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The Man behind the Gun: How Transthoracic Echo Examination Might Identify Thrombotic Mechanical Prosthetic Mitral Valves and Guide Therapy in Limited Resources Areas

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ABSTRACT:
Background: Heart prosthetic valve (PV) dysfunction is still difficult to diagnose because it is hard to predict but not rare. Complete prosthetic valve evaluation by transthoracic echocardiography (TTE) is sometimes challenging due to acoustic shadowing and artifacts. Transoesophageal echocardiography (TEE) remains the first choice test to assess prosthetic valve dysfunction (PVD) but is resource-intensive and carries risk. Transthoracic 2D Doppler echocardiography is the preferred method for evaluating prosthetic valve function, particularly in areas with limited TEE or imaging facilitation. A high-quality TTE may be used to detect PVD and reduce the need for further investigation by TEE.
Objective: To present a case of mitral prosthetic valves dysfunction and highlight the role of TTE in mitral prosthetic valves (MPV) evaluation.
Case Illustration: A 57-year-old woman referred to our Emergency Department presented with progressive dyspnea since a week ago. Two years earlier, she had undergone mitral valve replacement with a 27-mm St. Jude bileaflet mechanical prosthesis. One month before admission, anticoagulant therapy was discontinued due to neurological problems. An echocardiogram showed obstruction with high gradient pressure at the prosthetic valve (MVA 0.44 cm2, MVG 14-18 mmHg). Heparinization was started with a target APTT 1-1.5x the normal value. After 3 days of heparinization, in-patient TEE showed a decrease in transmitral gradient compared to the previous echo (18 mmHg □ 7 mmHg), MVA 1.3 cm2. The patient was scheduled for an outpatient TTE in 3 months and discharged home with adequate anticoagulant treatment. Repeated follow-up TTE 3 months after discharge revealed the resolution of the previous thrombi in the mitral valve ring, and the mechanical mitral valve prosthesis was functioning normally.
Conclusion: Early detection and appropriate treatment can reduce the risk of valve dysfunction. The use of TTE to establish prosthetic valves dysfunction is reliable, especially in areas with minimal facilities.

Introduction

Prosthetic mitral valve dysfunction is considered an unusual case. Based on a study by Ma WG et al., it was found that the prevalence of mechanical heart valve replacement is around 0.28%.[1] Meanwhile, other studies showed that the incidence of obstructive valve thrombosis were around 0.3% to 1.3% per patient-year.[2] The rare occurrence of prosthetic mitral valve dysfunction may cause clinicians to overlook the disease due to the unfamiliarity and low load cases. In truth, there are several ways to evaluate prosthetic heart valves.

The primary method for evaluating individuals with prosthetic heart valves is through echocardiography. The American Society of Echocardiography (ASE) and the European Association of Echocardiography (EAE) have developed comprehensive guidelines for the echocardiographic evaluation of prosthetic heart valves (EAE).[3–5] the transthoracically derived parameters E

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(peak early mitral inflow velocity), pressure half-time, and the ratio of mitral inflow velocity-time integral (VTIMV) to left ventricular outflow tract velocity-time integral (VTILVOT) have all been shown to be useful in detecting significant prosthetic dysfunction in mechanical mitral valves in several studies.[6] Meanwhile, transesophageal echocardiography (TEE) is needed to detect complications in prosthetic heart valves and to visualize more clearly.[7] In general, developed countries recommend the use of TEE to detect valve prosthetic dysfunction along with determining the etiology.

In this case, TTE is a reliable tool for screening and treating the patient even though TEE was not done. The case proved that TTE only examination could be relied on to detect prosthetic valve dysfunction, especially in developing countries with minimal facilities.

Case Illustration

A 57-year-old woman was presented to the emergency department with progressive dyspnoea, bloated stomach, nausea, and ankle edema. The patient was hemodynamically unstable, with hypotension 87/50 mmHg, irregular heart rate 77-85 bpm, tachypnea 28x/min, but good peripheral oxygen saturation (SpO2 96%). Mechanical valve sound was heard from the auscultation; the sound was decreased. Rhonchi was also heard on the bilateral basal lungs. Hepatomegaly and bilateral ankle edema were also found.

