Why Don't We Use Physiology More Often in the Cath. Labo ?

Takashi Akasaka, MD, PhD, FESC, FAPSC, FJCS
Department of Cardiovascular Medicine
Wakayama Medical University, Japan

TCTAP 2019, Seoul

Wakayama Medical University

Disclosure Statement of Financial Interest

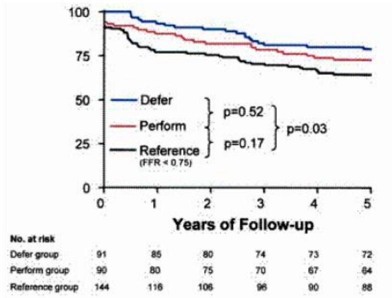
Takashi Akasaka, MD, PhD

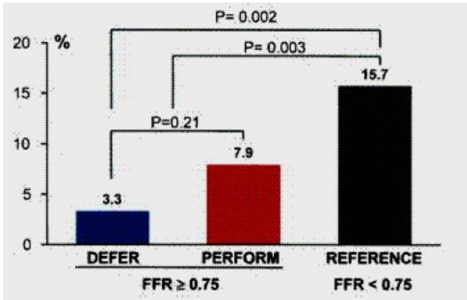
Within the past 12 months, I or my spouse/partner have had a financial interest/arrangement or affiliation with the organization(s) listed below.

- **Grant/Research Support** : Abbott Vascular Japan
  Boston Scientific Japan
  Nipro Inc.
  Terumo Inc.
- **Consulting Fees/Honoraria** : Abbott Vascular Japan
  Daiichi-Sankyo Pharmaceutical Inc.
  Nipro Inc.
  Terumo Inc.

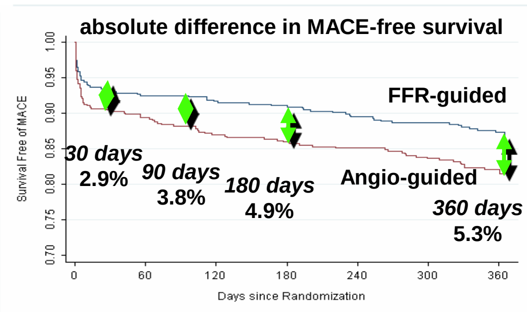
Clinical Evidence in FFR

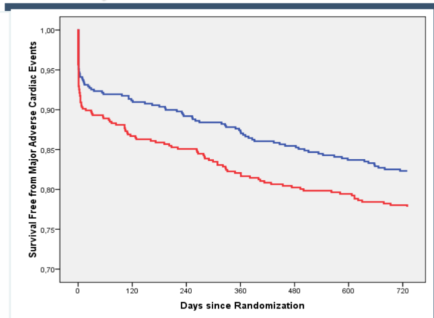
DEFER: J Am Coll Cardiol 2007;49:2105-2111



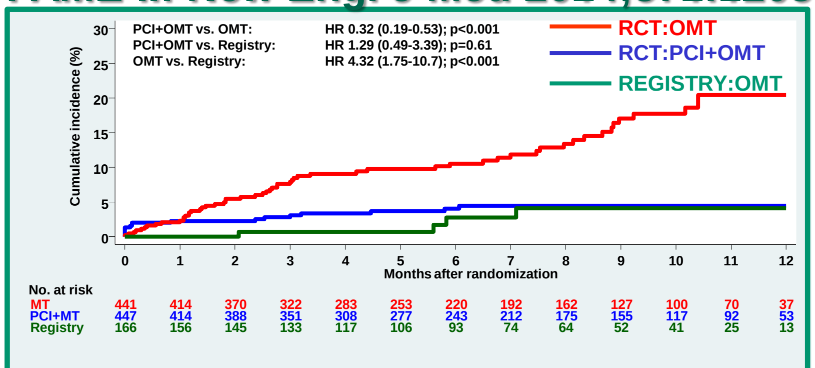


FAME I: New Engl J Med 2009;360:213-224





FAME II: New Engl J Med 2014;371:1208-1218



Intracoronary imaging & physiology in ESC guideline 2014

Recommendations	Class[a]	Level[b]	Ref.[c]
FFR to identify haemodynamically relevant coronary lesion(s) in stable patients when evidence of ischaemia is not available.	I	A	50,51,713
FFR-guided PCI in patients with multivessel disease.	IIa	B	54
IVUS in selected patients to optimize stent implantation.	IIa	B	702,703,706
IVUS to assess severity and optimize treatment of unprotected left main lesions.	IIa	B	705
IVUS or OCT to assess mechanisms of stent failure.	IIa	C	
OCT in selected patients to optimize stent implantation.	IIb	C	

Eur Heart J. 2014;35:2541-2619

Wakayama Medical University

ESC European Society of Cardiology
European Heart Journal (2018) **00**, 1–96
doi:10.1093/eurheartj/ehy394

ESC/EACTS GUIDELINES

2018 ESC/EACTS Guidelines on myocardial revascularization

The Task Force on myocardial reva
Society of Cardiology (ESC) and Eu
Cardio-Thoracic Surgery (EACTS)

Developed with the special contrib
Association for Percutaneous Card

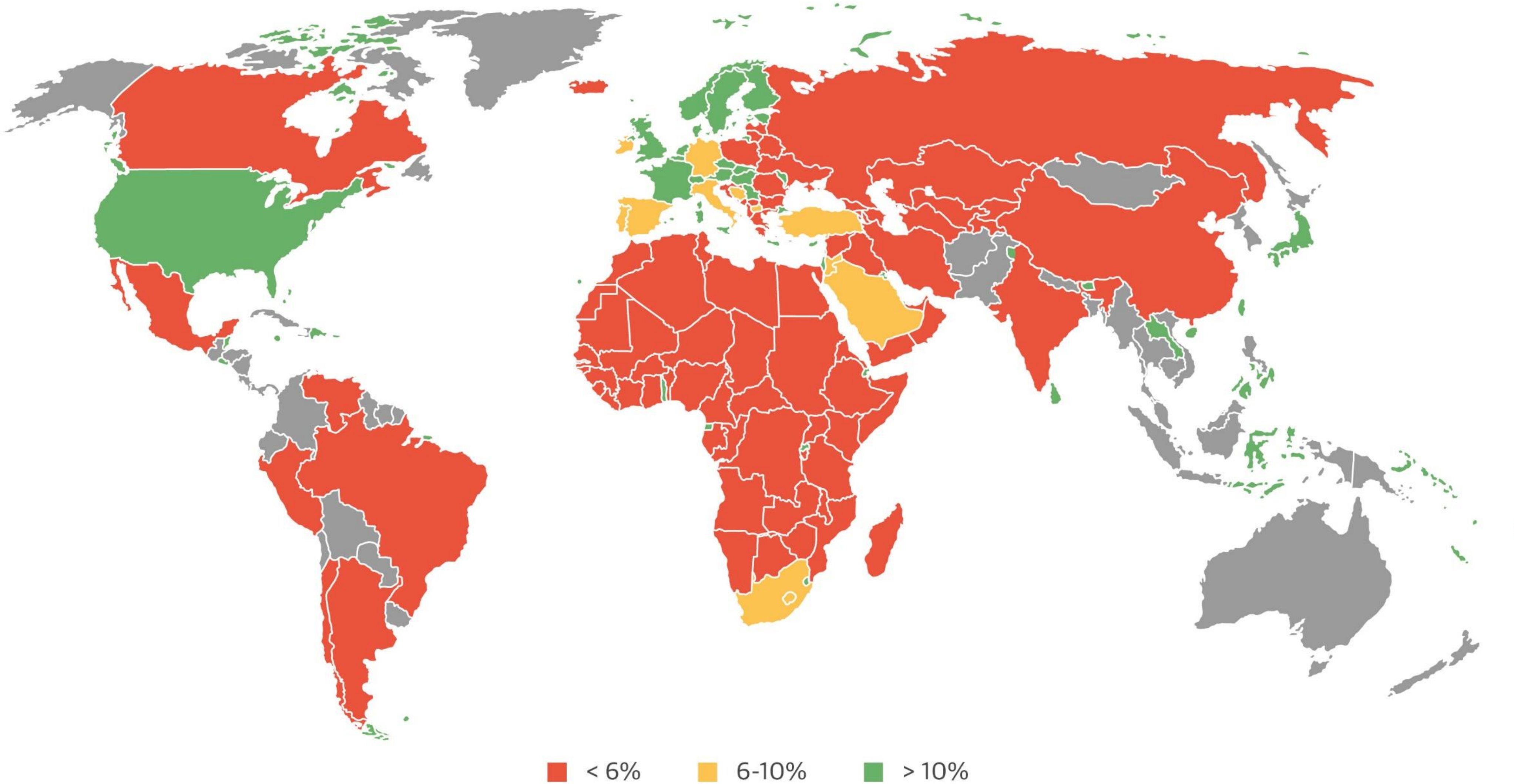
Authors/Task Force Members: Franz-Josef I
(Germany), Miguel Sousa-Uva*[1] (EACTS C
(Sweden), Fernando Alfonso (Spain), Adria
(UK), Robert A. Byrne (Germany), Jean-Ph
(Germany), Stuart J. Head[1] (The Netherlar
Adnan Kastrati (Germany), Akos Koller (H
Josef Niebauer (Austria), Dimitrios J. Richt
Dirk Sibbing (Germany), Giulio G. Stefanini
(Switzerland), Rashmi Yadav[1] (UK), Michae

Document Reviewers: William Wijns (ESC Review Co-
Co-ordinator) (Canada), Victor Aboyans (France), Step
(Norway), Felicita Andreotti (Italy), Emanuele Barbat
(Canada), Héctor Bueno (Spain), Patrick A. Calvert (U

Recommendations on functional testing and intravascular imaging for lesion assessment

Recommendations	Class[a]	Level[b]
When evidence of ischaemia is not available, FFR or iwFR are recommended to assess the haemodynamic relevance of intermediate-grade stenosis.[15,17,18,39]	I	A
FFR-guided PCI should be considered in patients with multivessel disease undergoing PCI.[29,31]	IIa	B
IVUS should be considered to assess the severity of unprotected left main lesions.[35–37]	IIa	B

Global Adoption of Coronary Physiology to Guide Revascularization Decision Making in 2016



Gōtberg M, et al. J Am Coll Cardiol 2017;70:1379-1402

Why Don't We Use Physiology More Often in the Cath. Labo?

Coronary Psychology

Do You Believe?*

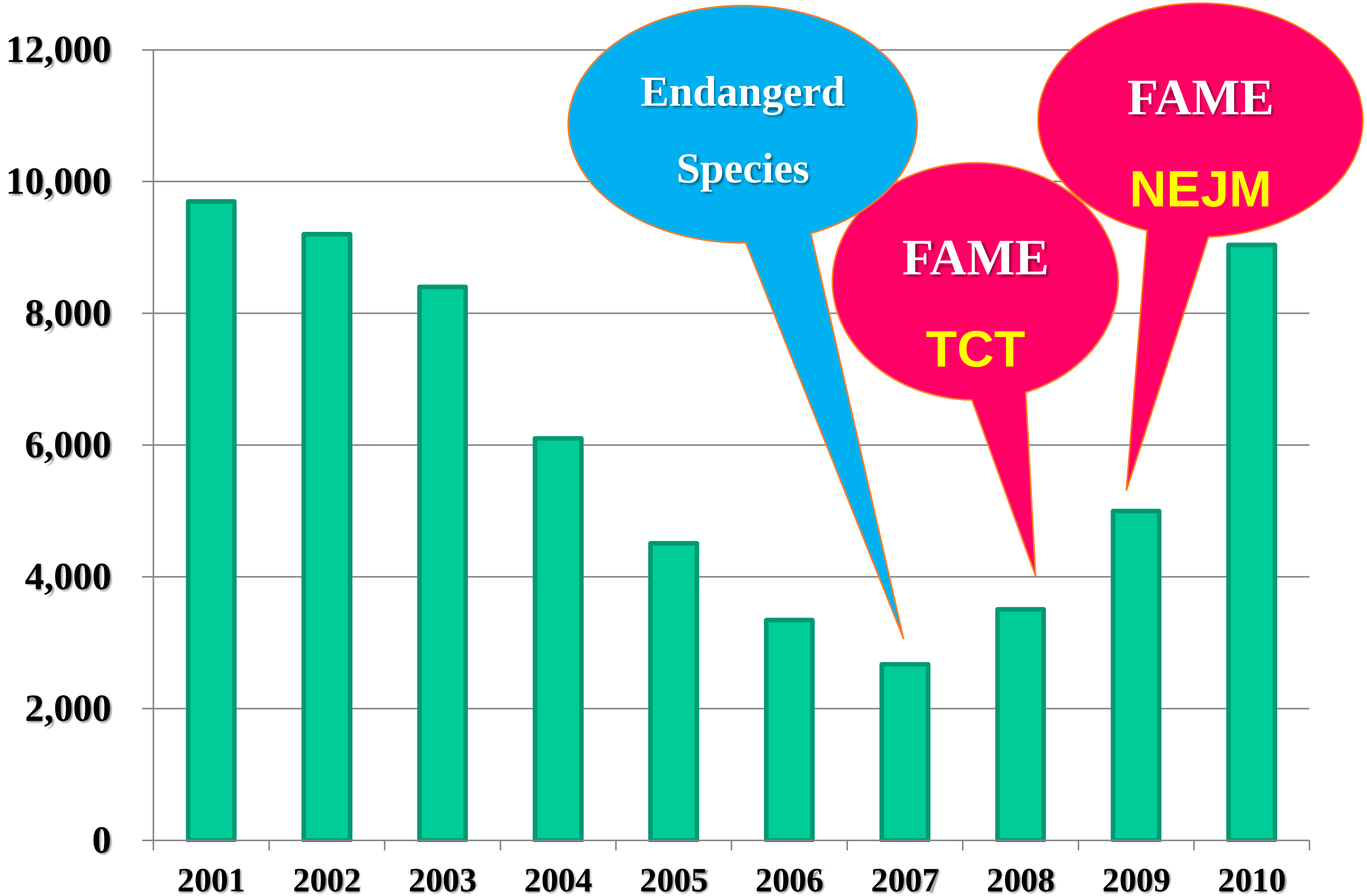
Nils P. Johnson, MD, MS,[a] Bon-Kwon Koo, MD, PhD[b] J Am Coll Cardiol Intv 2018;11:1492-1494

claimed it was due to a knowledge barrier ("I do not understand enough about FFR"). Additionally, <5% of responses identified attitude barriers, for example "I do not trust FFR." Instead, the dominant responses focused on reimbursement and the time necessary to perform the procedure. A logical conclusion from this survey was that we should focus on environmental barriers to improve the penetrance of coronary physiology.

