Reconstruction of Mitral Valve with Regurgitation due to Ruptured Chordae Tendineae of Anterior Leaflet

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The decision to treat mitral regurgitation due to ruptured chordae tendineae surgically is reached on the basis for the extent of the valvular segment that has lost chordal support, pliability of the leaflet tissue and the condition of the subvalvular apparatus. There seems to be wide agreement on the feasibility of valvuloplastic surgery for mitral regurgitation due to ruptured chordae tendineae of the posterior leaflet and our experience also shows a high rate of success of plastic repair.

On the other hand, mitral regurgitation due to rupture of the chordae tendineae attached to the anterior leaflet varies greatly in severity, and the method of surgery should be selected cautiously according to the anatomical alterations. Here we reviewed our experience with surgery on the mitral apparatus with ruptured chordae tendineae of the anterior leaflet and present our indications for reparative surgery of this lesion.

Clinical Materials

Eleven patients were treated with mitral valve surgery for ruptured chordae tendineae of the anterior leaflet. Their ages ranged from 25 to 63 years. Five were male and six female. These patients are divided into two groups according to the operative procedure.

Group I consists of five patients who had mitral valve replacement (Table 1). A

Key words: Mitral regurgitation, Ruptured chordae tendineae, Anterior Leaflet, Valvulo-and Annuloplasty, Carpentier ring.

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Table 1.

Patients with ruptured chordae tendineae of the anterior leaflet
Group I MVR as procedure of choice

<table>
<thead>
<tr>
<th>Patient</th>
<th>E.M</th>
<th>K.H</th>
<th>M.N.</th>
<th>K.T.</th>
<th>M.K</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>25</td>
<td>25</td>
<td>51</td>
<td>28</td>
<td>30</td>
</tr>
<tr>
<td>Sex</td>
<td>m</td>
<td>f</td>
<td>m</td>
<td>t</td>
<td>m</td>
</tr>
<tr>
<td>Chief Complaint</td>
<td>Easy Fatigability</td>
<td>Palpitation</td>
<td>Orthopnea</td>
<td>Palpitation</td>
<td>Dyspnea</td>
</tr>
<tr>
<td>CTR %</td>
<td>56</td>
<td>59</td>
<td>71</td>
<td>67</td>
<td>68</td>
</tr>
<tr>
<td>ECG RSR, LVH, LAH</td>
<td>AF, LVH, LAH</td>
<td>RSR, LVH, LAH</td>
<td>AF, LVH</td>
<td>RSR, LVH</td>
<td></td>
</tr>
<tr>
<td>Pp/Ps</td>
<td>40/104</td>
<td>30/110</td>
<td>67/126</td>
<td>58/96</td>
<td>42/104</td>
</tr>
<tr>
<td>PC(m) mmHg</td>
<td>14</td>
<td>15</td>
<td>32</td>
<td>26</td>
<td>22</td>
</tr>
<tr>
<td>PC(v) mmHg</td>
<td>45</td>
<td>21</td>
<td>58</td>
<td>30</td>
<td>39</td>
</tr>
<tr>
<td>C I</td>
<td>3.42</td>
<td>3.93</td>
<td>1.39</td>
<td>1.90</td>
<td>2.23</td>
</tr>
<tr>
<td>Grade of MR</td>
<td>4+</td>
<td>3+</td>
<td>Not performed</td>
<td>3+</td>
<td>4+</td>
</tr>
<tr>
<td>NYHA</td>
<td>II</td>
<td>III</td>
<td>I V</td>
<td>III</td>
<td>I I</td>
</tr>
<tr>
<td>Etiology</td>
<td>B.E</td>
<td>R.h.d</td>
<td>Ischemic d</td>
<td>R.h.d</td>
<td>R.h.d</td>
</tr>
<tr>
<td>Site of rupture</td>
<td>ParaMed Chord ant., post.</td>
<td>ParaMed Chord ant., post.</td>
<td>ParaMed Chord Main Chord</td>
<td>ParaMed Chord posterior</td>
<td></td>
</tr>
<tr>
<td>Remarks</td>
<td>S-E D (S-E B 10A)</td>
<td>S-E B 3M</td>
<td>S-E B 3M</td>
<td>L-K 22 M</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Alive</td>
<td>Alive</td>
<td>Alive</td>
<td>Alive</td>
<td></td>
</tr>
</tbody>
</table>

**S-E D:** Starr-Edwards disc valve
**S-E B:** Starr-Edwards ball valve
**L-K:** Lillehei-Kaster pivoting disc valve

Table 2.