From the electrocardiography, the basic rhythm was atrial fibrillation with a heart rate of 97 bpm and no ischemic changes. Her chest x-ray was consistent with cardiomegaly and lung congestion. A mechanical valve was seen in CXR. From bedside echocardiography, we found dilated left atrium, left ventricle ejection fraction of 30% with D-shaped LV, reduced right ventricular function (TAPSE 9 mm), moderate aortic regurgitation with PHT of 280 ms, mild pulmonary regurgitation, and severe tricuspid regurgitation. Meanwhile, as shown in **Figure 1** mitral valve area estimated by velocity time integral (VTI) was 0.71 cm^2 and by pressure half time was 0.44 cm^2, MVG was high (11-14 mmHg); therefore, prosthetic mitral valve dysfunction was suspected with thrombus as the etiology. Laboratorium examination showed an INR of 1.24 on the day of admission, hyperglycemia (blood sugar 431), and impaired kidney function (Cr 2.57, eGFR 19).

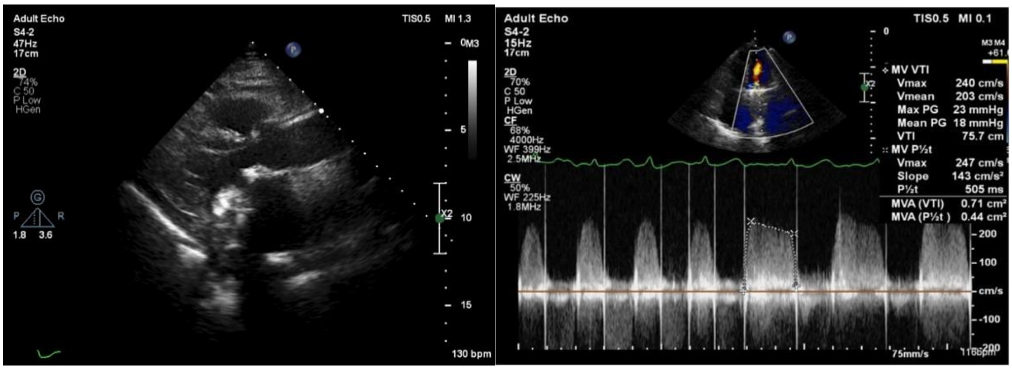

Figure 1. TTE Evaluation of Mechanical Mitral Valve

The patient underwent mitral valve replacement (MVR) in 2019 with a 27-mm St. Jude mechanical valve and left atrial reduction due to rheumatic heart disease (RHD). She also has hypertension, type 2 diabetes mellitus, atrial fibrillation, hypercholesterolemia, chronic kidney disease, and a history of nephrectomy from 2006, all of which are managed with drug therapy. She has been routinely consuming warfarin, an oral anticoagulant. Her health had been generally stable over the years until she experienced transient neurological events in June 2021. She was then instructed to discontinue anticoagulant treatment and initiate dual antiplatelet therapy, but she ended up not taking all of these medicines due to hesitation.

The patient was subsequently treated with intravenous furosemide, candesartan 1x8mg, and spironolactone 1x25mg. Warfarin was reintroduced. Bisoprolol was deferred due to acute episodes of decompensated heart failure. The patient was then discharged due to improved hemodynamics and heart failure symptoms.

