Detection of Vulnerable Plaque by Coronary CT: Evolution and more?

James K. Min, MD FACC

President, Society of Cardiovascular Computed Tomography Associate Professor of Medicine, UCLA School of Medicine Associate Professor of Medicine and Imaging, Cedars-Sinai Medical Center Co-Director, Cardiac Imaging, Cedars-Sinai Heart Institute Director, Cardiac Imaging Research, Cedars-Sinai Medical Center

Disclosures: Research support (NHLBI; Qatar National Research Fund; GE Healthcare; Philips Medical, Vital Images, Infinitt/Xelis); Medical Advisory Board (GE Healthcare); Medical Consultant (Edwards Life Sciences); Equity Interest (TC3 Cardiovascular Core Laboratories; Cedars-Sinai Medical Center)

Case: 46 y/o Caucasian Man

- <u>Chest pain</u>: Atypical chest pain prompted CT angiogram at OSH
 - Reported to have left main dissection
 - High-grade stenosis in LAD
 - Other coronaries reported as "moderate"
 - Now CP-free
- Self-refers to 2 cardiologists for 2nd and 3rd opinion
 - Coronary CT angiogram re-reviewed

"What is my risk?"



- No left main dissection, MLA 7.2 mm2
- Obstructive coronary stenosis, pLAD
- Moderate grade stenosis, LCx/OM
- Left dominant

Case: 46 y/o Caucasian Man

- Patient recommended to undergo LHC
 - LM IVUS (7.0 mm²)
 - Severe CAD in LAD
 - Recommended to undergo CABG
- Patient flies to 2 additional hospitals for 4th and 5th opinion, and then returns to PCP for 6th opinion
 - Based upon COURAGE, recommended to undergo optimal medical therapy alone
- Patient presents 2 weeks later with CP and large lateral STEMI from proximal LCx lesion

Vulnerable Plaque – Thematic Consistences



- Ruptured plaques large, >50% CSA
- Positive remodeling compensatory for preservation of flow
- Lipid-rich necrotic cores
- Thin-cap fibroatheroma
- "Spotty" calcifications

Adverse Plaque Characteristics





Remodeling Ratio (RR) = EEM area lesion / EEM area proximal reference





"Spotty" calcification



Source: Schoenhagen et al. Circulation2000; Ehara et al. AHJ 2003; Haegawa et al. AHJ; many others

PROSPECT: A Landmark Study

~700 patients 3-vessel imaging post PCI

Culprit artery, followed by

non-culprit arteries

Angiography (QCA of entire coronary tree)



PROSPECT

Providing Regional Observations to Study Predictors of Events in the



*Likelihood of one or more such lesions being present per patient. PB = plaque burden at the MLA

Does CAD characterization by CT extend the prognostic utility beyond stenosis?



- <u>Atherosclerotic plaque characteristics</u>
 - Stenosis measures (MLD, MLA)
 - Non-obstructive CAD
 - Plaque burden (thickness, volume, area)
 - Plaque composition (mixed [TCFA], NCP, CP)
 - "Lipid dense" intraplaque core (low attenuation)
 - Arterial remodeling (positive, negative, intermediate)

Added Prognostic Value of CCTA:

Extends the 'at-risk' paradigm beyond stenosis itself

38 pts with ACS and 33 pts with SAP prior to PCI. Coronary plaques evalauted for remodeling, consistency of non-calcified plaque (<30 HU vs. 30<NCP<150 HU), and spotty vs.large calcification.





Positive remodeling, NCP<30 HU and spotty calcification more frequent in culprit ACS lesions than SAP.

Adverse Plaque Characteristics: 'At-Risk' Paradigm Extents Beyond Stenosis



- 1,059 patients examined for positive remodeling (PR) and low attenuation plaque (LAP)
- ACS for 2-FPP (22.2%), 1-FPP(3.7%), 0-FPP(0.5%)
- All events in patients with <75% stenosis
- Limited by number of new ACS (n=14)

Source: Motoyama et al. JACC 2009

Adverse Plaque Characteristics:

'At-Risk' Paradigm Extents Beyond Stenosis



Source: Shmilovich et al. Atherosclerosis 2011

Adverse Plaque Characteristics:

'At-Risk' Paradigm Extents Beyond Stenosis

%revTPD related to number of APCs



Adverse Plaque Characteristics:



Source: Shmilovich et al. Atherosclerosis 2011

How Good is CT for Plaque?

r=0.95, p <0.0001

no significant difference between obs. and IVUS (101.6 \pm 57.1 vs. 102.5 \pm 58.6 mm³, p=0.8)



Utilized 2 experienced observers with consensus agreement

AutoPlaq:

Automated method for plaque characterization



- % Diameter Stenosis (MLD)
- % Area Stenosis (MLA)
- NCP volume
- CP volume
- Remodeling index
- "Spotty" calcification
- Lesion- / vessel-/ patient PB
- Transluminal contrast gradients

No significant difference between APQ and IVUS (97.8 \pm 56.9 vs. 102.5 \pm 58.6 mm³, p=0.3)

r=0.92, p <0.0001

Source: Dey et al JCCT 2009

CCTA Prognosis by Plaque Characteristics The CONFIRM Registry:

Coronary CT Angiography Evaluatio<u>N</u> For Clinical Outcomes: An Inte<u>R</u>national <u>M</u>ulticenter Registry



- Dynamic registry of >32,000 consecutive patients undergoing CCTA
- V.1. 12-centers in 6 countries (US, Canada, Germany, Switzerland, Italy, and S. Korea), Database lock 09/10 *Derivation Cohort*
- V.2. 6 add'l sites (Miami, California, Vancouver, New York, Innsbruck, Seoul) Validation Cohort

• V.3. <u>>3</u> add'l sites (Milan, Italy; Portugal; Warsaw, Poland?) - ~12-14K Source: Min et al. JCCT 2011

Age- and Gender-Stratified Prognosis

23,854 patients w/o known CAD (57+13 years), 2.3 year f/u



Male <65 Female <65 Male >65 Female >65

Non-Obstructive CAD & Mortality: 18,037 Patients with <50% Stenosis by CCTA



• Independent non-linear increase in mortality for every additional coronary segment with CAD (HR 1.17, 95% CI 1.10-1.25, p<0.001)

Source: Lin et al. J Am Coll Cardiol 2011; Min et al. ACC 2011 Scientific Sessions 2011; Chow et al. AHA 2011

CONFIRM-ACS

Adult Individuals with Suspected CAD Undergoing CCTA

1:1 (306:306) Match for Pts who Did versus Did Not Experience Subsequent ACS (~224 d) – Adjudicated by cath, troponin, ECG

Comprehensive Quantification and Characterization of Atherosclerotic Plaque (Per-patient, Per-vessel, Per-Lesions)

CONFIRM-ACS

~20-fold number of ACS as PROSPECT and Motoyama et al.



Manual and Automated Quantification of Plaque Characteristics



CONFIRM-PROGRESS



CONCLUSIONS

- 1. Is CCTA as good as invasive measures for plaque characterization? No . . . But definitely getting better
- CCTA offers added ability to quantify per-lesion
 / per-vessel / and per-patient plaque volume
- 3. Longitudinal studies of CCTA will help determine characteristics of plaque that increase LK of future adverse events