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EACVI SURVEY

The evaluation of aortic stenosis, how the new guidelines are implemented across Europe: a survey by EACVI

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Aortic stenosis (AS) is the most prevalent valvular disease in developed countries, with a prevalence that is set to expand further with an ageing population. The most recent guidelines on valvular heart disease published by the European Society of Cardiology and the European Association for Cardio-Thoracic Surgery, aim to standardize the diagnosis and management of valvular heart diseases. The imaging criteria of the current guidelines are mostly based on EACVI Recommendations, with an appropriate diagnostic workflow being of major importance, to ensure streamlined and efficient patient assessment and accurate diagnoses and decisions regarding the timing of surgery. The EACVI Scientific Initiatives Committee, therefore, created a survey on the imaging assessment of patient with AS to investigate the diagnostic patient pathways used in different centres across Europe. In particular, we conducted this survey to better understand the use and access of advanced imaging techniques in AS including 3D transthoracic echocardiography and 3D transoesophageal echocardiography, cardiac computed tomography, and cardiovascular magnetic resonance.

Keywords aortic stenosis • EACVI • multimodality

Introduction

Aortic stenosis (AS) is the most prevalent valvular disease in developed countries, with a prevalence that is set to expand further with an ageing population.[1] Estimates of incidence rate of severe AS vary from 4% to 7% in patients >65 years of age.[2] Despite the efforts of our current healthcare systems, AS remains undiagnosed even in high-income countries, especially in deprived socioeconomic groups.[3] Additionally, among those who are diagnosed with AS, we need to clarify the optimal timing of surgery which is currently based predominantly on the presence of both severe stenosis on imaging and symptoms attributable to valve disease. Echocardiography plays a major role in the diagnosis and management of AS, but the role of cardiac computer tomography (CCT) and cardiovascular magnetic resonance (CMR) is also growing. The most recent guidelines on valvular heart disease published by the European Society of Cardiology (ESC) and the European Association for Cardio-Thoracic Surgery (EACTS) aim to standardize the diagnosis and management of valvular heart diseases.[4] The imaging criteria of the current guidelines are mostly based on EACVI Recommendations, with an appropriate diagnostic workflow being of major importance, to ensure streamlined and efficient

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patient assessment and accurate diagnoses and decisions regarding the timing of surgery.[5]

The EACVI Scientific Initiatives Committee network includes imaging centres across Europe and all over the world and conducts surveys to explore imaging-related management of patients.[6–8] We conducted a survey to better understand the use and access of advanced imaging techniques including 3D transthoracic echocardiography and 3D transoesophageal echocardiography (3D TTE and 3D TOE), CCT, and CMR in diagnosis, management, and treatment of AS.

Methods

The survey was designed and conducted by the EACVI Scientific Committee. Using the EACVI survey network (www.escardio.org/eacvi/surveys), 150 centres were invited to participate.[2] The survey was performed from 11 September to 1 October 2019, consisted of 20 questions, and was focused on the use of recent guidelines on valvular heart disease published by the ESC and the EACTS.[4] Survey questions focused on the use of and access to advanced imaging techniques in the evaluation of AS including, 3D TTE, 3D TOE, CCT, and CMR in the diagnosis and management of patients with AS.

Results

Characteristic of responding centres

In total, 125 centres (83%) from 32 different countries responded to the survey. The majority of the centres was European. Centres were located in Australia (1), Belgium (3), Brazil (1), Canada (1), Croatia (2), Denmark (1), Finland (1), France (3), Germany (9), Greece (3), Hungary (1), Italy (14), Japan (2), Lithuania (2), Macedonia (1), Malta (2), Mexico (1), Netherlands (7), Norway (7), Oman (2), Poland (16), Portugal (2), Romania (1), Saudi Arabia (1), Slovenia (6), Spain (10), Sweden (1), Switzerland (4), Turkey (2), UK (9), and the USA (3). Most of the centres were tertiary centres or University Hospitals (87%), whilst the remaining were secondary care or private hospitals. In all, 40% of the centres performed >300 TTEs per week, 33% from 100 to 150 per week and 15% performed <100 TTEs per week.

