Obstructive Coronary Artery Disease

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Disclosures

GE Healthcare
Consultant
Research support
Speakers bureau
Coronary Atherosclerosis

- Atherosclerosis begins as early as 1st decade.
- Endothelial dysfunction, proliferation of SM cells, and accumulation of fatty streaks in the wall.
- Lesions accumulate cholesterol within the intima and media.
- Fibrous cap separates the lipid pool from the coronary artery lumen.
Coronary Atherosclerosis

- Inflammatory invasion of macrophages and activation of matrix metallo-proteinases cause weakening of the fibrous cap.
- Inflammation also weakens coronary wall with widening of the outer wall leading to
  - **Positive remodeling**
- Often these plaques may be missed by conventional invasive coronary angiography.
Coronary Atherosclerosis

- Vulnerable plaques may rupture when exposed to shear stress.
- Thrombogenic lipid material contacts blood.
- Thrombus progression turns a vulnerable plaque into a culprit lesion.
- Leads to myocardial ischemia, ventricular fibrillation, and death.
- Acute coronary events and unheralded myocardial infarction more often are associated with vulnerable plaques.
Coronary Atherosclerosis

- Chronic nonfatal plaque rupture and healing leads to fibrocalcified lesions
- Cause **negative remodeling** with shrinking of the vessel lumen
- Reduced flow leads to myocardial ischemia.
- Stable angina more often is associated with stable plaques.
CT Angiography

- Coronary CT angiography (CTA) has a high negative predictive value for stenotic CAD as compared with cardiac catheterization.
- CTA may serve as a reliable noninvasive alternative to rule out CAD.
- Unlike cardiac catheterization, CTA as a cross-sectional modality also has the ability to display the coronary artery wall.
Plaque Characterization

- Atherosclerotic plaque components
  - Calcium
  - Lipid
  - Fibrotic tissue

- CT characterizes by HU density*
  - Calcifies plaques > 400 HU
  - Atheromatous plaques ~ 50 HU
  - Fibrotic plaques 80-90 HU
Calcified Plaques

MRI has unique potential to identify the key features of the vulnerable plaque. The excellent soft tissue contrast provided by MRI allows evaluation of compositional and morphologic features of carotid atherosclerotic plaques.

In particular, it has been shown that in vivo carotid MRI is able to identify and to quantify the lipid-rich/necrotic core, calcification, hemorrhage, thrombus, and the fibrous cap with good correlation to histopathology.

Furthermore MRI is noninvasive.

**Fig. 1.** Axial (A) and oblique cross-sectional (B) views of a calcified atherosclerotic coronary plaque associated with mild luminal obstruction in the mid-left anterior coronary artery. The mean attenuation of the plaque is 1134 HU, compared with the contrast-enhanced lumen (424 HU) and epicardial fat (-90 HU).

**Fig. 2.** Axial (A) and oblique cross-sectional views (B) of a noncalcified atherosclerotic coronary plaque associated with mild luminal obstruction in the proximal left anterior coronary artery. The mean attenuation of the plaque is 55 HU, compared with the contrast-enhanced lumen (416 HU) and epicardial fat (-92 HU).
Soft Plaques

-82 HU

45 HU

399 HU

Monday, September 5, 2011
Fibrous Plaques

-90 HU
87 HU
433 HU
Complex Plaques

Atheroma
Fibrosis
Calcium
Plaque Evolution

- 55 yo male
- 1 yr statin Tx

Initial CTA 32 HU
Follow-up CTA 76 HU

Monday, September 5, 2011
Color Coding Plaques

- Assign color based on HU
  - Ca plaques > 400 HU
  - Atheromatous ~ 50 HU
  - Fibrotic ~ 80-90 HU
Color Coding Plaques

- Calcium
- Enhanced-Blood
- Fibrous Plaque
- Fatty Plaque

Calcium node

Fatty plaque

Calcified nodule

Fibrous plaque
Color Coding Plaques

Fibrosis 88 HU
Contrast 192 HU
As per
Carrascosa et al
Am J Cardiol 2006
97(5):598-602
### Plaque Detection: CT vs IVUS

