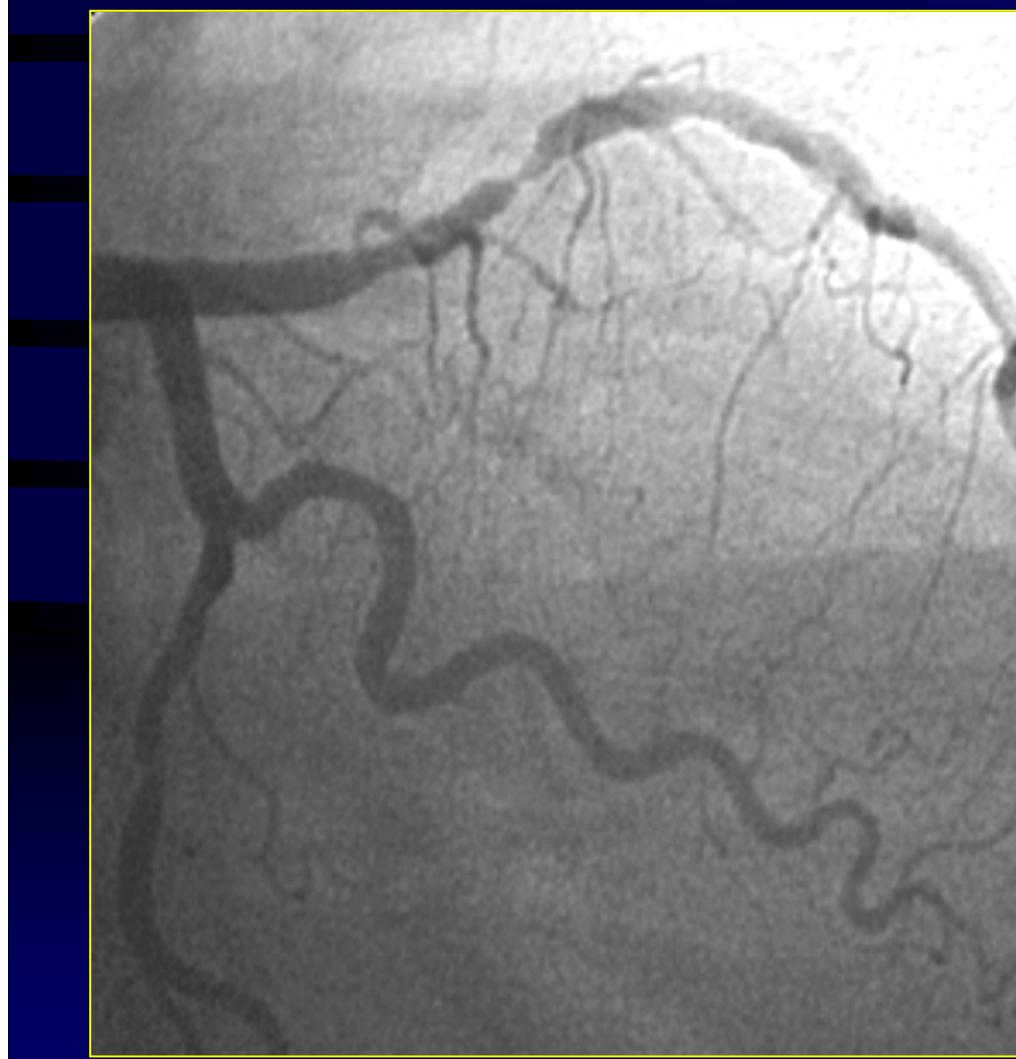


B. De Bruyne et al., Circulation 1996; 94: 1843-49

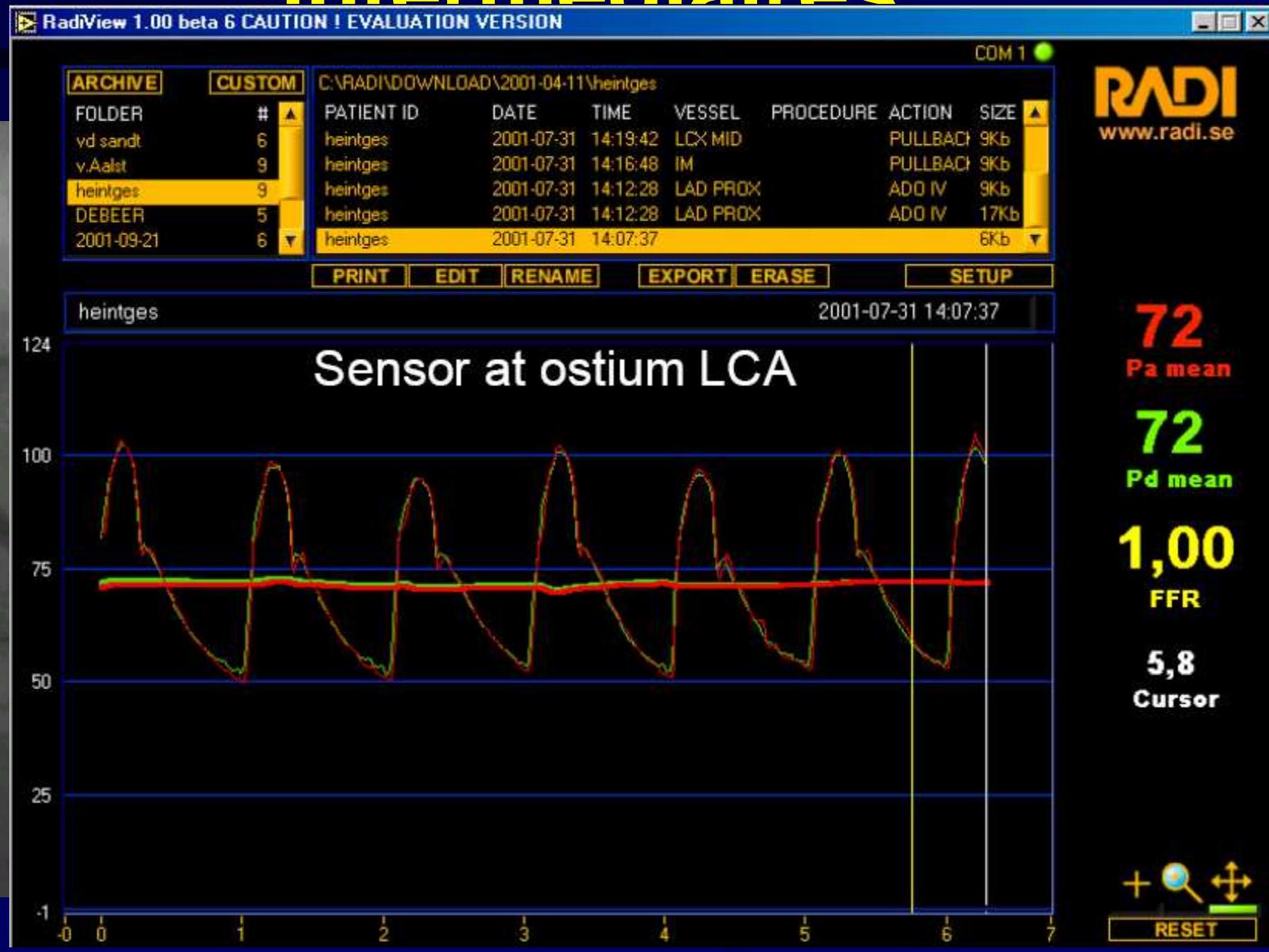
