

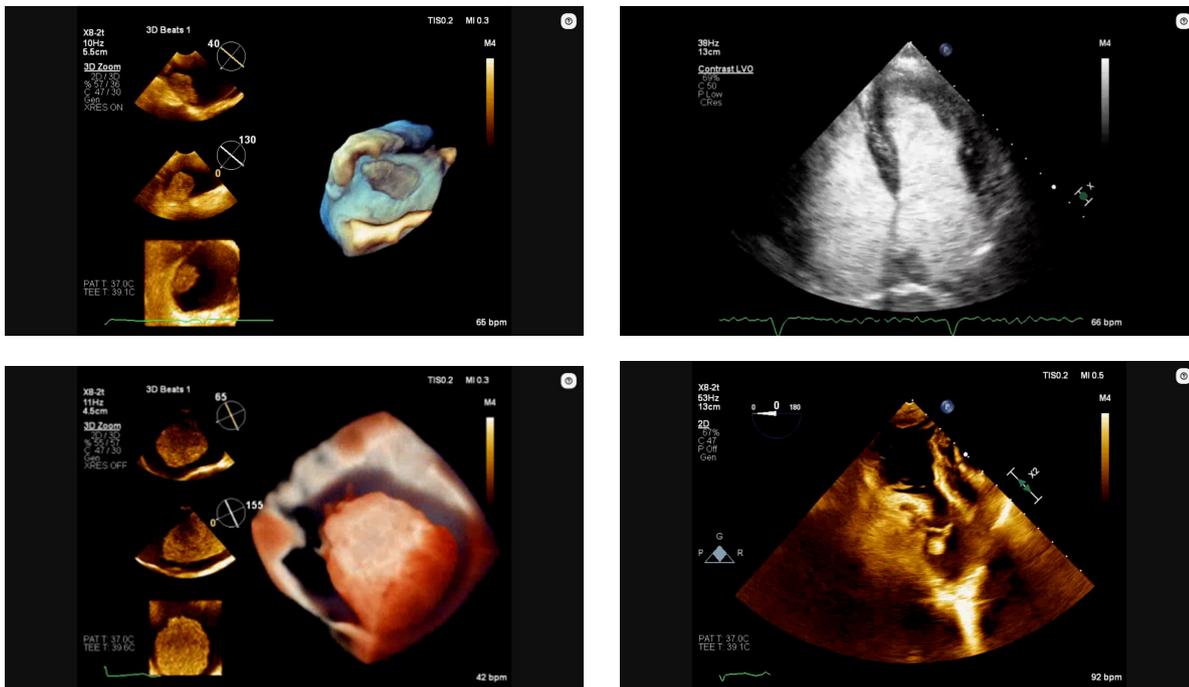
Cardiac Tumors: Recognition Is Essential!

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Central Illustration: Cardiac Tumors: Recognition Is Essential!



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Abstract

Although cardiac tumors are rare and often found accidentally, they can be associated with constitutional, cardiac, or embolic symptoms and, thus, must always be considered in diagnostic hypotheses. Three-dimensional Doppler echocardiography and contrast enhancement are

additional diagnostic resources and can help determine the most appropriate surgical approach, when necessary.

Keywords

Heart Neoplasms; Echocardiography; Three-Dimensional Echocardiography.

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Introduction

Cardiac tumors can be classified as primary or secondary (metastatic), benign or malignant, and asymptomatic or symptomatic.^{1,2} The incidence of clinically diagnosed primary cardiac tumors is approximately 1.380/100 million individuals.³ Primary tumors are rare and approximately 75% are benign, the majority being myxomas and fibroelastomas, with the remaining 25% being malignant. Of malignant tumors, 90% are sarcomas. The metastatic diseases that most often affect the heart are lung adenocarcinoma, squamous cell carcinoma, lymphoma, and breast cancer.^{4,5} Studying them in detail is essential for correct diagnosis. In a series of 149 patients, the sensitivity of two-dimensional (2D) echocardiography for detecting a tumor previously confirmed by histopathology was 93.3% at a size of 0.5-1.0 cm², while that of 2D transesophageal Doppler echocardiography was 96.8%.⁶

Regarding current echocardiographic techniques, 3D Doppler echocardiography is an improvement over 2D, providing more detailed information about the appearance of the tumor, its exact location, its relationship with adjacent structures, whether there is a cleavage plane between the tumor and the structures, and whether there is a pedicle. If surgery is indicated, these preoperative data are important for determining the most appropriate approach.⁷

Contrast-enhanced ultrasound plays an important role in cardiac mass assessment, since it indicates the presence of vascularization. For example, since metastatic tumors are hypervascularized, the flash-replenishment technique will cause the tumor to shine brightly due to filling with contrast agent. Another example is when thrombi must be differentiated from myxomas: since thrombi are avascular they will not be penetrated by the agent, whereas myxomas, despite being poorly vascularized, will show some penetration (Video 1). It is important to highlight that fibroelastomas are also avascular and will not be penetrated by contrast agents.⁸

