Off Pump Coronary Artery Bypass Grafting in Patients with Left Ventricular Dysfunction

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Surgical Options of Ischemic Heart Failure

◆ Isolated CABG or *OPCAB*
◆ Heart transplantation
◆ Artificial Heart or Ventricular Assist Device
◆ Mitral valve repair
◆ Dynamic Cardiomyoplasty
◆ Left Ventricular Volume Reduction Surgery
◆ Cell Transplantation with or without bypass grafting
Surgical considerations in LV dysfunction

◆ Completeness of revascularization
  Complete versus incomplete
◆ Graft selection for good perfusion and long-term patency
  Vein versus Artery
◆ Myocardial protection
  On-Pump versus Off-Pump
Complete Revascularization

Comparison of complete and incomplete revascularization in CABG-patients with severely impaired LV function

U Boeken et al. Z Kardiol 2004;93:216-21

◆ 263 patients with LVEF ≤ 30%
◆ Definition of incomplete revascularization:
  The difference between preoperatively estimated grafts and the number of grafted vessels
◆ Group A (complete revascularization) : 158 patients
◆ Group B (incomplete revascularization) : 105 patients
Table 1a  Intraoperative underlying reasons for incomplete revascularization in group B (ICR; n=105)

<table>
<thead>
<tr>
<th>Reason</th>
<th>Number of appearance</th>
<th>Portion (%)</th>
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</thead>
<tbody>
<tr>
<td>Diffuse coronary artery disease</td>
<td>49</td>
<td>46.7</td>
</tr>
<tr>
<td>Massive sclerotic coronary vessel wall</td>
<td>38</td>
<td>36.2</td>
</tr>
<tr>
<td>Failure of exhibition of the coronary vessel</td>
<td>11</td>
<td>10.5</td>
</tr>
<tr>
<td>Coronary artery too small</td>
<td>12</td>
<td>11.4</td>
</tr>
<tr>
<td>Quality of (venous) graft too poor</td>
<td>8</td>
<td>7.6</td>
</tr>
</tbody>
</table>

Table 2  Intraoperative parameters in groups A (CR) and B (ICR)

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Op. in cardioplegia</td>
<td>61</td>
<td>59</td>
<td>n.s.</td>
</tr>
<tr>
<td>(Breitschneider-solution) (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of grafts</td>
<td>3.59 ± 0.58</td>
<td>2.92 ± 0.47</td>
<td>&lt; 0.05</td>
</tr>
<tr>
<td>Duration of surgery</td>
<td>223 ± 21</td>
<td>207 ± 20</td>
<td>n.s.</td>
</tr>
<tr>
<td>(min)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Duration of ECC (min)</td>
<td>103 ± 11</td>
<td>95 ± 14</td>
<td>n.s.</td>
</tr>
<tr>
<td>Duration of ischemia (min)</td>
<td>57 ± 9</td>
<td>46 ± 12</td>
<td>&lt; 0.05</td>
</tr>
<tr>
<td>Catecholamines (%)</td>
<td>33</td>
<td>48</td>
<td>&lt; 0.05</td>
</tr>
<tr>
<td>(adrenaline, noradrenaline, dobutamine)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IABP (%)</td>
<td>1.8</td>
<td>6.6</td>
<td>&lt; 0.05</td>
</tr>
<tr>
<td>Controll. reperfusion (%)</td>
<td>5.4</td>
<td>19.8</td>
<td>&lt; 0.05</td>
</tr>
</tbody>
</table>
Table 3  Postoperative parameters (I) in groups A (CR) and B (ICR)

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mech. ventilation (h)</td>
<td>12.1 ± 3.4</td>
<td>20 ± 5.2</td>
<td>&lt; 0.05</td>
</tr>
<tr>
<td>Duration of ICU (h)</td>
<td>72 ± 14</td>
<td>101 ± 14</td>
<td>&lt; 0.05</td>
</tr>
<tr>
<td>Catecholamines (%)</td>
<td>38</td>
<td>54</td>
<td>&lt; 0.05</td>
</tr>
<tr>
<td>IABP (%)</td>
<td>5.4</td>
<td>6.6</td>
<td>n.s.</td>
</tr>
<tr>
<td>CK (U/l) (first day)</td>
<td>148 ± 42</td>
<td>230 ± 65</td>
<td>&lt; 0.05</td>
</tr>
<tr>
<td>CK-MB (% of CK) (first day)</td>
<td>10 ± 4</td>
<td>13 ± 5</td>
<td>n.s.</td>
</tr>
<tr>
<td>ECG-changes (ST, Q) (%)</td>
<td>10</td>
<td>8</td>
<td>n.s.</td>
</tr>
<tr>
<td>Arrhythmias (AF, VES) (%)</td>
<td>29</td>
<td>24</td>
<td>n.s.</td>
</tr>
</tbody>
</table>