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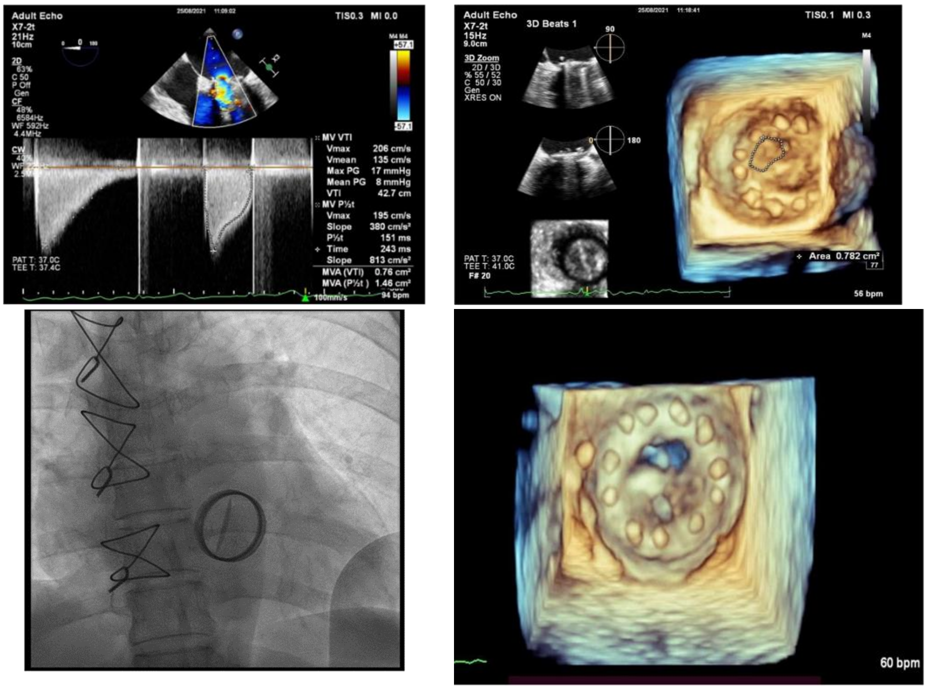

Figure 1.

One week after discharge, the patient was readmitted due to rapid atrial fibrillation and was treated with digoxin. Unfractionated heparin (UFH) was started due to a suspected thrombus at the prosthetic valve. The patient was then scheduled for fluoroscopy and transesophageal echocardiography (TEE). The fluoroscopy showed that one leaflet opened well, but the movement of the other leaflet was not visualized (Figure 2). TEE demonstrated limited prosthetic valve opening in one of the discs, a mean mitral valve gradient (MVG) of 8 mmHg, and a mitral valve area (MVA) of 0.7 cm2. There was a decrease in transmitral gradient compared to the previous echocardiography (from 18 mmHg to 7 mmHg), with an MVA of 1.3 cm2 (Figure 2). UFH was continued and overlapped with warfarin. After a 15-day hospital stay, she was discharged home again in a stable condition.

Intensive INR monitoring was conducted for closer control of anticoagulation. A follow-up transthoracic echocardiogram (TTE) in November 2021 revealed that the prosthetic valve was well-seated and opening properly (both leaflets), with no leakage observed. Doppler evaluation indicated a normal prosthetic mitral valve gradient (MVG 3 mmHg, MVA 2.44 cm2), suggesting that the mechanical mitral valve prosthesis was functioning normally.

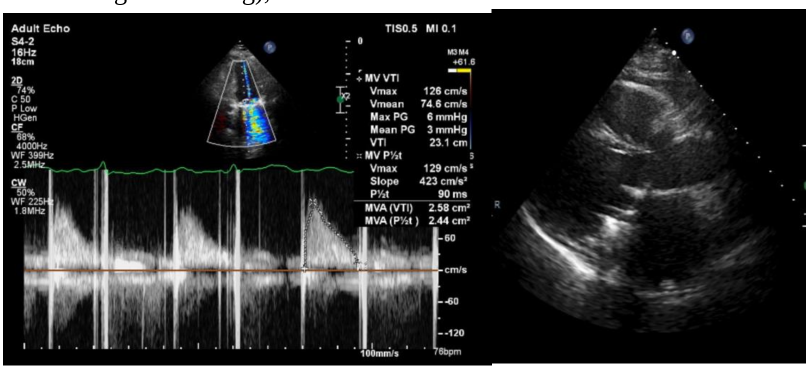

Figure 3. TTE evaluation after discharge, shows normal gradient and good movement of both mitral valves (MVG 3 mmHg, MVA 2.44 cm2)

