REGRESSION OF LEFT VENTRICULAR HYPERTROPHY AFTER AORTIC VALVE REPLACEMENT FOR AORTIC STENOSIS WITH DIFFERENT VALVE SUBSTITUTES

Ruggero De Paulis, MD
Luigi Sommariva, MD
Luisa Colagrande, MD
Giovanni Maria De Matteis, MD
Simona Fratini, MD
Fabrizio Tomai, MD
Carlo Bassano, MD
Alfonso Penta de Peppo, MD
Luigi Chiariello, MD

Objective: **Stentless biologic aortic valves are less obstructive than stented biologic or mechanical valves. Their superior hemodynamic performances are expected to reflect in better regression of left ventricular hypertrophy. We compared the regression of left ventricular hypertrophy in 3 groups of patients undergoing aortic valve replacement for severe aortic stenosis. Group I (10 patients) received stentless biologic aortic valves, group II (10 patients) received stented biologic aortic valves, and group III (10 patients) received bileaflet mechanical aortic valves.** ***Methods:*** **Echocardiographic evaluations were performed before the operation and after 1 year, and the results were compared with those of a control group. Left ventricular diameters and function, left ventricular wall thickness, and left ventricular mass were assessed by echocardiography.** ***Results:*** **Group I patients had a significantly lower maximum and mean transprosthetic gradient than the other valve groups (*P* = .001). One year after operation there was a significant reduction in left ventricular mass for all patient groups (*P* < .01), but mass did not reach normal values (*P* = .05). Although the rate of regression in the interventricular septum and posterior wall thickness differed slightly among groups, their values at follow-up were comparable and still higher than control values (*P* = .002). The ratio between interventricular septum and posterior wall and the ratio between wall thickness and chamber radius did not change significantly at follow-up.** ***Conclusions:*** **Because the number of patients was relatively small, we could not use left ventricular mass regression after 1 year to distinguish among patients undergoing aortic valve replacement for aortic stenosis by means of valve prostheses with different hemodynamic performances. (J Thorac Cardiovasc Surg 1998;116:590-8)**

Aortic valve replacement with a prosthetic valve in patients with aortic stenosis greatly reduces the afterload of the left ventricle, with consequent better hemodynamic performance and improved clinical status. Residual postoperative gradients are often present when small-sized prosthetic valves are implanted. The presence of this residual gradient has been considered to be the cause of the lack of regression or of the reduced regression of left ventricular hypertrophy that is the objective of optimal surgical treatment. Regression of left ventricular hypertrophy is a more direct parameter to quantify the reduced work of the left ventricle and therefore to judge the hemodynamic efficiency of the aortic valve substitute. Recently, biologic stentless aortic valves have been introduced in the clinical arena because of their optimal hemodynamic characteristics reflected by a significantly lower transprosthetic gradient than that of stented or mechanical valves of the same size.[1,2] Therefore their use appears particularly advantageous in the case of a small aortic anulus.

In a recently published study[3] in which we compared 2 groups of patients with aortic stenosis receiving bileaflet mechanical valves of different sizes, we did not find a significant difference in the regression of left ventricular hypertrophy 3 years after the operation. In the present study we wanted to test the hypothesis that the better hemodynamic performances of stentless valves were also reflected by a greater reduction in left

From the Cardiac Surgery Department, Tor Vergata University of Rome, Italy.

Received for publication Dec 22, 1997; revisions requested Jan 29, 1998; revisions received May 26, 1998; accepted for publication May 28, 1998.

Address for reprints: Ruggero De Paulis, MD, Cattedra di Cardiochirurgia, Università di Roma, Tor Vergata, European Hospital, via Portuense 700, 00149 Rome, Italy.

0022-5223/98 $5.00 + 0 **12/1/92148**

Table I. *Patient characteristics*

	Group I (stentless valve)	*Group II (stented valve)*	*Group III (mechanical valve)*	*Control (healthy subjects)*	P *value*
Age (y)	70.7 ± 3.3	73.6 ± 4.1	64.8 ± 8	61.3 ± 8.2	.01
Sex (M/F)	7/3	3/7	6/4	4/6	NS
BSA (m^2)	1.70 ± 0.1	1.69 ± 0.1	1.70 ± 0.1	1.71 ± 0.1	NS
Associated AI	2	2	2	—	NS
Valve size (mm)	24.1 ± 3.2*	21.4 ± 0.9	21.4 ± 0.9	—	.02
Anulus diameter/BSA	1.36 ± 0.1	1.27 ± 0.1	1.25 ± 0.1	—	NS
Diastolic blood pressure (mm Hg)	71.8 ± 8.7	70 ± 6.2	72 ± 10.4	73 ± 8.2	NS
Maximum gradient preop (mm Hg)	88.2 ± 28	101.2 ± 32	85.2 ± 30	—	NS

BSA, Body surface area; *AI*, aortic insufficiency; *NS*, not significant.
*Significantly different from groups II and III.

ventricular mass when compared with conventional prosthetic valves. Therefore we analyzed the regression of hypertrophy in 3 groups of patients who received a stentless, a stented, or a mechanical valve.

