Are There Indications for Atrial Switch (or Atrial Inversion Surgery) in the 21st Century?

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No disclosures
Transposition of Great Arteries in the 21st century

**Few doubts about ....**

- Total and neonatal correction is the treatment of choice!!
- Clinical and anatomic diagnosis - ECHO
- Timing of operation – first 2 weeks
- Jatene operation (ASO) – treatment of choice

**BUT ....**

- Unfavourable anatomical, clinical, logistical and structural condition
- Other surgical option should be considered ......
Neonatal ASO for D-TGA by Year in the PCCC Registry (1984 to 2007)
Surgical Treatment of TGA - InCor

1990-2016
n - 685
295 Senning
390 Jatene
Surgical Treatment of TGA - InCor

1990-2016 n - 685
295 Senning
390 Jatene
Dextro-Transposition of the Great Arteries
Long-term Sequelae of Atrial and Arterial Switch

Christiane Haeffele, MD, MPH⁵,⁎, George K. Lui, MD⁶,⁷

Fig. 2. Overall surgical trend from 1974 to 2006 for repair of TGA. The Mustard operation was the primary repair early on but was gradually replaced by the Senning procedure as surgical technique improved. The arterial switch had high mortality rates early on as the technique was introduced but, with experience, replaced the Senning as the operation of choice for D-TGA. (From Horer J, Schriber C, Cleuziou J, et al. Improvement in long-term survival after hospital discharge but not in freedom from reoperation after the change from atrial to arterial switch for transposition of the great arteries. J Thorac Cardiovasc Surg 2009;137(2):348; with permission.)
# Dextro-Transposition of the Great Arteries
## Long-term Sequelae of Atrial and Arterial Switch

Christian Haeffele, MD, MPH, George K. Lui, MD

## Indications for intervention on complications

<table>
<thead>
<tr>
<th>Complications of Atrial Switch</th>
<th>Indication for Intervention</th>
</tr>
</thead>
</table>
| **Baffle leak**                | • Left to right shunt with Qp:Qs > 1.5  
• Dilation of the LV (subpulmonic ventricle)  
• Paradoxic embolus  
• Pacemaker/ICD (increased risk of paradoxic embolus) |
| **Baffle stenosis**            | • Symptoms  
• Pacemaker/ICD implantation and stenosis prevents placement of pacemaker leads |
| **Atrial flutter**             | • Catheter ablation if recurrent symptomatic or drug refractory |
| **Severe tricuspid regurgitation** | • Primary tricuspid valve disease  
• PA band can be considered as bridge to transplantation |
| **Failing RV**                 | • Heart transplant  
• PA band  
• Atrial switch takedown and ASO |

<table>
<thead>
<tr>
<th>Complications of Arterial Switch</th>
<th>Indication for Intervention</th>
</tr>
</thead>
</table>
| **Coronary artery stenosis**    | • Symptoms  
• Evidence of ischemia by exercise testing or cardiac markers |
| **PA stenosis**                 | • Symptoms  
• Greater than 50% stenosis of branch PA  
• RV systolic pressure > 50 mm Hg |
| **Neo-aortic regurgitation**    | • Symptoms  
• Evidence of LV dysfunction or progressive LV dilation |
Historical Notes

Senning A, Surgery; 1959;45:966–80
Historical Notes

Mustard WT, Surgery; 1964;55:469–72
Atrial switch operation

• Advantages
  – First effective surgical treatments for TGA
  – Aplication in complex cases of TGA
  – Favourable immediate results
  – Shorter learning curve

• Disadvantages
  – Must be familiar with the technique (lot of details!!)
  – Non anatomical correction
  – Different long term complications with difficult resolution
  – Morbidity during “waiting time” for correction
TGA study CHSS (85/89)

845 pts TGA – 286 op. Atrial level

- **Mortality 4.9% while waiting**
- **Mortality 8% while waiting**

**Figure 2.** Patients assigned to the atrial switch protocol. TGA, transposition of the great arteries; IVS, intact ventricular septum; VSD, ventricular septal defect.
TGA study CHSS (85/89)

TGA – atrial switch

Mustard - 89% - 20 years

Senning - 73% - 20 years

Actuarial survival – Mustard X Senning

## TGA study - CHSS (85/89)

### 281 Operations atrial level

Reoperation after Mustard and Senning

<table>
<thead>
<tr>
<th>Indication</th>
<th>N of patients</th>
<th>Moratlity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RV failure</td>
<td>2</td>
<td>2/2 (100)</td>
</tr>
<tr>
<td>Systemic venous pathway obstruction</td>
<td>7</td>
<td>3/7 (43)</td>
</tr>
<tr>
<td>SVC only</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>IVC only</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>SVC + IVC</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Pulmonary venous pathway obstruction</td>
<td>5</td>
<td>2/5 (40)</td>
</tr>
<tr>
<td>Baffle leak</td>
<td>5</td>
<td>0/5 (0)</td>
</tr>
<tr>
<td>Total</td>
<td>19</td>
<td>7/19 (37)</td>
</tr>
</tbody>
</table>

