Archives of Cardiovascular Disease (2017) xxx, xxx—xxx

Available online at
ScienceDirect
www.sciencedirect.com

Elsevier Masson France
EM|consulte
www.em-consulte.com/en

EDITORIAL

Diagnosis of paradoxical low-flow/low-gradient aortic stenosis: A complex process!

Rétrécissement aortique paradoxal : une succession d'étapes avant de retenir le diagnostic

KEYWORDS
Aortic stenosis;
Paradoxical aortic stenosis;
Low-flow/low-gradient;
Preserved ejection fraction;
Management

MOTS CLÉS
Rétrécissement aortique ;
Rétrécissement aortique paradoxal ;
Bas gradient—bas debit ;
Fraction d'ejection préservée ;
Diagnostic ;
Prise en charge

Background

Severe aortic stenosis is currently defined by the European Society of Cardiology [1] as a maximum velocity across the valve (V_{max}) > 4 m/s, a mean transaortic pressure gradient (MG) > 40 mmHg, and an aortic valve area (AVA) < 1 cm^2 or < 0.6 cm^2/m^2. However, these parameters are discordant in 20—30% of patients [2]. These discordances usually correspond to a V_{max} < 4 m/s (or MG < 40 mmHg) in favour of moderate aortic stenosis and an AVA < 1 cm^2 (or < 0.6 cm^2/m^2) in favour of severe aortic stenosis. Thus, a new four-way classification of severe aortic stenosis with preserved left ventricular ejection fraction (LVEF) (defined by AVA < 1 cm^2 or < 0.6 cm^2/m^2 and LVEF > 50%) has been proposed according to the value of MG (≥ or < 40 mmHg) and stroke volume index (SVI) (≥ or < 35 mL/m^2). The first two groups correspond to patients with AVA < 1 cm^2 and MG ≥ 40 mmHg, with either SVI ≥ 35 mL/m^2 (normal-flow/high-gradient severe aortic stenosis) or SVI < 35 mL/m^2 (low-flow/high-gradient severe aortic stenosis). There is no doubt about the haemodynamic severity of aortic stenosis in these two groups. The other two groups are characterized by AVA < 1 cm^2 but with low gradient < 40 mmHg, and with either SVI ≥ 35 mL/m^2 (normal-flow/low-gradient aortic stenosis) or SVI < 35 mL/m^2 (also called paradoxical low-flow/low-gradient [LF/LG] aortic stenosis) [3].

It is generally accepted that aortic stenosis with AVA < 1 cm^2, with normal flow and low gradient, corresponds to non-severe aortic stenosis [4], as the only logical explanation for reduction of the MG to < 40 mmHg in the presence of severe aortic stenosis with preserved LVEF is a significant reduction in cardiac output. In other words, if LVEF is preserved, the association of MG < 40 mmHg and normal flow (SVI ≥ 35 mL/m^2) is in favour of moderate aortic stenosis. Accordingly, a normal-flow/low-gradient aortic stenosis pattern is associated with favourable survival under medical management compared to normal-flow/high-gradient severe aortic stenosis [3]. However, the outcome of patients with paradoxical LF/LG aortic stenosis is currently under debate. These patients are usually elderly women.

Abbreviations: AVA, aortic valve area; LF/LG, low-flow/low-gradient; LVEF, left ventricular ejection fraction; MG, mean transaortic pressure gradient; SVI, stroke volume index; V_{max}, maximum velocity across the valve; VTI, velocity time integral.

http://dx.doi.org/10.1016/j.acvd.2017.01.003

Hypertension is very frequently present and is often associated with decreased systemic arterial compliance [3,4]. This combination of preserved LVEF/low MG and severe aortic stenosis can be explained by left ventricular remodelling with a small left ventricle responsible for a reduction of stroke volume despite preserved LVEF [4]. This reduction of stroke volume and aortic transvalvular flow accounts for the low gradient. These patients usually present an alteration of longitudinal contractility reflected by a reduction of global longitudinal strain on speckle tracking [5]. Initially considered to be common (> 20% of cases of severe aortic stenosis), the frequency of paradoxical LF/LG aortic stenosis among severe aortic stenosis in recent published series ranges from 3% to 13% [3,6—8]. The real prevalence of severe LF/LG aortic stenosis remains unknown. Rigorous prospective studies are still needed to establish this prevalence. The prognosis of paradoxical LF/LG aortic stenosis remains a 'hot' subject of debate [9]. The two main questions about this entity are the following: how to diagnose 'true' LF/LG aortic stenosis with preserved LVEF and what management should be proposed?

