The Second Best Arterial Graft:

A Propensity Analysis of the Radial Artery Versus the Right Internal Thoracic Artery to Bypass the Circumflex Coronary Artery

Beth Israel  St. Luke’s Roosevelt


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The Second Best Arterial Graft: Radial Artery vs Right Internal Thoracic Artery

Continuum Cardiovascular Centers of New York

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  Kamellia R Dimitrova, MD
  David J Lucido, PhD
  Charles M Geller, MD
  Wilson Ko, MD

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  Sandhya K Balaram, MD, PhD
  Gabriela R Dincheva, BS
RA versus RITA: Background

- Improved long term survival using a 2nd arterial graft:
  
a) LITA plus RITA vs. LITA/SV.
  
b) LITA plus RA vs. LITA/SV.

- BITA use stagnant at 5% in USA.

- Is the RA a viable alternative to the RITA?
RA versus RITA: Comparison studies

Four previous studies (2 for RA, 1 neutral and 1 for RITA):

- 200 to 300 patients in each group
- only short to mid-term follow up (18 m to 6 yrs)
- a high proportion (40% to 50%) where 2nd arterial graft bypassed the RCA

To better determine if the RA or the RITA is the 2nd best arterial graft to bypass the circumflex coronary artery during CABG using the LITA-LAD.
RA versus RITA: Methods

Continuum Cardiovascular Centers of New York
5,666
Primary, isolated CABG with LITA
1995 to 2008

2,707
Received a second arterial graft: RA or RITA

2,488
Received RA or RITA to the LCX

219 excluded:
108 had RA or RITA to RCA
111 had both RA and RITA grafts

1,334
RA patients
Beth Israel Medical Center

1,154
RITA patients
St. Luke’s Roosevelt Hospital
RA versus RITA: Methods

**Statistical Methods:**
- Propensity matching on 31 prospectively collected variables.
- Kaplan Meier estimates of survival.
- Cox proportional hazard regression.

**Primary endpoints:**
1. all cause mortality using the SSDI (10/2012).
2. major adverse events.
### Before Propensity Matching

<table>
<thead>
<tr>
<th></th>
<th>Radial (n=1,334)</th>
<th>RITA (n=1,154)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RA use: 40%</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean EF ± SD</td>
<td>47.5 ± 13.3</td>
<td>45.8 ± 14.7</td>
<td>0.002</td>
</tr>
<tr>
<td>Cerebrovascular disease</td>
<td>5.4%</td>
<td>9.4%</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Aortoiliac PVD</td>
<td>1.9%</td>
<td>3.2%</td>
<td>0.039</td>
</tr>
<tr>
<td>Femoral Popliteal PVD</td>
<td>5.2%</td>
<td>9.6%</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Hemodialysis</td>
<td>0.3%</td>
<td>3.0%</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Creatinine &gt;2.5mg</td>
<td>1.8%</td>
<td>3.0%</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Hypertension</td>
<td>66.6%</td>
<td>48.4%</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td><strong>Diabetes</strong></td>
<td>37.6%</td>
<td>35.3%</td>
<td>0.237</td>
</tr>
<tr>
<td>Mean cross-clamp time ± SD</td>
<td>70.4±19.4</td>
<td>70.0±26.6</td>
<td>0.658</td>
</tr>
<tr>
<td>Mean Perfusion Time ± SD</td>
<td>93.3±23.4</td>
<td>128.5±34.7</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Arterial Grafts per patient ±SD</td>
<td>2.4 ± 0.6</td>
<td>3.1 ± 0.7</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>
Kaplan Meier Survival for Unmatched RA and RITA Patients.

