

Cardiology Update 2015

Davos, Switzerland

Hybrid Imaging

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Zurich**



**University of
Zurich** ^{UZH}

Disclosures

- Speaker honoraria:
 - Astra Zeneca, Abbott Vascular, GE Healthcare, Guerbet
- Consultant fees:
 - Abbott Vascular
- Research grant:
 - Abbott Vascular



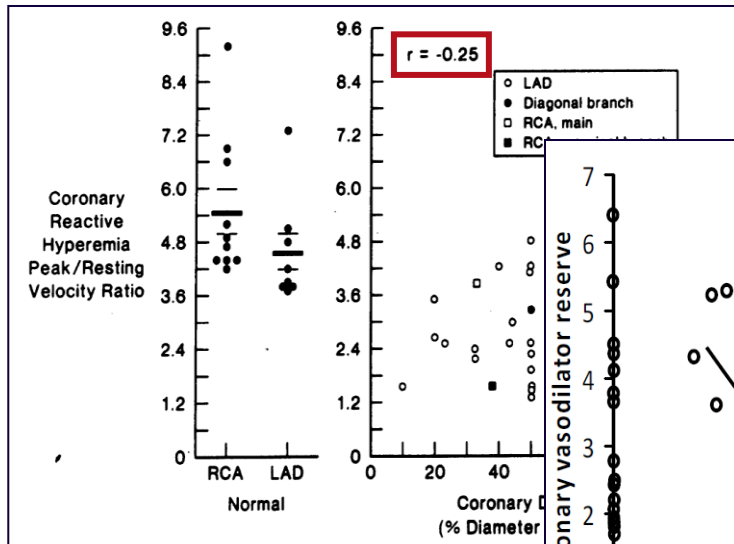
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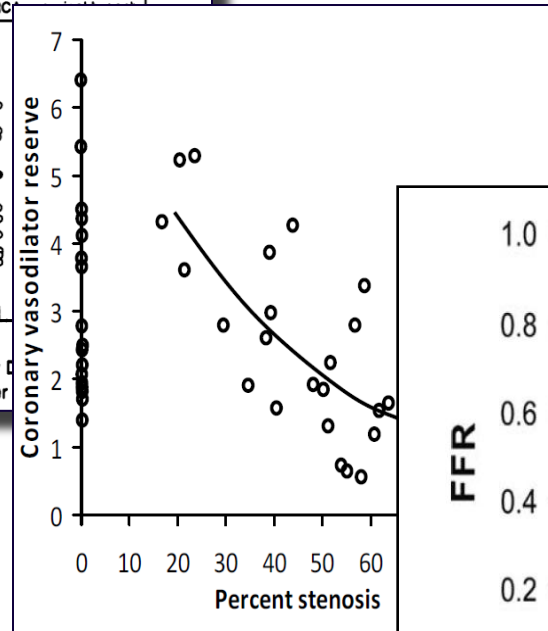
University of
Zurich^{UZH}

Pathophysiological basis for anatomic-functional imaging:

Disagreement between coronary morphology and perfusion



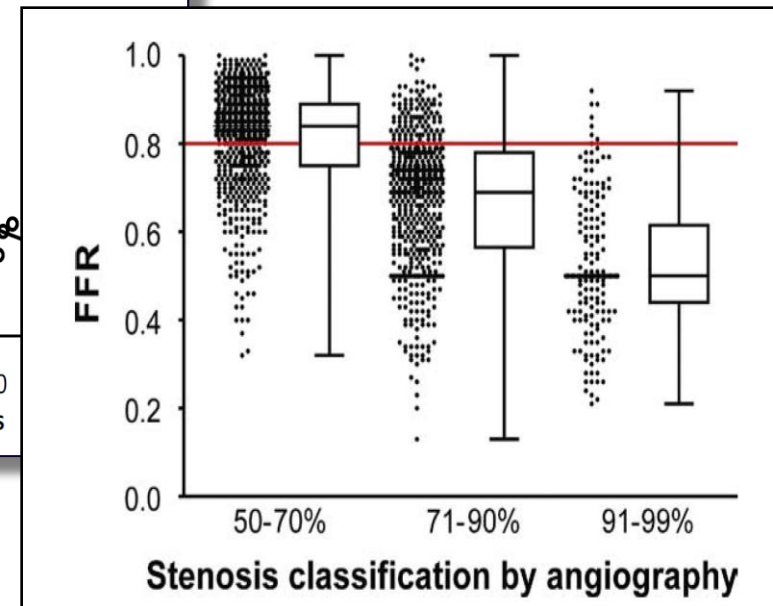
White CW. NEJM 1984
Intraoperative Doppler flow



Uren NG. NEJM 1994
 ^{15}O -H₂O PET

„different techniques...

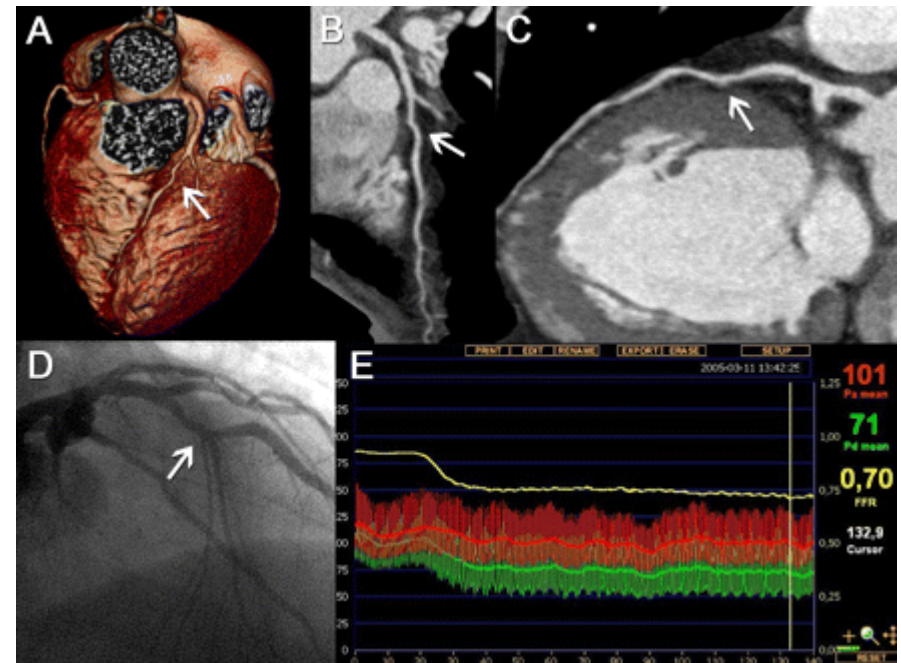
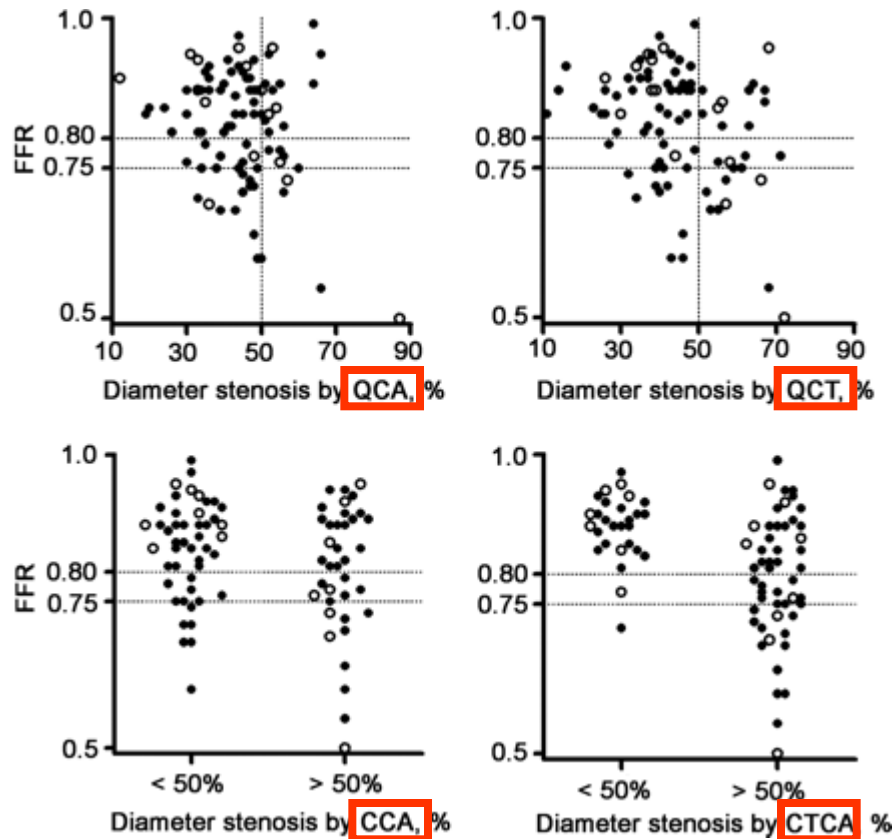
...same results“



