Degenerative Mitral Valve Repair Techniques: Classic Resectional Repair Techniques and Non-Resectional Techniques

Carpentier pursued developing mitral valve repair techniques and published a series of papers in 1980, 1983 and 1995. During this time the mitral valve pathology shifted from mainly rheumatic with minority degenerative (1980) to more degenerative and less rheumatic (1995). The 1990s became the era of mitral valve repair in degenerative disease (Carpentier Type I and II) with exploding applications in late 1990s and early 2000s. Different repair techniques were developed and applied to degenerative disease.

In the 1980s with the application of M-mode echo and advance of basic 2D echocardiography the postoperative issue of systolic anterior motion (SAM) of the mitral valve post repair in degenerative disease was seen in a small percentage of patients. Efforts to understand the etiology/mechanism of SAM and to better understand mitral valve pathology in degenerative disease led to surgical techniques to reduce the risk of post repair SAM in degenerative disease. Post repair SAM still remains an issue.

Today repair techniques for degenerative have tremendous results:

1) David et al reported freedom from reoperation at 12 years of 96% for posterior disease, 88% for anterior disease, and 94% for bileaflet prolapse. Anterior leaflet prolapsed was the only independent predictor for reoperation.

2) Lytle et al (Cleveland) for posterior prolapse reported a 15 year survival of 76% superior to age and sex matched population. At 10 years freedom from mitral valve reoperation was 97%. At 10 years residual MR was 77% none or 1+, 11% had 3+ or 4+. Repair durability was jeopardized by not using annuloplasty ring, presence of left atrial enlargement, and left ventricular remodeling and dysfunction

3) Cohn (Brigham in Boston) et al reported for degenerative disease. 30 day mortality 0.6%. Ten and 20 year freedom from operation were 90% and 66%.

I) Carpentier

Classic Carpentier resectional techniques involve the global concept of trying to “normalize” the mitral valve apparatus. The rationale to “normalize” mitral annular and leaflet anatomy in repair was an attempt to normalize stress and tension on the valve and achieve longevity of repair.

Classically for degenerative valves this included:

1) In case of prolapsed/flail chordate, resecting (all or portion) of the offending posterior leaflet scallop (usually P2), performing an annular plication (to reduce tension at posterior scallop junction). This is the classic quadrangular resection of P2.
   a. Plication of the posterior annulus at scallop resection was necessary.
   b. After posterior annular placation the remaining posterior leaflet scallops approximated/sutured to obtain functioning posterior leaflet.

2) A reduction annuloplasty was then performed along the posterior annulus to “normalize” annular dimensions (reducing leaflet stress) and a rigid annuloplasty ring sewn in place.
   a. Annular ring served to provide stability over time, and prevent further dilation.
3) Classic Carpentier annuloplasty ring is rigid, maintains ¾ AP/Transverse commissural dimensions. Numbering of ring was based on intercommissural diameter of ring.

4) Sizing of ring to implant was based on ring that would best approximate the anterior leaflet height.

The issue of torn chordae/flail anterior leaflet:

1) Anterior leaflet chordal reconstruction using “flipover” technique from opposing posterior leaflet scallop.
   a. Involved taking opposing posterior scallop with normal chordae, resecting this scallop with chordae intact and inserting on the flail anterior leaflet to support.
   b. Posterior scallop annular region plicated and closed or slide technique performed.

The issue of elongated chordae in P1 and P2 led to development of

2) Posterior leaflet with elongated chordae not amenable to resection could have chordae shortened by a variety of techniques.

Ultimately these chordal maneuvers were difficult to perform and found to have reduced long term stability. This led to the interest in neochordae implantation from papillary heads to mitral valve leaflets. This technique of neochordae has been shown to be successful and more stable than earlier chordal techniques.

The resectional approach in general resulted in P1 and P3 moving centrally resulting in chordal tension tethering the scallops ventricularly resulting in a single leaflet (anterior leaflet) motion of the mitral valve.

