Surgical Treatment of Annulo-aortic Ectasia

YASUMASA HIROOKA, M.D., MAKOTO SUNAMORI, M.D.
ATUSI TANAKA, M.D., AND AKIO SUZUKI, M.D.

Surgical interventions for annulo-aortic ectasia were analyzed and the following conclusions were obtained: 1) In the treatment of annulo-aortic ectasia, Bentall operation is not always the first choice, and satisfactory result can be achieved by either aortic valve replacement (AVR) plus tube graft replacement or AVR plus aneurysmorrhaphy. 2) Bentall operation is indicated to the cases with a) Marfan syndrome, b) aneurysm with thin wall and c) aortic regurgitation from dissection. 3) In the technique using composite graft, wrapping with aneurysmal wall is not always necessary and sinus-shaped composite graft is an advantage to prosthetic valve motion, reducing tension around the coronary artery anastomosis. 4) Aorto-coronary bypass should be combined with Bentall operation in the cases with coronary ostium involved by dissection and displaced coronary ostium.

Many surgical interventions have been attempted to annulo-aortic ectasia in the last 15 years. 

Recently Bentall operation have been accepted as a standard operation for this disease, however some disagreement remained in the particular issue whether or not Bentall operation is the most suitable technique for all of the cases of annulo-aortic ectasia.

We revealed 4 cases underwent aortic valve replacement (AVR) plus aneurysmorrhaphy and 4 cases of modified Bentall operation in these technical aspects.

MATERIALS AND METHODS

There were 5 cases which underwent AVR plus aneurysmorrhaphy and 4 cases treated by modified Bentall operation from Feb 1976 to Apr 1980.

Key Words:
Marfan syndrome
Annulo aortic ectasia
Modified Bentall operation
Aneurysmorrhaphy
Sinus shaped composite graft

The 7 men and 2 women ranged in age from 21 to 55 years (mean 34.2 years).

Four patients had clinical features of Marfan syndrome and one patient had been diagnosed as aortitis syndrome. As the associated anomalies, 2 patients had funnel chest and one patient had tetralogy of Fallot.

In patients who treated by aneurysmorrhaphy, 3 patients were in NYHA class II, one patient in class III, and the remaining patient in class IV while patients of modified Bentall group were all in class III.

The chest X-ray showed 54.8% of cardio-thoracic ratio on the average in aneurysmorrhaphy group and 64.3% in modified Bentall group. The aortography revealed aortic regurgitation: one case with Seller's 2nd degree and 4 cases with 3rd degree in aneurysmorrhaphy group, while 3 cases with 3rd degree and one case with 4th degree in modified Bentall group.

Mean left ventricular end-diastolic pressure and cardiac index were 11.8 mmHg and 3.3 L/min/m² in aneurysmorrhaphy group and 17 mmHg and 3.1 L/min/m² in the modified Bentall group respectively.

Follow up data on the 9 patients were ob-
### TABLE I: CLINICAL SUMMARY OF 9 CASES OF ANNULO-AORTIC ECTASIA

