

협심증 검사 결과의 임상적 해석

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울산의대, 서울아산병원, 심장내과

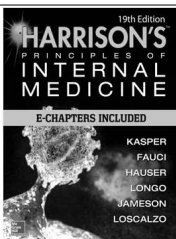
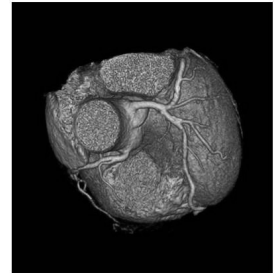
협심증 검사

- 언제 무슨 order 를 할 것인가 ?
- 결과를 어떻게 해석하고 치료해야 할까?

Ischemic Heart Disease (IHD)

허혈성 심질환 ?

- 58세 남자
- 고혈압 약물 치료중
- 흡연 과거력: 10년전까지
- 심한 운동을 하면 조금 숨이 차다
- 흉통은 없다



- **Ischemic heart disease (IHD)** is a condition in which there is an inadequate supply of blood and oxygen to a portion of the myocardium (ischemia); it typically occurs when there is an imbalance between myocardial oxygen supply and demand.
- The most common cause of myocardial ischemia is atherosclerotic disease of an epicardial coronary artery (or arteries) sufficient to cause a regional reduction in myocardial blood flow and inadequate perfusion of the myocardium supplied by the involved coronary artery.

What is the appropriate next step to diagnose IHD ?

Coronary Angiography ?



Guideline of Coronary Angiography for Unstable Coronary Artery Disease (CAD) or Myocardial Infarction (MI)

Generally indicated for need of revascularization

Indication of Coronary Angiography for Stable CAD

CLASS I

unacceptable ischemic symptoms despite medical treatment and who are amenable to, and candidates for coronary revascularization.

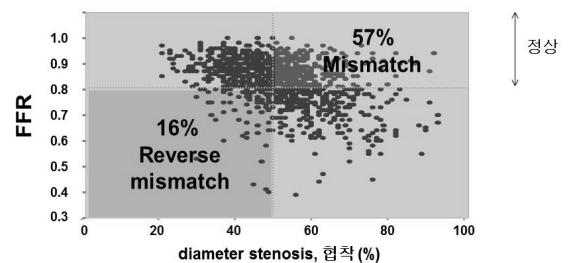
CLASS IIA

1. Reasonable for high likelihood of severe IHD and who are amenable to and candidates for coronary revascularization.
2. Patients cannot undergo diagnostic stress testing, or have indeterminate or nondiagnostic stress tests

Discrepancy between Angiography vs. Fractional Flow Reserve (FFR)

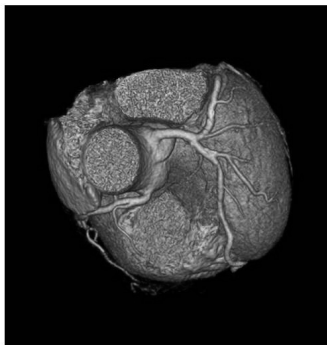
혈관조영술 협착과 허혈 검사의 차이

1066 non-left main coronary artery

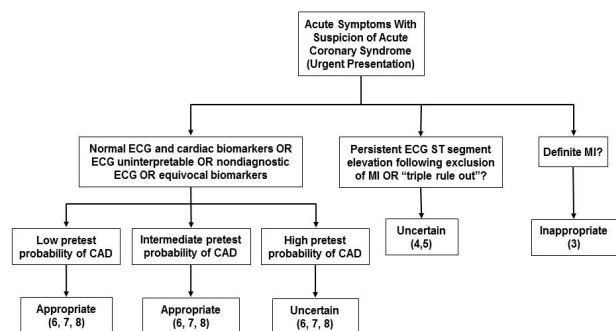


Park SJ, Ahn JM, Kim YH et al. JACC interv 2012;5:1029

Coronary CT 는 언제 order 하는 것이 적절한가?



