Early Results of Simultaneous Transaortic Transcatheter Aortic Valve Implantation and Total Arterial Off-Pump Coronary Artery Revascularization in High-Risk Patients

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Background: Transcatheter aortic valve implantation (TAVI) has become an alternative procedure for treating aortic stenosis (AS) in patients with advanced age and severe comorbidities. Ischemic heart disease (IHD) is present with AS in 40–50% of patients with typical angina. Considering the high operative mortality and morbidity rates in these patients, hybrid TAVI and off-pump CABG (OPCAB) have become realistic treatment options.

Methods and Results: Between August 2014 and November 2015, 12 patients were evaluated for simultaneous TAVI and OPCAB. Because of their advanced age and comorbidities these patients were not considered suitable for standard open heart surgery. PCI was also considered unsuitable, because of left anterior descending artery (LAD) proximal lesions and/or high SYNTAX score. TAVI was conducted through a median sternotomy after left internal thoracic artery (LITA) to LAD anastomosis. In 11 cases OPCAB with LITA and composite RA graft was performed using an aorta no-touch technique. Mean age at operation was 81±6.3 years. Average number of distal anastomoses was 2.6. Perivalvular leakage was mild in 3 patients, trivial in 8, and none in 1. There was no conversion to on-pump procedure and no hospital deaths.

Conclusions: Simultaneous transaortic TAVI and OPCAB in high-risk patients with severe AS and IHD is a reasonable option. This method could be an alternative to surgical aortic valve replacement and CABG. (Circ J 2016; 80: 1946–1950)

Key Words: Coronary artery bypass; Heart disease; Surgery; Valves
With severe AS and IHD.

Methods

Between August 2014 and November 2015, 115 patients underwent TAVI procedures, comprising 65 TF approach, 33 TA approach and 17 transaortic approach. Of these, 12 patients were evaluated for simultaneous TAVI and OPCAB. These patients were not suitable for standard open heart surgery because of their advanced age and comorbidities. The transfemoral approach was not appropriate because of the presence of peripheral artery disease or abdominal aortic aneurysms.

Table. Demographic Data of the Study Patients Undergoing Transaortic TAVI and OPCAB and Summary of Operative Results