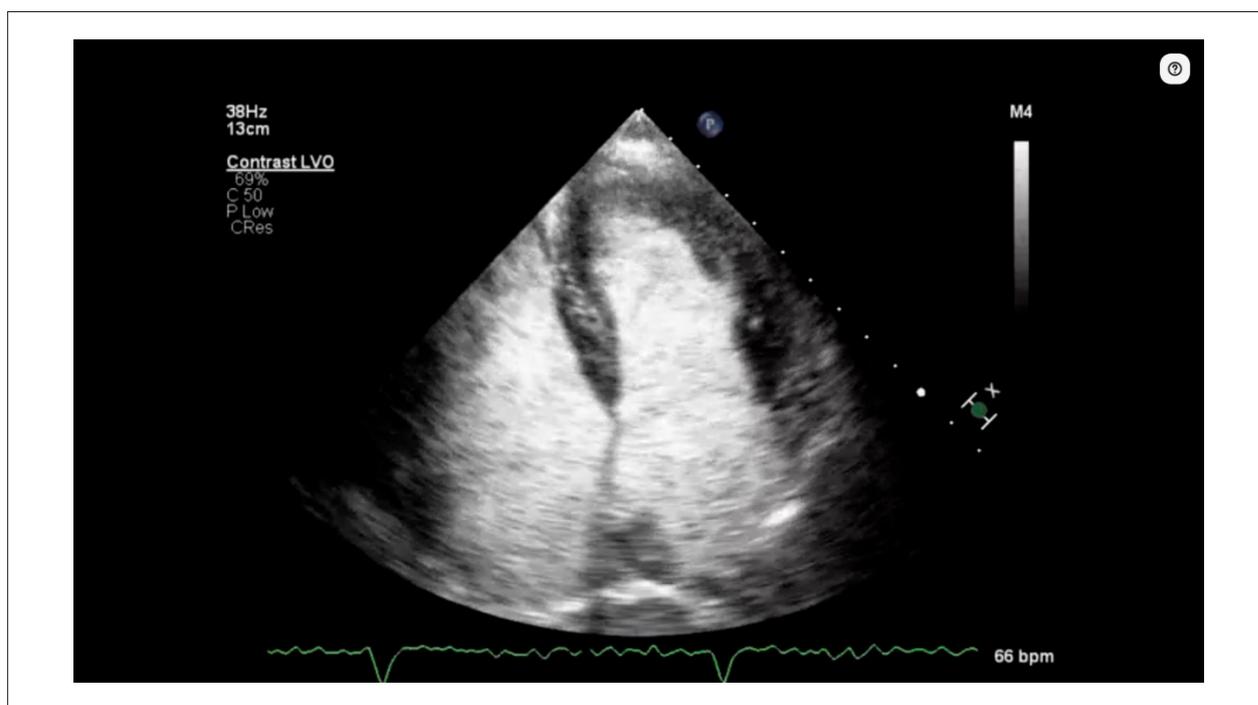
Myxomas are the most common benign tumors in adults, probably originating from precursor mesenchymal cells. The symptoms range from fever and arrhythmia to dyspnea caused by the mass obstructing the inlet, with behavior similar to that of severe mitral stenosis (tumor plop).^{1,9} Their presentation varies, including a lobular, ovoid, multilobular, solitary, or heterogeneous mass with a smooth or irregular surface, and internal points of calcification or hemorrhaging. They are most commonly located in the oval fossa of the left atrium (75%), being anchored or not by a pedicle to the interatrial septum (Videos 2 and 3). Small tumors are more friable and tend

to embolize. Larger tumors have a smoother surface, with a grape-cluster appearance.¹⁰ Fifteen percent of myxomas involve the right atrium and 5% involve the right and left ventricle¹¹ (Videos 2 and 3).

Regarding diagnosis, contrast-enhanced ultrasound will show some penetration in myxomas after the flash-replenishment technique, since they are poorly vascularized (Video 1). They may be associated with the Carney complex, a mutation in the PRKAR1A gene, chromosome 17q24, which results in myxomas, hyperpigmented skin lesions, endocrine hyperactivity, ductal adenomas of the breast, schwannomas, Sertoli cell tumors, and osteochondromyxomas. Diagnosis of this syndrome requires 2 major clinical criteria or 1 major criterion and a positive family history.^{12,13}

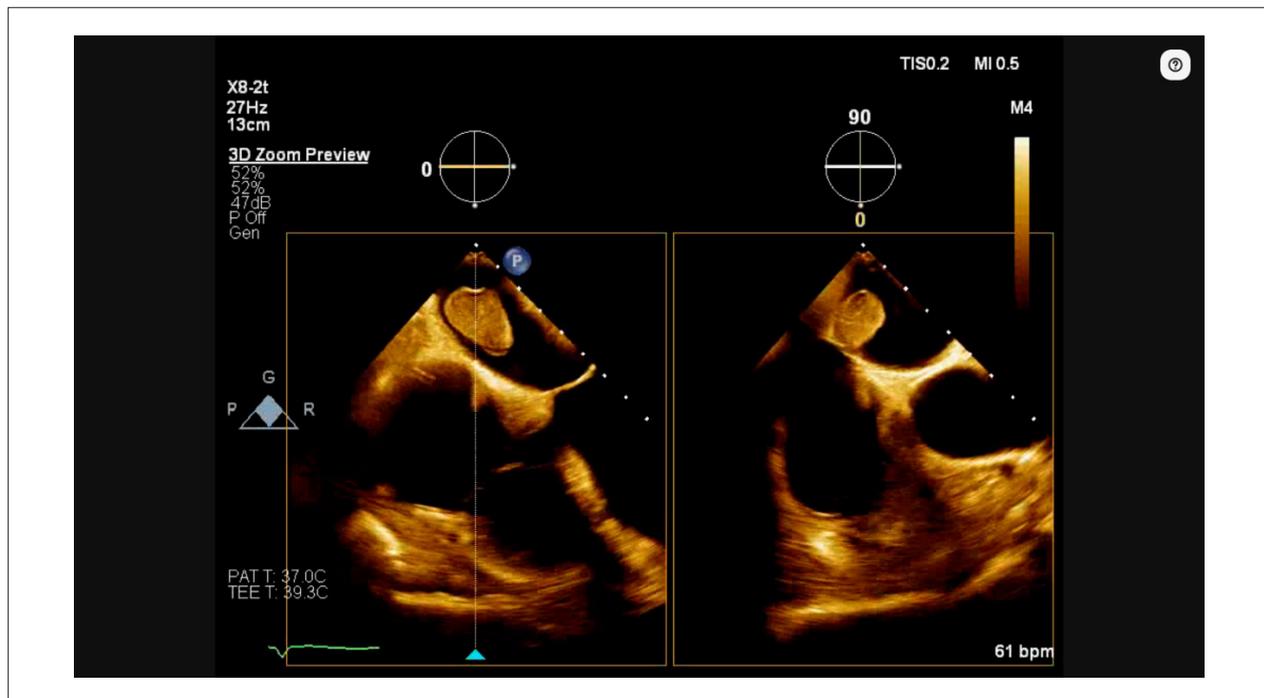
In the absence of mitral valve disease or atrial fibrillation without left atrial enlargement, the presence of an internal mass suggests myxoma. Treatment is surgical, although incomplete resection results in a 2-5% recurrence rate.^{14,15} Intraoperative transesophageal Doppler echocardiography is essential for determining that the tumor has been completely resected. Thereafter, annual 2D transthoracic echocardiography is necessary.