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Senning – 44 patients

Follow-up > 20 years

Age (20 to 33 y)
median = 23 y

- NYHA - FC I = 42
  FC II = 2
- Regular sports practice = 9
- Graduated/working = 20
Senning – 44 patients

Arrhythmias

• Arrhythmias detected in Holter – 100%
• Simptomatic – 20 - 44,5%
  – Tachiarrhythmias with CHF : 5 ( 2 Flutter )
  – ER procurement : 11
  – Hospitalization : 7
  – Pace maker implant : 3

• Use of medications = 30 - 68%
  Antiarrhythmics, Ieca, diuretics
Gated RV and LV

2001 x 2008

- RV EF 2001
- RV EF 2008
- LV EF 2001
- LV EF 2008

p = 0.1338

p = 0.1988
Senning – 44 pacientes
Morbidity

- Stroke sequelae / cerebral disrrhythmia ...... 5
- Morbid obesity ........................................ 4
- Pulmonary enphisema ............................. 1
- Tuberculosis ........................................... 2
- Arterial hypertension ............................... 5

Maternity = 4 ( CHF grade III – post pregnancy = 2 )
• n=468 (operated TGA)

• Mustard or Senning between 1967-2003

• mean age at the time of surgery: 1.9y

• 319 males

• perioperative mortality: 93 (20%)
• Median follow-up: 26.1y
  pacemaker implantation - 63 patients (15%)
  reoperation – 27 (7%)
  death – 176 (38%)
  heart transplant – 8 (2%)

• Patients with pacemakers increased mortality
• Special focus on the function of the right ventricle and TV

Circulation. 2015;132:633-38
Brasil X Brazil

Case 1

- FRD, 18m, female
- From Amazon region
- Cyanosis since birth (1st clinical exam at 17m)
- TGA + Large ASD + small PDA
- Surgical options – Senning operation

Case 2

- HW, 1 day, male
- From Southeast region
- Prenatal ECHO – L TGA
- Jatene operation in 3 rd day of life
- Discharged in 10th PO day
- Normal LV function, no symptoms after 4 years
Current indications

- Late presentation for TGA intact septum
- Anatomical concerns (coronary anatomy)
- Clinical condition (infection, low weight, etc.)
- Surgical team option (experience and structure)
- Part of other complex surgeries (Double switch)
- Complex clinical condition (PH)
Atrial switch in TGA

Late presentation

• **Structure of Health System**
  - Lack of diagnosis (pre and post birth)
  - Lack of beds for neonatal operations
  - Lack of adequate transportation from center to center

• **Human (Professional) Possible Causes**
  - Adequate medical formation and information
  - Adequate numbers of professionals
  - Adequate distribution for all areas
Coronary Artery Pattern and Outcome of Arterial Switch Operation for Transposition of Great Arteries
A Meta-Analysis
Sara K. Pasquali, et al

Intramural Coronary Artery

<table>
<thead>
<tr>
<th>Studies</th>
<th>Usual Higher</th>
<th>Variant Higher</th>
<th>Event Rates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretre</td>
<td>297</td>
<td>25.0</td>
<td>3.7</td>
</tr>
<tr>
<td>Hutter</td>
<td>138</td>
<td>16.7</td>
<td>15.9</td>
</tr>
<tr>
<td>Blume</td>
<td>153</td>
<td>25.0</td>
<td>6.7</td>
</tr>
<tr>
<td>Wernovsky</td>
<td>302</td>
<td>7.7</td>
<td>7.3</td>
</tr>
<tr>
<td>Day *</td>
<td>51</td>
<td>25.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Yamaguchi</td>
<td>207</td>
<td>85.7</td>
<td>18.0</td>
</tr>
<tr>
<td>Planche</td>
<td>91</td>
<td>44.4</td>
<td>6.1</td>
</tr>
<tr>
<td>Combined</td>
<td>1239</td>
<td>29.6</td>
<td>8.8</td>
</tr>
</tbody>
</table>

Odds Ratio

Circulation  November 12, 2002
Palliative Senning in the Treatment of Congenital Heart Disease with Severe Pulmonary Hypertension

Juliano Comes Penha, Leina Zorzanelli, Antonio Augusto Barbosa-Lopes, Edimar Atik, Leonardo Augusto Miana, Carla Tanamati, Luiz Fernando Caneo, Nana Miura, Vera Demarchi Aiello, Marcelo Bisegli Jatene

Instituto do Coração do Hospital das Clínicas da Faculdade de Medicina da USP, São Paulo, SP – Brazil