<table>
<thead>
<tr>
<th>Case no.</th>
<th>Sex</th>
<th>Age (years)</th>
<th>BW (kg)</th>
<th>BSA</th>
<th>AVA (cm²)</th>
<th>Comorbidities</th>
<th>STS score</th>
<th>SYNTAX Score</th>
<th>Device</th>
<th>Size</th>
<th>CABG procedure</th>
<th>Op-time (min)</th>
<th>Complications</th>
<th>Postprocedural echo/Doppler Mean PG (mmHg)</th>
<th>PVL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>M</td>
<td>65</td>
<td>44.0</td>
<td>1.40</td>
<td>0.81</td>
<td>Scleroderma, COPD, steroid user, PAD</td>
<td>6.5</td>
<td>21</td>
<td>Sapien XT</td>
<td>26</td>
<td>OPCAB ×3 (LITA-LAD, LITA-RA-Dx-PL)</td>
<td>510</td>
<td>Re-exploration for bleeding</td>
<td>8</td>
<td>Trivial</td>
</tr>
<tr>
<td>2</td>
<td>F</td>
<td>84</td>
<td>46.0</td>
<td>1.40</td>
<td>0.48</td>
<td>Frailty</td>
<td>5.1</td>
<td>16</td>
<td>Sapien XT</td>
<td>23</td>
<td>OPCAB ×2 (LITA-LAD, LITA-RA-PDA)</td>
<td>266</td>
<td>None</td>
<td>9</td>
<td>Trivial</td>
</tr>
<tr>
<td>3</td>
<td>F</td>
<td>90</td>
<td>31.0</td>
<td>1.09</td>
<td>0.54</td>
<td>Frailty</td>
<td>5.1</td>
<td>22</td>
<td>Sapien XT</td>
<td>23</td>
<td>OPCAB ×3 (LITA-LAD, LITA-RA-Dx-HL)</td>
<td>280</td>
<td>None</td>
<td>13</td>
<td>Trivial</td>
</tr>
<tr>
<td>4</td>
<td>F</td>
<td>80</td>
<td>44.8</td>
<td>1.36</td>
<td>0.43</td>
<td>Severe aortic root calcification</td>
<td>4.2</td>
<td>25</td>
<td>Sapien XT</td>
<td>23</td>
<td>OPCAB ×2 (LITA-LAD, LITA-RA-PDA)</td>
<td>257</td>
<td>None</td>
<td>5</td>
<td>Trivial</td>
</tr>
<tr>
<td>5</td>
<td>F</td>
<td>81</td>
<td>40.7</td>
<td>1.30</td>
<td>0.81</td>
<td>Frailty, chronic hepatitis</td>
<td>5.3</td>
<td>25</td>
<td>Sapien XT</td>
<td>23</td>
<td>OPCAB ×3 (LITA-LAD, LITA-RA-Dx-PL)</td>
<td>251</td>
<td>None</td>
<td>10</td>
<td>Mild</td>
</tr>
<tr>
<td>6</td>
<td>M</td>
<td>79</td>
<td>52.0</td>
<td>1.53</td>
<td>0.70</td>
<td>CRF, poor LV function, DM, insulin user</td>
<td>10.0</td>
<td>30</td>
<td>Sapien XT</td>
<td>26</td>
<td>OPCAB ×3 (LITA-LAD, LITA-RA-Dx-PDA)</td>
<td>361</td>
<td>None</td>
<td>6</td>
<td>Trivial</td>
</tr>
<tr>
<td>7</td>
<td>M</td>
<td>84</td>
<td>52.5</td>
<td>1.57</td>
<td>0.55</td>
<td>Frailty</td>
<td>5.8</td>
<td>16</td>
<td>Core-Valve</td>
<td>29</td>
<td>OPCAB ×3 (LITA-LAD, LITA-RA-PL-PDA)</td>
<td>271</td>
<td>None</td>
<td>3</td>
<td>Mild</td>
</tr>
<tr>
<td>8</td>
<td>F</td>
<td>81</td>
<td>47.0</td>
<td>1.39</td>
<td>0.69</td>
<td>Severe aortic root calcification</td>
<td>6.2</td>
<td>31</td>
<td>Core-Valve</td>
<td>26</td>
<td>OPCAB ×3 (LITA-LAD, LITA-RA-PL-PDA)</td>
<td>265</td>
<td>None</td>
<td>8</td>
<td>Trivial</td>
</tr>
<tr>
<td>9</td>
<td>M</td>
<td>83</td>
<td>72.8</td>
<td>1.81</td>
<td>0.71</td>
<td>Frailty</td>
<td>2.9</td>
<td>12</td>
<td>Sapien XT</td>
<td>26</td>
<td>OPCAB ×3 (LITA-LAD, LITA-RA-PDA)</td>
<td>239</td>
<td>None</td>
<td>10</td>
<td>None</td>
</tr>
<tr>
<td>10</td>
<td>F</td>
<td>88</td>
<td>50.0</td>
<td>1.45</td>
<td>0.66</td>
<td>Frailty</td>
<td>9.8</td>
<td>27</td>
<td>Sapien XT</td>
<td>23</td>
<td>OPCAB ×1 (LITA-LAD)</td>
<td>237</td>
<td>None</td>
<td>11</td>
<td>Trivial</td>
</tr>
<tr>
<td>11</td>
<td>F</td>
<td>80</td>
<td>81.1</td>
<td>1.80</td>
<td>0.74</td>
<td>Frailty, severe obesity</td>
<td>4.1</td>
<td>19</td>
<td>Sapien XT</td>
<td>23</td>
<td>OPCAB ×3 (LITA-LAD, LITA-RA-Dx-PL)</td>
<td>263</td>
<td>Functional MR</td>
<td>9</td>
<td>Trivial</td>
</tr>
<tr>
<td>12</td>
<td>F</td>
<td>76</td>
<td>50.8</td>
<td>1.41</td>
<td>0.46</td>
<td>Frailty, PAD, CRF</td>
<td>8.6</td>
<td>25</td>
<td>Sapien XT</td>
<td>26</td>
<td>OPCAB ×2 (LITA-LAD, LITA-RA-Dx)</td>
<td>313</td>
<td>Sealed rupture</td>
<td>11</td>
<td>Mild</td>
</tr>
</tbody>
</table>

AVA, aortic valve area; BSA, body surface area; BW, body weight; CABG, coronary artery bypass grafting; CRF, chronic renal failure; COPD, chronic obstructive pulmonary disease; Dx, diagonal branch; HL, high lateral branch; LAD, left anterior descending artery; LITA, left internal thoracic artery; LV, left ventricular; MR, mitral regurgitation; OPCAB, off-pump coronary artery bypass grafting; PAD, peripheral artery disease; PDA, posterior descending artery; PL, posterolateral branch; RA, radial artery; TAVI, transcatheter aortic valve implantation.
under rapid ventricular pacing (Figure 1). CoreValve implantation was performed over a super-stiff guidewire under ventricular pacing to maintain systolic blood pressure between 80 and 90 mmHg. After valve insertion the peak-to-peak transvalvular pressure gradient immediately dropped to less than 10 mmHg with trivial or mild aortic regurgitation.

Finally, the radial artery was anastomosed to the diagonal, circumflex, and right coronary branches in a consecutive fashion (Figure 1). An apical suction device (Starfish, Medtronic) was used to elevate the left ventricular apex, and the anastomosis sites were immobilized with a stabilizer. Side-to-side anastomosis was performed in a diamond shape. In patients without chronic kidney disease, intraoperative angiography of the LITA was performed to evaluate graft patency (Figure 2). This OPCAB technique has been reported previously.7

Results

Mean age at operation was 81±6.3 years. Mean STS score was 6.1±2.2 (Table). The Sapien XT was used in 10 cases, and the CoreValve in 2. Average number of distal anastomoses was 2.6. There was no conversion to on-pump procedure and no hospital deaths. All patients were extubated soon after the procedure and mobilized on postoperative day 1. All patients were discharged from the hospital 7 days after TAVI without any complications. Transthoracic echo/Doppler study showed a mean transvalvular pressure gradient of 8.7±2.9 mmHg. Perivalvular leakage was mild in 3 patients, trivial in 8, and none in 1. There was 1 case of suspected sealed rupture on
transesophageal echocardiography after TAVI implantation, and 1 case of re-exploration for bleeding. Severe mitral regurgitation occurred in 1 patient during the procedure, probably because of papillary muscle trapping with the super-stiff guide wire.

