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Echocardiographic prediction of preservation of left ventricular function after surgical correction for severe aortic regurgitation

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Background

Left ventricular (LV) dysfunction is an indication for surgical correction of aortic valve in patients with severe aortic regurgitation (AR). This study sought to determine whether echocardiographic variables before surgery for AR predict postoperative LV dysfunction.

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Methods and Results

We studied 55 patients (20–85 years old, mean age 58 years old) with isolated AR who underwent surgical correction (aortic valve replacement or repair). Echocardiographic studies were performed in preoperative and postoperative (14.3±1.8 months after surgery) periods. The incidence of postoperative LV dysfunction (left ventricular ejection fraction (LVEF) <50%) was 25% (14/55). The incidence of postoperative LV dysfunction was high in patients with preoperative LVEF<50% (11/24, 46%), preoperative LV end-systolic dimension (LVESD) >50mm (6/14, 43%), preoperative LV end-diastolic dimension (LVEDD) >70mm (2/3, 67%), preoperative LVESD normalized to body surface area (LVESD/BSA) ≥25mm/m2 (12/28, 42%). The optimal cutoff value for LVESD/BSA to predict the postoperative normalization of LVEF (LVEF≥50%) was 26.5mm/m2 with a sensitivity of 86% and a specificity of 70%, whereas LVEDD of 62mm had 64% sensitivity and 71% specificity, LVESD of 47mm had 79% sensitivity and 77% specificity.

Conclusion

In patients with AR, LVEF<50% and/or LVESD/BSA≥26.5mm/m^2 should be carefully considered for surgical intervention, which reduces the risk of post operative LV dysfunction.

Key words

Aortic regurgitation, echocardiography, function

Current guidelines suggest surgical intervention in severe aortic regurgitation (AR) if there are significant symptoms or at the onset of signs of LV dysfunction, such as an ejection fraction (EF) of ≤50% or significant left ventricular (LV) dilatation with an end-diastolic dimension (EDD) of >70–75 mm and/or end-systolic dimension (ESD) of >50–55 mm [1,2]. Previous studies demonstrated that patients with severe or moderately severe AR and conservative management incur excess mortality compared with expected, excess mortality in patients with severe symptoms, and excess mortality rate in patients asymptomatic with LVEF<55% or LVESD normalized to body surface area ≥25 mm/m^2 [2,3–5].

The postoperative outcome for patients with a reduced EF depends on the magnitude of the reduction of EF. These patients generally have an improvement in the EF postoperatively as a result of relief of the high afterload [6,7]. In contrast, LVEF is a powerful predictor of cardiovascular outcome in heart failure patients across a broad spectrum of ventricular function [8,9]. It still remains a clinical dilemma when a physician should recommend surgery to a patient experiencing AR with minimal symptoms in order to preserve the postoperative LV function. The purpose of this study was to determine whether echocardiographic indices before aortic valve surgery are predictive of postoperative LV function and useful for deciding the optimal timing of aortic valve surgery.

Methods

Patients

This study was based on a retrospective review of our experience with aortic valve surgery for isolated AR. The inclusion criteria were (1) surgical correction (repair or replacement) of AR performed between January 1, 2001 and December 31, 2005; and (2) immediate postoperative survival allowing for observation of late after surgery. Patients with associated coronary artery bypass graft surgery or ascending aortic surgery were included. The exclusion criteria were (1) moderate to severe aortic stenosis; (2) aortic dissection; (3) previous operation for AR; (4) previous or associated mitral valve replacement (tricuspid valve repair was not excluded); (5) infective endocarditis; and (6) operative death, defined as occurring during the first postoperative month or within the same hospitalization.