Papillary fibroelastomas are rare, round heart tumors, whose etiology is not yet well defined, although they are associated with areas involving endothelial damage. They represent 10% of cardiac tumors and are the most common valve tumors; data suggest that they have surpassed myxomas in resected tumor masses.¹⁵ Papillary fibroelastomas occur mainly in adults (average age 60 years). When exposed to saline solution, they look like a sea anemone. The most



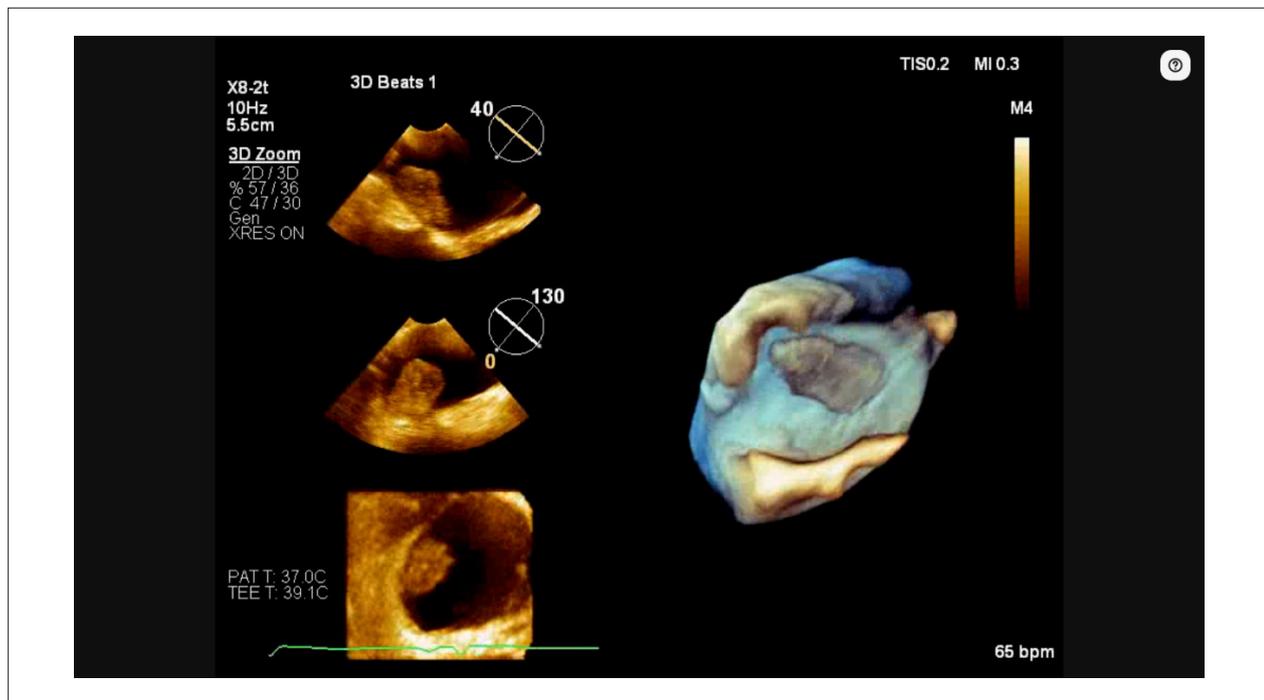
Video 1 – Use of an ultrasound contrast agent in suspected left atrial myxoma. Note that immediately after the flash (high mechanical index), microbubble destruction occurs. Since the tumor is vascularized, it will be filled by the ultrasound contrast agent.

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Video 2 – Using the X-plane mode, the tumor is visualized in different planes, confirming its location in the interatrial septum, close to the oval fossa, which is compatible with myxoma.

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Video 3 – In three-dimensional zoom, the myxoma can be seen attached to the interatrial septum in the mid-septum by a broad base but without a pedicle.

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affected valves are the aortic (44%), mitral (35%), and tricuspid (15%) (Video 4).^{11,15} They are often found on the ventricular aspect of the mitral valve and the aortic aspect of the aortic valve (downstream).¹

Pulmonary fibroelastomas are rare and occur in < 8% of cases with edges, presenting a “shimmering” appearance (Video 5). They are often small (< 20 mm), but tumors measuring 70 mm have been reported.¹⁶ Although the majority of fibroelastomas are located in the heart valves, 20% can be found in other locations, such as the left ventricular outflow tract¹¹ (Video 6).

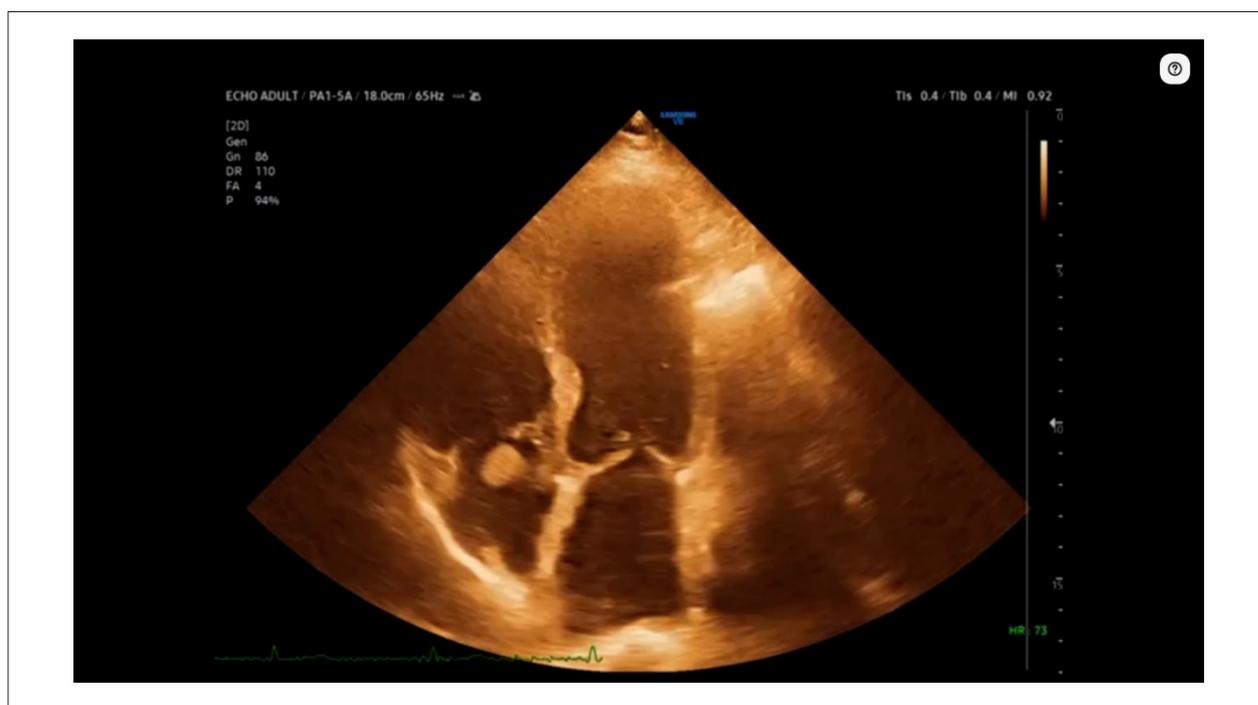
Fibroelastomas > 1 cm are at greater risk of embolization.¹ Three-dimensional echocardiography helps detect the pedicle and the tumor’s exact location when 2D echocardiography cannot.¹ 3D echocardiography helps distinguish it from other diagnoses, given that the pedicle differentiates it from Libman-Sacks endocarditis. Surgical resection is recommended for left-valve fibroelastomas greater than 1.0 cm due to the risk of embolization, which can cause stroke, acute myocardial infarction, or peripheral embolism.¹⁷ Although right-sided fibroelastomas are treated clinically, if the patient presents embolization or hemodynamically significant obstruction, surgical treatment is indicated.^{1,18}

