Moderate Coronary Artery Stenosis:
Is there a differentiation in Revascularization options between the Left and Right Coronary beds?

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Royal Melbourne Hospital
University of Melbourne
Australia
Moderate stenosis only in Large Right Coronary

Angiogram 5 years post op
What is moderate coronary artery Stenosis?

- 50 – 70% probably all agree
- 70 – 80% ??
- 70 – 90% ?????
• There is some scientific/objective data relating “stenosis” to graft patency
• But not much on Right CA vs Left CA
Patency - many confounding factors

• Hierarchy of graft patency
  Applies to all grafts - LAD > Cx > RCA
• Size of Coronary – ease of anastomosis
• “run off”
• Length of graft
• Quality of graft - 1st or 4th

Valves, branches,
RITA patency by coronary territory over time to 15 years post-op
Kaplan – Meier Method  n = 991

Patency (%)

Years post-op

- RITA-LAD  n=149
- RITA-Cx     n=436
- RITA-RCA/PDA  n=406

P 0.01
Right Internal Thoracic Artery - patency
Influence of Native Coronary artery stenosis

Patencies of Arterial/Coronary Conduits

Degree of Stenosis

- 80-100%
- 60-79%
- <60%

Time to Reangiogram (months)

Cumulative Patency

p 0.001
Is visual assessment of coronary stenosis accurate consistent reproducible?

Does it correlate to functional importance?
FAME studies

Visual impressions do not match/translate to physiologic importance

Studies in 1980s, 1990s using hyperaemic responses showed similar results
FAME I, II studies
1414 lesions

Angiographic Stenosis (visual)  FFR<0.8
Functionally important

50 - 70%  35%
70 - 90%  80%
>90%  96%

Tonino et al  JACC  2010;55: 2816-21
Figure 1: Angiographic Severity Versus Functional Severity of Coronary Artery Stenoses

Box-and-whisker plot showing the fractional flow reserve (FFR) values of all lesions in the categories of 50% to 70%, 71% to 90%, and 91% to 99% diameter stenosis. The red horizontal line corresponds to the FFR cut-off value for myocardial ischemia (FFR < 0.80 corresponds with myocardial ischemia).

Tonino et al  JACC  2010;55: 2816-21
Is there a difference between the Left and Right Coronary Systems?

Relative difference because of baseline size

50% in 4mm RCA vs 50% in 2mm OM
Why not graft anyway if a stenosis of >50% is present?
FAME Study: One Year Outcomes

1,005 patients with MVD randomized to FFR or Angio-guided PCI

- Angio-Guided
- FFR-Guided

| Event          | Angio-Guided | FFR-Guided | Stat
|----------------|--------------|------------|-----
| Death          | ~40% ↓       | ~30% ↓     | 3  1.8 p=0.04 |
| MI             | ~35% ↓       | ~35% ↓     | 8.7 5.7 |
| Repeat Revasc  | ~30% ↓       | ~35% ↓     | 9.5 6.5 |
| Death/MI       | ~35% ↓       | ~35% ↓     | 11.1 7.3 |
| MACE           | ~30% ↓       | ~18.3 ↓    | 13.2 18.3 p=0.02 |

Less progression of disease in non bypassed coronary arteries!! CASS RCT
3,888 segments

Alderman et al JACC 1993;22: 1141-54
Is there a difference between the Left and Right Coronary Systems?

Ungrafted, **Moderate RCA** LESS LIKELY to progress  (Moderate Stenosis = 40-70%)

**RAPCO** (RCT) (Buxton, Melbourne, Australia)
N=619 patients, 1242 grafts, 386 moderate lesions
mean FU angio 6.2 years

**Stenosis Progression**

<table>
<thead>
<tr>
<th></th>
<th>Non Grafted</th>
<th>Grafted</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moderate Right</td>
<td>14%</td>
<td>40%</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Moderate Left</td>
<td>47%</td>
<td>36%</td>
<td>0.20</td>
</tr>
</tbody>
</table>

**Moderate Left sided lesions MORE LIKELY to progress grafted or ungrafted**

Hayward, Buxton et al  JTCVS 2013;145:140-9
Why the difference in behaviour between Right and Left ??

