Symptomatic Left Ventricular Outflow Tract Obstruction Caused by Mitral Annular Calcification

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INTRODUCTION

Left ventricular outflow tract (LVOT) obstruction is defined as a peak gradient ≥ 30 mm Hg at rest or with provocation. A peak gradient ≥ 50 mm Hg is the conventional threshold for percutaneous or surgical intervention in the presence of symptoms not relieved by medical therapy.[1] The most common cause of LVOT obstruction (LVOTO) is hypertrophic obstructive cardiomyopathy, seen in nearly 75% of patients with elevated gradients across the outflow tract.[2] However, obstructive physiology can result from a diverse array of structural abnormalities, including subaortic stenosis, sigmoid septum, takotsubo cardiomyopathy, and mitral valve abnormalities.[3] Correct identification of the etiology of LVOTO is a critical step in determining appropriate medical and surgical therapy. In the present case, we describe severe mitral annular calcification (MAC) leading to LVOTO. This is an uncommon phenomenon with significant clinical ramifications.

CASE PRESENTATION

An 80-year-old woman presented to the hospital with a several-week history of progressive dyspnea on exertion and chest pain. She was asymptomatic at rest. Pertinent medical history included hypertension, hyperlipidemia, chronic diastolic heart failure, chronic kidney disease stage III, and coronary artery disease with stents in the right coronary artery and ramus. Blood pressure on admission was 121/57 mm Hg, heart rate was 55 beats/min, respiratory rate was 18 respirations/min, and oxygen saturation was 98% on room air. On physical examination, a holosystolic murmur at the left upper sternal border was appreciated, along with a soft systolic murmur at the apex. Jugular venous pressure was not elevated, lungs were clear, and she had minimal lower extremity edema. Laboratory evaluation was notable for three sets of negative cardiac enzymes. Electrocardiography showed normal sinus rhythm. Chest radiography was without evidence of significant interstitial edema.

Ejection fraction was 70% on transthoracic echocardiography (TTE). The interventricular septum measured 1.5 cm, and there was an intracavitary gradient of 44 mm Hg. Diffuse severe MAC was seen with involvement of the anterior and posterior leaflets. Mitral stenosis was estimated as mild, with a peak gradient of 14 mm Hg, a mean gradient of 5 mm Hg, and a pressure half-time of 87 msec. Transesophageal echocardiography (TEE) showed moderate holosystolic mitral regurgitation (regurgitant orifice area 0.20 cm^2) and moderate mitral stenosis with peak and mean gradients of 9 and 3 mm Hg and mitral valve area of 1.4 cm^2 by three-dimensional planimetry. There was evidence of dynamic LVOTO secondary to a calcified subvalvular apparatus, with a peak gradient of 55 mm Hg (Figure 1, Videos 1 and 2). There was no significant septal hypertrophy or systolic anterior motion (SAM) of the mitral valve. Although the gradient by TTE was thought to be intracavitary, TEE more clearly demonstrated the location of this gradient at the LVOT. Although hemodynamics can typically be assessed adequately using TTE, TEE in this patient fostered a more precise understanding of the mechanism of obstruction. Furthermore, the gradient may have been worsened during TEE by virtue of the relative hypotension and hypovolemia associated with procedural sedation and overnight fasting.

Noncontrast computed tomography of the chest, performed for surgical planning, confirmed severe MAC with extension into the myocardial wall and subvalvular apparatus (Figure 2). There was no significant calcification of the aortomitral curtain.

Left heart catheterization revealed patent stents in the right coronary artery and ramus with otherwise nonobstructive disease. There was a gradient of 7 mm Hg across the aortic valve at rest. On right heart catheterization, right atrial mean pressure was 13 mm Hg, pulmonary artery pressure was 46/12 mm Hg with a mean pulmonary artery pressure of 20 mm Hg, and mean pulmonary capillary wedge pressure was 20 mm Hg. Fick cardiac output was 3.74 L/min, with a Fick cardiac index of 2.04 L/min/m^2.