Exemple: FFR_{myo} Normale



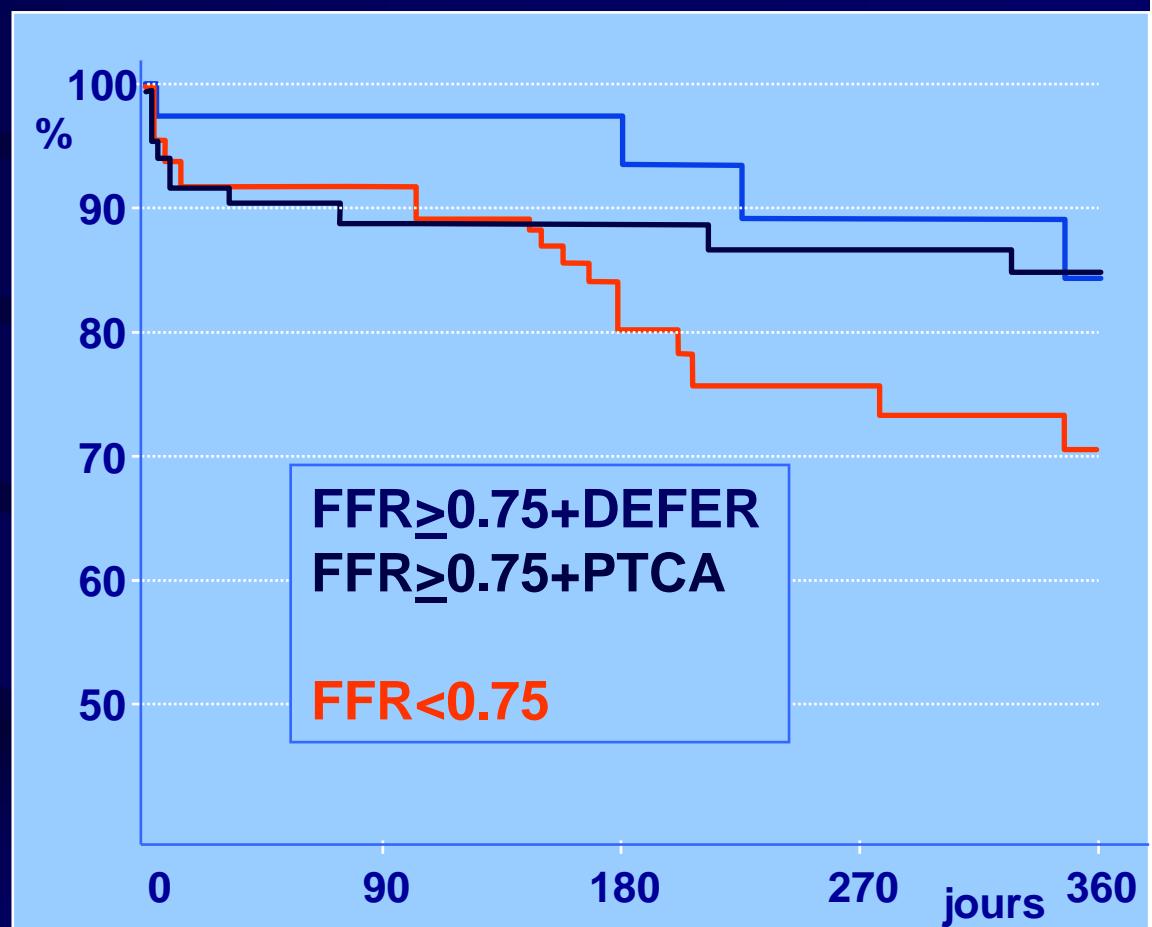
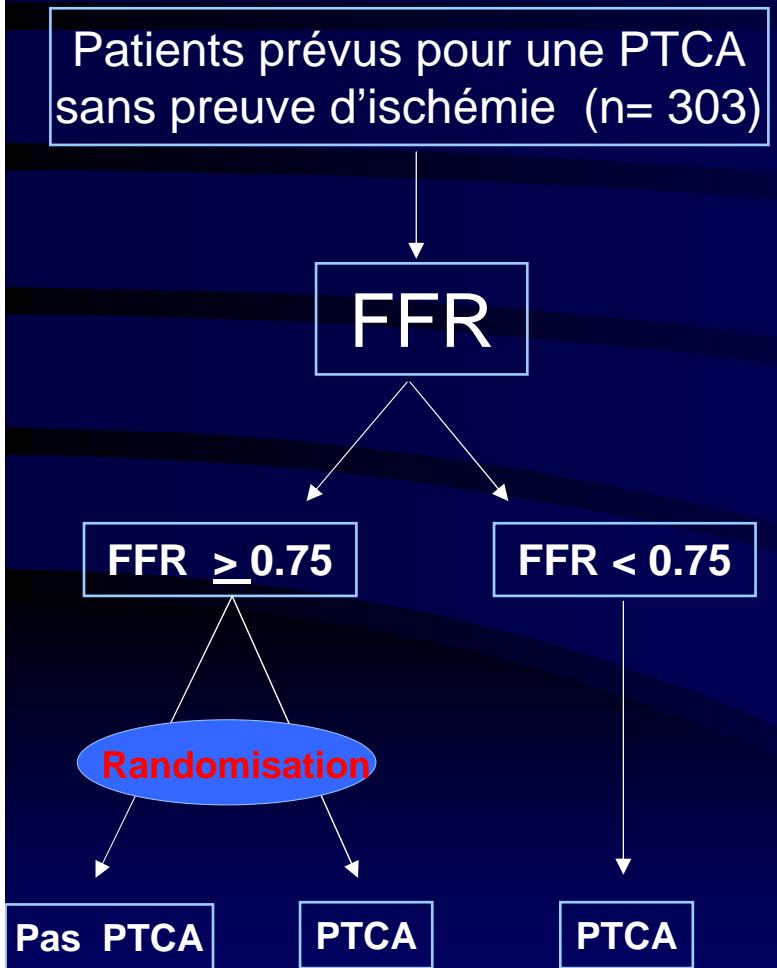
Exemple: FFR_{myo} Anormale



