ARCHIVES OF ACOUSTICS
9, 1-2, 267-274 (1984)

ECHOCARDIOGRAPHY IN THE FOLLOW-UP OF PATIENTS WITH PROSTHETIC HEART VALVES

E. KOUDELKOVÁ, A. GROŠPIC,
P. NIEDERLE

Institute for Clinical and Experimental Medicine, Prague, Czechoslovakia

In 26 patients with aortic and in 25 with mitral valve disease changes in the size, hypertrophy and function of the left ventricle (LV) within 2 years of aortic or mitral valve replacement were evaluated and compared with the preoperative echocardiographic findings.

LV size decreased significantly within the first month after aortic valve replacement as well as after operation for pure or predominant mitral insufficiency. LV hypertrophy regressed in both groups of aortic valve disease. However, in patients with maximum LV dilatation and hypertrophy valve replacement failed to effect complete normalization of LV size and mass. Postoperative evaluation of LV function showed a distinct improvement in patients operated for aortic stenosis. In the groups of patients with mitral stenosis and pure aortic or mitral insufficiencies no significant change of LV function after surgery was demonstrated.

Preoperative echocardiographic measurements of the LV end systolic dimension and the end systolic wall stress proved to be very useful noninvasive predictors of long-term postoperative changes of the LV function after surgical correction of the aortic or mitral valve disease.

1. Introduction

The noninvasive evaluation of postoperative changes of the left ventricular size, hypertrophy and function in patients after heart valve replacement provides useful data about the reversibility of morphological and functional abnormalities of the left ventricle after surgical correction of the valvular disease. In this study, the patients after successful aortic and mitral valve replacement were followed-up up to 2 years after operation and preoperative echocardiographic findings of the patients with reversible left ventricular dilatation, hypertrophy and dysfunction were compared with those of patients with ir-

reversible left ventricular impairment. We tried to answer the question if any of the preoperative echocardiographic parameters can be valuable in predicting the long-term postoperative course and in detecting the patients at high risk of irreversible dysfunction of the left ventricle.

2. Methods

Using *M*-mode echocardiography, we examined 26 patients with aortic and 25 patients with mitral valve disease within a month before and after implantation of the Björk-Shiley prosthetic valve. Fifteen patients underwent valve replacement for predominant aortic stenosis, 11 patients for aortic insufficiency. In the mitral valve disease group, 15 patients had pure or predominant mitral stenosis with calcification or advanced fibrosis of the mitral valve, 10 patients had pure mitral insufficiency. Echocardiography was performed with an Echocardio-Visor 03 system (Organon Teknika — Holland), using a standard technique of left ventricular measurements. Echocardiographic parameters of the left ventricle that were evaluated in half-year intervals up to 2 years after operation, are summarized in Table I. From the measurements of the end-diastolic diameter and wall thickness, the left ventricular mass was calculated according to the formula recommended by Teichholz. The index R/Th represents the end-diastolic (or end-systolic) radius to the wall thickness ratio and provides important information about the character of hypertrophy. The wall thickness was calculated as the average of the posterior wall and the septal thicknesses.

Table 1. Echocardiography — LV measurement

Size	Hypertrophy	Function
D_d	T_{PW}	FS
D_s	T_{IVS}	EF
	LVM	V_{CF}
	R/Th	ESS

D_d — end-diastolic left ventricular dimension, D_s — end-systolic dimension, T_{PW} — left ventricula posterior wall thickness at end-diastole, T_{IVS} — interventricular septal thickness at end-diastole, LVM — left ventricular mass, R/Th — end-systolic radius to wall thickness ratio, FS — fractional shortening, EF — ejection fraction, V_{CF} — mean velocity of circumferential fiber shortening, ESS — end-systolic left ventricular wall stress.

The end-systolic stress, the recently developed noninvasive index of the left ventricular peak circumferential wall stress, was derived in the groups of patients with pure aortic or mitral insufficiency from the product of peak systolic arterial blood pressure, measured by a cuff manometer, and echocardiographic end-systolic radius to the wall thickness ratio, using the formula recommended by Quinones [4].