Assessment of valve morphology and AS

Valve morphology (trileaflet vs. bicuspid valves), if not clear on routine TTE, was next assessed in most of the centres by TOE (85%), computed tomography (CT, 46%), or CMR (32%) (*Figure 1*). In the evaluation of AS severity, almost all centres (98%) used peak velocity and mean transvalvular pressure gradient measurement from the apical view, and 52% also routinely obtained measurements from the right parasternal view. Aortic valve area (AVA) evaluation by the continuity equation was done in 93% centres, and in 74% of centres, AVA was routinely indexed to body surface area (indexed AVA). Planimetric evaluation of AVA was utilized in 43% of centres, most commonly on TTE but also on 3D TTE (10%), TOE (53%), 3D TOE (41%) contrast CT (14%) and CMR (12%). Only half the centres routinely assessed the stroke volume index (55%) and the dimensionless index (48%). The echocardiographic calcification index was routinely assessed in only 2% of centres.

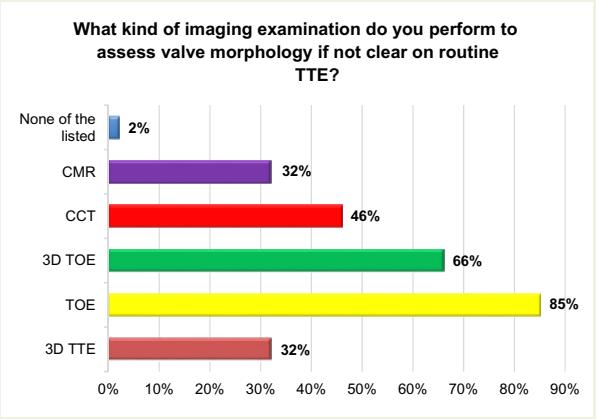

Figure 1 What kind of imaging examination do you perform to assess valve morphology if not clear on routine TTE? 3D TOE, three-dimensional transoesophageal echocardiography; 3D TTE, three-dimensional transthoracic echocardiography; CCT, cardiac computer tomography; CMR, cardiac magnetic resonance; TOE, transoesophageal echocardiography.

Two-thirds of centres (66%) assessed blood pressure routinely in patients undergoing TTE evaluation for AS, whilst the presence of anaemia was assessed in half the responding centres (55%). In patients with moderate AS and significant calcification, a follow-up TTE was performed every 6 months in 53% of centres, every 12 months in 49%.

Assessment of the left ventricle

In almost all centres, left ventricular function was routinely assessed using ejection fraction calculated by the Simpson method (95%) and by the global longitudinal strain (58%). In almost half (47%) of the labs, left ventricular function was presented using non-quantitative assessments (mild, moderate, and severe systolic dysfunction). Ejection fraction was evaluated by CMR in 22% of centres, and in 21%, myocardial fibrosis was assessed by the CMR late gadolinium enhancement technique.

Low-flow, low-gradient AS

In patients with discordant echocardiographic measurements (AVA <1.0 cm^2 and mean gradient <40 mmHg) and with preserved ejection fraction, stroke volume was measured by TTE in 93% of centres, and 28% used TOE and 25% used CMR to measure stroke volume in difficult cases.

In patients with suspected low-flow, low-gradient AS with preserved ejection fraction (paradoxical low-flow AS), 87% of centres evaluated the visual appearances of the valve (degree of calcification and opening profile) to help in the assessment of disease severity. In 82% of centres, reassessment of the key TTE measurements, such as left ventricular outflow tract (LVOT) dimension and Velocity Time Integral measurements, was performed. Interestingly, in two-thirds of centres, CT aortic valve calcium scoring was performed to help adjudicate AS severity. A fifth of centres would routinely ask a second expert for corroboration of the findings, whilst only 7% of centres used CMR for confirmation.