Evaluation des tests intermédiaires

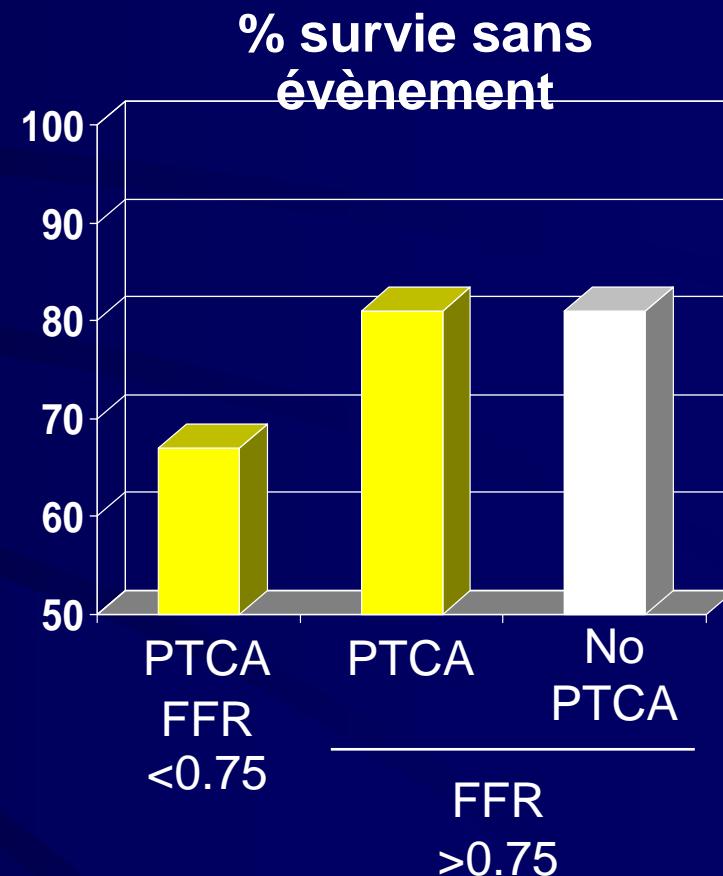
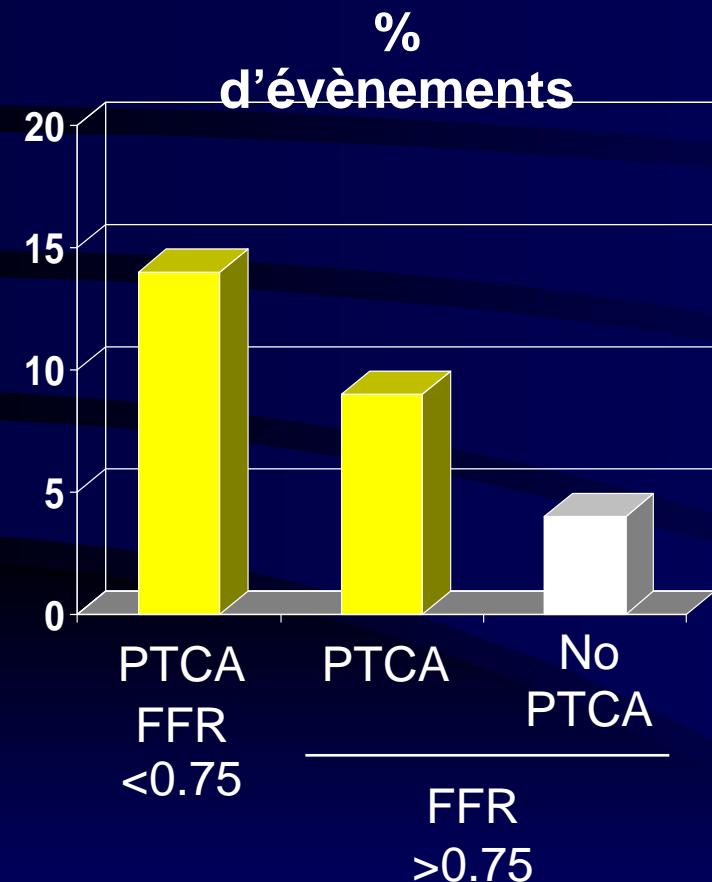


Etude DEFER : Event Free Survival



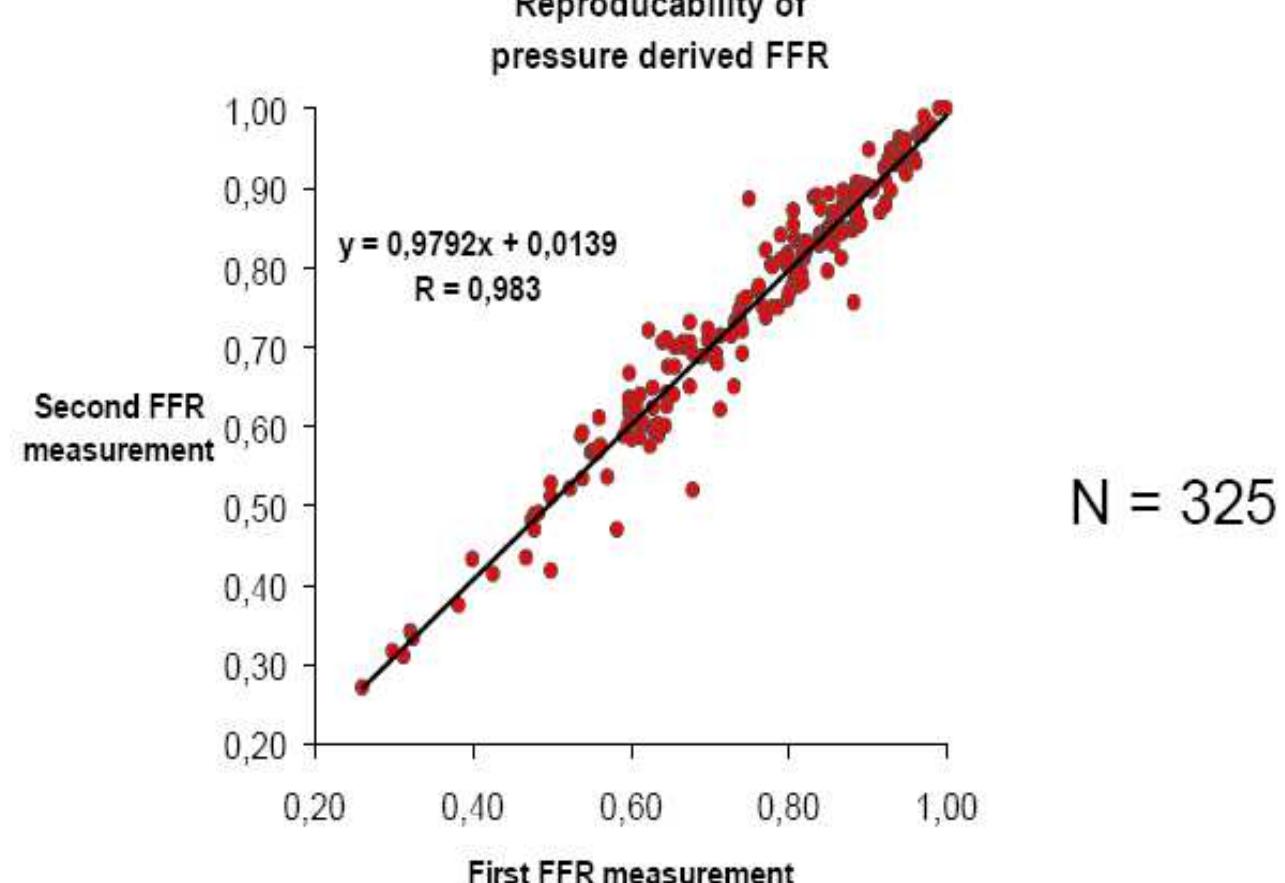
Bech et al., Circulation 2001; 103: 2928-34