Lipomas, which represent 8% of benign cardiac tumors, begin occurring around 50 years of age. They consist of encapsulated fatty cells and can appear in any chamber in the subepicardial and endocardial regions. They can affect the interatrial septum, and differential diagnosis is based on lipomatous hypertrophy of the interatrial septum.^{11,19}

Fibromas and rhabdomyomas are the most common tumors in children, with multiple rhabdomyomas being found in more than 90% of cases among children at 1 year of age or in fetal echocardiography. Approximately half of the cases are associated with tuberous sclerosis.²⁰ They are well-defined, rounded, hyperechoic, multiple tumors, often located in the ventricles. They have a good prognosis and tend to regress partially or completely (Video 7). Surgery is only indicated in patients with intractable arrhythmias, ventricle inflow or outflow obstruction, or heart failure. The presence of multiple masses and association with tuberous sclerosis excludes fibroma as a diagnosis.

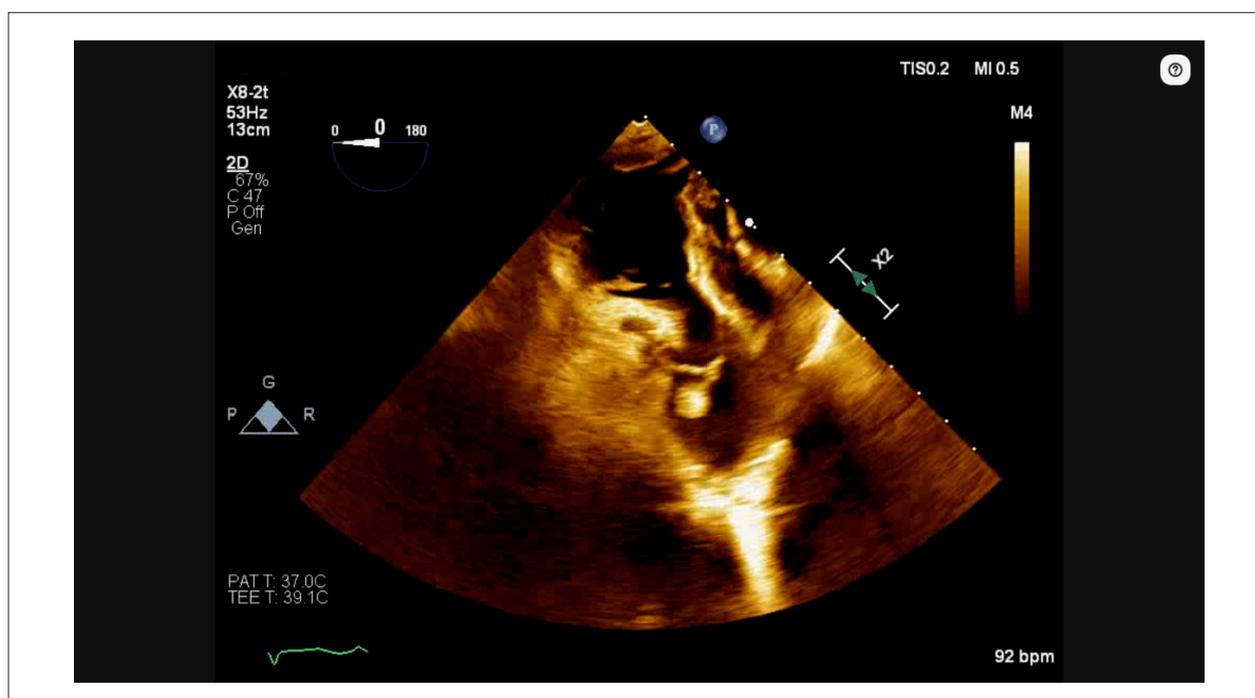
Fibromas are well-demarcated, hyperechogenic tumors with central calcification, being formed of fibroblasts and collagen fibers. They are located in the ventricular myocardium, the left ventricular free wall or the interventricular septum, mimicking hypertrophic cardiomyopathy. They may also be associated with familial adenomatous polyposis or Gorlin syndrome. Surgical resection is indicated due to the risk of sudden death.^{1,21}

Of primary malignant tumors, sarcomas are the most common and aggressive, spreading into the chambers and pericardium. They include angiosarcomas, rhabdomyosarcomas, fibrosarcomas, and leiomyosarcomas. Age at presentation can vary from 1 to 76 years, with an average of 40 years. They can be lobulated, large, polypoid, or intramyocardial masses with a predilection for the right atrium extending to the inferior vena cava. Angiosarcomas can have calcification¹ (Video 8). Rhabdomyosarcomas are the most commonly found sarcoma in children and, unlike