Tonino PA et al. JACC 2010
Fractional flow reserve

Pathophysiological basis for anatomic-functional imaging:

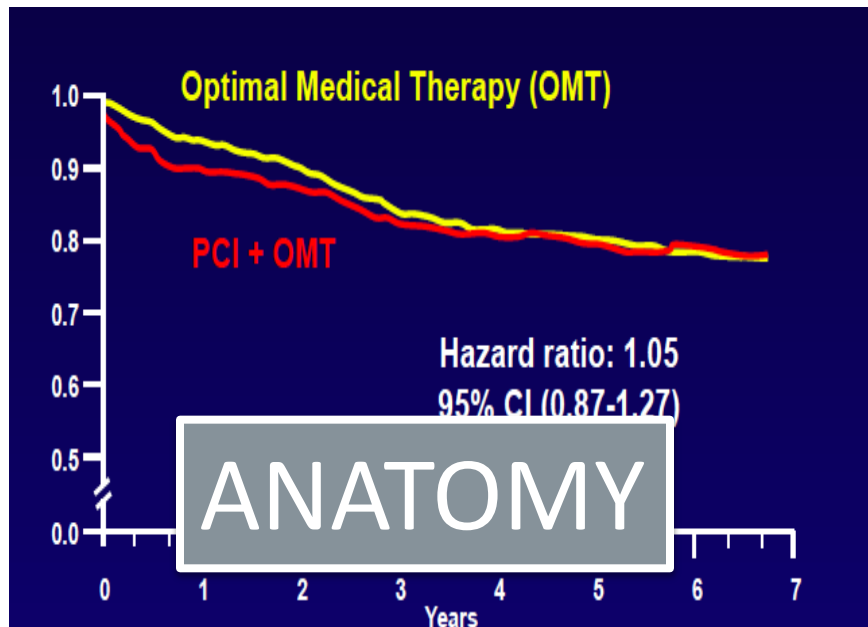
Neither QCA nor CTCA predict the functional significance of coronary lesions



Visual analysis: **CCA**: <50%; **CTCA**: <50%
Quantitative analysis: **QCA**: 44%; **QCT**: 40%
FFR=0.70

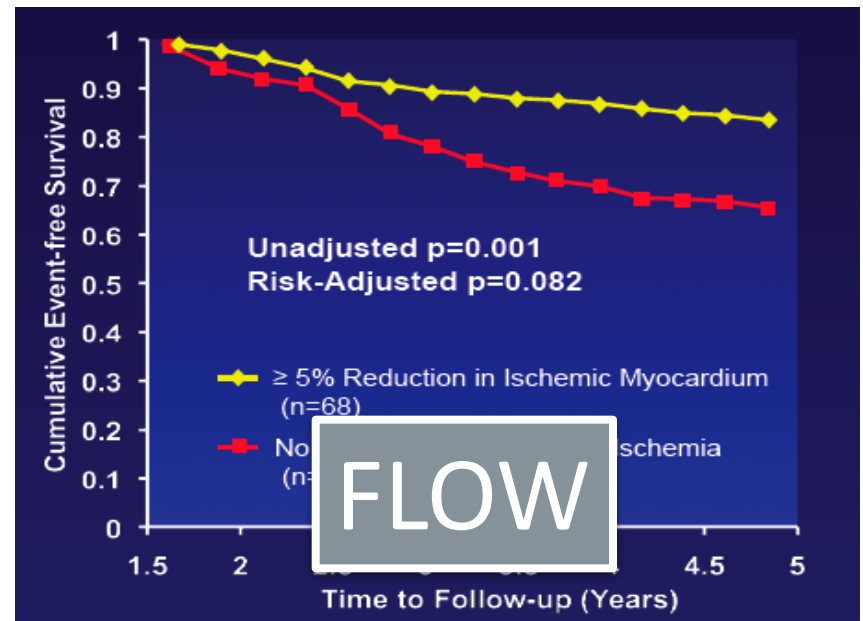
„When it comes to outcome, flow always trumps anatomy“

COURAGE



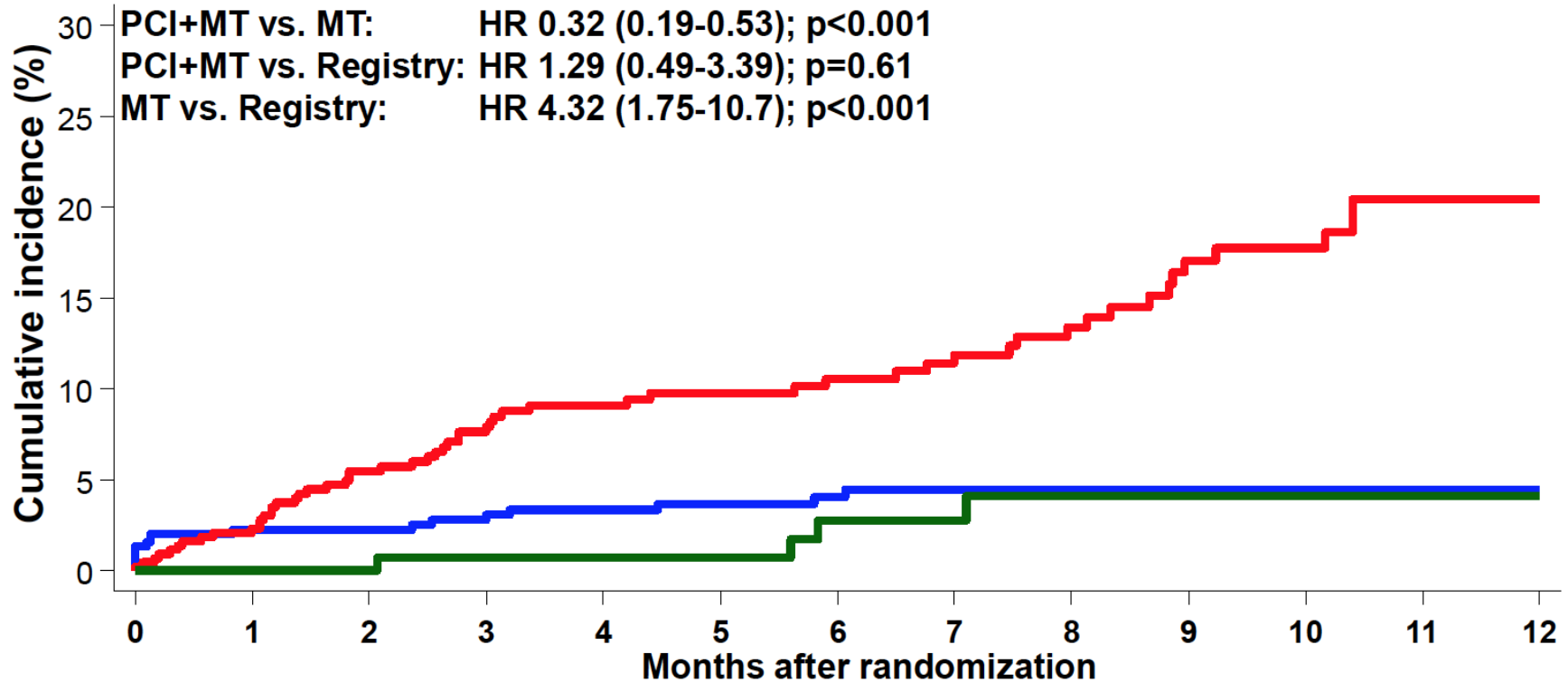
Boden WE. NEJM 2007;356:1503

COURAGE Nucl substudy



Circulation. 2008 Mar 11;117(10):1283-91

FAME II



No. at risk

MT	441	414	370	322	283	253	220	192	162	127	100	70	37
PCI+MT	447	414	388	351	308	277	243	212	175	155	117	92	53
Registry	166	156	145	133	117	106	93	74	64	52	41	25	13