<table>
<thead>
<tr>
<th>Case</th>
<th>Sex</th>
<th>Age</th>
<th>Cause</th>
<th>Associated Anomaly</th>
<th>Duration of Symptoms</th>
<th>CTR (%)</th>
<th>ECG</th>
<th>NYHA</th>
<th>Catheterization &amp; Angiogram</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>AR (Sellers)</td>
</tr>
<tr>
<td>1</td>
<td>M</td>
<td>21</td>
<td>Marfan</td>
<td>Funnel chest.</td>
<td>1 (yr.)</td>
<td>50</td>
<td></td>
<td>IIIo</td>
<td>IIIo</td>
</tr>
<tr>
<td>2</td>
<td>M</td>
<td>25</td>
<td>Aortitis Hypert.</td>
<td>(-)</td>
<td>2</td>
<td>55</td>
<td>LVH</td>
<td>IIo</td>
<td>IIo</td>
</tr>
<tr>
<td>3</td>
<td>M</td>
<td>36</td>
<td>Hypert. ICMN</td>
<td>(-)</td>
<td>5</td>
<td>57</td>
<td>LVH</td>
<td>IIo</td>
<td>IIIo</td>
</tr>
<tr>
<td>4</td>
<td>M</td>
<td>55</td>
<td>Hypert. ICMN</td>
<td>(-)</td>
<td>10</td>
<td>54</td>
<td>LVH</td>
<td>IIo</td>
<td>IIIo</td>
</tr>
<tr>
<td>5</td>
<td>M</td>
<td>28</td>
<td>Marfan</td>
<td>Tetralogy of Fallot</td>
<td>28</td>
<td>58</td>
<td>LVH RVH</td>
<td>IVo</td>
<td>IIIo</td>
</tr>
<tr>
<td>6</td>
<td>F</td>
<td>43</td>
<td>ICMN</td>
<td>(-)</td>
<td>12</td>
<td>75</td>
<td>LVH VPC</td>
<td>IIIo</td>
<td>IIIo</td>
</tr>
<tr>
<td>7</td>
<td>M</td>
<td>34</td>
<td>Hypert. ICMN</td>
<td>(-)</td>
<td>1</td>
<td>69</td>
<td>LVH</td>
<td>IIIo</td>
<td>IIIo</td>
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<tr>
<td>8</td>
<td>F</td>
<td>35</td>
<td>Marfan</td>
<td>(-)</td>
<td>2</td>
<td>54</td>
<td>LVH</td>
<td>IIIo</td>
<td>IIIo</td>
</tr>
<tr>
<td>9</td>
<td>M</td>
<td>31</td>
<td>Marfan</td>
<td>Funnel chest.</td>
<td>3</td>
<td>59</td>
<td>LVH</td>
<td>IIIo</td>
<td>IVo</td>
</tr>
</tbody>
</table>

ICMN = idiopathic cystic medionecrosis

### TABLE II: OPERATIVE FINDINGS & PROCEDURES

<table>
<thead>
<tr>
<th>Case</th>
<th>Aneurysm Size (mm)</th>
<th>Dissection</th>
<th>Operation</th>
<th>Procedure</th>
<th>Result</th>
<th>Pathologic Findings</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Valve</td>
<td>Procedure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>85 × 160</td>
<td>(-)</td>
<td>B.S. 31A</td>
<td>AVR</td>
<td>Alive 4yr. NYHA I</td>
<td>CMN</td>
</tr>
<tr>
<td>2</td>
<td>55 × 70</td>
<td>(-)</td>
<td>29A</td>
<td>AVR</td>
<td>Alive 1.5yr. NYHA I</td>
<td>Aortitis</td>
</tr>
<tr>
<td>3</td>
<td>52 × 70</td>
<td>(-)</td>
<td>29A</td>
<td>AVR</td>
<td>Alive 1yr. NYHA I</td>
<td>CMN</td>
</tr>
<tr>
<td>4</td>
<td>55 × 60</td>
<td>(-)</td>
<td>27A</td>
<td>AVR</td>
<td>Alive 3yr. NYHA I</td>
<td>CMN</td>
</tr>
<tr>
<td>5</td>
<td>53 × 70</td>
<td>(-)</td>
<td>27A</td>
<td>AVR</td>
<td>Alive 1.8yr. NYHA I</td>
<td>CMN</td>
</tr>
<tr>
<td>6</td>
<td>75 × 75</td>
<td>(-)</td>
<td>27A</td>
<td>Modified Bentall AC-Bypass</td>
<td>Alive 2yr. NYHA I</td>
<td>CMN</td>
</tr>
<tr>
<td>7</td>
<td>90 × 80</td>
<td>(-)</td>
<td>29A</td>
<td>Modified Bentall</td>
<td>Alive 11mo. NYHA I</td>
<td>CMN</td>
</tr>
<tr>
<td>8</td>
<td>73 × 113</td>
<td>(+) DeBakey I</td>
<td>29A</td>
<td>Modified Bentall</td>
<td>Alive 8mo. NYHA I</td>
<td>CMN</td>
</tr>
<tr>
<td>9</td>
<td>97 × 83</td>
<td>(+) DeBakey I</td>
<td>29A</td>
<td>Modified Bentall Repair of funnel chest</td>
<td>Alive 1.2yr. NYHA I</td>
<td>CMN</td>
</tr>
</tbody>
</table>

CMN = cystic medionecrosis

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TABLE III MYOCARDIAL PROTECTION

