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Saudi Heart Association

CT-FFR

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ESC European Society of Cardiology
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FASTTRACK CLINICAL RESEARCH
Imaging

Real-world clinical utility and impact on clinical decision-making of coronary computed tomography angiography-derived fractional flow reserve: lessons from the ADVANCE Registry

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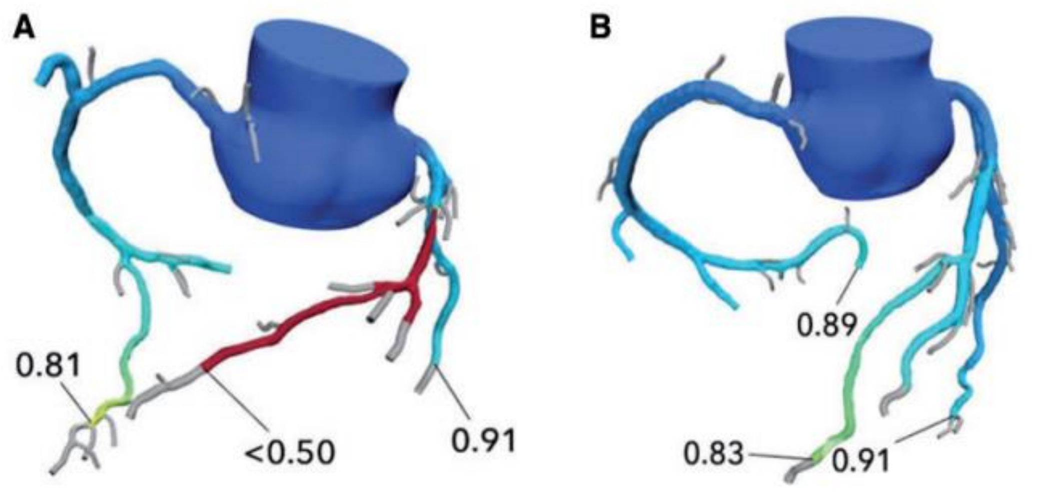


Figure 6 Three-dimensional coronary computed tomography angiography-derived fractional flow reserve pressure model of (*A*) a 59-year-old male with a 50–70% mid left anterior descending coronary artery stenosis yet severe ischaemia (coronary computed tomography angiography-derived fractional flow reserve ≤0.50) who experienced an NSTEMI in follow-up. (*B*) In comparison, a 71-year-old male with a more severe stenosis (70–90%) in the mid-left anterior descending without lesion specific ischaemia (coronary computed tomography angiography-derived fractional flow reserve 0.83) who was clinically well through 90 days follow-up.

- Multi-center, prospective registry
- Clinical outcomes of FFR_{CT} guided treatment in **clinically stable** symptomatic patients
- 5083patients from up to 38 sites in Europe, USA, Canada and Asia

Primary endpoint :

- Reclassification rate between the management plan based on coronary CTA alone versus CTA plus FFR_{CT}
  (a) optimal medical therapy
  (b) percutaneous coronary intervention
  (c) coronary artery bypass graft surgery

Secondary endpoints:

