Pacemaker After Transcatheter Aortic Valve Implantation: Where, When and How?

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Europace 2011
Conflict of Interest

• Research grants from device companies (MDT, Biotronik, SJM)
• Steering committee and PI on MDT and BSCI studies
• Lectures for MDT, BSCI
Types of Valves

The Edwards Sapien (Stainless steel, balloon expandable)

- Transfemoral
- Transapical
- Transaortic

Corevalve (Nitinol, self expanding)

- Transfemoral
- Transaxillary
- Transaortic

Piazza Circ interv 2008
## Incidence of Conduction Abnormalities Following Transfemoral TAVI

<table>
<thead>
<tr>
<th>Valve Type</th>
<th>New LBBB (%)</th>
<th>High degree AVB (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Core Valve</td>
<td>40 (30– 65) 1,3,5</td>
<td>30 (12 - 44) 1,3,5,4</td>
</tr>
<tr>
<td>Edwards</td>
<td>12 (6-18) 1,7</td>
<td>5 (0-27) 1,6</td>
</tr>
</tbody>
</table>

1. Nuis Eur Heart J 2010
2. Roten AJC 2010
4. *Maier et al. TCT 2010 Lowest incidence with more superior positioning
5. Guetta Glikson 2011
7. Godin Am J Cardiol 2010
Anatomy of the Aortic Root

Figure 6. This image of the aortic root opened from the left ventricle shows the fibrous continuities between the interleaflet triangles, the fibrous trigones, and the membranous septum. A-M indicates aortic-mitral.
Location of the Conduction System

6 mm from bottom of NCC to emergence of LBB
Evidences for Multiple levels of Conduction System Injury

- Both AH and HV prolongation following TAVI \(^1\)
- Histologic evidence of hemorrhage next to His \(^2\)
- Some patients have narrow QRS escape while many have wide QRS escape

1- Rubin Circ Interv 2011
2- Moreno Circ 2009
Depth of Implantation and LBBB

New-onset LBBB:
10.3 ± 2.7 mm  
(range, 6.7 to 14.6 mm)

Related to depth of implantation

No LBBB:
5.5 ± 3.4 mm  
(range, 0.7 to 12.2 mm)

Early and Persistent Intraventricular Conduction

P = 0.005
### Predictors of High Degree AVB with CoreValve

**- Baseline Parameters -**

<table>
<thead>
<tr>
<th>Class</th>
<th>Predictors</th>
<th>OR/HR</th>
<th>Ref</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preexisting CSD</td>
<td>RBBB</td>
<td>OR &gt; 40</td>
<td>4,5</td>
</tr>
<tr>
<td></td>
<td>LBBB+long PR</td>
<td></td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Wide QRS</td>
<td>3.45</td>
<td>2</td>
</tr>
<tr>
<td>LVOT and AV anatomy</td>
<td>IVS hypertrophy</td>
<td>1.18</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>NCC thickness</td>
<td>1.5</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>AV Calcifications</td>
<td></td>
<td>2</td>
</tr>
</tbody>
</table>

# Predictors of High Degree AVB with CoreValve

## - Procedural Parameters -

<table>
<thead>
<tr>
<th>Class</th>
<th>Parameter</th>
<th>OR/HR</th>
<th>Ref</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth</td>
<td>Depth of Implantation &gt; 6 mm</td>
<td>OR &gt; 20</td>
<td>4,5</td>
</tr>
<tr>
<td>Size</td>
<td>Balloon : Annulus ratio &gt; 1.3</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Large prosthesis (29)</td>
<td>2.5</td>
<td>2</td>
</tr>
</tbody>
</table>

Course of AVB Over Time in TAVI

• 40-80% occur during the procedure, 50% of which occur during balloon pre-dilatation

• Later there are opposing processes of resolution of edema / inflammation vs. self expanding nature of CoreValve
  – Periprocedural AVB “resolved” (?) in 35% at discharge, 64% within ≥ 30 days
  – 20-60% of HDAVB develop AFTER procedure most of them within 5 days
  – Few reports of late onset AV block after discharge, few cases of late SCD
  – Most new LBBB persist @ 6m

1- Roten Am J Cardiol 2010
2- Nuis Eur Heart J 2010
3- Guetta & Glikson 2011
4- Piazza Eurointerv 2010
5- Fraccaro Am J Cardiol 2011
Time to Development of High Degree AV Block

\[ n = \frac{25}{70} \]

Guetta, Glikson 2011
Periprocedural ECG Changes and Later Progression to HDAVB

• Periprocedural AVB is the strongest predictor of persistent AVB (in our series ALL had permanent pacemakers implanted)
• New LBBB is a poor predictor of later HDAVB (6/33)
• Of 39 cases with periprocedural worsening of conduction (other than HDAVB) only 8 progressed later to HDAVB
• Of 15 patients with late HDAVB only 8 had demonstrated periprocedural conduction system changes
• In patients with normal QRS both before and after TAVI, rate of later development of HDAVB was 0 – 13%

1-Khawaja, Circulation 2011
2-Guetta and Glikson 2011
Permanent Pacing After TAVI

• Absolute:
  – New high degree AV block of any duration (immediate or early implantation of a permanent pacemaker)
  – Alternating BBB

• Relative:
  – Preexisting LBBB + 1st degree AVB with any change ?
  – Preexisting RBBB with any change ?
  – New LBBB + 1st degree AV block ? ?