Fifty-five patients had aortic valve operations due to isolated severe AR and had echocardiographic studies immediately before surgery and late after surgery (at least 6 months after surgery). Of the 55 patients, the mean age was 58±16 years, 42 (76%) were men, and 11 (20%) were in atrial fibrillation. The cause of AR was defined as degenerative (33 patients), rheumatic (8 patients), aortic root dilatation (6 patients), bicuspid aortic valve (5 patients), and aortic valve prolapse (3 patients). Before surgery, 24 patients were in *New York Heart Association* functional class III or class IV. The surgical procedure performed was valve repair in 11 patients and valve replacement in 44 (bioprosthesis in 11 patients and mechanical prosthesis in 30). Coronary artery bypass graft surgery was performed in 4 patients and ascending aortic surgery was performed in 7 patients.

Echocardiography

Echocardiographic examinations were performed within 1 month before and late after surgery (at least 6 months after surgery). Before surgery, the degree of AR was determined by color flow Doppler method and 2 quantitative methods: 1) quantitative Doppler using aortic and mitral stroke volumes, allowing calculation of regurgitant volume and regurgitant fraction, and 2) the proximal isovelocity surface area method to calculate ERO area [10]. LV end-diastolic dimensions (LVEDD) and end-systolic dimensions (LVESD) were measured using 2D parasternal long-axis view. LV end-diastolic and end-systolic volumes and EF were measured by the biapical Simpson's disk method [11].

Statistical Analysis

Results are presented as mean ± SD. To determine whether the difference in the values between the 2 groups was statistically significant, a paired t test was performed; the level of significance was set to $P<0.05$. Receiver-operating curves were generated for comparison of pre-operative echocardiographic indices for discriminating patients with or without LV dysfunction late after aortic valve replacement (AVR).

Results

The preoperative and late after surgery (mean 14.8±1.8 months) echocardiographic data of the study patients are displayed in Table 1. After aortic valve surgery, both LVEDD and LVESD decreased significantly. The LVEF was 54±12% before surgery and was 55±12% late after surgery. The incidence of postoperative LV dysfunction (LVEF<50%) was 25 % (14/55).

Table 1. **Echocardiogaphic indices**

	Before surgery	After surgery
	(14.8±1.8 months)	
LVEF (%)	52±13	56±11
LVEDD (mm)	60±8	46±7*
LVESD (mm)	43±9	31±9*
LVESD/BSA (mm/m^2)	26±5	19±6*

LVEF, left ventricular ejection fraction; LVEDD, left ventricular end-diastolic dimension; LVESD, left ventricular end-systolic dimension; BSA, body surface area
*$P<0.001$ vs. Before surgery

Table 2. **A comparison of clinical characteristics of patients whose postoperative LVEF≥50% or postoperative LVEF<50%**

Post-operative LVEF			
	≥50%	**<50%**	***P* value**
No. of patients	41	14	
Male (%)	32 (78)	10 (74)	
Age (years)	55±16	65±10	0.03
NYHA III-IV (%)	16 (39)	8 (57)	0.12
Hypertension (%)	26 (63)	8 (57)	0.84
Dyslipidemia (%)	5 (12)	4 (29)	0.42
Diabetes (%)	5 (12)	3 (21)	0.28
Creatinine >1.5 mg/dl	0 (0)	3 (21)	0.001
Medication			
ACEI/ARB (%)	19 (46)	4 (29)	0.22
Beta-blocker	8 (20)	1 (7)	0.28

A comparison of clinical characteristics of patients whose postoperative LVEF≥50% or postoperative LVEF<50% is shown in Table 2. Patients with postoperative LV dysfunction were significantly older than those with postoperative LVEF>50%.

Table 3 shows the incidence of postoperative LV dysfunction according to the preoperative echocardiographic indices. The incidence of postoperative LV dysfunction was high in patients with preoperative LVEF<50% (11/24, 46%), preoperative LVESD>50 mm (6/14, 43%), preoperative LVEDD>70 mm (2/3, 67%), LVESD/BSA≥25mm/m^2 (12/28, 42%). On univariate analysis, the preoperative LVEF (r=0.61, $P<0.0001$, Figure 1), LVESD (r=–0.29, P=0.02, Figure 2) and LVESD/BSA (r=–0.48, $P<0.0001$, Figure 3) were predictive of postoperative LVEF. The optimal cutoff value for LVESD/BSA to predict the postoperative LV dysfunction was 26.5mm/m^2 with a sensitivity of 86%

