

Low-flow/low-gradient aortic stenosis without contractile reserve—a case report

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Background

Diagnosis and management of low-flow/low-gradient aortic stenosis are very challenging. Resting echocardiography is not capable of differentiating between different types and origins of low-flow and low-gradient state in aortic valve stenosis. Therefore, dobutamine stress echocardiography (DSE) and cardiac computed tomography (CCT) are necessary. This case report should illustrate the importance of these assessments.

Case summary

A 73-year-old woman presented to our emergency department with New York Heart Association III symptoms of exertional dyspnoea. In addition, the patient complained of fatigue and low resilience. On physical examination, auscultation revealed a systolic murmur over the aortic valve. Further diagnostic steps revealed a low-flow/low-gradient aortic valve stenosis (LF/LGAS) without contractile reserve (CR) in DSE and massive valve calcification in CCT.

Discussion

In this case, we demonstrate the importance of different assessments and workflow. The prognosis of LF/LGAS has been re-evaluated during the last decade and the current guidelines recommend the treatment of such patients even in the absence of CR. Furthermore, we are discussing the results of LF/LGAS.

Keywords

Low-flow/low-gradient aortic stenosis • Dobutamine stress echocardiography • Cardiac computed tomography • Case report

Learning points

- Stepwise approach in the diagnosis of low-flow/low-gradient aortic stenosis (LFLG AS).
- Dobutamine stress echocardiography (DSE) and cardiac computed tomography (CCT) are the most important assessment modalities in LFLG AS.
- Patients with LFLG AS and without contractile reserve benefit from valve intervention when the diagnosis of severe aortic stenosis is proven in CCT.

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Guideline

2021 ESC/EACTS Guidelines for the management of valvular heart disease.

Introduction

Patients with low-flow/low-gradient aortic stenosis (LF/LGAS) represent a challenging patient cohort regarding diagnosis and treatment. Usually, aortic valve stenosis is defined as aortic jet velocity >4 m/s, mean aortic valve gradient >40 mmHg, and/or an aortic valve area (AVA) <1 cm². Low-flow/low-gradient aortic valve stenosis presents primarily with discordant echocardiographic findings—a small calculated AVA (<1 cm²) with low mean gradient (<40 mmHg). These circumstances raise uncertainty about the severity of the valve stenosis. The reason for such contradictory findings is normally a low-flow over the aortic valve, which leads to a reduction in gradient and thus further to an underestimation of the degree of severity. It is nearly impossible to confirm the presence of a severe aortic valve stenosis only with resting echocardiography in this context.¹ Pathophysiologically, there are two reasons for the presence of a low-flow state: systolic dysfunction due to reduced left ventricular ejection fraction (LVEF), and diastolic dysfunction with preserved LVEF (often due to left ventricular hypertrophy). Low-flow/low-gradient aortic valve stenosis with a reduced left ventricular function is called classical LF/LGAS, with preserved left ventricular function it is called paradoxical LF/LGAS. To identify different types of classical LF/LGAS and to evaluate different treatment options, dobutamine stress echocardiography (DSE) is recommended by recent guidelines.² The most complex group of patients are those without contractile reserve (CR). In this situation, DSE cannot provide additional information about the degree of aortic valve stenosis because the left ventricle is not able to generate more flow—consequently, valve stenosis is underestimated. Cardiac computed tomography (CCT) adds information on the degree of valve calcification and can help in decision-making.³ In the current ‘2021 ESC/EACTS Guidelines for the management of valvular heart disease’, the important role of CCT in this special patient cohort was highlighted.²

This case report shows a patient with LFLG aortic stenosis and illustrates the importance of a stepwise approach in the diagnosis of this complex disease.

