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ORIGINAL RESEARCH

Dysfunction of Bileaflet Aortic Prosthesis

Accuracy of Echocardiography Versus Fluoroscopy

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OBJECTIVES The authors sought to investigate the accuracy of transthoracic echocardiography (TTE)-derived parameters in the identification of bileaflet aortic prosthesis dysfunction, compared with fluoroscopy (FL).

BACKGROUND Identification of bileaflet aortic prosthesis dysfunction is challenging, because high mean pressure gradient (MPG >20 mm Hg) is not proof of prosthetic obstruction (AVPO), and may be due to prosthesis–patient mismatch (PPM). Conversely, high gradients may not be manifest in AVPO and low cardiac output.

METHODS TTE and FL were prospectively performed in 100 nonconsecutive patients with bileaflet aortic prosthesis. TTE included the estimation of MPG, indexed effective orifice area (EOAi), Doppler velocity index (DVI), intraprosthetic regurgitation, acceleration time (AT), ejection time (ET), AT/ET, and the difference (dA) between the expected prosthetic orifice area and EOA. FL allowed the calculation of opening and closing angles, and the discrimination of AVPO from normal (NL) and PPM.

RESULTS On the basis of FL examination and MPG and EOAi at TTE, patients were classified as NL (42%), PPM (32%), and AVPO (26%). High MPG (>20 mm Hg) was present in 65% of the patients, with higher values in PPM (36 ± 8 mm Hg) and AVPO (43 ± 16 mm Hg) than in NL (16 ± 6 mm Hg). DVI was reduced in PPM (0.30 ± 0.05) and AVPO (0.25 ± 0.04) compared with NL (0.42 ± 0.09). In AVPO, dA (0.59 ± 0.32 cm^2), AT (108 ± 20 ms), and AT/ET (0.35 ± 0.05) significantly differed from NL (dA = −0.12 ± 0.43 cm^2, AT = 74 ± 15 ms, AT/ET = 0.25 ± 0.05) and PPM (dA = 0.15 ± 0.24 cm^2, AT = 78 ± 13 ms, AT/ET = 0.26 ± 0.04). Moderate or severe intraprosthetic regurgitation was observed only in AVPO. All considered TTE-derived parameters were found related to obstruction, and dA (accuracy = 87%), AT (94%), and AT/ET (89%) showed the highest accuracy in discriminating normofunctioning prostheses from AVPO.

CONCLUSIONS In the presence of high MPG, TTE parameters play a key role in aortic prosthesis examination. Especially time indices and dA add to the functional assessment of prosthetic aortic valves. However, the TTE discrimination between AVPO and PPM may be suboptimal, and fluoroscopy is a complementary and essential diagnostic step. (J Am Coll Cardiol Img 2013;6:196–205) © 2013 by the American College of Cardiology Foundation

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Bileaflet prosthetic valves (PV) are the most frequently implanted mechanical valves, but the assessment of their function in aortic position remains a challenge. Doppler transthoracic echocardiography (TTE) is the most widely used tool to assess PV function (1). Nevertheless, the identification of prosthetic leaflet motion by means of 2-dimensional echocardiography has been shown to be poorly feasible (2,3). Moreover, the sole use of gradients in the assessment of prosthetic function is limited, because gradients depend, not only on flow magnitude, but also on valve type and size (4,5). In fact, high transprosthetic velocity alone is not proof of intrinsic aortic valve prosthesis obstruction (AVPO), but rather may be secondary to high flow, to prosthesis–patient mismatch (PPM), or to pressure recovery at the smaller central valvular orifice (6–8). Conversely, high transprosthetic gradients may not be evident in the case of low cardiac output, even in the presence of obstruction (9). Prosthetic effective orifice area (EOA) provides a parameter that is less dependent on flow, but still relies on a priori knowledge of valve size (10). New parameters of AVPO have been recently proposed, in particular delayed peak systolic velocity (1,11), leading to longer acceleration times (AT) and higher acceleration to ejection time (ET) ratios (AT/ET).

The aim of this study was to investigate the accuracy of multiple TTE-derived parameters in the identification of bileaflet AVPO versus normal (NL) prosthesis and PPM, compared with cinefluoroscopy (FL), considered as the gold standard.

METHODS

One hundred patients (age 64 ± 10 years, 41 men) with bileaflet PV admitted to Centro Cardiologico Monzino were prospectively enrolled in the study between 2001 and 2010. Patients were selected among those hospitalized; 49% of the patients were hospitalized because of suspected AVPO on the basis of high gradients, 27% for heart failure, and the remaining for other cardiovascular reasons (cardioversion of atrial fibrillation, coronary artery disease).

The local ethical committee approved the study protocol, and written informed consent was obtained from each patient.

Transthoracic Doppler echocardiography. Two-dimensional and Doppler TTE were performed using a Sonos 7500 or iE33 ultrasound equipped with a S3 sector array probe (Philips Medical Systems, Andover, Massachusetts).

A complete 2-dimensional TTE evaluation was performed in multiple cross-sectional and off-axis views. Color Doppler was used for screening and evaluating the degree of intra- and/or paraprosthetic regurgitation.

Doppler-derived parameters of PV function included peak velocity, mean pressure gradient (MPG), and velocity-time integral of the jet by continuous-wave Doppler performed from apical, right parasternal, right supraclavicular, and suprasternal positions. Prosthetic EOA was derived from the continuity equation and calculated as the product of the cross-sectional area of the left ventricular outflow tract (LVOT), measured during the same TTE examination, and the LVOT velocity-time integral, divided by the velocity-time integral through the aortic prosthesis itself, using continuous-wave Doppler (10,11). The LVOT was measured below the insertion of the PV, as the distance between the junction of the sewing ring and the ventricular septum, and the junction of the sewing ring and the base of anterior mitral leaflet (1). The LVOT velocity-time integral was obtained using pulsed-wave Doppler and positioning the sample volume 5 mm below the aortic prosthesis.

An indexed EOA (EOAi) was defined as the ratio between EOA and the body surface area. Moreover, the difference between expected prosthetic orifice area, as reported in the literature (5), and TTE-derived EOA (dA) was considered. A Doppler velocity index (DVI) was also calculated as the ratio between the proximal velocity-time integral in the LVOT and the velocity-time integral through the valve (1).

The systolic time intervals of flow through the PV were measured using the velocity curve from continuous wave Doppler recording (Fig. 1): ET was measured as the interval from the onset to the end of systolic flow across the PV; AT was defined as the time elapsed from the beginning of systolic flow to its peak velocity. Finally, the AT/ET ratio was calculated. Systolic time intervals were routinely collected only starting from 2009, following the publication of the relevant recommendations (1). Therefore, for those patients enrolled before 2009, the same parameters were retrospectively calculated based on the images digitally stored on the picture archiving and communication system of our institution.

ABBREVIATIONS AND ACRONYMS

AT = acceleration time
AVPO = aortic valve prosthesis obstruction
CA = closing angle
dA = difference between expected prosthetic orifice area and transthoracic echocardiography–derived area
DVI = Doppler velocity index
EOA = effective orifice area
EOAi = indexed effective orifice area
ET = ejection time
FL = fluoroscopy
LVOT = left ventricular outflow tract
MPG = mean pressure gradient
NL = normal
NYHA = New York Heart Association
OA = opening angle
PPM = prosthesis–patient mismatch
PV = prosthetic valve
ROC = receiver-operating characteristic
TTE = transthoracic echocardiography