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Discussion

Mechanical mitral prosthetic valves (MPVs) have significantly improved overall long-term outcomes. However, prosthetic valve dysfunction (PVD) remains a major and challenging issue, associated with high mortality and morbidity rates. Several studies have explored the causes of PVD and found that thrombosis, pannus, and paraprosthetic regurgitation all contribute to PV failure. The clinical presentation can range from asymptomatic to acute heart failure and cardiac arrest, with a variable timeframe between valve replacement and the onset of PVD. To date, two-dimensional echocardiography is the gold standard for evaluating prosthetic valve issues. However, transthoracic echocardiography (TTE) can be limited due to acoustic shadowing and poor acoustic windows. Some of these limitations may be overcome by transesophageal echocardiography (TEE). While TEE and CT scans are considered gold standards in diagnosing PVD, an integrated imaging strategy that includes various parameters by TTE is necessary to appropriately refer suspected PVD cases to TEE or CT and to formulate the best treatment plan.

Mechanical PVs are generally more durable than biological PVs, but they are more thrombogenic, requiring long-term anticoagulant therapy to prevent thrombosis, which could lead to valve damage or stroke. Our patient had compliance issues with anticoagulant treatment due to a lack of medical knowledge, which led to transient neurological events from which, fortunately, she fully recovered. The American Society of Echocardiography (ASE) guidelines recommend evaluating prosthetic heart valves with echocardiography and incorporating relevant clinical history in addition to echocardiography and Doppler evaluation. In this case, we will discuss step by step the evaluation of the mitral prosthetic valve and compare it with the latest guidelines. There are three steps to examine a PV according to ASE, which are:

1. Obtaining clinical data

It's essential to document all of the patient's clinical history for echocardiographic studies because Doppler interpretation depends on the type and size of the replacement valve as well as the patient's clinical data. Information on the date of surgery is also vital as it serves as a reference point for comparing echo findings over time during prosthetic valve evaluations, particularly when abnormalities are identified in echo studies. The next set of data consists of physical examinations and history of previous treatments related to the patient's current condition, such as a history of routine medication, permanent pacemaker (PPM) insertion, surgery or cardiac catheterization. We have gathered all medical histories by using secondary patient data from digital and paper medical records, which include past medical history, surgeries, and the patient's routine medications.

2. Echocardiographic Imaging

Echocardiographic assessment of patients with prosthetic valves includes standard measurements and evaluation of cardiac chamber sizes, left ventricular wall thickness and mass, as well as left ventricular systolic and diastolic function indices. As explained earlier, in this patient we performed a series of TTEs to assess the function of the mitral valve, starting from before the MVR surgery, postoperatively, and during annual evaluations.

3. Doppler Echocardiography

Doppler assessment is a key component in evaluating the function of prosthetic valves using TTE. Given that the use of TTE can be limited due to the presence of acoustic shadowing, Doppler serves as the main assessment tool in such cases. One of the complications of prosthetic valves is stenosis, and the evaluation of significant valve obstruction using various Doppler parameters is incredibly helpful in assessing prosthetic mitral valve function. The ASE guidelines describe several parameters for diagnosing obstructive dysfunction of prosthetic valves. The image below provides an example of a comparison between normal gradient and obstructed mitral prosthetic valves.

In our patient's in-patient TTE conducted two years post-surgery, there was significant obstruction of the prosthetic mitral valve, indicated by an MVA of 0.7 cm2, an MVG of 18 mmHg, and a DVI of 5.4. These assessment results align with the ASE guidelines concerning the criteria for obstructed mitral prosthetic valves.

The table image above outlines the parameters used in evaluating the function of the mitral prosthetic valve. Almost all of these parameters in this patient have been measured using Doppler echocardiography.