The patient was treated with gentle diuresis and β-blockade, but her symptoms did not improve. Her functional status remained severely limited by dyspnea and chest discomfort on minimal exertion. With lack of response to medical therapy, open heart surgery was performed. She underwent debridement of diffuse MAC with resection of the subvalvular apparatus, including a calcified papillary muscle weighing 4.01 g. The mitral valve was replaced with a #31 Biocor prosthetic valve (St. Jude Medical, St. Paul, MN), and the posterior annulus was repaired with a bovine pericardial patch. Histopathologic examination of the anterior leaflet of the mitral valve demonstrated mild calcification and mild fibrosis. Examination of the excised papillary muscle was remarkable for extensive nodular calcification. Intraoperative TEE showed a well-seated bioprosthesis with a mean gradient of 3 mm Hg across the valve, no periprosthetic mitral regurgitation, and no residual LVOTO (Figure 3).

Postoperatively the patient developed sinus node dysfunction requiring a dual-chamber pacemaker. Recovery was otherwise uncomplicated, with discharge home on postoperative day 14. At follow-up 2 months after surgery, she endorsed complete resolution of exertional symptoms.

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VIDEO HIGHLIGHTS

Video 1: TEE with color-compare showing calcification of the subvalvular apparatus causing LVOTO with correlating flow acceleration in the LVOT on color flow Doppler.

Video 2: TEE with three-dimensional multiplanar reconstruction of the mitral valve showing LVOTO secondary to MAC extending into the subvalvular apparatus.

View the video content online at www.cvcasejournal.com.

DISCUSSION

Although LVOTO is classically observed in the setting of hypertrophic cardiomyopathy, it can be seen in a wide variety of conditions. MAC is a rare cause of LVOTO and typically occurs in conjunction with SAM of the mitral valve[4] or severe sigmoid septal hypertrophy.[5] It has been proposed that anterior displacement of the mitral ring, frequently seen in MAC, predisposes to SAM.[6] Here we present a case of MAC without associated SAM or significant septal thickening, revealing that obstruction can result exclusively from extensive calcific disease.

MAC is a chronic and slowly progressive process with a reported prevalence between 8% and 15%, with the posterior annulus being more often affected than the anterior annulus.[7] Prevalence increases significantly with advanced age, chronic kidney disease, and other cardiovascular risk factors. There is no formal grading system to describe the severity of MAC, but numerous imaging modalities can be used to quantify the burden of disease. MAC is readily observed on TTE, the cornerstone in evaluation of calcific mitral pathology. Assessment should be systematic and include extent of calcification (focal vs circumferential), location of degenerative changes according to the Carpentier nomenclature, and extent from base to coaptation line.[8] Computed tomography provides complementary data, well suited to defining the precise location and extent of MAC because of its high x-ray attenuation and spatial resolution. It can identify involvement of MAC in extra-annular structures and is thus an integral modality in surgical planning.

MAC is most often an incidental finding, generally sparing the mitral valve commissures and therefore having little effect on valve function until late in the disease course. In rare instances, the hemodynamic and clinical consequences of MAC extend beyond the mitral valve. With encroachment of MAC into the subvalvular apparatus, as seen in this case, obstruction across the LVOT may ensue. This unique finding highlights the need for a thorough evaluation not only of the mitral valve but also of left ventricular structure and function when MAC is identified.

Our patient's debilitating symptoms seemed out of proportion to the degree of mitral valve dysfunction identified on TTE, prompting further evaluation with multimodality imaging. TEE was an invaluable tool in this case, providing thorough interrogation of the mitral valve and capturing the key finding of a dynamic peak gradient across the LVOT measuring ≥50 mm Hg. Computed tomography better delineated the calcium burden and provided the anatomic data needed for surgical intervention. Collectively, these imaging modalities yielded a comprehensive picture of the structural and functional elements involved in our patient's pathophysiology and enabled her to receive a curative procedure.