Table 3. **Incidence of postoperative LVEF<50% according to the preoperative echocardiographic indices**

Post-operative LVEF		
	≥50%	**<50%**
Preoperative LVEF		
LVEF≥50%	28	3 (10%)
LVEF<50%	13	11 (46%)
Preoperative LVEDD		
LVEDD>70 mm	1	2 (67%)
LVEDD≤70 mm	40	12 (23%)
Preoperative LVESD		
LVESD>50 mm	8	6 (43%)
LVESD≤50 mm	33	8 (20%)
Preoperative LVESD/BSA		
LVESD/BSA≥25 mm/m^2	16	12 (42%)
LVESD/BSA<25 mm/m^2	25	2 (7%)

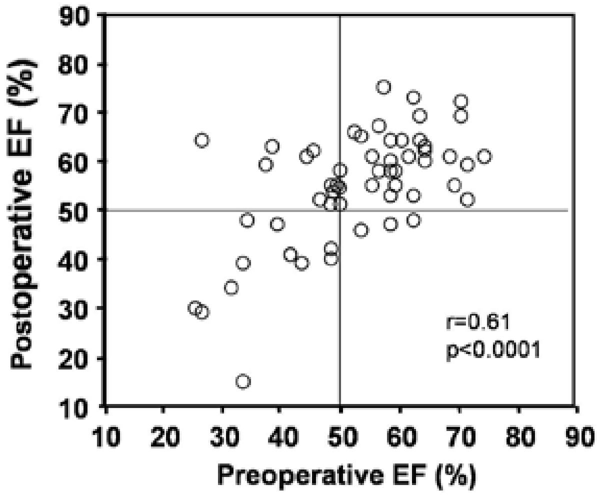

Figure 1. Relationship between preoperative and postoperative left ventricular (LV) ejection fraction (EF). The preoperative EF<50% is predictive of postoperative LV dysfunction

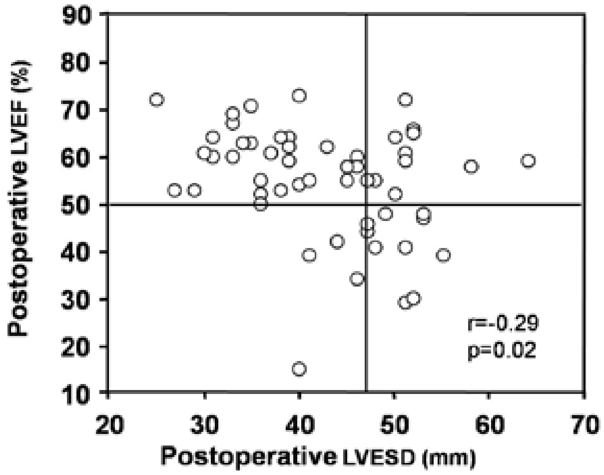

Figure 2. Relationship between preoperative left ventricular (LV) end-systolic dimension (ESD) and postoperative LV ejection fraction (EF). The preoperative ESD≥47 mm is predictive of postoperative LV dysfunction

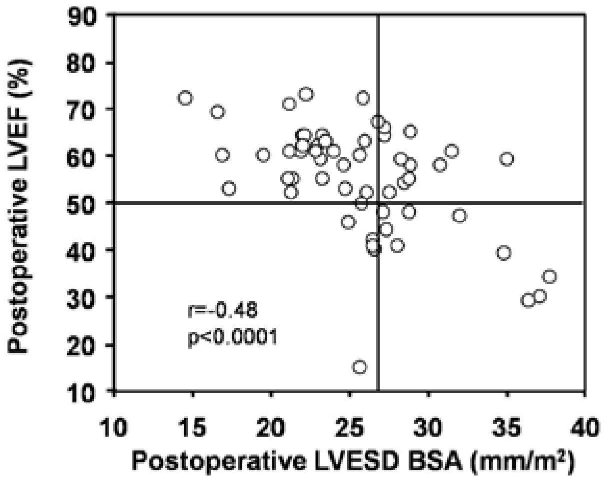

Figure 3. Relationship between preoperative left ventricular (LV) end-systolic dimension (ESD) normalized to body surface area (BSA) and postoperative LV ejection fraction (EF). The preoperative ESD/BSA≥26.5 mm is predictive of postoperative LV dysfunction