Prosthetic Heart Valve (PHV) Thrombosis

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THE lack of standardized, routine imaging and infrequent recommendations for imaging in guidelines limit the ability to accurately assess prosthetic heart valve (PHV) thrombosis. The mechanisms of PHV thrombosis are complex and varied. The development of endovascular thrombus appears to be influenced by three main mechanisms, which can be divided into three categories: surface-related, hemodynamic, and hemostasis-related aspects.[9-13]

Transthoracic echocardiography (TTE), transesophageal echocardiography (TEE), fluoroscopy, and/or multidetector CT imaging are recommended for patients with suspected non-structural prosthetic valve malfunction to examine valve function, leaflet mobility, and the presence of thrombus. The aim is to determine the etiology and management of prosthetic valve malfunction. For symptomatic left-sided mechanical valve thrombosis, the choice between surgery, anticoagulation, and systemic thrombolysis should be made after consultation with the heart valve team. It's important to involve the patient in a shared decision-making process, taking into account local experience and expertise. Systemic fibrinolysis is an appropriate alternative to reoperation in patients with a minor thrombus burden, mild heart failure symptoms (NYHA I-II), low bleeding risk, and a high surgical risk.[13,14]

In this case, the patient had not previously received optimal anticoagulation, resulting in a thrombus. Also, the patient had recently experienced an episode of ischemic stroke, making fibrinolysis contraindicated. However, after heparinization, the degree of obstruction decreased along with the gradient. The decision was made for this patient to continue optimal anticoagulation for three months, after which a follow-up echocardiogram was repeated.[2-3]

	Pannus	Thrombosis
Chronology	Minimum 12 months, commonly >5 years from surgery date	Occurs at any time (if late usually associated with pannus)
Relation to anticoagulation (low INR)	Poor relationship	Strong relationship
Location	MV > AV	TV >> MV = AV
Morphology	• Small mass • Mostly involve suture line (Ring) • Centripetal growth • Confine to the disk plane • Growth beneath disc	• Larger mass than pannus • Independent motion common • Thin outer ring maybe visible • Project into LA for MV position • Mobile elements
Echo density (video-intensity ratio)	More >0.7 (100% specific)	Less (<0.4)
Cardiac CT: attenuation value	>200 HU	<200 HU
Impact on gradient	AV > MV	MV > AV
Impact on valve orifice	AV > MV	MV > AV
Impact on disc motion	Yes/no	Yes

AV, aortic valve; LA, left atrial; MV, mitral valve; TV, tricuspid valve.

Figure 8. The Difference of Thrombus and Pannus[16]

The most probable cause of acquired mechanical prosthetic heart valve (PHV) obstruction is thrombosis (0.3 to 8% per patient-year)[16], while pannus formation is very unlikely in patients. Our patient was diagnosed with mitral prosthetic valve dysfunction due to obstructive thrombus. According to the 2016 ESC recommendation about imaging assessment of prosthetic heart valves, thrombus can occur at any time, whereas pannus forms typically more than 5 years after surgery. Our patient underwent MVR two years ago. Thrombus formation is strongly linked with anticoagulation, and as explained earlier, our patient discontinued anticoagulant therapy for more than a month before acute decompensated heart failure occurred. Therefore, the etiology of valve obstruction in this case is consistent with thrombus formation.

Measurements of hemodynamic Doppler variables on TTE examination can accurately identify a significant number of patients without notable prosthetic mitral regurgitation (MR), according to a 1999 study by Olmos et al., minimizing the need for further evaluation with echocardiography.

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Conclusion

In this case, TTE played a crucial role in diagnosing mitral prosthetic valve dysfunction and evaluating treatment. Using TTE, we were able to evaluate leaflet movement and gradient changes. However, TTE has limitations, particularly in detecting thrombus or pannus, which are often suspected as the etiology of prosthetic valve dysfunction. For this, we need TEE. Although TEE facilities remain rare and may be challenging to perform in unstable patients, there is also a high risk associated with repeating TEE in a short time. Therefore, every cardiologist must be confident in using TTE to evaluate a prosthetic valve. Prosthetic valve dysfunction can be reduced if detected early and treated promptly. The integration of several TTE-Doppler parameters is crucial for detecting prosthetic valve dysfunction. The use of TTE to diagnose prosthetic valve dysfunction is reliable, especially in areas with limited facilities.

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