![Graph showing survival rates over years after CABG for RA Graft and RITA Graft patients.](image)

**Patients at risk:**

<table>
<thead>
<tr>
<th></th>
<th>RA 1329</th>
<th>1124</th>
<th>675</th>
<th>146</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>RA</td>
<td>1329</td>
<td>1124</td>
<td>675</td>
<td>146</td>
<td>0</td>
</tr>
<tr>
<td>RITA</td>
<td>1132</td>
<td>904</td>
<td>470</td>
<td>121</td>
<td>0</td>
</tr>
</tbody>
</table>

**Legend:**
- **RA Graft**
- **RITA Graft**

**Survival (%)**
- 100%
- 75%
- 50%
- 25%
- 0%

**Years after CABG**
- 0
- 5
- 10
- 15
- 20

**Survival at 8 years:**
- RA Graft: 88%
- RITA Graft: 72%

**Statistical significance:**
- $p < 0.001$
## After Propensity Matching

<table>
<thead>
<tr>
<th></th>
<th>Radial (n=528)</th>
<th>RITA (n=528)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean age/years ± SD</td>
<td>60.0 ± 7.9</td>
<td>61.0 ± 11</td>
<td>0.100</td>
</tr>
<tr>
<td>Male</td>
<td>78.4%</td>
<td>76.9%</td>
<td>0.555</td>
</tr>
<tr>
<td>Mean EF ± SD</td>
<td>47.3 ± 13.6</td>
<td>47.5 ± 14.4</td>
<td>0.868</td>
</tr>
<tr>
<td>Cerebrovascular disease</td>
<td>6.8%</td>
<td>6.4%</td>
<td>0.805</td>
</tr>
<tr>
<td>Aortoiliac PVD</td>
<td>1.7%</td>
<td>2.7%</td>
<td>0.292</td>
</tr>
<tr>
<td>Femoral Popliteal PVD</td>
<td>7.8%</td>
<td>8%</td>
<td>0.909</td>
</tr>
<tr>
<td>Hemodialysis</td>
<td>0.8%</td>
<td>0.8%</td>
<td>1.000</td>
</tr>
<tr>
<td>Creatinine &gt;2.5mg</td>
<td>1.9%</td>
<td>1.5%</td>
<td>0.634</td>
</tr>
<tr>
<td>Diabetes</td>
<td>36.6%</td>
<td>35.6%</td>
<td>0.749</td>
</tr>
<tr>
<td>Hypertension</td>
<td>56.8%</td>
<td>56.3%</td>
<td>0.852</td>
</tr>
<tr>
<td>Mean cross-clamp time ± SD</td>
<td>69.3 ± 21.9</td>
<td>67.0 ± 25.8</td>
<td>0.144</td>
</tr>
<tr>
<td>Mean Perfusion Time ± SD</td>
<td>92.6 ± 25.2</td>
<td>125.0 ± 34.4</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Arterial Grafts per patient ±SD</td>
<td>2.7 ± 0.6</td>
<td>2.8 ± 0.7</td>
<td>0.016</td>
</tr>
</tbody>
</table>
Kaplan Meier Survival for Matched RA and RITA Patients.

![Graph showing Kaplan-Meier survival for RA and RITA grafts.]

- Patients at risk:
  - RA: 525, 447, 282, 62, 0
  - RITA: 519, 438, 276, 73, 0

- Survival rates at specific years:
  - 85% at 10 years
  - 80% at 15 years

- p-value: 0.060
<table>
<thead>
<tr>
<th>Predictor</th>
<th>Hazard Ratio</th>
<th>95% CI</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radial artery use</td>
<td>0.85</td>
<td>(0.64-1.13)</td>
<td>0.277</td>
</tr>
<tr>
<td>Femoral PVD</td>
<td>2.31</td>
<td>(1.57-3.42)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Age per year</td>
<td>1.06</td>
<td>(1.04-1.08)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Diabetes</td>
<td>1.55</td>
<td>(1.17-2.07)</td>
<td>0.003</td>
</tr>
<tr>
<td>Hypertension</td>
<td>1.63</td>
<td>(1.17-2.27)</td>
<td>0.004</td>
</tr>
<tr>
<td>COPD</td>
<td>1.66</td>
<td>(1.16-2.36)</td>
<td>0.005</td>
</tr>
<tr>
<td>Ejection fraction</td>
<td>0.99</td>
<td>(0.98-1.00)</td>
<td>0.010</td>
</tr>
<tr>
<td>CHF</td>
<td>1.59</td>
<td>(1.10-2.31)</td>
<td>0.015</td>
</tr>
</tbody>
</table>
## Major Adverse Events

