CT Coronary Angiography

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Clinical Application of CTCA

1. Normal anatomy and congenital anomalies
2. Coronary calcium scoring
3. Detection of coronary a. stenosis / occlusion
4. Evaluation of atherosclerotic plaque
5. Post-op. evaluation of bypassed vessels
6. Evaluation of stent patency
7. Myocardial perfusion, viability
8. LV function, regional wall motion

Vulnerable Plaque

TABLE 1. Underlying Pathologies of "Culprit" Coronary Lesions

Ruptured plaques (≈70%)
Stenotic (≈20%)
Nonstenotic (≈50%)
Nonruptured plaques (≈30%)
Erosion
Calcified nodule
Others/Unknown

*Adapted from Falk and associates,[6] Davies,[7] and Virmani and colleagues.[7]

Naghavi M et al. Circulation 2003

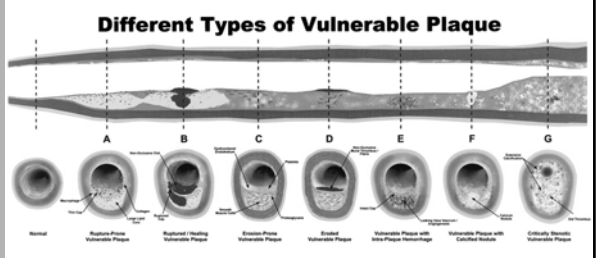
Vulnerable Plaque

TABLE 4. Criteria for Defining Vulnerable Plaque, Based on the Study of Culprit Plaques

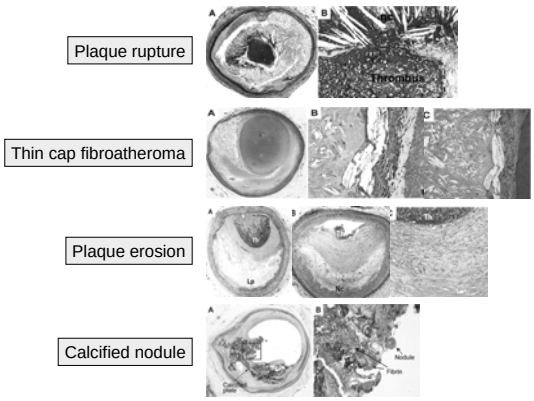
Major criteria
- Active inflammation (monocyte/macrophage and sometimes T-cell infiltration)
- Thin cap with large lipid core
- Endothelial denudation with superficial platelet aggregation
- Fissured plaque
- Stenosis >90%

Minor criteria
- Superficial calcified nodule
- Glistening yellow
- Intraplaque hemorrhage
- Endothelial dysfunction
- Outward (positive) remodeling

Naghavi M et al. Circulation 2003



Naghavi M et al. Circulation 2003

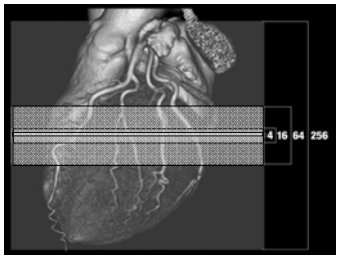


Virmani R. J Am Coll Cardiol. 2006

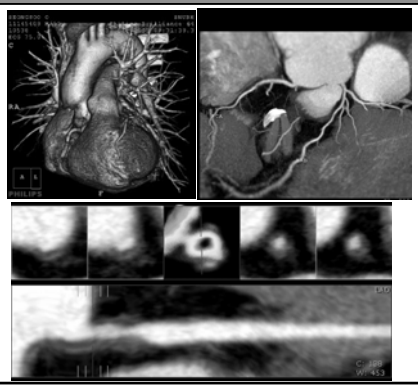
Medicine is a science of uncertainty and an art of probability
Sir William Osler (1849–1919)

Coronary CT Angiography: Hype or New Paradigm?
Garcia MJ. JAMA 2005; 293: 2531 - 2533.

Coronary CT Angiography: The end of the beginning
Schmermund A, Erbel R. Eur Heart J, 2005; 26: 1451 - 1453.