Timeline

Day 0	16:07	73-year-old woman presents to our emergency department with NYHA III symptoms of exertional dyspnoea
	16:25	Electrocardiogram shows atrial fibrillation (90/min)
	16:40	Chest X-ray shows mild pulmonary congestion with little pleural effusions
	18:00	Transthoracic echocardiography (TTE) shows poor left ventricular function—ejection

Continued

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		fraction (EF 18%) and suspected low-flow/low-gradient aortic stenosis
Day 1	18:15	Admission for further investigations Cardiac catheterization: no pathological findings in the coronary arteries, pressure gradients of the aortic valve (from TTE) could be confirmed
Day 2		Dobutamine stress echocardiography—no contractile reserve
Day 4		Cardiac computed tomography—massive calcification of the aortic valve, Agatston Score of 2500 HU
Day 6		Heart Team Discussion—decision for transcatheter aortic valve implantation
Day 9		Transfemoral transcatheter aortic valve implantation
Day 11		Post-procedure echocardiography—left ventricular function stable, excellent working prosthesis with a mean gradient of 7 mmHg and an effective orifice area of 2.26 cm ²
Day 16		Discharge to home
6 months later		Patient-reported improved performance. Stable left ventricular ejection fraction and a good function of the aortic valve prosthesis

Case presentation

A 73-year-old woman presented to our emergency department with New York Heart Association functional Status III symptoms of exertional dyspnoea. In addition, the patient complained about fatigue and low resilience for the last few weeks. Usually, she was able to walk her dog for 20 min every day, but that has not been possible for a fortnight. At the moment she is not able to go to the second floor of her apartment. Physical examination revealed a systolic murmur over the aortic valve and in the basal area of the lungs, a reduction in breath sounds on both sides. In her past medical history, she had a stroke with no residuals, paroxysmal atrial fibrillation, and was diagnosed with diabetes Type 2. Her premedication included anticoagulation with vitamin K antagonists, a beta-blocker, and a lipid-lowering agent. Electrocardiogram at admission showed atrial fibrillation with a frequency of 90/min. The chest X-ray revealed mild pulmonary congestion with little bilateral pleural effusion. Echocardiography revealed poor left ventricular function [ejection fraction (EF) 22% by Simpson method] and presence of LF/LGAS (maximum gradient 33 mmHg, mean gradient 21 mmHg, stroke volume 33 mL, stroke volume index 16 mL/m², AVA 0.6 cm²) (Figure 1). The AVA was calculated with continuity equation and velocity-time integral (LVOT VTI 11.2 cm, AV VTI 59.6 cm, DVI 0.19). The dimensions of the left ventricle were measured as follows: LVEDd 69.9 mm, IVSd 11.4 mm, PWDd 13 mm. There was no evidence of LVOT obstruction.

The laboratory assessment showed highly elevated *n*-terminal pro-B-type natriuretic peptide (9701 ng/L) levels. Coronary angiography was without pathological findings. To evaluate the aortic valve stenosis further, a DSE was performed in line with the protocol