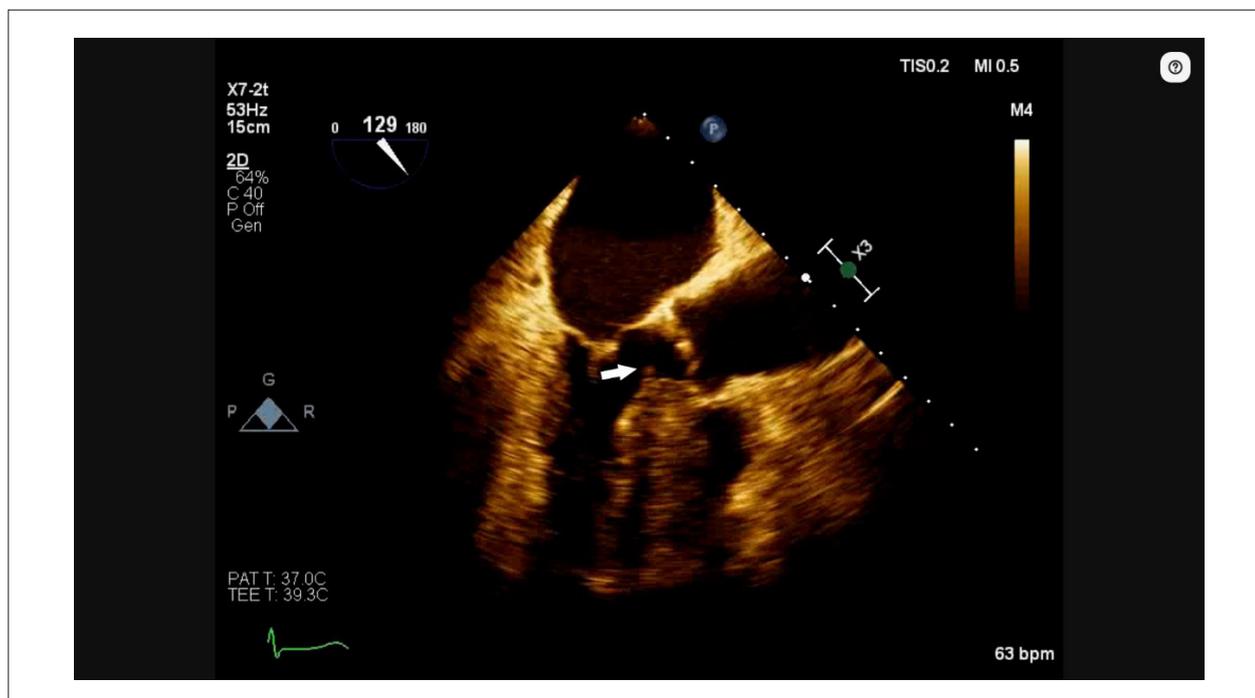
Video 4 – The 4-chamber plane in 2-dimensional echocardiography shows an echogenic intracardiac focus associated with a rounded septal cusp in the tricuspid valve, which is compatible with fibroelastoma.

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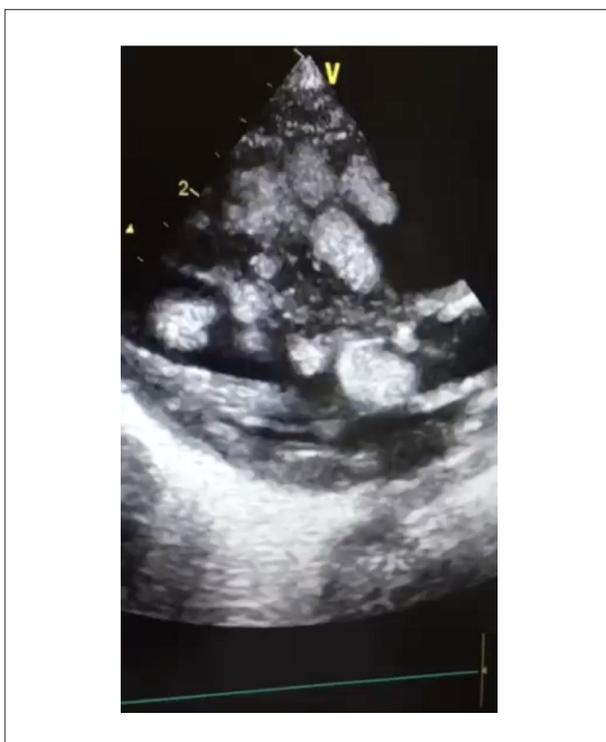
Video 5 – 2D echocardiography in the transgastric plane showing the right ventricular outflow tract. The pulmonary valve is well visualized, with the fibroelastoma attached to one of its valves by a pedicle.

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Video 6 – 2D transesophageal echocardiography in the 129° plane shows a round, mobile echogenic intracardiac focus attached to the basal septum of the left ventricle that is compatible with fibroelastoma.

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Video 7 – 2D longitudinal parasternal view showing masses of varying dimensions in the left and right ventricles and intramyocardial spaces, obstructing the left ventricle outflow tract, which is compatible with rhabdomyoma (Courtesy of Dr. Andrei Monteiro)
Link: http://abcimaging.org/supplementary-material/2024/3702/2024-0032_video_07.mp4

other cardiac sarcomas, they are located in both the atria and ventricles. Osteosarcomas and undifferentiated sarcomas are found predominantly in the left chambers.¹¹ The right atrium is the most common site for angiosarcomas, followed by the other chambers and the pericardium. Unlike other sarcomas, left atrial involvement is rare.²²

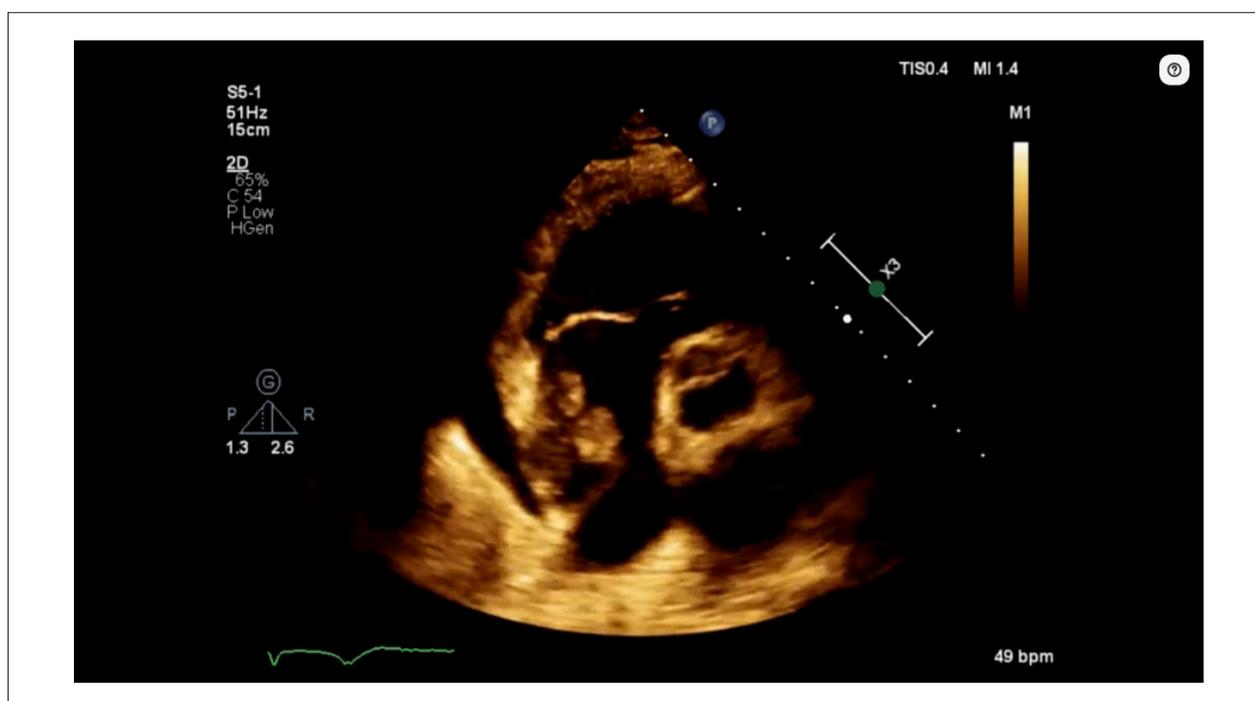
In addition to angiosarcomas, mesotheliomas should be highlighted among primary neoplasms of the pericardium. They manifest as diffuse lesions or a solitary fibrous tumor, which, in the pleura, usually presents as a well-defined nodular lesion. Metastases are more frequent than primary pericardial involvement, whereas secondary pericardial involvement most often arises from lung and breast neoplasms, lymphomas, leukemias, and melanomas.²³

