JMSCR Vol||11||Issue||10||Page 01-13||October 2023

http://jmscr.igmpublication.org/home/
ISSN (e)-2347-176x ISSN (p) 2455-0450
crossref DOI: https://dx.doi.org/10.18535/jmscr/v11i10.01

Journal Of Medical Science And Clinical Research
IGM Publication
An Official Publication Of IGM Publication

# Contrast Tuned Imaging for Detection of Left Ventricular apical thrombus: A Case Report

Authors
**Akhil Mehrotra[1], Mohammed Shaban[2], Shubham Kacker[3]**
[1]Chief, Pediatric and Adult Cardiology, Prakash Heart Station, Nirala Nagar, Lucknow, UP, India
[2]Cardiac Technician, Prakash Heart Station, Nirala Nagar, Lucknow, UP, India
[3]Lead PMO, Tech Mahindra, New Delhi, India
Corresponding Author
**Dr. Akhil Mehrotra**
Chief, Non Invasive Cardiologist, Pediatric and Adult Cardiology, Prakash Heart Station, D-16 Nirala Nagar, Lucknow, UP India

**Abstract**

*Thrombi represent the most frequently found intracardiac masses. Left ventricular thrombus (LVT) is an important complication in patients with ischemic heart diseases and in those with dilated cardiomyopathy and systolic heart failure. The diagnosis of left ventricular thrombus remains important since anticoagulation will reduce the risk of systemic embolization and stroke. Despite advances in other imaging modalities, echocardiography remains the most important tool for diagnosis and risk stratification in patients predisposed to develop left ventricular thrombi. We are presenting a case report of 62 years old gentleman who had suffered from anterior wall myocardial infarction (AWMI) in the recent past, and now has developed LVT which was detected by contrast tuned imaging (CTI) technology based contrast echocardiography. This is a first case report of detection of LVT by this ingenious technology.*

**Keywords:** *Thrombus, Left Ventricle, Ischemic Heart Disease, Anterior Wall Myocardial Infarction, Contrast Tuned Imaging, Left Ventricular Opacification.*

## Introduction

Typically, thrombus is defined as a discrete echo dense mass with a well-defined margin and is visualized throughout systole and diastole. Conventionally, left ventricular thrombi are generally located in the areas of severe wall motion abnormalities[1].

"Virchow's triad" is considered to be the pathophysiologic mechanism for left ventricular thrombus (LVT) formation and was postulated in patients with acute myocardial infarction or with dilated cardiomyopathy and congestive heart failure. The triad consists of stasis of blood, endothelial injury or dysfunction and a hypercoagulable state. LV regional wall akinesia and dyskinesia result in blood stasis; prolonged ischemia leads to sub-endocardial tissue injury with inflammatory changes and a hypercoagulable state. Thus the combination of blood stasis, endothelial injury and hypercoagulability, often referred to as Virchow's triad, is a prerequisite for in vivo thrombus, composed of fibrin, red blood cells, and platelets. Thrombi occupying in heart chambers are designated as mural thrombi. Abnormal myocardial contraction or endocardial injury promotes cardiac mural thrombi formation. In patients with dilated cardiomyopathy, low-velocity swirling of blood within the left ventricle predisposes to the development of a thrombus due to poor myocardial contractility. Thrombi may undergo propagation, embolization and dissolution. The older thrombi become organized by the growth of endothelial cells, smooth muscle cells and fibroblasts. Eventually, with remodeling and contraction of the mesenchymal elements, only a fibrous lump may remain to mark the original thrombus. The fibrosed thrombi may undergo hyalinization and calcification[1].

It has been speculated that LV thrombus provides a positive role by offering mechanical support to the myocardium and therefore protecting against LV rupture. The thrombus becomes firmly attached to its site of origin, enhancing the underlying myocardial scar, partially restoring the thickness of the myocardial wall and limiting the potential of its expansion (Figure 1)[1].

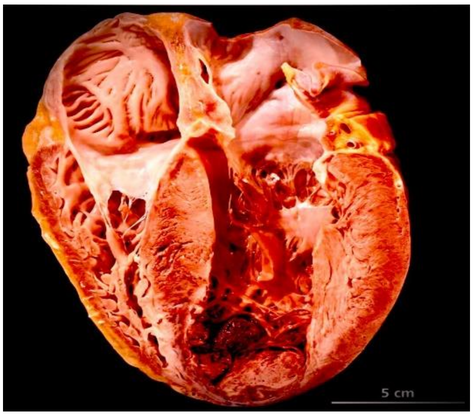



**Figure 1:** Pathological specimen of LV apical thrombus. The thrombus is firmly attached to the apex and helps in enhancing the underlying myocardial scar alongwith restoring the thickness of the myocardial wall.