<table>
<thead>
<tr>
<th>Case</th>
<th>Technique</th>
<th>Aortic Cross Clamp Time (min)</th>
<th>CPB Time (min)</th>
<th>CPB Support After Declamp (min)</th>
<th>Defibrillation (15ms)</th>
<th>Inotropic Support</th>
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<tbody>
<tr>
<td>1</td>
<td>TC</td>
<td>84</td>
<td>150</td>
<td>15</td>
<td>x 3</td>
<td>(+)</td>
</tr>
<tr>
<td>2</td>
<td>TC</td>
<td>90</td>
<td>178</td>
<td>35</td>
<td>x 5</td>
<td>(−)</td>
</tr>
<tr>
<td>3</td>
<td>MC2 + TC</td>
<td>73</td>
<td>114</td>
<td>20</td>
<td>x 1</td>
<td>(−)</td>
</tr>
<tr>
<td>4</td>
<td>TC</td>
<td>60</td>
<td>108</td>
<td>23</td>
<td>x 1</td>
<td>(−)</td>
</tr>
<tr>
<td>5</td>
<td>MC4 + TC</td>
<td>98</td>
<td>200</td>
<td>46</td>
<td>x 1</td>
<td>(+)</td>
</tr>
<tr>
<td>6</td>
<td>MC4 + TC</td>
<td>170</td>
<td>258</td>
<td>33</td>
<td>x 2</td>
<td>(+)</td>
</tr>
<tr>
<td>7</td>
<td>MC3 + TC</td>
<td>186</td>
<td>290</td>
<td>44</td>
<td>x 3</td>
<td>(+)</td>
</tr>
<tr>
<td>8</td>
<td>MC4 + TC</td>
<td>166</td>
<td>227</td>
<td>44</td>
<td>x 1</td>
<td>(+)</td>
</tr>
<tr>
<td>9</td>
<td>MC3 + TC</td>
<td>132</td>
<td>182</td>
<td>30</td>
<td>x 3</td>
<td>(+)</td>
</tr>
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</table>

TC = topical cooling
MC = multiple cardioplegia (GIK solution)
CPB = cardiopulmonary bypass

AVR + ANEURYSMORRHAPHY
TOTAL CORRECTION OF TOF
CASE J.I. 28yrs. M

(A)

![Preoperative aortogram (Case 5).](image)

(B)

![Postoperative aortogram, 1yr.](image)

Fig.1. (A) Preoperative aortogram (Case 5). Annulo aortic ectasia with Marfan syndrome and tetralogy of Fallot. Ascending aortic aneurysm, aortic regurgitation and infundibular pulmonary stenosis (arrows) are shown.

(B) The one year postoperative aortogram showing neither recurrence of aneurysm nor any other complications.

RESULTS

Operative Findings and Technique

The mean aneurysmal size was 60 x 86 mm in the aneurysmorrhaphy group and 86 x 87.8 mm in the modified Bentall group.

Two cases which underwent modified Bentall operation were associated with aortic dissection of DeBakey I type. The repair of funnel chest was performed in 2 cases of Marfan syndrome.

Total correction by AVR plus aneurysmorrhaphy was performed in one case of tetralogy of Fallot and aorto-coronary saphenous vein grafting combined with Bentall operation was done in one case (Table II).

Intra-operative Myocardial Protection

In the aneurysmorrhaphy group, 3 patients underwent topical cooling with systemic hypothermia, and 2 patients combined technique of topical cooling and multiple cardioplegia (GIK solution). In the Bentall group, all patients underwent combined technique.
Consequently, the duration of aortic cross clamp time, cardiopulmonary bypass time and assist perfusion time after removal of aortic cross clamp were longer in the modified Bentall group.

The cases that underwent modified Bentall operation had required more intensive postoperative care than the aneurysmorrhaphy group (Table III).