Primary cardiac lymphomas originate from B cells, are aggressive, and are observed in immunosuppressed patients. They present non-specific symptoms and are mostly found in the right chambers as homogeneous, infiltrative masses, thickening the myocardial wall or invading the chambers and pericardium, causing effusion. Diagnosis occurs through biopsy of the mass (since they are located on the right side) or by pericardial fluid analysis. Treatment includes chemotherapy and radiotherapy (Videos 9 and 10).^{24,25}

Mesotheliomas, which are rare, highly aggressive, and have a poor prognosis, generally originate in the pericardium in cases presenting with pericardial effusion. They appear predominantly in men, around the fifth or sixth decade of life. Treatment is palliative.

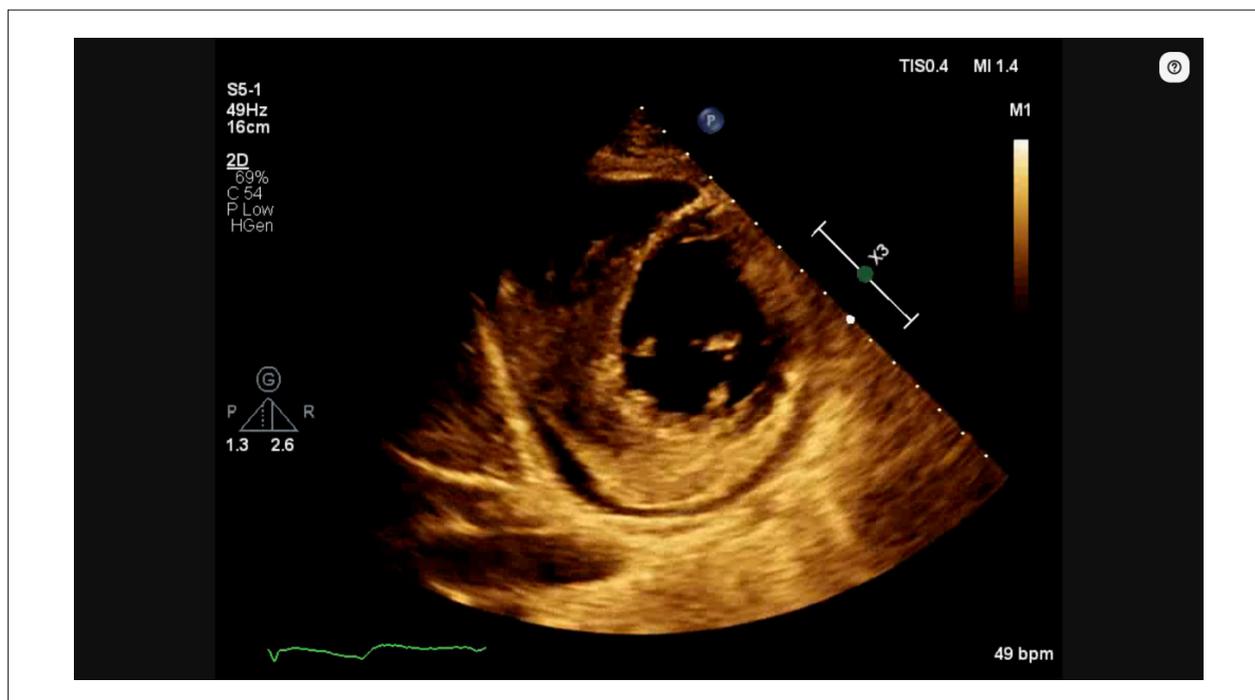


Video 8 – 2D echocardiography showing a large tumor with irregular edges infiltrating the myocardium and expanding into the left ventricular cavity, which is compatible with sarcoma.
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Video 9 – 2D echocardiography in the aortic valve plane, showing heterogeneous masses with no tricuspid valve involvement in the right atrium, which is compatible with cardiac lymphoma.

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Video 10 – 2D echocardiography in the transverse plane of the left ventricle, showing myocardial infiltration by the lymphoma.

Link: http://abcimaging.org/supplementary-material/2024/3702/2024-0032_video_10.mp4

Although cardiac metastases are 20-40 times more common than primary malignant tumors, the heart is relatively less affected by metastatic disease than other organs. Metastatic tumors can invade directly by contiguity or via hematogenous routes, pulmonary veins (Videos 11, 12, 13), or the lymphatic system. Lung, breast, and esophageal carcinomas are the most common types to metastasize to the heart,²⁶ but melanomas, renal cell carcinomas, and gynecological malignancies can also do so. Melanomas commonly metastasize to the pericardium or myocardium. In these cases, the tumors are vascularized and contrast-enhanced ultrasound will corroborate the diagnosis.¹¹

Cardiac involvement through metastasis should be suspected in patients with a known malignancy and cardiovascular symptoms, such as conduction disturbance, valve dysfunction, or heart failure. Treatment of such cases must be individualized.

Differential diagnosis of intracavitary masses should always be considered, such as a thrombus in the left ventricular apex, which will be easily differentiated with contrast-enhanced ultrasound due to lack of penetration (Video 14). Another extremely important finding is a lack of segmental changes in the apical region; in this case, diagnosis of a tumor mass must be considered.²⁷

Echocardiography is essential for screening and monitoring possible complications, given that chemotherapy can cause cardiac dysfunction. Blood flow through the left ventricle can be obstructed due to tumor size and location (e.g., myxomas), or embolization can occur (e.g., fibroelastomas and metastatic tumors, such as breast tumors).

Three-dimensional echocardiography offers important data for surgical planning, in addition to facilitating differential diagnosis. Contrast-enhanced-ultrasound helps analyze the cardiac mass, determining whether it is hypervascularized (indicating malignant tumors) or poorly vascularized (indicating myxoma) or avascular tumors, such as fibroelastoma and thrombus. The integrated use of these techniques is essential to achieve correct diagnosis when assessing cardiac masses.

