Surgical coronary revascularization in pediatric patients: a European congenital heart surgeons association (ECHSA) multi-centric study


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University of Padua Medical School
Introduction

• Surgery on coronary arteries in neonates or in pediatric patients may be associated with potential serious complications, especially in case of anomalies of origin and position.

• Pediatric coronary artery bypass grafting (CABG) together with other coronary artery procedures (OCAP) has been rarely employed to treat congenital and iatrogenic CA problems, excluding Kawasaki disease.


Aim and criteria

• We sought to evaluate hospital and follow-up outcome of pediatric patients (<18 yo) requiring myocardial revascularization in the pediatric age group within the ECHSA* community.

• EXCLUDED patients with Kawasaki disease

*ECHSA: European Congenial Heart Surgeon Association
Outcomes

1) Hospital mortality
2) Late mortality
3) Clinical status at follow-up
4) Freedom from reoperation/reinterventions
5) Patency of grafts / coronary arteries
Patients

Period: 1973-2011

80 patients from 13 ECHSA centers

Median age at CA procedure: 2.3 yrs (2 days- 16.9 yrs)
33 pts (41%) < 12 months of age

- 65 pts (81%): CABG ± OCAP
- 15 pts (19%): other isolated OCAP
## Main diagnoses

<table>
<thead>
<tr>
<th>Condition</th>
<th>Count (Percentage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>D-TGA</td>
<td>37 (47%)</td>
</tr>
<tr>
<td>ALCAPA</td>
<td>12 (15%)</td>
</tr>
<tr>
<td>Aortic valve disease</td>
<td>7 (8.7%)</td>
</tr>
<tr>
<td>Truncus arteriosus</td>
<td>4 (5%)</td>
</tr>
<tr>
<td>PA-IVS</td>
<td>3 (3.7%)</td>
</tr>
<tr>
<td>Supra-valvar AS</td>
<td>3 (3.7%)</td>
</tr>
<tr>
<td>Other CA anomalies*</td>
<td>14 (16.9%)</td>
</tr>
</tbody>
</table>
Anomalous CA pattern  
(n=59, 74%)

<table>
<thead>
<tr>
<th>Condition</th>
<th>Count (Percentage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LM CA stenosis</td>
<td>22 (37.2%)</td>
</tr>
<tr>
<td>Intramural LM CA</td>
<td>9 (15.2%)</td>
</tr>
<tr>
<td>Anomalous origin CA</td>
<td>7 (11.8%)</td>
</tr>
<tr>
<td>Intramural RCA</td>
<td>2 (5%)</td>
</tr>
<tr>
<td>CX coronary from RCA</td>
<td>2 (3.3%)</td>
</tr>
<tr>
<td>Double looping CAs</td>
<td>2 (3.3%)</td>
</tr>
<tr>
<td>Intramuscular CA</td>
<td>2 (3.3%)</td>
</tr>
<tr>
<td>CX stenosis</td>
<td>2 (3.3%)</td>
</tr>
<tr>
<td>Other Ca anomalies</td>
<td>11 (17.6%)</td>
</tr>
</tbody>
</table>
CABG
(n=65, 70 CABG - Single: 60 pts, double: 5 pts)

Emergency CABG: 29 pts (45%)
- Unplanned rescue: 21 pts
- Dictated by pts clinical status /symptoms: 8 pts
  (after median time of 0.4 years, 4 days-13.9 years from initial surgery)

Planned CABG: 36 pts (55%)
  (after median time of 0.4 years, 4 days-13.9 years from initial surgery)