Timeline/Developments of Cardiac Hybrid Imaging

ICA+ SPECT Hybrid
(Schindler TH)



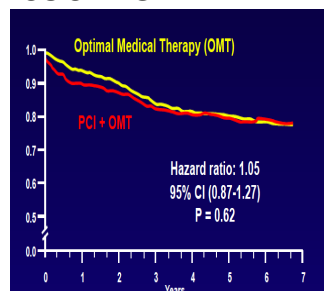
$^{13}\text{NH}_3$
1999

64-slice CT



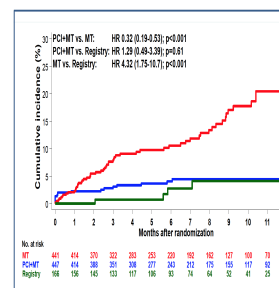
2005

COURAGE



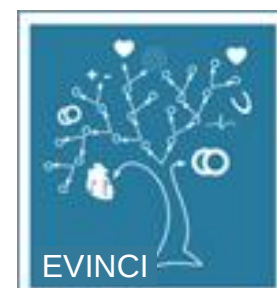
2007

FAME II



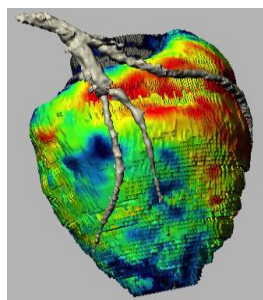
2013

EVINCI



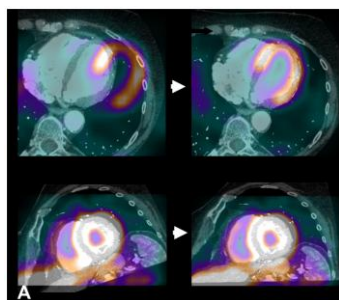
2014

2001



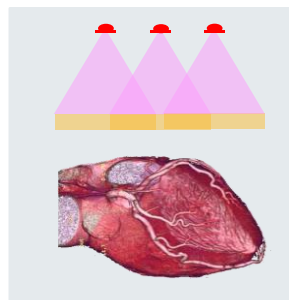
Feasibility of hybrid
PET/CTCA (Zurich)