**Follow Up**

All of the patients have been survived for 2.2 years on the average in the aneurysmorrhaphy group and 1.2 years on the average in the modified Bentall group postoperatively. The one-year postoperative angiogram of the patients who underwent AVR plus aneurysmorrhaphy and total correction of tetralogy of Fallot presented...
TABLE V  POST OPERATIVE EARLY COMPLICATION IN SELECTED SERIES (COMPOS,
ITE GRAFT TECHNIQUE)

<table>
<thead>
<tr>
<th>Series</th>
<th>Year</th>
<th>No of Cases</th>
<th>% Marfan Syndrome</th>
<th>Operative Mortality</th>
<th>Hemorrhage Requiring Re-OP</th>
<th>AMI (%)</th>
<th>LOS (%)</th>
<th>Arrhythmia</th>
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<tbody>
<tr>
<td>1. Edward</td>
<td>1970</td>
<td>3</td>
<td>0</td>
<td>33.3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>2. Kouchoukos</td>
<td>1977</td>
<td>25</td>
<td>20</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>20</td>
<td>0</td>
</tr>
<tr>
<td>3. Bentall</td>
<td>1978</td>
<td>23</td>
<td>90</td>
<td>17.3</td>
<td>4</td>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>4. Mayer</td>
<td>1978</td>
<td>16</td>
<td>38</td>
<td>6.2</td>
<td>6</td>
<td>6.2</td>
<td>0</td>
<td>6.2</td>
</tr>
<tr>
<td>5. McCreadly</td>
<td>1979</td>
<td>15</td>
<td>13</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>304</td>
<td>7</td>
</tr>
<tr>
<td>6. Bedderman</td>
<td>1980</td>
<td>6</td>
<td>14.2</td>
<td>16.6</td>
<td>16.6</td>
<td>16.6</td>
<td>30</td>
<td>85.7</td>
</tr>
<tr>
<td>7. Helseth</td>
<td>1980</td>
<td>41</td>
<td>21.4</td>
<td>2.4</td>
<td>0</td>
<td>0</td>
<td>2.4</td>
<td>0</td>
</tr>
<tr>
<td>9. Koizumi</td>
<td>1977</td>
<td>7</td>
<td>28.5</td>
<td>14.2</td>
<td>42.8</td>
<td>28.5</td>
<td>85.7</td>
<td>85.7</td>
</tr>
<tr>
<td>10. Kazui</td>
<td>1979</td>
<td>5</td>
<td>100</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>11. Hashimoto</td>
<td>1980</td>
<td>42</td>
<td>52.3</td>
<td>9.5</td>
<td>9.5</td>
<td>9.5</td>
<td>4.7</td>
<td>4.7</td>
</tr>
</tbody>
</table>

**Total**

| Mean | 187 | 43.8 | 14.1 | 10.9 | —   | 10.3 | —   |

AMI = acute myocardial infarction
LOS = low output syndrome

TABLE VI  LATE COMPLICATION: AVR PLUS ASCENDING AORTIC TUBE GRAFT REPLACEMENT AND AVR PLUS ANEURYSMORRHAPHY

<table>
<thead>
<tr>
<th>Series</th>
<th>Mean Follow Up Month</th>
<th>No of Case</th>
<th>Mortality</th>
<th>Recurrent Aneurysm Formation</th>
<th>Aortic Valvular Leak</th>
<th>Distal Aneurysm</th>
<th>Dissection</th>
<th>Myocardial Infarction</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Groves</td>
<td>6</td>
<td>4</td>
<td>3</td>
<td>50</td>
<td>0</td>
<td>30</td>
<td>25</td>
<td>0</td>
</tr>
<tr>
<td>2. Ferlic</td>
<td>—</td>
<td>—</td>
<td>3</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3. Liddicoat</td>
<td>—</td>
<td>—</td>
<td>63</td>
<td>32</td>
<td>—</td>
<td>0</td>
<td>1.6</td>
<td>3.2</td>
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<tr>
<td>4. Nasrallah</td>
<td>—</td>
<td>—</td>
<td>42</td>
<td>—</td>
<td>33.3</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>5. McCready</td>
<td>54</td>
<td>52</td>
<td>65</td>
<td>32</td>
<td>24</td>
<td>8</td>
<td>14</td>
<td>0</td>
</tr>
<tr>
<td>6. Miller</td>
<td>—</td>
<td>90</td>
<td>4</td>
<td>8</td>
<td>24</td>
<td>5</td>
<td>11</td>
<td>0</td>
</tr>
<tr>
<td>7. Akins</td>
<td>—</td>
<td>5</td>
<td>23</td>
<td>4.3</td>
<td>1.7</td>
<td>0</td>
<td>2.8</td>
<td>0</td>
</tr>
</tbody>
</table>

**Total**

| Mean   | 39.8 | 43 271 | 20.5 | 17 | 8.8 | 12.5 | 1.36 | 0.54 | 4.2 | 12.5 | 6.1 |

neither recurrence of aneurysm nor complication (Fig. 1).