• Role of EPS ?
  • Prophylactic pacing ?
  • Early decision after procedure ?
Temporary Pacing in TAVI

- Initial experience with relatively high rate of complications, mainly perforations (ASA, Plavix)
- Prolonged temporary pacing associated with infections, perforations and dislocations
- Balance between risk of development of HDAVB and the risks of prolonged temporary pacing
- Practical approach:
  - Inserted before procedure via RIJV for stability
  - Use balloon tipped pacing catheters semi filled with saline to decrease risk of perforation *
  - Temporary pacemaker left in for 48 hours in most patients
  - Early or immediate permanent pacing when indicated

* Some use screw-in leads for stability
Monitoring After TAVI

• In-hospital monitoring for 5 days
• 3 days for “low risk” patients?
• Holter before discharge in borderline cases
• Role of pre discharge EPS?
Preventive Measures

• Use Edwards Sapien in pts with RBBB
• High position of Corevalve
• Preventive permanent pacing before TAVI:
  – Absolute :
    • Preexisting indications for PPM (History of syncope, holter !)
  – Relative :
    • All patients with RBBB undergoing CoreValve implantation ?
    • All patients with preexisting LBBB + 1st degree AV block undergoing CoreValve implantation ??
Conclusions

- High degree AV block is a common consequence of TAVI, especially of the CoreValve type
- Its strongest predictors are preexisting RBBB and low valve position
- Temporary pacing for 48 hours and monitoring for 5 days is indicated in all patients following TAVI
- With increased operator experience, new tools and high implant position, lower incidence of HDAVB is anticipated
Thank You!
Backup Slides
Methods

- We retrospectively reviewed 79 cases of CoreValve TAVI performed between 2008 to 2010 in 3 medical centers in Israel.
- Seven patients with PPM prior to implantation and two patients who died within the 24 hours of implantation were excluded from this study.
- We evaluated clinical, angiographic, electrocardiographic, and echocardiographic parameters at baseline and following TAVI in 70 patients included in our final analysis.
- In patients undergoing PPM implantation, underlying rhythm was assessed 3 months following implantation.
## Baseline and Procedural Patient Characteristic

<table>
<thead>
<tr>
<th></th>
<th>ALL N: 70</th>
<th>NO HDAVB: n= 45(%)</th>
<th>HDAVB: n=25(%)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>AGE</strong></td>
<td>83±5</td>
<td>84±4</td>
<td>82±6</td>
<td>0.08</td>
</tr>
<tr>
<td></td>
<td>66-91</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td><strong>MALE GENDER</strong></td>
<td>26</td>
<td>15</td>
<td>11</td>
<td>0.09</td>
</tr>
<tr>
<td><strong>IHD</strong></td>
<td>38(54)</td>
<td>26(57)</td>
<td>12(48)</td>
<td>0.27</td>
</tr>
<tr>
<td><strong>DIABETES MELLITUS</strong></td>
<td>24(34)</td>
<td>15(33)</td>
<td>9(36)</td>
<td>0.78</td>
</tr>
<tr>
<td><strong>HYPERTENSION</strong></td>
<td>58(83)</td>
<td>35(80)</td>
<td>22(84)</td>
<td>0.72</td>
</tr>
<tr>
<td><strong>RENAL FAILURE</strong></td>
<td>18()</td>
<td>11()</td>
<td>7()</td>
<td>0.86</td>
</tr>
<tr>
<td><strong>NYHA</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>III</td>
<td>51(72)</td>
<td>36(78)</td>
<td>15(60)</td>
<td>0.52</td>
</tr>
<tr>
<td>IV</td>
<td>20(28)</td>
<td>10(22)</td>
<td>10(40)</td>
<td></td>
</tr>
<tr>
<td><strong>CABG</strong></td>
<td>16(23)</td>
<td>9(20)</td>
<td>7(28)</td>
<td>0.42</td>
</tr>
<tr>
<td><strong>VALVE TYPE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>34(49)</td>
<td>24(52)</td>
<td>10(40)</td>
<td>0.33</td>
</tr>
<tr>
<td>29</td>
<td>36(51)</td>
<td>22(48)</td>
<td>15(60)</td>
<td></td>
</tr>
</tbody>
</table>
## PRE-EXISTANT ECG