2005



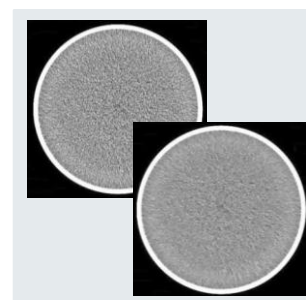
Dedicated software
packages

2007



Prospective ECG
triggering
→ 2-3 mSv

2010

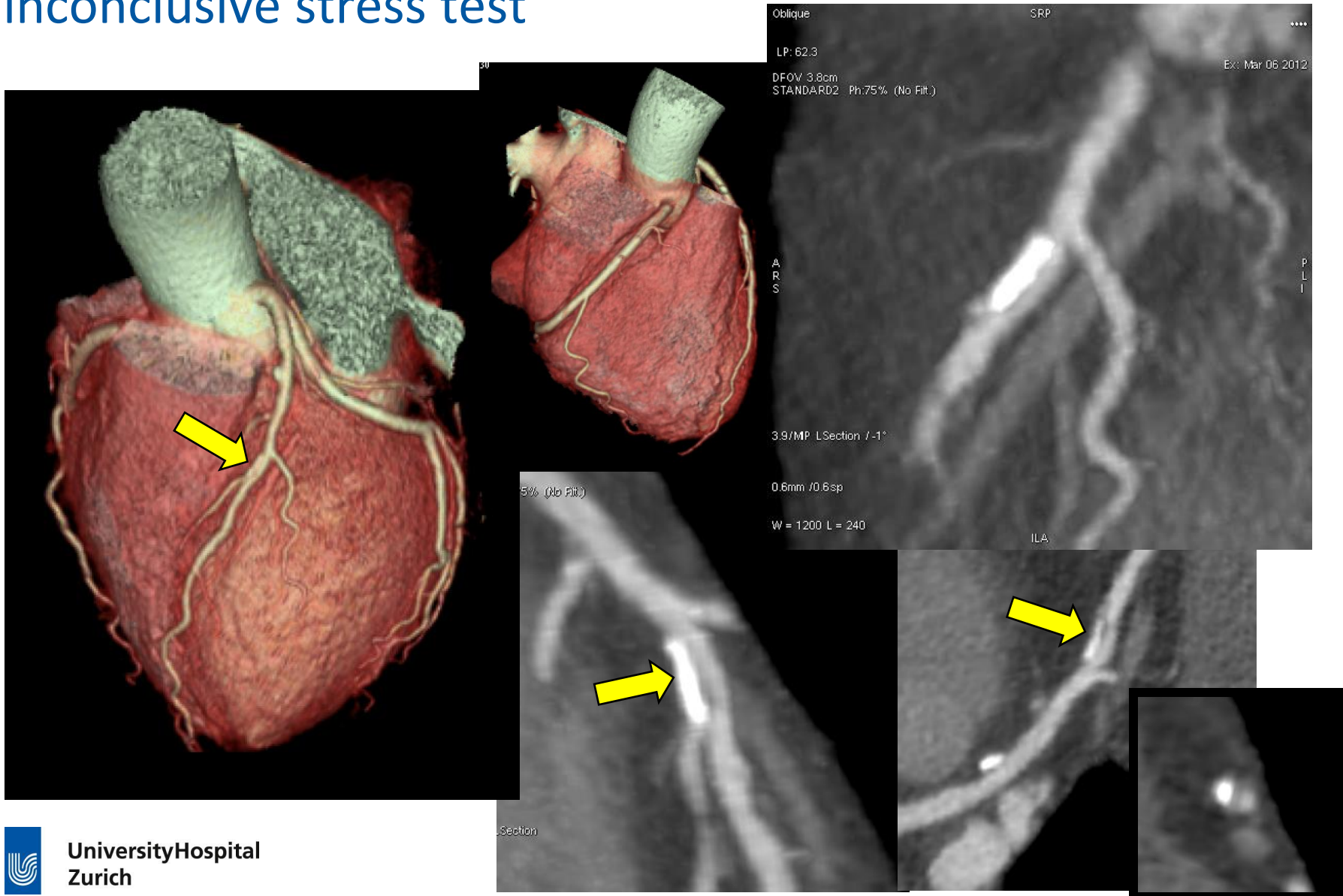


Iterative reconstruction
algorithms → <1mSv

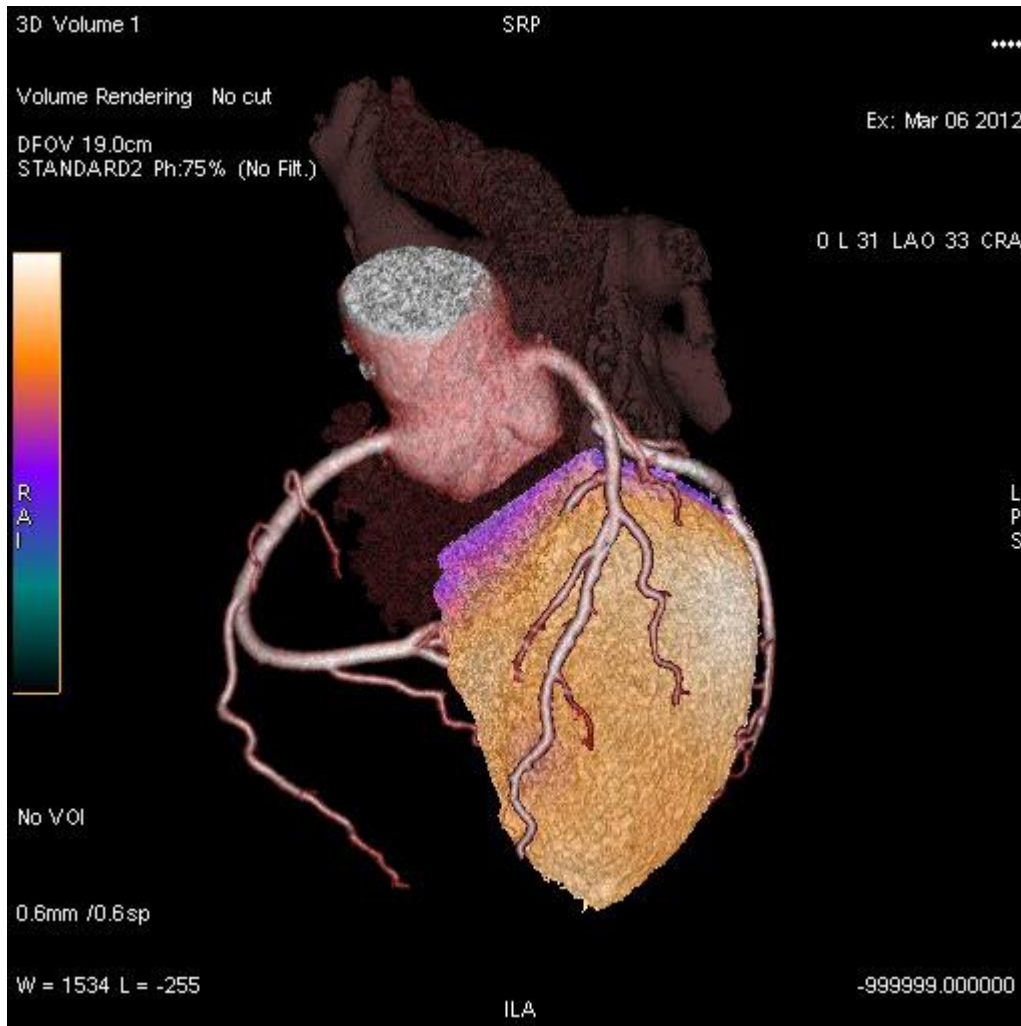


Hybrid devices

56 yo lady, atypical chest pain, Fam. Hx of CAD, inconclusive stress test



Hybrid SPECT/CTCA



Diagnostic accuracy of cardiac hybrid imaging (SPECT/CTCA and PET/CTCA)

Author	Hybrid system	N	Gold standard (definition of significant CAD)	Sens	Spec	PPV	NPV
Namdar et al. 2005	$^{13}\text{N-NH}_3$ PET/ 4-slice CTCA	25	Flow-limiting coronary stenoses requiring revascularization (ICA +PET)	90	98	82	99
Rispler et al. 2007	SPECT/16-slice CTCA	56	Flow-limiting coronary stenoses (>50% stenosis on ICA + SPECT pos.)	96	95	77	99
Groves et al. 2009	^{82}Rb PET/ 64-slice CTCA	33	>50% stenosis on ICA	88	100	97	99
Sato et al. 2010	SPECT/64-slice CTCA*	130	>50% stenosis on ICA	94	92	85	97
Kajander et al. 2010	$^{15}\text{O-H}_2\text{O}$ PET/64-slice CTCA	107	Flow-limiting coronary stenosis (>50% stenosis of ICA + FFR)	93	99	96	99
Schaap et al. 2013	SPECT/64-slice CTCA	98	Flow-limiting coronary stenosis (>50% stenosis of ICA + FFR)	96	95	96	95
Danad et al. 2013¶	$^{15}\text{O-H}_2\text{O}$ PET/64-slice CTCA	120	Flow-limiting coronary stenosis (>50% stenosis of ICA + FFR)	76	92	86	84
Thomassen et al. 2013	$^{15}\text{O-H}_2\text{O}$ PET/64-slice CTCA	44	>50% stenosis on ICA (QCA)	91	100	100	92
Dong et al. 2014	SPECT/64-slice CTCA	78	Flow-limiting coronary stenoses (>50% stenosis on ICA + SPECT pos.)	94	72	88	86

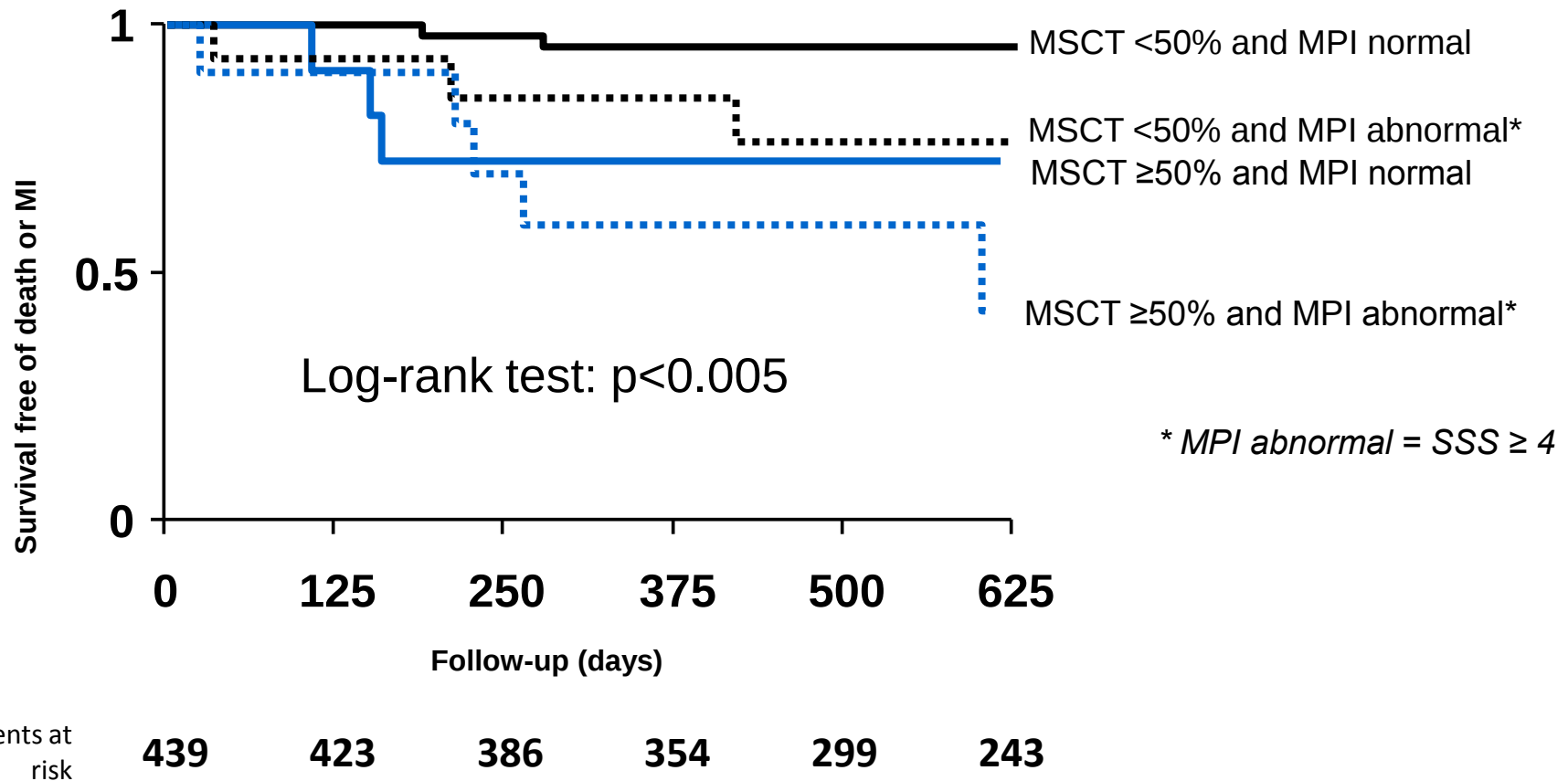
*Hybrid SPECT/CTCA only applied for non-evaluable arteries on CTCA (14%)