Etude DEFER



Bech et al., Circulation 2001; 103: 2928-34

Reproductibilité de la mesure de FFR dans l'étude DFFFR



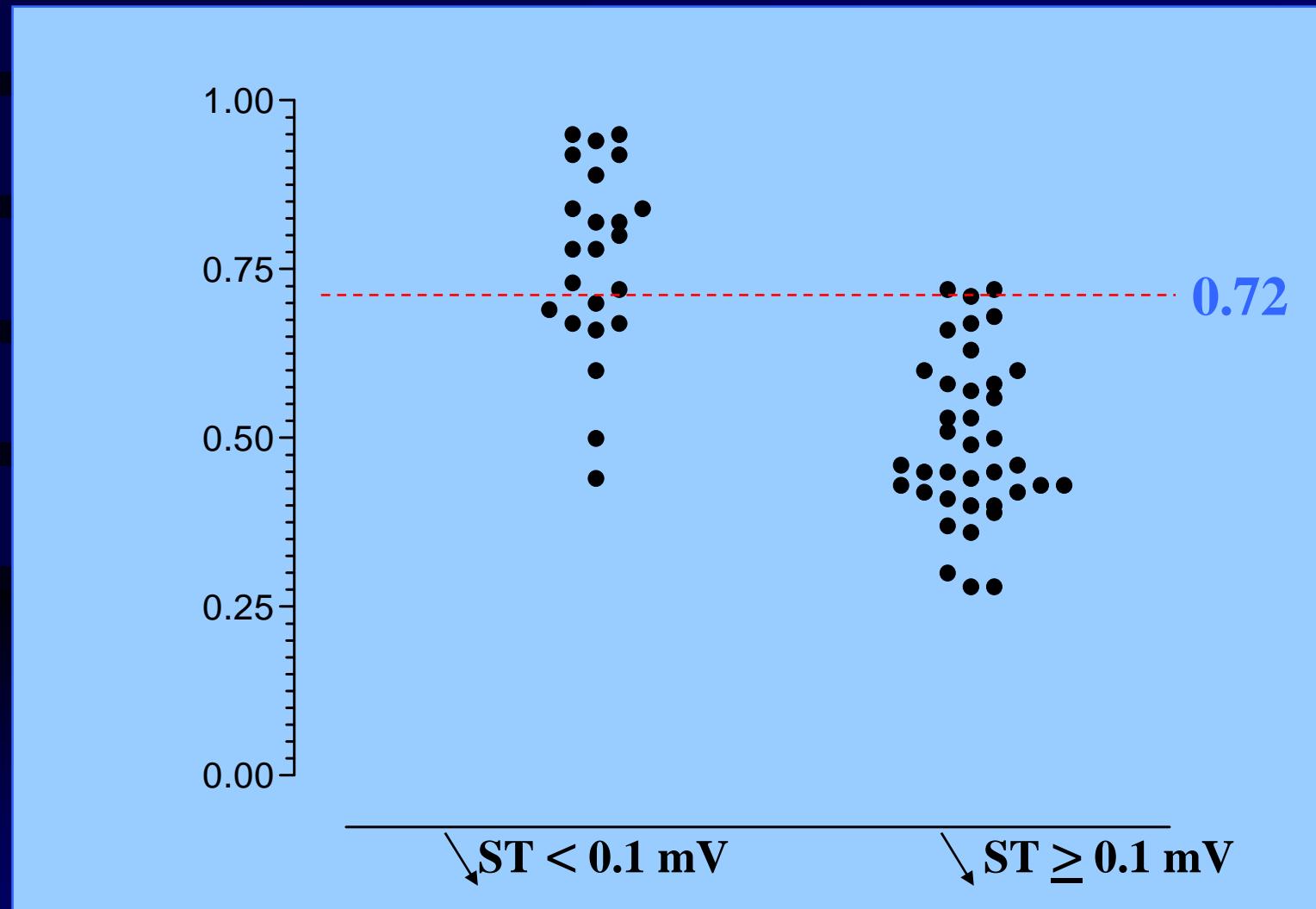
Bech et al., Circulation 2001; 103: 2928-34

Evaluation du stenting par FFR: la FFR a une forte valeur prédictive dans l'évaluation du risque de resténose

- FFR > 0.90: risque de resténose à 6 mois est de 6%
- FFR < 0.90: risque de resténose à 6 mois est de 25%