Associated OCAP: 12 pts (18%)
- CA patch plasty 6 pts
- Unroofing LM CA 4 pts
- RCA fistula closure 1 pt
- CABG patch plasty 1 pt
CABG

target and grafts

<table>
<thead>
<tr>
<th></th>
<th>LAD</th>
<th>RC</th>
<th>CX</th>
</tr>
</thead>
<tbody>
<tr>
<td>n=70</td>
<td>56 (80%)</td>
<td>13 (18%)</td>
<td>1 (2%)</td>
</tr>
<tr>
<td>LIMA</td>
<td>49 (70%)</td>
<td>48</td>
<td>-</td>
</tr>
<tr>
<td>RIMA</td>
<td>12 (17%)</td>
<td>1</td>
<td>11</td>
</tr>
<tr>
<td>SVG</td>
<td>9 (13%)</td>
<td>7</td>
<td>2</td>
</tr>
</tbody>
</table>

LAD: left anterior descending, RC: Right coronary, CX: circumflex
LIMA: left internal mammary artery, RIMA: right internal mammary artery, SVG: saphenous venous graft
Other isolated OCAP
(n=15)

Isolated OCAP:

- CA patch plasty 8 pts
- Unroofing LM CA 4 pts
- Reduction RCA aneurysm 2 pts
- PTCA LM CA 1 pt

15 pts

Emergent isolated OCAP: 5 pts (3 at time of correction and 2 after correction for signs of myocardial ischemia)

Planned isolated OCAP: 10 pts (after a median time of 2 years, range 1-10.9 years after corrective procedure)
Hospital outcome

Median ICU stay: 4 days (1-120 days)

45 postop complications in 38 patients (47%)

- Difficult weaning from CPB, req. ECMO (n=17)
- Delayed sternal closure (n=10)
- Postop LOS (n=9)
- Bleeding re. reoperation (n=4)
- Phrenic nerve palsy (n=2)
- Arrhythmias (n=2)
- Acute renal failure req. temp diasysis (n=1)
Hospital mortality

12 patients (15%)

Cause for death:
- LV infarction (n=9)
- RV infarction (n=1)
- Sudden cardiac arrest (n=1)
- ECMO related complication (n=1)
## Hospital mortality

<table>
<thead>
<tr>
<th></th>
<th>Hospital mortality n=12 pts</th>
<th>Survivors n=68 pts</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, days (range)</td>
<td>60.5 (9-660)</td>
<td>994 (97-3713.5)</td>
<td>0.02</td>
</tr>
<tr>
<td>Emergency procedure, n (%)</td>
<td>11 (91.7%)</td>
<td>23 (33.8%)</td>
<td><strong>0.0004</strong>&lt;sup&gt;*&lt;/sup&gt;</td>
</tr>
<tr>
<td>Abnormal coronary pattern, n (%)</td>
<td>8 (66.7%)</td>
<td>51 (75%)</td>
<td>0.72</td>
</tr>
<tr>
<td>CABG, n (%)</td>
<td>11 (91.7%)</td>
<td>54 (79.4%)</td>
<td>0.44</td>
</tr>
<tr>
<td>OCAP, n (%)</td>
<td>1 (8.3%)</td>
<td>14 (20.6%)</td>
<td></td>
</tr>
<tr>
<td>CPBP time, min (range)</td>
<td>278 (246.5-403.5)</td>
<td>101.5 (69-182.5)</td>
<td><strong>0.0001</strong></td>
</tr>
<tr>
<td>Aortic cross clamp, min (range)</td>
<td>98 (93.25-111.25)</td>
<td>42 (27-70.75)</td>
<td><strong>0.007</strong></td>
</tr>
<tr>
<td>Complications, n (%)</td>
<td>12 (100%)</td>
<td>26 (38.2%)</td>
<td>&lt;0.00001</td>
</tr>
<tr>
<td>ECMO support, n (%)</td>
<td>9 (75%)</td>
<td>8 (11.8%)</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

CPB: cardiopulmonary bypass, Percentages are relative to the total in each group, CABG: coronary artery bypass grafting, OCAP: other coronary artery procedures

<sup>*</sup>: At logistic regression analysis (considering preoperative variables)
p=0.004, OR 21.5 (95% CI 2.6-177.1)
Discharge data

