Imaging of Coronary artery Bypass grafts and Stents

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• No relevant disclosures
Objectives

• CT technique in the evaluation of bypass grafts and stents
• Post processing and image analysis
• Post surgical anatomy
• Complications
Background

• Cardiovascular disease is the leading cause of death in the US with over 450,000 deaths.
• Approximately 469,000 coronary artery bypass grafts (CABGs) are performed annually in the US.
• CT coronary angiography has now established itself as an equally accurate modality for the assessment of grafts.
## Accuracy

<table>
<thead>
<tr>
<th>Analysis Type and (n= No of studies)</th>
<th>Number of grafts</th>
<th>Sensitivity (%)</th>
<th>Specificity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Graft occlusion (16)</td>
<td>2023</td>
<td>97.6</td>
<td>96.7</td>
</tr>
<tr>
<td>16 section (9)</td>
<td>1047</td>
<td>96.9</td>
<td>96.4</td>
</tr>
<tr>
<td>64 section (6)</td>
<td>976</td>
<td>98.1</td>
<td>96.9</td>
</tr>
<tr>
<td>Occlusion (10)</td>
<td>1308</td>
<td>99.3</td>
<td>98.7</td>
</tr>
<tr>
<td>&gt; 50 % Stenosis (9)</td>
<td>871</td>
<td>94.1</td>
<td>98.0</td>
</tr>
</tbody>
</table>

_Hamon et al. Radiology 2007_
CT Technique

- Beta blockers, if HR > 65/ min
- 64 MDCT : Peak + 6 seconds
- Sublingual nitroglycerin
- Triphasic technique
  - Timing bolus 15 ml @ 5ml/sec
  - Contrast bolus of 70 ml @ 5 ml/sec
  - Contrast/ Saline mix of 50 ml (60/40 mix) @ 5mls/ sec
  - Saline chase of 50 ml
• Craniocaudal coverage: 2cm above aortic arch to 2cm below base of the heart
• 0.5 - 0.7 mm collimation
• 0.16 - 0.24, based on heart rate for prospective triggering
• kVp: based on a BMI chart
• mAs: based on a BMI chart
• Acquisition time: 6 – 8 seconds
Image analysis

• Start with axial images
  – Reformats (curved planar, linear lumen and cross sectional)
  – Maximum intensity projection (MIPs)
  – 3D volume rendering (VR)
• Assess proximal anastomosis, graft proper and distal anastomosis.
• Sequential or jump graft
• Distal runoff and native coronary arteries
• Position of the graft in relation to the sternum
• Incidental findings with larger FOV
Knowledge of surgical anatomy

- Saphenous vein
- Internal mammary artery (LIMA and RIMA)
- Radial artery
- Right Gastroepiploic artery
SVG
LIMA
PA
AORTA
LV
RV
Saphenous Vein grafts (SVG)

- **Advantages**
  - Ease of harvest
  - Larger caliber than arteries
  - Fewer surgical clips

- **Disadvantages**
  - Atherosclerosis and intimal hyperplasia
  - 73% and 41% patency rates at 5 and 10 years
Internal Mammary Artery Grafts (LIMA or RIMA)

- Advantages
  - In situ graft
  - Graft of choice for revascularization of LAD and diagonals
  - Superior patency rates, > 90% at 10 years
  - Relatively resistant to atherosclerosis

- Disadvantages
  - Smaller caliber
  - Use of more surgical clips
Complications

- Graft thrombosis
  - Acute: typically SVG
    - < 1 month post operatively
    - Typically 3-12%
    - Endothelial injury during graft harvest
  - Late graft thrombosis and stenosis
    - Atherosclerotic plaque
    - IMA is relatively resistant
Nubbin sign

• Acute graft thrombosis manifesting as a small outpouching on the anterior aorta.
Graft Aneurysm

• True
  – 5 – 7 years post surgery
  – Atherosclerotic
  – Almost half of them may be asymptomatic

• Pseudoaneurysms
  – Acute complication (< 6 months)
  – Infection
  – Tension at the graft site or suture dehiscence
• Graft malposition
• Graft spasm
• Pleural and pericardial effusions
• Wound and sternal infections
Relationship to sternum
• In a survey of 2,046 catastrophic bleeding events in reoperations reported by 1,116 surgeons, the most common cardiac structures injured were the right ventricle (39%), SVG (20%), aorta (15%), IMA (12%), and innominate vein (6%).

Stents

- Over 6,00,000 coronary artery stent placements annually in the US
- Bare metal stents (Steel, Titanium, Nitinol) and drug eluting stents
- Lower rate of stenosis than angioplasty
- In stent restenosis (ISR) 25-30% for bare metal and 5-10% for drug eluting stents
## Accuracy

<table>
<thead>
<tr>
<th></th>
<th>Number of patients</th>
<th>Sensitivity</th>
<th>Specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Das et al 2007</td>
<td>53 (107 stents)</td>
<td>96.9%</td>
<td>88%</td>
</tr>
<tr>
<td>Schuijf et al 2007</td>
<td>50 (76 stents)</td>
<td>100%</td>
<td>98%</td>
</tr>
<tr>
<td>Pugliese et al 2008</td>
<td>100 (178 stents)</td>
<td>94%</td>
<td>92%</td>
</tr>
<tr>
<td>Oncel et al 2008</td>
<td>35 (87 stents)</td>
<td>100%</td>
<td>94%</td>
</tr>
<tr>
<td>Pooled data</td>
<td>1397 stents</td>
<td>90.5%</td>
<td>91.5%</td>
</tr>
</tbody>
</table>

*Sun et al. Eur Journal of Radiology 2010*
Image analysis

• Sharp kernel
• Loss of contrast enhancement within the stent implies occlusion
• Reduced contrast enhancement distally implies occlusion or retrograde perfusion
• Look for stent fracture
Conclusion

• MDCT coronary angiography is an invaluable tool for the assessment of coronary artery bypass grafts and stents.
  – Accurate
  – Relatively non invasive
  – Information about vessel wall
  – Incidental findings