• Unknown

• Smaller LCA branches
  same increase in plaque volume may have greater impact
Slow progression of Moderate RCA disease

Case for leaving Moderate RCA stenosis
Faster progression of Moderate LCA disease

Case for bypass in Moderate Left Coronary Artery stenosis

If so - Which Conduit?
Patency of Grafts
to moderately stenosed coronary arteries

<table>
<thead>
<tr>
<th></th>
<th>Left</th>
<th>Right</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arterial</td>
<td>84%</td>
<td>75%</td>
<td>0.05</td>
</tr>
<tr>
<td>SVG</td>
<td>77%</td>
<td>72%</td>
<td></td>
</tr>
</tbody>
</table>
Graft Patency - Moderately stenosed (40-70%) vessels

All Grafts

Hayward, Buxton et al  JTCVS 2013;145:140-9
Graft Patency - Moderately stenosed (40-70%) vessels

Hayward, Buxton et al  JTCVS 2013;145:140-9
1 year patency
By degree of stenosis
ITA vs SVG to Diag/Cx/PDA

1 year patency
By degree of stenosis
ITA vs SVG to RCA

Radial Artery Patency according to Coronary Stenosis - 20 years

Gaudino et al, JACC 2016; 68: 803-10
Radial Artery Patency according to Coronary Stenosis

Deb, Fremes JACC 2012;60:28-35
RA patency according to Right or Left

- RCA 79%
- Left Cx 95% p 0.02

382 distal anastomoses
12 months post op
LITA 99%. RITA 92%

RA patency according to degree of native coronary stenosis (NCAS)

<table>
<thead>
<tr>
<th>NCAS</th>
<th>% Patency</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>50-75%</td>
<td>79%</td>
<td></td>
</tr>
<tr>
<td>75-90%</td>
<td>85%</td>
<td></td>
</tr>
<tr>
<td>&gt; 90%</td>
<td>98%</td>
<td>0.002</td>
</tr>
</tbody>
</table>

382 distal anastomoses
12 months post op

Radial Artery Patency according to Coronary Stenosis Left or Right

<table>
<thead>
<tr>
<th>Groups</th>
<th>Native coronary artery status</th>
<th>Total</th>
<th>p-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>90% &lt; stenosis</td>
<td>50% &lt; stenosis &lt; 90%</td>
<td></td>
</tr>
<tr>
<td>Overall RA graft patency</td>
<td>100/102, 98.0%</td>
<td>60/72, 83.3%</td>
<td>160/174, 92%</td>
</tr>
<tr>
<td>RA target vessel site LCAT</td>
<td>74/102, 72.5%</td>
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<tr>
<td>Patency</td>
<td>73/74, 98.6%</td>
<td>53/61, 86.9%</td>
<td>126/135, 93.3%</td>
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<td>RA target vessel site RCAT</td>
<td>28/102, 27.4%</td>
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<td>Patency</td>
<td>27/28, 96.4%</td>
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<td>126/135, 93.3%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Grafted RCA</th>
<th>RITA (37 patients)</th>
<th>RGEA (92 patients)</th>
<th>SVG (81 patients)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MLD (mm)</td>
<td>Functional grafts, n (% of MLD category)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>20 (100)</td>
<td>38 (97)</td>
<td>33 (94)</td>
</tr>
<tr>
<td>0.01–0.645</td>
<td>1 (100)</td>
<td>3 (100)</td>
<td>6 (86)</td>
</tr>
<tr>
<td>0.645–1.30</td>
<td>3 (42)</td>
<td>17 (59)</td>
<td>14 (82)</td>
</tr>
<tr>
<td>&gt;1.3</td>
<td>1 (11)</td>
<td>2 (10)</td>
<td>17 (77)</td>
</tr>
<tr>
<td>% stenosis</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100</td>
<td>20 (100)</td>
<td>38 (97)</td>
<td>33 (94)</td>
</tr>
<tr>
<td>99–73</td>
<td>1 (50)</td>
<td>4 (100)</td>
<td>5 (83)</td>
</tr>
<tr>
<td>72–50</td>
<td>3 (43)</td>
<td>4 (52)</td>
<td>15 (88)</td>
</tr>
<tr>
<td>&lt;50</td>
<td>1 (12)</td>
<td>2 (11)</td>
<td>17 (74)</td>
</tr>
</tbody>
</table>