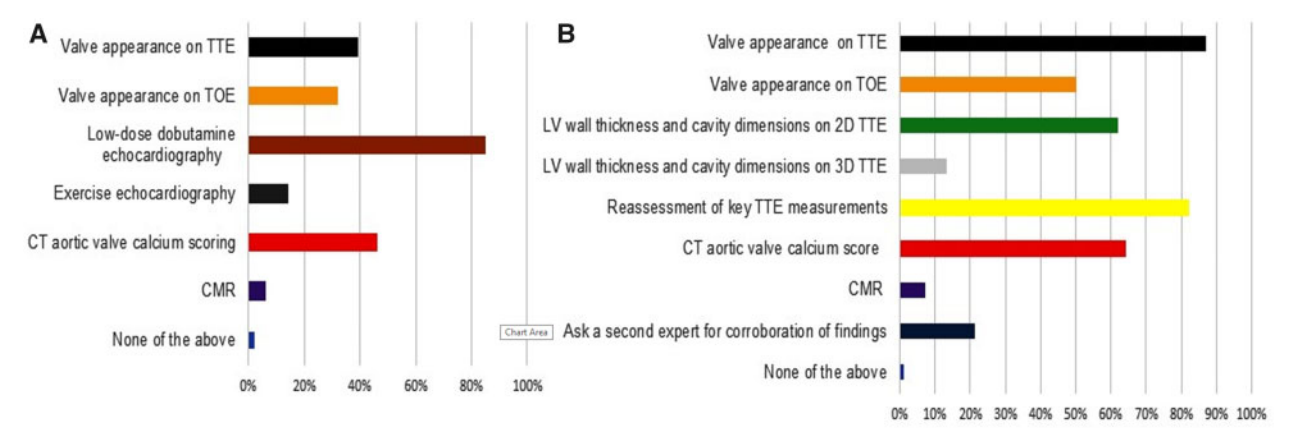

Figure 2 Low-flow, low-gradient AS with reduced and preserved ejection fraction—other factors used to differentiate severe from pseudo-severe AS. (*A*) Low-flow, low gradient with reduced ejection fraction. (*B*) Low-flow, low-gradient aortic stenosis with preserved ejection fraction. 3D TOE, three-dimensional transoesophageal echocardiography; 3D TTE, three-dimensional transthoracic echocardiogram; CMR, cardiac magnetic resonance; CT, computer tomography; TOE, transoesophageal echocardiogram; TTE, transthoracic echocardiogram.

In patients with suspected low-flow, low-gradient AS with reduced ejection fraction, 85% of respondents performed low-dose dobutamine TTE (*Figure 2*) and 46% used CT aortic valve calcium scoring to distinguish severe from pseudo-severe AS.

Only 14% of centres used exercise echocardiography to evaluate low-flow, low-gradient patients and 13% used exercise echocardiography in the diagnosis of paradoxical low-gradient AS. However, this technique was used in more than a half of centres (54%) to further evaluate symptomatic status in apparently asymptomatic patients. Ten percent of centres did not perform either exercise or dobutamine echocardiography.

Valve teams, transcatheter aortic valve implantation, and AS

We asked participating centres if there is a valve team at their institution and which specialists this team included. Results showed that 87% of centres had a valve team that commonly included cardiac surgeons, interventional cardiologists, general cardiologists, and echo specialists. In a one-third of centres, a specialist in CT/CMR was part of the team (37%), although a geriatrician was only included in the team in 8% of centres (*Figure 3*).

In almost all the centres, TTE (94%) and contrast CT angiography (86%) were performed routinely in patients considered for transcatheter aortic valve implantation (TAVI). Half the centres (49%) also routinely performed CT aortic valve calcium scoring as part of their CT protocol. Only 38% of centres routinely performed TOE, with 21% of those centres using 3D TOE.

During TAVI implantation half of the centres used fluoroscopy guided by the CT angiogram for intra-procedural monitoring with live 2D TOE the second most frequent technique (*Figure 4*).

Follow-up after TAVI (*Figure 4*) was relatively consistent across the centres with 82% reporting routine follow-up of TAVI patients, 9% reporting follow-up only in patients with complications, and 9% reporting follow-up in a hospital other than the one that performed the procedure. In 39% of centres, patients underwent follow-up using

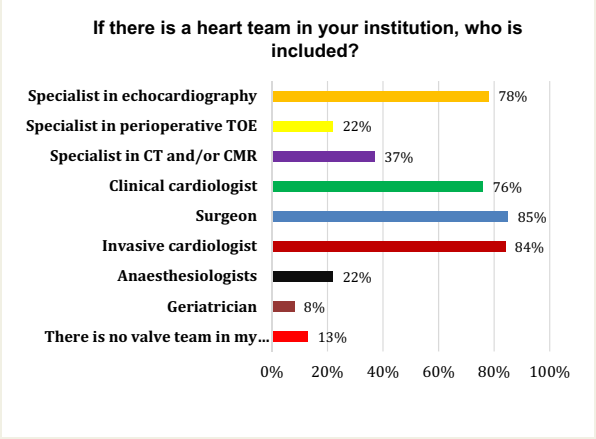

Figure 3 If there is a heart team in your institution, who is included? CMR, cardiac magnetic resonance; CT, computer tomography; TOE, transoesophageal echocardiography.