<table>
<thead>
<tr>
<th></th>
<th>ALL N=70 (%)</th>
<th>NO HDAVB N=45 (%)</th>
<th>WITH HDAVB N=25 (%)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>LBBB</strong></td>
<td>13 (18)</td>
<td>11 (24)</td>
<td>2 (8)</td>
<td>0.67</td>
</tr>
<tr>
<td><strong>RBBB</strong></td>
<td>9 (13)</td>
<td>1 (2)</td>
<td>8 (32)</td>
<td>0.002</td>
</tr>
<tr>
<td><strong>1st degree AV block</strong></td>
<td>5 (7)</td>
<td>3 (6)</td>
<td>2 (8)</td>
<td>0.48</td>
</tr>
<tr>
<td>ECHOCARDIGRAM</td>
<td>ALL N=70 (%)</td>
<td>No HDAVB N=45 (%)</td>
<td>HDAVB N=25 (%)</td>
<td>P</td>
</tr>
<tr>
<td>-------------------------------------</td>
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<td>----</td>
</tr>
<tr>
<td><strong>IVS (mm, Mean ±SD)</strong></td>
<td>1.4±0.3</td>
<td>1.4±0.4</td>
<td>1.4±0.2</td>
<td>0.50</td>
</tr>
<tr>
<td><strong>LVOT (mm, Mean ±SD)</strong></td>
<td>2.0±0.3</td>
<td>2.0±0.3</td>
<td>2.1±0.2</td>
<td>0.61</td>
</tr>
<tr>
<td><strong>NCC (mm, Mean ±SD)</strong></td>
<td>6.3±1.2</td>
<td>6.3±1.2</td>
<td>6.3±1.2</td>
<td>0.93</td>
</tr>
<tr>
<td><strong>Pulmonary hypertension</strong>*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>40 (56)</td>
<td>28 (61)</td>
<td>12 (48)</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>14 (20)</td>
<td>12 (26)</td>
<td>4 (16)</td>
<td>0.04</td>
</tr>
<tr>
<td>3</td>
<td>17(24)</td>
<td>6 (13)</td>
<td>9 (36)</td>
<td></td>
</tr>
<tr>
<td><strong>MAC</strong></td>
<td>66 (93)</td>
<td>43 (93)</td>
<td>23 (92)</td>
<td>0.74</td>
</tr>
<tr>
<td><strong>Aortic Valve Calcification</strong>*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>19 (27)</td>
<td>14(30)</td>
<td>5(20)</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>52 (73)</td>
<td>32(70)</td>
<td>20(80)</td>
<td>0.45</td>
</tr>
<tr>
<td></td>
<td>ALL N=70 (%)</td>
<td>No HDAVB N=45 (%)</td>
<td>HDAVB N=25 (%)</td>
<td>P</td>
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<tr>
<td>----------------------</td>
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</tr>
<tr>
<td>Annulus size</td>
<td>22.1±2.0</td>
<td>22.2±1.8</td>
<td>22.1±2.0</td>
<td>0.76</td>
</tr>
<tr>
<td>(mm, Mean ±SD)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Depth of valve</td>
<td>5.9±1.4</td>
<td>5.5±1.2</td>
<td>6.5±1.4</td>
<td>0.001</td>
</tr>
<tr>
<td>from the lower edge</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>of NCC (mm, Mean</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>±SD)</td>
<td></td>
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</tr>
</tbody>
</table>
Frequency of HDAVB According to Valve Depth of Implantation

- <2mm: 20%
- 2 to 6 mm: 30%
- 6 to 8 mm: 70%
- > 8 mm: 80%
Risk of TAVI Patients With or Without CRBBB in Preprocedural ECG to Develop HDAVB According to Valve Implantation Depth

- no RBBB
- < 6mm
- RBBB-<6 mm
- > 6 mm- no RBBB

% HDAVB
Time to Development of High Degree AV Block Related to CRBBB and Depth of Valve Implantation

Non-RBBB + Valve Depth < 6mm
P<0.001

RBBB + Valve Depth < 6mm

Non-RBBB + Valve Depth > 6mm

RBBB + Valve Depth > 6mm
The 3 Months of follow up

- 28 patients with permanent pacemaker, 25 patients with HDAVB and 3 patients without HDAVB.
- 10 out of 25 patients with HDAVB (40%) still had HDAVB underlying their paced rhythm, 4 of the 10 had the onset of their HDAVB during the procedure whereas 6 developed later.
- None of the three patients who had been implanted for non HDAVB indication had HDAVB underlying the paced rhythm.
Summary

✓ We looked for the predictors to develop HDAVB (not PPM), since HDAVB is an objective parameter.

✓ HDAVB complicating CoreValve TAVI occurred in 36% of patients, 60% and 96% of whom within 24 and 120 hours of TAVI, respectively.

✓ Baseline conduction abnormalities (CRBBB) and low valve implantation (>6mm) significantly predict the need of HDAVB after CoreValve TAVI.
Conclusions

- The association of deep implantation with HDAVB, in our study support recommendation and training to perform high valve implantation (<6mm).
- The very high rate of HDAVB in patients with preexisting RBBB as well as the potential complications of temporary pacing suggests that a permanent pacemaker implantation prior to the procedure or immediately after it should be seriously considered in all patients with preexisting RBBB.
Conclusions (Cont.)

✓ The high incidence rate of late (rather than immediate periprocedural) development of HDAVB is probable related to the fact that the Core Valve system continues to expand following implantation.

✓ Based on our data it is recommend that all patients should be monitored until 6 days following the procedure.