Patients with ruptured chordae tendineae of the anterior leaflet
Group II Reparative Surgery as procedure of choice

<table>
<thead>
<tr>
<th>Patient</th>
<th>E.W</th>
<th>K.M</th>
<th>J.W</th>
<th>S.I</th>
<th>N.O</th>
<th>A.U</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>46</td>
<td>63</td>
<td>46</td>
<td>41</td>
<td>28</td>
<td>37</td>
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<tr>
<td>Sex</td>
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<td>f</td>
<td>m</td>
<td>f</td>
<td>f</td>
<td>m</td>
</tr>
<tr>
<td>Chief Complaint</td>
<td>Orthopnea</td>
<td>Orthopnea</td>
<td>Dyspnea</td>
<td>Dyspnea</td>
<td>Easy Fatigability</td>
<td></td>
</tr>
<tr>
<td>CTR %</td>
<td>67</td>
<td>66</td>
<td>59</td>
<td>56</td>
<td>50</td>
<td>54</td>
</tr>
<tr>
<td>ECG RSR, LVH</td>
<td>AF, LVH, LAH</td>
<td>AF, LVH, LAH</td>
<td>RSR, LVH, LAH</td>
<td>RSR, LVH, LAH</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pp/Ps</td>
<td>80/136</td>
<td>37/136</td>
<td>54/100</td>
<td>72/100</td>
<td>28/104</td>
<td>31/125</td>
</tr>
<tr>
<td>PC(m) mmHg</td>
<td>32</td>
<td>17</td>
<td>22</td>
<td>13</td>
<td>28</td>
<td>14</td>
</tr>
<tr>
<td>PC(v) mmHg</td>
<td>59</td>
<td>24</td>
<td>48</td>
<td>19</td>
<td>48</td>
<td>20</td>
</tr>
<tr>
<td>C I</td>
<td>2.33</td>
<td>1.60</td>
<td>4.70</td>
<td>3.00</td>
<td>4.18</td>
<td>2.92</td>
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<tr>
<td>Grade of MR</td>
<td>4+</td>
<td>4+</td>
<td>4+</td>
<td>3+</td>
<td>4+</td>
<td></td>
</tr>
<tr>
<td>NYHA</td>
<td>II</td>
<td>III</td>
<td>III</td>
<td>IV</td>
<td>II</td>
<td>II</td>
</tr>
<tr>
<td>Etiology</td>
<td>Luetic ?</td>
<td>Idiopathic</td>
<td>Idiopathic</td>
<td>Idiopathic</td>
<td>Idiopathic</td>
<td>B.E</td>
</tr>
<tr>
<td>Procedures performed</td>
<td>MVR (S-E B 3M)</td>
<td>TAP</td>
<td>MVR (S-E B 4M)</td>
<td>MVR (S-E B 3M)</td>
<td>Suture of cleft in the mural leaflet</td>
<td></td>
</tr>
<tr>
<td>Remarks</td>
<td>Sudden onset Alive</td>
<td>Died of LOS</td>
<td>Sudden onset residual MR 2+</td>
<td>Sudden onset Died of Bleeding</td>
<td>Alive residual MR 2+</td>
<td>Alive residual MR 1+</td>
</tr>
</tbody>
</table>

**Table 2**

history of rheumatic fever was elicited in three patients (K.H., K.T. and K.M.), of bacterial endocarditis in one (E.M.) and of ischemic heart disease in one (M.N.). In three patients (E.M., K.H. and K.T.), the excised mitral valve was deformed with rigid,
nodurally thickened orifices and with thickened, fused and shortened chordae. Rupture of the chordae was found at the mid-portion of the valvular orifice, the para medial chordae of Carpentier et al., in two patients (E. M. and K. H.) with thickened and rounded edges (Fig. 1) and at the posterior commissural region, the para commissural chordae, in one (K. T.). In these patients, rupture of the chordae was probably secon-
dary to degenerative change in the valvular leaflet and chordae. In the remaining two patients (M. N. and M. K.), the broad segment of the anterior leaflet had lost chordal support, and it was clear that reparative surgery was not feasible. In the excised valve of patient M. N., pliability was preserved with slight thickening in the orifice area. Almost all of the chordae attached to the posterior commissure of the anterior leaflet were ruptured. In the other patient (M. K.), the excised mitral valve was thin except for the mid-region of the anterior leaflet. Deformity of the intact chordae seemed to be very slight. The para commissural chordae of the anterior and posterior commissures were ruptured (Fig. 2). In these two patients, rupture of the chordae was presumed to be the primary lesion.

