Symptomatic Severe Chronic Aortic Valve Disease. A Comparative Study of Cardiac Magnetic Resonance Imaging and Echocardiography

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Objective

To show the real value of cardiac magnetic resonance imaging (CMRI) in the evaluation of patients with symptomatic chronic aortic valve disease.

Methods

Seventy patients – 35 with aortic stenosis (AoS) and 35 with aortic regurgitation (AoR) with surgical indication, who underwent preoperative echocardiogram (ECHO) and CMRI to assess ventricular function, volumes, and left ventricular mass index using cine magnetic resonance imaging, were studied.

Results

No statistically significant difference was observed between the AoS and AoR groups when ECHO and CMRI variables were compared. When compared with the type of symptom, ECHO and CMRI variables showed the same pattern.

Conclusion

CMRI data were in agreement with ECHO data regarding the assessment of left ventricular volume and ejection fraction, and with the clinical presentation of patients with chronic aortic valve disease.

Key words

chronic aortic valve disease, cardiac magnetic resonance imaging, echocardiogram, functional class

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The natural history of chronic aortic valve diseases – aortic stenosis (AoS), and aortic regurgitation (AoR) is associated with degrees of left ventricular remodeling that do not correspond[1-3] to clinical manifestations.

Chronic aortic valve diseases, mainly of rheumatic etiology (which is prevalent in Brazil), with a significant valve involvement may be stratified according to assessments based on cardiac imaging tests[4-6].

Dyspnea on ordinary exertion as a manifestation of heart failure, as well as the presence of chest pain and syncope, generally result from left ventricular dysfunction, and less frequently from myocardial dysfunction.

Studies evaluating the clinical and morphological progression of aortic valve disease in the occasional presence of left ventricular dysfunction are lacking[7-9]. Thus, well-conducted studies still seek for predictive indexes using cardiac imaging methods that could bring forward the timing for surgery with increased safety. It is difficult to homogenize values of echocardiographic measurements due to the multiplicity of changes in ventricular remodeling. In this line of research, the left ventricular remodeling may be followed by an alteration in the clinical manifestation, which would warn us of the optimal timing for surgical treatment.

Thus, in patients with severe valvular heart diseases, the assessment of ventricular function using CMRI may be useful, because this is a diagnostic method that has become one of the main non-invasive supplementary tests in Cardiology in the past few years. Among its main advantages, we can point out the excellent anatomical resolution between the tissues, the acquisition of a three-dimensional rebuilding without using ionizing radiation, and non-nephrotoxic contrast medium (Gadolinium).

Thus, we attempted to associate clinical data with cardiac magnetic resonance imaging (CMRI) and transthroracic echocardiogram (ECHO), a supplementary method of the utmost importance used to track the assessment of left ventricular function in aortic valve diseases.

Objective

To assess the alterations in CMRI in the analysis of patients with symptomatic chronic aortic valve disease[10] in comparison with echocardiographic parameters.

Methods

Seventy symptomatic patients (35 with AoS and 35 with AoR) from the Outpatient Clinic of the Medical Unit of Valvular Heart Diseases of the *Instituto do Coração do Hospital das Clínicas, Faculdade de Medicina da Universidade de São Paulo* (InCor/HC-FMUSP) were prospectively studied from May, 2001 to July, 2003. The mean age was 46.6 ± 12.4 years with predominance of males in 54 cases, and 75% of the patients with valvular heart disease of rheumatic etiology, followed by bicuspid and degenerative valve.

The inclusion criteria for patients with severe chronic aortic valve disease and surgical indication were: clinical symptoms such as angina pectoris on exertion, syncope and dyspnea on moderate and mild exertion (paroxysmal nocturnal dyspnea, orthopnea) with a gradient between the left ventricle and the aorta above 50 mmHg by catheterization, and > 70 mmHg by ECHO, for AoS[11]. For AoR, the inclusion criteria were defined according to Spagnuolo et al[12] as modified criteria, namely: cardiothoracic index > 0.50, presence of left ventricular hypertrophy as assessed by electrocardiogram, pulse pressure ≥ 80 mmHg, diastolic blood pressure ≤ 60 mmHg as assessed by ECHO, in that one single criterion was enough to admit the patient in the AoR group.

The exclusion criteria used in this study were: patients under eighteen and above 65 years of age; concurrent mitral valve disease; previous heart valve surgery; comorbidities (diabetes mellitus, high blood pressure, and dyslipidemia); and other heart diseases (aorta diseases, coronary artery diseases, myocardial diseases).

This project was analyzed and approved by the Ethics Committee of the *Instituto do Coração do Hospital das Clínicas da Faculdade de Medicina da Universidade de São Paulo.* All patients admitted in the study gave their written consent after obtaining information about the study and the method used.

Study schedule - Data on the occurrence of key symptoms such as angina pectoris, syncope and dyspnea on moderate and mild exertion (paroxysmal nocturnal dyspnea, orthopnea) were particularly recorded during the clinical history taking. Patients were then scheduled for diagnostic tests such as electrocardiograms, chest radiographs, ECHO, CMRI, and cardiac catheterization[11-13]. ECHO was performed prior to CMRI.

Echocardiogram - Echocardiograms were interpreted according to recommendations of the American Association of Echocardiography.

All patients underwent ECHO and ventricular function, left ventricular end-diastolic (EDV) and systolic (ESV) volumes, and ventricular mass index (LVMI)[14,15]. Left ventricular ejection fraction (EF) was calculated using the Teichholz method[16].

Cardiac magnetic resonance imaging - CMRI was performed to assess volumes, function and left ventricular mass index (EDV, ESV, EF, and LVMI) using cine magnetic resonance with the FIESTA technique (Fast Imaging Employing Steady-state Acquisition). Figure 1 shows left ventricular dilation and intense blood flow through the aorta in a CMRI long-axis section of AoR. Figure 2 – a short-axis section of AoS – shows a hypertrophic left ventricle with a small right ventricle. The first pulse sequence – the cine magnetic resonance with the FIESTA technique[17], was used to assess the global ventricular function (volumes and ejection

fraction)[18]. LVMI, EDV, ESV, and EF were calculated by detecting epicardial and endocardial borders in contiguous short-axis sections at the end-diastole and end-systole of cine magnetic resonance images using the Simpson's rule[19-20].

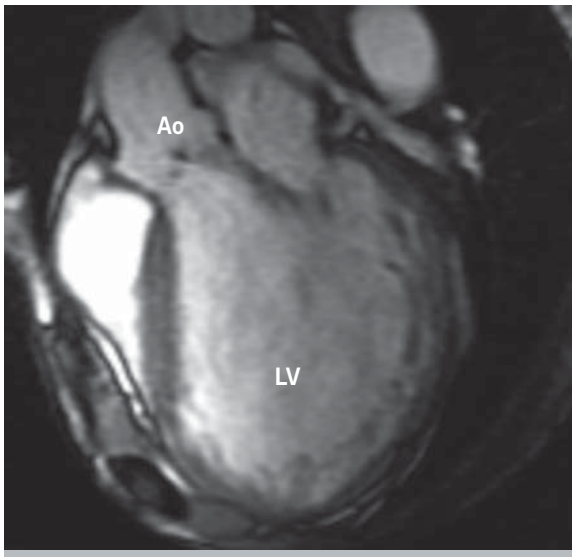

Fig. 1 *– Magnetic resonance in AoR*

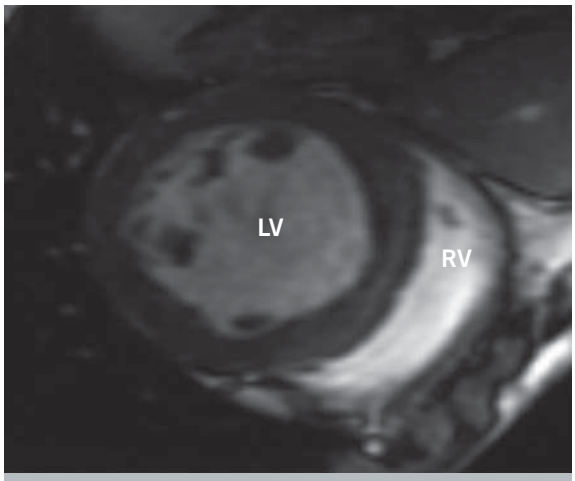

Fig. 2 *– Magnetic resonance in AoS*

Statistical analysis

Descriptive analysis - The calculation of means and standard deviation was performed for CMRI and ECHO variables.

Comparative analysis - The one-factor analysis of variance was used for comparisons of EF groups between ECHO and CMRI, and Bonferroni correction[21] was used for multiple comparisons.

The logistic regression model was used to obtain a cut-off point for EF in relation to the clinical presentation.

Pearson's correlation coefficient was used to study the correlation between EF and the clinical manifestation[22].

For all variables calculated, the level of statistical significance of p = 0.05 was used.

Results

Comparison between CMRI and ECHO

Aortic stenosis - The comparison of variables between the two methods – CMRI and ECHO in the AoS group is shown in table 1.

Table 1 – Variables between CMRI and ECHO in AoS

Variables/AoS	CMRI	ECHO	p
EF	0.59 ± 0.1	0.58 ± 0.1	NS
EDV (ml)	214 ± 112	193.4 ± 160	NS
ESV (ml)	127 ± 102	94.8 ± 92	NS
LVMI (g/m²)	166 ± 76	155 ± 60	NS

CMRI- Cardiac magnetic resonance imaging; ECHO- Echocardiogram; AoS- Aortic stenosis; EF- Ejection fraction; EDV- End diastolic volume; ESV- End systolic volume; LVMI- Left ventricle mass index

No difference was observed in the calculation of variables between CMRI and ECHO in the AoS group.

Aortic regurgitation - The comparison of variables between CMRI and ECHO in the AoR group is shown in Table 2.

Table 2 – Variables between CMRI and ECHO in AoR

Variables/AoR	CMRI	ECHO	p
EF	0.5 ± 0.1	0.5 ± 0.1	NS
EDV (ml)	393 ± 141	334.5 ± 157	NS
ESV (ml)	235.6 ± 131	183.5 ± 105	NS
LVMI (g/m²)	220 ± 70	195 ± 65	NS

CMRI- Cardiac magnetic resonance imaging; ECHO- Echocardiogram; AoR- Aortic regurgitation; EF- Ejection fraction; EDV- End diastolic volume; ESV- End systolic volume; LVMI- Left ventricle mass index

Similarly to the AoS group, no significant statistical difference of variables between the CMRI and ECHO was observed in the AoR group.

Analysis between CMRI and ECHO variables and clinical manifestations in AoS and AoR - The comparison between CMRI and ECHO variables and clinical manifestations in AoS is shown in Tables 3 and 4.

Only the EF variable in ECHO/CMRI showed a statistical significance in the AoS group.

The comparison between CMRI and ECHO variables and clinical manifestations in AoR is shown in Tables 5 and 6.

All CMRI and ECHO variables showed a statistical significance in AoR, unlike in the AoS group.

Table 3 – CMRI variables in AoS

CMRI	Syncope/Angina (3)	Dyspnea (32)	p
EF	0.47 ± 0.1	0.39 ± 0.1	0.01
EDV (ml)	323 ± 141	344.2 ± 157	NS
ESV (ml)	235.6 ± 131	283.5 ± 105	NS
LVMI (g/m²)	220 ± 70	225 ± 65	NS

CMRI- Cardiac magnetic resonance imaging; EF- Ejection fraction; EDV- End diastolic volume; ESV- End systolic volume; LVMI- Left ventricle mass index

Table 4 – ECHO variables in AoS

ECHO	Syncope/Angina (4)	Dyspnea (31)	p
EF	0.49 ± 0.1	0.40 ± 0.1	0.01
EDV (ml)	333 ± 141	355.2 ± 167	NS
ESV (ml)	245.6 ± 131	295.4 ± 115	NS
LVMI (g/m²)	225 ± 74	225 ± 68	NS

ECHO- Echocardiogram; EF- Ejection fraction; EDV- End diastolic volume; ESV- End systolic volume; LVMI- Left ventricle mass index

Table 5 – CMRI variables in AoR

CMRI	Syncope/Angina (4)	Dyspnea (31)	p
EF	0.46 ± 0.1	0.37 ± 0.1	0.01
EDV (ml)	223 ± 141	354.5 ± 151	<0.01
ESV (ml)	122.6 ± 131	282.5 ± 103	0.001
LVMI (g/m²)	170 ± 70	220 ± 65	0.02

CMRI- Cardiac magnetic resonance imaging; AoR- Aortic regurgitation; EF- Ejection fraction; EDV- End diastolic volume; ESV- End systolic volume; LVMI- Left ventricle mass index

Table 6 – ECHO variables in AoR

ECHO	Syncope/Angina (4)	Dyspnea (31)	p
EF	0.47 ± 0.1	0.36 ± 0.1	0.01
EDV (ml)	233 ± 141	374.5 ± 153	<0.01
ESV (ml)	127.6 ± 131	292.5 ± 103	0.001
LVMI (g/m²)	177 ± 70	228 ± 68	0.02

ECHO- Echocardiogram; AoR- Aortic regurgitation; EF- Ejection fraction; EDV- End diastolic volume; ESV- End systolic volume; LVMI- Left ventricle mass index

Discussion

Aortic valve diseases represented by AoS and AoR have different natural histories, though with similar clinical manifestations and diagnoses.

This is a pioneering study in which the advantages of CMRI in relation to ECHO were compared by studying the variables generally used to track a severe aortic valve disease. In addition, the literature lacks studies evaluating the interaction of these methods with the clinical presentation.

When the two diagnostic imaging methods – CMRI and ECHO – were used to calculate the variables, no differences between the clinical groups – AoS and AoR – were observed. Moriuchi et al[23] studied 55 hypertensive patients by assessing end systolic and diastolic volumes, and left ventricular mass using CMRI and ECHO. No statistically significant differences were observed, which was similar to the data obtained in our study. Likewise, Shelton et al[24] compared the left ventricular mass index of patients with hypertrophic cardiomyopathy between these two imaging methods and did not find any advantages in the analysis of CRMI and ECHO (0.6 versus 0.8, respectively).

Also similar to our results, when analyzing the ejection fraction in AoR, Pflugfelder et al[25] showed that no superiority was observed in the analysis of both methods. However, when the variables of the methods were analyzed with the clinical manifestations, the importance of the methods was remarkable in diagnosing the variables with the clinical presentation more precisely in the AoR group[26]. This can be correlated with a more intense ventricular dilation and, consequently, with a more intense ventricular maladaptation in the AoR group. Berko et al[27] showed the contribution of imaging methods, emphasizing the ECHO in the diagnosis and prognosis of aortic valve disease, mainly related to patients with heart failure in the pre and postoperative of aortic valve surgery.

Likewise, Baxley et al[28] showed, both qualitatively and quantitatively, the value of CMRI in patients with aortic valve disease, quantifying their heart failure symptoms and the status of the aortic valve prosthesis following surgery. Therefore, according to our results and the literature, CMRI is as efficient as ECHO in providing qualitative and quantitative information in aortic valve diseases, and proved superior when planimetry is used to calculate the valve area[24,25]. Additionally, CMRI may be an alternative imaging method when ECHO is unable to clearly show the variable calculations due to limitations of the visual window.

In conclusion, no statistically significant difference was found between the variables analyzed by ECHO and CMRI in both clinical groups.

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