Cardiac CT for Acute Chest Pain



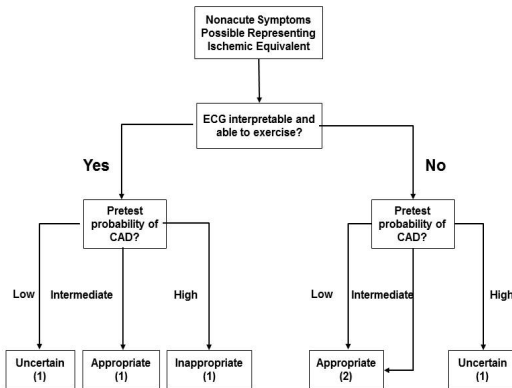
Triple Rule-out

- Coronary disease
- Pulmonary embolism
- Aortic dissection

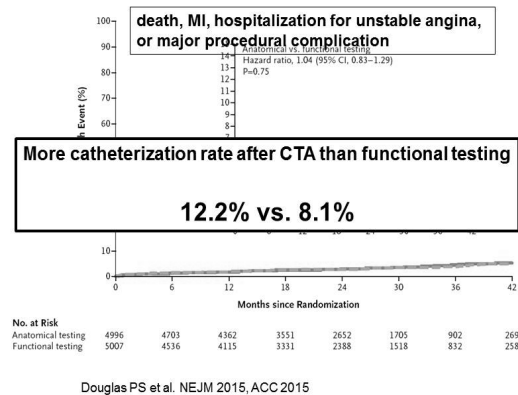
Guideline for Acute Chest Pain

Suspicion of ACS	Pre-test probability of CAD	ACCF 2006	ACCF 2010	ASCI 2010	KOREA 2013
Definite MI	-	I	I	I	I – C
Persistent ECG ST-segment elevation following exclusion of MI	-	-	U	-	U – B
TRO	-	U	U	A	A – B
Persistent probability of CAD	Low	U	A	U	A – A
	Intermediate	A	A	A	A – A
	High	U	U	A	A – A*

Cardiac CT for Chronic Symptom



PROMISE Trial Initial CTA vs. Functional Test

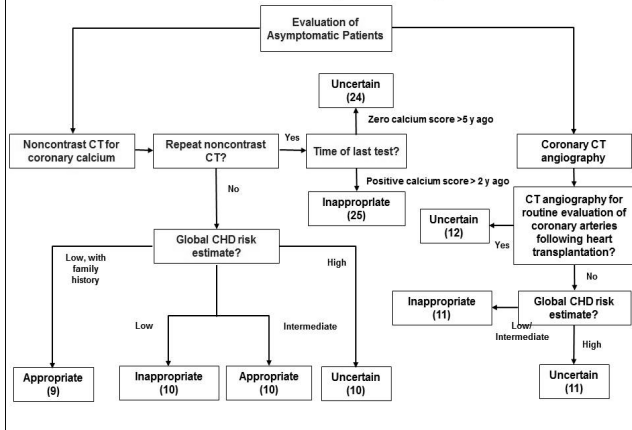


Pretest Probability of CAD (%)

CTA 는 stable 한 환자는 intermediate risk group 에서 할 수 있다.

	Typical angina		Atypical angina		Non-anginal pain	
	Men	Women	Men	Women	Men	Women
Age						
30-39	59	28	29	10	18	5
40-49	69	37	38	14	25	8
50-59	77	47	49	20	34	12
60-69	84	58	59	28	44	17
70-79	89	68	69	37	54	24
>80	93	76	78	47	65	32

Cardiac CT Screening for Asymptomatic



Indications of Revascularization (PCI or CABG) for Stable Angina

	Subset of CAD by anatomy	Class	Level
For prognosis	Left main >50% *	I	A
	Any proximal LAD >50% *	I	A
	2VD or 3VD with impaired LV function *	I	B
	Proven large area of ischemia (> 10%LV)	I	B
	Single remaining patent vessel >50% stenosis *	I	C
	1VD without proximal LAD and without >10% ischemia	III	A
For symptoms	Any stenosis >50% with limiting angina or angina equivalent, unresponsive to OMT	I	A
	Dyspnea/CHF and >10%LV ischemia/viability supplied by >50% stenotic artery	Ia	B
	No limiting symptoms with OMT	III	C

* With documented ischemia or FFR < 0.8

Evaluation for Functional Ischemia

• Noninvasive method (비침습적 검사)

