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Echocardiography in Severe Aortic Stenosis

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1. Introduction

Aortic stenosis (AS) is the most frequent valvular heart disease in west developed and developing countries, with prevalence between 0.02% in adults under 44 years and 3-9% in elderly over 80 years. Patients with this disease may remain asymptomatic for years, particularly in elderly with naturally limited exercise. If the patients remain untreated after they become symptomatic, the mortality at 10 years follow-up is 80-90%. Based on the etiology, mainly are three types of AS: 1) Calcific AS, which is most frequent type in adults of advanced age (2–7% of the population), 2) Congenital, which dominates in the younger patients, and 3) Rheumatic AS, which is becoming rare in developed countries.

Patient history and physical examination remain important in the diagnosis of AS. For the proper patient management, the evidence of the symptoms characteristic for AS: exertional shortness of breath, angina, dizziness, or syncope. Further diagnostic right direction is characteristic systolic murmur.

The disappearance of the second aortic sound is specific to severe AS.

Aortic valve replacement (AVR) is the only effective treatment for severe aortic AS. It is performed either isolated or concomitantly with coronary artery by-pass graft operation, which take place in almost 50% of patients with AS. The overall mortality of isolated AVR is 3-5% in patients below 70 years and 5-15% in elderly. After successful AVR, symptoms and quality of live improves significantly. The long term 10 years survival after successful AVR is very satisfied and it resulted till 75%. The most important factors that may affect the survival are old age, high NYHA functional class, associated aortic regurgitation, concomitant coronary aortic by-pass graft and atrial fibrillation.

2. Echocardiography in aortic stenosis patients

Echocardiography is the key diagnostic tool, not only to confirm the presence of AS, but also to assesses the degree of valve calcification, LV function and wall thickness. Today, echocardiography provides prognostic information in patients with AS.

The severity of AS is provided with a very high sensitivity and specificity by Doppler echocardiography. A valve area 1.0 cm^2 in a patient with AS is considered severe. The indexing of aortic valve area to body surface area is more powerful parameter, and a cut-off value of 0.6 cm^2/m^2 is considered severe AS. However, valve area detected by Doppler

echocardiography cannot be the only parameter for clinical decision making for aortic valve replacement, and it should be considered in combination with flow rate, pressure gradient and ventricular function, as well as functional status of an individual patient.

In patients with AS and normal left ventricular (LV) ejection fraction (EF) the mean pressure gradient of 50 mmHg (Figure 1), was used as a cut-off for the decision making for aortic valve replacement. However, in patients with depressed global LV function, even in patients with severe AS, Doppler echocardiography may result with low pressure gradients (underestimated gradients). In these patients, stress echocardiography using low-dose dobutamine may be helpful to distinguish truly severe AS patients from the rare cases of pseudosevere AS. In patients with truly severe AS, only small changes in valve area, but significant increase in pressure gradients are shown, whereas in pseudosevere AS patients are registered significant increase of valve area surface, but only minor changes in pressure gradients, before and at peak dose of dobutamine. The dobutamine stress-echocardiography is useful also to detect the presence of contractile reserve, which has prognostic implications.