Group II consists of six patients who were treated with valvuloplasty (Table 2). In two patients (E. W. and K. M.) simple annuloplasty was performed at both the anterior and posterior commissures. However, regurgitation could not be eliminated, so prosthetic valves were inserted. Patient E. W. was in good health until a productive cough developed suddenly three years prior to operation. Since then, a cardiac murmur had been noted. The mitral valve was pliable with a dilated mitral annulus. There was a flail segment in the posterior commissural region of the anterior leaflet due to loss of chordal support. The site of rupture was the para commissural chordae. If this flail segment could be plicated by annuloplasty, regurgitation might be suppressed to a minimum. Patient K. M. had a history of persistent congestive heart failure since shortly after the ligation of a patent ductus arteriosus two years before mitral exploration. She had a gigantic left atrium with widely dilated mitral annulus. The main chordae of the anterior commissure of the anterior leaflet were found to be ruptured. Three patients were treated with plication of the flail segment of the anterior leaflet with interrupted stitches and annuloplasty at both commissures (patient. J. W.), or at the anterior commissure (patient S. I.), or at the posterior commissure (patient N. O.). In the last patient (A. U.) wedge-shaped excision and repair of the redundant segment of the leaflet was combined with annuloplasty with a Carpentier ring. Three patients (J. W., N. O. and A. U.) survived surgery, but in one (S. I.) the sutures of the annuloplasty broke down because of the fragility of the annular and left atrial wall tissue, and mitral regurgitation recurred shortly after bypass was discontinued. A prosthetic valve was inserted, but the patient died of bleeding on the operating table. The appearance of the mitral valve in these four patients was somewhat similar. The flail segment of the valve was small, and the pliability of the valve leaflet was well preserved. Rupture had occurred in the anterior para commissural chordae in two patients (J. W. and S. I.), and in the posterior para commissural chordae in two (N. O. and A. U.). Patient A. U. had an additional rupture of the cleft chordae in the posterior leaflet, the redundant segment of which was excised in the same manner as the anterior leaflet. Postoperative echocardiography of the three surviving patients showed improvement with a decrease in the diastolic descending ratio and in the left atrial diameter, and postoperative left ventriculograms revealed residual mitral regurgitation of grade 1 to 2 plus with decrease in left atrial size (Fig. 3).
Discussion

Our experience with reconstruction of the anterior leaflet of the mitral valve with regurgitation due to ruptured chordae tendineae has been described. Three of five patients who had mitral valve replacement as the procedure of choice had deformed, rigid valves and fused, thickened and shortened chordae. The other two had pliable leaflet tissue with a broad area of valve devoid of chordal support. In six patients, reparative mitral valve surgery was attempted; it was successful in three. These patients had pliable leaflet tissue with small area of flail segments in the anterior leaflet.

Reparative surgery of the mitral valve apparatus with regurgitation due to ruptured chordae tendineae includes reconstruction of the ruptured chordae and plastic repair of the mitral valve and annulus. In the reconstruction of the chordae, direct reattachment of the ruptured end to the papillary muscle or substitution with autologous pericardium, Teflon fabric, and suture materials have been employed. In these reports, however, reconstruction of the chordae of the anterior leaflet is mentioned only a few cases. There is an assumption that with chordal substitute, shrinkage of the left ventricular cavity might lead to redundancy of new chordae with eversion of the leaflet into the left atrium and recurrent insufficiency and potential thrombogenic materials were inserted in
the left ventricular cavity\(^4\). The authors did not attempt reconstruction of ruptured chordae in the present series, since none of the patients were good candidates for the procedure.

Simple annuloplasty at both commissures in two patients did not eliminate regurgitation. Valvuloplasty of the evertting segment of the leaflet combined with standard annuloplasty in two cases and wedge-shaped excision of the redundant tissue along with annuloplasty using a Carpentier ring in one case gave satisfactory results in this series. Only a few reports have been published of patients with ruptured chordae tendineae of the anterior leaflet who have had reparative surgery of the mitral valve\(^4\). Some authors who have recommended plastic repair employ valve replacement for regurgitation due to ruptured chordae tendineae of the anterior leaflet\(^{5(14)151921}\), presumably because of the difficulty of eliminating regurgitation completely and the fear of progression of residual regurgitation. However, as reported in this paper, patients with a small regurgitant area are apt to have pliable leaflet tissue with slight fibrous thickening around the involved valve segment and this slight thickening affords a good base for securing stitches of plication which approximate the neighboring intact chordae. Annuloplasty combined with the above procedure reduced regurgitation to an acceptably small grade. The authors think that candidates for mitral valve replacement with this entity should be restricted to those patients with a deformed and degenerated mitral apparatus and with a broad valve segment of the anterior leaflet devoid of chordal support.