Table 4  Postoperative parameters (II) in groups A (CR) and B (ICR)

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Periop. myoc. infarction (%)</td>
<td>2.2</td>
<td>6</td>
<td>&lt; 0.05</td>
</tr>
<tr>
<td>Angina pect. postop. (%)</td>
<td>2.6</td>
<td>2.7</td>
<td>n.s.</td>
</tr>
<tr>
<td>LV-EF (+% compared to preop.)</td>
<td>10</td>
<td>8</td>
<td>n.s.</td>
</tr>
<tr>
<td>Region. dyspnoea (new) (%)</td>
<td>3.3</td>
<td>4</td>
<td>n.s.</td>
</tr>
<tr>
<td>Pulmonary edema (%)</td>
<td>21</td>
<td>29</td>
<td>&lt; 0.05</td>
</tr>
<tr>
<td>Mortality in hospital (%)</td>
<td>3.2</td>
<td>6</td>
<td>&lt; 0.05</td>
</tr>
</tbody>
</table>
Graft selection

Long-term event-free survival after CABG is not only related to the preoperative status of the patient the progression of atherosclerotic disease in the native coronary arteries but is also dependent on the patency of the bypass conduits used

Vein grafts

◆ Mild degree of stenosis

◆ Large myocardial flow demand in severely hypertrophied ventricle - Perioperative Hypoperfusion Syndrome
Arterial Grafts

◆ Influence of the IMA graft on 10 year survival & other cardiac event – Loop et al, N Engl J med 1986;314:1-6

◆ IMA to LAD with or without SV vs. only SV grafts
◆ 10 year actuarial survival rate: 93.4% vs. 88%
◆ Risk of

Death: 1.61 times
Late MI: 1.41 times
Hospitalization: 1.25 times
Cardiac Reoperation: 2 times
Single versus bilateral IMA grafts with concomitant saphenous vein grafts for multiessel coronary artery bypass grafting; Effects on mortality and event-free survival – Stevens, Cartier et al, JTCS 2004;127:1408-1415

- Single IMA + SV (n=2547) vs. BIMA + SV (n=1835)
- 30 day mortality: 2.3% vs. 1.3% (p=0.007)
- 10 year survival: 88% vs. 93%
- Hazard ratio: Death – 0.74, MI – 0.79, Reoperation – 0.41
OPCAB in LV Dysfunction

- Is low ejection fraction safe for off-pump coronary bypass operation
- EF ≤ 30%
- OPCAB: 45 patients vs. CABG: 132 patients
- Mean distal graft
  - OPCAB: 2.7 vs. CABG: 3.3 (p=0.001)
- Op. mortality
  - OPCAB: 4.4 vs. CABG: 7.7 (p=ns)
- Cardiopulmonary bypass was the only predictor for all postoperative complications (transfusion and CK-MB release)
**Surgical revascularization in patients with poor left ventricular function: On- or Off-pump?**


- **EF \( \leq 35\% \)**
  
  OPCAB : 31 patients vs. CABG : 46 patients

- **Graft number**
  
  OPCAB : 2.8 vs. CABG : 3.9 (p<0.01)
  
  Fewer graft to OM and PDA

- **Mortality**
  
  OPCAB : 3.2% vs. CABG : 10.9% (p=0.39)

- **Less** transfusion, less ventilatory support in OPCAB

- **More** atrial fibrillation in OPCAB
  
  OPCAB : 29% vs. CABG : 10.9% (p<0.05)
Multi-vessel off-pump revascularization in patients with severe left ventricular dysfunction


- Retrospective study
- EF ≤ 30%
  - OPCAB : 100 patients vs. CABG : 110 patients
- Mean grafts
  - OPCAB : 3.5 vs. CABG : 3.6 (p=ns)
- Mortality
  - OPCAB : 3% vs. CABG : 10.9% (p=ns)
◆ 6 and 12 months survival
  OPCAB : 90% and 85%
  CABG : 82% and 75% ($p=0.592$)
◆ The only statistically significant difference was postoperative renal failure ($p=0.003$)
  OPCAB : 3% vs. CABG : 16%
◆ Factors attributed to low mortality
  - Achievement of multi-vessel revascularization
  - Liberal use of IABP
    Preop. OPCAB : 16% vs. CABG : 24%
    Intraop. OPCAB : 6% vs. CABG : 8%
  - Experienced cardiac anesthesiologist
Avoidance of cardiopulmonary bypass improves early survival in multi-vessel coronary artery bypass patients with poor ventricular function