- Exercise EKG
- Stress echocardiography
- SPECT
- MRI
- PET
- Functional CT

• Invasive method (침습적 검사)

- With angiography
- Fractional flow reserve (FFR)
- Coronary flow reserve (CFR)
- etc

Strength and Weakness of Invasive Tests

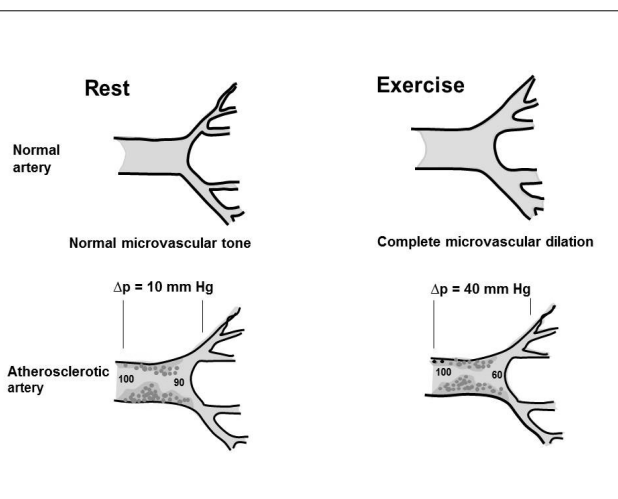
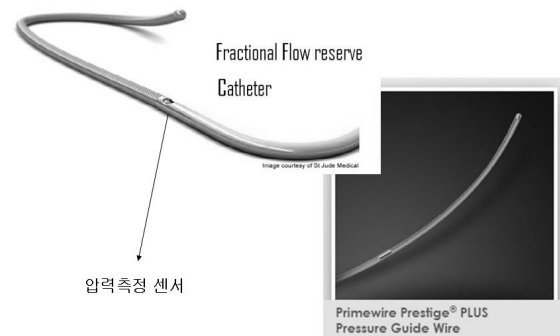
• Good

- Sensitive for local ischemic information
- Clear anatomic information with angiography or intravascular imaging
- Good for switch to subsequent PCI

• Bad

- Need of hospitalized in general
- Risk of procedural complication
- No information on myocardial area at risk
- High cost

Invasive Methods to Detect IHD



Invasive Functional Evaluation using FFR Wire

Rest and stress FFR with adenosine infusion

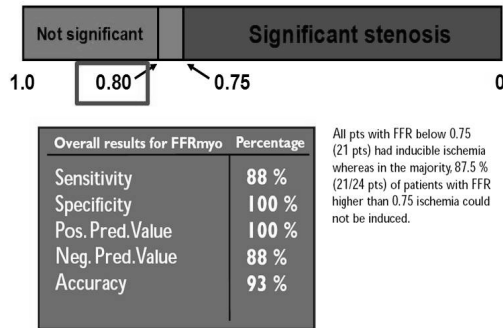


• FFR (hyperemic Pd/Pa)
= 0.62

• CFR (coronary flow reserve)
= hyperemic flow / resting flow
= (1/ hyper Tmn) / (1/ rest Tmn)
= Tmn rest / Tmn hyper
= 2.2 (abnormal ≤ 2.0)

• IMR (index of microcirculatory resistance)
= Δ pressure / flow
= Distal pressure / (1/ Tmn)
= Pd X hyper Tmn = 79 X 0.19
= 15.0 (abnormal ≥ 25)

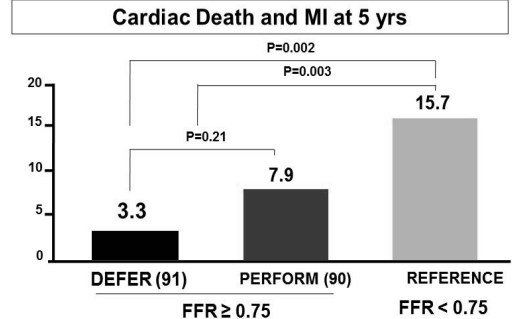
FFR 수치 vs. Myocardial ischemia



Pijls et al. NEJM 1996;334

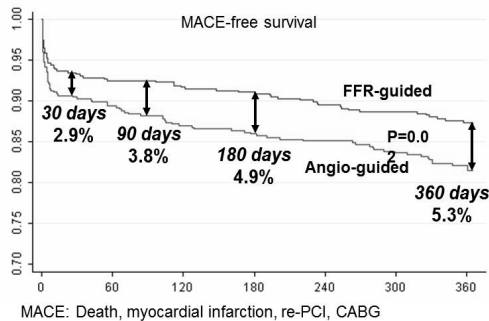
FFR 이 정상 (0.75 이상) 인 경우 시술하지 않았을 때 (DEFER) 임상 경과