Patients and methods

Patient population. From January 1994 to January 1996, 158 patients underwent isolated aortic valve replacement. From among them we selected 30 consecutive patients who fulfilled the following criteria: (1) preoperative echocardiographic evaluation done at our institution; (2) absence of other associated valvular disease; (3) no history of hypertension or else mild hypertension well controlled with medical therapy; (4) normal left ventricular function; (5) no or trivial aortic regurgitation at follow-up; (6) a diameter between 21 and 23 mm for stented valves. Patients younger than 70 years received a mechanical valve prosthesis; patients older than 70 years received a biologic valve. The choice between stentless or stented biologic valves was based on the surgeon's preference. We obtained 3 groups of patients: Ten patients (group I) received a stentless aortic valve of various sizes (Toronto SPV [St Jude Medical, Inc, St Paul, Minn] and Sorin stentless valve [Sorin Biomedica, Saluggia, Italy] with a mean size of 24 ± 3.2).

Ten patients (group II) received a Hancock stented valve (Hancock Extracorporeal Inc, Anaheim, Calif), size 21 mm (8 cases) or size 23 mm (2 cases). Ten patients (group III) received a CarboMedics bileaflet mechanical valve (Sulzer Carbomedics Inc, Austin, Tex), size 21 mm (8 cases) or size 23 mm (2 cases). A fourth group of 10 healthy subjects, without heart disease on routine diagnostic echocardiography and without a history of systemic hypertension, served as a control group.

All patients were evaluated before the operation and after a mean time of 13 ± 6 months for group I, 15 ± 4 months for group II, and 12 ± 7 months for group III. For patients of groups I and III, an echocardiographic study was also available after a mean of 2 years' follow-up. The time frame of the study was 15 months. Medical ethics committee approval and informed patient consent for participation in the study were obtained in all cases.

Patient characteristics are shown in Table I. Because our policy is to implant biologic valves after the age of 70 years, patients receiving bioprostheses were slightly older than both the patients receiving mechanical valves and the control subjects. Although the difference was not significant, the group receiving stented bioprostheses contained a higher proportion of women than did the other groups. All patients had pure aortic stenosis; however 2 patients in each group had minimal evidence of aortic regurgitation. None of the patients had postoperative prosthetic valve insufficiency. Two patients in the groups receiving biologic valves and 1 patient in the group receiving mechanical valves had associated coronary artery disease. The diameter of the implanted prosthesis was significantly larger for patients receiving stentless valves than for the other patient groups. Diastolic pressure was an average of blood pressure as measured before the operation 3 times a day over a period of more than 4 consecutive days. Three patients in each group were receiving a daily dose of angiotensin-converting enzyme inhibitors (10 to 20 mg).

Echocardiographic measurements and calculations. At each follow-up period, M-mode, 2-dimensional, and Doppler echocardiography were performed with a Hewlett-Packard series 77025A echocardiograph with a 2.0 to 2.5 MHz transducer (Hewlett-Packard Company, Andover, Mass). Standard apical, parasternal, and subcostal views were obtained. The following parameters were measured: left ventricular end-diastolic and end-systolic diameters; ejection fraction and fractional shortening; interventricular septum and posterior wall thickness, and maximum and mean flow velocity across the valve.

Then the following parameters were calculated: (1) the ratio between interventricular septum and posterior wall thickness; (2) the ratio between left ventricular wall thickness (interventricular septum plus posterior wall thickness) and left ventricular chamber radius; (3) the left ventricular mass, which was calculated from the M-mode measurements by means of the formula modified by Devereux and Reicher[4]; (4) maximum and mean gradient, which were calculated by means of the modified Bernoulli equation. All values were indexed for the body surface area.

All parameters were measured and calculated independently by 2 expert echocardiographers. The echocardiograms were

The Journal of Thoracic and
Cardiovascular Surgery
October 1998

Table II. *Left ventricular diameters, left ventricular function, and mean gradient for patients receiving stentless bioprostheses (group I), stented bioprostheses (group II), and mechanical valves (group III) and for control subjects*

	Echocardiographic parameters					
	LVEDDi (mm/m²)	*LVESDi (mm/m²)*	*EF (%)*	*FS (%)*	*Maximum gradient (mm Hg)*	*Mean gradient (mm Hg)*
Group I						
Preoperative	28.8 ± 4.1	18.4 ± 4.5	67 ± 10	36 ± 10	88.2 ± 28	57.7 ± 20.4
Follow-up	26 ± 3.3	16.1 ± 2.8	68 ± 11	37 ± 9	15.1 ± 7.5*	7.9 ± 4*
Group II						
Preoperative	28.3 ± 4.7	18.4 ± 5.7	63 ± 12	34 ± 10	101.2 ± 32	61.1 ± 18.2
Follow-up	26 ± 3.6	16.3 ± 4.7	64 ± 11	35 ± 9	34.6 ± 12.6	18.2 ± 4.6
Group III						
Preoperative	29.4 ± 2	18.4 ± 1.9	65 ± 7	36 ± 6	85.2 ± 30	52 ± 22.4
Follow-up	27 ± 3	17.9 ± 2.4	61 ± 8	33 ± 6	29.5 ± 8.9	15.7 ± 3.8
Control	28.8 ± 2.7	18.9 ± 2.7	62 ± 10	34 ± 7	—	—

