# Vulnerable Plaque Detection by CTA Opportunity to Prevent MI and SCD



James A. Goldstein MD Director of Research and Education Dept of Cardiovascular Medicine William Beaumont Hospital

# Can we Use Imaging to Prevent MI?

#### 1.2 million MI/annum 300,000 SCD Most from Lipid-Rich Plaques





## These LCP lesions Do Not develop Overnight!

# VP Hypothesis Satisfying "Koch's Postulates"





Anthrax Spores

Identify VP as Culprit in ACS Patients

Prove VP Induce Future ACS Events



Prove that Rx (PCI-Medical) Improves Outcomes

Establish that CTA Screen can "At Risk" Pts

### Hallmarks of a Plaque Suspected to be Vulnerable

Increased plaque volume

Lipid core

Expansive Remodeling

#### **Neovascularization &** intraplaque hemorrhage





Adventitial vasa vasorum proliferation Intraplaque hemorrhage

Thin cap

### Inflammation





### PROSPECT: Event Rates According to TCFA Role of IVUS-VH



Stone GW et al. N Engl J Med 2011;364:226-235.

CTA Morphologic Features of "High Risk" and Disrupted Plaques

- Bulky Low Attenuation Plaque (LAP)
- Positive Remodeling
- Minimal MLA
- Napkin Ring Sign
- Intra-Plaque Dye Penetration (IDP)
- Ulceration

### Late Fibroatheroma: LCP "Napkin-Ring Sign"

Donnelly, P. et al. J Am Coll Cardiol Img 2010;3:876-880



(A) Histo: Thick fibrous cap (black arrows) and large necrotic core (\*)

(B) OFDI: Thick fibrous cap (white arrows) and large necrotic core (\*).

(C) IVUS : Heterogeneous plaque.with echolucent core

(D) CTA: Noncalcified plaque , with central low attenuation area (necrotic core\*) and rim of high CT attenuation (corresponding to fibrous plaque tissue)

"Napkin-ring sign"

# CTA IN ACS

#### Motoyama S et al. JACC 2007;50:319



### Bulky, Low Attenuation, Positively Remodeled

#### **March 2008**

#### April 2009



10001 10001 10001 7.0.1 1252, wrmshild CID 60531

EID-94 EDT: 18-27 07-APR-3008 OFDI

i limman/ litery 7.0.2 1254\_217 CEX.

# CTA in ACS High Risk Plaques (HRPs) LAP, Positively Remodeled



Motoyama S et al. JACC 2007;50:319

Motoyama S, et al. JACC 2015;66(4):337-46

### **Napkin-Ring Sign and Subsequent ACS**

Otsuka, et al. JACC Imag 2013;6(4):448



### **Disrupted and "Vulnerable" Plaques by CTA**

Bilolikar A, Goldstein JA Eur Heart J CV Imaging 2016;17:247-259



LAP, Plaque Ulceration and Intraplaque Dye Penetration (IDP)

## Plaque Disruption by Coronary CT Angiography



Madder and Goldstein Circ Cardiovasc Imaging 2011;4:105-113

### Patient with ACS and Plaque Ulceration

#### Bilolikar A, Goldstein JA Eur Heart J Cardiovasc Imaging 2016;17:247-259



#### Late Fibroatheroma with Intraplaque Hemorrhage



(A)Histopath: Intraplaque hemorrhage (black arrowheads)
(B) OCT: Inhomogeneous plaque .
(C) IVUS: Unable to depict intraplaque hemorrhage.
(D) CTA: Intraplaque contrast accumulation.

Donnelly, P. et al. J Am Coll Cardiol Img 2010;3:876-880

#### Plaque Ulceration and Intraplaque Dye Penetration (IDP)

Madder & Goldstein Circ Cardiovasc Imaging 2011;4:105-113



68 yo Female with Acute IMI January 12, 2012



#### 3 Months Prior: "Atypical CP" November 4, 2011



aVF

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Bilolikar A, Goldstein JA Eur Heart J CV Imaging 2016;17:247-259 Mechanisms of Disrupted Plaques "Inside Out" or "Outside In"

"Inside Out" : Erosions and Frank Ruptures

"Outside In": Leaky Vaso Vasorum?



## Plaque Disruption "Inside Out"

### A) Plaque Rupture

### (B) Plaque Erosion

### (C) Calcified Nodule

Higuma T, et al. JACC Intv. 2015;8:1166-76

Plaque Disruption "Inside Out"

### Vasa Vasorum Proliferation & Intimal Neovascularization



Taruya A, et al. JACC 2015;65(23):2469-77



Kwon T-G, et al. JACC 2015;65(23):2478-80

### **Multiple Complex Plaques in Acute MI**

Goldstein JA et al. NEJM 2000;343:915



### 50% Cases had Unstable Plaque Remote from Culprit

### **ACS with Multiple Unstable Plaques**

Bilolikar A, Goldstein JA Eur Heart J CV Imaging 2016;17:247-259



# CTA evidence of at least one vs. multiple disrupted plaques in stable clinical patients vs ACS



#### Bilolikar A, Goldstein JA Eur Heart J Cardiovasc Imaging 2016;17:247-259

Connecting the Dots CTA LAP and Lipid Core Plaque

### Connecting the Dots: 54 Year Old w Inferior-Posterior MI



Angiogram After PTCA with Small Balloon Flow Restored Made

Madder et al JACC Intervent 2013;6:838-46









# LCP by NIRS

Madder and Goldstein Circ CV Imaging 4:105: 2011



#### 64 year old presents with STEMI in March 2012

#### Unstable angina October 2012



## **CTA for Plaque Detection and Characterization**

CTA Provides Novel 3-D Snapshot: Lumen + Intramural

Delineates Presence or Absence of CAD: Fabulous!

Quantitates Lumen % Stenosis & MLD: But not as Well as Angio or IVUS/OCT

 Plaque Character: Volume, Eccentricity, Attenuation, Disruption But not=Resolution as IVUS/OCT
Can Delineate Frankly Disrupted Plaques

Potential to Identify "Vulnerable Plaques"