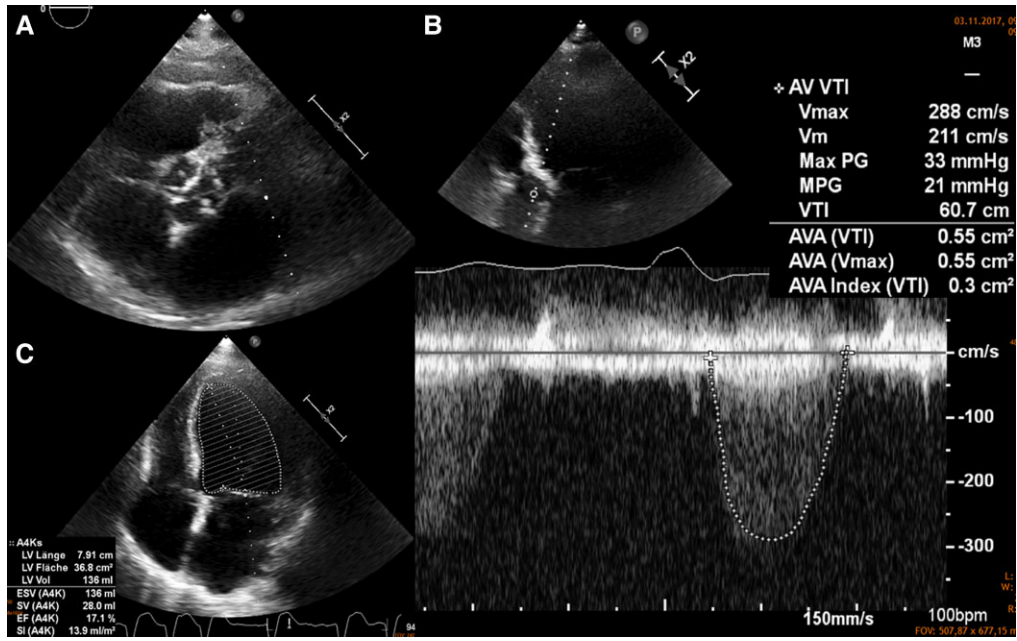


Figure 1 Transthoracic echocardiography: (A) parasternal short axis—calcification of the tricuspid aortic valve, (B) velocity measurement of the aortic valve in the apical five-chamber view, (C) four-chamber view for the assessment of ventricular function.

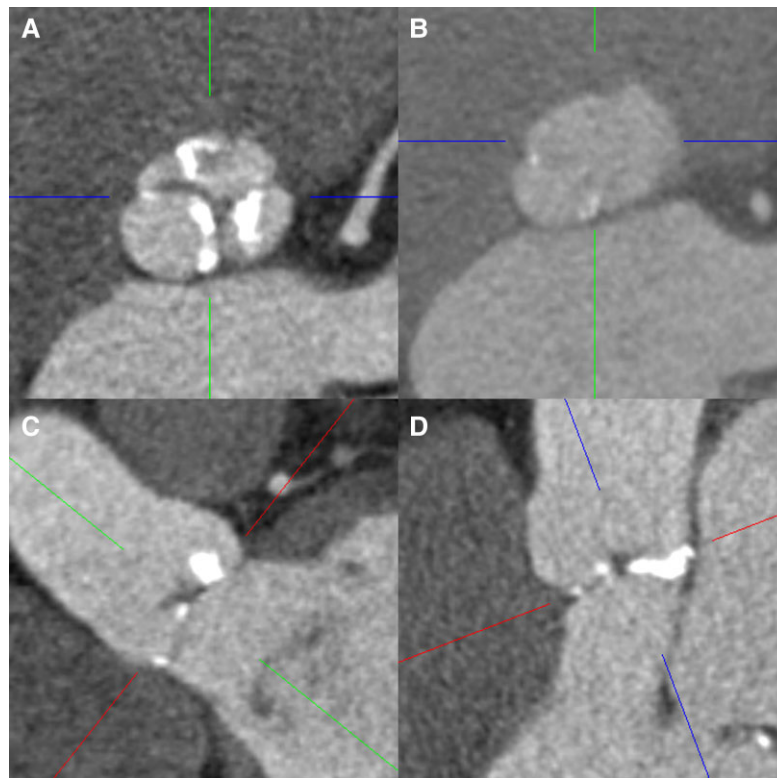


Figure 2 Cardiac computed tomography is showing massive calcification in the aortic valve. The Agatston Score of the aortic valve is 2500 HU. (A) Transverse axis—sinus of Valsalva; (B) transverse axis—ortic annulus; (C) coronal axis; (D) sagittal axis.