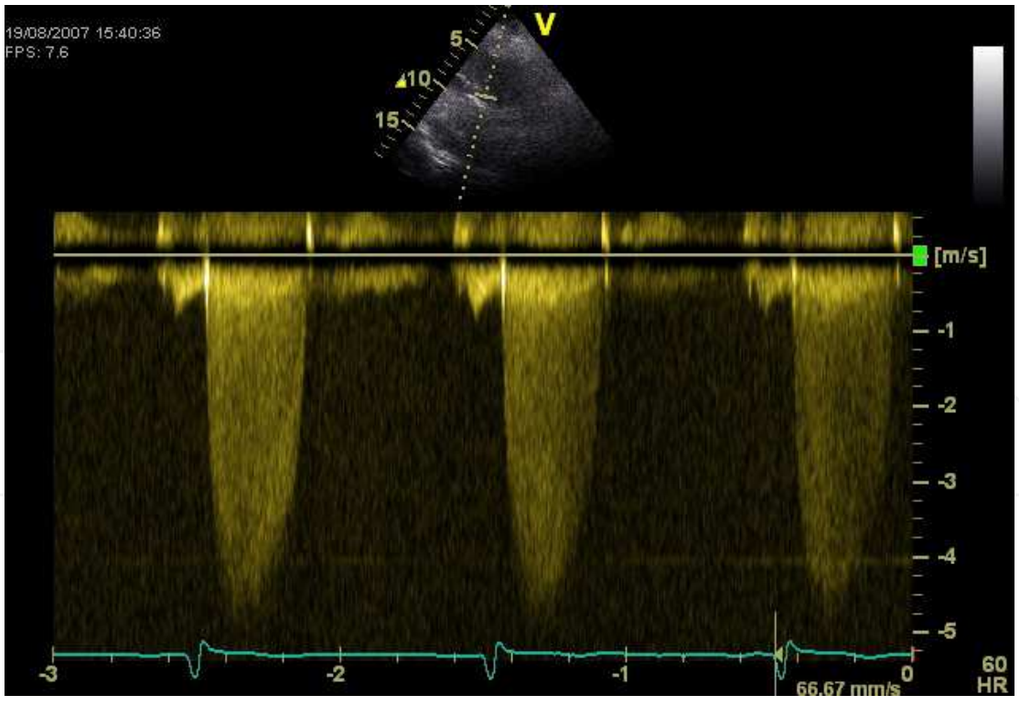

Fig. 1. Continues Doppler velocity of the aortic valve, in a patient with high pressure gradient and normal EF, before aortic valve replacement.

3. Outcome of patients with aortic stenosis

Aortic stenosis is a chronic progressive disease. Patients with AS may remain asymptomatic for a long period of time, and the duration of the asymptomatic phase varies widely among individuals. The most frequent cause of death in symptomatic patients is sudden cardiac death. However, sudden cardiac death in asymptomatic patients with AS is very rare.

Older age, presence of atherosclerotic risk factors, valve calcification, peak aortic jet velocity, low LV EF and increase of transvalvular pressure gradient with exercise, were shown as independent predictors of poor outcome in AS patients.

The development of symptoms on exercise testing, in physically active patients with AS, predicts a very high likelihood of symptom development within 12 months. The occurrence of symptoms, in these patientsş is a correlate of poor prognosis. The increased of mortality in these patients has been reported within months of symptom onset, which is often not promptly reported by patients.

4. Echocardiographic predictors in patients with severe aortic stenosis and poor left ventricular systolic function

Left ventricular systolic function was shown as one of more important predictors of patients with AS. Patients with AS and LV systolic dysfunction have a poor prognosis if valve replacement is not performed. LV EF, as the most important conventional parameter for the LV global systolic function, was consistently reported as a postoperative prognostic factor in patients with severe AS. Patients with severe left ventricular dysfunction have increased intra-operative mortality, and there are yet contradictions about their improved outcomes after the AVR. Generally, the LV systolic dysfunction is not a contraindication to surgery. It was shown that patients who underwent AVR have a 5-year survival rate 60–70%, with a high operative mortality in the range of 10–15% for patients with LV systolic dysfunction. To predict the postoperative outcome of patients with severe AS and impaired LV function, the preoperative dobutamine stress echocardiography is useful technique. The presence of good contractile reserve in dobutamine stress echocardiography supports potential benefit from AVR and better outcome in these patients.

AVR decreases the LV afterload, through transvalvular pressure drop (Figure 2), resulting in regression of LV hypertrophy.

LV mass regression predominantly occurs within the first 6 months of surgery. Even there are few publications regarding the pre-operative echocardiographic predictors of LV functional recovery in AS patients with low EF, it justify the statement to consider these patients for the operation, after individual assessment of the patient, considering co morbidities and general conditions.

Recovery of LV function was evident after aortic valve replacement in the majority of patients with aortic stenosis and pre-operative LV dysfunction.

Patients with increased LV end-systolic dimension and/or LV systolic volume index seem to have less chance for the LV functional recovery. It seems that these patients loosed

contractile reserve, and up to now there is no evidence that they may improve LV systolic function after operation, and therefore we should less encourage these patients for the AVR. However, there are studies that have shown that even in patients with poor LV systolic function, there is still ability for a LV function recovery after AVR, explaining it through the mechanism of the markedly reduction of outflow tract resistance.

Studies have shown that stented and stentless valves have similar effect on the LV mass reduction after AVR in all patients that underwent this procedure, despite significant differences in indexed effective orifice area and peak flow velocity in favor of the stentless valve. However, in patients with AS and markedly reduced ventricular function, there was shown more rapid LV mass and function normalization in stentless patients compared to similar patients receiving a stented valve. The luck of large randomized studies for these prostheses makes even more difficult decision. However, a numerous retrospective studies have shown improvement in symptoms and LV EF in about 70% of the survivors after AVR in patients with low LV EF.