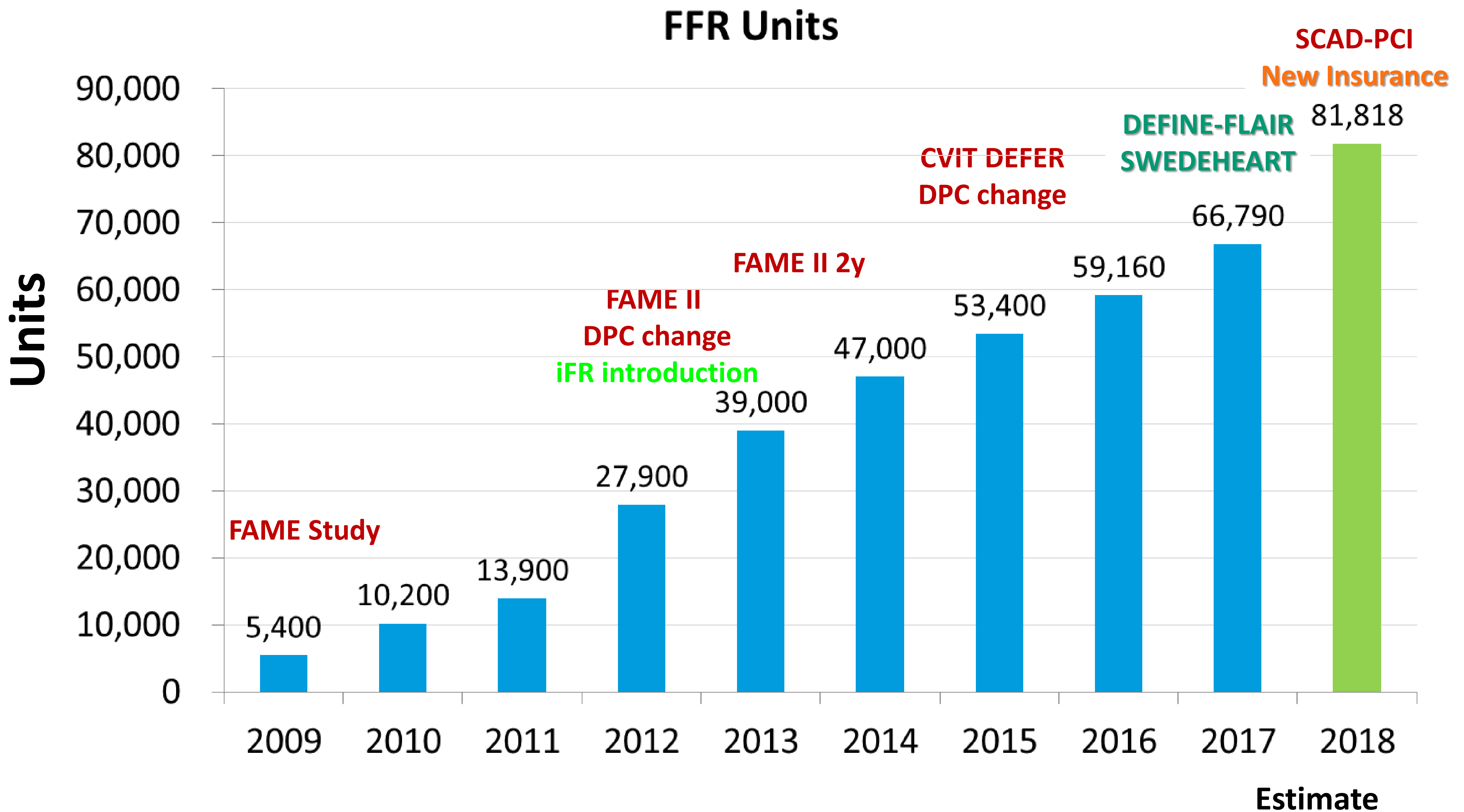
Why Don't We Use Physiology More Often in the Cath. Labo?

- Re-imbursement issue: insurance coverage
- Oculo-stenotic reflex: Many interventionist might be anatomy first more than physiology as angio-believers.
- Difficulty to understand the concept of coronary physiology completely.
- Difficulty of the wire manipulation compared with other work force wires.
- Patients discomfort & time consuming procedure.

FFR market in Japan



Recent PGW market in Japan (Yano Keizai)



Source: 2009~2017 Yano Keizai, 2018 estimate

Public Reporting of Coronary Physiology Uptake

Johnson NP & Koo BK. J Am Coll Cardiol Intv 2018;11:1492-1494

Country (Ref. #)	Year	PW	PCI	PW/PCI	Temporal Change	Hospital-Level Reporting?
Sweden (9)	2017	NR	NR	26%	3.1-fold in 10 yrs	Yes
United Kingdom (10)	2016	18,811	100,483	19%	3.5-fold in 8 yrs	Yes
Italy (11)	2016	11,000	218,751	5%	1.4-fold in 4 yrs	Yes
Europe EAPCI (12)	2015	NR	889,957	16%	2-fold in 5 yrs	Per country
United States (13)	2014	3,465*	NR	31%	3.8-fold in 5 yrs	No
Australia (14)	2015	NR	3,869	19%	100-fold in 9 yrs	Per state

*Limited to a subset of the 59,375 patients in the National Cardiovascular Data Registry CathPCI Registry with lesions deemed 40–70% by visual assessment.

EAPCI = European Association of Percutaneous Cardiovascular Interventions; NR = not reported; PCI = percutaneous coronary intervention; PW = intracoronary pressure wire.

Why Don't We Use Physiology More Often in the Cath. Labo?

- Re-imbursement issue: insurance coverage
- Oculo-stenotic reflex: Many interventionist might be anatomy first more than physiology as angio-believers
- Difficulty to understand the concept of coronary physiology completely.
- Difficulty of the wire manipulation compared with other work force wires.
- Patients discomfort & time consuming procedure.

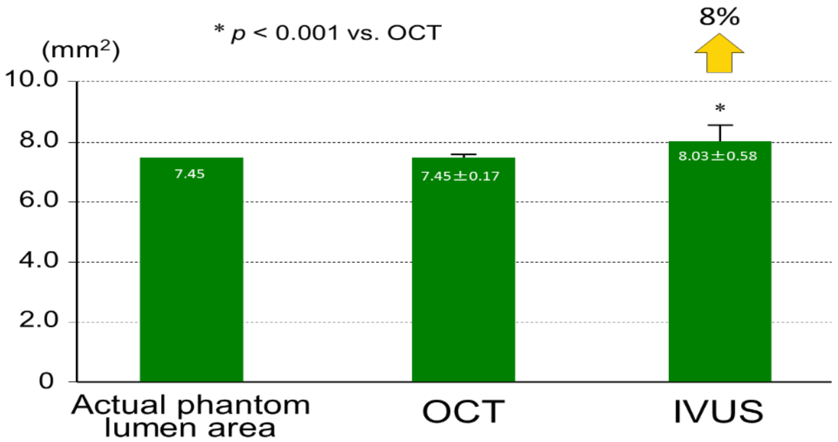
Anatomy can predict physiology ?

Table 3. Summary of Literature Predicting Physiology From Minimum Lumen Area

Method	FFR Reference	Reference	Stenoses, n	Best MLA Cutoff, mm²*	Area Under ROC Curve	Correlation
3D-QCA	<0.8	Yong et al[17]	63	1.9	0.79	0.63
IVUS	≤0.8	Koh et al[48]	55	1.8	0.70	0.30
	≤0.8	Gonzalo et al[56]	61	2.4	0.63	
	≤0.8	Gonzalo et al[56]	61	2.4	0.63	0.10
	<0.8	Park et al[41]	1066	2.4	0.76	0.47
	<0.8	Kang et al[47]	784	2.4	0.77	0.48
	<0.8	Kang et al[57]	236	2.4	0.80	0.51
	<0.8	Koo et al[46]	267	2.8		
	<0.8	Chen et al[58]	323	3.0	0.77	
	<0.75	Takagi et al[50]	51	3.0		0.79
	<0.8	Kwan et al[59]	169	3.0	0.86	0.50
	<0.8	Waksman et al[55]	367	3.1	0.65	0.30
	<0.8	Ben-Dor et al[60]	205	3.1	0.73	0.36
	<0.8	Ben-Dor et al[61]	92	3.2	0.74	0.34
	≤0.8	Koh et al[48]	38	3.5	0.82	0.55
	<0.75	Briguori et al[62]	53	4.0		0.41
	<0.8	Park et al[41]	63	4.8†	0.83	0.56
	<0.8	Kang et al[43]	55	4.8†	0.90	0.62
	<0.75	Jasti et al[63]	55	5.9†		0.74
	<0.75	Lee et al[54]	86		0.87	

Johnson NP, et al. Circ Cardiovasc Imaging 2013;6:817-832

Anatomy can predict physiology ?



OPUS-CLASS study

Kubo T, et al. JACC Cardiovasc Img. 2013;6:1095-1104

Much better accuracy in the measurement has been demonstrated in OCT compared with IVUS.

Table 3. Summary of Literature Predicting Physiology From Minimum Lumen Area

Method	FFR Reference	Reference	Stenoses, n	Best MLA Cutoff, mm²*	Area Under ROC Curve	Correlation
OCT	≤0.8	Reith et al[44]	62	1.6	0.81	0.62
	<0.75	Shiono et al[64]	62	1.9	0.90	0.75
	<0.75	Shiono et al[64]	62	1.9	0.90	0.75
	≤0.8	Gonzalo et al[56]	61	2.0	0.74	
	≤0.8	Gonzalo et al[56]	61	2.0	0.74	0.33

Several randomised studies and meta analysis demonstrated that there are moderate correlation between anatomical and physiological lesion severity assessment, and optimal cut-off value of FFR < 0.80 should be vessel dependent.

Johnson NP, et al. Circ Cardiovasc Imaging 2013;6:817-832

Multivariable logistic regression analysis For functionally significant stenosis (FFR<0.75)

Shiono Y, et al. Catheter Cardiovasc Interv. 2014 ;84:406-413

	OR	95% CI	p value
Minimal lumen diameter	0.022	0.007-0.062	<0.001
Lesion length	1.049	1.020-1.079	＝0.001
Supply area (modified APPROACH score)	1.102	1.068-1.137	<0.001

OR = odds ratio; CI = confidence interval; LAD = left anterior descending coronary artery; APPROACH score = Alberta Provivncia Project for Outcome Assessment in Coronary Heart Disease score

Fighting the "Oculostenotic Reflex"

Grace A. Lin, MD, MAS; R. Adams Dudley, MD, MBA

JAMA Internal Medicine 2014;174:1621-1622

In rec
tific c
cutan

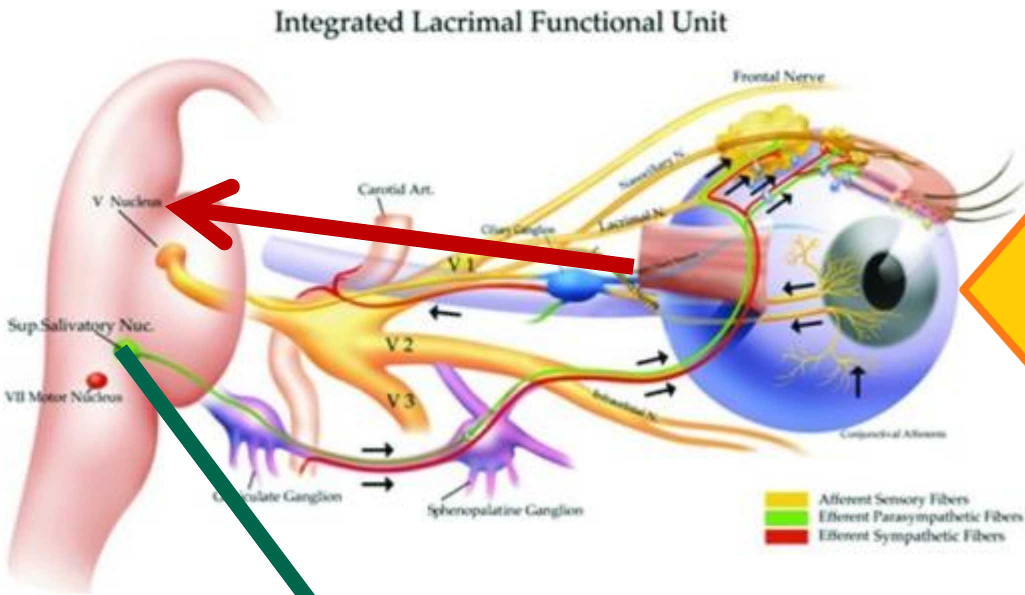
Relatec
1623 ar

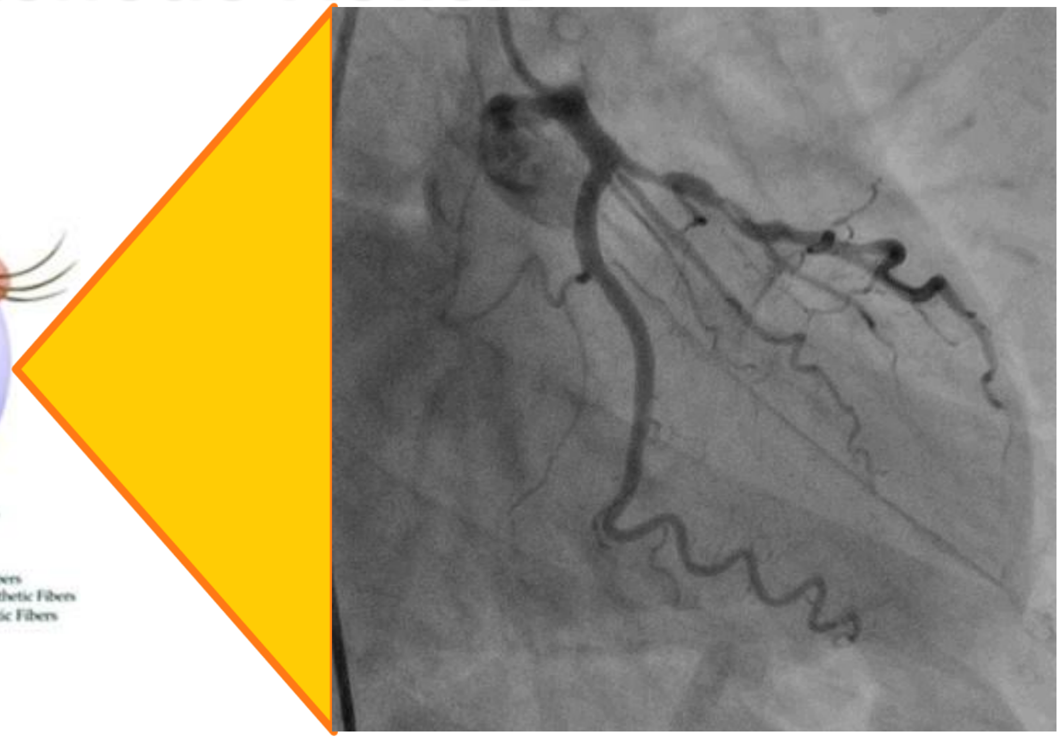
myoc
diova
howe
term
this si
concl
with
Unite
angin

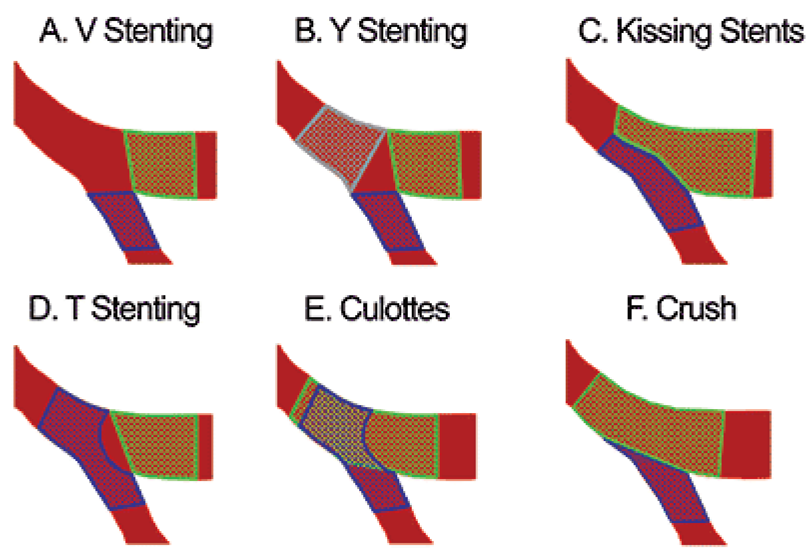
show
gina
In th
to th
cula
tion
also
The
agn
the
of b

major reason for current practice. Many physicians are influenced by the so-called oculostenotic reflex, in which any significant stenosis seen during the catheterization is subject to treatment, even if evidence suggests no benefit. In focus groups conducted in 2007,[4(p1606)] cardiologists described how patients "could not escape" a procedure once they were in the catheterization laboratory. One physician stated, "I think we all know that we're not necessarily preventing heart attacks by treating asymptomatic stenosis…but nonetheless that patient leaves the lab with an open artery, the best that my interventional partners can offer." The medical culture appears to reinforce this cognitive bias toward intervention, resulting in non-evidence-based treatment decisions.