<table>
<thead>
<tr>
<th>Major Adverse Events</th>
<th>RA (%) N=528 pts</th>
<th>RITA (%) N=528 pts</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stroke</td>
<td>0.8</td>
<td>2.1</td>
<td>0.069</td>
</tr>
<tr>
<td>Myocardial infarction</td>
<td>1.1</td>
<td>0.6</td>
<td>0.315</td>
</tr>
<tr>
<td>Sternal infection</td>
<td>1.1</td>
<td>2.7</td>
<td>0.071</td>
</tr>
<tr>
<td>Sepsis</td>
<td>0.8</td>
<td>0.6</td>
<td>0.705</td>
</tr>
<tr>
<td>Renal failure</td>
<td>0.6</td>
<td>0.6</td>
<td>1.000</td>
</tr>
<tr>
<td>Reop for bleeding</td>
<td>1.5</td>
<td>1.9</td>
<td>0.634</td>
</tr>
<tr>
<td>Respiratory failure</td>
<td>1.1</td>
<td>4.0</td>
<td>0.003</td>
</tr>
<tr>
<td>In hospital mortality</td>
<td>0.6</td>
<td>1.7</td>
<td>0.082</td>
</tr>
<tr>
<td>Total MAE</td>
<td>7.6</td>
<td>14.0</td>
<td>0.001</td>
</tr>
</tbody>
</table>
Odds Ratios for Major Adverse Events

- **DM**: 0.002
- **Obesity**: 0.001
- **COPD**: 0.032
- **Female**: 0.116
- **EF<40%**: 0.097
- **Age >60 years**: 0.032
- **Overall**: 0.002
Hazard Ratios for Death

- DM
- Obesity
- COPD
- Female
- EF<40%
- Age >60 years
- Overall

P values:
- DM: 0.091
- Obesity: 0.450
- COPD: 0.015
- Female: 0.233
- EF<40%: 0.124
- Age >60 years: 0.032
- Overall: 0.277
13.8% of patients (343/2,488) had cardiac catheterization an average of 5 years postop.

<table>
<thead>
<tr>
<th>Conduit</th>
<th>Patients (n)</th>
<th>Distal anastamoses (n)</th>
<th>Patency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RA (BIMC)</td>
<td>236</td>
<td>329</td>
<td>83.9</td>
</tr>
<tr>
<td>RITA (SLR)</td>
<td>107</td>
<td>183</td>
<td>87.4</td>
</tr>
<tr>
<td>LITA</td>
<td>343</td>
<td>396</td>
<td>92.7</td>
</tr>
<tr>
<td>SV</td>
<td>343</td>
<td>464</td>
<td>56.7</td>
</tr>
</tbody>
</table>

P=0.155
RA versus RITA: Summary

- Largest study comparing RA to RITA with the longest follow up (mean of 10 years).
- RA and RITA patients have similar survival.
- RA patients have fewer MAE.
- RA use results in better survival in COPD and in older patients.
- Midterm RA patency is similar to RITA patency.
Either the RA or RITA may be used to bypass the circumflex coronary artery.

RA grafting is an excellent alternative to the RITA and, in selected patients, better than the RITA.

The choice of the second arterial conduit should be guided by patient profiles and surgeon preference.
Thank you.
Endoradial technique

- Intraoperative Allen’s test and pulse oximetry to confirm collateral circulation.
- No touch endoscopic technique using the harmonic scalpel.
- IV diltiazem perioperatively; oral nitrates POD 1 and for 6 months.
BITA use rates.