Currently, myriads of imaging modalities are at our disposal (Figure 2), to identify and illustrate the characteristics of LVT: cardiac magnetic resonance (CMR), cardiac computed tomography (CCT), left ventriculography, strain imaging utilising speckle tracking echocardiography, standard 2Dimensional transthoracic echocardiography (TTE) and contrast echocardiography.

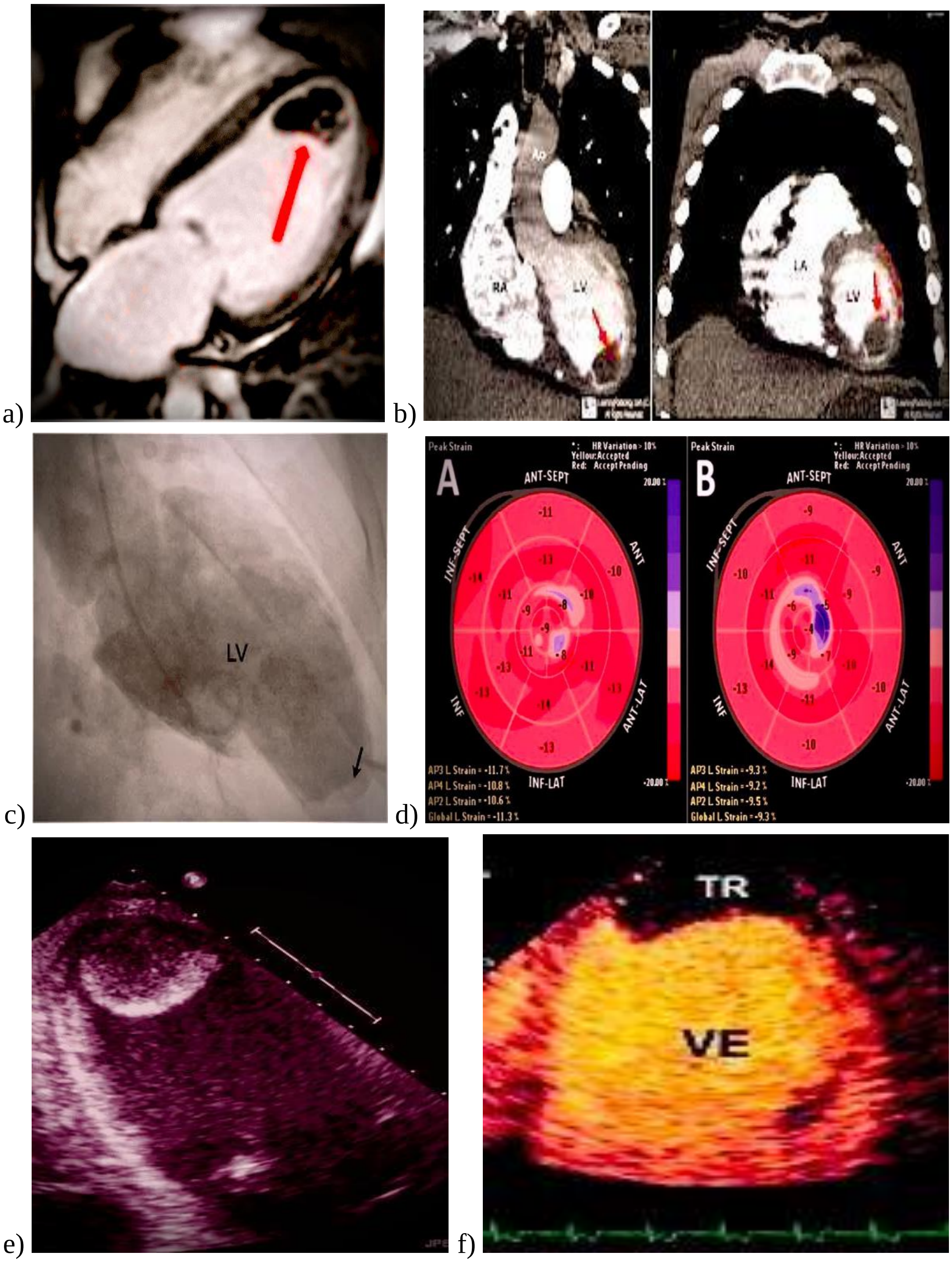



**Figure 2:**

a) Cardiac Magnetic Resonance Imaging of LV apical thrombus.