Oculostenotic Reflex



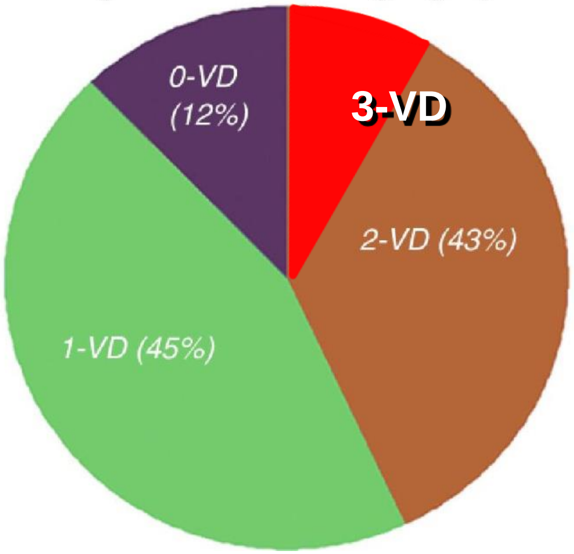




Lesion assessment in FAME Study
Angiography vs FFR

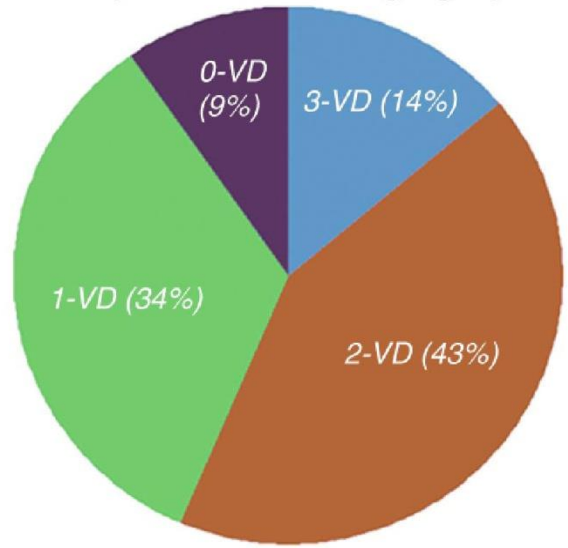
Tonino PAL, et al. J Am Coll Cardiol 2010;55:2816-2821

Number of functionally diseased vessels (0-, 1-, 2-, or 2-VD) as proportions of all patients with angiographic 2-VD (n=394)



Angiographic 2-VD

Number of functionally diseased vessels (0-, 1-, 2-, or 3-VD) as proportions of all patients with angiographic 3-VD (N=115)*



Angiographic 3-VD

There might be concern about the reduction of PCI number if physiological assessment has to be performed frequently.

Why Don't We Use Physiology More Often in the Cath. Labo?

- Re-imbursement issue: insurance coverage
- Oculo-stenotic reflex: Many interventionist might be anatomy first more than physiology as angio-believers
- Difficulty to understand the concept of coronary physiology completely.
- Difficulty of the wire manipulation compared with other work force wires.
- Patients discomfort & time consuming procedure.

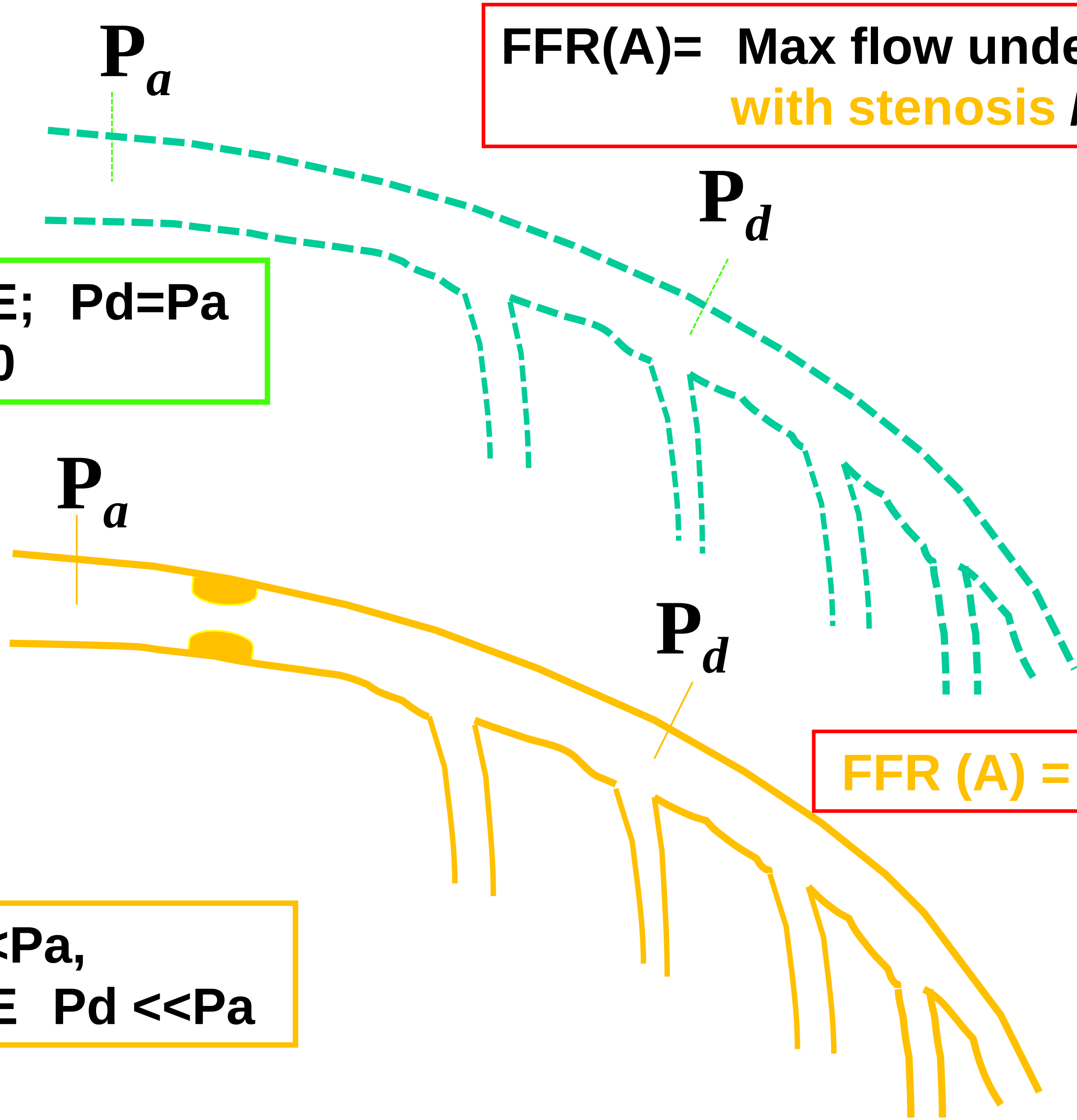
Measurement of FFRmyo

FFR(A)= Max flow under the condition with stenosis / without stenosis

No stenosis

During HE; Pd=Pa
$P_d / P_a = 1.0$

Stenosis（A）



FFR (A) = P_d / P_a during HE

Rest Pd<Pa,
During HE Pd <<Pa

Concept of FFRmyo

First, it will be p
pressure (P_a) and
subtraction of ver
purpose, suppose i
P_v, that $R_s=\infty$ and
and $P_d=P_w$ by defi

and

Therefore

P
P

Equation A1a can
forms, which will b

and

where C_1, C_2, and
collateral resistanc
dial bed supplied b
The second step
of the stenotic cor

Because $Q_c^N=0$:

Substitution of
tion A1b, gives th

$FFR_{cor}=$

Next, fractional
calculated as follo

$FFR_{myo}=$

Equation A3 ha

The contributi
calculated as follo

Therefore:

and because $Q_s^N=$

In case of inte
maximum vasodil
pressure P_a-P_v. T
through the coron
intervention (situ

By substitution

Note that for evalu
stenotic artery after
better measure than
independent of arter
clear that

$$\frac{FFR_{cor}^{(2)}}{FFR_{cor}^{(1)}}=\frac{P_d^{(2)}-P_w}{P_a^{(2)}-P_w}$$

$$=\left(1-\frac{\Delta}{P_a^{(2)}}\right.$$

The expression FF
of FFR_{cor} of the dila
called pressure-correc
previous study.[11]
Equation A5a can a
the following:

$$\frac{Q_s^{(2)}}{Q_s^{(1)}}=\frac{Q^{(2)}-Q_c}{Q^{(1)}-Q_c}$$

and by substituting E
Theoretically, maxi
dium can be compare

$$\frac{Q^{(2)}}{Q^{(1)}}=$$

or, if correction for p

$$\frac{FFR_{myo}^{(2)}}{FFR_{myo}^{(1)}}=\frac{P_d^{(2)}-P_v^{(2)}}{P_a^{(2)}-P_v^{(2)}}$$

$$=\left(1-\frac{\Delta}{P_a^{(2)}}\right.$$

Finally, the theoretical relation between collateral flow at different degrees of stenosis can be obtained. From Figure 1, it is clear that $Q_c=(P_a-P_d)/R_c$. Therefore:

$$\frac{Q_c^{(2)}}{Q_c^{(1)}}=\frac{(P_a^{(2)}-P_d^{(2)})/R_c}{(P_a^{(1)}-P_d^{(1)})/R_c}=\frac{\Delta^{(2)}P}{\Delta^{(1)}P} \quad \text{(A7a)}$$

or, if correction for pressure changes is made:

$$\frac{Q_c^{(2)}}{Q_c^{(1)}}=\frac{\Delta^{(2)}P}{P_a^{(2)}-P_v^{(2)}}:\frac{\Delta^{(1)}P}{P_a^{(1)}-P_v^{(1)}} \quad \text{(A7b)}$$

In fact, Equation A7 states that decrease of ΔP by improved stenosis geometry after PTCA induces a proportional decrease of the relative contribution of collateral flow to total myocardial flow, which will be further clarified in the following examples.

Application of these equations in clinical practice also will be demonstrated.

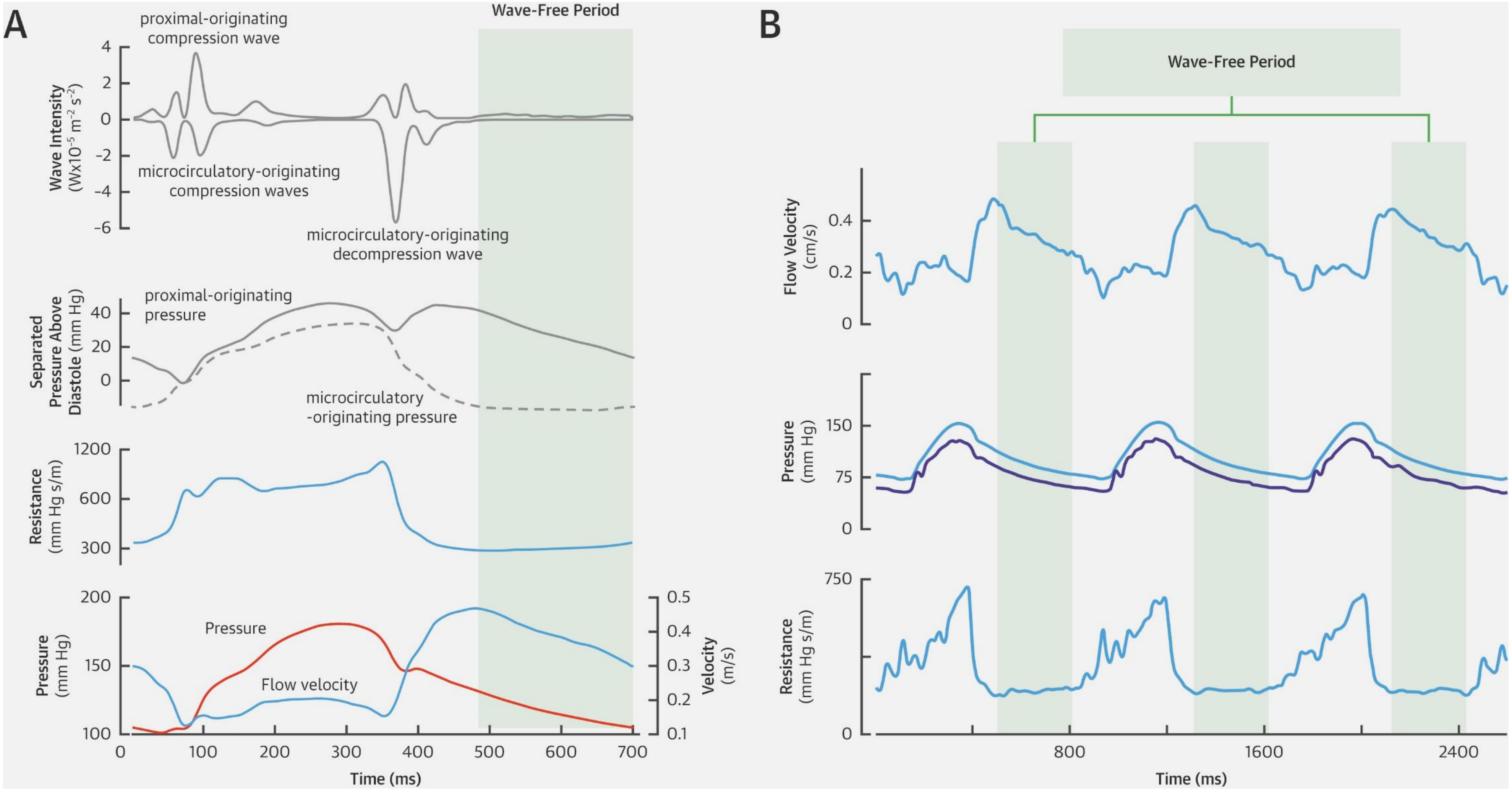
Example 1

The first example is based on the simple hemodynamic case in which systemic pressures (P_a and P_v) are unchanged during PTCA. Therefore, according to Equation A1a, wedge pressure (P_w) also is constant.

Before and after PTCA of one of the coronary arteries, pressure measurements are performed by the pressure-monitoring guide wire at maximum coronary hyperemia induced by intracoronary administration of papaverine or adenosine. Mean arterial pressure (P_a) is 90 mm Hg both before and after the procedure; transstenotic pressure gradient ΔP is reduced from 50 mm Hg before to 10 mm Hg after the procedure; and venous pressure (P_v) is 0 both before and after the procedure. P_w measured during balloon inflation, is 20 mm Hg. Therefore, $P_a^{(1)}=P_a^{(2)}=90$ mm Hg, $P_d^{(1)}=40$ mm Hg, $P_d^{(2)}=80$ mm Hg, $P_v^{(1)}=P_v^{(2)}=0$ mm Hg, and $P_w^{(1)}=P_w^{(2)}=20$ mm Hg.