LVEDDi, Left ventricular end-diastolic diameter index; *LVESDi*, left ventricular end-systolic diameter index; *EF*, ejection fraction; *FS*, fractional shortening.
*P = .001 versus groups II and III.

reviewed by a third investigator if the first 2 investigators were not in agreement.

Statistical analysis. Two-factor repeated-measures analysis of variance with repeated measures on 1 factor was used to compare echocardiographic parameters in the 4 groups of patients. When significant differences were detected, pairwise comparisons were made by the Scheffé F test. Comparisons of the remaining continuous or discrete variables among groups were performed by means of an unpaired Student *t* test or a χ^2 test, respectively (SPSS for Windows Software, SPSS, Inc, Chicago, Ill). Data are expressed as mean ± 1 standard deviation unless otherwise indicated.

Results

At follow-up all patients had an improvement in functional class. The majority of patients (23/30, 77%) were in New York Heart Association (NYHA) class I. Three patients in group II and 2 patients each in the other groups were in NYHA class II.

Preoperatively, left ventricular diameters and function were comparable among study groups and not significantly different from the control group. At follow-up, all values changed slightly, remaining within the normal range (Table II).

As expected from their known optimal hemodynamic performances, stentless bioprostheses assured a significantly lower maximum and mean transprosthetic gradient that was independent of the size of the prosthesis implanted (P = .001) (Table II). One year after operation left ventricular mass index was significantly reduced (P < .01) for all patient groups, but it was still different from control values (P = .05). There were no significant differences in the rate of regression in left ventricular mass among the 3 groups of patients (Fig 1).

Group I patients (stentless valves) had a significant reduction in the interventricular septum (P = .03) and posterior wall (P = .04) thickness; group II patients (stented valve) had a significant reduction in the interventricular septum only (P = .01); group III patients (mechanical valves) had a significant reduction in the posterior wall (P = .04) and in the interventricular septum thickness, although in the latter it reached borderline statistical significance (P = .06) (Table III).

Although the rate of regression in the interventricular septum and posterior wall thickness appeared to be slightly different among patient groups, at follow-up there were no significant differences among the 3 groups in the ventricular wall thickness. Similar values were reached in the 3 groups, and they were still significantly higher than control values (P < .003) (Fig 2).

The ratio between interventricular septum and posterior wall and the ratio between left ventricular wall thickness and chamber radius (Fig 3) did not change significantly at follow-up and in all patient groups remained significantly different from control values.

Left ventricular mass index at 2 years in groups I (stentless valves) and III (mechanical valves) did not change significantly (137 ± 33 g/m² and 136 ± 35 g/m²; P = NS vs values at 1 year of follow-up, respectively).

Discussion

Stentless aortic valve prostheses have demonstrated better hemodynamic performances than stented biologic and mechanical valve prostheses.[2,5] Because of their peculiar anatomic features, their hemodynamic characteristics appear to be similar to those of homograft valves. These optimized hemodynamic characteristics should result in a more complete regression of left ventricular hypertrophy, which is known to be associated with cardiovascular morbidity and mortality.[6] Even