DEFER study: Single vessel disease (325명)



J Am Coll Cardiol 2007;49:2105-11

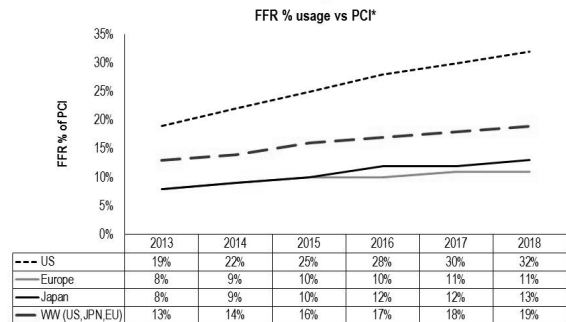
FFR 값을 근거로 PCI 를 할 때 (혈관조영술 근거 시술과 비교)
FAME – I: FFR vs. Angio-guided DES for multivessel diseases



Tonino PAL et al, N Engl J Med 2009;360:213

FFR 사용량

Worldwide Annual Coronary Pressure Wire Use

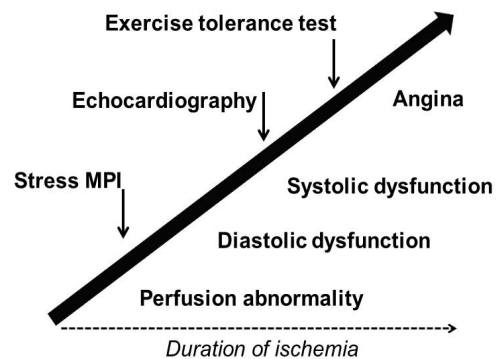


Total number of FFR Procedures divided by number of PCI
Source: Millennium Research Group (2013-2015)

Evaluation for Functional Ischemia

- Noninvasive method
 - Exercise EKG
 - Stress echocardiography
 - SPECT
 - MRI
 - PET
 - Functional CT
- Invasive method
 - Fractional flow reserve (FFR)
 - Coronary flow reserve (CFR)
 - etc

Ischemic Cascade

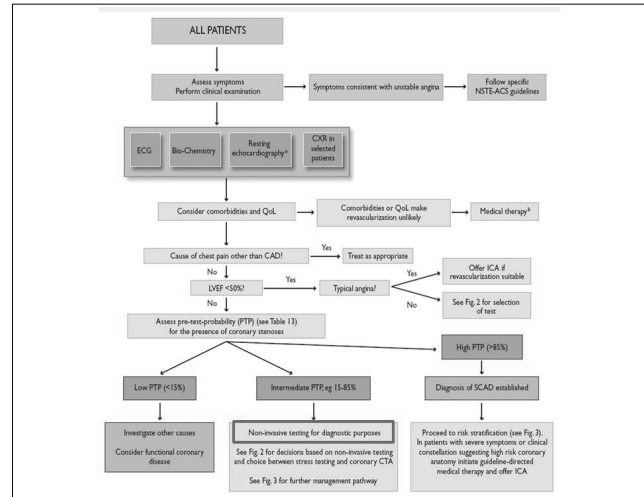


Heart 2005;91:1110

Diagnostic Accuracy to Detect IHD

Method	Sensitivity (%)	Specificity (%)
Exercise ECG	45 – 50	85 – 90
Exercise stress echocardiography	80 – 85	80 – 88
Exercise stress SPECT	73 – 92	63 – 87
Dobutamine stress echocardiography	79 – 83	82 – 86
Dobutamine stress MRI	79 – 88	81 – 91
Vasodilator stress echocardiography	72 – 79	92 – 95
Vasodilator stress SPECT	90 – 91	75 – 84
Vasodilator stress MRI	67 – 94	61 – 85
Coronary CT angiography	95 – 99	64 – 83
Vasodilator stress PET	81 – 97	74 – 91