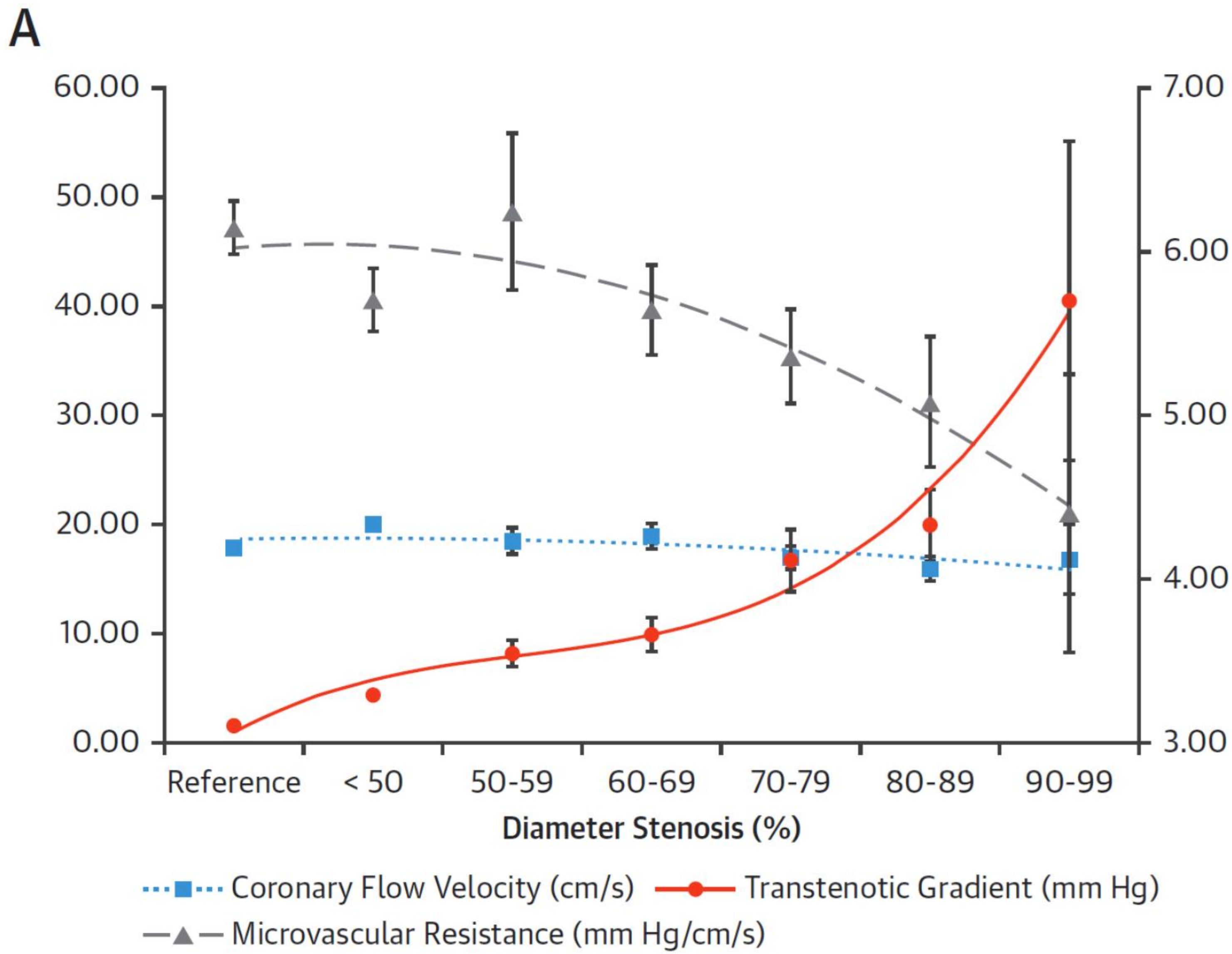
With Equations A6b, A5b, and A7b, the following is obtained:

Wave free period & iFR



Nijjer SS, et al. Circ J 2015;79:1172–1184.

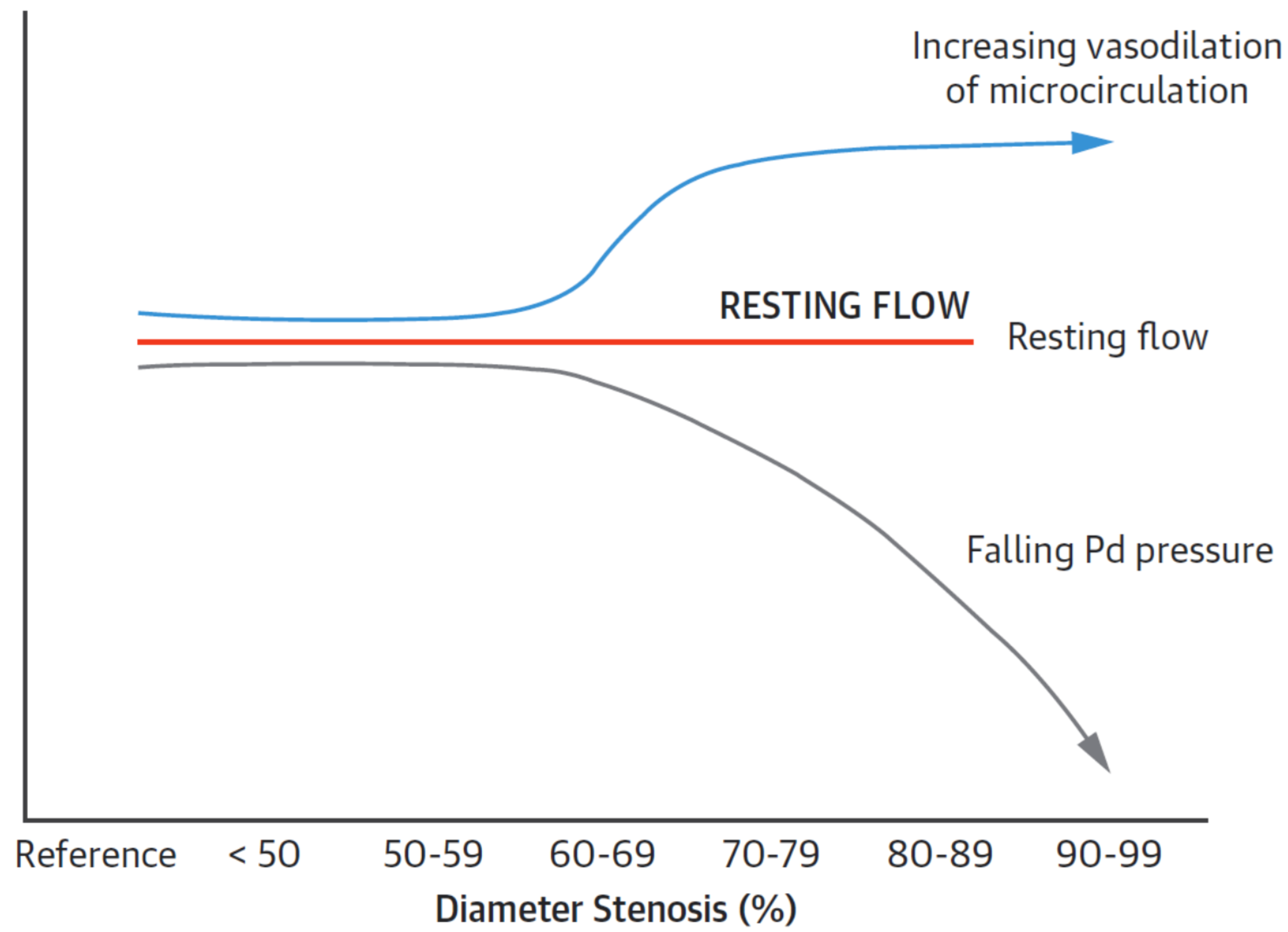
Coronary Autoregulation as a Means of Quantifying Stenosis Severity Under Resting Conditions



Gōtberg M, et al. J Am Coll Cardiol 2017;70:1379-1402

Wakayama Medical University

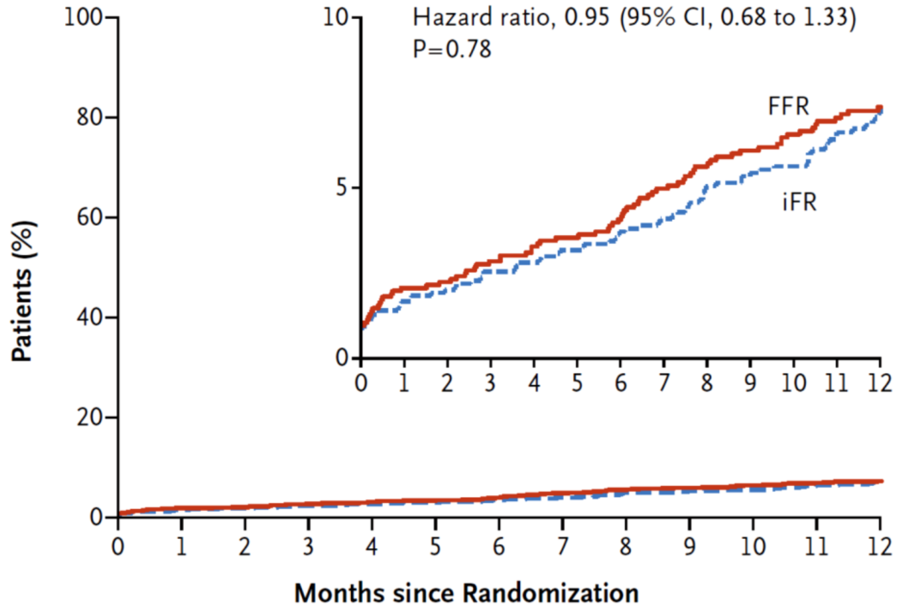
Coronary Autoregulation as a Means of Quantifying Stenosis Severity Under Resting Conditions



Gōtberg M, et al. J Am Coll Cardiol 2017;70:1379-1402

DEFINE-FLAIR

Cumulative Risk of the Primary Endpoint



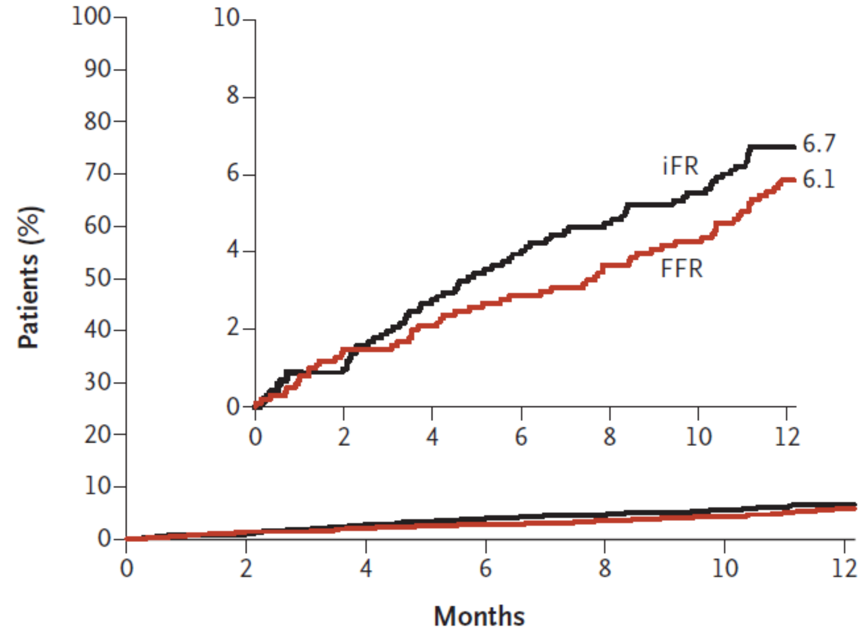
No. at Risk

iFR	1242	1149	1131	1122	1118	1111	1088	1052	1037	1027	1019	995	764
FFR	1250	1169	1156	1149	1144	1141	1119	1081	1066	1055	1046	1017	793

Davies JE, et al. N Engl J Med 2017;376:1824-34.

SWEDEHEART

Kaplan-Meier Curve for the Primary Endpoint



No. at Risk

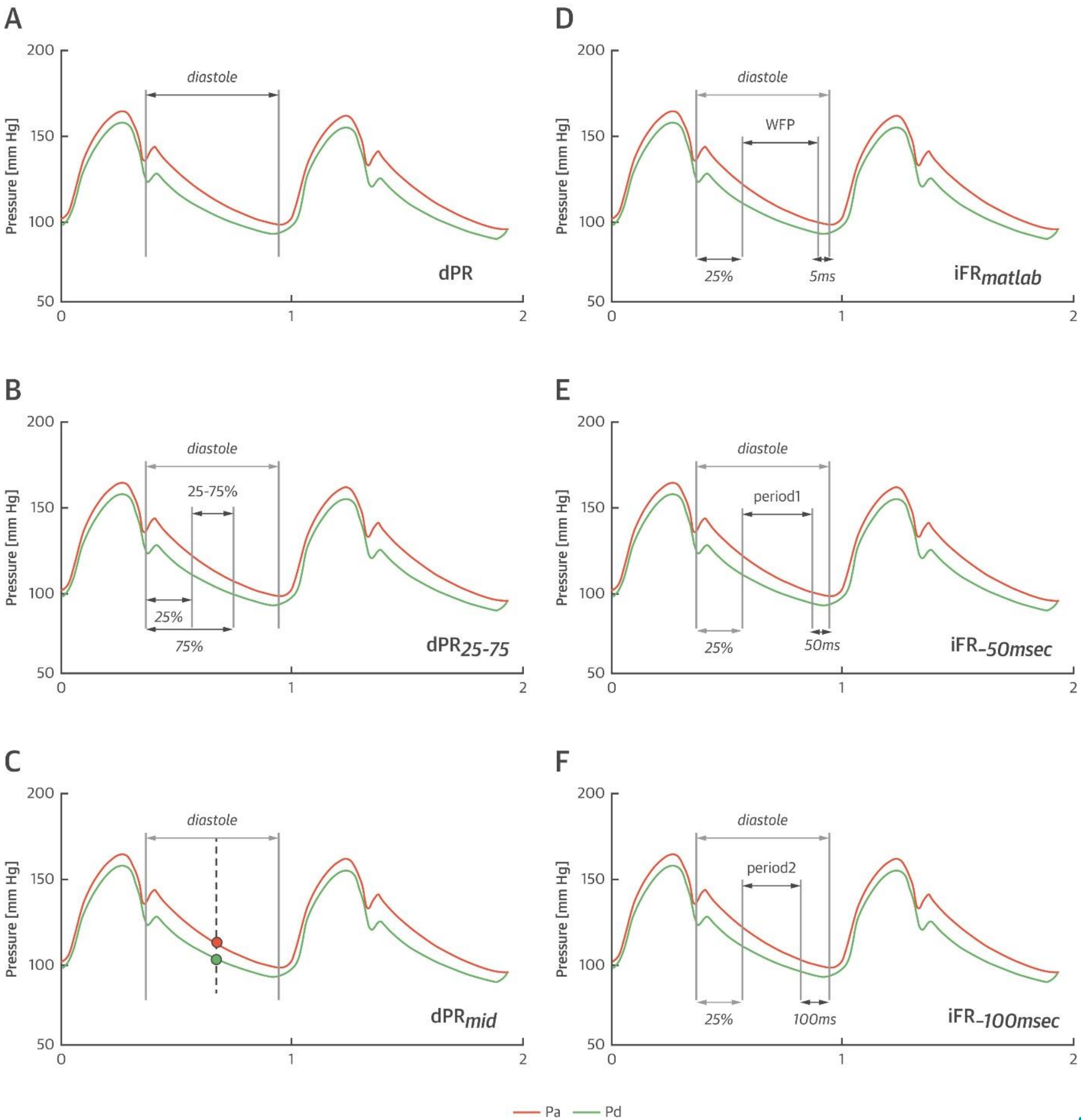
iFR	1012	1002	984	971	963	956	944
FFR	1007	990	984	976	968	961	946

Gōtberg M, et al. N Engl J Med 2017;376:1813-23.