Coronary CT Angiography
- Hype or New Paradigm ? -



Coronary Stenosis: Accuracy

	Nieman, Circulation 2002	Ropers, Circulation 2003	AMC, 2003
대상환자	58	77	42
유병률 환자	(51/58) 88%	(41/77) 53%	(33/42) 79%
혈관	(86/231) 37%	(78/308) 25%	(77/264) 29%
환자당 대상 혈관	4	4	6.3
대상혈관의 직경	2mm 이상	1.5mm 이상	1.5 mm 이상
평균 심박동수	56/min	62/min	59/min
분석가능빈도 환자		74%	66%
혈관	214/231 93%		210/264 91%
결과 (모든 혈관) 민감도	95%	73%	75%
특이도	86%		85%
양성예측도	80%		67%
음성예측도	97%		89%
결과 (분석가능) 민감도		92%	87%
특이도		93%	84%
양성예측도		79%	67%
음성예측도		97%	94%
결과 (모든 환자) 민감도		85%	97%
특이도		78%	33%
양성예측도		82%	84%
음성예측도	100%	81%	75%
판독방법	Axial / Reformatted 영상 (> 400)	Axial / Reformatted 영상 (> 400)	Reformatted 영상 (180)

Failure of Coronary CTA

	Left main	Left anterior descending	Left circumflex	Right coronary	Total
Cardiac motion/arrhythmia	0	0	2	14	16
Extensive calcifications	1	6	5	3	15
Small vessel (<1·5 mm)	0	0	12	0	12
Adjacent contrast-filled structures*	0	1	6	3	10
Non-cardiac motion (breathing)	0	0	2	5	7
Poor opacification	0	1	2	1	4

*Veins or ventricle.

Table 2: **Reasons for non-assessability of vessel segments**

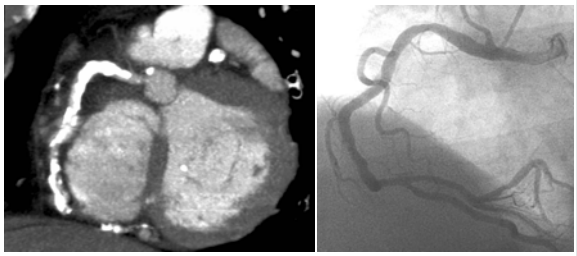
Nieman, et al. Lancet 2001

Heart Rate

	Overall	HR < 60 bpm
Ropers Circulation 2003	88% (270/308)	96% (138/144)
AMC	91% (240/264)	97% (165/170)

- Beta-blocker: if HR > 60 bpm

Severe Calcification



Blooming Artifact

Courtesy of Choi SI, SNUBH

Effect of Calcification on Accuracy of Coronary CTA

	All Segments	Patients With Ca Score <1,000
Patients (n)	60	46
Segments (n)	780	598
Lesions by CCA (n)	75	40
Correct positive lesions by MSCT (n)	54	39
False positive (n)	21	10
Sensitivity	0.72	0.98
Specificity	0.97	0.98
Positive predictive value	0.72	0.80
Negative predictive value	0.97	1.0

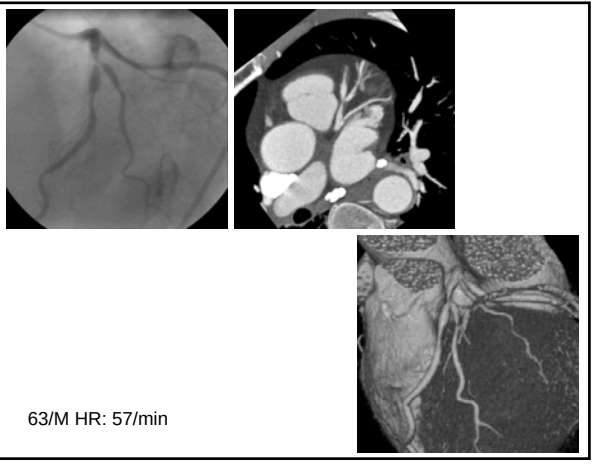
- Even with 16-MDCT, Severe calcification limit interpretability of coronary CTA.

Kuettner A, JACC, 2004

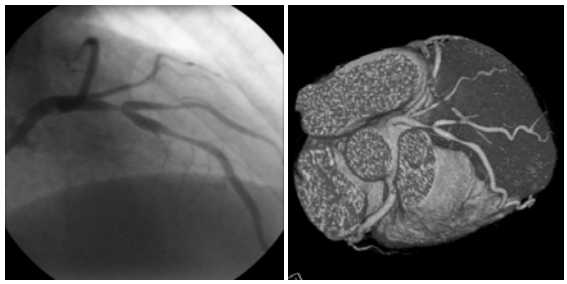
16-slice MDCT

Achenbach et al. Eur H J 2005; 26:1978-1986

- Sensation 16 Cardiac CT scanner (Siemens Medical Solutions, Erlangen, Germany)
- 375 ms gantry rotation time
- 3.0 mm table feed per rotation
- 16 x 0.75 mm collimation
- 409 ± 32 mA tube current
- Initial reconstruction starting at 65% of the R-R interval → Additional reconstructions were performed if motion artifacts were present (in 5% increments and decrements)