the 3, 6, and 12 months protocol, 21% performed a single follow-up visit 1 month post-TAVI, 16% 3 months post-TAVI, and 16% 6 months post-TAVI. In patients found to have high-pressure gradients through the prosthetic valve after TAVI, 80% of centres would perform TOE (56% 3D TOE), whilst 41% chose contrast CT angiography for this indication.

Contrast CT angiography in patients with AS

Contrast CT angiography used in 81% of the assessment of patients referred for TAVI and was also performed in 14% of centres for the assessment of patients being considered for surgical aortic valve replacement (SAVR). Half of the centres used contrast CT angiography to evaluate aortic root dilatation and to exclude a porcelain aorta

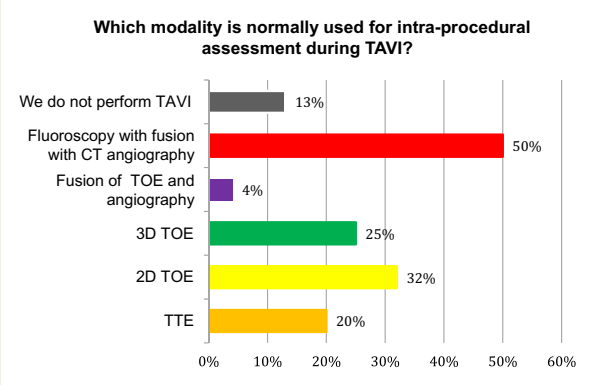

Figure 4 Which modality is normally used for intra-procedural assessment during TAVI? 2D TOE, two-dimensional transesophageal echocardiography; 3D TOE, three-dimensional transesophageal echocardiography; CT, computer tomography; TAVI, transcatheter aortic valve implantation; TOE, transoesophageal echocardiography; TTE, transthoracic echocardiography.

(46%). A third of centres used CT coronary angiography to assess the coronary arteries prior to surgery in patients with a low probability of coronary artery disease (36%) and to assess the degree of valve calcification (33%). In contrast, 15% of centres did not perform any contrast CT angiography for patients with AS.

Discussion

This survey by the EACVI scientific initiatives committee evaluated the use of current guidelines in the diagnosis and management of AS and involved more than 120 centres all over the world. Overall, adherence to guidelines was satisfactory. Echocardiography with Doppler technique is still the most commonly used imaging technique to evaluate AS, whilst computer tomography is emerging. Patients with low-flow, low-gradient AS are the most challenging group for diagnosis and management, and the majority of centres used a multimodality approach in these patients. The use of 3D TTE, exercise echocardiography, and external clinical factors was rare. Follow-up after aortic interventions varied significantly across centres.

Evaluation of the aortic valve morphology and function

Our survey confirmed transthoracic echocardiography as the first-line imaging test for the assessment of patients with AS. An interesting observation was that external clinical factors that can influence the echocardiographic assessment of AS were not routinely examined across all centres, e.g. blood pressure was recorded in only two-thirds of centres, and anaemia and thyroid function in less than half of centres. Further emphasis on these additional clinically important measures may be required in future recommendations.

When it is not clear whether the aortic valve is bi- or tricuspid on TTE, the majority of centres used TOE to establish valve morphology, and frequently also 3D TOE. Around half of centres used CT and a third CMR. The use of 3D TTE was relatively low, which may be explained by inadequate echo windows or lack of availability of the technique.[9]

The TTE evaluation of AS severity was performed in line with ESC guideline recommendations in the majority of centres.[4] Almost all respondents evaluated peak velocity mean transvalvular pressure gradient, and the AVA using the continuity equation. Interestingly, only half of the centres routinely confirmed velocities acquired at the apex from the right parasternal position. This too may require further emphasis in future guidelines.