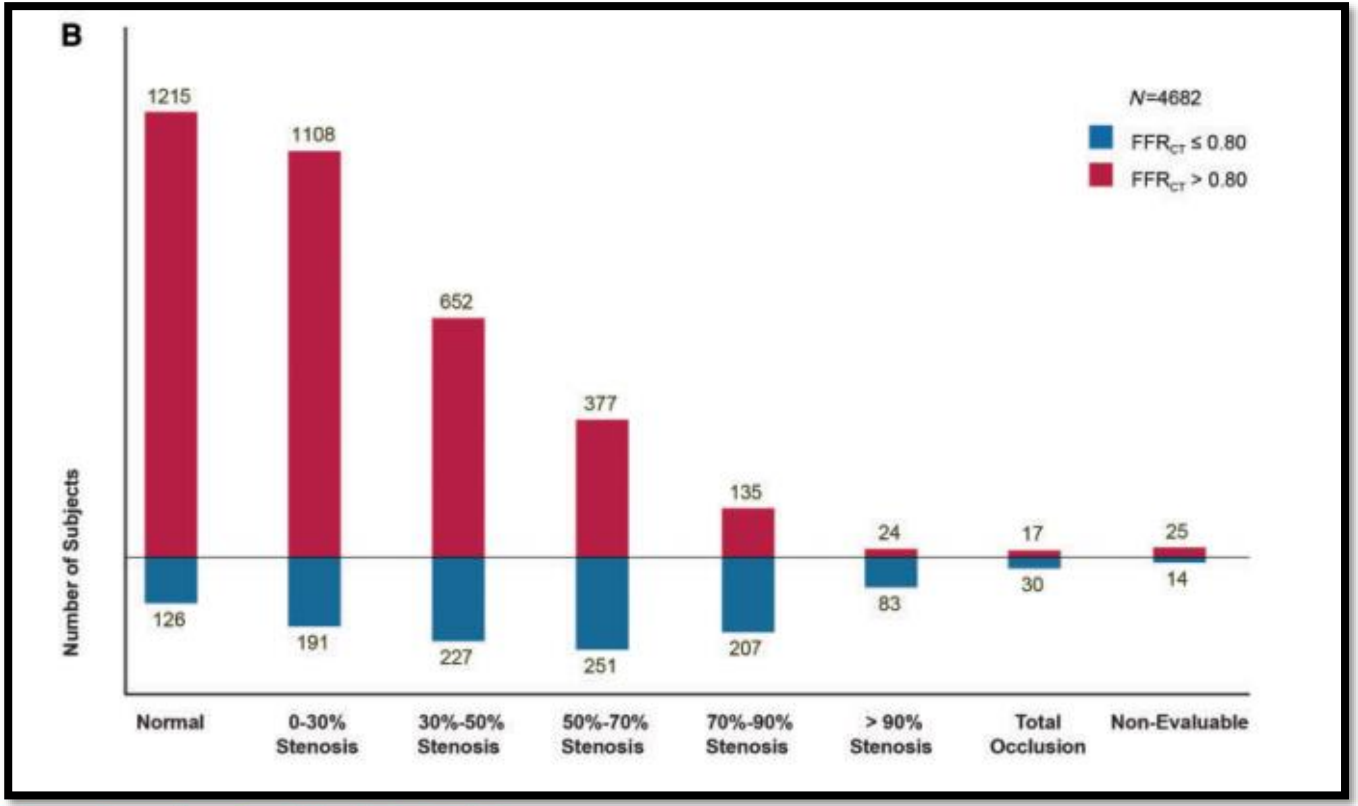
- Evaluation of the rate of invasive coronary angiography (ICA)
- Revascularization & MACE, at 3-year follow-up
- Cumulative radiation dose exposure

Should FFR_{CT} change management in these patients?