Towards the diagnosis of paradoxical low-flow/low-gradient severe aortic stenosis

The problem is to distinguish 'true' paradoxical LF/LG severe aortic stenosis with preserved LVEF from moderate aortic stenosis. This diagnosis should be rigorously established after following several steps.

First step: systematically measure blood pressure during echocardiography to eliminate poorly controlled hypertension. Indeed, high blood pressure can result in decreased cardiac output and gradient. In this case, echocardiographic assessment must be repeated after control of blood pressure [10].

Second step: check echocardiographic measurements to avoid error. The most common error is related to the evaluation of the diameter of the left ventricular outflow tract, which can sometimes be difficult to evaluate because of the presence of calcifications and/or poor echogenicity [4]. Furthermore, anatomical studies based on computed tomography scans have shown that the left ventricular outflow tract is often elliptic [4,9] with, in this case, a risk of underestimation of AVA by calculation based on the diameter measured on echocardiography (a smaller diameter of the ellipse). The second error is the frequent underestimation of MG when only the apical view is used [8], as higher velocity and MG are obtained in about 20% of cases on right parasternal or suprasternal views. Therefore, a significant proportion of patients with aortic stenosis are misclassified in terms of severity when gradient is evaluated by the apical imaging window alone. In our experience, the systematic use of right parasternal or suprasternal views often transforms paradoxical LF/LG aortic stenosis into classical high-gradient severe aortic stenosis. The third error concerns the positioning of the pulsed Doppler sample volume during measurement of the left ventricular outflow tract velocity time integral (VTI), responsible for possible underestimation or overestimation of the VTI and therefore of AVA. Furthermore, for patients in atrial fibrillation, five cardiac cycles must be averaged for these Doppler measurements of left ventricular outflow tract VTI and gradient. Importantly, when the left ventricle has a normal volume and LVEF is preserved, flow should logically be preserved and a low gradient in the absence of a small left ventricle is in favour of moderate aortic stenosis. It should also be noted that low $V_{max} < 3$ m/s or low MG < 20 mmHg are, in our opinion, arguments against a diagnosis of severe aortic stenosis with preserved LVEF, even when the estimated SVI is < 35 mL/m^2

Third step: calculate and consider the body surface area in patients with small body surface area to avoid 'underestimating' the aortic valve area. Indeed, paradoxical LF/LG aortic stenosis is often diagnosed in small women with a low body surface area [9]. In this case, it is recommended to systematically index AVA to body surface area to identify a possible discordance between an AVA < 1 cm^2 and an indexed AVA > 0.6 cm^2/m^2, which would be in favour of moderate aortic stenosis. However, indexing should be avoided in obese patients, in whom it is associated with a risk of overestimation of the severity of aortic stenosis.

Fourth step: measure the diameter of the ascending aorta to eliminate underestimation of AVA related to a pressure recovery phenomenon. The MG measured on echocardiography, compared to the gradient estimated by catheterization, does not take this phenomenon into account. This leads to overestimation of the Doppler gradient and transvalvular aortic VTI, which is significant especially in patients with a small ascending aorta, usually identified by measuring the diameter of the aorta at the sinotubular junction [11]. When this diameter is < 30 mm, this pressure recovery phenomenon must be systematically considered during echocardiography by calculating the energy loss index:

Energy loss index = $(AVA \times A_A)/(A_A - AVA)$,

where AVA corresponds to the functional aortic valve area calculated by the continuity equation and A_A corresponds to the area of the ascending aorta calculated from the diameter at the sinotubular junction ($A_A = \pi^2/4$). Severe aortic stenosis is then defined by an energy loss index < 0.6 cm^2/m^2. A small aorta is often observed in patients with low body surface area, and calculation of the energy loss index often allows these cases of paradoxical LF/LG aortic stenosis to be reclassified as more moderate aortic stenosis.

Fifth step: eliminate 'pseudo-severe' paradoxical LF/LG aortic stenosis. A multicentre study using stress echocardiography reported slightly more than 30% of 'pseudo-stenoses' in paradoxical LF/LG aortic stenosis, i.e. a low transvalvular flow leading to incomplete valve opening in the context of moderate aortic stenosis [12]. This relatively frequent situation can be detected by low-dose dobutamine or exercise echocardiography. These examinations may allow an increase of cardiac output, resulting in more complete aortic valve opening. In contrast, increased flow associated with increased MG (> 40 mmHg) and AVA remaining < 1 cm^2 are in favour of a diagnosis of 'true' severe paradoxical LF/LG aortic stenosis. Unfortunately, stress echocardiography is often difficult to perform in these elderly patients. Furthermore, this examination is non-contributive in patients who are unable to increase their cardiac output sufficiently during exercise or low-dose dobutamine, due to the left ventricular restrictive physiology.