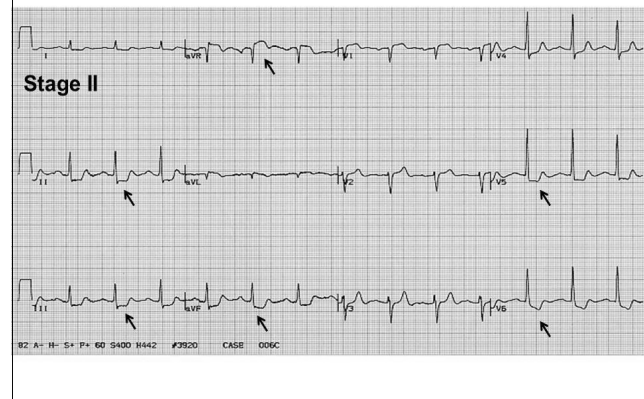
Eur Heart J 2013;34:2949



Pretest Probability of CAD (%) Intermediate risk 에 functional test 가 필요하다

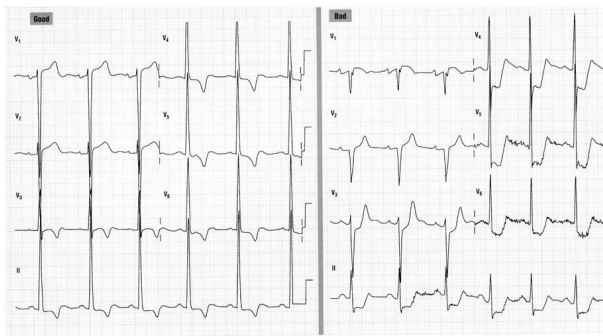
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Exercise ECG



Left ventricular hypertrophy

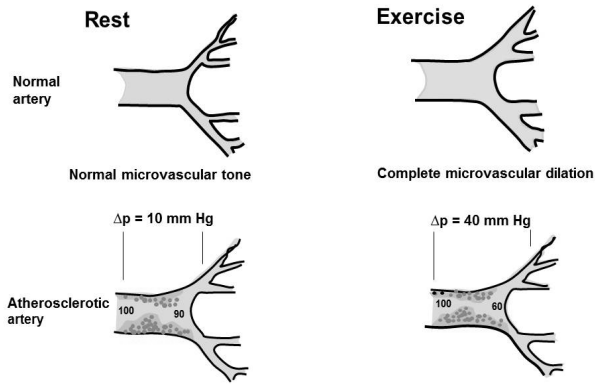
True ischemia



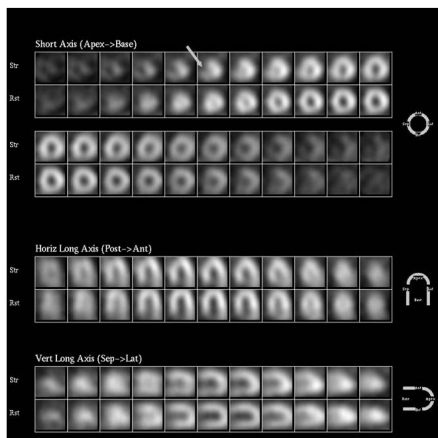
Cardiac Imaging

- Patients who can not perform stress EKG
- Good for lesion localization
 - 운동부하 심전도는 병변의 위치를 알 수 없다
- Better sensitivity and specificity for diagnosis of IHD than stress EKG
- Pharmacological stress with adenosine, dipyridamole, dobutamine
- Comparison with stress and rest images
- Nuclear imaging with thallium, sestamibi, technetium
- Echocardiogram
- MRI or CT

Coronary Steal Phenomenon

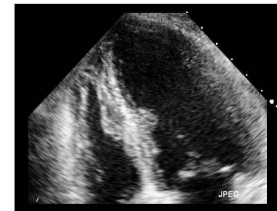
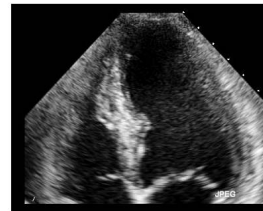