- STS database for USA 5%
- Mayo Clinic 12%
- Cleveland Clinic 20%
- Emory 23%
- Miami, Florida 48%
- Melbourne, Australia 56% peak, now 32%
- Calgary, Canada (AATS Forum session) 68%
- SLR, NYC 80%
- Seoul, Korea 90%
RA versus RITA: Surgical techniques

- **BIMC**: RA
  - LITA as pedicle graft
  - Single cross clamp technique
  - RA use initially 33%, now 75%. Overall 43% RA use
  - LITA as sequential graft in 4%
  - RA as sequential or Y graft in 18% of patients; Bilateral RA in 7%
  - 31% received >2 arterial grafts: 2.4 arterial grafts/pt
  - Off Pump: 1.1%

- **SLR**: FREE RITA
  - BITA as pedicle grafts
  - Side biting clamp technique
  - BITA use fairly constant at 80%
  - LITA as sequential graft in 43%
  - Free RITA as sequential or Y graft in 58%
  - 79% received >2 arterial grafts: 3.1 arterial grafts/pt
  - Off Pump: 1.1%
Selective RA use versus high RITA use resulted in significant heterogeneity.

Our study is retrospective with possible confounding effects of selection bias, despite propensity matching.

Catheterization data was limited to only our institutions.

University of Toledo Medical Center, Beth Israel Medical Center. Presented at the Society of Thoracic Surgeons Annual Meeting, Los Angeles, CA. January 27-30, 2013.
Radial Artery Conduits Improve Long-Term Survival After Coronary Artery Bypass Grafting

Robert F. Tranbaugh, MD, Kamellia R. Dimitrova, MD, Patricia Friedmann, MS, Charles M. Geller, MD, Loren J. Harris, MD, Paul Stelzer, MD, Bertram Cohen, PhD, and Darryl M. Hoffman, MD

Division of Cardiac Surgery and Office of Grants and Research Administration, Beth Israel Medical Center, New York, New York

**Background.** The second best conduit for coronary artery bypass graft surgery (CABG) is unclear. We sought to determine if the use of a second arterial conduit, the radial artery (RA), would improve long-term survival after CABG using the left internal thoracic artery (LITA) and saphenous vein (SV).

**Methods.** We compared the 14-year outcomes in propensity-matched patients undergoing isolated, primary CABG using the LITA, RA, and SV versus CABG using the LITA and only SV. In all, 826 patients from each group had similar propensity-matched demographics and multiple variables. The primary endpoint was all-cause mortality obtained using the Social Security Death Index.

**Results.** Perioperative outcomes including in hospital mortality (0.1% for the RA patients and 0.2% for the SV patients) were similar. Kaplan-Meier survival at 1, 5, and 10 years was 98.3%, 93.9%, and 83.1% for the RA group versus 97.2%, 88.7%, and 74.3% for the SV group (log rank, $p = 0.0011$). Cox proportional hazards models showed a lower all-cause mortality in the RA group (hazard ratio 0.72, confidence interval: 0.56 to 0.92, $p = 0.0084$). Ten-year survivals showed a 52% increased mortality for the SV patients (25.7%) versus the RA patients (16.9%; $p = 0.0011$). For symptomatic patients, RA patency was 80.7%, which was not different than the LITA patency rate of 86.4% but was superior to the SV patency rate of 46.7% ($p < 0.001$).

**Conclusions.** Using the LITA, SV, and a RA conduit for CABG results in significantly improved long-term survival compared with using the LITA and SV. The use of two arterial conduits offers a clear and lasting survival advantage, likely due to the improved patency of RA grafts. We conclude that RA conduits should be more widely utilized during CABG.


Fig 2. Comparison of Kaplan-Meier survival for propensity-matched patients ($p = 0.0011$, log rank test). CABG = coronary artery bypass graft surgery.
RA versus RITA: Few studies and conflicting evidence for the 2nd best arterial graft.

- **Pro RA**
  - Caputo et al: Survival at 18 months was the same with less MI, AF and bleeding with RA (325 pts).
    - J Thorac Cardiovasc Surg 2003;126:39-47
  - Hayward et al: RCT showed a trend (p=0.08) for better event free survival with RA (198 pts) at 6 years in patients <70 years.

- **Neutral**
  - Nasso et al: RCT finding no difference in survival at 3 years (204 RA pts).
    - J Thorac Cardiovasc Surg 2009;137:1093-100

- **Pro RITA**
  - Ruttmann et al: RITA had less MACCE and better overall (HR=0.23, p=0.022) and event free (HR=0.18, p=p<0.001) survival in 277 propensity matched patients at 33 months.