RGEA, MLD: Mantel–Haenszel chi-square (1 df) = 44.4, P < .0001. RITA, MLD: Mantel–Haenszel chi-square (1 df) = 24.1 P < .0001. SVG, MLD: Mantel–Haenszel chi-square (1 df) = 3.5, P = .06. MLD, Minimum lumen diameter; RCA, right coronary artery; RGEA, right gastroepiploic artery; RITA, right internal thoracic artery; SVG, saphenous vein graft.
Patency by Minimum Lumen Diameter (MLD)

Glineur et al JTCVS 2011;142:980-8
faster progression of Moderate LCA disease

Case for bypass in Moderate Left Coronary Artery stenosis

If so - Which Conduit?

Saphenous Vein
Arterial graft
   ITA
   RA

An ITA

If diameter at stenosis is < 0.7mm, could also use RA
Grafting coronary arteries with only moderate stenoses
Effect on long-term mortality

Sabik et al JTCVS 2016;151:806-11
Grafting coronary arteries with only moderate stenoses
Effect on long-term mortality

Sabik et al. JTCVS 2016;151:806-11
FFR and Arterial Grafts  (Glineur  EACTS 2018)

Threshold

FFR < 0.78  >95% patency

In RCA system

need FFR < 0.71 for > 90% patency
Conclusions

• Moderate RCA lesions less likely to progress – leave

• Moderate Left sided lesions more likely to progress - Graft

• FFR an important adjunct

• For arterial grafts, The lower the FFR the better the Patency
Grafting Strategy
Moderate Stenoses
<70 yrs

- LAD – LITA
- Cx - RITA
- RCA  FFR, Leave ?? Later Stent
Grafting Strategy
Moderate Stenoses
>70 yrs

- LAD – LITA
- Cx - RITA, FFR/RA, SVG
- RCA FFR/SVG,
  Leave ? Later Stent / Hybrid
## RA Patency

### Influence of Native Coronary Artery Stenosis

<table>
<thead>
<tr>
<th>NCAS</th>
<th>Patency</th>
<th>Count</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;60%</td>
<td>73.9%</td>
<td>68/92</td>
<td>_0.02</td>
</tr>
<tr>
<td>60% - 79%</td>
<td>90.0%</td>
<td>247/276</td>
<td></td>
</tr>
<tr>
<td>80% - 99%</td>
<td>92.5%</td>
<td>396/428</td>
<td></td>
</tr>
<tr>
<td>100%</td>
<td>92.6%</td>
<td>138/149</td>
<td></td>
</tr>
</tbody>
</table>

<60% group comprised only 9% of all RA grafts
RITA patency by Native Coronary Artery Stenosis (NCAS)

NCAS <60%
NCAS 60-79%
NCAS 80-99%
NCAS 100%

Patency (%)

Years

P 0.02
LITA $n = 1345$

Patency by territory 88 months

LAD 1131 / 1165 97% $p < 0.01$

CxOM 165 / 180 92%

49 LITA grafts failed (4%)
Patencies of Arterial/Coronary Conduits

Arterial to coronary conduits
Target vessel stenosis vs patency

* p<0.01
* p<0.001
* p<0.01
Maniar

- RA Y
Moderate stenosis only in Large Right Coronary

'Very sign'