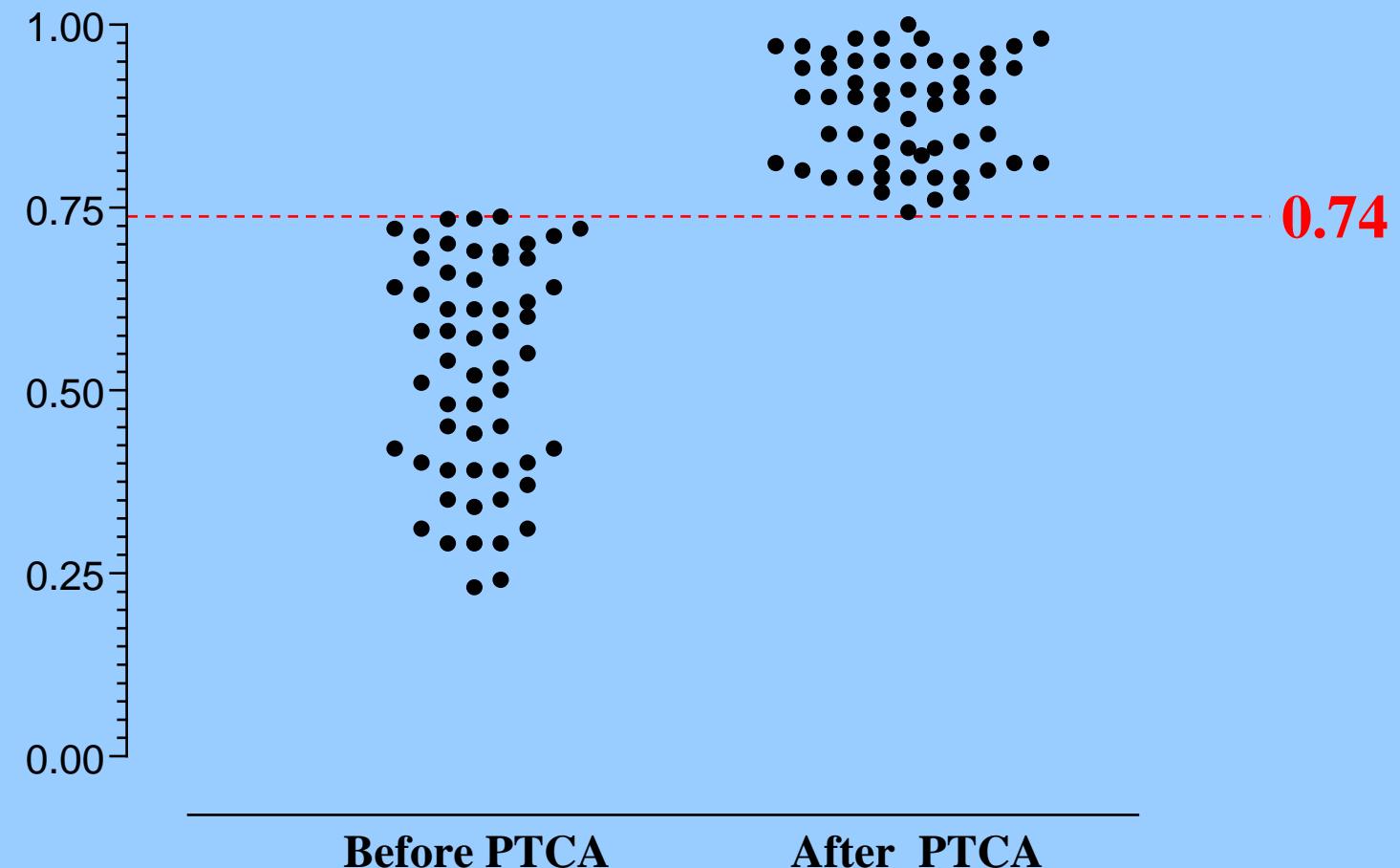
Et ce, malgré des résultats
angiographiques équivalents!