**DISCUSSION**

**Early and Late Complication of Bentall Operation**

Bentall operation has been thought to be an optimal operation for this disease, because there is less recurrence of aortic root aneurysm by enblock replacement of the composite graft and it is easy to control the intraoperative hemorrhage from the graft or the anastomosis site by wrapping with aneurysmal wall7–36.

However, the complications of Bentall operation have been reported in recent years (Fig. 2)12,23,26,34.

We attempted to compare the early and late complications between AVR plus aneurysmorrhaphy and modified Bentall operation.

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Table VII Late Complication in Selected Series (Composite Graft Technique)

<table>
<thead>
<tr>
<th>Series</th>
<th>No. of Cases</th>
<th>Mean Follow Up Month</th>
<th>Mortality</th>
<th>Coronary pseudoaneurysm, Leak</th>
<th>Compression of tube graft</th>
<th>Distal Embolization</th>
<th>SBE Myocardial Infarction</th>
<th>Diastolic Aneurysm</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Bentall</td>
<td>23</td>
<td>78</td>
<td>26.3</td>
<td>4</td>
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<td>2. Konstand</td>
<td>25</td>
<td>77</td>
<td>12</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3. Housner</td>
<td>26</td>
<td>79</td>
<td>14</td>
<td>7</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>4. McCready</td>
<td>16</td>
<td>77</td>
<td>12.5</td>
<td>7</td>
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<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>5. McCardle</td>
<td>26</td>
<td>79</td>
<td>12.5</td>
<td>7</td>
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<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>6. Hekmat</td>
<td>41</td>
<td>77</td>
<td>4.8</td>
<td>7.1</td>
<td>0</td>
<td>0</td>
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<td>0</td>
</tr>
<tr>
<td>7. Haldimann</td>
<td>42</td>
<td>77</td>
<td>9.5</td>
<td>7.1</td>
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<tr>
<td>Mean</td>
<td>36.1</td>
<td>175</td>
<td>6.4</td>
<td>7.1</td>
<td>0</td>
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</tbody>
</table>

AVR + Aneurysmorrhaphy

(A) Teflon felt. Teflon mesh wrapping.

(B) Spindle shape resection of aneurysmal wall.

Groves (1964)

Fig. 3. This figure depicts the operative technique of AVR + aneurysmorrhaphy.
(A) This drawing indicates the technique in our institute: spindle shape resection of aneurysmal wall, closing of aortic wall using Teflon felt strips and Teflon mesh wrapping.
(B) This figure depicts Grove's technique. Multiple tuck can be taken in the sinus Valsalva area.

In our experience, the AVR plus aneurysmorrhaphy technique brings satisfactory results if we select the appropriate case, because this operation is simple in method, shorter in operating time and less complicated than modified Bentall operation in our institute.

We selected modified Bentall operation for the cases of big and spherical aneurysm with thin wall.

Regarding the quality of various operative methods of annulo aortic ectasia, we failed to make proper evaluation, since each institute has neither enough numbers of patients nor sufficient long-term follow up information for statistical analysis.

We collected the available English and Japanese literatures on the surgical treatment of annulo-aortic ectasia and mainly analyzed and reviewed the complications.
COMPOSITE GRAFT  
(Proximal Anastomosis)

(A) Mattress suture in the annular anastomosis.  
(B) Suturing the prosthetic valve 3 mm inner the proximal graft edge.  
(C) Partial covering the proximal anastomotic site with aneurysmal wall.

On the early complication of AVR plus tube graft technique, Marfan syndrome observed in 36.4% and mean hemorrhage and incidence of low output syndrome (LOS) are revealed in 11.4% and 13.7% respectively 3,4,15,16,20,23,24 (Table IV).

On the early complication of Bentall operation, Marfan syndrome is observed in 43.8%, mean operative mortality in 12.9%, mean hemorrhage rate in 10.9% and LOS in 10.3% 7,8,10,11,14, 23,26,29,32,33,36 (Table V).