Comparison among coronary physiology measurement

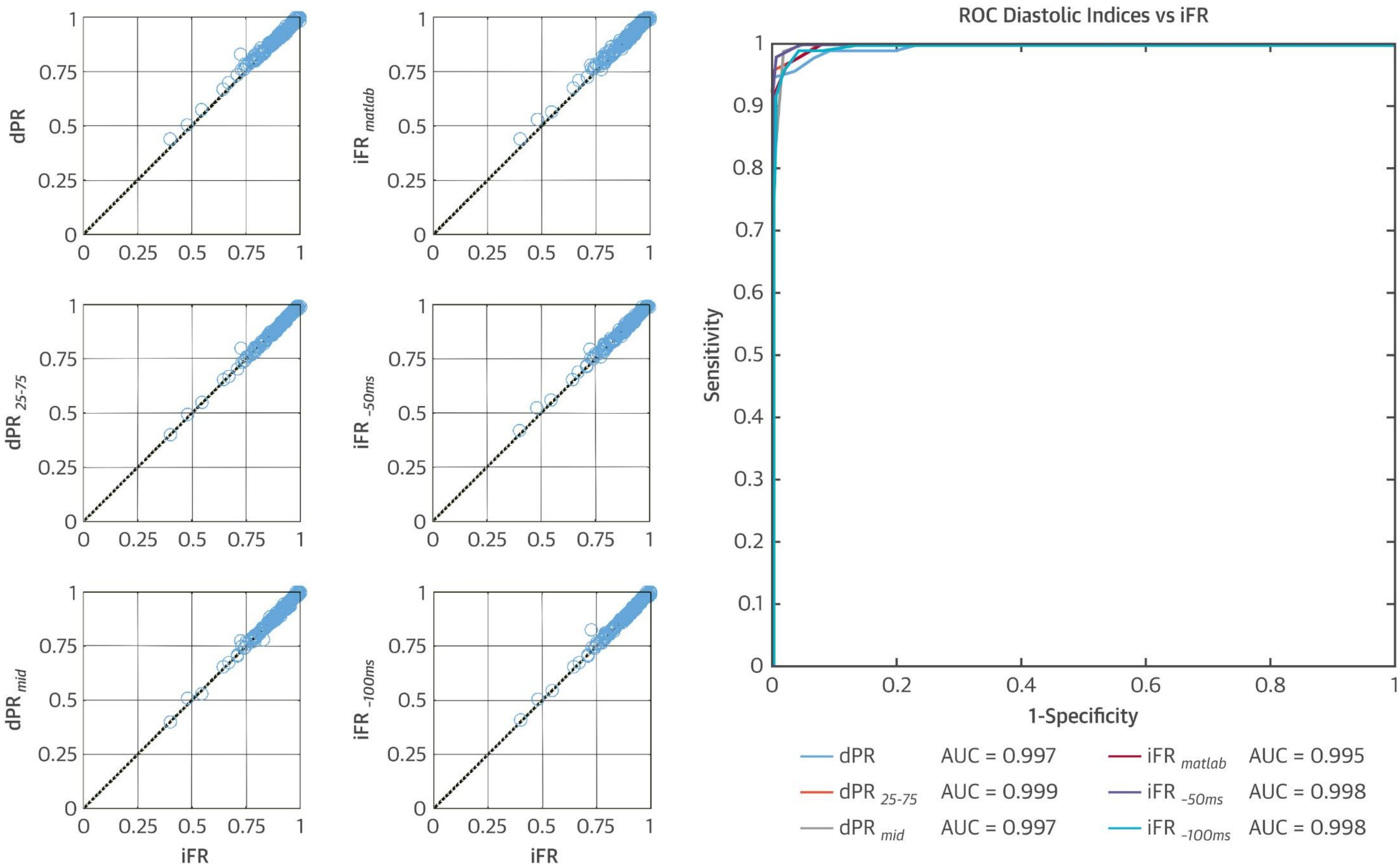
System	Abbott	Acist	Boston	Opsens	Philips
Type of Sensor	Piezo-Electric	Optical	Optical	Optical	Piezo-Electric
Torqueability	△	N/A	○	◎	△
Drift	△	○	○	◎	△
Reconnection	△	N/A	○	◎	△
Display	◎	△	○	△	○
Evidence	◎	△	△	△	○
Flow data	◎	-	-	-	○
Co-registration	-	-	-	-	◎
Resting index	RFR	dPR	DFR	dPR	iFR

Different diastolic indexes



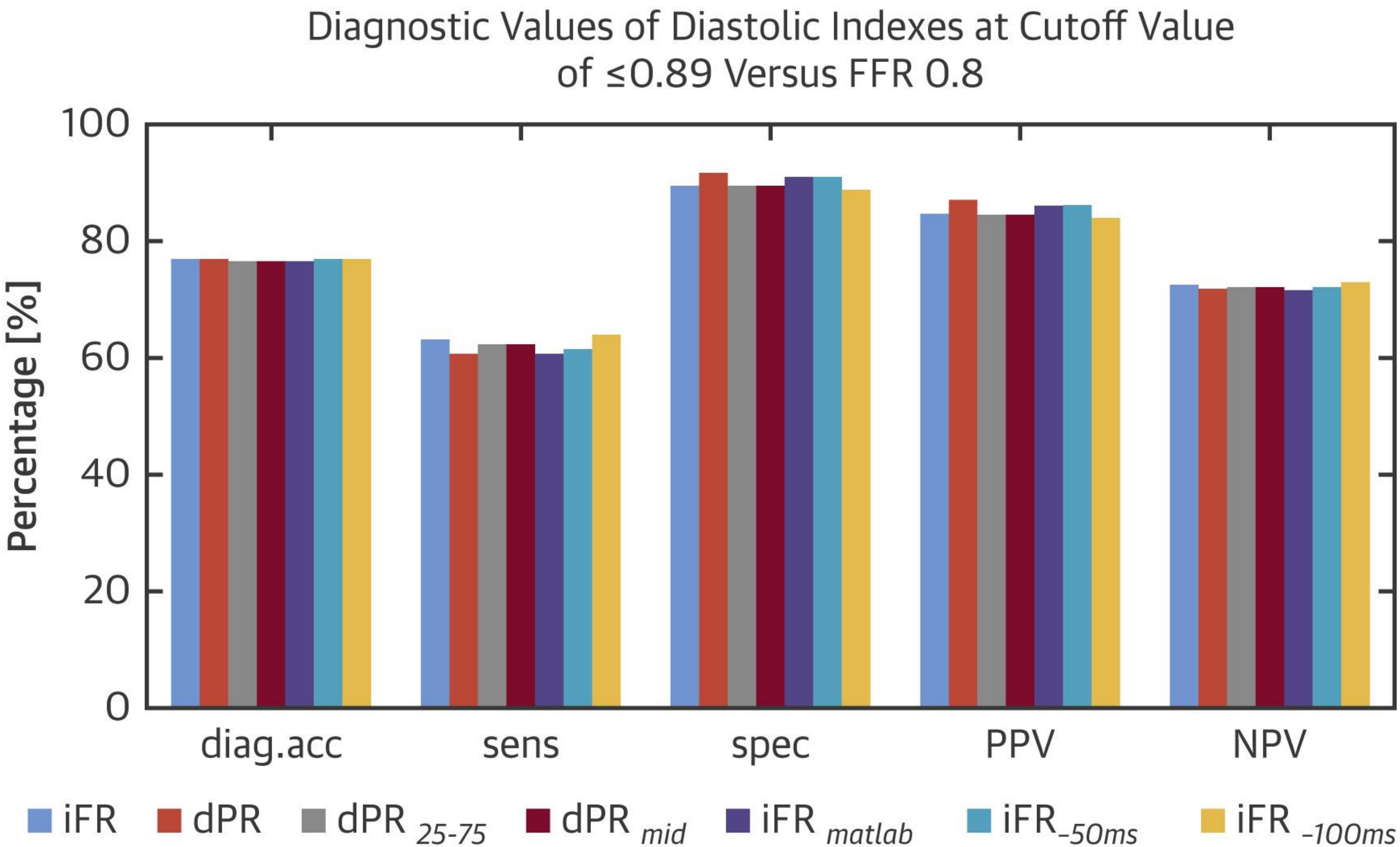
van’t Veer M, et al. J Am Coll Cardio 2017;70:3088-3096.

Comparison among different diastolic indexes & iFR

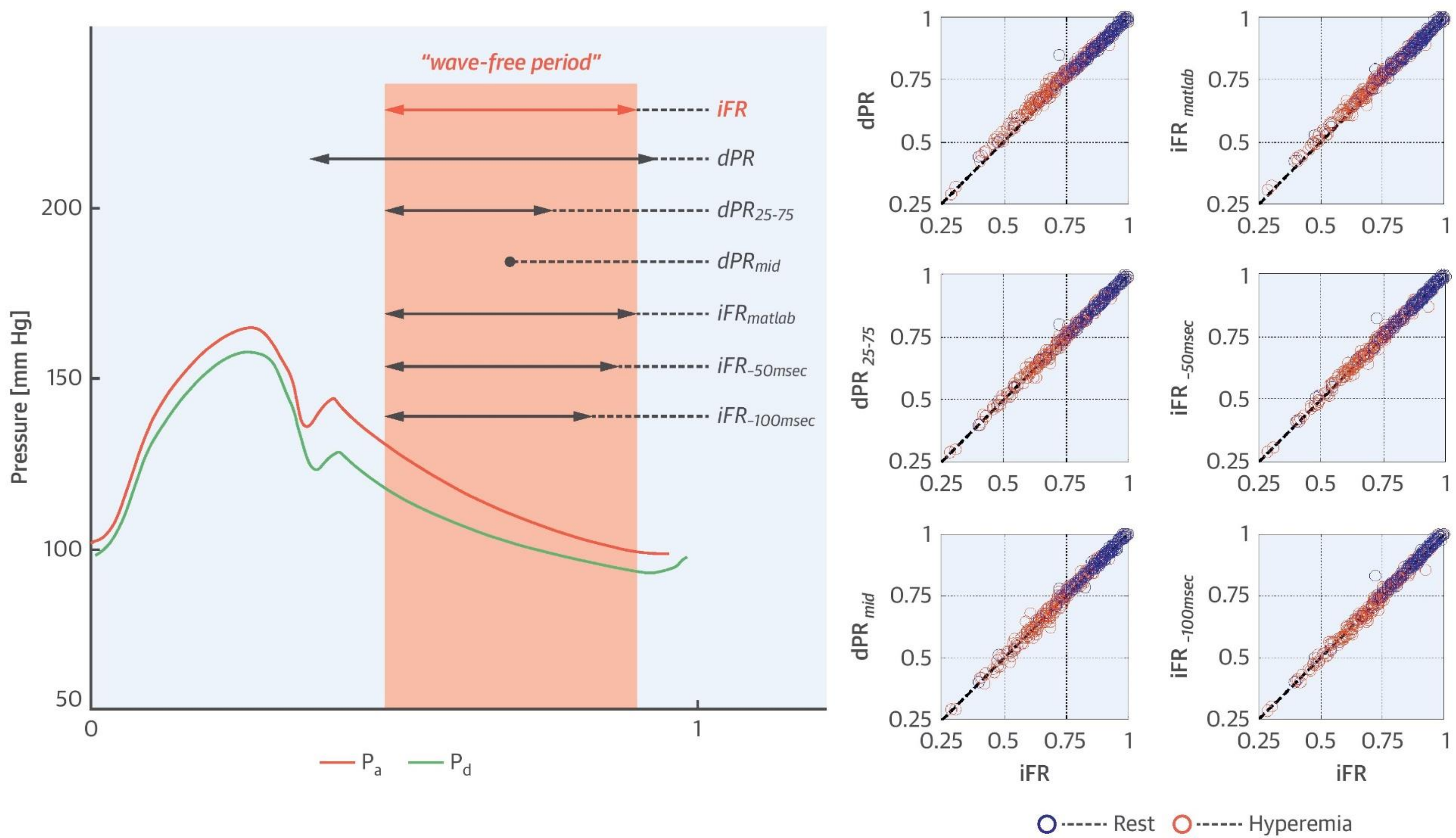


van't Veer M, et al. J Am Coll Cardio 2017;70:3088-3096.

Wakayama Medical University

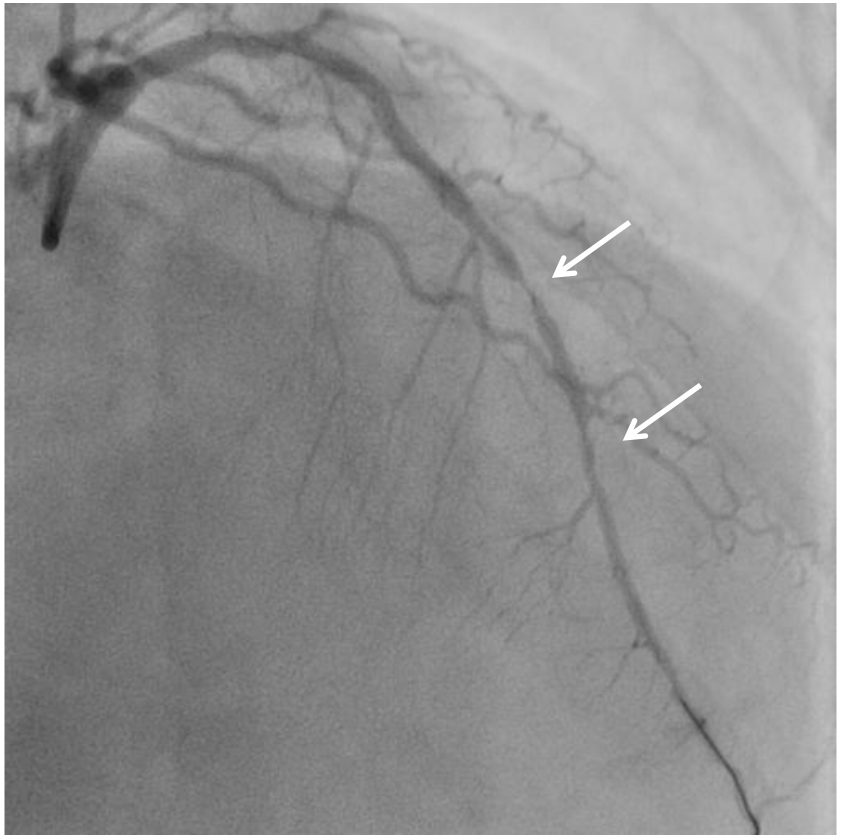

Diagnostic Values of Diastolic Indexes at Cutoff Value
of ≤0.89 Versus FFR 0.8
Percentage [%]
100
80
60
40
20
0
diag.acc
sens
spec
PPV
NPV
iFR
dPR
dPR 25-75
dPR mid
iFR matlab
iFR-50ms
iFR -100ms

CENTRAL ILLUSTRATION: Correlations and AUC Values >0.99 for All Resting Pd/Pa Ratios Over Different Periods in Diastole Compared With iFR as the Reference Standard