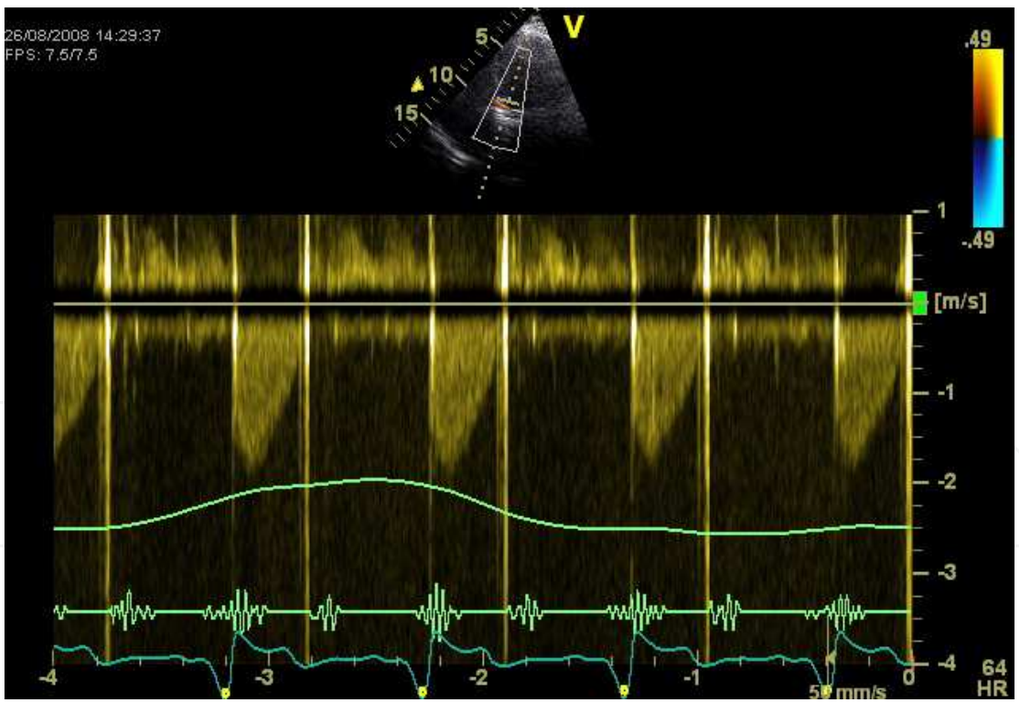

Fig. 2. Continues Doppler velocity of the aortic valve, in the same patient, two weeks after aortic valve replacement.

They suggest that despite increased operative mortality, these patients should not be denied aortic valve replacement, given the substantial potential clinical benefit from AVR replacement.

In conclusion, in patients with severe aortic stenosis with impaired LV global systolic function, assessed by LV EF, AVR has significantly better outcome compared to those treated medically. These patients are likely to carry a high risk operation (up to 10%), than to have a very poor prognosis for 10 years survival in medical treatment.

5. Echocardiographic predictors in patients with severe aortic stenosis and preserved left ventricular systolic function

Global LV function, assessed by conventional EF remains normal in most of AS patients. However, the long axis systolic function, assessed by M-mode echocardiography and/or tissue Doppler imaging (TDI) velocities, decreases even in patients with preserved EF. In AS patients with preserved EF, the longitudinal velocity, strain and strain rate are decreased and deteriorate further as AS become severe. These changes reflect that the LV myocardial dysfunction beginning at the subendocardium in early stages of AS and progress to mid-wall and to transmural contraction impairment in patients with severe AS. Recent studies have shown also that in patients with AS and preserved LV EF, the apical rotation and LV twist are increased and untwist is delayed compared to normals, as compensatory mechanisms for the increased intracavitary pressure overload and subendocardial ischaemia. Also, it was shown that these LV myocardial correlate with the severity of AS. However, these compensatory mechanisms are lost after the LV EF deterioration.

Strong evidence exists showing beneficial effect of AVR, not only in improving patients' symptoms but also in recovering, even partially, overall cardiac function. Improvement of LV ventricular function in these patients is interpreted on the basis of regression of myocardial hypertrophy, increased myocardial perfusion and hence overall cavity performance, at early and mid-term post-operative periods. While EF is the most popular measure of pre-operative LV systolic function in such patients, and surgical risk assessment it lacks representing subendocardial component of the LV function.

Severe aortic stenosis causes significant subendocardial dysfunction despite preserved ejection fraction. Aortic valve replacement surgery and removal of left ventricular afterload results in recovery of intrinsic subendocardial function within a week of surgery, well before mass regression and reverse remodeling. Such degree of pre-operative subendocardial disturbances may represent early changes that if ignored may substantiate and become irreversible. Thus, the presence of such abnormalities in symptomatic patients, even with normal ejection fraction, may suggest further evidence for a need for valve replacement in order to maintain overall integral ventricular function and to avoid potential clinical complications.

In patients with severe aortic stenosis and and maintained LV EF, the left ventricular twist is increased as compared with normal subjects suggesting a wall motion compensation for the reduced long axis motion in the aim to preserve LVEF. These motions alter towards normal values within six months of aortic valve replacement (Figure 3). These findings are growing evidence that on LV dysfunction and their improvement after AVR, even in asymptomatic patients, and may assist in identifying patients needing surgery before LV damage becomes irreversible.