¶Non-fused images

Adapted from Gaemperli O et al. EHJ 2011

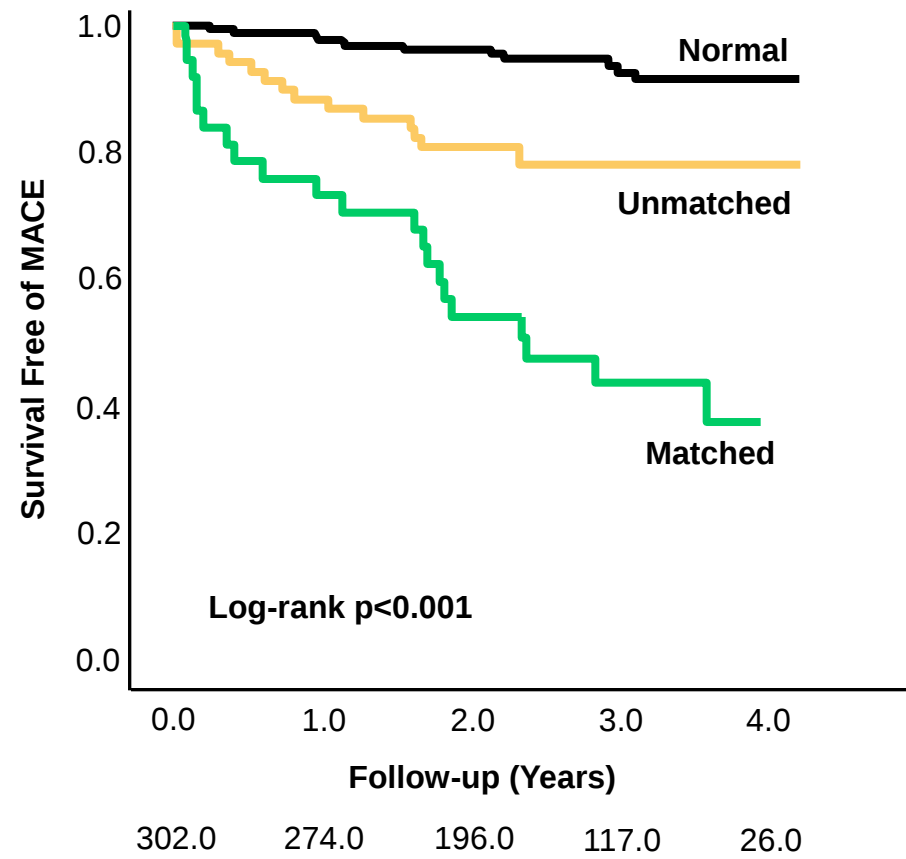
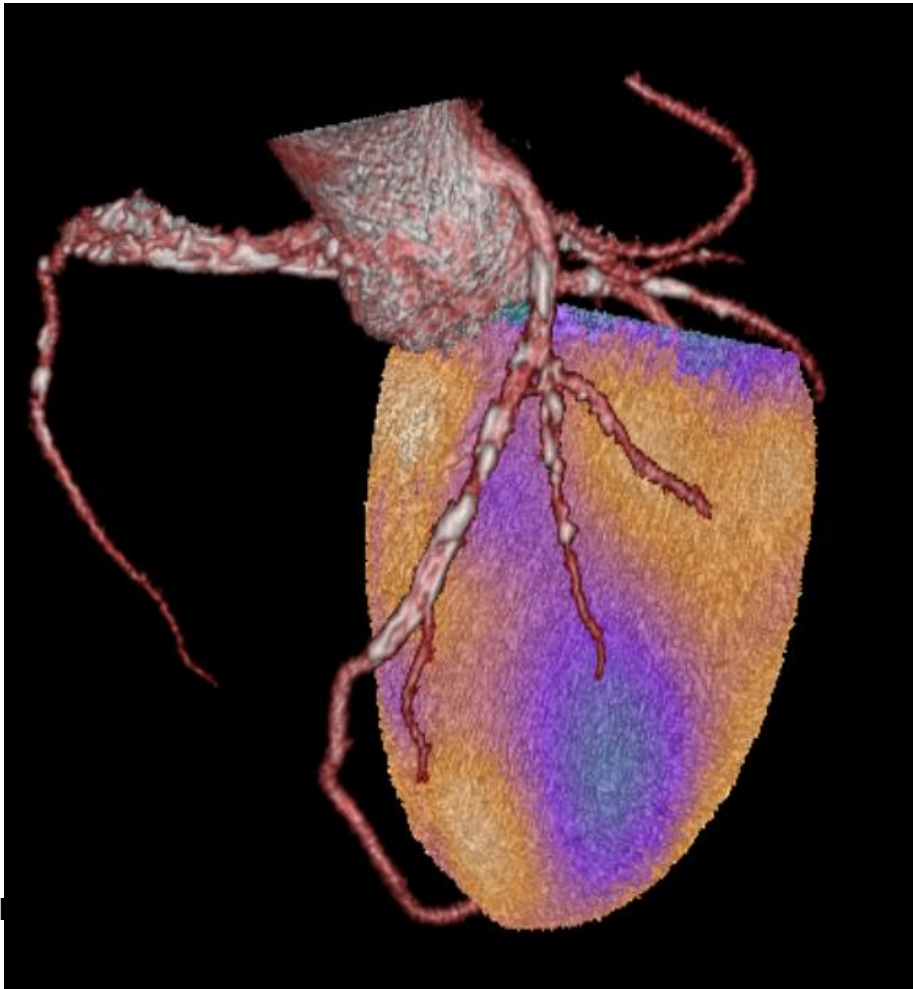