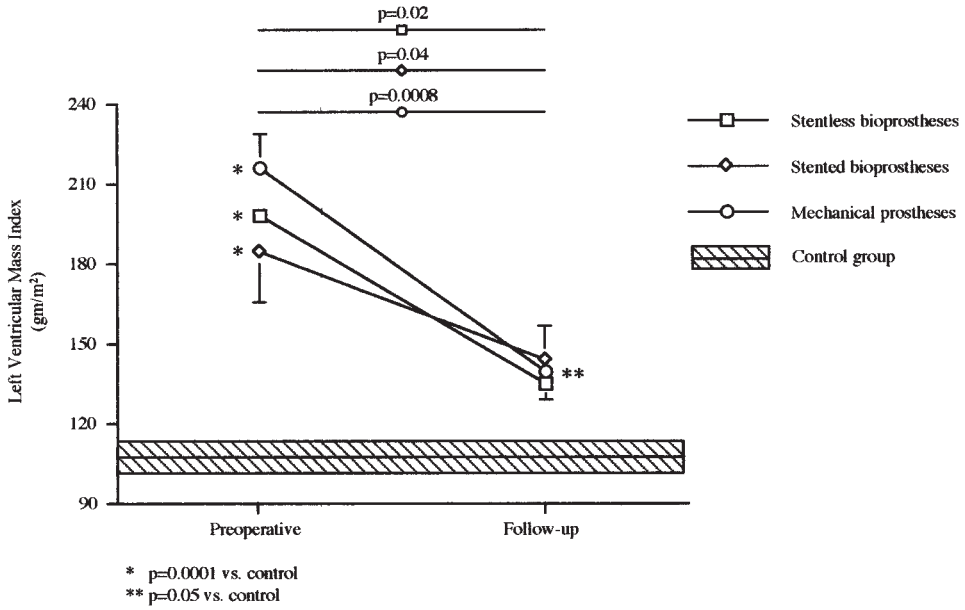

Fig 1. Mean values (± standard error of the mean) of left ventricular mass index in patients with stentless bioprostheses, stented bioprostheses, and mechanical prostheses referenced against the control group before the operation and at postoperative follow-up. A significant reduction in left ventricular mass is present for all groups of patients although it remained above the normal values. **P* = .0001 vs control; ***P* = 0.05 vs control.

Table III. *Left ventricular mass index, interventricular septum and posterior wall thickness, their ratio, and the ratio between left ventricular wall thickness and radius for patients receiving stentless bioprostheses (group I), stented bioprostheses (group II), and mechanical valves (group III) and for control subjects*

	Echocardiographic parameters				
	LV mass index (g/m^2)	*IVS (mm)*	*PW (mm)*	*IVS/PW*	*Th/r*
Group I					
Preoperative	198 ± 45	15.5 ± 2.4	13.1 ± 1.1	1.20 ± 0.1	0.57 ± 0.13
Follow-up	135 ± 32	13.2 ± 1.8	12.1 ± 1.3	1.12 ± 0.1	0.58 ± 0.1
Group II					
Preoperative	185 ± 56	14.6 ± 2.7	12.2 ± 1.3	1.22 ± 0.2	0.57 ± 0.12
Follow-up	144 ± 37	12.7 ± 2.2	12.2 ± 2.2	1.05 ± 0.1	0.59 ± 0.1
Group III					
Preoperative	216 ± 36	15 ± 2.1	13.4 ± 2.5	1.16 ± 0.3	0.57 ± 0.1
Follow-up	139 ± 31	12.7 ± 2.1	10.8 ± 1.7	1.17 ± 0.2	0.51 ± 0.1
Control	107 ± 17	9.4 ± 1.1	9.1 ± 1.1	1.04 ± 0.1	0.37 ± 0.05

LV, Left ventricle; *IVS,* interventricular septum; *PW,* posterior wall; *Th/r,* ratio between left ventricular thickness and radius (*P* values are indicated in Figs 1 to 3).

moderate left ventricular hypertrophy can often be the cause of arrhythmias, congestive heart failure, or sudden death.[7] Therefore the extent and rate of regression in left ventricular hypertrophy after aortic valve replacement has been considered an important determinant of long-term survival. The beneficial effects of a less obstructive valve have often been demonstrated, considering together patients with aortic stenosis and aortic insufficiency, as well as patients with good or depressed ventricular function. In this study we selected a group of patients with pure aortic stenosis and normal ventricular function in whom we thought it easier to observe and quantify the beneficial effect of an optimal reduction of afterload. Although patients with impaired ventricular function might receive greater clinical benefit from a minimal or absent transprosthetic gradient, regression in their left ventricular mass index would have been difficult to compare with that of patients with normal ven-