63/M HR: 57/min



Evaluation of coronary stenosis (16 slice MDCT)

Author	Journal	Sensitivity	Specificity	PPV	NPV
Garcia MJ	JAMA 2006	89%	65%	13%	99%
Kaiser C	Eur H J 2005	30%	91%	47%	83%
Nikolaou K	AJR 2006	80%	99%	57%	99%
Achenbach S	Eur H J 2005	94%	96%	68%	99%

Evaluation of coronary stenosis (16 slice MDCT)

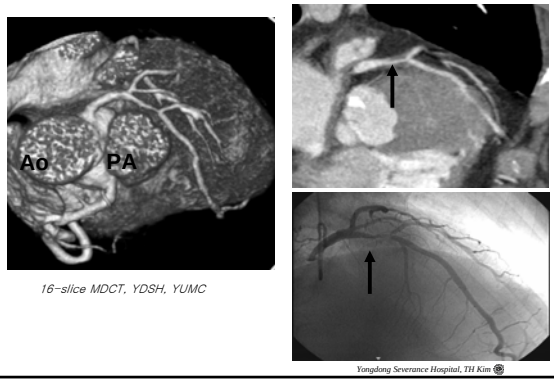
Author	Journal	Unevaluable segments	TP	TN	FP	FN
Garcia MJ	JAMA 2006	472/1629	79	996	544	10
Kaiser C	Eur HJ 2005	491/2110	128	1532	146	304
Nikolaou K	AJR 2006	32/420	4	380	3	1
Achenbach S	Eur HJ 2005	28/663	50	559	23	3

64-slice MDCT

Leschka S et al. Eur H J 2005; 26:1482-1487

- Sensation 64, Siemens, Forchheim, Germany
- 330 ms gantry rotation time
- 3.8 mm table feed per rotation
- 32 X 2 number of scan 0.6 mm collimation
- X-ray tube potential: 120 kV
- Effective tube current: 680 mA
- Over all scan time: 10.7 ~ 11.9 sec

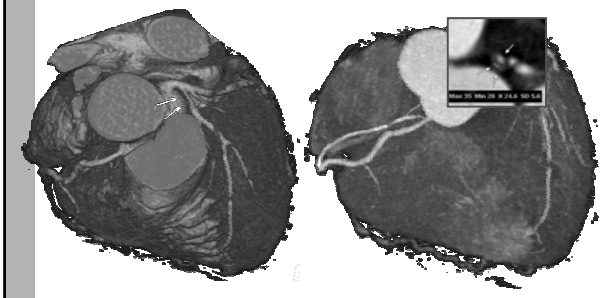
Coronary CTA Analysis: ***Soft Plaque***



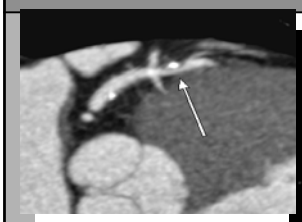
16-slice MDCT, YDSH, YUMC

Yongdong Severance Hospital, TH Kim

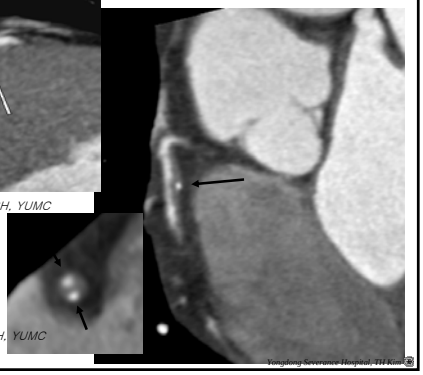
Coronary CTA Analysis: ***Soft (fatty) plaque***



Coronary CTA Analysis: ***Mixed plaque***



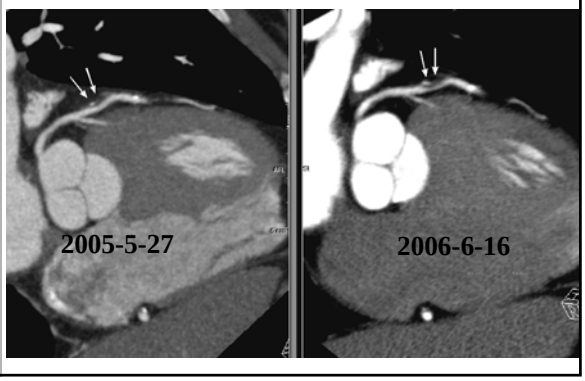
16-slice MDCT, YDSH, YUMC



64-slice MDCT, YDSH, YUMC

Yongdong Severance Hospital, TH Kim

Coronary CTA Analysis: ***Follow-up for plaque***



Evaluation of coronary stenosis (64 slice MDCT)