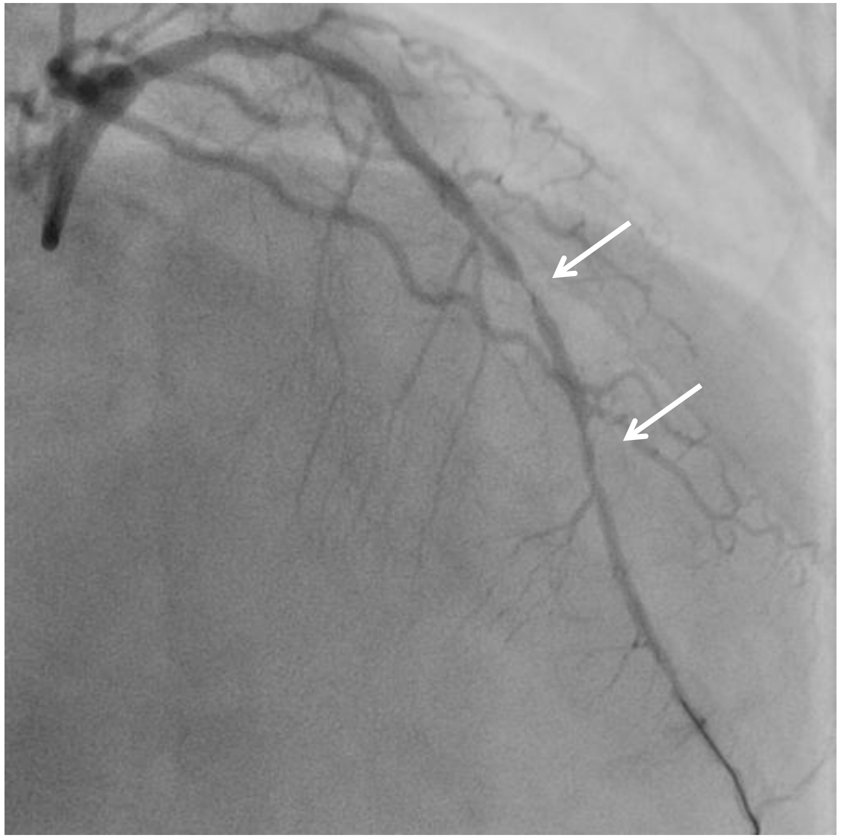


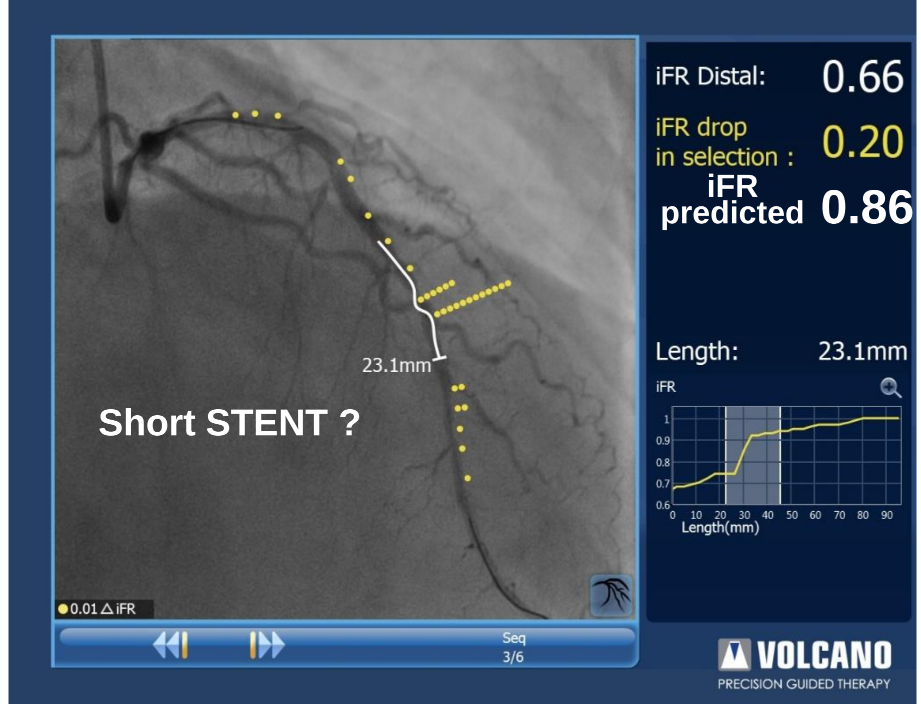
van't Veer, M. et al. J Am Coll Cardiol. 2017;70(25):3088-96.

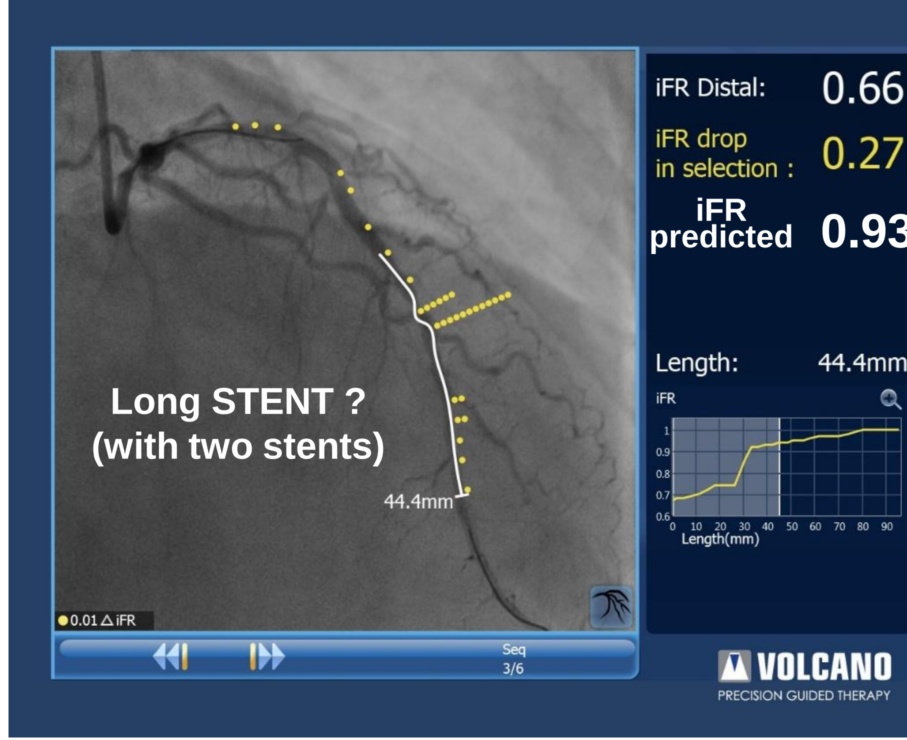
PCI case with iFR co-registration



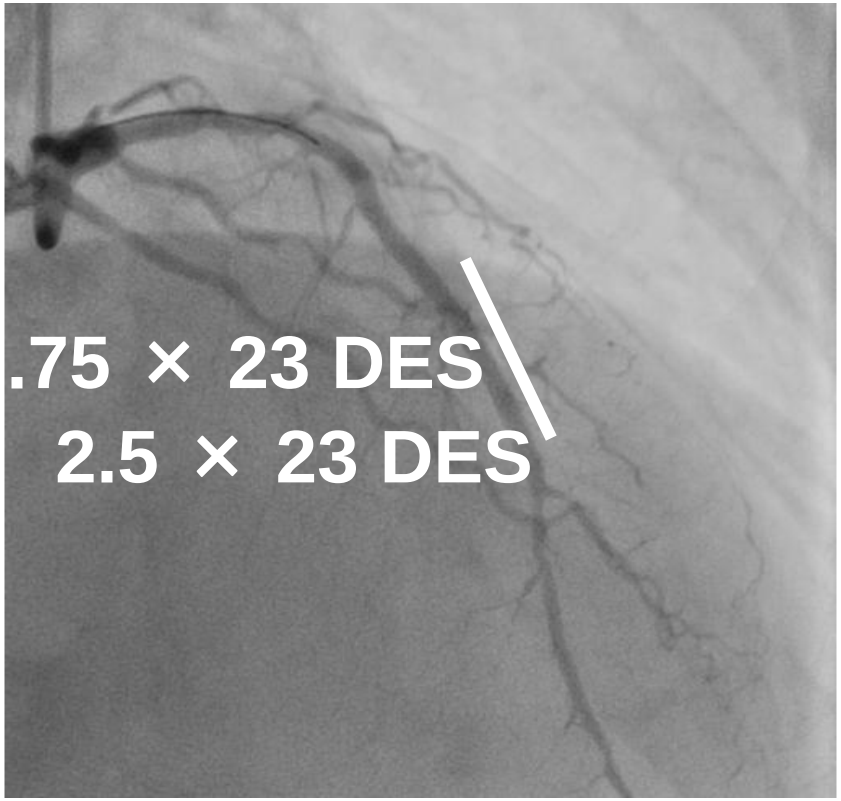
Prediction of post PCI iFR by Syncvision

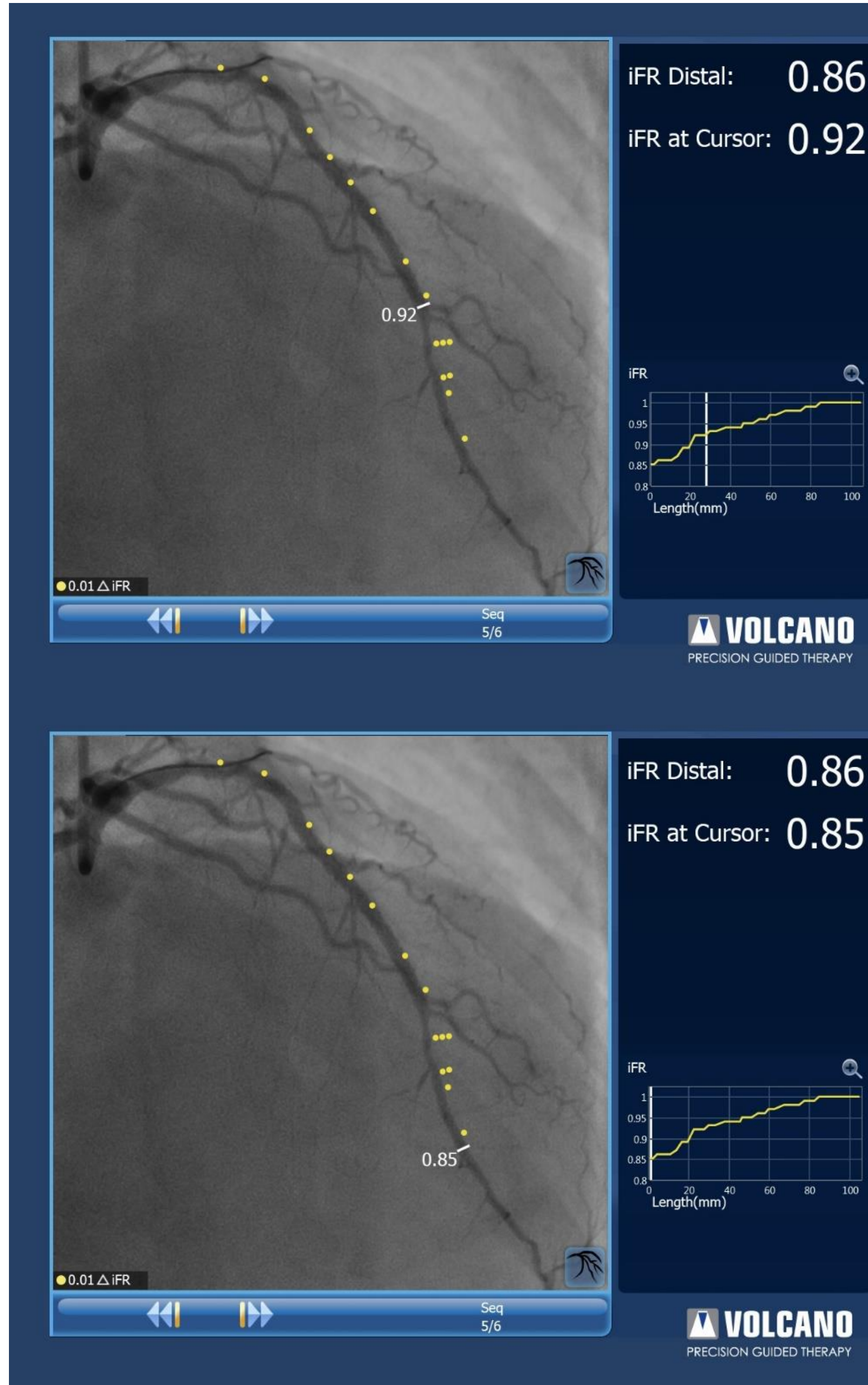






Prediction of post PCI iFR by Syncvision

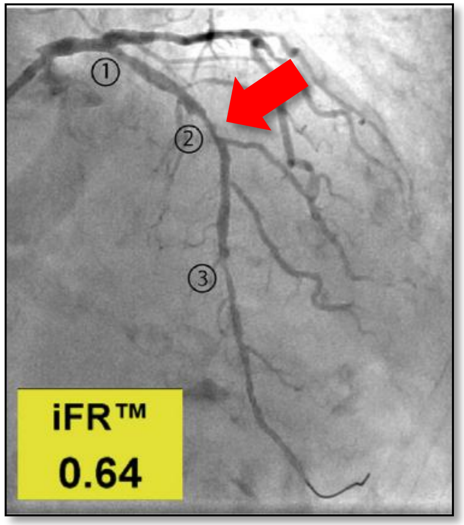


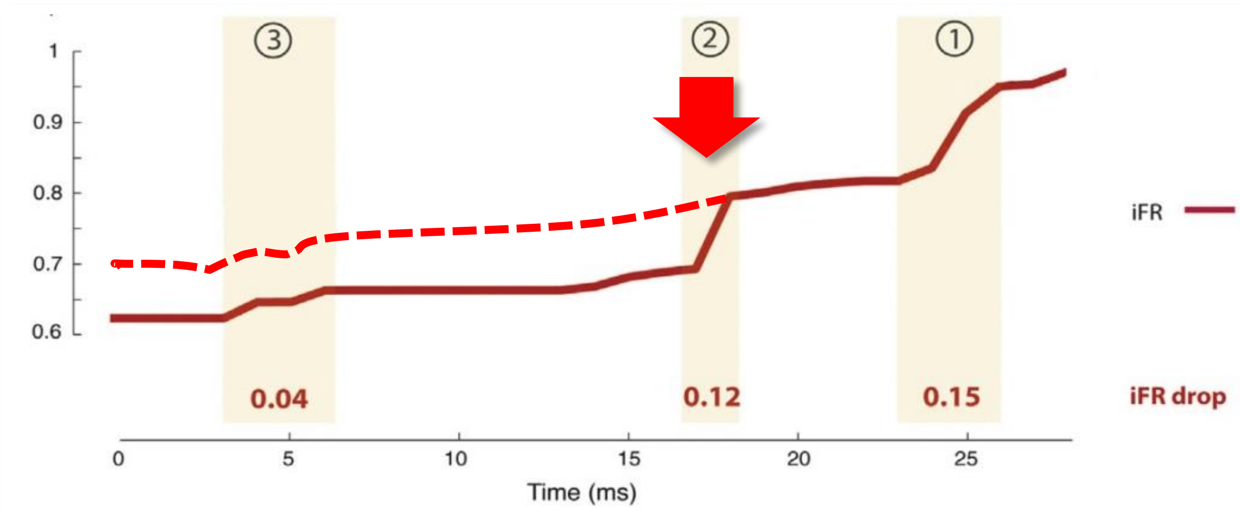


We chose a short stent.