68 patients (85%)
Median hospitalization 16 days

Median LV EF: 50% (12-69%)
Mitral regurgitation: 19 patients
- none-mild (n=13)
- Moderate (n=5)
- Severe (n=1)

21 pts (31%): coronary angiography at discharge
(20 patent, 1 occluded graft)
Antiaggr /anticoag therapy
(n= 68 pts)

41 patients (60%): ASA
9 patients (13%): warfarin
18 patients (27%): no antithrombotic therapy
Follow-up

Median 7.6 years (0.9-23 years)

3 late cardiac deaths
(after median time of 3 years, 9 months-8.8 years)
  - LV failure (n=2)
  - Sudden infarction (n=1)

Lower LV at discharge (p=0.05)

14 symptomatic patients (20.5%)
  - CHF (n=10)
  - Angina (n=4)
Control CA angiography

46 / 64 patients (70%)

PGABG
- Patent (n=27)
- Stenotic (n=5)
- Occluded (n=10)

CAs after OCAP
- Patent (n=3)
- Stenotic (n=1)

16/46, 35%

NO association with antithrombotic therapy and patency
## Follow-up

<table>
<thead>
<tr>
<th></th>
<th>Symptoms at follow-up n=14 pts</th>
<th>Asymptomatic patients at follow-up n=54 pts</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>LV-EF at discharge, % (range)</td>
<td>50 (40-55)</td>
<td>55 (44-60)</td>
<td>0.09</td>
</tr>
<tr>
<td>LV-EF at follow-up, % (range)</td>
<td>40 (20-41.25)</td>
<td>60 (50-65)</td>
<td>&lt;0.0001*</td>
</tr>
<tr>
<td>MR ≥ moderate at discharge, n (%)</td>
<td>4 (28.6%)</td>
<td>2 (3.7%)</td>
<td>0.014</td>
</tr>
<tr>
<td>MR ≥ moderate at follow-up, n (%)</td>
<td>6 (42.9%)</td>
<td>1 (1.9%)</td>
<td>0.0003</td>
</tr>
<tr>
<td>PCABG</td>
<td>12 (85.7%)</td>
<td>42 (77.7%)</td>
<td>0.8</td>
</tr>
<tr>
<td>OCAP</td>
<td>2 (14.3%)</td>
<td>12 (22.2%)</td>
<td></td>
</tr>
<tr>
<td>PCABG/OCAP stenosis at FU CATH</td>
<td>7/11 (63.6%)</td>
<td>10/36 (27.8%)</td>
<td>0.07</td>
</tr>
</tbody>
</table>


*: At logistic regression analysis p=0.001, OR 0.78 (95% CI 0.67-0.9)
Reintervention

6 patients (8.8%)

For myocardial impaired perfusion
  - CA angioplasty /stent (n=3)
  - Heart transplantation (n=2)
  - Redo CABG (n=1)

- ALL of them had an occluded/stenotic CABG (p=0.01)
- Lower LV EF (p=0.02)
- Symptomatic (p=0.001)
Limitations

• Wide time era in the study (1973-2011)

• No preoperative 2D echo data (LV EF, valvar function)

• No control CA angiography in all patients

• Intra-center / inter-center variability
Conclusions

CABG and OCAP:

1) suitable surgical options in pediatric patients with impaired myocardial perfusion
2) Increase operative and mid-term survival

Age at CA surgery, emergency procedures correlates with hospital mortality
Conclusions