- EF ≤ 30%
- OPCAB : 204 Patients vs. CABG : 713 patients
- Graft number
  OPCAB : 3.23 vs. CABG : 3.53 (p<0.001)
- Mortality
  OPCAB : 2.9% vs. CABG : 6.3% (p=0.069)
- Risk adjusted Mortality
  OPCAB : 1.5% vs. CABG : 4.1% (p<0.001)
◆ **OPCAB shows less morbidity**
  - Lower incidence of reoperation
  - Lower blood product use
  - Decreased postoperative ventilatory time
  - Fewer days in ICU
  - Lower incidence of IABP use

◆ **Logistic regression analysis**
  
  *Cardiopulmonary bypass*
  and *Previous bypass surgery*

  is an **independent risk factors for death**
Preoperative prediction of long-term survival after coronary artery bypass grafting in patients with low LVEF

Derose et al. JTCS 2005;129:314-321

<table>
<thead>
<tr>
<th>TABLE 2. Intraoperative characteristics, early mortality, length of stay and major complication after CABG in patients with low EF (≤25%, n=544)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Intraoperative characteristics</strong></td>
</tr>
<tr>
<td>Two or more arterial grafts (No.)</td>
</tr>
<tr>
<td>Number of distal anastomoses (mean ± SD)</td>
</tr>
<tr>
<td>OPCAB (No.)</td>
</tr>
<tr>
<td>Microscope use (No.)</td>
</tr>
<tr>
<td><strong>Early mortality and length of stay</strong></td>
</tr>
<tr>
<td>EuroSCORE standard (mean ± SD)</td>
</tr>
<tr>
<td>30-d mortality (No.)</td>
</tr>
<tr>
<td>In-hospital death (No.)</td>
</tr>
<tr>
<td>Stay (d, mean ± SD)</td>
</tr>
<tr>
<td><strong>Major complications</strong></td>
</tr>
<tr>
<td>Intraoperative stroke (No.)</td>
</tr>
<tr>
<td>Over 24 h stroke (No.)</td>
</tr>
<tr>
<td>Postoperative myocardial infarction (No.)</td>
</tr>
<tr>
<td>Deep sternal wound infection (No.)</td>
</tr>
<tr>
<td>Bleeding/reoperation (No.)</td>
</tr>
<tr>
<td>Sepsis/endocarditis (No.)</td>
</tr>
<tr>
<td>Gastrointestinal bleeding, perforation, or infarction (No.)</td>
</tr>
<tr>
<td>Renal failure/dialysis (No.)</td>
</tr>
<tr>
<td>Respiratory failure (No.)</td>
</tr>
</tbody>
</table>
5 year survival

OPCAB : 45% vs. CABG : 70%

OPCAB had higher Euroscore (9.3 vs. 8.0)
Early and Mid-term impacts of cardiopulmonary bypass on coronary artery bypass grafting in patients with poor left ventricular dysfunction – A propensity Score Analysis -


◆ Isolated CABG : 1473 patients
◆ EF ≤ 35% : 155 patients (10.5%)
  Exclusion : 2 on-pump conversion from OPCAB surgery
  Mean EF ; OPCAB : 28.8 ± 5.1   CABG : 28.1 ± 7.1
◆ Off-pump group : 100
◆ On-pump group : 53

Propensity score case matching

50 pts
50 pts
◆ Graft number
  OPCAB : 3.2 vs. CABG : 3.4 (p=ns)
◆ Total arterial bypass grafting
  OPCAB : 60% vs. CABG : 48% (p=ns)
◆ Complete revascularization
  OPCAB : 84% vs. CABG : 94% (p=ns)
◆ OPCAB group show
  more arterial graft
  less Inotropic use, CK-MB release
  Respiratory failure, ICU stay
◆ Expected mortality
  OPCAB : 11.2% vs. CABG : 10.1% (p=ns)
◆ Mortality
  OPCAB : 4% vs. CABG : 2% (p=ns)
Mid-term outcomes
(mean f/u time: 35.5±17.3 (range, 4 to 72 months))