Author	Journal	Sensitivity	Specificity	PPV	NPV	
[1]Leschka	Eur Hear J 2005	94%	97%	87%	99%	(segment)
[2]Mollet NR	Circulation 2005	99%	95%	76%	99%	(segment)
[3]Raff GL	JACC 2005	86%	95%	66%	98%	(segment)
		95%	90%	93%	93%	(patient)

[1] 67(73) patients with suspected CAD or prior to CABG
All vessels ≥ 1.5 mm, β-blocker (+)

[2] 52(70) patients with stable, unstable angina or non-STEMI scheduled for CAG
All vessels regardless of size, β-blocker (+)

[3] 70 consecutive patients undergoing elective CAG for suspected CAD
All vessels regardless of size, β-blocker (+)
26% ≥ 400 Agatston U, 25% HR > 70, 50% obese
Assessable: 773/935/1065 segments

Conclusion

- Image quality can be improved by
  - Reducing heart rate by < 60 bpm with ß-blocker
  - More visualization of arteries by using vasodilator
  - Newer technology (64 slice MDCT)

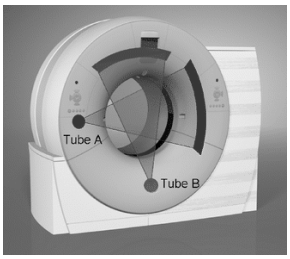
Conclusion

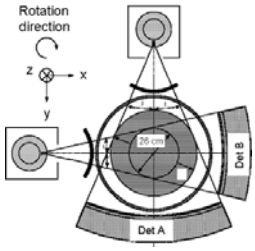
- Patients selection
  - Equivocal clinical presentation

    Low pre-test probability of CAD
  - Make no sense
    - In asymptomatic pts with no signs of myocardial ischemia
    - In patients with high degree of suspicion

      → should go straight to the CAG room

DSCT: system design

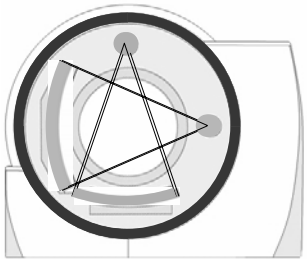


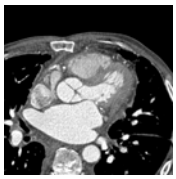


Angle Between tube A and tube B: 90°

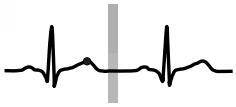
Det. A: 50cm, Det. B: 26cm (due to limitation of gantry size)

Dual Source CT: Heart rate independent temporal resolution





Temporal Resolution = $\frac{\text{Rotation Time}}{4}$ = **83 ms**



Temporal Resolution

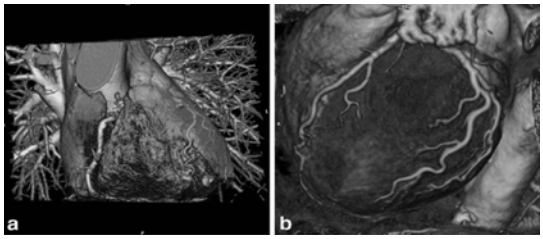
4-detector MDCT : 250 msec
16-detector MDCT : 200 msec
64-detector MDCT : 160 msec
EBCT : 100 msec

Dual source CT : 80 msec

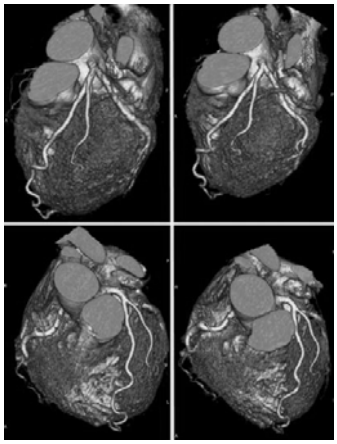
Spatial Resolution

EBCT : 3.0 mm
4-detector MDCT : 1.0 mm
16-detector MDCT : 0.8 mm
64-detector MDCT : 0.6 mm

Dual source CT : 0.6 mm



Johnson TRC et al
Eur Radiol, 2006



(VRT) of a 59-year-old man suspicion of RCA stenosis

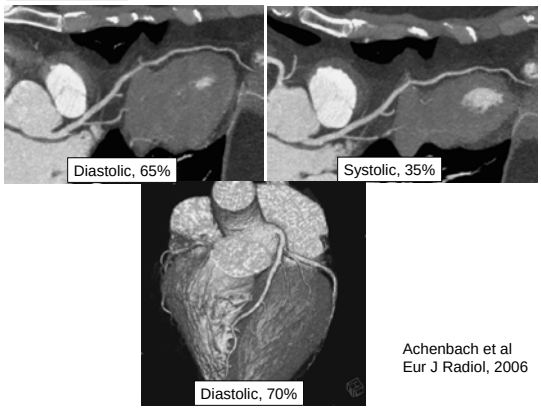
mean HR: 85 bpm.