3. Results

Examination after aortic valve replacement demonstrated normalization of the left ventricular size in most patients within the first month after surgery (Fig. 1). However, in patients with maximum dilatation of the left ventricle before operation, despite a significant decrease in the end-diastolic dimension in the first month after replacement, the left ventricular size failed to normalize completely in the following postoperative period.

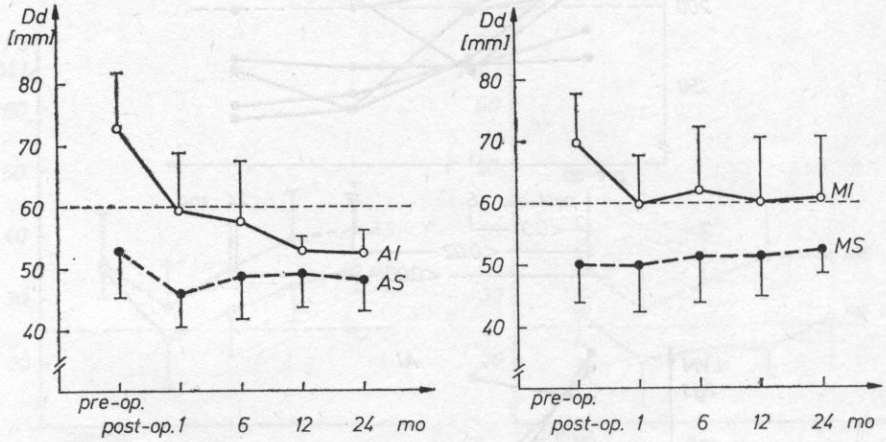

Fig. 1. Postoperative changes of the left ventricular end diastolic dimension (D_d) after aortic and mitral valve replacement. AI — aortic insufficiency, AS — aortic stenosis, MI — mitral insufficiency, MS — mitral stenosis

The left ventricular hypertrophy regressed significantly after aortic valve replacement, both for predominant aortic stenosis and predominant or pure aortic insufficiency (Fig. 2). However, echocardiographic as well as electrocardiographic signs of left ventricular hypertrophy normalized only in patients with a lesser degree of left ventricular hypertrophy before operation.

In a group of patients operated for aortic stenosis, the postoperative follow-up showed a distinct improvement of the echocardiographic parameters of the left ventricular function (Fig. 3). On the other hand, in the group of patients with aortic insufficiency no significant change in left ventricular functional parameters was demonstrated both 1 and 2 years after operation in comparison with the preoperative values.

In mitral stenoses, the size of the left ventricle did not change after operation. In the group of patients with predominant mitral insufficiency, mitral valve replacement was followed by a significant diminution of left ventricular dimensions (Fig. 1). This notwithstanding, the left ventricle remained enlarged in more than a half of those patients. Moreover, no significant improvement