b) Two reformatted gated CT images of the LV showing a filling defect (red arrow) in the apex, LA, left atrium, RA, right atrium.

c) Left ventriculography in right anterior oblique view demonstrating a filling defect within the left ventricular apex suggestive of an apical thrombus.

d) Strain imaging employing speckle tracking echocardiography. On the left panel (A) is “Bulls” eye mapping of strain imaging in a patient without LV apical thrombus, and on the right panel (B) is a patient of LV apical thrombus.

e) LV apical thrombus identified by standard 2D echocardiography.

f) Contrast echocardiography delineation of LV apical thrombus.

In the contemporary era of early revascularization and aggressive anticoagulation the incidence of LVT complicating an AWMI is likely reduced and is estimated at 5% - 15% [2 - 4].

TTE remains the most versatile imaging technique to accomplish a diagnosis of LVT and has a sensitivity of 90-95 % and specificity of 85 - 95 % for detection of LVT [5,6].

Asinger et al[7] enumerated the high risk echocardiographic features for development of LVT (Table 1).

**Table.1. High risk echocardiographic features for LVT [7].**

| S. No. | High risk echocardiographic features for the development of LVT |
|---|---|
| 1 | Large infarct size and extent |
| 2 | Anterior myocardial infarction >> inferior infarction |
| 3 | Severe global and regional LV systolic dysfunction, presence of CHF |
| 4 | Elevated end-systolic volume, LV dilatation |
| 5 | Spontaneous echo contrast |
| 6 | Abnormal flow pattern within the LV |
| 7 | Apical rotating flow |
| 8 | Vortex ring formation |

TTE can only detect around 10% of thrombi less than 1 cm in size,[8]. However it is noteworthy that suboptimal studies due to technically difficult visualization of endomyocardial borders[9], may limit the accurate assessment of segmental wall motion, ejection fraction (EF), and the presence or absence of left ventricular thrombus (LVT)[10, 11]. Contrast echocardiography has been shown to significantly improve the detection of a LVT (sensitivity and specificity are 61% and 99% respectively), enhancing endocardial border definition and overall image quality[12]. Thus, contrast echocardiography is recommended for consideration when standard imaging proves inconclusive, which may be in as many as half of imaging studies[10]. Contrast echocardiography is simple, cost-effectiveness and capable to improve detection of left ventricular thrombus in patients with MI[13].

**Contrast tuned imaging technology for left ventricular contrast echocardiography**

Contrast tuned imaging (CTI) is an advanced technology for contrast-enhanced ultrasound (CEUS) imaging. Based on low mechanical index and real-time scanning, CTI represents the best way to use second-generation contrast media [14]. CTI can be used for diagnosis and follow-up, as well as during interventional procedures. Its sophisticated architecture based on linear pulser technology, is capable of managing various typologies of pulsing techniques in order to optimize the beam forming management for a wide range of clinical applications.

Contrast-enhanced ultrasound has the advantages of the absence of ionizing radiation, widespread availability, even at the bedside, and the possibility to characterize a lesion as soon as it is detected on conventional 2-Dimensional echocardiography, commonly used as the first technique for exploration of the left ventricular opacification and other areas[15].

In CTI second generation contrast agents are utilized for left ventricular opacification. However, in the current case report we have employed CTI technology for left ventricular contrast echocardiography in the absence of intravenous contrast agent, to recognize and substantiate the presence of AHCM. To our knowledge, this is a first case report on CTI technology based contrast echocardiography for delineation of LVT.

**Case Report**

A 62 years old gentleman with a history of recent antero septal myocardial infarction (ASMI) diagnosed on resting ECG was referred to us for a comprehensive color doppler echocardiography. He denied the presence of any major cardiovascular risk factors. On clinical examination his pulse rate was 82/min, BP was 110/80 right upper limb in seated position, SPO2 was 98% at room air and respiratory rate was 16/min. On cardiovascular examination, the heart sounds were heard normally with the absence of clicks, murmurs or gallop sounds. Rest of the systemic examination was normal. Pathological investigations were unremarkable. High sensitivity troponin-T and lipid profile were within normal range. The resting ECG (Figure 3) identified the presence of pathological Q waves in leads $V_1$ - $V_3$ with T wave inversions in leads AVL and $V_1$ - $V_5$, consistent with sub-acute myocardial infarction. Xray chest PA view (Figure 4) was normal with absence of cardiomegaly or pulmonary venous congestion.