**Discussion**

Surgical AVR is the conventional treatment for AS, but recently, TAVI has emerged as a less invasive alternative therapy for patients with extremely high age, poor left ventricular function, and other comorbidities. In high-risk patients with AS and complex IHD, TAVI and coronary revascularization are feasible. Transfemoral TAVI and PCI is the least invasive method for these patients. However, the safety of TAVI irrespective of the extent and anatomy of IHD is still controversial, and Masson and associates reported that the 30-day mortality in patients with IHD (11.5%) was higher than that in patients without IHD (6.5%).

Elective PCI can be performed safely in patients with severe AS. Goel and associates compared the early mortality of PCI in patients with and without severe AS by propensity matching. Patients with severe AS and a low ejection fraction (<30%) had a higher mortality rate than patients with an ejection fraction >30% (5.4% vs. 1.2%, P=0.001). Early death of patients with STS score >10 was significantly more frequent than in patients with STS score <10 (10.4% vs. 0%, P=0.001). Thus neither TAVI before PCI nor PCI before TAVI is appropriate for high-risk patients. On the other hand, the SYNTAX trial for multivessel disease demonstrated that CABG had better long-term results than PCI in patients with complicated IHD. In patients with AS and complex 3-vessel IHD and high SYNTAX score (>22), with or without involvement of the proximal LAD lesion, late cardiac events and death increased in the PCI group compared with CABG.

OPCAB has become an established method of CABG, and the advantages over standard CABG with cardiopulmonary bypass have been reported in many retrospective studies. Previously, we reported similar clinical results for OPCAB and on-pump CABG in a randomized clinical trial. In Japan, OPCAB was performed in >60% of patients in 2012, and the operative mortality rate of OPCAB was lower than that for standard CABG. In addition, in high-risk patients the mortality rate for OPCAB is much lower than that for conventional CABG. Patients with comorbidities for cardiopulmonary bypass are also an indication of TAVI. Therefore performing TAVI and OPCAB simultaneously is reasonable.

MIDCAB at the same time as transapical TAVI has already been reported. In those reports only LITA to LAD anastomosis was performed before the transapical TAVI procedure. Although this operation is reasonable if patients have simple IHD and there are difficulties with the iliofemoral approach because of peripheral artery disease; abdominal aortic aneurysm, arterial tortuosity, and excessive atherosclerotic disease are also frequently associated with complex IHD in patients who need multiple CABG procedures.

Neurological damage is one of the most ominous complications after open heart surgery. Stroke is thought to be caused by embolism of atheromatous plaque during manipulation of the diseased aorta or jet flow to the atheroma during surgery. In the PARTNER trial, transapical TAVI showed a 2.3-fold higher incidence of neurological events post-procedure. The higher stroke rate in the transapical cohort of the PARTNER trial may be caused by patient-related and disease-related factors rather than an intrinsic feature of the procedure. The transapical approach is commonly used in patients with atherosclerotic peripheral artery disease and/or aortic aneurysm, which are both risk factors for neurological complications in open heart surgery. Another cause of this higher neurological event rate may be related to a very stiff guide wire used to cross the aortic arch during ballooning and launching.

The transapical approach became an option for patients contraindicated for transmembral access of both self-expandable devices, and balloon-expandable devices. This approach is very familiar to cardiac surgeons and the proximity to the aortic valve under direct aortic access probably provides improved catheter control during implantation. Simultaneous OPCAB with transaportic TAVI has been introduced for patients with comorbidities that require avoiding cardiopulmonary bypass. There are several advantages of this procedure compared with staged or simultaneous PCI and TAVI. In patients with chronic kidney disease the amount of contrast medium is conserved by avoiding simultaneous PCI. There is also no concern about late restenosis of PCI sites. Crossing with a stiff wire and large delivery system over the aortic arch can also be avoided. The risk of acute coronary ostial obstruction is low, and rapid pacing could be better tolerated after the LAD is revascularized with the LITA. However, the number of reported cases is small, and the operative mortality rate for this kind of procedure was reported to be as high as 15.7% (6/38) in Germany in 2013. Although the number of patients is still limited, in the present study there were no hospital deaths. In the near future, hybrid OPCAB and TAVI may be a more realistic option considering the lower rates of operative mortality and morbidity. Transapotic access TAVI after epicardiac echocardiographic evaluation of the ascending aorta and simultaneous OPCAB with an aorta no-touch technique under median sternotomy also has the advantage of avoiding the possibility of dislodging atherosclerotic plaque while passing the through the aorta.

In conclusion, simultaneous transapical TAVI and total arterial OPCAB is a reasonable option for high-risk patients.

**References**