Actuarial Survival

- OPCAB
- On-pump CABG

Freedom from cardiac death

- OPCAB
- On-pump CABG

Freedom from MACCE

- OPCAB
- On-pump CABG

Freedom from MACE

- OPCAB
- On-pump CABG
Changes of Echocardiographic results

EF

LVD

LVEDD

LVESD

MR

Mitril Regurgitation Grade

LAD

Left Atrial Diameter (mm)

Preop. Imm. postop. F/U

OPCAB group

On-pump CABG group

Preop. Imm. postop. F/U

OPCAB group

On-pump CABG group

Preop. Imm. postop. F/U

OPCAB group

On-pump CABG group

Preop. Imm. postop. F/U

OPCAB group

On-pump CABG group

EF

LVD

LVEDD

LVESD

MR

LAD

Preop. Imm. postop. F/U

OPCAB group

On-pump CABG group

Preop. Imm. postop. F/U

OPCAB group

On-pump CABG group

Preop. Imm. postop. F/U

OPCAB group

On-pump CABG group

Preop. Imm. postop. F/U

OPCAB group

On-pump CABG group

$\text{EF} \quad p = 0.40$

$\text{LVD} \quad p = 0.60$

$\text{LVEDD} \quad p = 0.60$

$\text{LVESD} \quad p = 0.79$

$\text{MR} \quad p = 0.35$

$\text{LAD} \quad p = 0.53$
CABG versus PCI *(Bare metal stent)*

<table>
<thead>
<tr>
<th>Early CABG versus medical therapy trials</th>
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<tbody>
<tr>
<td>Veterans Administration Trial of CABG for Stable Angina (VA Trial)</td>
</tr>
<tr>
<td>Veterans Administration Unstable Angina Cooperative Study (VA Study)</td>
</tr>
<tr>
<td>European Coronary Surgery Study (EURO)</td>
</tr>
<tr>
<td>Coronary Artery Surgery Study (CASS)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CABG versus PCI trials</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arterial Revascularization Therapies Study (ARTS)</td>
</tr>
<tr>
<td>Argentine Randomized Study (ERACI II)</td>
</tr>
<tr>
<td>Stent or Surgery (SoS) Trial</td>
</tr>
<tr>
<td>Emory Angioplasty versus Surgery Trial (EAST)</td>
</tr>
<tr>
<td>Bypass Angioplasty Revascularization Investigation (BARI)</td>
</tr>
<tr>
<td>Coronary Angioplasty versus Bypass Revascularization Investigation (CABRI)</td>
</tr>
<tr>
<td>First Randomized Intervention Treatment of Angina (RITA-1) Trial</td>
</tr>
<tr>
<td>First German Angioplasty Bypass Investigation (GABI-1)</td>
</tr>
<tr>
<td>Angina with Extremely Serious Operative Mortality Evaluation (AWESOME)</td>
</tr>
</tbody>
</table>
Conclusions of clinical trials


Survival advantage with CABG compared to PCI or medical therapy alone in patients with low EFs
More freedom from angina symptoms and heart events with CABG
More complete revascularization with CABG
More need for revascularization with PCI
More periprocedural morbidity with CABG
PCI more cost-effective within the first year after intervention
PCI less cost-effective after 1 year of intervention because of need for repeat interventions
CABG versus PCI

-Drug eluting stent-

- Revascularization in severe left ventricular dysfunction: DES vs. CABG


- Retrospective multicenter study
- 220 patients with LVEF $\leq 35\%$
- DES : 128 patients  CABG : 92 patients
- Mean graft
  - DES : 1.3 artery / pts, CABG : 3.0 $\pm$ 0.8 graft / pts
- Follow-Up : 2 years
No difference in early and 2 year F-U results

Survival from all-cause death

Survival from MACCE

P = NS

CABG

DES

CABG

DES

P = NS

Number at risk

<table>
<thead>
<tr>
<th></th>
<th>CABG</th>
<th>DES</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>92</td>
<td>128</td>
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<td>46</td>
<td>46</td>
<td>30</td>
</tr>
<tr>
<td>21</td>
<td>21</td>
<td>4</td>
</tr>
</tbody>
</table>
Off-pump Coronary Artery Bypass Grafting in Patients with Low Ejection Fraction

-Yonsei experience -
Materials

◆ Period: January 2001 ~ May 2007
◆ No. of Total CABG by single surgeon: 1412
◆ No. of LV dysfunction (EF ≤ 35%): 156 patients (11.0%)
◆ On-Pump CABG: 34 patients
◆ OPCAB: 122 patients
Demography (I)