Table 1 Demographics, coronary artery disease risk factors, and symptom status

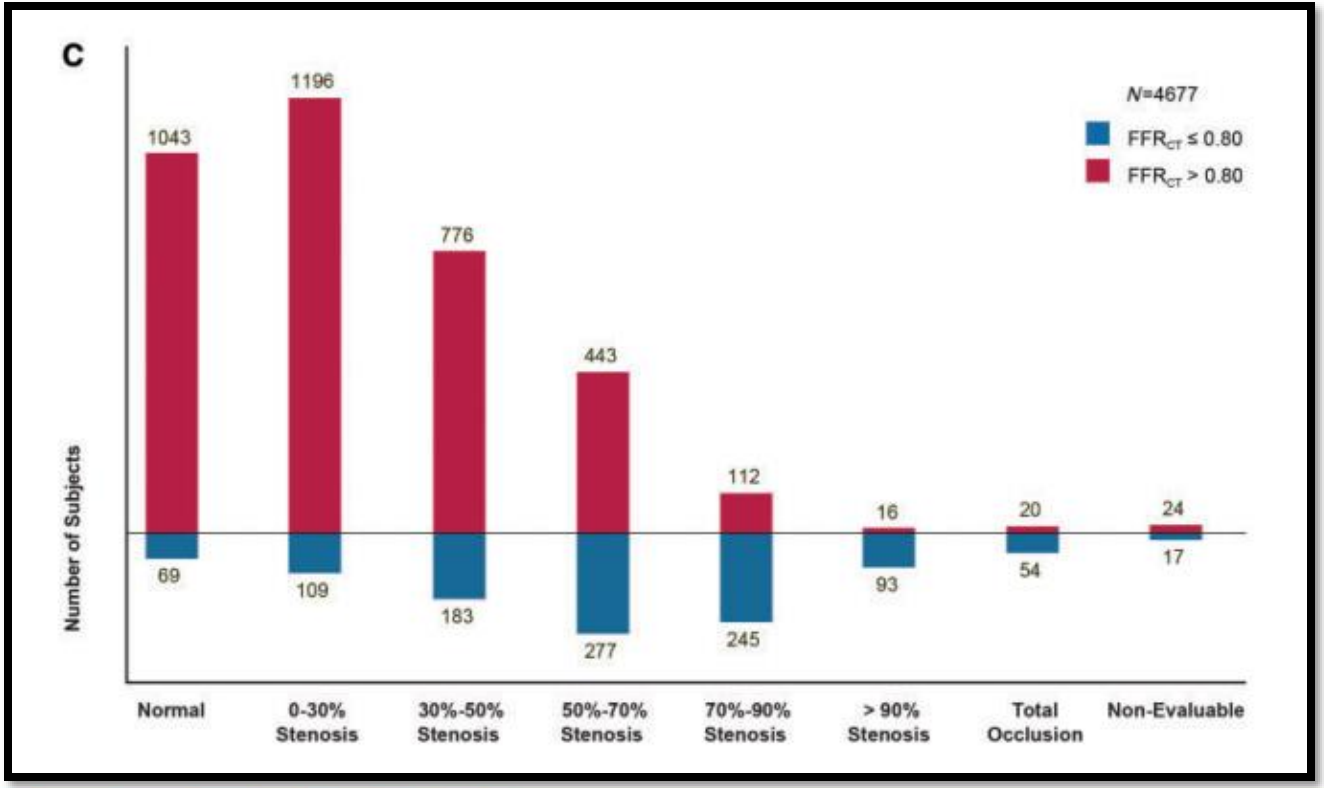
	CTA only (*n* = 346)	FFR_{CT} (*n* = 4737)	Total (*n* = 5083)
Age (years)	64.3 (11.1)	66.1 (10.3)	66.0 (10.3)
Male gender	215 (62.1%)	3134 (66.2%)	3349 (65.9%)
Hypertension	210 (60.7%)	2835 (59.8%)	3045 (59.9%)
Diabetes mellitus	99 (28.6%)	1037 (21.9%)	1136 (22.3%)
Hyperlipidaemia	204 (59%)	2753 (58.1%)	2957 (58.2%)
Smoking			
Current smoking	46 (13.3%)	797 (16.8%)	843 (16.6%)
Ex-smoker	118 (34.1%)	1615 (34.1%)	1733 (34.1%)
Never smoked	141 (41.6%)	1973 (41.7%)	2117 (41.6%)
Unknown	38 (11.0%)	352 (7.4%)	390 (7.7%)
Angina status			
Atypical	175 (50.6%)	1727 (36.5%)	1902 (37.4%)
Typical	41 (11.8%)	1025 (21.6%)	1066 (21.0%)
Non-cardiac pain	8 (2.3%)	297 (6.3%)	305 (6.0%)
Dyspnoea	34 (9.8%)	472 (10.0%)	506 (10.0%)
None	73 (21.1%)	1164 (24.6%)	1237 (24.3%)
Unknown	15 (4.3%)	52 (1.1%)	67 (1.3%)
CCS angina class			
Grade 1	18 (43.9%)	254 (24.8%)	272 (25.5%)
Grade II	16 (39.0%)	561 (54.7%)	577 (54.1%)
Grade III	5 (12.2%)	111 (10.8%)	116 (10.9%)
Grade IV	0	23 (2.2%)	23 (2.2%)
Unknown	2 (4.9%)	76 (7.4%)	78 (7.3%)
CCTA rejection rate			160 (3.1%)
Diamond–Forrester risk	46.8 (±19.9)	51.6 (±20.3)	51.3 (±20.3)

LCX



B
N=4682
$FFR_{CT} \leq 0.80$
$FFR_{CT} > 0.80$
Number of Subjects
1215
126
1108
191
652
227
377
251
135
207
24
83
17
30
25
14
Normal
0-30% Stenosis
30%-50% Stenosis
50%-70% Stenosis
70%-90% Stenosis
> 90% Stenosis
Total Occlusion
Non-Evaluable