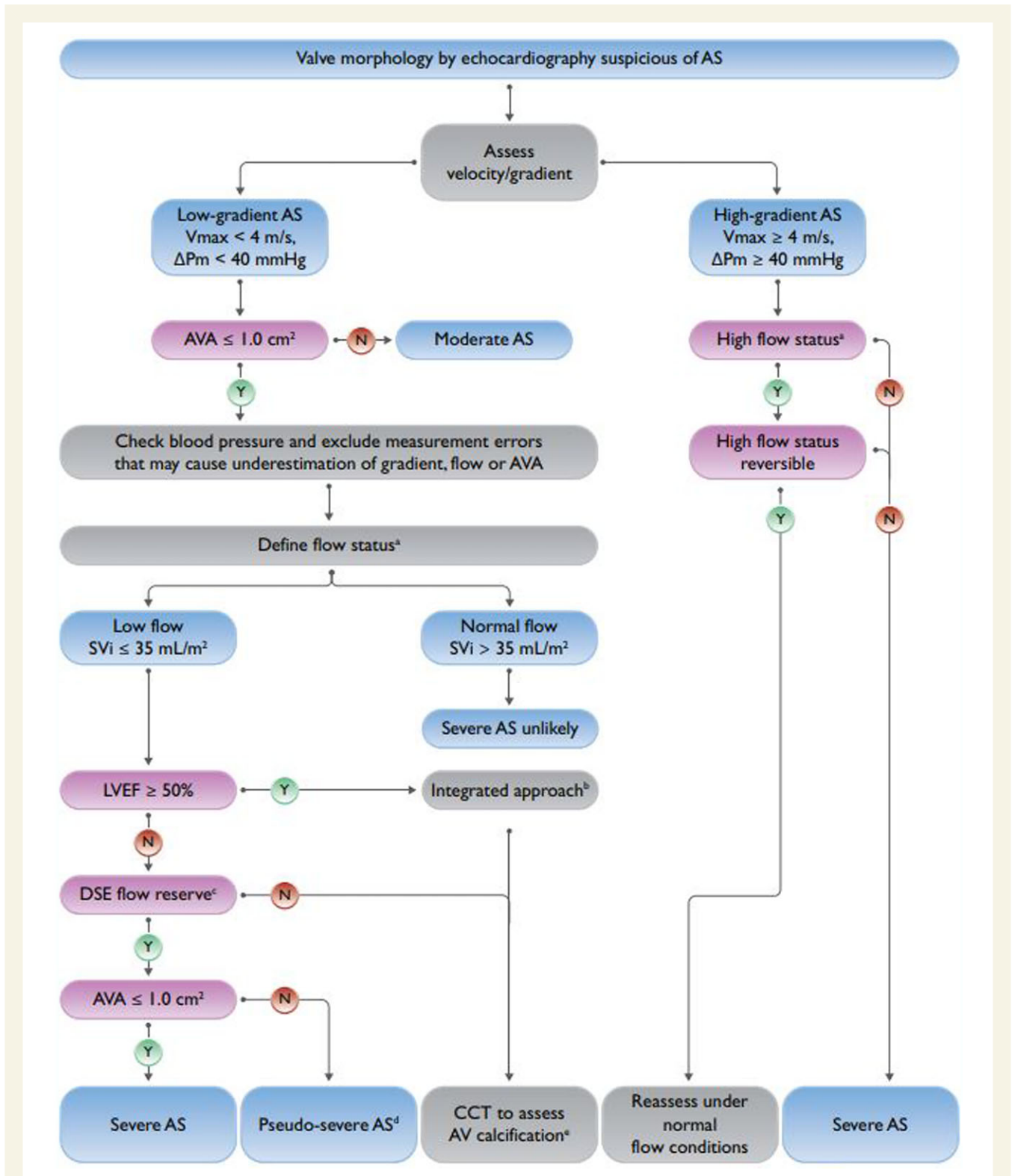


Figure 3 Proposed work flow for imaging in suspected aortic valve stenosis of the 2021 ESC/EACTS Guidelines for the management of valvular heart disease.²

recommended by the European Association for Echocardiography.⁴ Under dobutamine exposure, the stroke volume increased to 37 mL (SVI 19 mL/m²) and the EF to 26%. The mean gradient of the aortic

valve just increased to 22 mmHg (peak gradient 36 mmHg) and the AVA was stable with 0.6 cm² (LVOT VTI 8.83 cm, AV VTI 59.9, DVI 0.15). Furthermore, the blood pressure decreased under stress

from 97/80 to 80/40 mmHg. This assessment revealed no relevant CR, as stroke volume increased of 12% only (CR defined as >20% of stroke volume improvement).² A CCT showed massive calcification with an Agatston Score of 2500 units. (Figure 2) Based on all these observations, the diagnosis of a severe low-flow/low-gradient aortic stenosis was confirmed. Surgical risk evaluation depicted an EuroSCORE II of 8.6% and STS Score of 5%.

