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Despite improved surgical techniques and survival in patients following aortic valve replacement for aortic stenosis and aortic insufficiency, the proper timing for surgery remains controversial. The incomplete reversibility of left ventricular dysfunction remains a concern, and postoperative improvement of left ventricular function is not consistently demonstrated. We studied 11 patients with aortic stenosis and nine patients with aortic insufficiency using angiographic and radioisotope assessment of left ventricular function preoperatively. Postoperative left ventricular function was assessed over nine to 13 months by radioisotope multiple-gated acquisition (MUGA) scan. All patients with impaired left ventricular function preoperatively showed slow but significant recovery toward a normal left ventricular ejection fraction by nine to 13 months postoperatively. Patients with aortic stenosis or aortic insufficiency and depressed left ventricular function can clearly obtain substantial, albeit delayed, improvement after valve replacement. (Henry Ford Hosp Med J 1986;34:193-6)

The surgical management of aortic valve disease has improved since successful implantation of a ball valve prosthesis in 1960 (1). The operative mortality and incidence of prosthesis-related complications have both decreased. The proper timing of the operation remains controversial (2). Some authors, in view of the improved safety of the procedure, have advocated early valve replacement to prevent the development of irreversible left ventricular dysfunction (3-5). Several reports have shown variable improvement in left ventricular function following valve replacement in patients with aortic regurgitation, usually with reference to a single study after surgery. Postoperative assessment of left ventricular function in aortic stenosis has not been carefully evaluated (6).

The development of radioisotopic multiple-gated blood pool imaging has provided a valuable noninvasive tool which permits serial objective assessment of myocardial performance by measuring ejection fraction and changes in myocardial wall motion. In this report, this radioisotopic technique was used to assess left ventricular function at varying intervals after aortic valve surgery in patients with aortic valve stenosis or insufficiency to establish whether correction of the anatomic defect can affect left ventricular function.

Methods

Twenty patients with aortic valve disease were studied. Eleven consecutive patients with clinically significant aortic stenosis and nine with aortic insufficiency documented by cardiac catheterization were studied. The 11 patients with aortic stenosis included six men and five women between 39 and 74 years old. Four patients had a history of exertional dyspnea or syncope, and seven had a history of chest pain. Two patients had angiographic evidence of significant coronary artery disease with greater than 75% narrowing of at least one coronary artery. The nine patients with severe aortic insufficiency comprised seven men and two women between 26 and 48 years old. Two patients had exertional vertigo; six had chest pain; and two had significant angiographic evidence or coronary artery disease using the criteria outlined previously.

Radioisotopic method

Radioisotopic left ventriculography (MUGA) was performed within four days of cardiac catheterization and prior to surgery. Follow-up studies were repeated as close as possible to the one and nine month surgical anniversary for aortic stenosis patients and at nine and 13 months postoperatively for the aortic insufficiency patients. Radioisotope ventriculography was performed using 1 mL of nonradioactive pyrophosphate containing 0.3 mg of stannous chloride administered intravenously. This was followed 20 minutes later by the intravenous administration of 10 to 15 mCi of sodium pertecnetate. Multiple-gated acquisition studies using a commercially available Medical Data Systems (MDS) nuclear medicine computer system for acquisition were performed for a total collection time of ten to 15 minutes per view with a total count of 350,000 counts/frame over the heart. An Ohio Nuclear high-resolution scintillation camera was used for imaging, equipped with a parallel hole collimator. The myocardial wall motion, ejection fraction, and rate of change in vol-

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Table 1
Aortic Stenosis
The Relationship of Preoperative Ejection Fraction to Postoperative Improvement

	No. of patients	LEFT VENTRICULAR EJECTION FRACTION (LVEF) Preoperative	1 Month	9 Months
LVEF > 50%	5	62 ± 5	73 ± 5*	78 ± 9
LVEF < 50%	6	33 ± 6	51 ± 17	66 ± 10†
All	11	43 ± 21	61 ± 7*	64 ± 23

*$p < 0.02$.
†$p < 0.01$.

Table 2
Aortic Insufficiency
The Relationship of Preoperative Ejection Fraction to Postoperative Improvement

	No. of patients	LEFT VENTRICULAR EJECTION FRACTION (LVEF) Preoperative	6 Months	13 Months
LVEF > 50%	6	69 ± 11	63 ± 15	64 ± 7
LVEF < 50%	3	32 ± 11	51 ± 13*	62 ± 12*
All	9	54 ± 22	58 ± 15	62 ± 9

*$p < 0.005$.

ume over time (maximum DV/DT) were calculated for each patient using a standard MDS computer program. All patients were in sinus rhythm. This radioisotopic ejection fraction technique was compared to the ejection fraction calculated from contrast left ventriculography obtained during left cardiac catheterization. The correlation coefficient between these two techniques was 0.86.