Such a population of patients needs to be followed for life with stress test, myocardial scintigraphy, or cardiac catheterization to prevent and treat any possible cause of further myocardial ischemia during childhood and adulthood.
Grazie
<table>
<thead>
<tr>
<th>Basic anatomical diagnosis</th>
<th>n=80</th>
<th>HM n=12</th>
<th>Symptoms at FU n=14</th>
<th>Redo coronary interventions n=6</th>
<th>LM n=3</th>
</tr>
</thead>
<tbody>
<tr>
<td>TGA, n. pts (%)</td>
<td>37</td>
<td>5/37 (13%)</td>
<td>5/32 (15%)</td>
<td>2/32 (6.2%)</td>
<td>-</td>
</tr>
<tr>
<td>ALCAPA, n. pts (%)</td>
<td>12</td>
<td>2/12 (17%)</td>
<td>3/10 (30%)</td>
<td>1/10 (10%)</td>
<td>2/10 (20%)</td>
</tr>
<tr>
<td>Aortic valve dis, n. pts (%)</td>
<td>7</td>
<td>1/7 (8.3%)</td>
<td>2/6 (33%)</td>
<td>-</td>
<td>1/6 (17%)</td>
</tr>
<tr>
<td>Truncus arteriosus, n. pts (%)</td>
<td>4</td>
<td>2/4 (17%)</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>PA-IVS, n. pts (%)</td>
<td>3</td>
<td>-</td>
<td>-</td>
<td>1/3 (33%)</td>
<td>-</td>
</tr>
<tr>
<td>Supra-valvar AS, n. pts (%)</td>
<td>3</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Other CA anom*, n. pts (%)</td>
<td>14</td>
<td>2/14 (14%)</td>
<td>4/12 (33%)</td>
<td>2/12 (17%)</td>
<td>-</td>
</tr>
</tbody>
</table>


*: including coronary artery fistula, congenital coronary artery hypoplasia, anomalous coronary origin from improper sinus, congenital ostial stenosis and intramural coronary artery course.
# Preoperative and operative variables according to basic anatomical diagnosis

<table>
<thead>
<tr>
<th>Basic anatomical diagnosis</th>
<th>n</th>
<th>PCABG ± OCAP</th>
<th>OCAP alone</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>n=65</td>
<td>Emergent n=29</td>
</tr>
<tr>
<td>TGA, n. pts (%)</td>
<td>37</td>
<td>32 (86%)</td>
<td>13 (35%)</td>
</tr>
<tr>
<td>ALCAPA, n. pts (%)</td>
<td>12</td>
<td>12 (100%)</td>
<td>3 (25%)</td>
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<td>Aortic valve disease, n. pts (%)</td>
<td>7</td>
<td>6 (86%)</td>
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<tr>
<td>Truncus arterios., n. pts (%)</td>
<td>4</td>
<td>1 (25%)</td>
<td>1 (25%)</td>
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<tr>
<td>PA-IVS, n. pts (%)</td>
<td>3</td>
<td>3 (100%)</td>
<td>-</td>
</tr>
<tr>
<td>Supra-valvar AS, n. pts (%)</td>
<td>3</td>
<td>3 (33%)</td>
<td>1 (33%)</td>
</tr>
<tr>
<td>Other CA anom.*, n. pts (%)</td>
<td>14</td>
<td>10 (72%)</td>
<td>5 (36%)</td>
</tr>
</tbody>
</table>
Case

- P.S.
- **Diagnosis:** D-TGA, VSD s/p Rashkind
- **Age at surgery:** 11 days
- **Intraop diagnosis:** single ostium, intra-mural LCA
- **Procedure:** Arterial switch, VSD closure, PFO, closure, *CABG LIMA-LAD*
- **Chest closure:** 4 POD
- **Hospital discharge:** 10 POD

- 2D echo: good biventricular function, mild septal dyskinesia.
- Myocardial perfusion scintigraphy: within normal limits
Case P.S. follow-up

- Fu time: 4 years
- Symptoms: mild exercise intolerance
- 2D echo: normal LV function and dimensions, no AR.
- EKG: normal
- **Cardiac angiography:** normal LV function, LCA ostial stenosis, LIMA-LAD thrombosis, well developed intercoronary collaterals.
Case P.S. follow-up

- Myocardial perfusion scintigraphy: hypoperfusion anterior, mid and basal segments.