RA Graft

50%
## Target Vessel Stenosis influence on patency

<table>
<thead>
<tr>
<th>Conduit</th>
<th>Target Vessel Stenosis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt; 60%</td>
</tr>
<tr>
<td>LITA patency</td>
<td>92%</td>
</tr>
<tr>
<td>RITA patency</td>
<td>65%</td>
</tr>
<tr>
<td>RA patency</td>
<td>83%</td>
</tr>
</tbody>
</table>
Fig 4. Kaplan-Meier–estimated conduit patency rates. (LITA left internal thoracic artery; RA radial artery; SVG saphenous vein graft.)
Competitive flow

The Achille’s heel of Arterial Grafting especially with Radial Arteries
R Gastro-epiploic

- For optimal RA and RG EA patency
  Native coronary artery stenosis should be
  >80%
Do vein grafts have a role?

Yes!

- Older patients
- RAs Ca++, dominant
- Moderate stenosis
- RCA, PDA
Arterial Revascularization

- RA problems
  - $\text{Ca}^{tt}$
  - prior cannulation

* spasm not usually a problem
Vein Grafts 10 to 15 years old
All Arterial Grafts  (Total Arterial Revascularization)

Isolated CABG Surgery

Figure 5: All arterial grafts in isolated CABG On-Pump

25%
Arterial Conduits

**Isolated CABG Surgery**

**Figure 6: Arterial conduits used in isolated CABG On-Pump**

- SITA: 98%
- RA: 40%
- BITA: 28%

**Figure 7: Arterial conduits used in isolated CABG Off-Pump**

- SITA: 70%
- BITA: 28%

In 2014, on- and off-pump procedures had a similar use of ITA in total, being 95.7% and 97.7% respectively. However, there was a marked difference in BITA use, being 10.7% and 27.9% respectively. GEPA procedures, used in 0.4% of patients, are not indicated on these graphs.
Arterial Revascularization patterns of T.A.R. Royal Melbourne Hospital

TAR % of CABG

Years


RA

30%

78% 80%

0 20 40 60 80 100
**All Graft Survival**

![Graph showing graft survival over years of follow-up with two lines, one for left circulation and one for right circulation.](image)

<table>
<thead>
<tr>
<th>Year</th>
<th>Graft survival (%)</th>
<th>Left (n=193)</th>
<th>Right (n=48)</th>
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</thead>
<tbody>
<tr>
<td>4</td>
<td>98.2%</td>
<td>79.4%</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>94.6%</td>
<td>73.3%</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>92.7%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>89.4%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>83.2%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>78.4%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>73.9%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>27 (14.0%)</td>
<td>9 (18.8%)</td>
<td></td>
</tr>
</tbody>
</table>