Results

Changes following aortic valve replacement for aortic stenosis

A significant increase in left ventricular ejection fraction was noted in the entire group of 11 patients at one and nine months after operation when compared to the preoperative value ($p < 0.02$) as seen in Table 1 and Fig 1. Of 11 patients with aortic stenosis, five had normal preoperative ejection fractions (> 50%), and six had abnormal preoperative ejection fractions (< 50%). In the five patients with normal preoperative ejection fraction, left ventricular ejection fraction did not show any significant change until nine months after surgery, when improvement was noted (Table 1). In six patients with abnormal preoperative ejection fraction, improvement was delayed but progressive. By nine months the mean ejection fraction had improved significantly from 33 ± 6% to 66 ± 10% ($p < 0.01$) when compared to the preoperative value. Fig 2 indicates that this physiologic improvement was associated with improvement in the New York Heart Association (NYHA) functional classification at nine months.

Changes following aortic valve replacement for aortic insufficiency

The nine patients in this group were studied preoperatively and restudied at six- and 13-months after surgery. Overall, these patients did not demonstrate a significant change when compared to the preoperative assessment seen in Table 2 and Fig 3. This was due to the fact that the six patients with normal ejection fractions preoperatively remained stable postoperatively. When the three patients with depressed preoperative ejection fractions were considered separately, a significant improvement in ejection fraction occurred at the six- and 13-month study following surgery (Table 2).

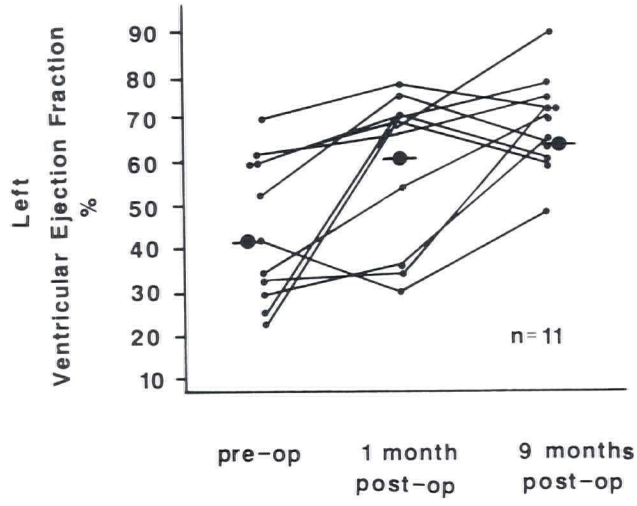

Fig 1—Aortic stenosis: serial change in left ventricular ejection fraction.

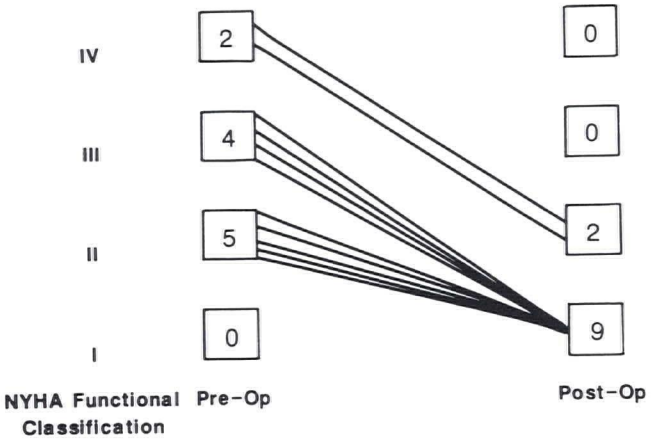

Fig 2—Aortic stenosis: Change in NYHA functional classification of 11 patients after aortic valve replacement.

The functional classification of the patients preoperatively and postoperatively is also shown in Fig 4. After successful replacement of the incompetent aortic valve, all patients improved their functional classification to NYHA class I or II.

Discussion

A number of studies have described both symptomatic and long-term improvement and survival following aortic valve replacement (5,7). In this study, functional improvement occurred in all patients, associated with improvement in ejection fraction. Knowledge of the reversibility of the impaired left ventricular function that existed prior to surgery is important in determining not only the indication for valve replacement but also the optimal time at which valve replacement should be carried out. Previous reports (1,8-10) indicate that the preoperative ejection fraction in patients with aortic valve disease may identify those with high surgical risk and increased perioperative mortality.

Serial studies after aortic valve replacement have demonstrated improved cardiac function (5,7,11,12). Although exercise response after valve replacement was normal in the study by Ross and associates (11), others have found some persistent mild impairment after surgery (2,5,10,13,14). Krayenbuehl and coworkers (4) observed improvement in ejection fraction but some persistence in impairment of left ventricular contractility. They observed that left ventricular contractile function was more severely impaired in patients with aortic regurgitation and less frequently reversible than in patients with aortic stenosis. In patients with aortic stenosis, persistent postoperative left ventricular dysfunction was more commonly associated with severe preoperative hypertrophy. Because of this, they argue for earlier surgery in patients with mild symptoms of aortic insufficiency. Gault and associates (15) noted that although left ventricular hemodynamics improved after aortic valve replacement for aortic insufficiency, there was no change in the inotropic state when assessed by time-velocity-length measurements. Echocardiographic studies by Henry and associates (16) failed to show any improvement in left ventricular ejection fraction after surgery for aortic regurgitation, but did show a decrease in left ventricular mass.