- 21 patients with TGA + VSD and Taussig-Bing DORV
- Retrospective study based on medical records between 1991 to 2014
- Included patients with no indication of definitive repair due to suprasystemic pulmonary pressure
- All patients underwent median sternotomy, opening of the pericardium and cardiopulmonary bypass
- VSD is maintained open
- 45% Mortality
Transposition of the Great Arteries in the Developing World: Surgery and Outcomes
Transposition of the Great Arteries in the Developing World: Surgery and Outcomes

A. WHO Weight/BMI for Age Percentile
- 48% <5th 371
- 14% 5th-14th 109
- 38% ≥15th 295

B. Age at Surgery
- 6%, 1 to 12 Years, 44
- 11%, ≤7 Days 83
- 45%, 31 Day to <1 Year 350
- 38%, 8-30 Days 301

Transposition of the Great Arteries in the Developing World: Surgery and Outcomes

C. TGA Operations and In-Hospital Mortality

## Univariate Associations with Mortality

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>OR</th>
<th>95% CI</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>TGA/IVS</td>
<td>1.00</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>TGA/VSD</td>
<td>1.30</td>
<td>1.00–1.69</td>
<td>0.05</td>
</tr>
<tr>
<td>Male</td>
<td>1.35</td>
<td>1.04–1.74</td>
<td>0.02</td>
</tr>
</tbody>
</table>

### WHO weight/BMI-for-age percentile

<table>
<thead>
<tr>
<th>Category</th>
<th>OR</th>
<th>95% CI</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;5th</td>
<td>2.20</td>
<td>1.48–3.29</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>5th–15th</td>
<td>1.69</td>
<td>0.92–3.10</td>
<td>0.09</td>
</tr>
<tr>
<td>≥15th</td>
<td>1.00</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Weight &lt;3 kg</td>
<td>1.71</td>
<td>1.09–2.68</td>
<td>0.02</td>
</tr>
<tr>
<td>Prematurity</td>
<td>2.26</td>
<td>1.13–4.53</td>
<td>0.02</td>
</tr>
<tr>
<td>Open chest post-surgery</td>
<td>1.82</td>
<td>0.90–3.69</td>
<td>0.10</td>
</tr>
</tbody>
</table>

### Average annual volume of TGA repair

<table>
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<tr>
<th>Category</th>
<th>OR</th>
<th>95% CI</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;10</td>
<td>4.66</td>
<td>2.08–10.4</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>10–19</td>
<td>2.82</td>
<td>1.12–7.09</td>
<td>0.03</td>
</tr>
<tr>
<td>≥20</td>
<td>1.00</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

## Multivariate Associations with Mortality

<table>
<thead>
<tr>
<th>Feature</th>
<th>OR</th>
<th>95% CI</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Patient characteristics</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WHO weight/BMI-for-age percentile</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;5th</td>
<td>2.23</td>
<td>1.48–3.33</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>5th–15th</td>
<td>1.66</td>
<td>0.91–3.04</td>
<td>0.10</td>
</tr>
<tr>
<td>≥15th</td>
<td>1.00</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Male</td>
<td>1.36</td>
<td>1.07–1.75</td>
<td>0.01</td>
</tr>
<tr>
<td><strong>Adding annual TGA volume</strong></td>
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<td></td>
</tr>
<tr>
<td>WHO weight/BMI-for-age percentile</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;5th</td>
<td>1.98</td>
<td>1.30–3.02</td>
<td>0.002</td>
</tr>
<tr>
<td>5th–15th</td>
<td>1.60</td>
<td>0.91–2.82</td>
<td>0.10</td>
</tr>
<tr>
<td>≥15th</td>
<td>1.00</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Male</td>
<td>1.45</td>
<td>1.10–1.90</td>
<td>0.008</td>
</tr>
<tr>
<td><strong>Average annual volume of TGA repair</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;10</td>
<td>4.71</td>
<td>2.10–10.5</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>10–19</td>
<td>2.41</td>
<td>0.91–6.41</td>
<td>0.08</td>
</tr>
<tr>
<td>≥20</td>
<td>1.00</td>
<td>—</td>
<td>—</td>
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Dr Baffes wrote in 1987:

“History tends to judge a human being on two counts: the use made of the time allotted to him and what, if anything, he leaves behind for the generations that follow”.

The surgeons who developed the atrial operations for transposition left behind them the inspiration for the subsequent impressive advancements in congenital heart surgery.

Are There Indications for Atrial Switch (or Atrial Inversion Surgery) in the 21st Century?
Are There Indications for Atrial Switch (or Atrial Inversion Surgery) in the 21st Century?

YES!!
• In 1987, Senning wrote:

“I think that the arterial switch—a real anatomical correction—will be the ‘golden standard’ in the near future and that the atrial switch will be used only for the few patients who are not suitable candidates for the arterial switch”