and a specificity of 70%, whereas LVEDD of 62 mm had 64% sensitivity and 71% specificity and LVESD of 47 mm had 79% sensitivity and 77% specificity.

Discussion

The timing of surgical correction for AR has traditionally been relied on symptoms or indexes of LV size or function associated with poor outcome. LVEF is an important predictor of cardiovascular outcomes in a broad spectrum of patients with heart failure [8]. Thus, to determine the timing, we must take into consideration not only postoperative survival but also the incidence of postoperative LV dysfunction.

We found that an LVEF of 50% and LVESV of 47 mm or LVESD/BSA of 26.5 mm/m^2 identified Japanese patients with a higher risk of postoperative LV dysfunction. The values of LVESD were lower than those recommended in the *American College of Cardiology* and the *American Heart Association* and the *European Society of Cardiology* guidelines [1,2]. These echocardiographic measures in Japanese patients may not be applied directly to patients in other countries, because the normal size of the heart is different [12]. Previous studies demonstrated that after surgery for AR, women exhibit an excess late mortality. The generalization to women of the unadjusted LV diameter surgical criteria established in men results in irrelevant criteria almost never reached in women [13,14]. This undoubtedly was related to the fact that women have smaller body sizes. Recent study has demonstrated that asymptomatic patients with severe AR and LV end-systolic volume index ≥45 ml/m^2 had higher cardiac event rates and surgery for AR reduced cardiac events [15]. These results emphasize the importance of normalization of LV size to body size in patients with AR.

A preoperative LVEF<50% is associated with a poor postoperative LV function and, despite the controversy about the prognostic usefulness of LV variables [13], should remain an indicator for surgical correction of AR. When the LVEF is reduced preoperatively because of increased afterload with preserved contractile function, the decrease in afterload and wall stress leads to an improvement in LVEF and this mechanism may explain the favorable effects of aortic valve replacement on LVEF [16–18]. However, in some patients, the persistent LV damage after aortic valve replacement is presumably resulting from irreversible myocardial contractile dysfunction before AVR. These findings indicated the need for surgical intervention for AR before the development of irreversible myocardial damage. In this study, LVESD normalized to body surface area manifested as excessive LV dilatation raises the concern that irreversible LV contractile dysfunction might have already occurred. Although there is no ideal clinical measure of ventricular contractility, end-systolic indices are less load dependent than diastolic or ejection phase measurements [19].

Study Limitations

We defined LV dysfunction as LVEF<50%. However, postoperative LV performance is not determined by LVEF alone. We studied postoperative LVEF, which was easy to measure, but it is only aspect of LV performance. We did not take into account the effect of medications. Recent studies including the experimental study demonstrated that unloading therapy or beta-blocker therapy has a beneficial effect on LV remodeling and function [20,21]. Long-term vasodilator therapy with nifedipine or enalapril, however, did not reduce or delay the need for AVR in patients with asymptomatic severe AR [22]. The possible benefit of medical treatment still remains a matter of controversy and further study is needed to clarify this problem. It might be wondered if newer prostheses or surgical advances could, in the future, decrease the incidence of late postoperative LV dysfunction.

Conclusion

In Japanese patients with severe AR, echocardiographic parameters of LVEF and LVESD are good predictors of postoperative LV dysfunction and useful as objective markers to decide the timing of surgery. LVEF<50% and/or LVESD/BSA≥26.5 mm/m^2 should be carefully considered for surgical intervention, which reduces the risk of postoperative LV dysfunction.

Conflict of interest: None declared

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