Radionuclide Imaging



Stress Echocardiography

(Adenosine upto 200ug/Kg/min)

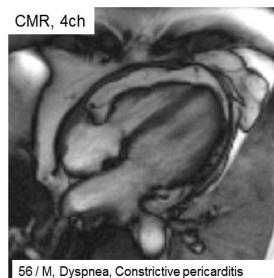


Baseline

Peak dose

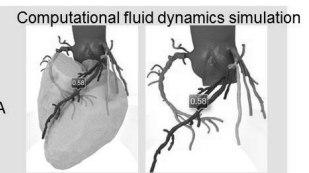
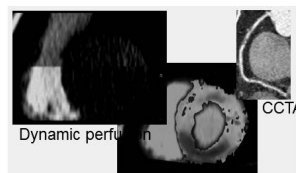
No abnormality

Cardiac MRI



1. The ability to obtain images in all plane directions
2. Good spatial (> ECHO) and temporal (> CT) resolution
3. Reliable endocardial border detection
4. Independency of geometrical assumption
5. Function to detect myocardial perfusion and viability

CT-based Functional Imaging

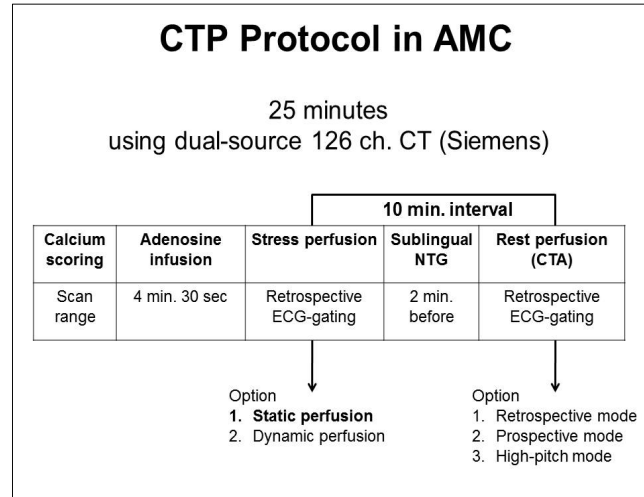
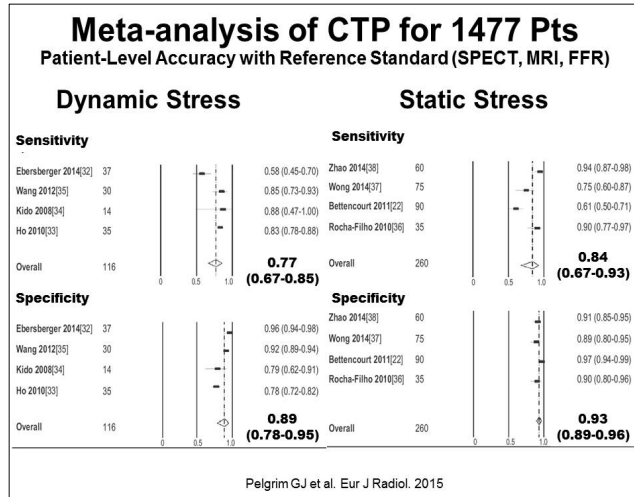


CT Perfusion (CTP)

- | | |
|-------------|---|
| Pros | <ul style="list-style-type: none"> ✓ Direct view of myocardium ✓ Easy to perform ✓ No special software |
| Cons | <ul style="list-style-type: none"> ✓ Radiation dose concern (two scans; stress + rest) ✓ Requirement of adenosine |

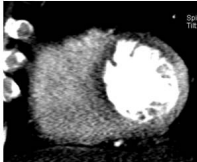
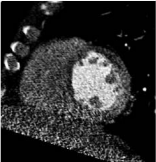