RCA

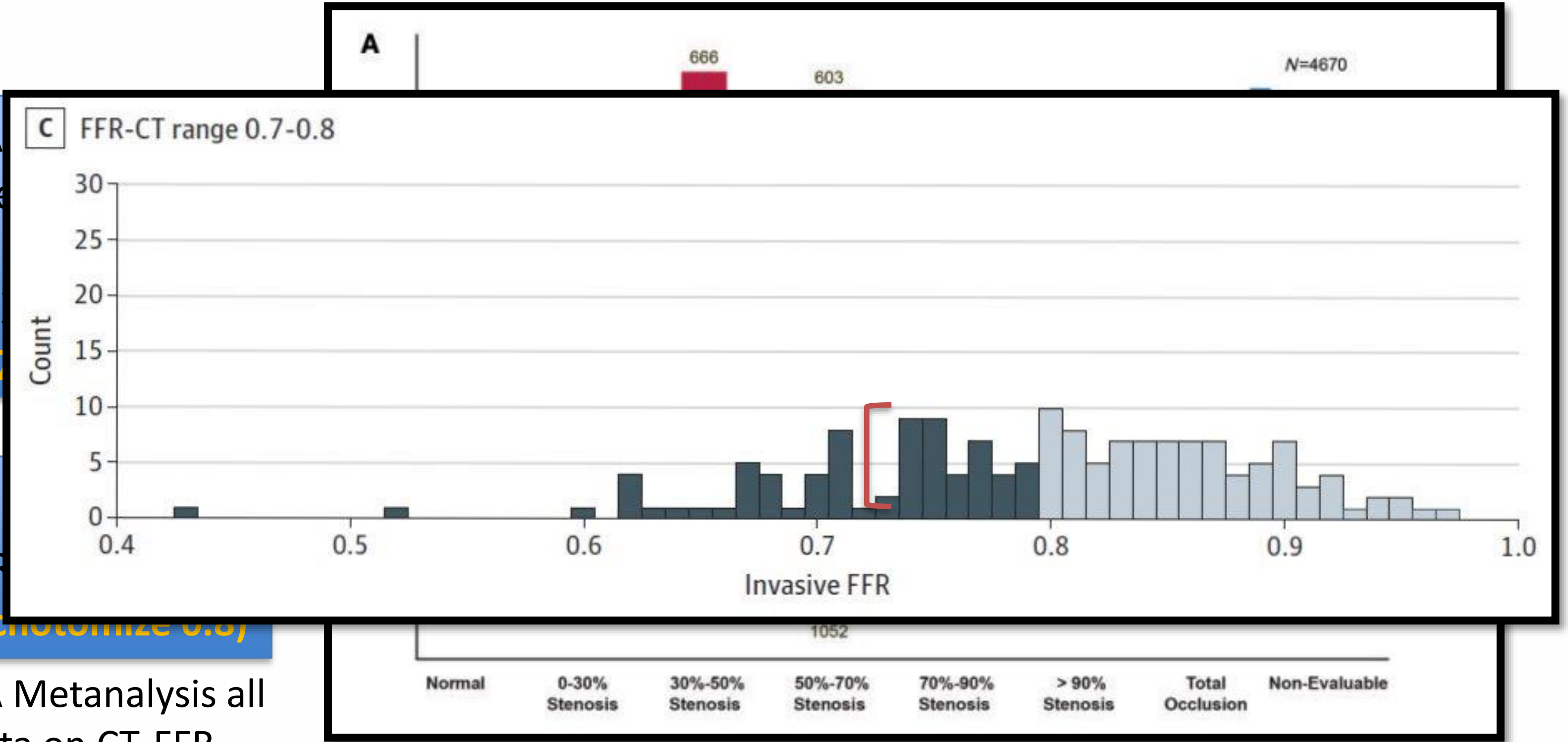


C
N=4677
FFR$_{CT}$ ≤ 0.80
FFR$_{CT}$ > 0.80
Number of Subjects
1043
69
1196
109
776
183
443
277
112
245
16
93
20
54
24
17
Normal
0-30% Stenosis
30%-50% Stenosis
50%-70% Stenosis
70%-90% Stenosis
> 90% Stenosis
Total Occlusion
Non-Evaluable