### Spectrum of Repair Difficulty

<table>
<thead>
<tr>
<th>Complexity of Repair</th>
<th>Repair Type</th>
<th>Mitral Valve Pathology</th>
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<tbody>
<tr>
<td>Simple</td>
<td>Annular Ring</td>
<td>Dilated Annulus</td>
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<tr>
<td>More Complex</td>
<td>Annular Ring Quadrangular resection</td>
<td>Dilated Annulus Flail Posterior Scallop</td>
</tr>
<tr>
<td>Increased Complexity</td>
<td>Annular Ring Quadrangular Resection Posterior leaflet height adjustment to Prevent SAM</td>
<td>Dilated Annulus Flail Posterior Scallop Increased Posterior Scallop height</td>
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<tr>
<td>More Complex</td>
<td>Annular Ring +/- Quad Resection Artificial Chordae vs. Transfer to Larger Ring</td>
<td>Dilated Annulus Tom Chordae Risk for SAM</td>
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<tr>
<td>More Complex</td>
<td>Above Plus Anterior Leaflet - resection - shortening - artificial chord</td>
<td>Barlow’s Above plus anterior leaflet pathology</td>
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<tr>
<td>More Complex</td>
<td>Closing Commissure</td>
<td>Commisural Scallop Prolapse</td>
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<tr>
<td>Complex</td>
<td>- Assessing mechanism of post Repair SAM How to fix it Do you want to fix it</td>
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**Table 1. Summary of Repair Techniques**
Carpentier with time developed other rings to complement his “Classic” ring:

**Classic Carpentier Edwards Mitral Valve Annuloplasty Ring**

a. Carpentier classic rigid annular ring is sized by commissural diameter.
b. Ring tries to reconstruct classic 3 to 4 ratio anterior diameter to transverse commissural diameter of normal mitral valve.
c. A/P diameter is not given
d. Criticized for its rigidity and perhaps predisposing to SAM in postrepair situations.

**Carpentier Edwards Physio Mitral Valve Annuloplasty Ring**

In response to criticism of his rigid ring (and to compete with Duran flexible ring) in mid 1990’s Carpentier introduced the Physio Ring. Incorporated concept of the anterior mitral annulus shape (saddle), which was rigid with flexible posterior annulus component of ring.

<table>
<thead>
<tr>
<th>Lesion</th>
<th>Surgery</th>
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<tbody>
<tr>
<td><strong>NORMAL MOBILITY</strong></td>
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<tr>
<td>Annular dilatation</td>
<td>Annuloplasty</td>
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<tr>
<td>Papillary muscle malposition/dysfunction</td>
<td>Annuloplasty</td>
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<tr>
<td>Leaflet perforation</td>
<td>Patch suture</td>
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<tr>
<td><strong>INCREASED MOBILITY</strong></td>
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<tr>
<td>Chordal elongation</td>
<td>Papillary muscle sliding plasty</td>
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<td></td>
<td>Papillary muscle head repositioning</td>
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<td></td>
<td>Chordal transposition (“flip-over”)</td>
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<td></td>
<td>Artificial chordae</td>
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<td></td>
<td>Leaflet resection</td>
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<tr>
<td>Chordal rupture</td>
<td>Leaflet resection</td>
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<tr>
<td></td>
<td>Artificial chordae</td>
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<tr>
<td>Papillary muscle elongation/malposition</td>
<td>Papillary muscle repositioning</td>
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<tr>
<td>Papillary muscle rupture</td>
<td>Reimplantation</td>
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<tr>
<td><strong>REDUCED MOBILITY</strong></td>
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<tr>
<td>Commissural fusion</td>
<td>Commissurotomy</td>
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<tr>
<td>Calcific nodules</td>
<td>Excision</td>
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<tr>
<td>Chordal fusion, thickening</td>
<td>Fenestration</td>
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<td></td>
<td>Resection</td>
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<td>Chordal retraction</td>
<td>Papillotomy</td>
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<td></td>
<td>Resection</td>
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<tr>
<td>Leaflet retraction</td>
<td>Leaflet enlargement</td>
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<tr>
<td>Subvalvular thickening</td>
<td>Papillotomy</td>
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</table>