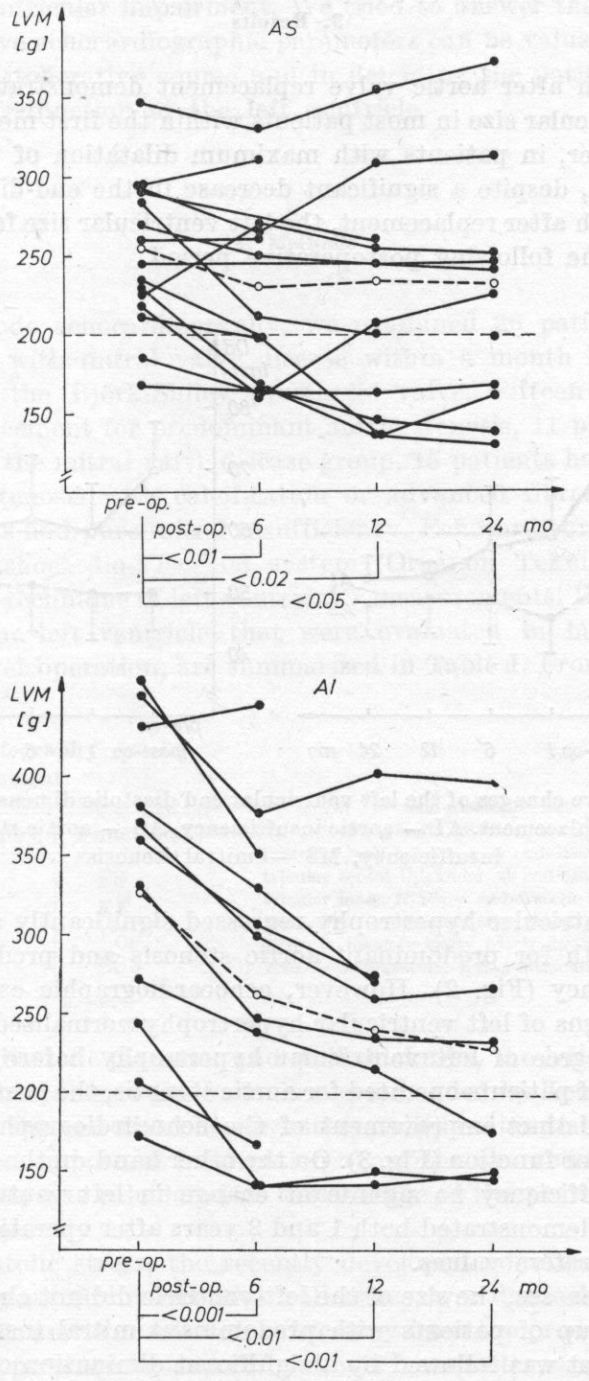

Fig. 2. Postoperative changes of the left ventricular mass after valve replacement for predominant aortic stenosis (AS) and aortic insufficiency (AI)

of the left ventricular function was found after operation for predominant mitral insufficiency in the patients with the evidence of left ventricular dysfunction before operation (Fig. 3).

Comparison of the preoperative echocardiographic parameters of the left ventricle in patients with reversible left ventricular dilatation and dysfunction with those with irreversible left ventricular impairment showed that the combination of a marked end-systolic dilatation of the left ventricle with inappropriate hypertrophy, which resulted in an increase in the wall stress, was the most sensitive and specific index determining patients at high risk for persistent

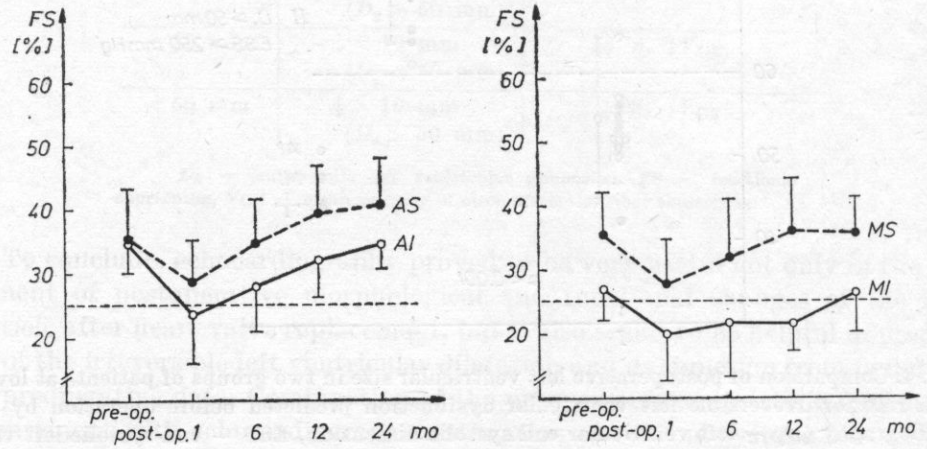

Fig. 3. Postoperative changes of echocardiographic parameters of the left ventricular systolic function after aortic and mitral valve replacement (FS — fractional shortening)