A hybrid approach to calculate the AVA with the continuity equation (using LVOT areas measured on 3D TOE or contrast CT) was used in a small minority of centres. Planimetry of the AVA was performed in half the centres using TTE, TOE, or 3D TOE. These results suggest that most of the centres and doctors working there trust in the results of AVA obtained from continuity equation in TTE and use planimetry measurements only in selected cases.

Left ventricular structure and function

Left ventricular function was assessed in the vast majority of centres using TTE estimation of the ejection fraction with the Simpsons biplane method according to the recommended method.[10]

Half of centres also used longitudinal strain assessments, indicating the emerging use of this method, and supported by the growing literature demonstrating impairment in global longitudinal strain before reductions in left ventricular ejection fraction become apparent.[11,12] Recent data also indicate the role of longitudinal strain in patients with bicuspid aortic valve and mixed aortic regurgitation and AS.[13]

Interestingly, nearly half the centres also provided a description of left ventricular function by visual assessment (normal or mild, moderate-severe systolic dysfunction).

About one-fifth of centres used CMR for ejection fraction calculation and the evaluation of myocardial fibrosis. As outlined in the guidelines this technique can be useful in patients where echocardiographic assessments are unclear and can provide further prognostic information. Further work is ongoing to evaluate whether fibrosis assessments can help identify left ventricular decompensation and improve the timing of aortic valve intervention.[14–16]

AS in challenging patients

The assessment of patients with discordant echocardiographic measurements (AVA <1.0 cm^2 and mean gradient <40 mmHg) is a clinical challenge in routine echocardiography. ESC guidelines recommend assessment of the stroke volume index in those with preserved ejection fraction.[3,4] However, only half of centres reported routine calculation of the stroke volume index, indicating limited adherence to this guideline. In cases with unclear flow status on TTE, centres were equally likely to use CMR as TOE to gain further information, indicating a growing use of CMR for this purpose.

In patients with suspected low-flow, low-gradient AS with the preserved ejection fraction (paradoxical low-flow AS), the majority of centres carefully reviewed the original TTE scans examining valve appearance, opening profile, and how measurements of peak velocity, mean gradient, and LVOT diameter were made. More than half (60%) of centres performed a CT aortic valve calcium scoring in cases of ongoing diagnostic uncertainty. These results are consistent with the latest guideline recommendation.[3]

In patients with suspected low-flow, low-gradient AS with reduced ejection fraction (classical low-flow AS), most centres used low-dose dobutamine echocardiography to adjudicate disease severity. CT calcium scoring was also used in over 60% of centres. Despite the expanding literature on exercise echocardiography to assess these patients, this method was rarely used among the participating centres,[17,18] Exercise echocardiography has a Class I indication for SAVR in asymptomatic patients with severe AS when symptoms occurs during the test.[4] The explanation of the underuse of this method was not explored.

Transcatheter aortic valve implantation

The role of TAVI in AS is rapidly increasing with imaging central in appropriate patient selection and crucial for procedure planning. Valve teams are established in most centres participating in this survey and included an expert in echocardiography in the vast majority and an expert in CT or CMR in one-third of centres. A geriatrician was part of the team in only 8%. Ideally, this proportion should be higher given the advanced age of patients being considered with TAVI and the complexity of decisions regarding frailty and futility in this patient population.[19]

Almost all centres used TTE and contrast CT angiography to evaluate patients considered for TAVI, whilst only a third performed a TOE. During the procedure more than half used fluoroscopy alongside the CT angiogram results, with the remainder using live TOE or TTE. According to the guidelines, CT angiography is the method of choice for the evaluation of anatomy, shape of the aortic root, calcification of the leaflets, and coronary ostia.[4] The role of TOE for monitoring and evaluating the results of TAVI, although highlighted by the guidelines, is not fully utilized, and perhaps reflects the emergence of TAVI performed under local not general anaesthetic.

The follow-up of patients following surgical AVR or TAVI was largely performed with echocardiography. In a half of patients, this was performed at a single time point, whilst <40% of patients had an echocardiogram 3, 6, and 12 months post-TAVI as recommended in the guidelines.[4,20,21] These results indicate that the recommendations of three echocardiograms within the first year after TAVI may be too resource consuming and not feasible in clinical practice.

Limitations

The majority of responses was received from high-volume university or tertiary hospitals limiting the extrapolation of results to other centres.