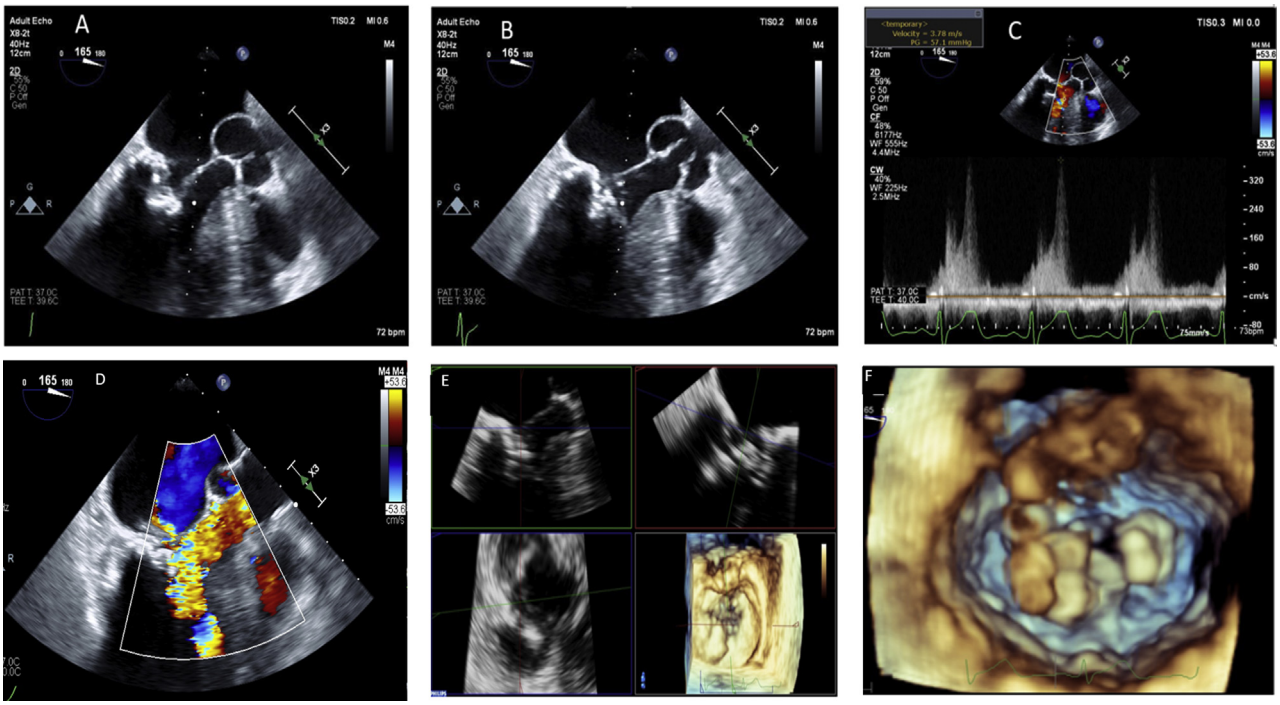

Figure 1 TEE showing **(A)** severe calcification of the subvalvular apparatus in diastole and in systole **(B)**, with continuous-wave Doppler **(C)** demonstrating a dynamic LVOTO. **(D)** Turbulent flow across the LVOT demonstrated by color Doppler. Three-dimensional imaging with multiplanar reconstruction **(E)** and view from the ventricle **(F)** showing severe calcification of the mitral annulus, leaflets, and subvalvular apparatus.