left ventricular dilatation and dysfunction. All patients with preoperative end-systolic dimension greater than 50 mm and simultaneously increased end-systolic left ventricular wall stress above the value of 250 mm Hg, had a marked and progressive left ventricular dysfunction after surgery, when evaluating postoperative echocardiographic parameters of the systolic ejection function of the left ventricle (fractional shortening and ejection fraction), as well as parameters of left ventricular contractility (especially the mean rate of circumferential fiber shortening). Five of the 8 patients in this high risk group failed to improve after surgery and had symptoms of chronic cardiac decompensation (III-IV class of the NYHA), 2 patients died due to congestive heart failure. Figs. 4 and 5 show a significant postoperative difference in the left ventricular size and parameters of function in two groups of patients with good and bad prognosis that can be separated using the above mentioned preoperative echocardiographic indexes.

Only a marked end-systolic dilatation of the left ventricle before operation, even with a simultaneous decrease in the left ventricular wall stress can be

reversible and the left ventricular function can improve after operation even in these cases. We found that the long-term improvement of the left ventricular function after operation depends on the early change of the end-systolic dimension of the left ventricle within the first month after surgery. This change when evaluated simultaneously with preoperative parameters of the left ventricular function, seems to be useful in prediction of the long-term postoperative course and in identifying the patients, in whom we can expect an improvement of the

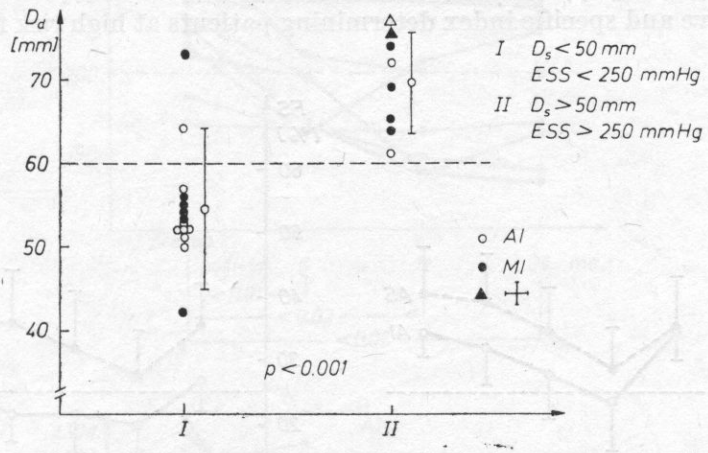

Fig. 4. Comparison of postoperative left ventricular size in two groups of patients at low and high risk for irreversible left ventricular dysfunction predicted before operation by echocardiography (D_s — left ventricular end systolic dimension, ESS — end-systolic left ventricular wall stress)