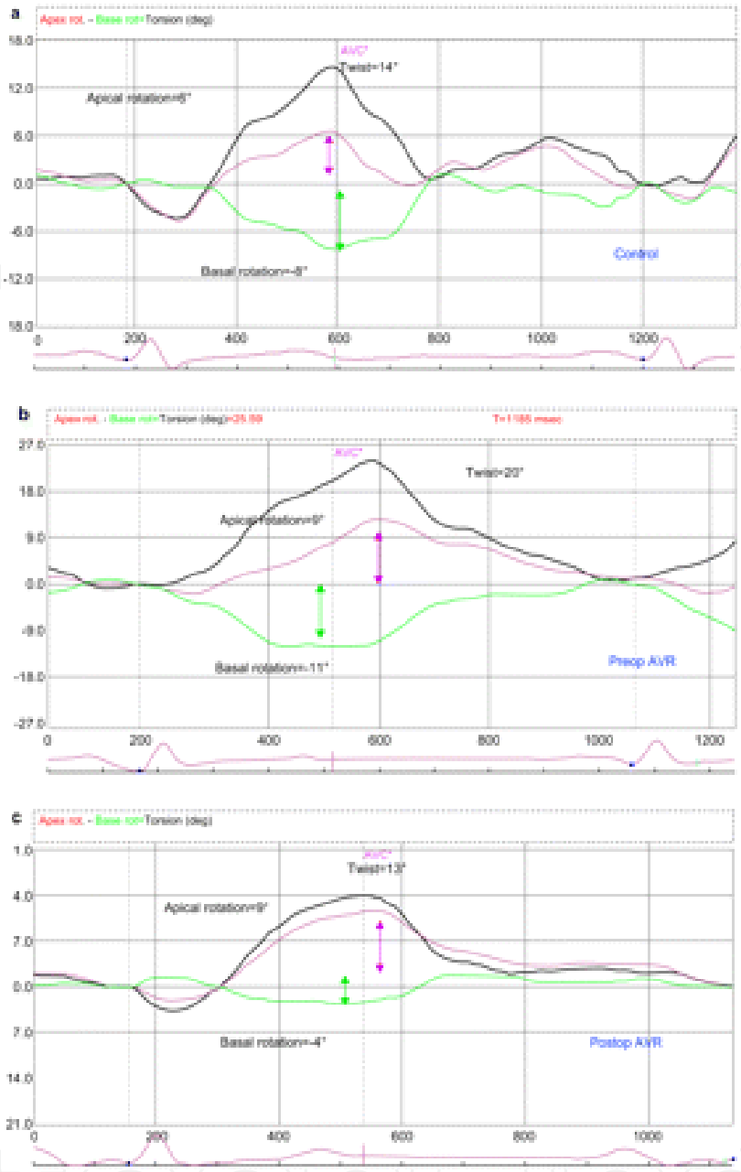

Fig. 3. Example of LV rotation and twist in control, pre AVR and post AVR. Purple line showing peak of apical rotation and green showing peak basal rotation. AVR, aortic valve replacement (Reproduced from *Lindqvist P et al.* Aortic valve replacement normalizes left ventricular twist function. Interact CardioVasc Thorac Surg 2011;12:701-706, doi:10.1510/icvts.2010.262303, with permission from the European Association for Cardio-Thoracic Surgery).

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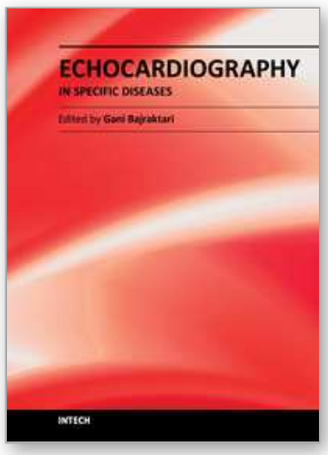

Echocardiography - In Specific Diseases

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The book "Echocardiography - In Specific Diseases" brings together contributions from well- known researchers from around the world, some of them specialized in imaging science in their clinical orientation, but also representatives from academic medical centers. Each chapter is structured and written to be accessible to those with a basic knowledge of echocardiography but also to be stimulating and informative to experts and researchers in the field of echocardiography. This book is primarily aimed at cardiology fellows during their basic echocardiography rotation, fellows of internal medicine, radiology and emergency medicine, but also experts in echocardiography. During the past few decades technological advancements in echocardiography have been developing rapidly, leading to improved echocardiographic imaging using new techniques. The authors of this book tried to explain the role of echocardiography in several special pathologies, which the readers may find in different chapters of the book.

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