Electron and light microscopic examination of left ventricular tissue removed at surgery in patients with aortic valve disease revealed that cardiac cell degeneration and fibrosis was observed in patients with combined aortic stenosis and insufficiency and with aortic insufficiency alone, but not with pure aortic stenosis (17). These findings may explain impaired cardiac performance in patients with chronic aortic valve disease and particularly those with aortic regurgitation (2). Schwarz and associates (18) studied the relationship of myocardial cell diameter obtained from surgical biopsies to left ventricular end-diastolic pressure, wall thickness, and volume. They concluded that myocardial cell diameter and not fibrosis was the major determinant of whether normalization of the elastic stiffness of the left ventricle occurs following surgery.

Our data confirm the observations that left ventricular performance improves after surgery in patients with aortic valve disease (5,7,19) and, in addition, provides a temporal framework for this improvement. Patients differ in the pattern of improvement based on preoperative ejection fraction and the nature of aortic valve dysfunction. Those with normal ejection fractions prior to surgery, as one would suspect, either showed no change or had early improvement in left ventricular ejection fraction (Figs 1 and 3). In these patients, abnormalities of ejection fraction are probably directly related to increased afterload and/or preload. Patients with impaired left ventricular function, reflected in a low ejection fraction, showed a delayed recovery. Significant improvement in left ventricular performance can be demonstrated within one month of surgery in patients with aortic stenosis, and this improvement continued at the nine-month

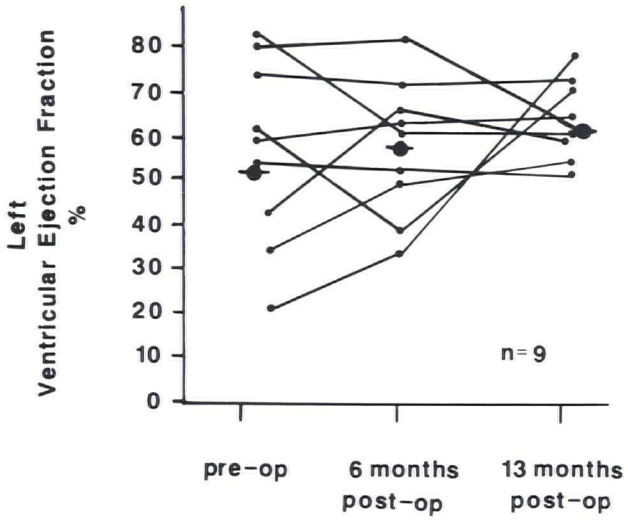

Fig 3—Aortic insufficiency: Serial change in left ventricular ejection fraction.

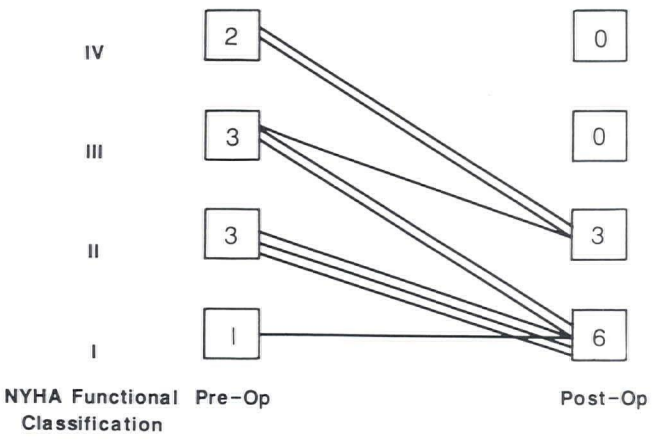

Fig 4—Aortic insufficiency: Change in NYHA functional classification of nine patients after aortic valve replacement.

study (Fig 1). Improvement in the depressed ejection fraction with aortic regurgitation occurred more slowly with improvement continuing to 13 months. Although relief of afterload and/or preload is necessary to effect improvement, alteration in myocardial mechanics almost certainly plays a role in this group. Radionuclide cineangiographic studies performed during exercise may be a more sensitive assessment of left ventricular function in patients with aortic regurgitation than those performed at rest (5,7,19,20). Although a severely depressed ejection fraction in patients with either aortic stenosis or insufficiency presages a high surgical mortality and possibly worse long-term prognosis (10), it does not preclude substantial improvement which may not be immediately apparent.

Previous studies to assess the recovery of myocardial function after surgery for aortic valve disease have shown conflicting results. Both persistent dysfunction and recovery of ventricular function have been reported (2,6,10,21). From our observations, this discrepancy may, in part, relate to the different times at which the patients were studied postoperatively. We cannot answer the question about optimal timing of surgery, but the belief that operating too late in these patients is associated with irreversible left ventricular dysfunction cannot be substantiated by our data.

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