University

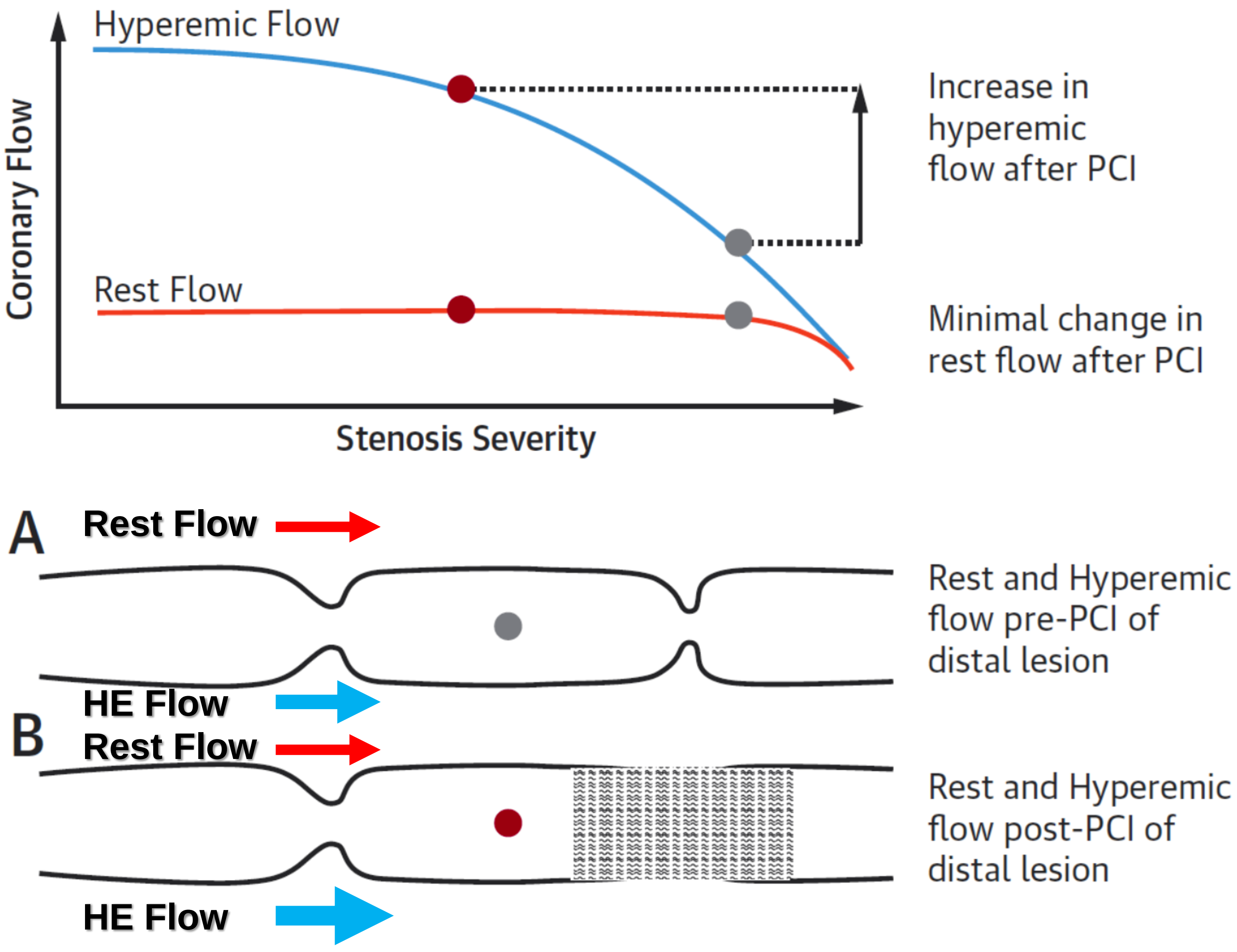
iFR Pullback





Nijjer S, et al. JACCint 2014; 12: 1386-1396.

The Expected Behavior of Hyperemic and Resting Flow After Removal of Stenosis



Gōtberg M, et al. J Am Coll Cardiol 2017;70:1379-1402

Why Don't We Use Physiology More Often in the Cath. Labo?

- Re-imbursement issue: insurance coverage
- Oculo-stenotic reflex: Many interventionist might be anatomy first more than physiology as angio-believers
- Difficulty to understand the concept of coronary physiology completely.
- Difficulty of the wire manipulation compared with other work force wires.
- Patients discomfort & time consuming procedure.

Comparison among coronary physiology measurement

System	Abbott	Acist	Boston	Opsens	Philips
Type of Sensor	Piezo-Electric	Optical	Optical	Optical	Piezo-Electric
Torqueability	△	N/A	○	◎	△
Drift	△	○	○	◎	△
Reconnection	△	N/A	○	◎	△
Display	◎	△	○	△	○
Evidence	◎	△	△	△	○
Flow data	◎	-	-	-	○
Co-registration	-	-	-	-	◎
Resting index	RFR	dPR	DFR	dPR	iFR

Why Don't We Use Physiology More Often in the Cath. Labo?

- Re-imbursement issue: insurance coverage
- Oculo-stenotic reflex: Many interventionist might be anatomy first more than physiology as angio-believers
- Difficulty to understand the concept of coronary physiology completely.
- Difficulty of the wire manipulation compared with other work force wires.
- Patients discomfort & time consuming procedure.

Procedural Characteristics (DEFINE-FLAIR)

Superiority of iFR to FFR

Variable	iFR Group (N=1242)	FFR Group (N=1250)	P Value†
Stents placed with postdilation — no. (% of total stents placed)	407 (49.5)	425 (46.9)	0.28
PCI procedures performed with pressure wire — no. (% of total stents placed)	261 (31.8)	278 (30.7)	0.63
Patient-reported adverse procedural symptoms or signs — no. of patients (%)	39 (3.1)	385 (30.8)	<0.001
Patient-reported dyspnea — no. of patients (%)	13 (1.0)	250 (20.0)	
Patient-reported chest pain — no. of patients (%)	19 (1.5)	90 (7.2)	
Physician-reported adverse procedural signs — no. of patients (%)			
Heart-rhythm disturbance	2 (0.2)	60 (4.8)	
Significant hypotension	4 (0.3)	13 (1.0)	
Vomiting or nausea	1 (0.1)	11 (0.9)	
Ventricular arrhythmia or bronchospasm¶	1 (0.1)	8 (0.6)	
Other	4 (0.3)	38 (3.0)	

Davies JE, et al. N Engl J Med 2017;376:1824-34.

Procedural Characteristics (DEFINE-FLAIR)

Superiority of iFR to FFR

Variable	iFR Group (N=1242)	FFR Group (N=1250)	P Value†
Radial-artery approach — no. of patients (%)	896 (72.1)	888 (71.0)	0.54
Procedure time — min			
Median	40.5	45.0	0.001
Interquartile range	27.0–60.0	30.0–66.0	
Hyperemic agent administered — no. of patients (% of total no. who received a hyperemic agent)			
Total	NA	1608 (100)	
Intracoronary adenosine	NA	455 (28.3)	
Intravenous adenosine	NA	950 (59.1)	
Other agent	NA	203 (12.6)	
Multivessel disease — no. of patients (%)	505 (40.7)	519 (41.5)	0.66
Type of vessel evaluated — no. (% of total vessels evaluated)‡			
Total	1575 (100)	1608 (100)	0.58
Left anterior descending artery	844 (53.6)	845 (52.5)	0.56
Left circumflex artery	323 (20.5)	333 (20.7)	0.89
Right coronary artery	374 (23.7)	393 (24.4)	0.65
Other	33 (2.1)	31 (1.9)	0.74
Unknown	1 (0.1)	6 (0.4)	0.06

Davies JE, et al. N Engl J Med 2017;376:1824-34.

Procedural Characteristics (SWEDEHEART)

Superiority of iFR to FFR

Characteristic	iFR Group (N=1012)	FFR Group (N=1007)	P Value
Radial-artery approach — no. of patients (%)	841 (83.1)	811 (80.5)	0.13
Contrast material used per patient — ml			0.10
Median	110	115	
Interquartile range	80–155	80–160	
Procedure time — min†			0.09
Median	50.8	53.1	
Interquartile range	13.8–87.8	18.1–88.1	
Fluoroscopy time — min			0.57
Median	10.5	10.2	
Interquartile range	6.3–16.8	6.5–16.0	
Intravenous adenosine administered — no. of patients (%)	NA	695 (69.0)	
Total no. of lesions evaluated	1568	1436	
Chest discomfort during procedure			<0.001†
None	982 (97.0)	319 (31.7)	
Mild	26 (2.6)	316 (31.4)	
Moderate	2 (0.2)	285 (28.3)	
Severe	2 (0.2)	87 (8.6)	

Gotberg M, et al. N Engl J Med 2017;376:1813-23

ESC European Society of Cardiology
European Heart Journal (2018) **00**, 1–96
doi:10.1093/eurheartj/ehy394

ESC/EACTS GUIDELINES

2018 ESC/EACTS Guidelines on myocardial revascularization

The Task Force on myocardial reva
Society of Cardiology (ESC) and Eu
Cardio-Thoracic Surgery (EACTS)

Developed with the special contrib
Association for Percutaneous Card

Authors/Task Force Members: Franz-Josef I
(Germany), Miguel Sousa-Uva*[1] (EACTS C
(Sweden), Fernando Alfonso (Spain), Adria
(UK), Robert A. Byrne (Germany), Jean-Ph
(Germany), Stuart J. Head[1] (The Netherlar
Adnan Kastrati (Germany), Akos Koller (Hu
Josef Niebauer (Austria), Dimitrios J. Richte
Dirk Sibbing (Germany), Giulio G. Stefanini
(Switzerland), Rashmi Yadav[1] (UK), Michae

Document Reviewers: William Wijns (ESC Review Co-
Co-ordinator) (Canada), Victor Aboyans (France), Step
(Norway), Felicita Andreotti (Italy), Emanuele Barbato
(Canada), Héctor Bueno (Spain), Patrick A. Calvert (UI

Recommendations on functional testing and intravascular imaging for lesion assessment

Recommendations	Class[a]	Level[b]
When evidence of ischaemia is not available, FFR or iwFR are recommended to assess the haemodynamic relevance of intermediate-grade stenosis.[15,17,18,39]	I	A
FFR-guided PCI should be considered in patients with multivessel disease undergoing PCI.[29,31]	IIa	B
IVUS should be considered to assess the severity of unprotected left main lesions.[35–37]	IIa	B

Why Don't We Use Physiology More Often in the Cath. Labo?

Coronary Psychology

J Am Coll Cardiol Intv 2018;11:1492-1494

Do You Believe?*

Nils P. Johnson, MD, MS,[a]

don't interventional cardiologists use coronary physiology?" As demonstrated by both virtual (4) and real-world (2) studies, and large temporal increases in its uptake (**Table 1**), factors such as cost, reimbursement, need for hyperemic drugs or pressure sensor design and delivery play minor roles. Although operators can be reluctant to admit it (3), the fundamental reason has received different labels: attitude, belief, local practice, "experience," and culture. Put simply, we as a profession do not yet emotionally accept coronary physiology to guide treatment. Call it "coronary psychology."

Take home message

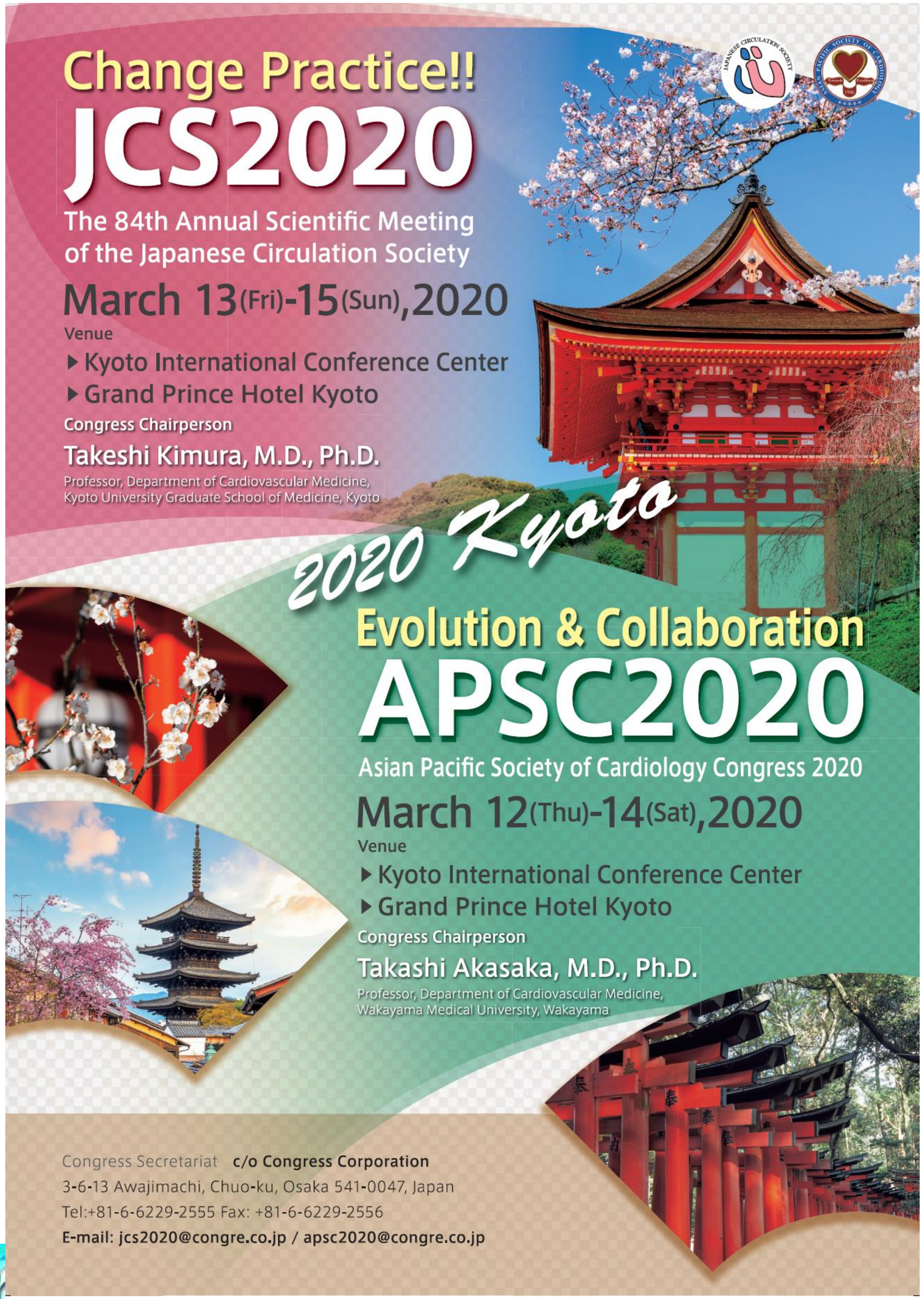
Why Don't We Use Physiology More Often in the Cath. Labo ?

My private opinion with no scientific evidence!!

- There are many issues which lead the interventionists not to use physiology so often in the cath. labo.
  - Re-imbursement & income
  - Difficulty of coronary physiology concept

Let’s Use Physiology !!