On the review of the late complications of AVR plus tube graft replacement and AVR plus aneurysmorrhaphy, 43 aneurysmorrhaphy cases and 271 tube graft cases are reported 5,15,19, 20,23,27 The mean follow up term is 39.8 months, and the mortality rate is 20.5% in the former case and 17% in the latter case. The recurrence rate of aneurysm is 4% in the former case and 8.8% in the latter case, and distal aneurysm formation is reported 1.54% in the latter case (Table VI).

On the review of the late complication of Bentall operation, mean follow up term is 36.1 months, mortality rate 14.6%, aneurysm on the coronary anastomosis site 6.4%, graft compression 2.2% and aneurysm formation distal to graft 6.1% 9,11,14,23,26–29,32–36 (Table VII).

In the comparison of the late complication between AVR plus aneurysmorrhaphy and Bentall operation, no significant difference is

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Fig. 6. (A) Technique of buttressing coronary ostium suture line with Teflon felt.
(B) Reinplantation of the coronary artery to the composite graft as a Currel's patch.

Fig. 7. Postoperative aortogram showing reinplantation of left coronary ostia into a composite graft and right coronary bypass grafting.

seen in the mortality rate.

We would like to emphasize the fact that the occurrence of pseudo-aneurysm formation at the site of coronary anastomosis in the Bentall operation is nearly equal to the recurrence of aneurysm in the AVR plus aneurysmorrhaphy.

From these results, we think that Bentall operation is undoubtedly excellent one, however it is not radical operation for the potential degeneration of coronary artery and distal aorta.

For the early postoperative course, the intraoperative hemorrhage and LOS are not rare in the Bentall operation. Therefore, we suggest that the case should be selected carefully and the attempt should be made to decrease the incidence of complication.

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TECHNICAL CONSIDERATION

AVR plus Aneurysmorrhaphy

Figure 3-A shows the operative technique of AVR plus aneurysmorrhaphy in our institute. The aneurysmal wall was resected in a spindle shape and the aortic valve was removed, then the prosthetic valve was replaced. After the reinforcement stitches was placed with Teflon felt, the Teflon mesh wrapping was added.

Figure 3-B shows other technique, added a tack to the dilated sinus Valsalva.

Modified Bentall Operation

Proximal anastomosis of composite graft

On our first case, we placed mattress sutures in the annular anastomosis using # 2-0 prolene with Teflon felt pledget, but massive hemorrhage were seen from the suture line. After that we have used a new type of composite graft in which the prosthetic valve was sutured 3 mm inner the proximal graft edge and the skirt-like remnant part of the graft was used for reinforcement sutures.

In the recent cases, the proximal anastomotic site was partially covered with the aneurysm wall for the prevention of suture line hemorrhage (Fig. 4).

Distal anastomosis of composite graft

When the patients has dissecting change, it may be preferred that the dissecting space is closed with # 3-0 prolene interrupted suture utilizing Teflon pledget and the distal edge of composite graft is sewn to the aortic wall with # 3-0 prolene mattress suture with Teflon felt strip technique.

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When the patients has not dissecting change, the composite graft may be anastomosed to the aorta with # 3-0 prolene continuously and reinforced with Teflon felt strip technique (Fig. 5).

Coronary anastomosis of composite graft

We have performed various individual technical modifications to revascularize the coronary arteries. One of these techniques is resemble to the original of Bentall operation, however, we experienced complication that the coronary anastomosis was compressed by pericraft hema-
toma following aneurysmal wall wrapping. Therefore the coronary ostium has been detached with cuff of aorta 2 cm in diameter and then reimplanted to the compositied graft as Currel patch (Fig. 6).

When the coronary ostia is markedly displaced or it is involved with dissection and when the aortic wall of surrounding coronary artery is very fragile, the concomitant saphenous vein grafting is very useful (Fig. 7).

Sinus shape composite graft

The composite graft was hand-made by two different sized tube grafts that the proximal site exceed the prosthetic valve rim by 4—5 mm, and the distal graft diameter adapts just to the distal non-aneurysmal aorta.

The use of sinus shape composite graft makes the insertion of coronary artery to the graft safer and free from tension, being an advantage to the prosthetic valve motion^25 (Fig. 8).

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