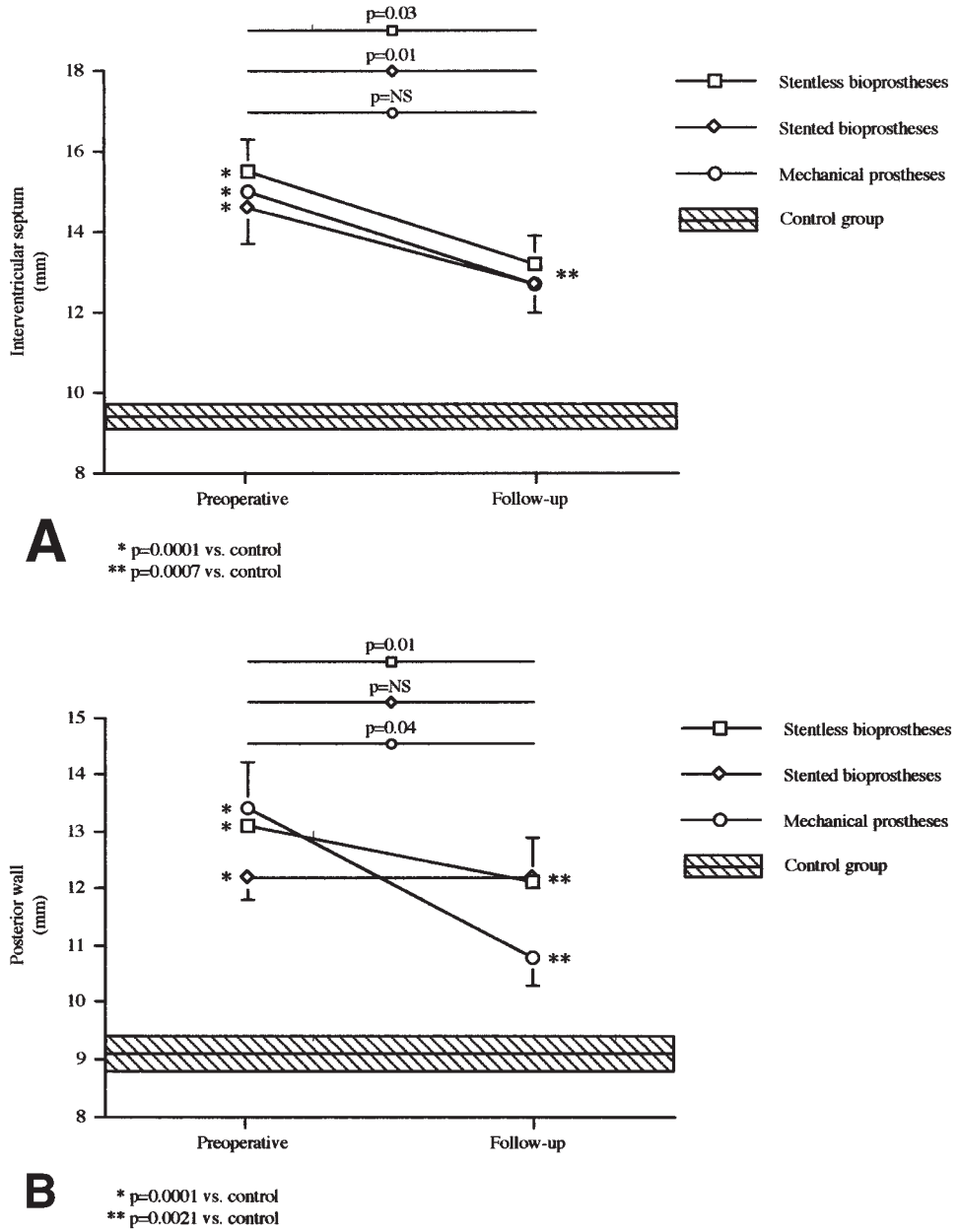

Fig 2. Mean values (± standard error of the mean) of interventricular septum **(A)** and left ventricular posterior wall thickness **(B)** in patients with stentless bioprostheses, stented bioprostheses, and mechanical prostheses referenced against the control group before the operation and at postoperative follow-up. A significant reduction in interventricular septum thickness is evident for all groups of patients, but at follow-up it was still significantly different from control values **(A).** Posterior wall thickness decreased significantly in group I and group III patients only, but in all groups it remained significantly higher than control values **(B).** **P* = .0001 vs control; ***P* = .0021 vs control.

tricular function. We found that all patients operated on for aortic stenosis had a significant reduction in left ventricular mass irrespective of the type of valve substitute. The reduction of the afterload after valve replacement was sufficient to cause in all patients a similar reduction of the left ventricular hypertrophy to a certain point, after which it decreased to a slower rate. We were expecting a much greater reduction in left ventricular mass in patients with stentless valves, especially because we had selected patients with relatively small-diameter biologic stented or mechanical valves. Patients with stentless valves showed a 32% reduction in left ventricular

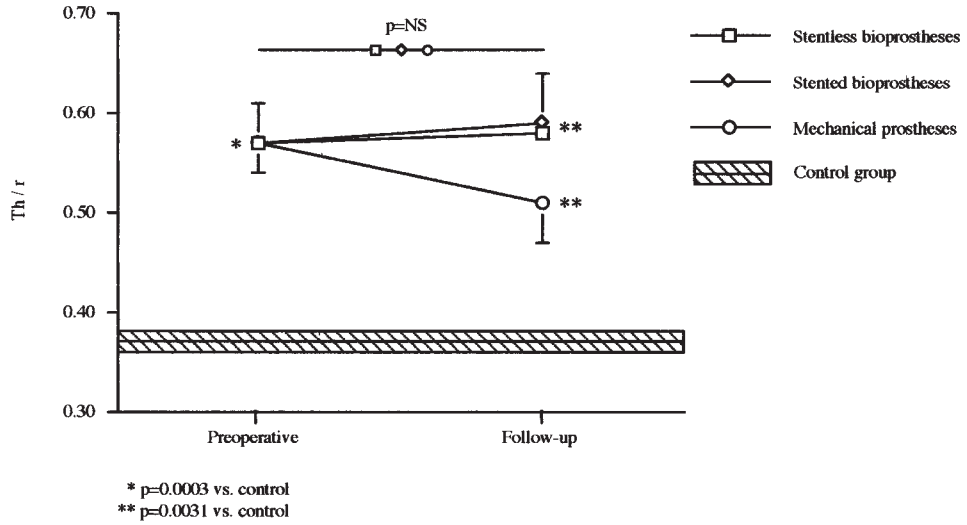

Fig. 3. Mean values (± standard error of the mean) of left ventricular wall thickness/chamber radius ratio *(Th/r)* in patients with stentless bioprostheses, stented bioprostheses, and mechanical prostheses referenced against the control group before the operation and at postoperative follow-up. There were no significant differences between the preoperative and postoperative results.