Incremental prognostic value of CT angio and MPI



Prognostic value of cardiac hybrid imaging with SPECT/CTCA

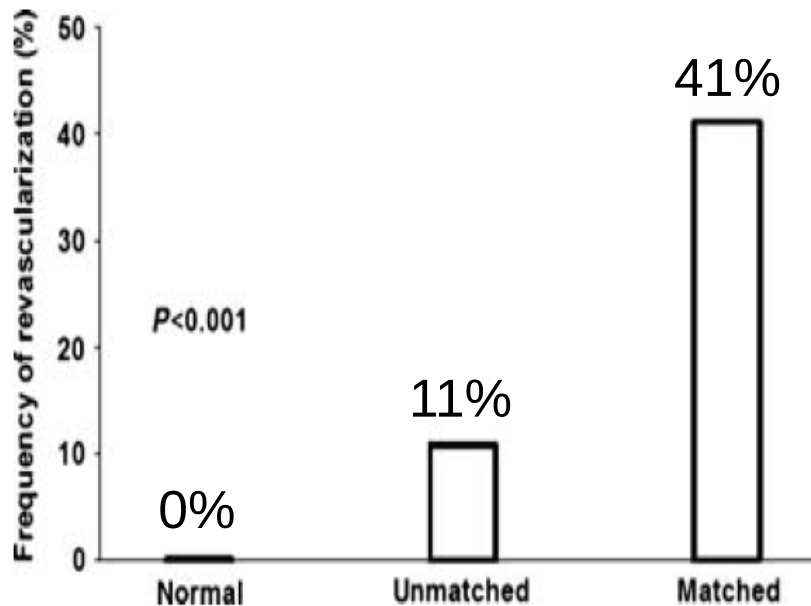
n=335 patients



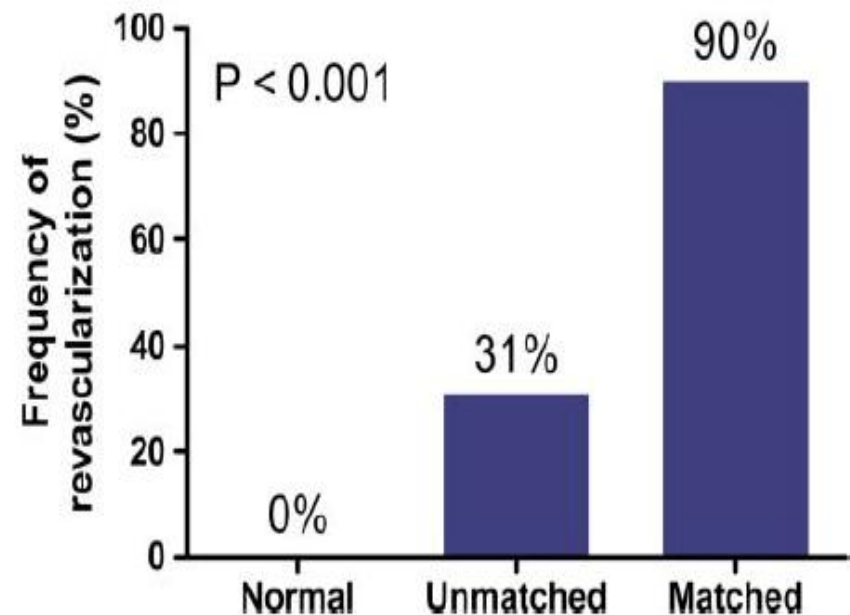
Pazhenkottil et al. *EHJ* 2011; Jun;32(12):1465-71

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Impact of hybrid imaging on patient management



Pazhenkottil et al. Eur Heart J. 2011 Nov;32(22):2824-9).



Schaap J et al. Heart. 2013 Feb;99(3):188-94.

Hybrid anatomic-functional imaging put into clinical practice

- Small studies indicate diagnostic and prognostic value of hybrid imaging for stable CAD patients
- But increased radiation and costs have to be considered!
- It is unclear which patients may derive benefit from hybrid imaging procedures
- Until we have more data, a reasonable approach to use of hybrid imaging should be practiced (CTO? MVD? Intermediate PTP?)

New developments of Hybrid imaging

- CT_{FFR}, CT Perfusion (CTP)
- Stress CMR/CT
- PET/CMR
- 3D Echo/CT?
- Real-time hybrid imaging

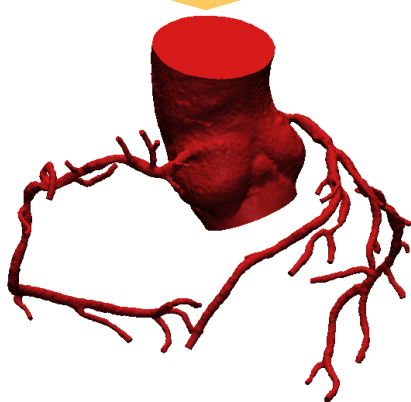
Non-invasive FFR (FFR_{CT})

Computational Model based on CCTA

3-D anatomic model from CCTA

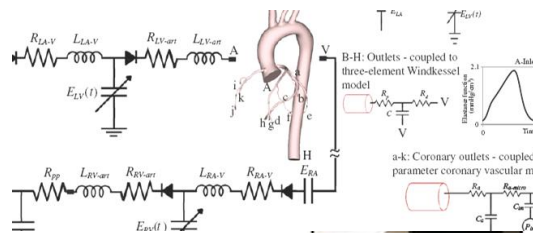


No additional imaging
No additional medications



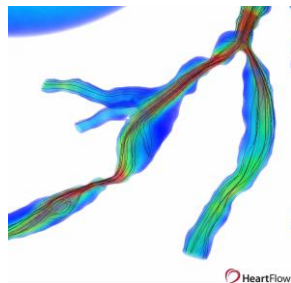
Blood Flow Solution

Blood flow equations solved on
supercomputer



$$\rho \bar{v}_{,t} + \rho \bar{v} \cdot \nabla \bar{v} = -\nabla p + \nabla \cdot \boldsymbol{\tau}$$

$$\nabla \cdot \bar{v} = 0$$

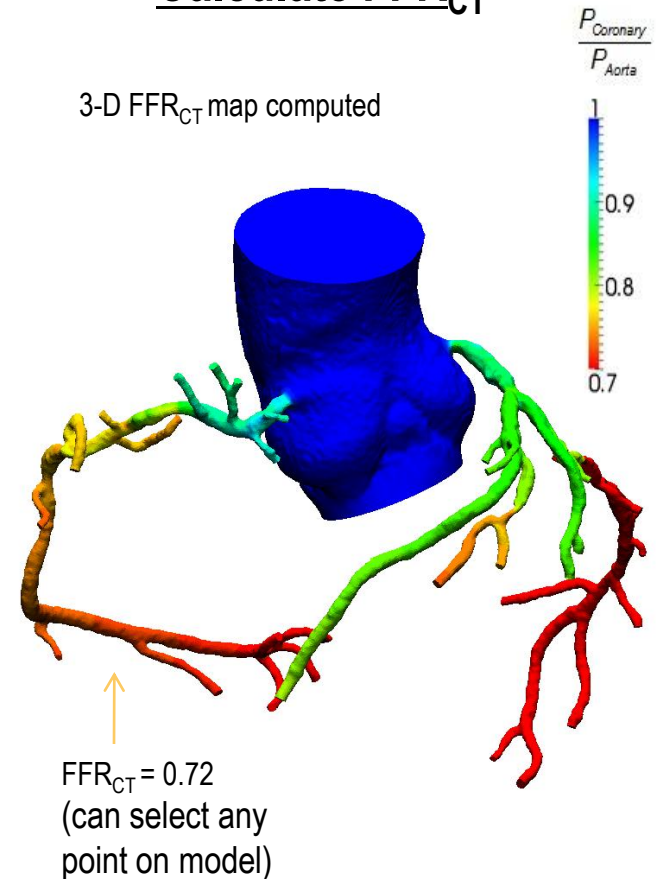


Physiologic models

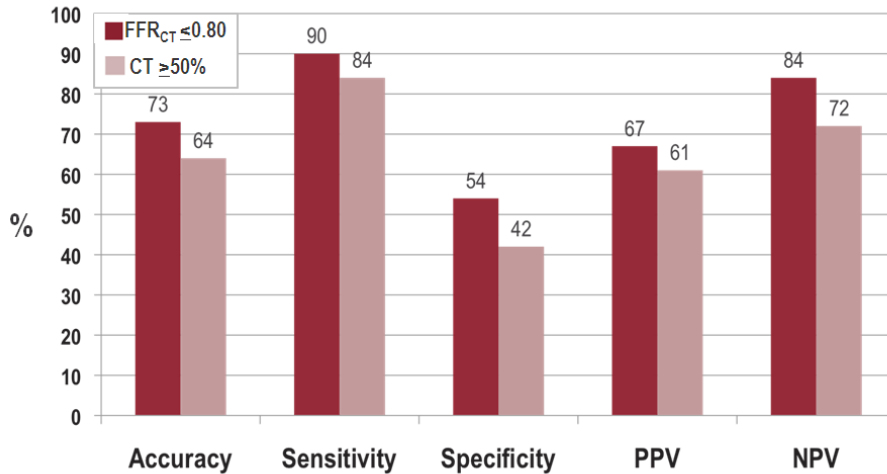
- Myocardial demand
- Morphometry-based boundary condition
- Effect of adenosine on microcirculation