Author Contributions

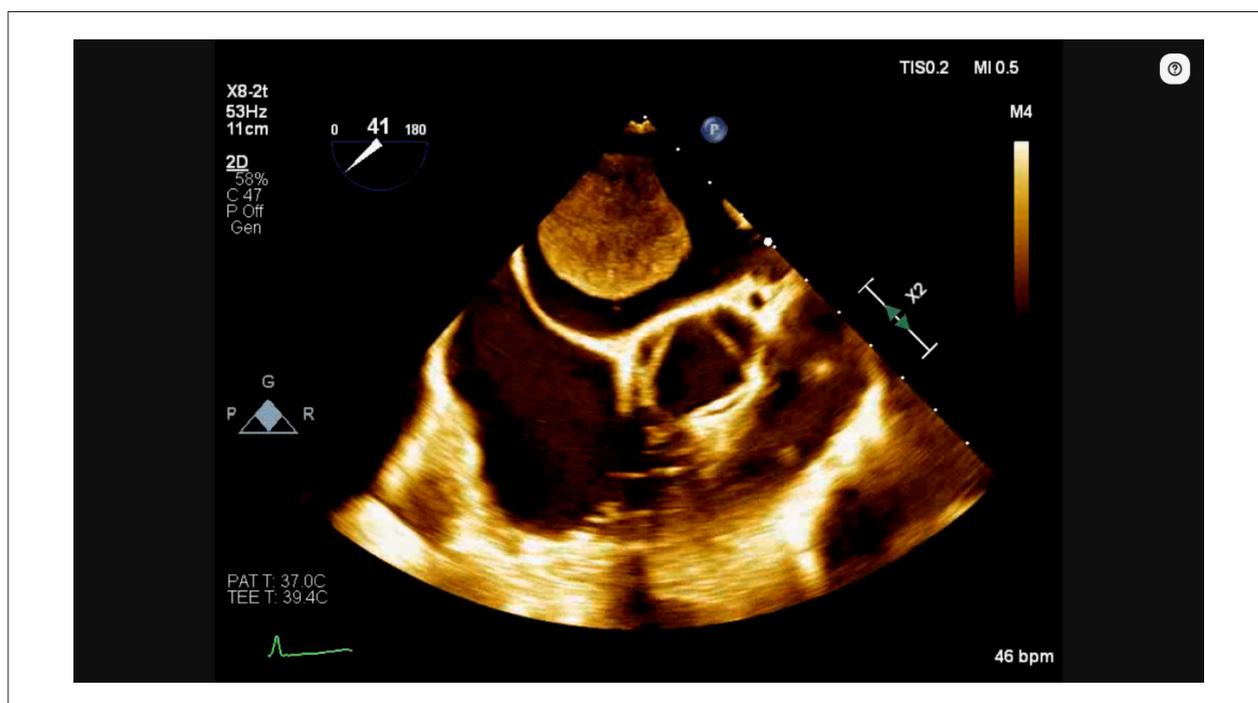
Conception and design of the research: Gripp E, Jácome BZ, Dias FBR, Almeida BBC, Rabischoffsky A; acquisition of data: Gripp E, Silva AEA, Rabischoffsky A; analysis and interpretation of the data: Gripp E, Jácome BZ; writing of the manuscript: Gripp E, Jácome BZ, Silva AEA, Almeida BBC; critical revision of the manuscript for intellectual content: Jácome BZ, Silva AEA, Dias FBR, Almeida BBC, Rabischoffsky A.

Potential Conflict of Interest

No potential conflict of interest relevant to this article was reported.

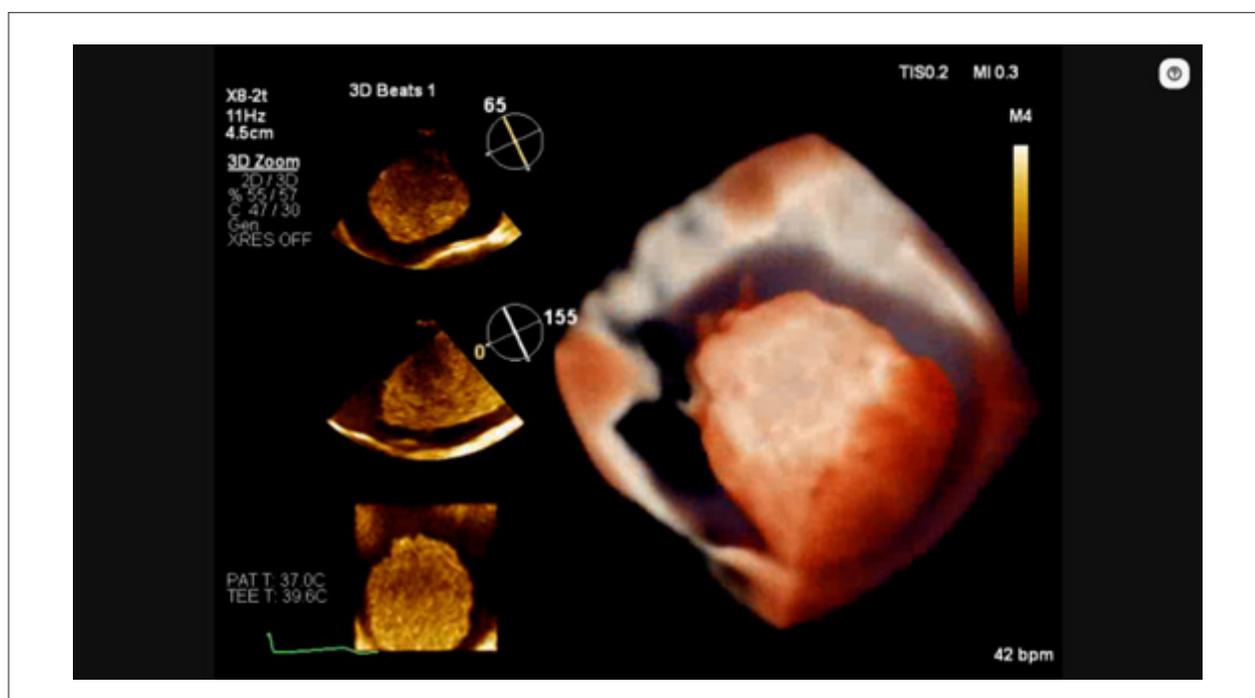
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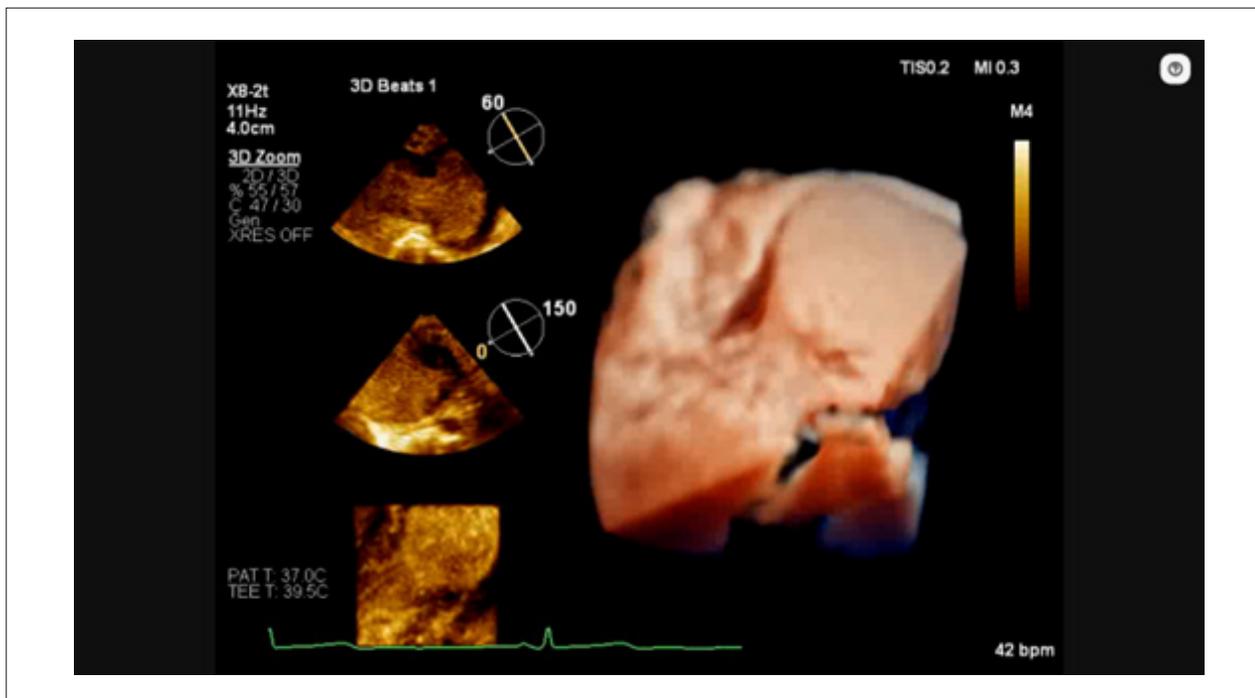
Video 11 – 2D transesophageal echocardiography on a 41° plane, showing a mass inside the left atrium compatible with metastasis of a primary breast tumor.