hypertrophy, compared with 28% for patients with stented biologic valves and 36% for patients with mechanical valves. Although at follow-up stentless valves showed a symmetric reduction in the left ventricular wall thickness that was more evident in the interventricular septum for stented biologic valves and in the posterior wall for mechanical valves, their final values were comparable and still higher than control values.

Very recently, many studies have shown a greater regression in left ventricular mass after aortic valve replacement with stentless valves than with classic valve substitutes.[8,9] Christakis and associates[10] did not find that the type of prosthesis could influence the extent of mass regression in the early postoperative period.[10] However, the same group reported an optimized mass regression with stentless valves after 1 year of follow-up.[11] Jin and colleagues,[12] who evaluated the regression of left ventricular hypertrophy in a large number of patients after aortic valve replacement with different types of valve substitutes, showed that the patient with a stentless or homograft valve had a greater reduction in the left ventricular mass than the patient who received a stented biologic or mechanical valve. After a follow-up period of more than 3 years, they reported a left ventricular mass index of 145 g/m^2 for all patients with aortic stenosis and 144 g/m^2 for patients with a stentless valve. Similarly, Gonzalez-Juanatey and associates,[13] who observed the changes in left ventricular mass in a group of patients with different sizes of biologic or mechanical valves, demonstrated a more complete regression in left ventricular hypertrophy in patients with larger valves. The left ventricular mass index was 137 g/m^2 for patients receiving 19 mm aortic prostheses and 124 g/m^2 for those receiving 25 mm aortic prostheses, with a rate of reduction of about 10% and 28%, respectively. However, although both studies demonstrated a greater reduction in left ventricular mass index in patients with lower transprosthetic gradients (homograft valve in 1 case and larger biologic or mechanical valve in the second case), the postoperative values in left ventricular mass and the rate of reduction from preoperative levels were similar to ours and still different from control values. Sim and associates,[14] who also demonstrated, after a follow-up period of 3 years, a less-pronounced reduction in left ventricular mass in patients with 19 mm stented or mechanical valves compared with similar valves of larger diameters, reported a postoperative mass index of 120 g/m^2 (with a preoperative value of only 129 g/m^2) that was not different from the postoperative mass index of patients with larger valves (ie, 125 g/m^2 for patients receiving 25 mm aortic prostheses). Finally, Lund and coworkers[15] recently analyzed the impact of size mismatch in a group of patients operated on for aortic stenosis with different sizes of St Jude Medical valves. After a mean period of 18 months their left ventricular mass index was 153 ± 53 g/m^2 with a posterior wall thickness of 12 ± 2 mm. Noteworthy, they found that small valve orifice diameter and valve prosthesis size mismatch (along with left ventricular

end-diastolic dimension and impaired left ventricular function) were independent determinants of Doppler gradients. Most interestingly, they did not find a correlation between the 18-month gradient and the left ventricular mass index or the rate of reduction in the left ventricular mass index from the preoperative level. These results led them to the conclusion that the incomplete hypertrophy regression could not be ascribed to the relatively obstructive mechanical prostheses.

There are several reasons why regression of left ventricular hypertrophy is incomplete after aortic valve replacement for aortic stenosis. First, the left ventricular myocardial collagen fibrosis especially in the interventricular septum might take a much longer time to return to normal or the myocardial structural abnormality might never regress in patients with truly pathologic hypertrophy.[16] Second, other host-related factors should be taken into consideration. Age is known to be an independent factor of left ventricular hypertrophy.[17] Lindroos and associates,[18] who evaluated the amount of left ventricular hypertrophy in an old patient population, found that the increase of left ventricular mass is due partly to age-related disease but also partly to an independent effect of age. The left ventricular mass was often found to exceed 70% of the standard limits in the oldest patient cohort (85 years old). Although our patients receiving mechanical valves or control valves were slightly younger than patients receiving biologic valves, the differences seem too small to justify an age-dependent difference in left ventricular mass index. Gender should also be considered, because left ventricular mass, when indexed either for body surface area or height, has been found to be greater in men than women.[19] However, female patients show a greater increase in left ventricular mass with advanced age, apparently because of the higher incidence of obesity in elderly women. Therefore it is unlikely that the high proportion of women in the group receiving stented biologic valves could have influenced the differences in left ventricular mass regression among our patient groups. Hypertension that is often present in an elderly patient population might significantly influence the rate of regression of left ventricular hypertrophy. In our study we excluded patients with evidence of hypertension, but we cannot rule out that patients with a blunted nocturnal fall in blood pressure might have an increased left ventricular mass. However, Verdecchia and coworkers[20] demonstrated that, at least in hypertensive men, daytime hypertension was a sufficient determinant of left ventricular wall thickening independent of the presence or absence of a nocturnal fall in blood pressure. Finally, the classic index of left ventricular mass for body surface area might be inappropriate. Lauer and associates[21] recently suggested a new method of indexing, independent of obesity, that might reduce the variability associated with body size and gender.

