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Echocardiographic mimicker of thrombus on a mechanical aortic valve prosthesis due to cavitation: A paradoxical phenomenon of pressure recovery

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Abstract

We describe a case of a mass-like echocardiographic density on a mechanical prosthetic aortic valve. We initially suspected a thrombus vs vegetation on transthoracic echocardiography, but after transesophageal echocardiography, the density was subsequently determined to be cavitation by reviewing the initial images in slow motion.

Keywords

aortic valve prosthesis; cavitation; mass; microbubbles; thrombus; vegetations

1 | INTRODUCTION

Aortic valve replacement remains the most common cardiac procedure performed to treat aortic valve stenosis. However, multiple challenges exist when assessing mechanical prosthetic valves, in part due to potential valve-induced enhancement artifacts. Cavitation is a challenging phenomenon in echocardiographic appearance which has been described exclusively in mechanical heart valves.¹ It is a phenomenon in which transient changes of local pressure in liquid lead to the formation of small gas-filled cavities, in places where the pressure is relatively low, resulting in the formation of microbubbles.² We propose a mechanism for the formation of cavitation through aortic valve prostheses as a paradoxical phenomenon of pressure recovery, occurring in diastole.

2 | PATIENT PRESENTATION

A 53-year-old man with a history of Stanford type A aortic dissection complicated by severe aortic regurgitation 2 months prior—previously treated with mechanical aortic valve replacement, hemiarch and endovascular stent graft placement to descending thoracic aorta—presented with syncope preceded by diaphoresis, nausea, and flushing. On admission, the

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SUPPORTING INFORMATION

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patient showed no evidence of systemic infection, anemia, or focal neurologic deficits. He had been on therapeutic anticoagulation with warfarin over the preceding 4 weeks with an international normalized ratio range of 2.7–3.7.

Laboratory examination showed a white blood cell count of 6.4 (reference range, $3.5\text{--}10.5 \times 10^9$ cells/L), hemoglobin of 13.8 g/dL (reference range, $13.5\text{--}17.5$ g/dL), and international normalized ratio of 3.6 (therapeutic reference range, $2.0\text{--}3.0$). Head computed tomography was negative for acute intracranial abnormalities. Formal evaluation by neurology concluded vasovagal syncope less likely seizure.

A transthoracic echocardiogram demonstrated mobile echo dense lesions on the ventricular surface of the mechanical aortic valve prosthesis, resembling thrombus, vs vegetation, strands, sutures, or surgical remnants (Figure 1A,B, Movies S1–S2). A transesophageal echocardiogram showed normally functioning mechanical aortic valve prosthesis with a mean Doppler gradient of 2 mm Hg and trivial washing jet regurgitation and without any echo dense lesions. There was no evidence of shunt at the atrial level by agitated saline contrast study (Figures 1C,D, Movies S3–S4). Detailed review of the transthoracic echocardiogram images in slow motion and frame-by-frame revealed a cluster of microbubbles in the left ventricular outflow tract that subsequently disintegrated and completely dissipated (Figure 1E,F).

3 | DISCUSSION

This case illustrates the diagnostic dilemma that clinicians may face in differentiating simple gas microbubbles from thrombus, vegetation, or surgical remnants in the evaluation of patients with a mechanical prosthetic heart valve. This case equally highlights the importance of incorporating clinical findings with echocardiographic examination in resolving diagnostic imaging dilemmas.

Cavitation is a phenomenon which has been described as spontaneous microbubbles which form exclusively in mechanical heart valves when local pressure falls quickly under evaporation pressure conditions and then rises again due to vortex flow during the movement of the mechanical disks.³ Prior cases have reported similar findings of short-lived mobile mass mimicking thrombus or vegetation, but primarily involving mechanical mitral valve prostheses.^{4,5} This is likely due to the sudden drop in ventricular systolic pressure against a low left atrial pressure after mechanical mitral valve closure, creating a more favorable condition for cavitation to occur compared to a lower aorto-ventricular pressure drop after closure of mechanical aortic valve prostheses. In two similar case reports involving aortic valve mechanical prostheses, cluster of microbubbles were initially misinterpreted as mechanical valve endocarditis in patients with concurrent underlying infections.^{6,7} Similar to our case, sequential detailed analysis of echocardiographic images revealed the phenomenon of cavitation with fast appearing and disappearing of gas bubbles. Both cases presented with clinical finding suggestive of systemic infection, which could justify the initial characterization of the mobile masses as vegetations. Although the type of prosthesis was not described in the case from Arias et al,⁶ ours is the first reported case of cavitation in an On-X mechanical heart valve (CryoLife, Inc). Indeed, this phenomenon occurs