LAD

LA
me
co
LC
0.7

Dis
FFR
(dichotomize 0.8)



JAMA Metanalysis all data on CT-FFR

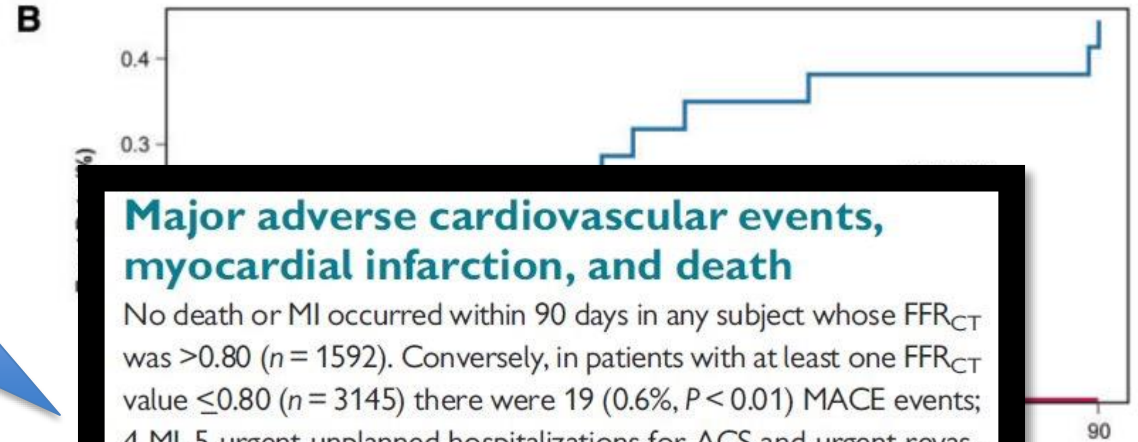
Table 2 FFR$_{CT}$-determined treatment plan and actual clinical management at 90 days

Actual treatment	Site-determined post-FFR$_{CT}$ treatment plan			
	Revascularization (n = 1418)	Medications (n = 2679)	Further diagnostics (n = 121)	Total (n = 4737)
MT	504 (35.5%)	2545 (95.0%)	92 (76.0%)	3573 (75.4%)
PCI	799 (56.3%)	115 (4.3%)	25 (20.7%)	1015 (21.4%)
CABG	115 (8.1%)	19 (0.7%)	4 (3.3%)	149 (3.1%)

Table 3 Actual treatment at 90 days (medical therapy vs. revascularization) stratified by coronary computed tomography angiography-derived fractional flow reserve values (0.05 increments)

Actual treatment	Site-determined post-FFR$_{CT}$ treatment plan						
	<0.71 (n = 1530)	0.71–0.75 (n = 615)	0.76–0.8 (n = 1000)	0.81–0.85 (n = 867)	0.86–0.9 (n = 595)	>0.9 (n = 130)	Total (n = 4737)
Medical treatment	709 (46.3%)	468 (76.1%)	874 (87.4%)	820 (94.6%)	578 (97.1%)	124 (95.4%)	3573 (75.4%)
Revascularization	821 (53.7%)	147 (23.9%)	126 (12.6%)	47 (5.4%)	17 (2.9%)	6 (4.6%)	1164 (24.6%)