Considering the clinical presentation, the echocardiography, the computed tomography, and the high surgical risk, the patient was scheduled for a transcatheter aortic valve implantation (TAVI). The procedure was uneventful using a self-expandable valve prosthesis (Medtronic Evolut R, 34 mm) through transfemoral access. The post-procedural echocardiogram showed an excellent working prosthesis with a mean gradient of 7 mmHg and an effective orifice area of 2.26 cm² (iEOA 1.14 cm²/m²). Left ventricular function remained stable with an EF of 26% and a stroke volume of 39 mL (SVI 19 mL). Finally, the patient was discharged on the 7th post-operative day. After 6 months, the patient presented to the outpatient clinic for a routine check-up. She reported much better resilience. Echocardiography showed stable LVEF (EF 29%) and unchanged prosthetic function (mean gradient 8 mmHg, iEOA 1.1214 cm²/m²).

Discussion

Low-flow/low-gradient aortic stenosis is a very challenging disease in terms of diagnosis and treatment. The recently published 2021 ESC/EACTS Guidelines for the management of valvular heart disease highlights the importance of CCT and DSE as well as a stepwise approach towards diagnosis. The proposed workflow of the society is illustrated in Figure 3.²

In the diagnosis of a LF/LGAS, the low-flow state and the low-gradient state may underestimate the severity of stenosis. In contrast, calculation of the AVA, using the continuity equation, may cause an overestimation of the stenosis. Therefore, it is unlikely to make a diagnosis merely with the information of a resting echocardiography.⁵

In classical LF/LGAS, it is recommended to assess the presence of CR using a DSE. The purpose of dobutamine is to generate positive inotropic stimulation of the myocardium and thus increase stroke volume. In patients with a CR, we can differentiate between true-severe aortic stenosis and pseudo-severe AS. True-severe aortic stenosis is presenting with constant aortic valve orifice area, increased gradient of the aortic valve, and increased transvalvular flow under dobutamine stimulation. In pseudo-severe AS, the augmented flow results in only mild increase of transvalvular gradient and an increase in valve area >0.2 cm². This subdivision is the key point in the final decision for a treatment. Fougères *et al.*⁶ could show that the 5-year survival of pseudo-severe AS under conservative therapy is better and comparable with a propensity-matched patient population with left ventricular dysfunction and no evidence of valve disease. However, in our case, the patient had no CR in DSE and thus we have not received any further information about the extent of aortic valve stenosis. Cardiac CT provides additional information about the extent of aortic valve calcification. In such cases, the current guidelines recommend an assessment of the calcium load, as this correlates strongly with the area of the aortic valve. Thresholds indicating a severe aortic stenosis are an Agatston score

men >3000 HU and women >1600 HU.³ Therefore, the present European guidelines recommend also an intervention in symptomatic low-flow, low-gradient patients, and reduced EF without flow reserve, when severe aortic stenosis is confirmed in CT (IIa, C).² It is reported by Monin *et al.*⁷ that patients without a CR have a high risk for operative mortality. Nevertheless, Tribouilloy *et al.*⁸ could show the beneficial effect of an aortic valve replacement (AVR) even in an operative setting. Also in other studies, the presence or absence of CR did not affect the prognosis after TAVI or surgical AVR.^{9–11}

To summarize, DSE is necessary for the detection of pseudo-severe AS. Cardiac CT is a valuable option for the confirmation of severe aortic valve stenosis in patients without a CR. The absence of CR is not a contraindication for an intervention.

Conclusion

This case highlights the challenges in the diagnosis and the treatment in a very complex patient population. Dobutamine stress echocardiography and CCT are the key assessments for an evidence-based decision in the treatment of low-flow/low-gradient aortic valve stenosis.

Lead author biography



Lukas Stastny is doing his residency in cardiac surgery at the Medical University of Innsbruck. His main fields of interests are aortic valve stenosis and transcatheter aortic valve implantation.

Consent: The authors confirm that written consent for submission and publication of this case report including images and associated text has been obtained from the patient in line with COPE guidance.

Conflict of interest: None declared.

Finding: None declared.

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