There are different opinions concerning the long term fate of mitral reconstructive surgery. Pakrashi et al. analysed their 89 survivors of mitral annuloplasty and found that clinical improvement was maintained for up to 14 years, further corroborating the beneficial effect of annuloplasty\(^15\). Reed reported that 80 per cent of the patients who had undergone his mitral annuloplasty showed good to excellent results for up to 7 years\(^17\). Oury et al. obtained excellent results with annuloplasty using the Carpentier ring\(^13\). On the contrary, initial good results were maintained for up to 4 years in only 16 of 29 patients treated with mitral annuloplasty by Penther et al., who concluded that the indication for annuloplasty were few, primarily mitral insufficiency without obvious cardiac enlargement, with normal sinus rhythm and with only a recent history of congestive heart failure.\(^16\) Angel stated that 50 per cent of patients who had had mitral annuloplasty for anterior leaflet lesions returned with very significant recurrent murmurs\(^1\). The survivors in the present series have a slight degree of residual mitral regurgitation, and this requires cautious follow up. Our experience with valvuloplastic surgery for congenital mitral regurgitation may afford some illumination on this problem. In a long term follow up of 29 cases, those patients with less than 2 plus residual mitral regurgitation have not shown any increased severity, and they have continued in a stable condition for at least 8 years\(^21\).

Conclusion

Experience with surgery of the mitral valve apparatus with ruptured chordae tendineae of the anterior leaflet has been reviewed from the view point of feasibility of reconstructive
RECONSTRUCTIVE MITRAL VALVE SURGERY

surgery. Simple annuloplasty could not eliminate regurgitation. Plication of the flail segment of the anterior leaflet combined with annuloplasty in two cases and wedge-shaped resection and repair of the flail segment of the valve combined with annuloplasty using the Carpentier ring in one case reduced regurgitation to an acceptably small grade. Plastic repair of mitral valve with regurgitation due to ruptured chordae tendineae of the anterior leaflet is feasible when the site of the rupture is eccentric and the number of ruptured chordae is small and the leaflet tissue is pliable.

References

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19) Roberts WC, Braunwald E et al: Acute severe mitral regurgitation secondary to ruptured


和文抄録

前尖腱索断裂による僧帽弁閉鎖不全症に対する弁形成術

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近畿大学医学部麻醉学教室

未 包 慶 太

腱索断裂による僧帽弁閉鎖不全症のうち，後尖腱索
断裂によるものは弁形成術で対処出来る症例が多いこ
とは諸家の指摘するところであり，若者らの成績もこ
れを支持しているが，前尖腱索断裂によるものについ
ては弁置換術を選ぶという報告が多い。しかし，腱索
断裂症例の弁尖の中には，柔軟で，肥厚度度であり，
切除するのに踏踏する場合もある。そこで，前尖腱索
断裂による僧帽弁閉鎖不全症の自験例11例を対象とし
て弁形成術の適応を検討した。

患者の年齢は25才から63才，男性5例，女性6例。
5例に弁置換術を，6例に弁形成術を第一選択とし
た。弁置換術を第一選択とした症例のうち3例の僧帽
弁は，変形高度で，硬化，細鱗状肥厚を示して可動性
は著しく障害されており，腱索は硬化，腫瘍，縮短
していた。他の2例では弁尖は薄く，可動性はよく保
たれていたが，腱索断裂の範囲が広く，弁形成術を考
慮する余地はなかった。弁形成術を第一選択とした症
例のうち，Para commissural chordae に断裂のあった1例と，main chordae に断裂のあった1例，計2
例に両交連部で弁輪縮窄術のみを行ったが逆流を残
せず弁置換術に切換えた。また，Para commissural chordae に断裂のあった3例に対して，腱索断裂部の
弁尖を縫合したのち，弁輪縮窄術を行ったところ，2
例で逆流を制御出来たが，弁輪及び左房組織の破壊で
あった1例では縫合部が裂開したので急拡人工弁置
換に切換えたが失敗。前尖の Para commissural chordae と後尖の cleft chordae に断裂のあった1例では断裂縫合部弁尖部を切除，縫合したのち，
Carpentier ring を用いて弁輪縫縮術を行い逆流を制
御出来る。弁形成術生存例3例の術後エコー検査では左
房径が減少しており，術後左室造影では心室壁の遺
残逆流を認めているが安定している。

前尖腱索断裂症例のうち，弁形成術が Para commis-
sural chordae の領域に限局して，その数が少
く，弁尖の肥厚度で軟弱な症例では弁形成術で対処
出来る余地が残されており，術式としては断裂縫合
着弁尖部を縫合又は切除縫合したのち，弁輪縫縮術を
併用する方法により逆流を制御可能である。