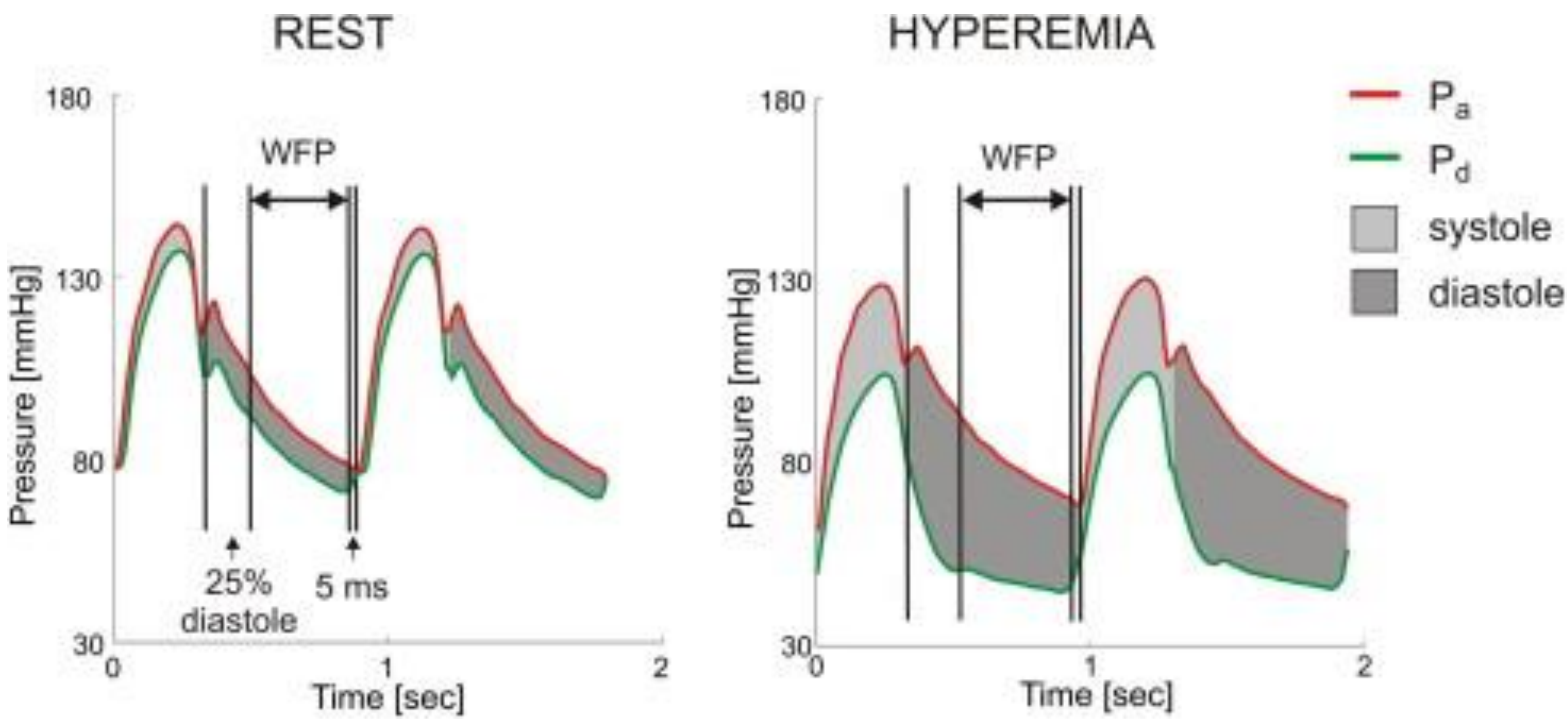
- There are still many visual first PCI physicians who are anatomy believer and staying in fantastic illusion world where PCI can improve patients prognosis even in stable coronary artery disease, and they cannot escape from the addiction of oculo-stenotic reflex.



Thank you for your kind attention !!

Welcome to APSC 2020 in Kyoto, Japan!!

iFR


REST
HYPEREMIA
180
130
80
30
Pressure [mmHg]
WFP
25%
diastole
5 ms
0
1
2
Time [sec]
P_a
P_d
systole
diastole

Validation of a novel non-hyperemic index of coronary artery stenosis severity - the Resting Full-cycle Ratio (RFR) - *VALIDATE RFR*

J Svanerud, JM Ahn, A Jeremias, M van 't Veer, A Gore, A Maehara, A Crowley, N. Pijls, B De Bruyne, N Johnson, B Hennigan, S Watkins, C Berry, KG Oldroyd, SJ Park, ZA. Ali

euro PCR 2018 LATE BREAKING TRIALS

Validation of a novel non-hyperaemic index of coronary artery stenosis severity: the Resting Full-cycle Ratio (VALIDATE RFR) study

Johan Svanerud[1], MSc; Jung-Min Ahn[2], MD; Allen Jeremias[3,4], MD; Marcel van 't Veer[5,6], MSc, PhD; Ankita Gore[3,7], BS, MSc; Akiko Maehara[3,7], MD; Aaron Crowley[3], MA; Nico H.J. Pijls[5,6], MD, PhD; Bernard De Bruyne[8], MD, PhD; Nils P. Johnson[9], MD, MS; Barry Hennigan[10], MD; Stuart Watkins[10], MD; Colin Berry[10,11], MD, PhD; Keith G. Oldroyd[10], MD; Seung-Jung Park[2], MD, PhD; Ziad A. Ali[3,7]*, MD, DPhil

1. Coroventis Research AB, Uppsala, Sweden; 2. Asan Medical Center, Seoul, South Korea; 3. Clinical Trials Center, Cardiovascular Research Foundation, New York, NY, USA; 4. St. Francis Hospital, Roslyn, NY, USA; 5. Catharina Hospital, Eindhoven, the Netherlands; 6. Eindhoven University of Technology, Department of Biomedical Engineering, Eindhoven, the Netherlands; 7. NewYork-Presbyterian Hospital/Columbia University Medical Center, New York, NY, USA; 8. The Cardiovascular Center, OLV Hospital, Aalst, Belgium; 9. Weatherhead PET Center, Division of Cardiology, Department of Medicine, McGovern Medical School at UTHealth and Memorial Hermann Hospital, Houston, TX, USA; 10. Golden Jubilee National Hospital, Clydebank, United Kingdom; 11. Institute of Cardiovascular and Medical Sciences, University of Glasgow, Glasgow, United Kingdom

KEYWORDS

- fractional flow reserve
- innovation
- other imaging modalities

Abstract

Aims: Randomised controlled trials have reported instantaneous wave-free ratio (iFR) to be non-inferior to fractional flow reserve (FFR) for major adverse cardiovascular events at one year; however, iFR is limited by sensitive landmarking of the pressure waveform, and the assumption that maximal flow and minimal resistance occur during a fixed period of diastole. We sought to validate the resting full-cycle ratio (RFR), a novel non-hyperaemic index of coronary stenosis severity based on unbiased identification of the lowest distal coronary pressure to aortic pressure ratio (Pd/Pa), independent of the ECG, landmark identification, and timing within the cardiac cycle.

Methods and results: VALIDATE-RFR was a retrospective study designed to derive and validate the RFR. The primary endpoint was the agreement between RFR and iFR. RFR was retrospectively determined in 651 waveforms in which iFR was measured using a proprietary Philips/Volcano wire. RFR was highly correlated to iFR (R^2=0.99, p<0.001), with a mean bias of –0.002 (95% limits of agreement –0.023 to 0.020). The diagnostic performance of RFR versus iFR was diagnostic accuracy 97.4%, sensitivity 98.2%, specificity 96.9%, positive predictive value 94.5%, negative predictive value 99.0%, area under the receiver operating characteristic curve of 0.996, and diagnostically equivalent within 1% (mean difference –0.002; 95% CI: –0.009 to 0.006, p=0.03). The RFR was detected outside diastole in 12.2% (341/2,790) of all cardiac cycles and 32.4% (167/516) of cardiac cycles in the right coronary artery where the sensitivity of iFR compared to FFR was lowest (40.6%).

Conclusions: RFR is diagnostically equivalent to iFR but unbiased in its ability to detect the lowest Pd/Pa during the full cardiac cycle, potentially unmasking physiologically significant coronary stenoses that would be missed by assessment dedicated to specific segments of the cardiac cycle.

**Corresponding author: Columbia University Medical Center; Cardiovascular Research Foundation; 1700 Broadway, 9th Floor; New York; NY 10019; USA. E-mail: zaa2112@columbia.edu*

SUBMITTED ON 30/03/2018 - REVISION RECEIVED ON 1st 28/04/2018 / 2nd 07/05/2018 - ACCEPTED ON 09/05/2018

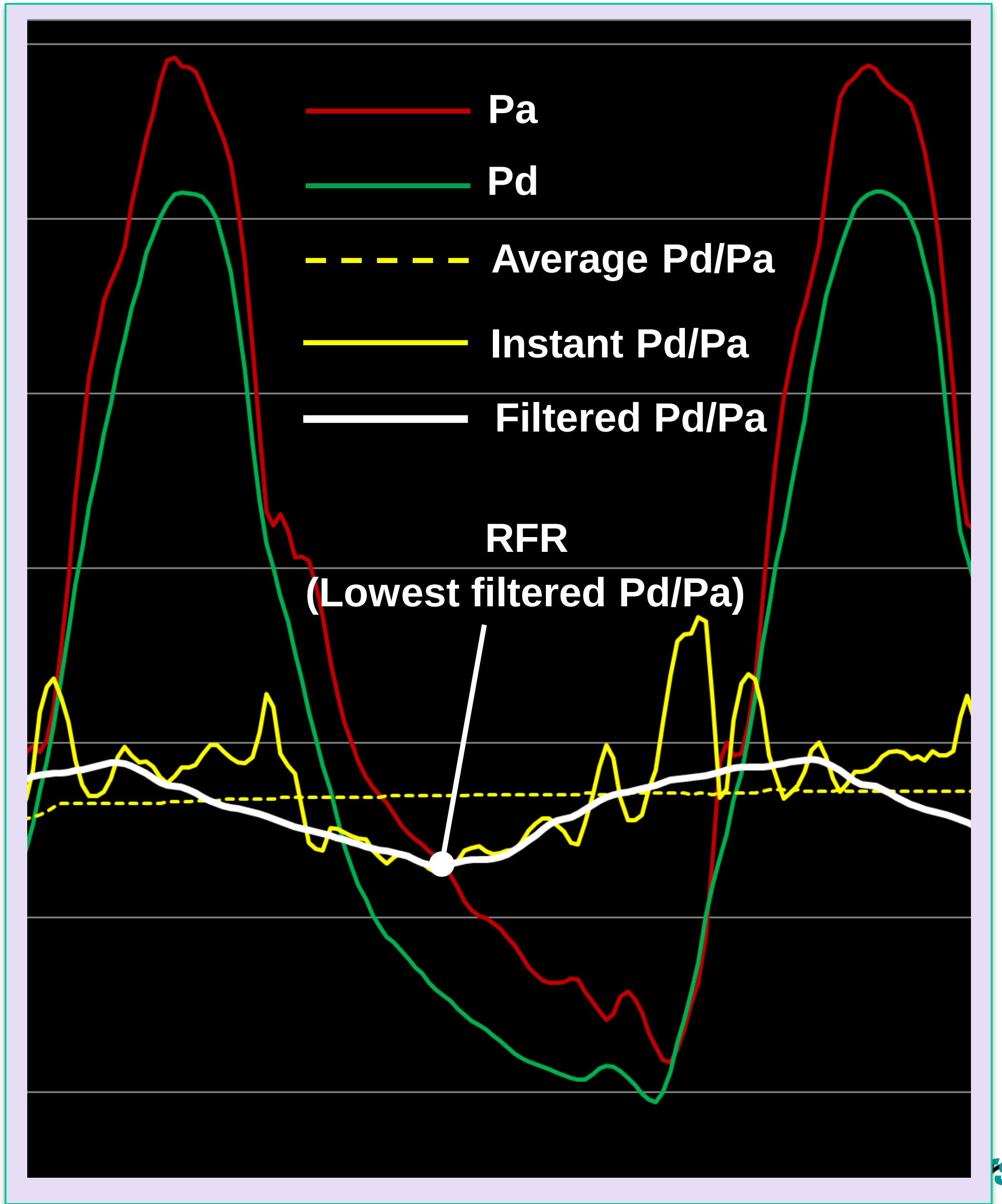
EuroIntervention 2018;14-online publish-ahead-of-print May 2018

DOI: 10.4244/EIJ-D-18-00342

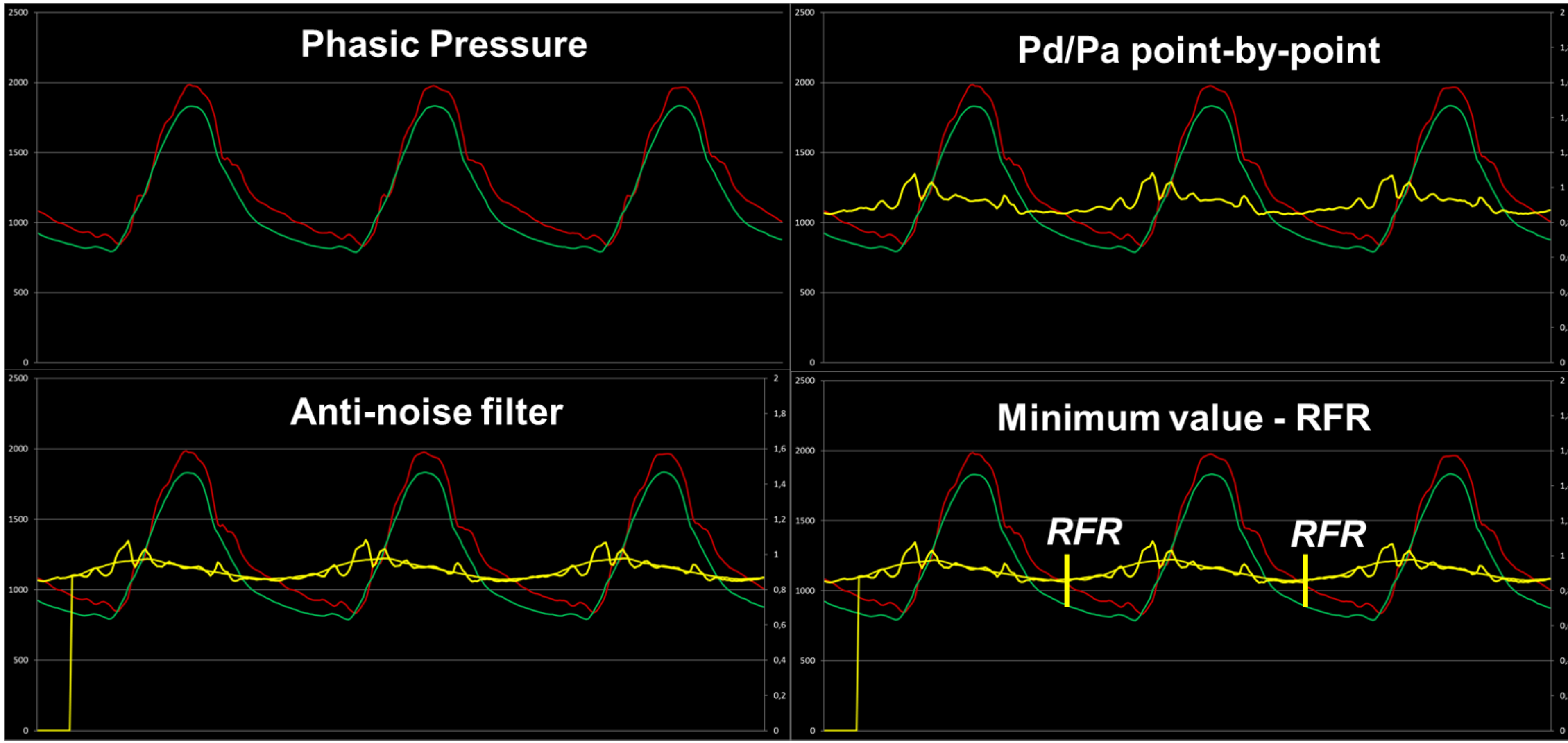
Resting Full-cycle Flow Ratio (RFR)

Lowest Pd/Pa ratio during the entire heart cycle

- Unbiased identification of lowest Pd/Pa in diastole or systole
- Independent of ECG
- No waveform landmark identification necessary
- Sensitive to small pressure changes during pullback
- High dynamic range



Resting Full-cycle Flow Ratio (RFR)



FR

- 4-5 consecutive heart cycles used to determine the RFR