Table 2. MITRAL VALVE REPAIR TECHNIQUES<sup>(4)</sup>
a. Retained commissural sizing
b. Although states maintains 3:4 ratio, also states that it increased the A/P diameter without defining or giving specific measurements

Carpentier Edwards Physio II Mitral Valve Annuloplasty Ring

a. Again in response to issues of rigidity and “saddle shapeness” of mitral annular rings
b. Physio II semi-rigid ring introduced in early 2000’s.
c. Some flexibility
d. Supposed double saddle shape to optimize tension
e. More “circular” in shape
f. Again sized commissure to commissure, other dimensions not given

II) Duran Resectional Repair Techniques

Duran was a contemporary of Carpentier. Developed similar techniques over time. As with Carpentier, emphasized the importance of trying to reconstruct a “normal” mitral valve from the pathology causing the defect. In degenerative techniques (non FED) the pathology generally involves excess, thick mitral valve tissue. Thus resectional techniques were applied including classic quadrangular resection of P2, and posterior leaflet slidingplasty. As repair techniques developed in late 1990s/early 2000s the application of neochordae was applied. Also specific techniques to prevent SAM in elongated anterior leaflets.

The difference with Duran is that he advocated use of a flexible ring:

1) Allowed mitral annulus to maintain dynamic motion
2) Allowed mitral annulus to change shape and orifice size throughout cardiac cycle.
3) Thought to produce less leaflet/annular tension compared to rigid ring because of #1 and #2 above.

Duran in his repair technique attempted to normalize mitral valve dimensions. In general the anterior mitral annulus does not dilate in degenerative disease. It is the posterior annulus that dilates. Therefore Duran advocated sizing his rings intertrigonly, to guide in approximating what the “normal” reconstructed annulus would be. Duran Rings and Bands are sized intertrigonly and have no correlation with commissural sized rings in terms of AP diameter and total circumference.

III) Mitral Bands

The mitral band is ideally applied from trigone to trigone, not commissure to commissure.

Advocates of the band like it because:

1) Anterior mitral annular stitches are more difficult to place, especially with left atriotomy incision and smaller left atrium
2) Even in robotic and mini-thoracotomy use of band removes issue of;
   a. More difficult anterior annular stitches
   b. Getting complete ring and sutures into smaller space
3) Advocates claim may retain anterior annular motion.
IV) Non-Resectional Mitral Valve Repairs

With the advent of chordal reconstruction using neochordae in the 1990s, some surgeons began to advocate nonresectional techniques. In the United States, Lawrie (The American Correction) is perhaps the biggest advocate of nonresectional techniques in degenerative valve repairs. His data is at least as good, and he would suggest possibly better than classic resectional techniques. In Europe, Perier advocated a similar (Respect Rather Than Resect) non resectional approach with excellent results. Lawrie uses a flexible ring, Perier uses a Carpentier-Edwards Physio Ring.

The technique of Lawrie involves:

1) Neochordae reconstruction along anterior leaflet
2) Neochordae reconstruction along posterior leaflet scallops
3) Chordal lengths are determined and tied down after:
   a. Filling LV to approximate end diastolic filling and isovolemic contraction
   b. Pulling posterior annulus anteriorly (with sutures) to approximate atrial contraction
   c. Aim to have appropriate rough zone coaptation of mitral valve leaflets.
4) Flexible ring is sized at step #3 to approximate annulus shape /circumference at this time.
5) Commissural issues not addressed in repair can be corrected by commissural plication.

His technique results in mobile posterior leaflet and rare if any SAM.

References: