Magnetic Resonance Imaging in the Evaluation of Valvular Prosthetic Function

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Introduction

Following patients with prosthetic valve replacement is quite difficult. Indeed, fibrosis, calcification and tearing of the leaflet are probably the fate of most bioprosthetic valves after 10 years. Separating valve dysfunction from other causes of symptoms, such as diminished left ventricular contractility, coronary arterial disease and pulmonary disease may be difficult. Catheterization is frequently different and risks are reported. Nowadays, the echo color Doppler is much more reliable even when the metallic structures in the mechanical valve cause echo reflections and shadowing which mask events distal to the struts. Therefore, detection of thrombus or vegetation around the metallic struts is not easy.

The transesophageal echocardiographic approach to the visualization of chambers posterior to the prosthesis gives good quality images of valvular and paravalvular structures because it is applied in proximity to the heart. However, artifacts and flow-masking caused by the synthetic material of the artificial valve prostheses may interfere with the diagnostic capabilities of transesophageal ultrasound analyses.

High-field magnetic resonance (MR) examinations (1.5 T) are considered safe for patients with biomedical prosthetic heart valves. In fact, in vivo evaluation of the beating heart showed that the deflection forces caused by the static magnetic field are lower than that exerted on the valve [1-10]. We considered different valve models to define: (1) the artifact entity for each type of valve; (2) the flow pattern in normo-functioning valve prostheses; (3) the pathological transvalvular or paravalvular leakage flow.

Material and Methods

Thirty-four patients (25 males and 9 females) with age ranging between 39 and 69 years (mean, 43 years) were included in our study. They had 28 aortic and 13 mitral valves replaced with 15 biological, 13 Carpentier-Edwards, 2 Hancock and 26 mechanical prostheses, which included 1 Hall-Kaster, 1 Edwards, 16 Sorin, 2 Bjork-Shiley, 3 St. Jude, 1 Duromedics and 1 Smeloff-Cutter.

A low-field MR unit (0.2 T) was used for the study, with cine-MR technique and short repetition time (TR) and echo time (TE) sequences (TR = 50 ms, TE = 15 ms, flip angle (FA) = 60°); the acquisition matrix was 160 x 256 with 35 cm field of view and slice thickness of 10 mm. The images were acquired on planes parallel and perpendicular to the valvular plane. The last 8 patients, including 5 with biological Carpentier-Edwards, 2 with Sorin and 1 with Edwards mechanical prostheses, were studied with a 0.5 T superconductive magnet with gradient echo short TR-TE sequences with cine-MR technique (TR = 15 ms, TE = 7 ms, FA = 40°).

A semiquantitative analysis with double-blind evaluation was performed by two experienced radiologists for definition of the artifact entity. Three classes were distinguished: (class 1) artifact of minimum entity, if circumscribed to the valvular structure, was considered not significant; (class 2) medium artifact, smaller than 1 cm in size in the images perpendicular to the valvular plane, allowed evaluation of valvular functionality; (class 3) significant artifact, severely impairing the evaluation of valvular functionality at cine-MR. Analysis of the flow was performed behind the valve to define normal or pathological function.

Mitral regurgitation was judged to be present when a signal void emanated from the mitral valve prosthesis into the left atrium during ventricular systole. Aortic regurgitation was identified by the appearance of a signal void extending from the aortic valve prosthesis into the left ventricular chamber during ventricular diastole. The origin, shape and extension of the signal void within the respective cardiac chamber were noted throughout the cardiac cycle. The transverse image that showed the largest signal loss was used for measurement of the signal void area. When there was more than one reflux, jet areas were added.

Transvalvular turbulent flow (evidence of signal loss) in which the jet originated from inside the valve ring was considered to be physiologic if small (2 – 3 cm² jet area),
or pathologic when large (over 3 cm$^2$ jet area). Paravalvular leakage was thought to be present if the jet originated laterally from the valve; such leakage was considered a pathological finding.

**Results**

Our investigation showed the presence of irrelevant artifacts produced by the biological valves. In particular, the analysis performed at aortic level showed artifacts in 12 patients, limited only to the area of the valve ring which did not impair the evaluation of the valvular function. In the 2 cases with aortic Hancock prostheses, the semilunar leaflets could be well visualized on the transvalvular scan plane. In the 3 Carpentier-Edwards mitral prostheses, artifacts were observed strictly at the annulus; evaluation of normal valve function was nevertheless possible (Fig. 1).

More relevant artifacts were produced by mechanical prostheses. Disc cardiac valves in particular produced significant artifacts which did not allow adequate transvalvular evaluation of valve function. Conversely, when scan planes were acquired perpendicularly to the valves, artifacts were produced in the region of the valve ring and obturator. At the supra-aortic level, turbulence in the ejection phase was always observed and could be explained by

**Fig. 1.** a Biological prosthesis. b Metallic valve ring produces artifacts at the level of the annulus (arrows)

**Fig. 2.** a Mechanical single disc prosthesis. b Mechanical mitral valve. Bar artifacts are present proximal to the annulus. c Coronal scans show small bar artifacts at telediastolic phase