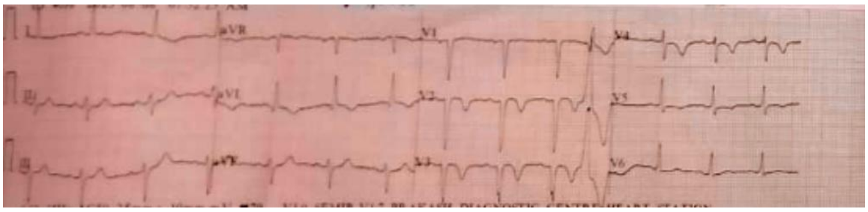


**Figure 3:** Resting ECG recognizes the presence of pathological Q waves in leads V1- V3 with T wave inversions in AVL and V1- V5, consistent with subacute AWMI. Moreover, there is presence of Normal Sinus Rhythm with left axis deviation.

**Figure 4:** X-ray Chest PA view appears to be normal. There is no cardiomegaly or pulmonary venous congestion.

**2Dimensional Transthoraic Echocardiography**

TTE was performed by the author in the left lateral decubitus position from the LX, SX, 4CH and 5CH views (Figure 5).

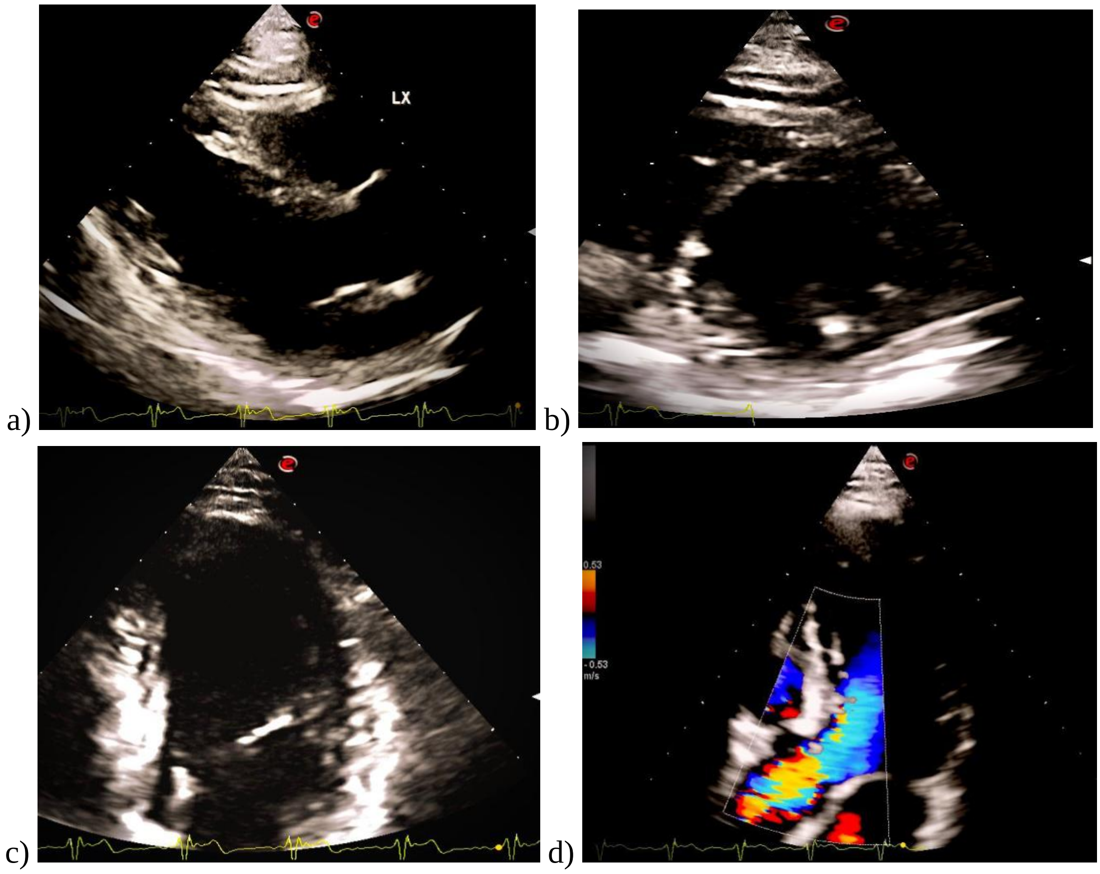



Figure 5: Standard 2Dimensional -,Transthoracic Echocardiography was performed in ( a), LX View, (b), SX View,(c), 4CH View(c) and ( d)5CH View. There was presence of hypokinesia in anterior, mid septum, mid anterior septum, apical and mid anterior wall (LAD Territory).

Presence of hypokinesia was recognised in anterior, mid septum, mid anterior septum apical and mid anterior wall, suggestive of a ischemia in the left anterior