FFR-CT

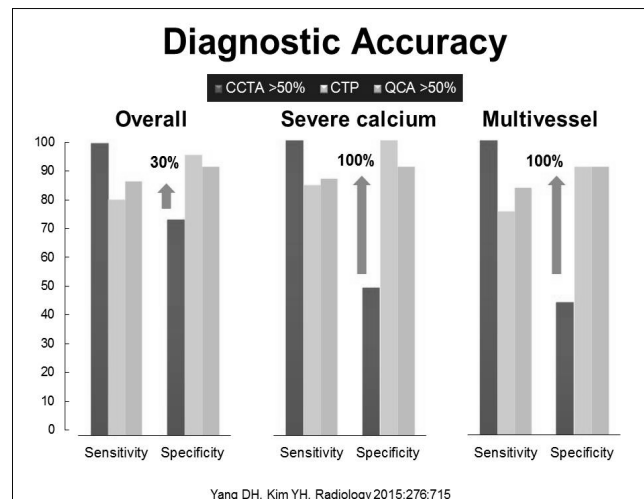
- | | |
|-------------|---|
| Pros | <ul style="list-style-type: none"> ✓ No additional scan ✓ No requirement of adenosine |
| Cons | <ul style="list-style-type: none"> ✓ Indirect view of ischemia ✓ Need supercomputer ✓ No information on perfusion. |



Visual Analysis of CTP

- Diagnostic indicator of myocardial ischemia
 - Low density lesion** conforming coronary territory
 - Persistent lesion** at systole and diastole (DDx) Transient motion or beam-hardening artifact
 - Wall motion abnormality (useful)**


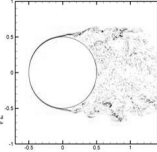





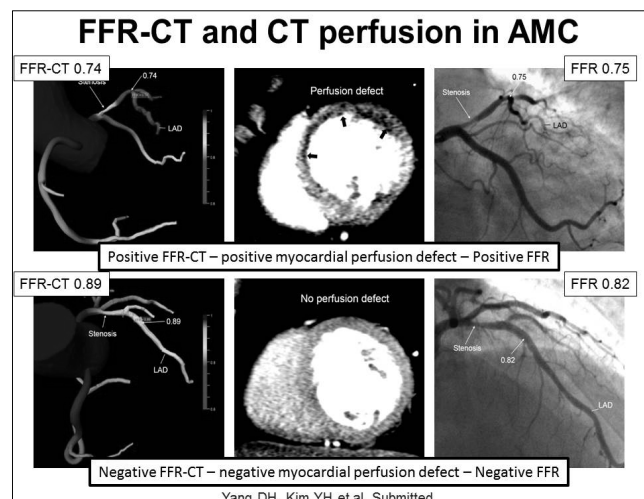


CT-Based FFR (FFR-CT): Principle

What is CFD?

Computational Fluid Dynamics (CFD) is the science of predicting fluid flow, heat transfer, mass transfer, chemical reactions, and related phenomena by solving the mathematical equations which govern these processes using a numerical process (that is, on a computer).



FFR-CT Published Data

	DISCOVER-FLOW		DeFACTO		NXT	
Year, Journal	2011, JACC		2012, JAMA		2013, JACC	
Pts. No	103		252		251	
Design	Single-center		Multicenter		Multicenter	
	CT	cFFR	CT	cFFR	CT	cFFR
Sensitivity	94%	93%	84%	90%	94%	86%
Specificity	25%	82%	42%	54%	34%	79%
PPV	58%	85%	91%	67%	40%	65%
NPV	80%	91%	72%	84%	92%	93%
Accuracy	61%	81%	64%	73%	53%	81

Hecht HS. The Game Changer? JACC 2014 April 1, 1156-8

Functional evaluation is still essential for diagnosis and treatment of IHD.

- 관상동맥 CT 는 증상이 있는 환자에서 시행할 수 있다.
- 심근의 허혈 여부가 협심증 진단과 치료의 가장 중요한 고려사항이다.
- 현재까지 스텐트 시술이나 수술적 치료는 객관적 심근 허혈의 증거가 기준이 된다.
- 허혈 검사는 침습적, 비침습적 검사들이 있으며 상황에 따라 선택한다.
- 허혈검사중 영상검사들은 해당 병변을 진단하는데 유리하다 (regional information).
- SPECT 검사가 가장 흔히 사용되는 허혈 검사 영상 검사이고 최근 심장 CT를 활용한 검사법이 개발되고 있다.
- 침습적 허혈 검사로는 FFR 검사를 가장 많이 사용한다.