Log rank = 0.051

**FIGURE 2.** Patency of all grafts to left and right circulations (moderately stenosed vessels). *Log rank = .051.
FIGURE 2. Patency of all grafts to left and right circulations (moderately stenosed vessels). *Log rank = .051.
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<td>Overall RA graft patency</td>
<td>100/102, 98.0%</td>
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<td>160/174, 92%</td>
</tr>
<tr>
<td>On-pump surgery group</td>
<td>43/102, 42.2%</td>
<td>40/72, 55.6%</td>
<td>83/174, 47.7%</td>
</tr>
<tr>
<td>Patency</td>
<td>42/43, 97.7%</td>
<td>33/40, 82.5%</td>
<td>75/83, 90.4%</td>
</tr>
<tr>
<td>Off-pump surgery group</td>
<td>59/102, 64.8%</td>
<td>32/72, 35.2%</td>
<td>91/174, 52.3%</td>
</tr>
<tr>
<td>Patency</td>
<td>58/59, 98.3%</td>
<td>27/32, 84.4%</td>
<td>85/91, 93.4%</td>
</tr>
<tr>
<td>Sequential grafting group</td>
<td>51/102, 50%</td>
<td>46/72, 63.9%</td>
<td>97/174, 55.7%</td>
</tr>
<tr>
<td>Patency</td>
<td>50/51, 98.0%</td>
<td>39/46, 84.8%</td>
<td>89/97, 91.8%</td>
</tr>
<tr>
<td>Non sequential grafting group</td>
<td>51/102, 50%</td>
<td>26/72, 36.1%</td>
<td>77/174, 44.3%</td>
</tr>
<tr>
<td>Patency</td>
<td>50/51, 98.0%</td>
<td>21/26, 80.8%</td>
<td>71/77, 92.2%</td>
</tr>
<tr>
<td>RA target vessel site LCAT</td>
<td>74/102, 72.5%</td>
<td>61/72, 84.7%</td>
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<td>126/135, 93.3%</td>
</tr>
<tr>
<td>Proximal technique: aortocoronary or cabrol</td>
<td>75/102, 73.5%</td>
<td>44/72, 61.1%</td>
<td>119/174, 68.4%</td>
</tr>
<tr>
<td>Patency</td>
<td>73/75, 97.3%</td>
<td>39/44, 88.6%</td>
<td>112/119, 94.1%</td>
</tr>
<tr>
<td>Proximal technique: LITA-Y</td>
<td>27/102, 26.5%</td>
<td>28/72, 38.9%</td>
<td>55/174, 31.6%</td>
</tr>
<tr>
<td>Patency</td>
<td>27/27, 100%</td>
<td>21/28, 75.0%</td>
<td>48/55, 87.3%</td>
</tr>
</tbody>
</table>

LCAT, left coronary territory; RCAT, right coronary territory.
<table>
<thead>
<tr>
<th>Target artery</th>
<th>Number</th>
<th>% Patency</th>
</tr>
</thead>
<tbody>
<tr>
<td>LITA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LAD</td>
<td>1193</td>
<td>97.2</td>
</tr>
<tr>
<td>Diag</td>
<td>84</td>
<td>96.4</td>
</tr>
<tr>
<td>Int, OM1, OM2</td>
<td>184</td>
<td>91.0</td>
</tr>
<tr>
<td>RITA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LAD</td>
<td>93</td>
<td>96</td>
</tr>
<tr>
<td>Diag</td>
<td>45</td>
<td>93</td>
</tr>
<tr>
<td>Int, OM1, OM2</td>
<td>224</td>
<td>90</td>
</tr>
<tr>
<td>RCA</td>
<td>139</td>
<td>79</td>
</tr>
<tr>
<td>PDA, PLV</td>
<td>123</td>
<td>87</td>
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</table>

**In situ RITA**

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>% Patency</th>
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</thead>
<tbody>
<tr>
<td>LAD, Diag</td>
<td>111</td>
<td>94.6</td>
</tr>
<tr>
<td>Int, OM1, OM2</td>
<td>52</td>
<td>84.7</td>
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<tr>
<td>PD, PLV, RCA</td>
<td>154</td>
<td>79.2</td>
</tr>
<tr>
<td>Total</td>
<td>317</td>
<td>85.5</td>
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</table>

**Free RITA**

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>% Patency</th>
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<tbody>
<tr>
<td>LAD, Diag</td>
<td>27</td>
<td>96.3</td>
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<tr>
<td>Int, OM1, OM2</td>
<td>172</td>
<td>91.9</td>
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<tr>
<td>PD, PLV, RCA</td>
<td>108</td>
<td>90.9</td>
</tr>
<tr>
<td>Total</td>
<td>307</td>
<td>90.9</td>
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‘String sign’
Patencies of Arterial/Coronary Conduits

Right Internal Thoracic Artery patency by Coronary territory

- Position
  - Left Anterior Descending
  - Circumflex Marginal
  - Right coronary

Cumulative Patency

Time to Reangiogram (months)
Figure 3. Cumulative RA patency associated with proximal target stenosis: moderately stenosed vessels with a significant increase in anastomotic failure versus critically stenosed targets (relative risk, 1.69; 95% CI, 1.25-2.20; $P < .001$).
1 year patency
By degree of stenosis
ITA vs SVG to LAD