descending artery territory. LV volumes and ejection fraction were estimated by utilizing biplane Simpson's method (Figure 6) and were observed to be normal. There was an absence of any LV dilatation and the LVEF was normal (64%).

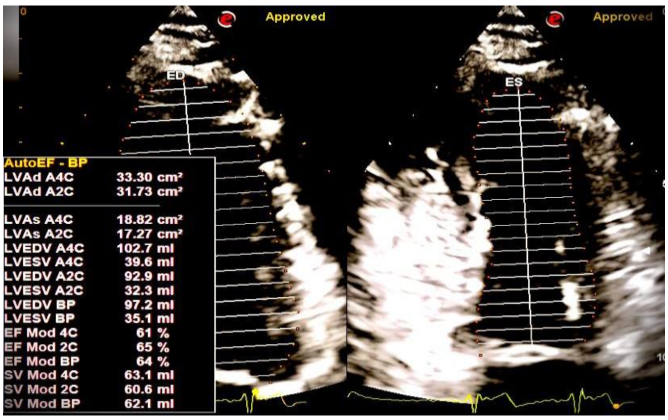



**Figure 6:** Biplane Simpson’s method was adopted for calculation of LV volumes and LVEF. There was absence of LV chamber dilatation with normal volumes and LV systolic function. LVEF was 64 %.

Pulse wave doppler (PWD) analysis (Figure 7) of mitral valve showed LV diastolic relaxation dysfunction (diastolic dysfunction grade 1) and moreover tissue doppler imaging (TDI) estimated the E/E` ratio to be 7: 1 which is within normal range

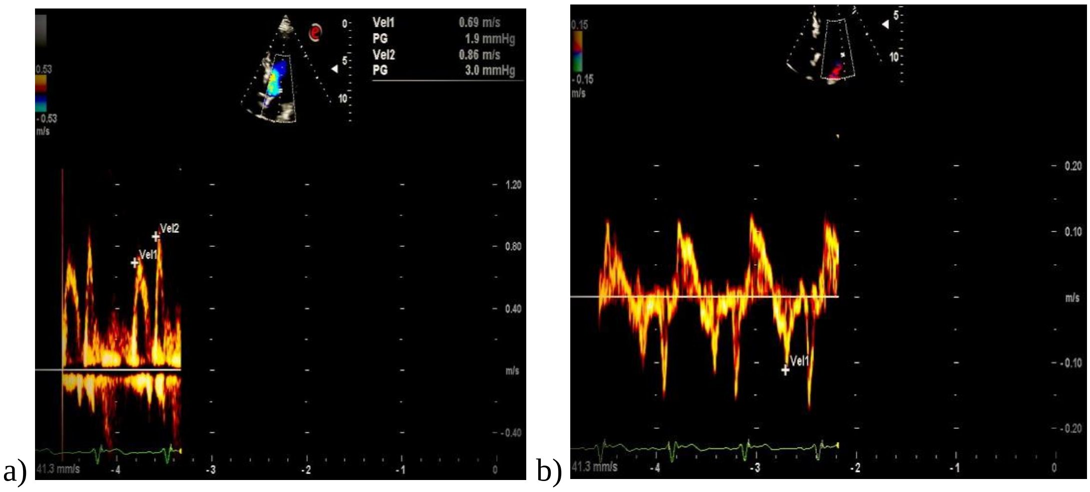



**Figure 7:** (a), On the left panel pulse wave doppler at the tip of mitral valve showed LV diastolic relaxation dysfunction (diastolic dysfunction grade 1), (b), On the right panel, tissue doppler Imaging of the LV estimated the E/E' ratio was 7:1 (within normal range).