All these considerations indicate that in an elderly population (ie, those most likely to receive a bioprosthesis) with reduced physical activity who often have hypertension and have had aortic stenosis for a great number of years, it might be difficult to observe a complete regression of left ventricular mass and to ascribe it to the type of valve substitute. Conversely, differences in the rate of regression of left ventricular hypertrophy could be easier to detect in a young patient population with a greater increase in cardiac output during daily activity. It is also possible that other parameters rather than the simple assessment of left ventricular mass could be more sensitive markers of the beneficial effects of an optimal reduction of ventricular pressure load. Noteworthy, Jin and colleagues[12] showed that patients with less obstructive valve prostheses (homograft or stentless biologic valves) had a substantially greater increase in the rates of dimensional shortening and wall thickening than patients with stented valve prostheses. They[22] had also previously shown that an early decrease in peak systolic stress was 50% greater after aortic valve replacement with a stentless valve than with a stented one. Additionally or alternatively to these more sensitive parameters, a more appropriate index could better help in distinguishing differences in left ventricular hypertrophy between patients with different valve substitutes.

One year of follow-up appears to be sufficient to assess the regression of left ventricular hypertrophy in patients undergoing aortic valve replacement. Jin and associates[12] found no differences in left ventricular mass or in left ventricular structure and function between 6 months and 3 years of follow-up. We also demonstrated in a group of patients operated on for aortic stenosis with different sizes of mechanical valves that the left ventricular mass index was not different between 1 year and 3 years of follow-up.[3] Similarly, in 2 groups of patients of the present study (group I and group III) in whom a longer follow-up of 2 years was also available, no changes in left ventricular mass index were present. Monrad and coworkers[23] had already clearly demonstrated that the regression of left ventricular hypertrophy is maximal within the first year of follow-up and that more than 8 years are necessary to detect a further reduction of ventricular mass. They considered only patients with different types of stented biologic or mechanical valves; therefore we cannot exclude the possibility that stentless valves or homografts will behave differently. Del Rizzo and col-

leagues,[11] after a careful follow-up of the Toronto SPV stentless valve, reported a progressive decrease in left ventricular mass index within the first year of follow-up but no differences in left ventricular mass regression between 1 year and 3 years of follow-up.

It is intuitive that an aortic valve prostheses with optimized hemodynamic performance and minimal or no residual postoperative gradient should result in better ventricular structure and function. In this study the simple assessment of left ventricular hypertrophy did not discriminate between patients with different types of valves after an intermediate period of follow-up. However, even when the beneficial effect of stentless valves on left ventricular mass regression becomes clear, it will be necessary to demonstrate that the incomplete regression of left ventricular mass after aortic valve replacement is sufficient to determine differences in clinical status or in overall survival. Large clinical trials comparing survival and cardiac related events within patients with stented and stentless valves are therefore warranted.

Limitations of the study. The major limitation of this study is the fact that patients were not randomized to receive a different type of valve prosthesis. Although selection criteria were very strict and most of the clinical variables were not different between the population groups, many other factors that could conceivably contribute to differences might not have been included. Selection bias often can be difficult to describe. However, inasmuch as the result of this study was different from what we were expecting, the possibility of selection bias may be attenuated. Our control patients were slightly younger than those in the study groups and might not have been an accurate basis for comparison, especially for patients receiving biologic implants. Nevertheless, control values are easily available in the literature. Finally, the relatively small group of patients considered indicates a low statistical power of the study. On the basis of the data on left ventricular mass regression available in the literature, and to identify a 25% decrease in left ventricular mass, a larger number of patients was necessary. Although, the statistical power of the study calculated from our data appears to be sufficiently high (from 87% to 95% for pairwise comparisons, at an α level of .05) it carries a strong β error. Obviously, a larger number of patients would have strengthened the results and improved the study. The strict selection of patients and the accuracy of follow-up has prevented us from concluding a larger study in a relatively short period of time. However, we think that the information obtained from this study is sufficient to show the need of a large randomized trial comparing different valve substitutes.

We thank A. Parma, MD, MSc, for his assistance in the statistical analysis of our data.