predominantly in mechanical prosthetic valves with a prevalence of 75% in bileaflet valves compared with 38.5% with tilting-disk valves ($P < 0.0001$).¹ Cavitation most often manifests as dense microbubble clusters at the inflow zone of the valve when flow velocity and pressure drop suddenly at the time of valve closing.⁸

The echocardiographic appearance is thought to be the result of vaporous cavitation (carbon dioxide degassing) and separation of the gas contained in the blood when the local pressure drops below ambient pressure as the blood travels through the narrowest portion of the prosthesis, the vena contracta, followed by a subsequent rise in pressure, forcing the gas to condense back into the liquid state in the blood (Figure 2).⁹ In contrast to mechanical mitral valve prosthesis, this process occurs in reverse (ie, diastole) in the setting of mechanical aortic valve prosthesis, resulting in the detection of microbubbles in the left ventricular cavity when the valve closes. As illustrated by this case, cavitation may pose diagnostic challenges during echocardiographic assessment as they can be difficult to distinguish from prosthetic valve thrombosis, vegetation, strands, or sutures.

Although the local pressure changes could lead to platelet activation, which is a precursor for blood clotting, making the cavitation a problem with complications such as hemolysis, thromboembolism, and valve failure,⁵ the activation is also dependent on exposure time to that pressure changes.¹⁰ Therefore, most cavitation arising from prosthetic cardiac valves appears to be benign due to the short lifespan of microbubbles. As demonstrated in this case, suggesting that most MBs dissolve on their way to the brain and are too small to be associated with any significant immediate risk of neurological deficit. Our patient underwent a head CT scan and formal neurology evaluation, which showed no evidence of acute intracranial abnormalities.

When cavitation is suspected during echocardiographic evaluation, images should be reviewed in slow motion to confirm visualization of microbubbles and their subsequent dissipation. Another option is to turn harmonics off to reduce potential enhancement of artifacts from the echogenic surrounding soft tissue.

4 | CONCLUSION

Clinicians should be aware of the echocardiographic appearance of microbubbles associated with mechanical valve prosthesis and differentiate them from other valve pathologies that might expose the patient to unnecessary diagnostic tests or medical interventions.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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FIGURE 1.

Image sequence illustrating the phenomenon of micro-cavitation. Transthoracic echocardiogram demonstrated echodensities (arrow head) on the ventricular surface of the mechanical aortic valve prosthesis at 2 different diastolic time points (A, B). Transesophageal echocardiogram showed normal mechanical aortic valve prosthesis without evidence of any echodensities (C, D). Detailed slow motion and frame-by-frame review of the transthoracic echocardiogram images revealed a cluster of microbubbles (arrow head) in the left ventricular outflow tract (E, F). AO = aorta; AVP = aortic valve prosthesis; LA = left

atrium; LVOT = left ventricular outflow tract; MASS = echodensities; MBs = microbubbles;
MV = mitral valve; RA = right atrium; RV = right ventricular

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FIGURE 2.

Mechanism of cavitation through aortic valve prostheses. The local pressure drops below ambient pressure as blood travels through the narrowest portion of the prosthesis, the vena contracta (VC), causing vaporous cavitation (carbon dioxide degassing) and separation of the gas contained in the blood, resulting in detection of microbubbles in the left ventricular (LV) cavity. The subsequent rise in pressure (pressure recovery) forces the gas to condense back into the liquid state in the blood. Ao = aorta; LVDP = left ventricular diastolic pressure; P_{max} = maximal pressure gradient between the vena contracta and the LV; P_{net} = net pressure gradient between the ascending aorta and LV (after pressure recovery); P_{Vc} = pressure in the vena contracta