Systolic anterior motion of the mitral valve: A 30-year perspective

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Objective: Systolic anterior motion (SAM) can occur after mitral valve repair (MVr), most frequently in patients with degenerative valve disease. Our initial observations (1981-1990) revealed that most patients with SAM can be successfully treated medically. Here the authors review the last 16 years of their experience with SAM after MVr.

Methods: Between January 1996 and October 2011, 1918 patients with degenerative mitral valve disease underwent MVr at our institution. We performed a retrospective analysis of SAM in this patient population.

Results: The incidence of SAM was 4.6% (89 of 1918) overall, 4.0% (77 of 1906) in patients who did not have SAM preoperatively (de novo). Compared with our previously published report, the incidence of SAM decreased from 6.4% to 4.0% ($P = .03$). Hospital mortality was 2.0% (38 of 1918) overall, 1.3% (14 of 1078) for isolated MVr. One patient with de novo SAM (1 of 77; 1.3%) died after emergency MVr. All patients with de novo SAM were successfully managed conservatively with intravenous fluids, α agonists, and/or β blockers. A higher incidence of SAM was associated with a left ventricular ejection fraction greater than 60% ($P = .01$), posterior leaflet resection ($P = .048$), and hypertrophic obstructive cardiomyopathy ($P < .01$). The incidence of SAM was lower in patients who underwent device mitral annuloplasty with a semirigid posterior band compared with a complete ring ($P = .03$).

Conclusions: In the more recent era, SAM occurs one-third less frequently after repair of degenerative mitral valve disease. Use of an incomplete annuloplasty band rather than a complete ring is associated with a lower incidence of SAM. The mainstay treatment of SAM continues to be medical management. (J Thorac Cardiovasc Surg 2014;148:2787-94)

Systolic anterior motion (SAM) of the mitral valve refers to the paradoxic movement of the anterior leaflet and/or chordae toward the interventricular septum during systole. Initially associated mainly with hypertrophic obstructive cardiomyopathy (HOCM), SAM was first described as a potential complication of mitral valve repair (MVr) in 1977.[1] This led to a significant amount of interest in the phenomenon, including a study of the incidence of SAM in our early MVr series in 1984,[2] and threatened to compromise the concept of MVr. Our observation that SAM occurred most frequently in patients with a large saillike anterior leaflet and excessive height of the posterior leaflet after extensive posterior leaflet resection led us to focus on efforts to lower the height of the repaired posterior leaflet with the attendant posterior relocation of the coaptation line. In addition, numerous other studies have been conducted to help understand the pathophysiology of SAM, and have led to the identification of major preoperative risk factors and adaptation of surgical repair techniques, including the frequently used techniques of sliding plasty or folding plasty repair for patients with the anatomic substrate for SAM requiring posterior leaflet resection. However, despite this knowledge and experience, the current incidence of SAM after MVr in patients with degenerative disease remains in the range of 6.1% to 11.0% in recent large studies.[3-6]

Previously, our group reported a 10-year single-institution experience (1981-1990) with SAM after MVr using mainly complete ring annuloplasty.[7] We now present our last 16 years of data (1996-2011) which incorporates changes in repair techniques, completing a 30-year retrospective on the incidence and management of SAM after MVr.

METHODS

The NYU Langone Medical Center Institutional Review Board granted a waiver of individual informed consent for analysis of de-identified data. Between January 1996 and October 2011, 2687 patients underwent MVr at our institution. Of these, 1918 had degenerative disease and were included in this study. MVr was performed via median sternotomy (n = 473), right anterior thoracotomy (n = 1439), or left thoracotomy (n = 6). All procedures were performed on cardiopulmonary bypass. Mitral valve

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Abbreviations and Acronyms

CABG = coronary artery bypass graft
HOCM = hypertrophic obstructive cardiomyopathy
LVEF = left ventricular ejection fraction
LVOT = left ventricular outflow tract
SAM = systolic anterior motion
TEE = transesophageal echocardiogram

repair techniques were chosen according to the pathology of the individual patient. These techniques were for the most part performed according to Carpentier's principles (Table 2). Exceptions included the introduction of the posterior leaflet folding plasty (n = 705) before the start of this study period as an alternative to the classic sliding plasty technique aimed at reducing posterior leaflet height. Regarding annuloplasty methods, we transitioned from the use of complete rings (n = 409; Carpentier-Edwards classic annuloplasty ring or physio annuloplasty ring; Edwards LifeSciences, Irvine, Calif) to use of semirigid posterior bands (n = 1172; CG Future Band; Medtronic Inc, Minneapolis, Minn) in 2001. We have avoided the use of complete ring annuloplasty since then, except for reduction annuloplasty for functional mitral regurgitation. Patients who underwent MVr with infrequently used annuloplasty devices (Seguin Semi-Rigid Ring, St Jude Medical, St Paul, Minn, n = 46; CG Future Ring, Medtronic Inc, Minneapolis, Minn, n = 78) or without an annuloplasty device specified (n = 214) were not included in the subgroup analysis comparing device types. Annuloplasty device sizes were determined based on the anterior leaflet height and the intertrigonal distance.