HR for death & MI
CI 0.88-246
Suggests underpowered



Major adverse cardiovascular events, myocardial infarction, and death

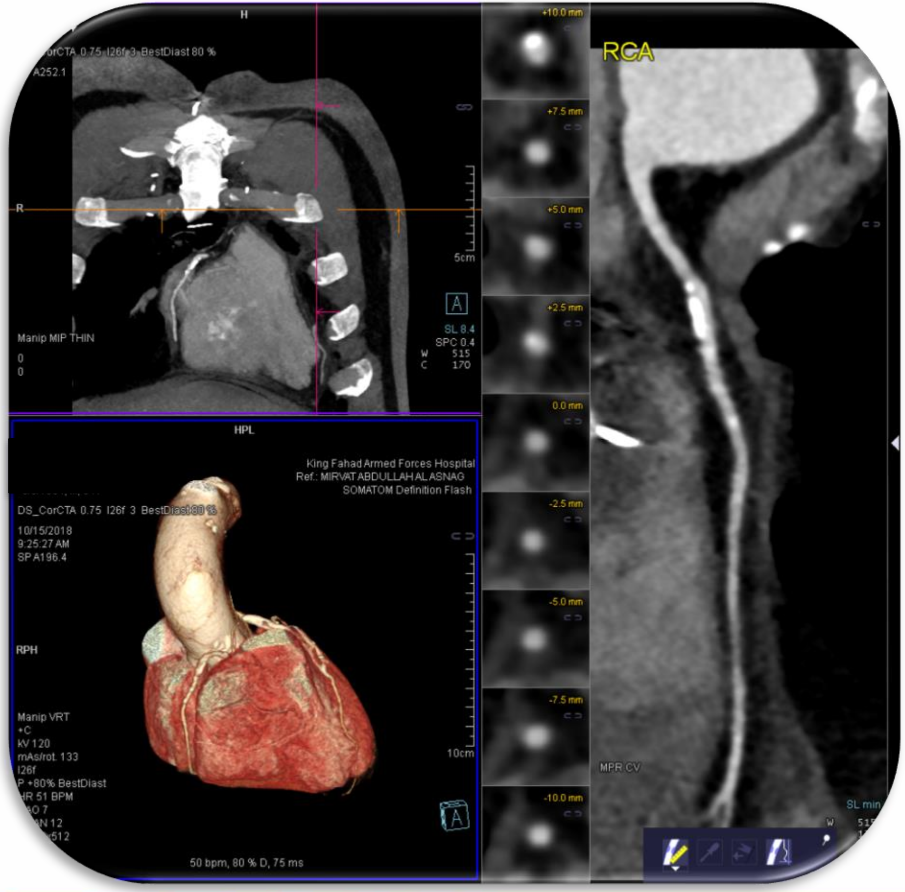
No death or MI occurred within 90 days in any subject whose FFR_{CT} was >0.80 ($n = 1592$). Conversely, in patients with at least one FFR_{CT} value ≤0.80 ($n = 3145$) there were 19 (0.6%, $P < 0.01$) MACE events; 4 MI, 5 urgent unplanned hospitalizations for ACS and urgent revascularization and 10 deaths. These events predominantly occurred in the lower FFR_{CT} ranges below 0.76 (18 of 19), indicating that an FFR_{CT} ≤0.80 increased the risk of an adverse event [MACE, hazard ratio (HR) 19.75, CI 1.19–326], P = 0.0008 and 14 death/MI, HR 14.68, CI 0.88–246, $P = 0.039$], (*Figure 5A* and *B*).

	30 Days	60 Days	90 Days
FFR_{CT} ≤ 0.80	0.25%(0.09%)	0.35%(0.11%)	0.45%(0.12%)
FFR_{CT} > 0.80	0.00%(0.00%)	0.00%(0.00%)	0.00%(0.00%)

- A severely **underpowered** non-randomized study
- Unexplained high event rate in a low FFR_{CT} in **stable** patients with very **few typical** symptoms

- Cami et al (JSCCT September 2018)
  - 930 patients $FFR_{CT \text{ and}}$ FFR_{Inv}
  - LAD, LCX, RCA distal to proximal segments
  - Distal vessel FFR_{CT} may overestimate significance of stenosis