Calculate FFR_{CT}

3-D FFR_{CT} map computed



Per-Patient Diagnostic Performance



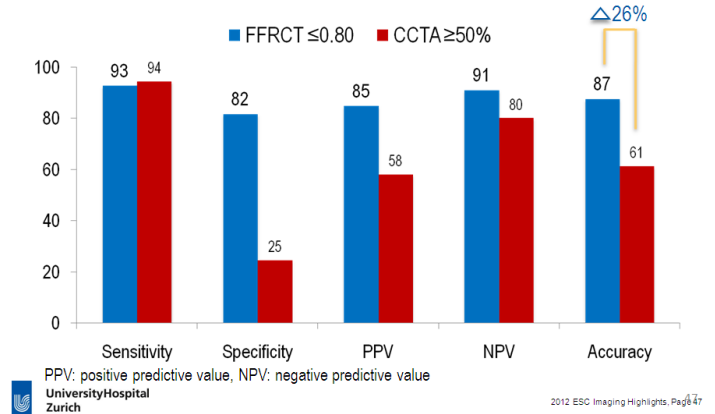
N=252	95% CI	95% CI	95% CI	95% CI	95% CI
FFR _{CT}	67-78	84-95	46-83	60-74	74-90
CT	58-70	77-90	34-51	53-67	61-81



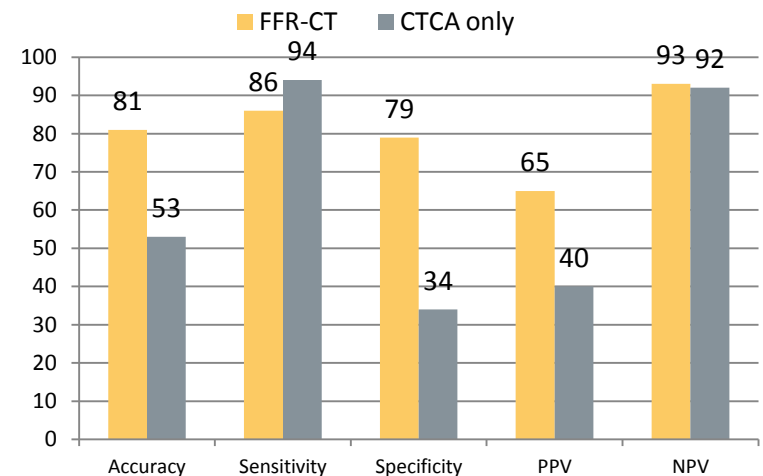
Non-inferiority Endpoint: Diagnostic Accuracy significantly over 70% (such that the lower boundary of the 1-sided 95% confidence interval of this estimate exceeded 70%):
Not met! DA 73% (95% CI, 67%-78%)

DISCOVER-FLOW

Per-patient analysis (n=103)



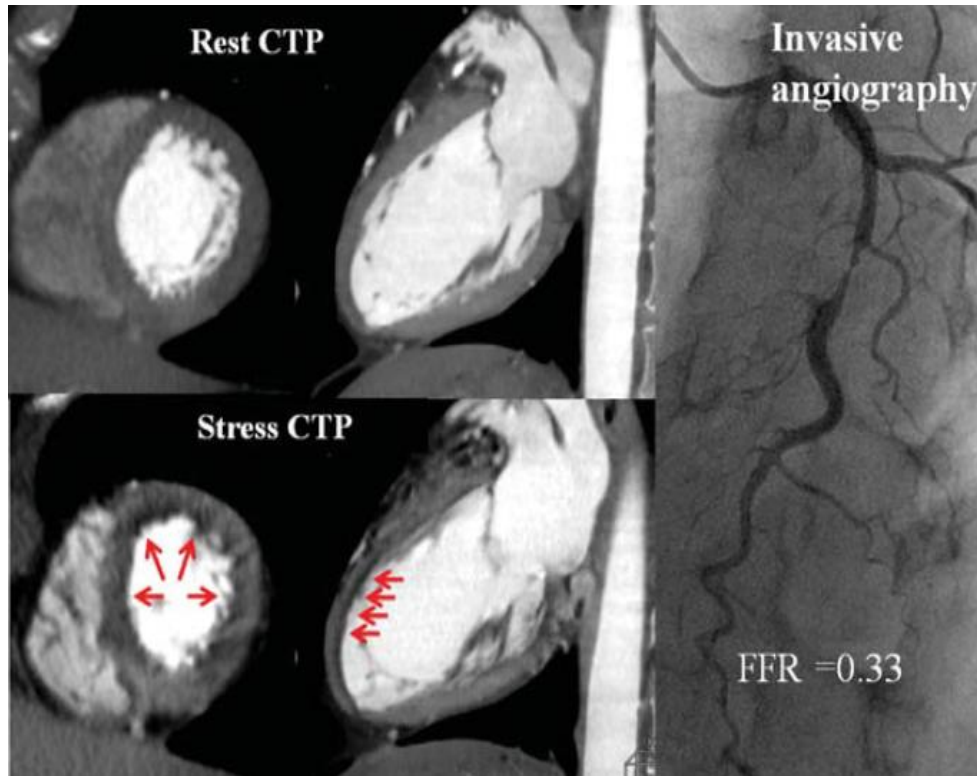
HeartFlow-NXT



N=254, *p<.05

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CT perfusion (+CTCA) – one stop-shop CT



320-row detector CT scanner (Aquilion ONE, Toshiba Medical Systems, Japan)

- Is generally obtained with adenosine-stress
- CT scanners with ability for 1-beat acquisition are preferred (320-slice, 128 DSCT)
- Obtained at the cost of higher radiation exposure (depending on the scan protocol) and contrast agent use

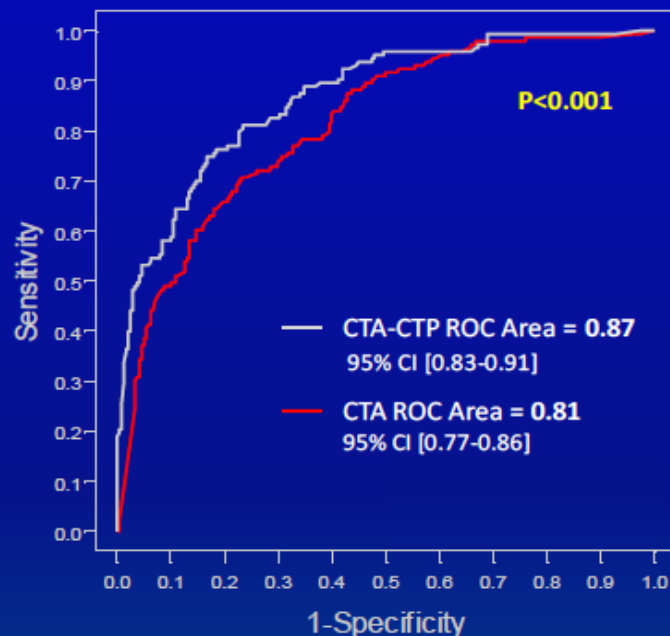
Ko BS et al. EHJ 2012;33:67–77

Diagnostic Performance of Combined Noninvasive Coronary Angiography and Myocardial Perfusion Imaging Using 320-row Detector Computed Tomography:

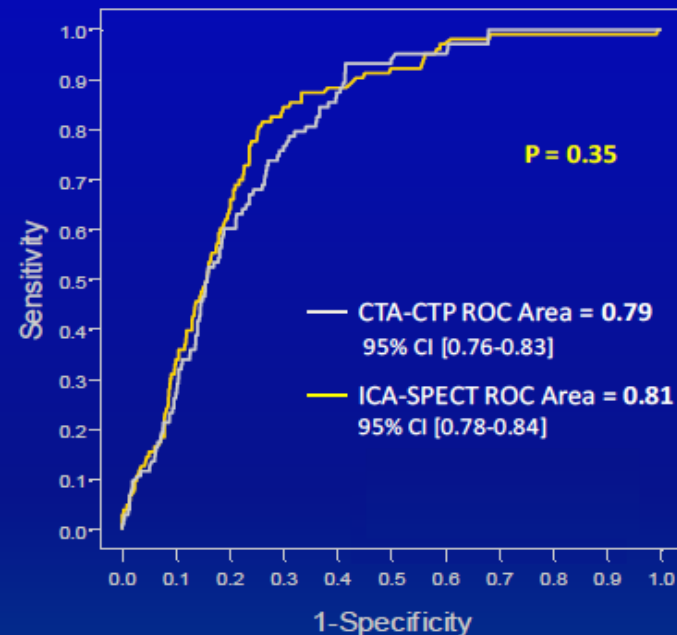
The CORE320 Multicenter International Study