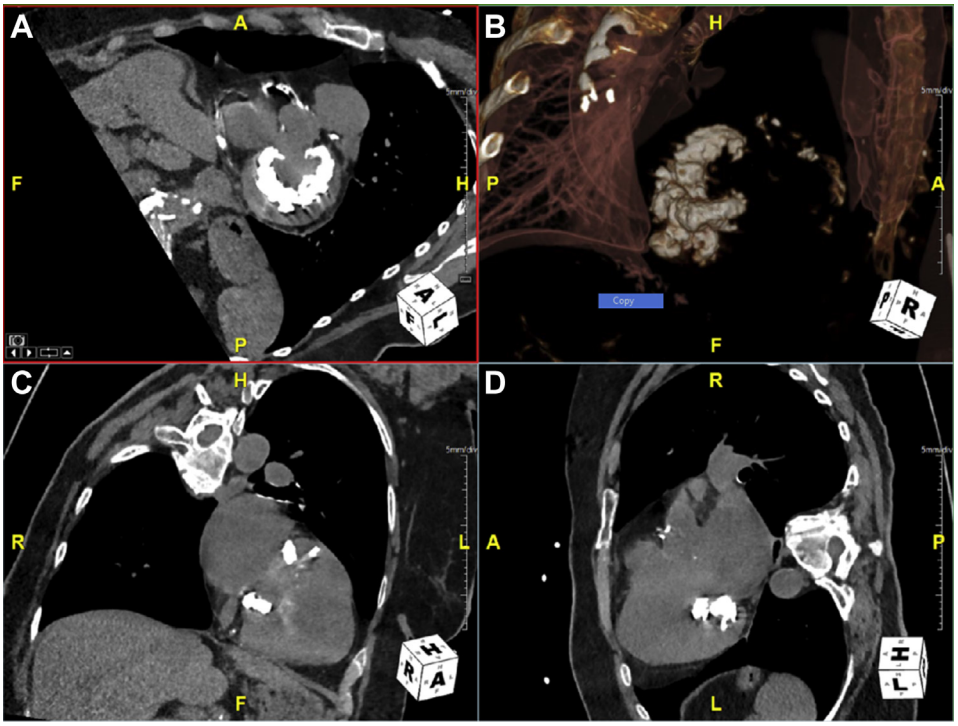

Figure 2 Chest computed tomography showing **(A)** axial view of severe calcification of the mitral annulus with extension into the subvalvular apparatus, **(B)** three-dimensional reconstruction of severe circumferential MAC, and **(C, D)** additional views of calcium encroaching into the subvalvular apparatus.

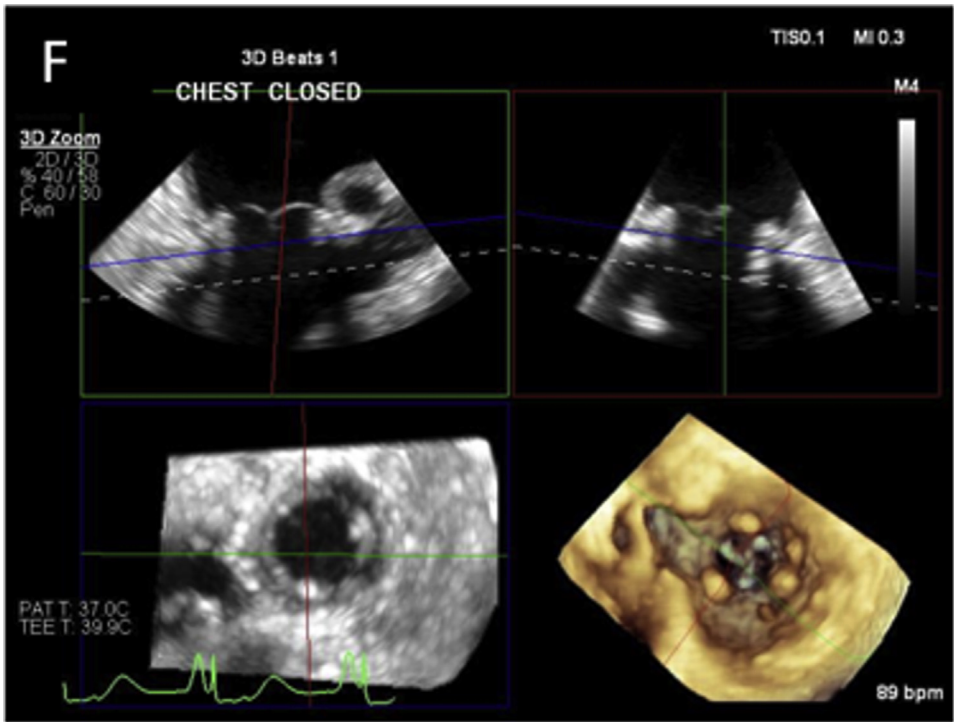

Figure 3 Three-dimensional TEE with multiplanar reconstruction after mitral valve replacement with excellent result, with no residual LVOTO.

CONCLUSION

We present a novel mechanism of LVOTO secondary to MAC extending into the subvalvular apparatus. This report highlights the role of multimodality imaging in elucidating the precise mechanism of LVOTO, which in turn guides appropriate intervention.

SUPPLEMENTARY DATA

Supplementary data related to this article can be found at https://doi.org/10.1016/j.case.2020.07.009.

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