Valeurs Seuil de la FFR_{myo} vs ECG d'Effort



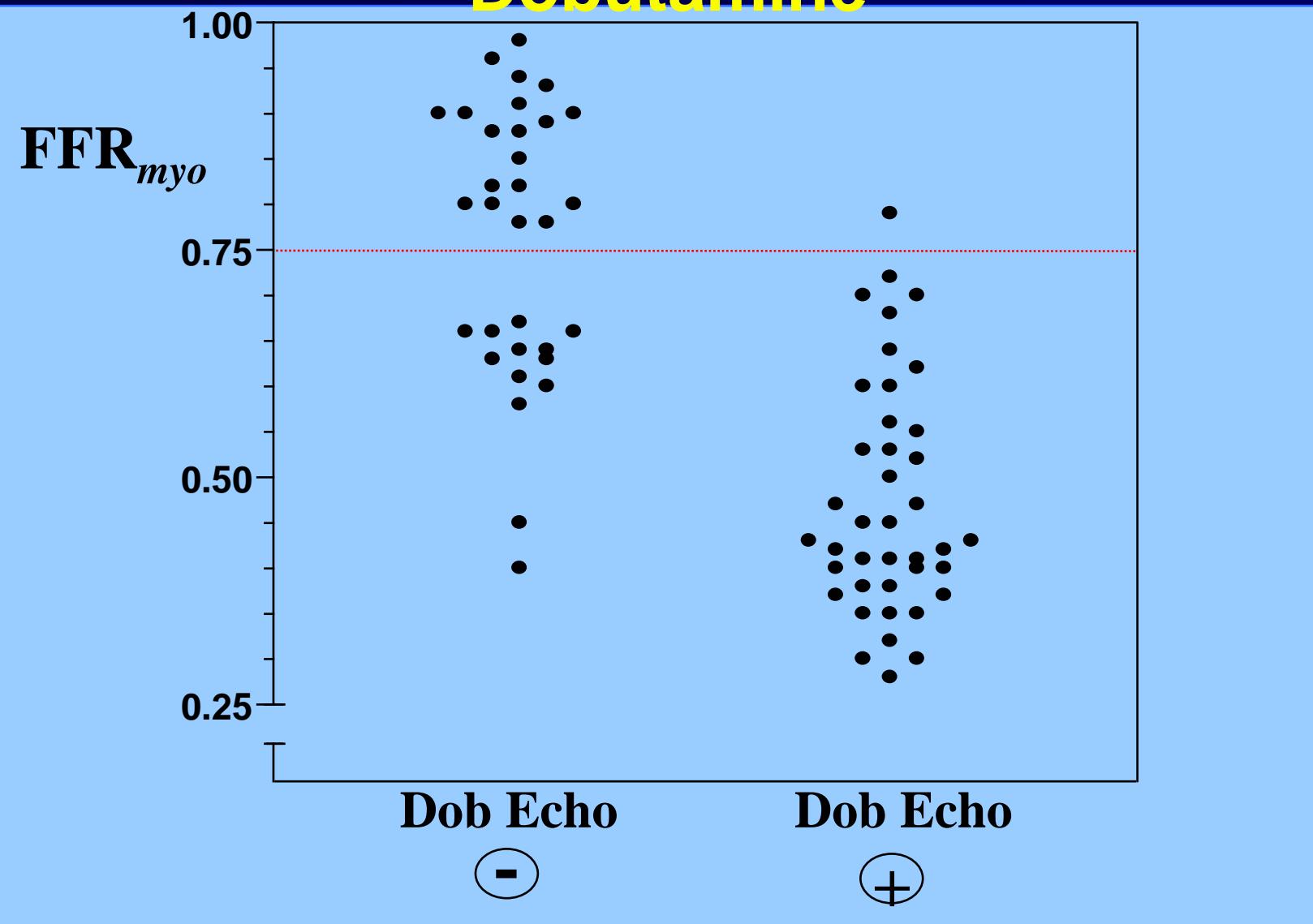
de Bruyne B et al. Circulation 1995

Valeurs Seuil de la FFR_{myo} vs ECG d'Effort



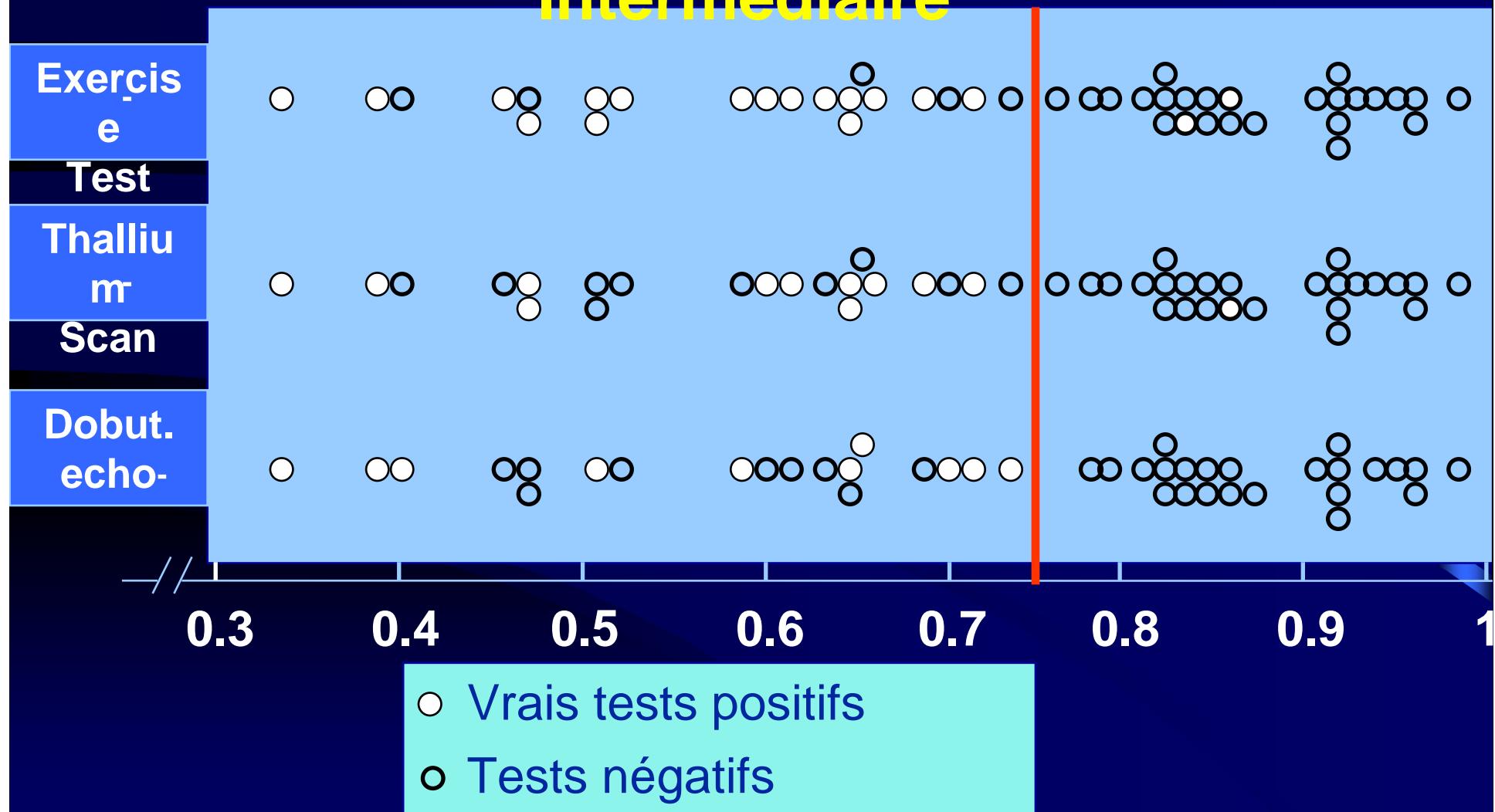
Pijls NHJ et al. Circulation 1995

FFR et Anomalies de la cinétique sous Dobutamine



Bartunek J et al. J Am Coll Cardiol 1996

Comparaison de la FFR avec des Tests Non-Invasifs sur des Lésions de Sévérité Intermédiaire



Pijls NHJ, de Bruyne B, Peels K et al. New Engl J Med 1996

Comparaison de la FFR avec des Tests Non-Invasifs sur des Lésions de Sévérité Intermédiaire

		Gold Standard	Gold Standard
		+	-
FFR < 0.75	FFR < 0.75	21	0
	FFR ≥ 0.75	3	21

Pijls NHJ, de Bruyne B, Peels K et al. New Engl J Med 1996

Evaluation du Déploiement d'un Stent : FFR vs IVUS

- n = 30 patients
- Primo implantation d'un Wiktor stent
- FFR et IVUS après 6, 8, 10, 12, 14, 16 atm. Jusqu'à ce que chaque paramètre soit optimal
- FFR Optimale > 0.94 ; IVUS Optimal = critères 'MUSIC'

	FFR +	FFR -
IVUS +	14	2
IVUS -	5	60

Taux de Concordance = 91%

C. Hanekamp et al. Circulation 1999;99:1015-

IVUS analyse l'anatomie

- dimension vaisseau
- extension de la plaque
- anatomie du segment
- apposition du stent
- complications: dissection/thrombus

FFR analyse flux du myocarde

- Atteste la signification physiologique de la lésion
- optimise la revascularisation des pluritronculaires

IVUS Criteria for the Assessment of the Functional Significance of Intermediate Coronary Artery Stenoses and Comparison With Fractional Flow Reserve

43 patients with angiographically intermediate coronary lesions underwent measurement of fractional flow reserve (FFR) and IVUS characteristics of stenosis severity. Relation between FFR and IVUS indexes was assessed in an analysis of

IVUS Characteristic	Correlation With FFR		ROC analysis (for FFR <0.75)		
	r	p-Value	Cut-off Value	Sensitivity	Specificity
Area stenosis (%)	-0.58	<0.001	>70%	100%	68%
Lesion length (mm)	-0.41	<0.004	>10 mm	41%	80%
MLD (mm)	0.51	<0.001	≤1.8 mm	100%	66%
MLA (mm ²)	0.41	<0.004	≤4.0 mm ²	92%	56%

Conclusion: IVUS parameters can be used for prediction

of FFR with high sensitivity and specificity.