Left: diastolic reconstruction at 65%

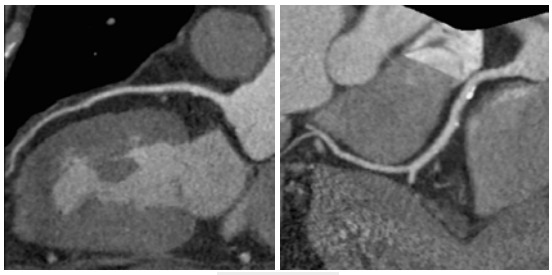
Right: end-systolic reconstruction at 28%

Flohr TG et al
Eur Radiol, 2006

HR: 55 bpm



Achenbach et al
Eur J Radiol, 2006



HR: 90 bpm

Achenbach et al
Eur J Radiol, 2006

Conclusion: *Present and Future*

- Role of MDCT *at Present*
  - Equivocal clinical presentation
  - Low pre-test probability of CAD
- Role of MDCT *in the Future*
  - *In pts with high degree of suspicion ?*

Detection and Characterization of "Vulnerable Plaque", although, it looks to be a tough way….

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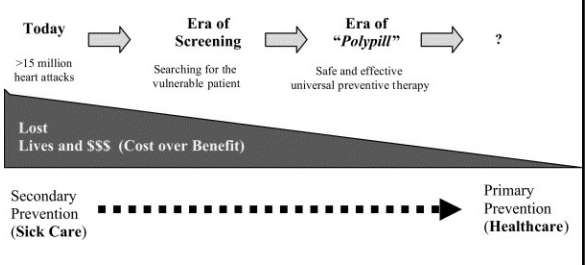
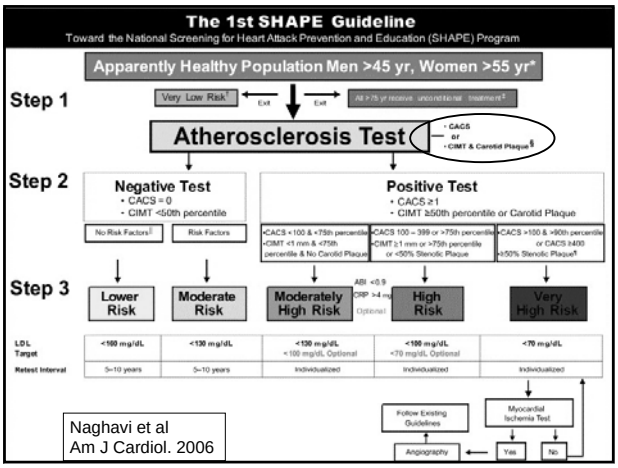
  - *In pts with high degree of suspicion*
  - *In asymptomatic pts with no signs of myocardial ischemia ?*

From Vulnerable Plaque to Vulnerable Patient—Part III: Executive Summary of the Screening for Heart Attack Prevention and Education (SHAPE) Task Force Report



Naghavi et al
Am J Cardiol. 2006



Naghavi et al
Am J Cardiol. 2006

From Vulnerable Plaque to Vulnerable Patient—Part III: Executive Summary of the Screening for Heart Attack Prevention and Education (SHAPE) Task Force Report

- Conclusion

  The SHAPE Task Force strongly recommends screening of the at-risk asymptomatic population (men 45–75 years of age and women 55–75 years of age) for subclinical atherosclerosis to more accurately identify and treat patients at high risk for acute ischemic events, as well as to identify those at lower risk who may be treated more conservatively.

Naghavi et al
Am J Cardiol. 2006

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Screening of the at-risk asymptomatic population: needs more robustness….

Medicine is a science of uncertainty…
And an art of probability…

Sir William Osler (1849–1919)

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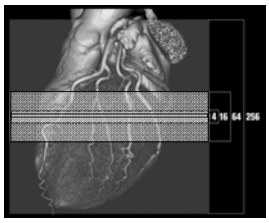

Thank you for your attention!!

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Siemens Medical Solutions