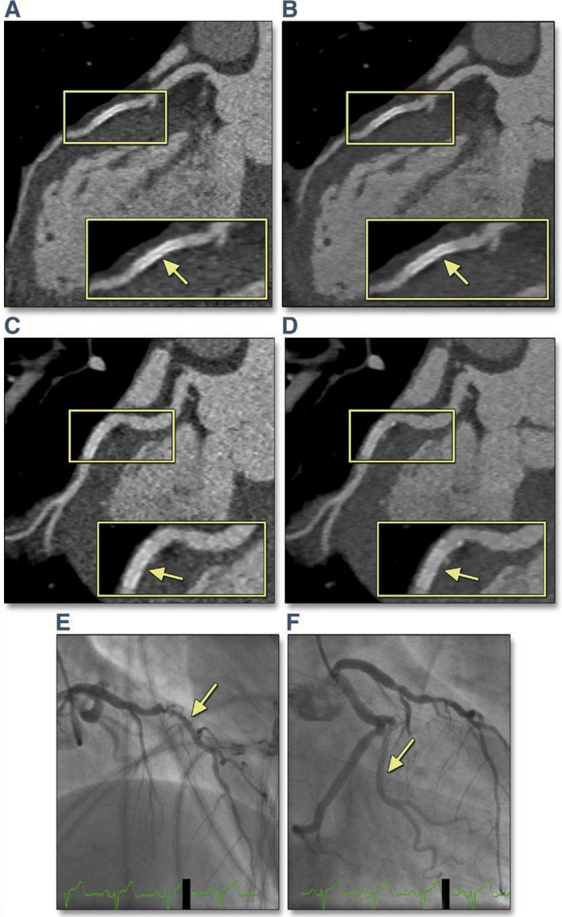
HeartFlow



H
CorCTA 0.75 I26f 3 BestDiast 80 %
A252.1
R
5cm
A
Manip MIP THIN
SL 8.4
SPC 0.4
W 515
C 170
HPL
King Fahad Armed Forces Hospital
Ref.: MIRVAT ABDULLAH AL ASNAG
SOMATOM Definition Flash
DS_CorCTA 0.75 I26f 3 BestDiast 80 %
10/15/2018
9:25:27 AM
SP A196.4
RPH
Manip VRT
+C
KV 120
mAs/rot. 133
I26f
P +80% BestDiast
HR 51 BPM
10cm
50 bpm, 80 % D, 75 ms
+10.0 mm
+7.5 mm
+5.0 mm
+2.5 mm
0.0 mm
-2.5 mm
-5.0 mm
-7.5 mm
-10.0 mm
RCA
MPR CV
SL min

+10.0 mm
+7.5 mm
+5.0 mm
+2.5 mm
0.0 mm
-2.5 mm
-5.0 mm
-7.5 mm
-10.0 mm
RCA
MPR CV
SL min
W 515
170


S
A
P
Vitrea®
W/L:249/123
Segmented
I



Jasmin Eisentopf et al. JIMG 2013;6:458-465

FAST FFR

Background

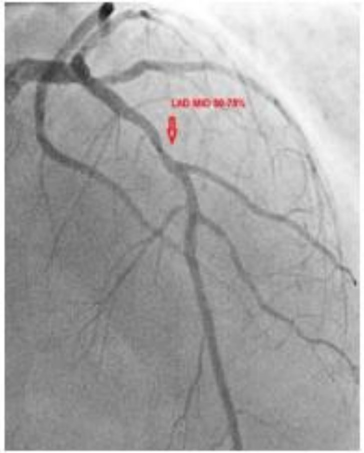
- FFR utilization, however, remains lower than expected because of a number of potential issues including the extra time it takes, wire handling characteristics, pressure wire drift, the need for hyperemia, and the expense.
- For all of these reasons, a technique for deriving FFR without the need of a pressure wire or hyperemic agent would be advantageous and could increase the adoption of physiology-guided revascularization.

Concept

- Coronary angiography-derived FFR (FFR_{angio}) is a new method for measuring FFR without a coronary pressure wire or hyperemic agent.

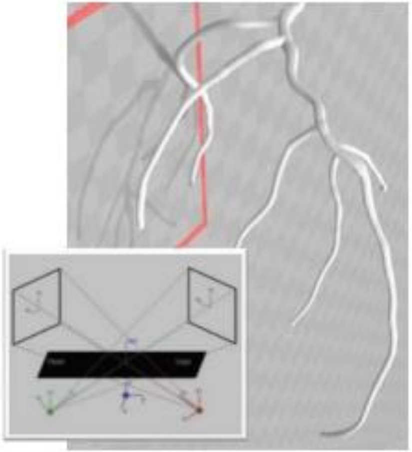
- FFR_{angio} relies on creating a three-dimensional (3D) reconstruction of the coronary arterial system and estimating the resistance and flow at each point along the entire coronary tree.

