Systolic Anterior Motion (SAM) of the Mitral Leaflets Post Repair in Patients with Degenerative Disease

Following the 1980 and 1983 publications by Carpentier of his experience, results, and techniques for mitral valve repair, surgeons worldwide became interested in mitral valve repair. During this time period there was no TEE. Transthoracic echo was M-mode, with 2D echo being introduced in the 1980s. Single plane transesophageal echocardiography was introduced in mid 1980s, followed by biplane and then multiplane TEE probes.

In 1984 Colvin/Kronzon et al in New York published a paper showing postrepair SAM by M-mode echo in 3 out of 32 patients undergoing mitral valve repair using Carpentier techniques. In 1986 Colvin/Kronzon et al published their long term follow-up after mitral valve repair, reporting the incidence of postoperative left ventricular outflow tract obstruction using M-Mode echo and some 2D echo. Seven out of 62 patients had LVOT obstruction and SAM.

Cosgrove et al at the Cleveland Clinic in 1986 reported on the incidence of SAM after Carpentier ring valvuloplastic for mitral valve prolapse. Five out of 45 patients had SAM defined by M-Mode echo and 2D echo. In 1988 Cosgrove reported their long term follow-up in mitral valve repair using Carpentier’s techniques and rigid ring. M-Mode echo and 2D echo was utilized to assess mitral valve function. For patients with degenerative disease 12 out of 200 repairs had post repair SAM and LVOT obstruction. In patients undergoing repair for non-degenerative disease none of 300 had post repair SAM and LVOT obstruction. Thus the post repair SAM/LVOT obstruction seemed to be a problem of patients with degenerative disease undergoing Carpentier repair.

Carpentier responded in 1988 reporting their findings of LVOT obstruction after mitral valve repair. They found SAM/LVOT obstruction in 14/100 with Type II disease, 0/20 with Type I and 0/30 with Type III mechanisms for mitral regurgitation. Thus it appeared to be patients with degenerative disease, and Type II prolapse that were at risk for SAM. They suggested that non-specific modifications by the rigid Carpentier ring caused anterior displacement of the posterior mitral leaflet and narrowing of the mitral aortic angle, contributing to SAM.

Concern arose that the rigidity of the Carpentier ring led to altered ventricular/LVOT/mitral relationships contributing to SAM. Yet SAM was also reported with Duran’s flexible ring. Of interest, Colvin and Cosgrove, two excellent surgeons, went on to develop their own mitral bands.

Work in the 1990s pointed to multifactorial explanations for postrepair SAM/LVOT obstruction in degenerative disease:

1) Incorrect sizing of rings. Mitral annular ring sized incorrectly to anterior leaflet and annuloplasty resulting in smaller ring than optimal size contributed to SAM. In fact cases were reported where SAM/LVOT obstruction was resolved by redoing the annuloplasty, presumably enlarging it.

2) Risk of a small ventricle predisposing for SAM

3) Realization that anterior displacement of anterior/posterior leaflet coaptation pre and post repair may be related to SAM

4) Realizations that subgroups of degenerative pathology did not involve solely P2. May have increased height (distance annulus to free edge) P1, P2, or P3.
a. This led to Carpentier developing the “posterior leaflet sliding” technique to reduce and normalize the height of abnormally elongated P1, P2, or P3.
   i. Cosgrove et al elaborated on this, altering the resection and plication technique to reduce annular reduction.
   ii. Plication techniques have been modified by many to optimize annuloplasty and/or sliding techniques.

b. This also led to foldingplasty techniques.

5) Realization that some anterior leaflets were also elongated, especially in true Barlows where all leaflets and scallops had increased height.
   a. Realization that these repairs were especially difficult and potentially problematic.
   b. Would need larger rings without anterior leaflet height reduction.
   c. Development of anterior leaflet height reduction techniques.
   d. Development of non-resectional techniques.

6) Led to application of foldingplasty technique for leaflet repair.

7) Maslow and Levine popularized these concepts in their paper on post repair SAM. They emphasized the anterior displacement of leaflet coaptation as a risk for SAM with their AL/PL coaptation ratio. Their use of C-sep distance as risk reflects this anterior displacement and perhaps small ventricle. Inherent in their study, but not as emphasized were the above mentioned concerns about increase height of anterior leaflet and posterior leaflet scallops.

Taking all these things together, to minimize post repair SAM in patients with degenerative disease undergoing resectional mitral valve repair techniques one should consider:

1) Anterior leaflet height (annulus to free edge distance) greater than 25 mm predisposes to increased SAM risk compared to normal height.
   a. Anterior leaflet height greater than 30mm places patient at increased risk for SAM
      i. May consider anterior leaflet height reduction
      ii. If no reduction, need for appropriately sized large annuloplasty ring.

2) Increase height P1, P2 and P3 greater than 15mm (annulus to free edge distance) may be risk for SAM. Height greater than 20mm places at high risk for SAM.
   i. Consider height reduction with slidingplasty or foldingplasty.
   ii. Tirone David attempts to keep posterior scallop height 10mm or less post repair. If posterior leaflet height allowed to be greater than 10mm (as in Barlow’s), height of posterior leaflet post repair should be one third the height of the anterior leaflet. (see excellent discussion with Carpentier /Mohr pg 1248-1247 of David’s JTCS 2005 paper).

3) Stress importance of appropriate sizing of annular ring/band (rigid, flexible, semi-rigid) and correct reduction annuloplasty/implantation.

4) From Levine/Maslow study (Figure 1):
   a. Measuring ratio of: anterior leaflet length (from annulus to coaptation) /posterior leaflet length (from annulus to coaptation)
      i. Pre-repair ratio less ≤ 1.3 placed patient at risk for SAM
   b. Pre-repair C-sep distance ≤ 2.5 or less placed patient at risk for SAM
   c. SAM considered related to more anterior position of anterior and posterior leaflet coaptation.

**Figure 3:** Surgical techniques for the repair of SAM. Numbers refer to references in the text.

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References:

4) Cosgrove et al. Long-term Follow-up of Patients With Left Ventricular Outflow Tract Obstruction After Carpentier Ring Mitral Valvuloplasty. 1988 Circulation;78 (supplement I):I-60-I-65