Briguori C, et al. AJC 2001, 87: 136-41

Optimizing Stent Deployment: QCA vs. IVUS vs. Pressure Wire

30 patients underwent stent implantation with the Wiktor stent at different inflation pressures 6, 8, 10, 12 and 14 atm as necessary. QCA IVUS and pressure measures were performed serially after each incremental inflation.

	FFR+	FFR-	QCA+	QCA-
IVUS+	14	2	15	3
IVUS-	5	60	42	27
Concordance	91% p <0.0001	FFR+ QCA+	48% p=NS	QCA-
FFR+	14		3	
FFR-	42		25	
Concordance		46% p=NS		

Optimal Criteria

QCA:

Final % DS < 10%

IVUS:

- (1) Complete stent apposition
- (2) Symmetry index > 0.7
- (3) Minimal CSA stent > 90% or ref CSA

FFR \geq 0.94

Conclusion:

IVUS and FFR were of similar value in assessing optimal stent deployment with the Wiktor, and FFR can be used as a cheap alternative to IVUS for that purpose.

Hanekamp CEE, et al. Circulation 1999;99:1015-

Validation clinique de l'IVUS:

Comparaison avec les données physiologiques

- 1. MLA < 3.0 mm²**
(Sensitivity 83.0%, specificity 92.3%)
- 2. Area stenosis > 60%**
(Sensitivity 92.0%, specificity 88.5%)
- 3. Combination of above both**
(All FFR < 0.75)

Tagaki A et al., Circulation 1999; 100: 250

Utilité de l'IVUS à l'ère des DES

- Resténose intra-stent
- Expension du stent (TCG, bifurcations...)
- SCA (morphologies complexes)
- Lésions ostiales
- Bifurcations avec large branche (+/-)
- Lésions très calcifiées
- Lésions longues et diffuses (diabète)

IVUS et SCA

Plaque Rupture and Thrombus

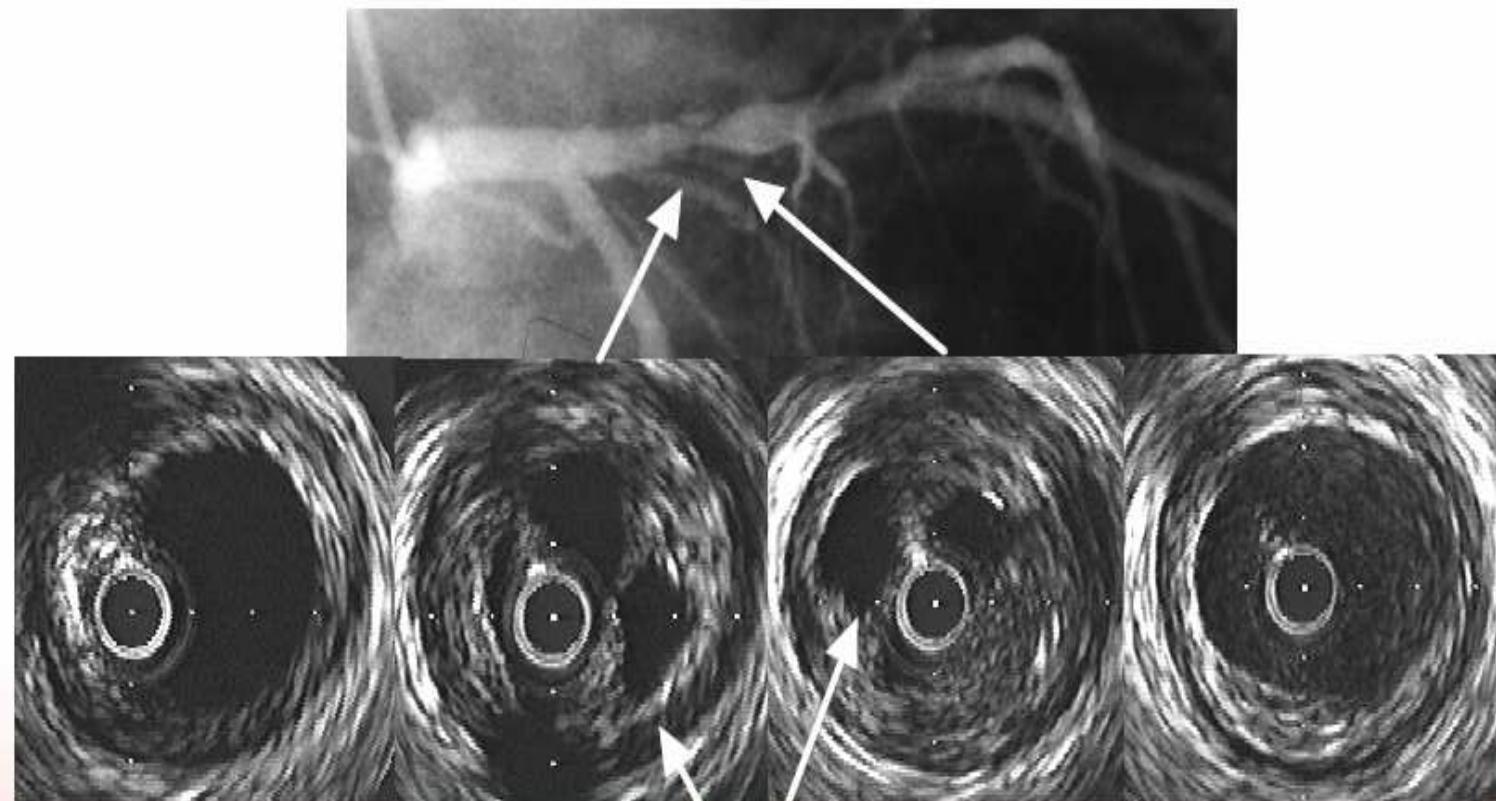


ulceration
thrombus
Unstable angina

IVUS et SCA

Slit-like lesion (AMI)

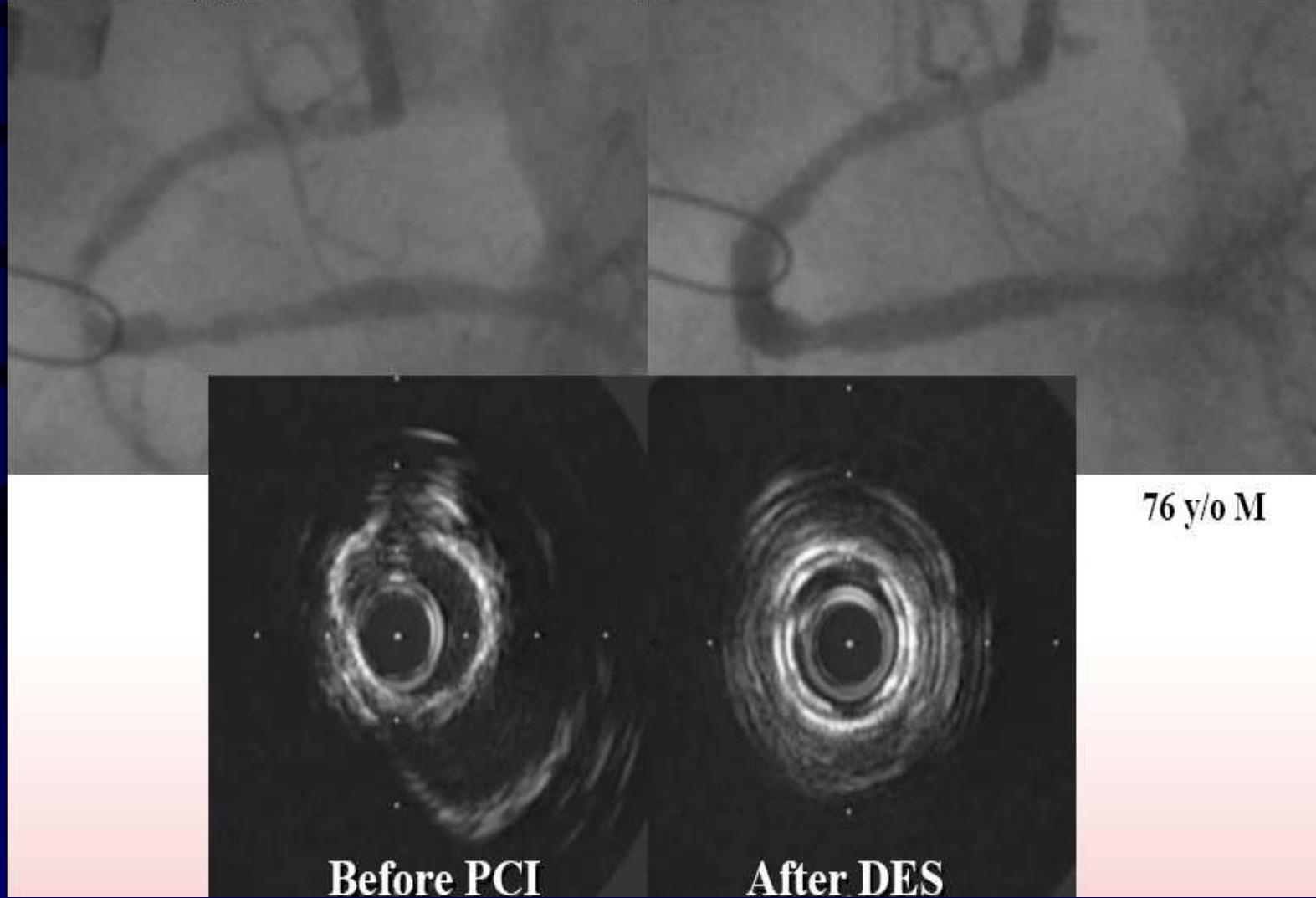
Post intravenous thrombolysis



Plaque rupture

IVUS et contrôle expansion stent

Difficult to Expand

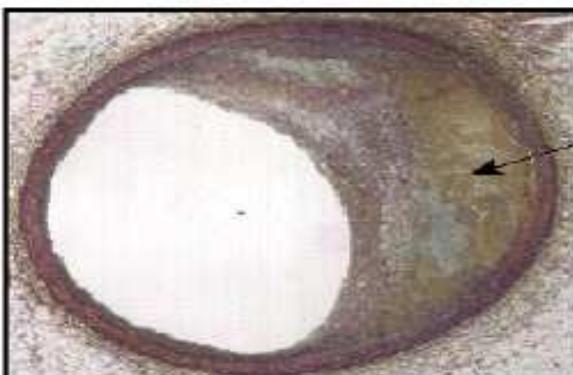


PCI GUIDELINES: adjunctive methods to assess coronary artery disease

- **Fonctionnal assessment: FFR, CFR**
 - pre-PTCA: lesion assessment
 - post-PTCA: endpoint
 - post-stent: IVUS-like deploiemt
- **Anatomic assessment: IVUS**
 - pre-PTCA: calcium, length...
 - post-stent: apposition, new lesions...
- **Additional applications: FFR, CFR, IVUS**
 - ambiguous lesions, multivessel PTCA
 - transplant arteriopathy

Fibrous**PA 80 %**

Densely packed bundles of collagen fibers with no evidence of intra-fiber lipid accumulation. No evidence of macrophage infiltration. Appears dark yellow on Movat stained section.



Fibrous tissue

Fibro-lipidic**PA 81 %**

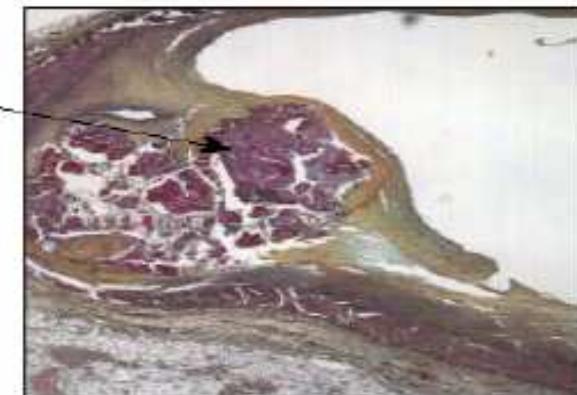
Loosely packed bundles of collagen fibers with regions of lipid deposition present. These areas are cellular and no cholesterol clefts or necrosis are present. Some macrophage infiltration. Increase in extracellular matrix. Appears turquoise on Movat stained section.



Fibro-lipidic region

Lipid Core**PA 86 %**

Highly lipidic necrotic region with remnants of foam cells and dead lymphocytes present. No collagen fibers are visible and mechanical integrity is poor. Cholesterol clefts and micro calcifications are visible.



Lipid Core

Calcium**PA 93 %**

Focal area of dense calcium. Appears purple on Movat. Usually falls out section, but calcium crystals are evident at borders.



Calcium

Nair A et al *Circulation*: 106:2200-2206, 2002

Domain: Histologie virtuelle ?

LM

Culprit lesion

Distal artery

Disease mostly lipid rich fibrotic tissue with no calcium