1 Optimal 2D angiography



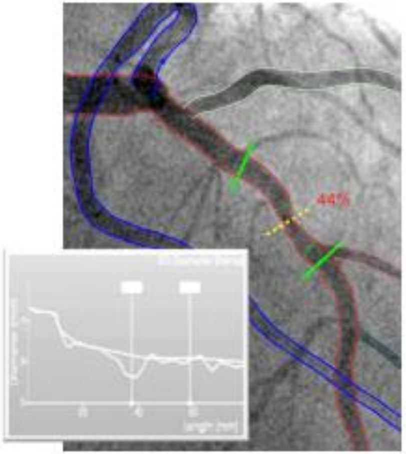
Optimal projections
Optimal frame
Motion compensation

2 3D model reconstruction



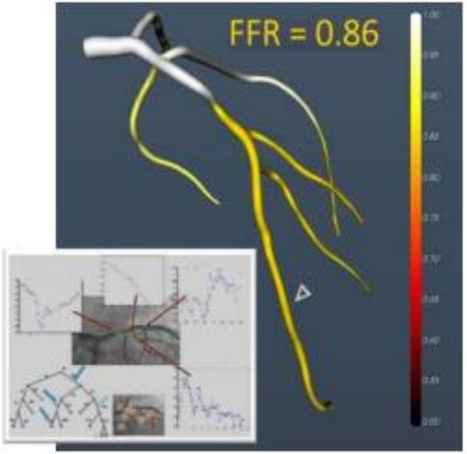
Extracting centerlines
Tree topology

3 Stenosis assessment



Bifurcation analysis
2D-QCA analysis
Estimating diameters

4 Hemodynamic evaluation

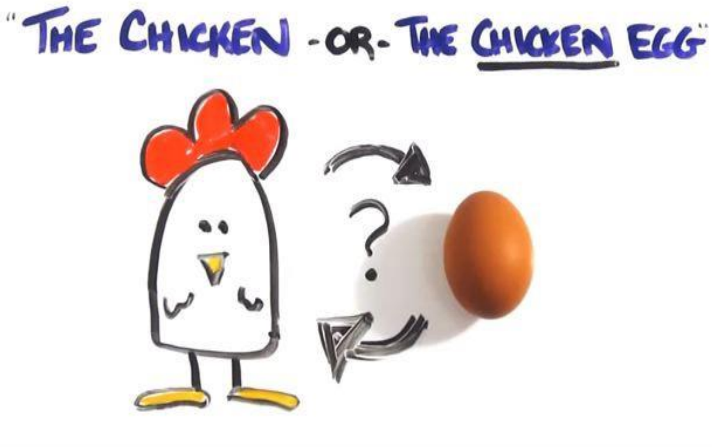


Resistance mapping
Maximum blood flow
Flow rate ratio

Summary

- FFR derived from routine coronary angiography (FFR_{angio}) had very high sensitivity, specificity and diagnostic accuracy, all of which were greater than 90% for predicting the reference standard, coronary pressure wire-derived FFR.
- FFR_{angio} and FFR remained highly correlated over the entire range of FFR values.
- FFR_{angio} was successfully measured in almost all cases included.

- Define anatomy
  - After conventional risk stratification
  - Part of risk stratification



- Preliminary studies have found that FFR_{angio} when measured off-site by experienced operators correlates well with pressure wire-derived FFR.

- FFR_{angio} has not been well validated when performed on-site by independent, local operators blinded to pressure wire-derived FFR and compared with core laboratory analyzed FFR values in a large, prospective, multicenter fashion.

Patients undergoing coronary angiography

3 roll-in patients / site

350 study patients

380 patients in total

FFR of ≥ 1 lesion as part of standard care

Reviewed by core-lab at CRF

Simultaneous blinded FFR_{angio} on-site

Reviewed by core-lab at CathWorks

Inclusion Criteria

- **Adult patients with stable angina, unstable angina, or non-ST elevation acute coronary syndromes undergoing coronary angiography with coronary pressure wire-derived FFR measurement of a coronary stenosis**

Clinical Exclusion Criteria

- STEMI within the past 12 months
- Prior CABG, valve surgery, or heart transplantation
- Severe aortic stenosis
- LV Ejection Fraction ≤ 45%

Angiographic Exclusion Criteria

- Left main stenosis > 50%
- Chronic total occlusion in target vessel
- < TIMI 3 flow in target vessel
- In-stent restenosis or recent stent placement in target vessel
- Severe diffuse disease
- Target vessel receiving collaterals