João A.C. Lima, M.D., Johns Hopkins Hospital

Incremental Value of CTA-CTP over CTA
(Reference Standard: 50% by ICA with
SPECT-MPI defect)



CTA-CTP vs. ICA/SPECT to predict
Vessel Level Revascularization
(Reference Standard: Revascularization at 30 days)

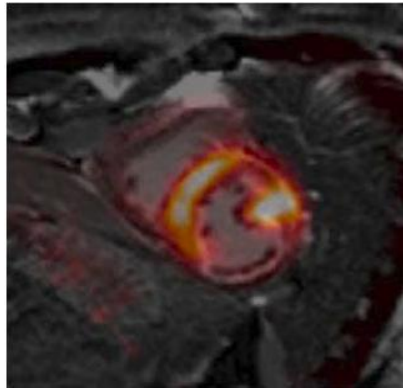


PET/CMR: Potential for use in cardiology

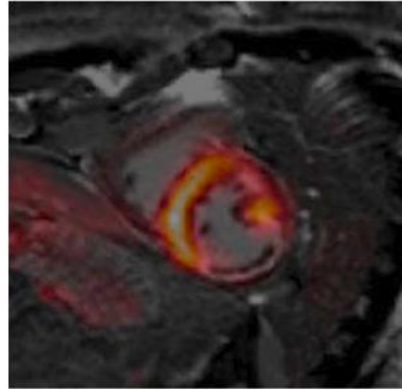
LG CMR



$^{13}\text{N-NH}_3$ PET/CMR

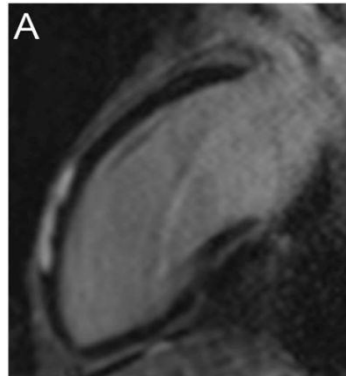


$^{18}\text{F-FDG}$ PET/CMR

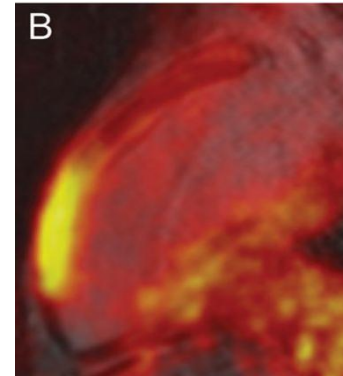


Assessment of scar, microvascular obstruction, perfusion and metabolic activity in affected myocardium after acute MI

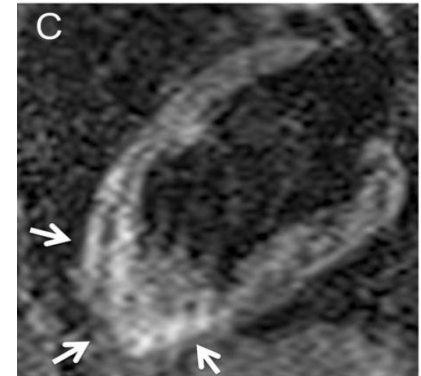
Assessment of inflammatory or infiltrative myocardial disease (e.g. sarcoidosis, myocarditis (see right))



LG CMR



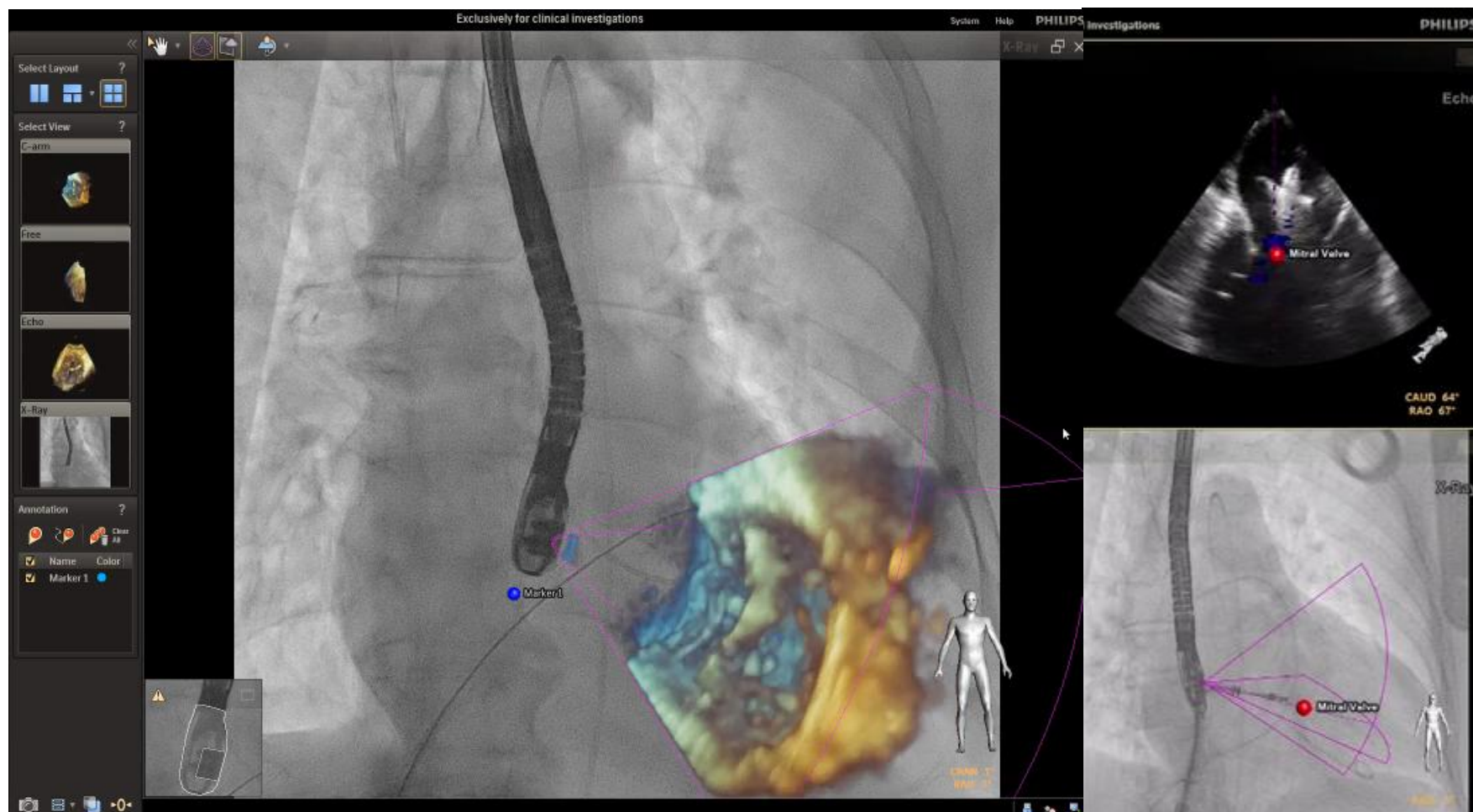
$^{18}\text{F-FDG}$ PET/CMR
(with myocardial glucose uptake suppression)



T2-weighted CMR
(edema)

Echo Nav

Real-time Fusion of fluoroscopy with TEE during percutaneous SHD procedure



Summary

Assessment of coronary morphology AND myocardial perfusion is crucial for appropriate management of stable CAD

Hybrid Imaging allows to identify flow-limiting coronary lesions („culprit lesions“) requiring revascularization and may be particularly helpful in selected patients (intermediate PTP, MVD, CTO)

Provides independent prognostic information through combination and coregistration of morphological and functional criteria

Novel modalities are available for hybrid imaging offering potential advantages (radiation, resolution, etc.) and novel applications (real-time hybrid, diseases other than CAD)

Thank You



PD Dr. med. Oliver Gaemperli

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