22 patients: 16 row MDCT and IVUS
83 coronary segments were imaged by IVUS

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Achenbach et al Circulation 2004
59 pts 64 MDCT vs CA
Stable angina pectoris
IVUS 18 patients; 32 arteries

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Leber et al JACC 2005
## Plaque Detection: CT vs IVUS

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Plaque Characterization

Calcified plaque  Fibrous plaque  Soft plaque  plaque
Plaque Characterization

Calcified plaque

Complex or mixed plaque

Soft plaque
Future Potential CCTA

- Identify vulnerable plaque
- Monitor medical therapy
- Directed contrast agents
Future Potential CCTA

- Identify vulnerable plaque
- Monitor medical therapy
- Directed contrast agents

Screening CT exams
Based upon risk profile
ID small low density plaques
Direct medical Tx or Intervention
Reduce rate of MI and ACS
Increase survival and quality of life
Future Potential CCTA

- Identify vulnerable plaque
- Monitor medical therapy
- Directed contrast agents

Initial CTA

32 HU

Follow-up CTA

76 HU
Future Potential CCTA

- Identify vulnerable plaque
- Monitor medical therapy
- Directed contrast agents

Cormode D P et al. Radiology 2010;256:774-782
Future Potential CCTA

- Identify vulnerable plaque
- Monitor medical therapy
- Directed contrast agents

Cormode D P et al. Radiology 2010;256:774-782
Stenosis Grading

- 2.8mm 0.7 mm 2.7mm
- 75%
- 2.7mm 0.8 mm 2.8mm
- 70%
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Virtually all Studies used 50% criteria
Stenosis Determination

Diameter
Stenosis =

\[
\frac{4.15 \text{ mm} - 2.1 \text{ mm}}{4.15 \text{ mm}} = \sim 50\%
\]
Stenosis Determination

\[
\text{Diameter Stenosis} = \frac{(6 \text{ to } 9) - (2 \text{ to } 4)}{(6 \text{ to } 9)} = 33-77\%
\]
Stenosis Grading vs CA

Figure 5. Bland-Altman Analysis of Stenosis Grading Using Multislice Computed Tomography (MSCT) vs Conventional Invasive Coronary Angiography

Dashed lines indicate 95% confidence limits; bold line, bias.

Stenosis Grading

- Using % is risky
- Not supported in literature
- Vessel may be only 4 – 10 voxels wide
- Use qualitative terminology
  - Mild, moderate, high grade etc
- As long as 50% (or 70%) threshold is surpassed, clinical RX may not change
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Stenosis Grading – None

Normal
Stenosis Grading - Mild

= Mild (<50%)
Approximately 50%

50% soft plaque
Moderate >50%

> 50% soft plaque
High Grade
Occlusion

Occlusion
Multiple Stenoses

- Moderate Grade RCA Stenosis
- High Grade RCA Stenosis
Case:
63 yr old Male new CP
Case FW: 63 yr old Male new CP

Clinical History: 63 yr old male. New CP
Smoker, no prior cardiac history

Prior Studies: Dual isotope MPI: 10.1 METS, 9:01 minutes
Basel-anterior reversible defect, 42% EF

CCTA Dx:

Follow-up:
3.7 mm
0.6 mm
1.9 mm
3.3 mm

75% Diameter reduction
Which of the following are true?

1. Only the LAD stenosis is > 50%
2. Both LAD and Cx stenoses are both >50%
3. Only the Cx stenosis is > 50%
4. Neither stenosis is > 50%
Which of the following are true?

1. Only the LAD stenosis is > 50%
2. Both LAD and Cx stenoses are both >50%
3. Only the Cx stenosis is > 50%
4. Neither stenosis is > 50%
Clinical History: 63 yr old male. New CP Smoker, no prior cardiac history

Prior Studies: Dual isotope MPI: 10.1 METS, 9:01 minutes Basel-anterior reversible defect, 42% EF

CCTA Dx: Mod-high grade LAD and Cx

Follow-up: CA performed 80% LAD; No Cx
Cardiac CT

• Ability for some plaque characterization
  • Overlap between fibrous and fatty plaque
  • Great promise in the future

• Stenosis detection and grading limitations
  • Cannot use % stenosis
  • Use qualitative descriptors
Thank You

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