Conclusions

Most centres adhered well to the latest recommendations by EACVI in valvular heart disease in patients with AS. Transthoracic echocardiography remains the cornerstone of patient assessment, although the role of CT, in particular, is expanding and was part of the routine evaluation of patients being considered for TAVI in the majority of centres. CMR, 3D echocardiography, and exercise echocardiography were used only in selected cases reflecting that further work is required to determine which patients would benefit from these evaluations. Follow-up after aortic interventions varied significantly across centres indicating that local resources determine management and follow-up.

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Conflict of interest: none declared.

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IMAGE FOCUS

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Coronary sinus ostial atresia with small cardiac vein as final myocardial conduit

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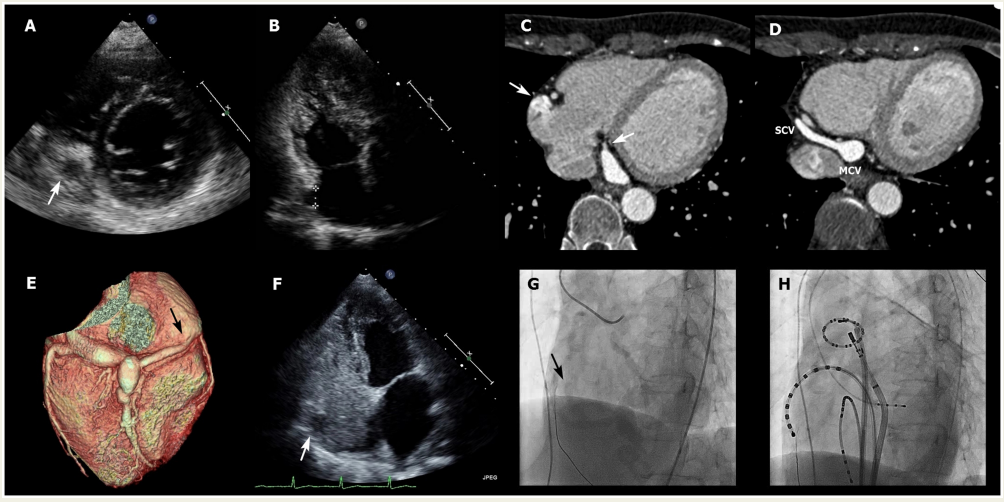

A 57-year-old woman complained palpitation and had been diagnosed as paroxysmal atrial fibrillation (AF) by Hol ter monitoring. She had been admitted for radio-frequency catheter abla-tion (RFCA) for AF. Echocardiography sho wed dilatation of middle cardiac vein (MCV) and small cardiac vein (SCV) (*Panels A* and *B*, arrow points to MCV, and dashed line to SCV; Supplementary data online, *Videos S1* and *S2*). Dilated coronary sinus (CS) is often encountered finding at echocardiogram in adult, but visualization of SCV or MCV by echocardiography are unusual. Cardiac computed tomography showed marked bulging of MCV and SCV with ostial atresia of CS (*Panels C* and *D*, Lt. arrow points to SCV, and Rt. arrow to blind ostium of CS). Volume-rendering image showed heavy engorgement of cardiac veins (*Panel E*). In par-ticular, dilated SCV was presumed to be terminating at lateral side of right atrium (RA) (black arrow). Intravenous infusion of agitated saline demonstrated that flow direction across SCV is toward RA, and there is no anomalous venous influx into CS (*Panel F*, arrow; Supplementary data online, *Video S3*). And, coronary angiography with delayed acquisition showed contrast emptying from SCV into RA (*Panel G*, arrow; Supplementary data online, *Video S4*). After acquiring information about cardiac vein malformation, RFCA was done. Ablation was successfully fulfilled despite of absence of electrocardiographic monitor by CS lead (*Panel H*). Most of CS ostial atresia that has been reported in the literature are accompanied by concomitant persistent left superior vena cava as bypass route of venous drainage from right upper extremity, or direct communication of CS into left atrium. But, this case is a unique type of cardiac vein anomaly with multimodal images that has never been reported worldwide. In conclusion, a final diagnosis was CS ostial atresia with SCV as final conduit of myocardial blood flow.

Supplementary data are available at *European Heart Journal - Cardiovascular Imaging* online.