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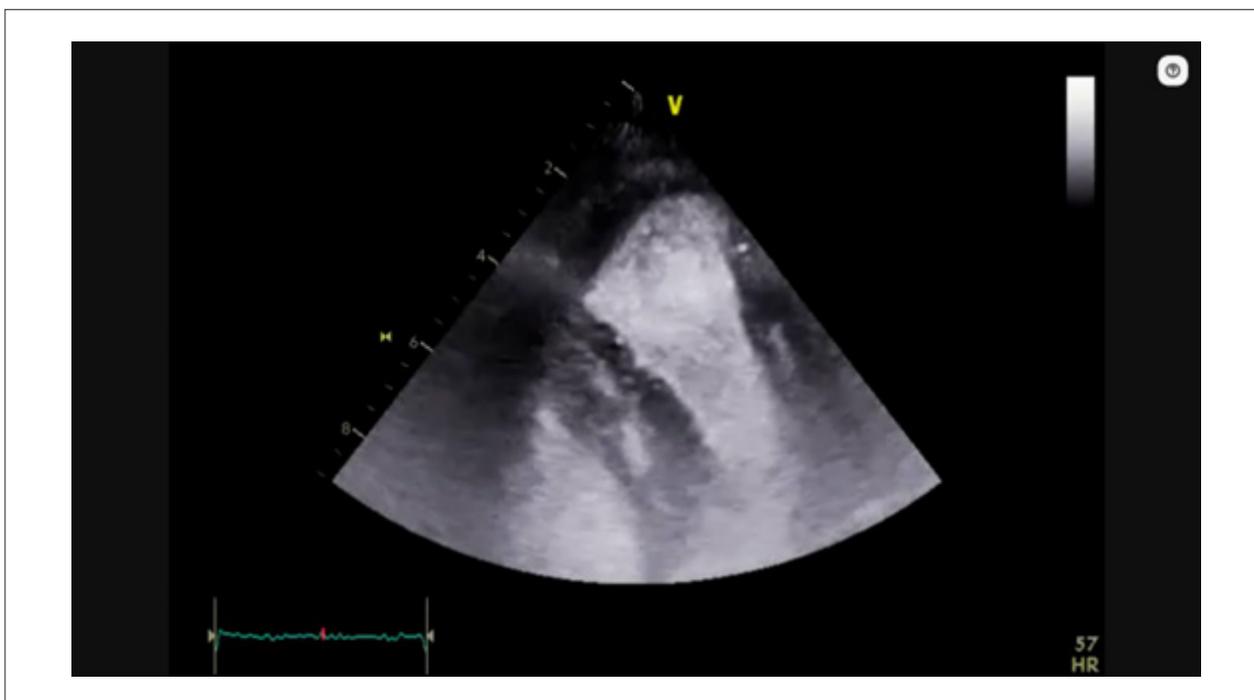
Video 12 – Three-dimensional transesophageal echocardiography in TrueVue mode detailing the irregularity of the mass' surface (highly mobile structures with a high risk of embolization).

Link: http://abcimaging.org/supplementary-material/2024/3702/2024-0032_video_12.mp4



Video 13 – Three-dimensional transesophageal echocardiography in TrueVue mode showing a tumor invading the left atrium through the right pulmonary vein.

Link: http://abcimaging.org/supplementary-material/2024/3702/2024-0032_video_13.mp4



Video 14 – 2D echocardiography performed with contrast-enhanced ultrasound. The contrast agent did not penetrate the apical region, which, along with contractility changes in this region, is compatible with a thrombus.

link: http://abcimaging.org/supplementary-material/2024/3702/2024-0032_video_14.mp4

Study Association

This study is not associated with any thesis or dissertation work.

Ethics Approval and Consent to Participate

This article does not contain any studies with human participants or animals performed by any of the authors.

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