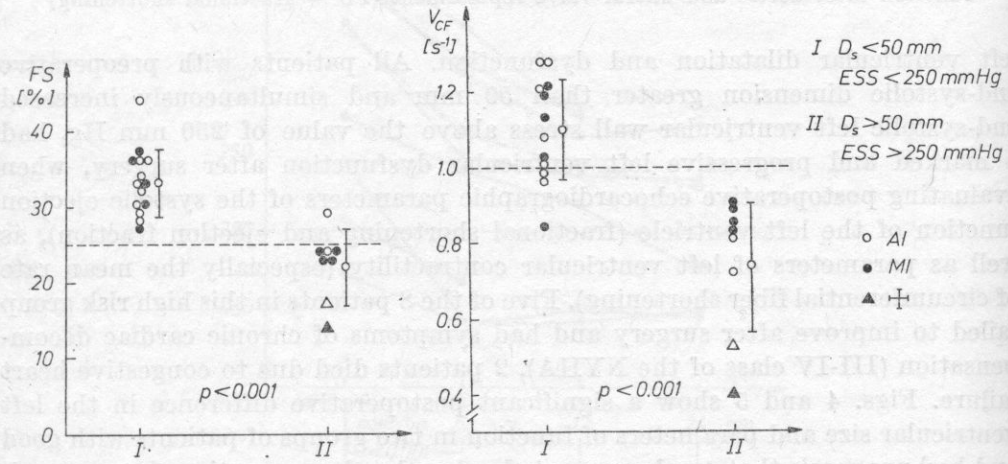

Fig. 5. Comparison of postoperative values of echocardiographic functional parameters in two groups of patients at low and high risk for irreversible left ventricular dysfunction predicted before operation by echocardiography. FS — fractional shortening, V_{CF} — mean velocity of circumferencial fiber shortening of left ventricle, D_s — end-systolic left ventricular dimension, ESS — end-systolic left ventricular wall stress

left ventricular function from those with persistent or progressive impairment of the left ventricular function (Table 2).

Table 2. Prediction of postoperative changes of LV function

Pre-op. D_s	ΔD_s 1 month after op.	ΔLV function 1–2 years after op.
> 50 mm	$\downarrow$ > 10 mm (D_s < 50 mm)	$\uparrow$FS, $\uparrow V_{CF}$
> 50 mm	$\downarrow$ < 10 mm (D_s > 50 mm)	$\downarrow$FS, $\downarrow V_{CF}$
< 50 mm	$\downarrow$ < 10 mm (D_s < 50 mm)	$\downarrow$FS, $\downarrow V_{CF}$
< 50 mm	$\downarrow$ > 10 mm (D_s > 50 mm)	$\downarrow$FS, $\downarrow V_{CF}$

D_S – end-systolic left ventricular dimension, FS – fractional shortening, V_{CF} – mean velocity of circumferential fiber shortening

To conclude, echocardiography proved to be very useful not only in the assessment of postoperative morphological and functional changes of the left ventricle after heart valve replacement, but it also seems to be helpful in prediction of the irreversible left ventricular dilatation and dysfunction from noninvasive preoperative data. Combination of the preoperative end-systolic dimension measurement with echocardiographic estimation of the end-systolic left ventricular wall stress was superior to the end-diastolic dimension measurement or calculation of echocardiographic indexes of the left ventricular systolic function in identifying patients at high risk for persistent or progressive left ventricular impairment. If both end-systolic left ventricular dimension and end-systolic wall stress were increased above the cut off values, more accurate prediction could be made. If only end-systolic dilatation of the left ventricle was present before operation, it was helpful to assess the early change in the parameter simultaneously with preoperative values of dilatation and the function of the left ventricle that correlated well with long-term postoperative changes in the left ventricular function and was valuable in prediction of normalization versus persistence of the preoperative left ventricular dysfunction. Our preliminary results were promising, but the groups of patients operated for pure aortic and mitral insufficiencies are still small. Therefore further studies will be necessary to verify the results on a greater number of patients.

References

[1] B. A. Carabello, N. P. Stanton, L. B. McQuire, *Assessment of preoperative left ventricular function in patients with mitral regurgitation. Value of the end systolic wall stress-send-systolic volume ratio,* Circulation, **64**, 6, 1212-1217 (1981).

[2] W. H. Gaasch *et al., Chronic aortic regurgitation. Prognostic value of left ventricular end-systolic dimension and end-diastolic radius thickness ratio,* J. Am. Coll. Cardiol, **1**, 3, 775-782 (1983).

[3] A. G. Kumpuris *et al., Importance of preoperative hypertrophy, wall stress and end-systolic dimension as echocardiographic predictors of normalization of left ventricular dilatation after valve replacement in chronic aortic insufficiency,* Amer. J. Cardiol, **49**, 5, 1091-1100 (1982).

[4] M. A. Quinones *et al., Noninvasive quantification of left ventricular wall stress. Validation of method and application to assessment of chronic pressure overload,* Amer. J. Cardiol, **45**, 4, 782-790 (1980).

[5] G. Schuler *et al., Temporal response of left ventricular performance to mitral valve surgery,* Circulation, **59**, 6, 1218-1230 (1979).