Each patient had intraoperative transesophageal echocardiograms (TEE) before and after cardiopulmonary bypass, and a transthoracic echocardiogram before discharge. All intraoperative TEE studies were performed by an echo certified cardiac anesthesiologist and reviewed by a dedicated operating room cardiologist. The diagnosis of SAM was made if present on any of these echocardiograms. SAM was defined as any chordal or mitral leaflet protrusion into the left ventricular outflow tract (LVOT) during systole regardless of the presence of hemodynamic effect. Initial management of postoperative SAM involved a combination of ventricular volume loading, vasoconstriction, elimination of inotropes, and/or β blockade. SAM that was managed medically intraoperatively and resolved was included in the study. Patients who continued to exhibit signs of SAM with moderate mitral regurgitation or LVOT obstruction despite pharmacologic manipulations underwent reoperation for either valve repair or replacement. Neither these practices nor the criteria for the diagnosis of SAM changed during the study period and did not differ from our previous study.

All data were collected prospectively in a database and a retrospective review of this database was performed for this study.[8] Individual echocardiographic images were not reviewed again for this study. Statistical analyses were performed using SPSS 20 (IBM Corp, Armonk, NY). Variables were considered complete if the data were available for more than 97% of the patients included in the study. When data were incomplete for a given variable, separate subgroup analyses were performed using only those patients for whom the data were available. Categorical variables are presented as incidence (percentage), continuous variables as means ± standard deviation. *P* values for univariable analyses were determined by χ^2 or Fisher exact test when appropriate. Multivariable regressions were performed using variables identified by a *P* value of 0.1 or less in the univariable analysis. Regressions were performed on subsets of patients with complete data for the variables of interest. Odds ratios (ORs) of multivariable predictors were determined by stepwise logistic regression.

RESULTS

The mean age of the patients was 62 ± 15 years with a mean New York Heart Association functional class (I-IV) of 2.3 ± 0.6 and a mean left ventricular ejection fraction (LVEF) of 56% ± 17%. Concomitant procedures were performed in 43.8% (840 of 1918), including 182 (9.5%) coronary artery bypass graft procedures and 282 (14.7%) other valve procedures. Baseline characteristics are summarized in Table 1.

In all patients, including those with preoperative SAM, the incidence of postoperative SAM was 4.6% (89 of 1918). Excluding patients with preoperative SAM (n = 12), the incidence of de novo SAM was 4.0% (77 of 1906). No patient with de novo SAM (0 of 77) required reoperation during this time period. One patient who presented with HOCM and SAM underwent reoperative mitral valve replacement 4 days after MVr because of persistent SAM with associated mitral regurgitation and moderate LVOT obstruction (1 of 89; 1.1%). Hospital mortality was 2.0% (38 of 1918) overall and 1.3% (14 of 1078) for isolated MVr. One patient with de novo SAM (1 of 77; 1.3%) died of multisystem organ failure after a prolonged hospital course. This patient had been admitted in cardiogenic shock requiring multiple inotropes and vasopressors before undergoing emergency MVr with posterior leaflet resection and suture reduction annuloplasty.

Univariable analysis (Table 2) showed a higher incidence of SAM in patients with preoperative LVEF greater than 60% ($P = .01$), posterior leaflet resection ($P = .048$), flail posterior leaflet ($P = .04$), severe mitral regurgitation ($P = .03$), and HOCM ($P < .01$). There was a lower incidence of SAM in patients who had a concomitant valve procedure ($P = .02$) and in patients who underwent mitral annuloplasty with a semirigid posterior band ($P = .03$). The incidence of SAM also decreased over time ($P < .01$) during the study period.

Multivariable analyses (Table 3) of preoperative risk factors for SAM identified by univariable analysis revealed that LVEF greater than 60% was associated with an increased risk of post-MVr SAM (OR, 2.7; $P = .04$). Specific preoperative echocardiographic anatomic information was only available in 730 of the patients in the study. Regression analysis of this subgroup demonstrated significant association between HOCM (OR, 14.2; $P = .03$) and flail posterior leaflet (OR, 2.4; $P = .046$) with the development of SAM. In patients who received either a complete ring annuloplasty device or a partial band annuloplasty device as part of their MVr and underwent posterior leaflet resection (n = 1098), multivariable analysis revealed complete ring annuloplasty (OR, 1.9; $P = .02$) to be the only procedural characteristic that was a significant independent risk factor for the development of post-MVr SAM.