REFERENCES

1. David TE, Pollick C, Bos J. Aortic valve replacement with stentless porcine aortic bioprosthesis. J Thorac Cardiovasc Surg 1990; 99:113-8.
2. Casabona R, De Paulis R, Zattera GF, et al. Stentless porcine and pericardial valve in aortic position. Ann Thorac Surg 1992;54: 681-5.
3. De Paulis R, Sommariva L, De Matteis GM, et al. Extent and pattern of regression of left ventricular hypertrophy in patients with small size CarboMedics aortic valves. J Thorac Cardiovasc Surg 1997;113:901-9.
4. Devereux RB, Reicher N. Echocardiographic determination of left ventricular mass in man. Circulation 1977;55:614-8.
5. David TE, Feindel CM, Bos J, Sun Z, Scully HE, Rakowsky H. Aortic valve replacement with a stentless porcine aortic valve. J Thorac Cardiovasc Surg 1994;108:1030-6.
6. Bikkina M, Larson MG, Levy D. Asymptomatic ventricular arrhythmias and mortality risk in subjects with left ventricular hypertrophy. J Am Coll Cardiol 1993;22:1111-6.
7. Ghali JK, Liao Y, Simmons B, Castaner A, Cao G, Cooper RS. The prognostic role of left ventricular hypertrophy in patients with or without coronary artery disease. Ann Intern Med 1992; 117:831-6.
8. Whalter T, Falk V, Diegler A, Schilling L, Autschbach R, Mohr FW. Left ventricular remodeling after stentless aortic valve replacement. In: Stentless bioprostheses [abstract book]. Second International Symposium, Noordwijk, The Netherlands: 1997. p. 71.
9. Del Rizzo DF, Sever J, Christakis GT, Fremes SE, Goldman BS. Left ventricular remodeling following aortic valve replacement with the Toronto SPV valve. In: Stentless bioprostheses [abstract book]. Second International Symposium, Noordwijk, The Netherlands. 1997. p. 67.
10. Christakis GT, Joyner CD, Morgan CD, et al. Left ventricular mass regression early after aortic valve replacement. Ann Thorac Surg 1996;62:1084-9.
11. Del Rizzo DF, Goldman BS, Christakis GT, David TE. Hemodynamic benefits of the Toronto stentless valve. J Thorac Cardiovasc Surg 1996;112:1431-46.
12. Jin XY, Zhong ZM, Gibson DG, Yacoub MH, Pepper JR. Effects of valve substitute on changes in left ventricular function and hypertrophy after aortic valve replacement. Ann Thorac Surg 1996;62:683-90.
13. Gonzalez-Juanatey JR, Garcia-Acuna JM, Vega M, et al. Influence of the size of aortic valve prostheses on hemodynamics and change in left ventricular mass: implications for the surgical management of aortic stenosis. J Thorac Cardiovasc Surg 1996; 112:273-80.
14. Sim EKW, Orszulak TA, Schaff HV, Shub C. Influence of prosthesis size on change in left ventricular mass following aortic valve replacement. Eur J Cardiothorac Surg 1994;8:293-7.
15. Lund O, Emmertsen K, Nielsen TT, et al. Impact of size mismatch and left ventricular function on performance of the St. Jude disc valve after aortic valve replacement. Ann Thorac Surg 1997;63:1227-34.
16. Krayenbuehl HP, Hess OM, Monrad ES, Schneider JS, Mall G, Turina M. Left ventricular myocardial structure in aortic valve disease before, intermediate, and late after aortic valve replacement. Circulation 1989;79:744-55.

17. Messerli FH. Clinical determinants and manifestations of left ventricular hypertrophy. In: Messerli FH, editor. The heart and hypertension. New York: Yorke Medical Books; 1987. p. 219-30.
18. Lindroos M, Kupari M, Heikkila J, Tilvis R. Echocardiographic evidence of left ventricular hypertrophy in a general aged population. Am J Cardiol 1994;74:385-90.
19. Shub C, Klein AS, Zachariah PK, Bailey KR, Tajik AJ. Determination of left ventricular mass by echocardiography in a normal population: effect of age and sex in addition to body size. Mayo Clin Proc 1994;69:205-11.
20. Verdecchia P, Schillaci G, Borgioni C, et al. Gender, day-night blood pressure changes, and left ventricular mass in essential hypertension: dippers and peakers. Am J Hypertens 1995;8:193-6.
21. Lauer MS, Anderson KM, Larson MG, Levy D. A new method for indexing left ventricular mass for differences in body size. Am J Cardiol 1994;74:487-91.
22. Jin XY, Gibson DG, Yacoub MH, Pepper JR. Perioperative assessment of aortic homograft, Toronto stentless valve, and stented valve in aortic position. Ann Thorac Surg 1995;60:S395-401.
23. Monrad ES, Hess OM, Murakami T, Nonogi H, Corin WJ, Krayenbuehl HP. Time course of regression of left ventricular hypertrophy after aortic valve replacement. Circulation 1988; 77:1345-55.