◆ Age : 62.1 ± 94
◆ M : F = 94 : 28
◆ Mean LV Ejection Fraction : 27.8 ± 5.8 %
◆ Canadian class : 2.5 ± 0.9
◆ NYHA class : 2.5 ± 0.9
◆ Euroscore : 7.1 ± 3.6
◆ Predicted mortality : 12.0 ± 13.9
Demography (II)

◆ Risk factors

DM 78 (63.9%)
Hypertension 68 (55.7%)
Acute MI(<30days) 52 (42.6%)
PAOD 18 (14.8%)
CVA 15 (12.3%)
Renal failure 20 (16.4%)

◆ Coronary disease

Left main disease or 3 VD 107 (87.7%)

◆ Preop. inotropic usage 18 (14.8%)

◆ Urgent or Emergency operation 17 (13.9%)

◆ Preop. IABP 3 (2.5%)
Operative Data (I)

◆ No. of Used Grafts 2.7 ± 0.6
  LIMA 121 (99.2%)
  RA 103 (84.4%)
  RIMA 46 (37.7%)
  SV 42 (34.4%)
  GEA 5 (4.1%)
◆ Y graft : 117 (95.1%)
◆ Sequential graft : 34 (27.4%)
Operative Data (II)

◆ Target territories
  LAD territories: 174 anastomoses
  LCx territories: 116 anastomoses
  RCA territories: 90 anastomoses

◆ Total arterial bypass grafting: 80 (65.6%)

◆ Used arterial grafts (mean): 2.4 ± 0.8

◆ Distal anastomoses (mean): 3.1 ± 0.8
Postoperative Results

- Postop. Inotrope use: 24 (19.7%)
- CK-MB (POD#1; mg/dL): 15.3 ± 34.1
- Postop. bleeding for 24 hours (mL): 755.0 ± 331.2
- Ventilation time (hrs): 22.4 ± 31.1
- ICU stay time (hrs): 62.3 ± 36.0
- Hospital stay (days): 14.2 ± 8.4
- Multi-slice CT evaluation:
  - 214 anastomoses (67 pts; 54.5%)
  - Patency rate: 98.6% (211/214)
Mortality and Morbidity

◆ In-hospital Mortality : 3 (2.5%)
- Cause of death : Acute MI and multiorgan failure (preop. CRF) (1), ventricular fibrillation (1), Hemothorax (1)

◆ Morbidity

<table>
<thead>
<tr>
<th>Condition</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atrial fibrillation</td>
<td>16</td>
<td>13.1%</td>
</tr>
<tr>
<td>Renal failure</td>
<td>4</td>
<td>3.3%</td>
</tr>
<tr>
<td>Perioperative MI</td>
<td>3</td>
<td>2.5%</td>
</tr>
<tr>
<td>Respiratory failure</td>
<td>1</td>
<td>0.8%</td>
</tr>
<tr>
<td>new IABP insertion</td>
<td>1</td>
<td>0.8%</td>
</tr>
<tr>
<td>Ventricular tachycardia</td>
<td>1</td>
<td>0.8%</td>
</tr>
<tr>
<td>UGI bleeding</td>
<td>1</td>
<td>0.8%</td>
</tr>
<tr>
<td>CVA</td>
<td>1</td>
<td>0.8%</td>
</tr>
<tr>
<td>Reoperation for bleeding</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>
Follow Up – 100%

◆ Follow up period: 30.6 ± 22.4 mo. (3 ~ 77mo.)
◆ Late death: 9 patients
  Cardiac death: 6
    AMI(3), Heart failure(1), Sudden cardiac arrest (?) (2)
  Non-cardiac death: 6
    hepatoma (1), respiratory failure (1), cerebral infarction (1), ESRD (1), unknown (2)

◆ Ejection fraction

  27.8 ± 5.8 %  P<0.001  37.6 ± 10.7%
Actuarial survival

6 year : 76 ± 7%
Freedom from cardiac death

6 year: 90 ± 4%
• Major adverse cardiac events
  ➢ All-cause late mortality (12), re-PTCA (2), non-fatal MI(1)

6 year: 69 ± 9%
Freedom from recurrence of angina

6 year: 80 ± 15%
Conclusions

◆ OPCAB improves myocardial function and favors lower morbidities in patients with severe left ventricular dysfunction

◆ No difference in mid-term results between OPCAB and CABG

◆ In patients with low ejection fraction, complete revascularization and total arterial OPCAB may further improve long term results