Because of the presence of subacute ASMI, involving the LV apex, 4CH echocardiography in diastole and systole was zealously attempted to rule out the presence of LVT.

**Contrast Tuned imaging technology based LV Contrast Echocardiography**

A hazy and unclear image was discovered at the LV apex (Figure 8), after repeated attempts of focused imaging with 2Dimensional echocardiography.

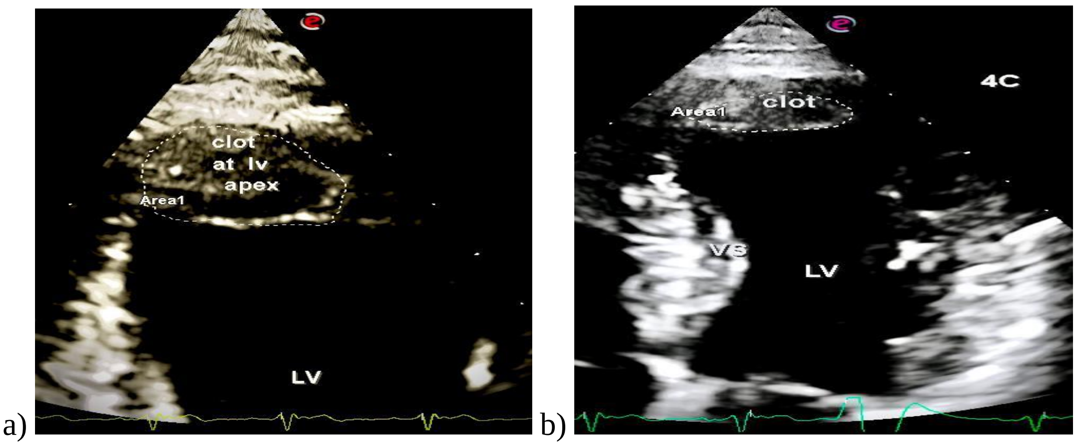
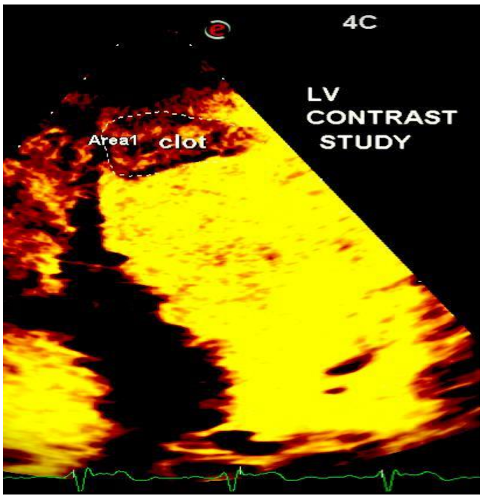



**Figure 8:** Transthoracic Echocardiography in 4CH View, (a), on the left panel in diastole and (b), on the right panel in systole, reveals a hazy and unclear image of LV apical thrombus, highlighted by tracing the edges of the thrombus with dotted line.

Nonetheless on contrast tuned imaging (CTI) technology based LV contrast echocardiography the LVT was distinctly appreciated (Figure 9). The LVT was of moderate size (3.28 sq.cm), non pedunculated, mildly mobile and non-calcified. (We want to clearly state that no intravenous contrast agent was used during this procedure)

a) 

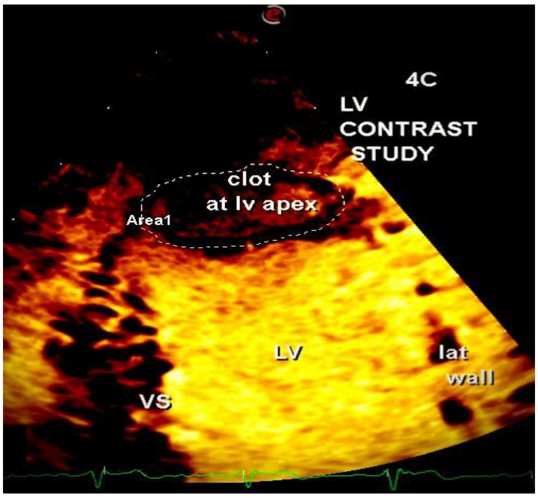
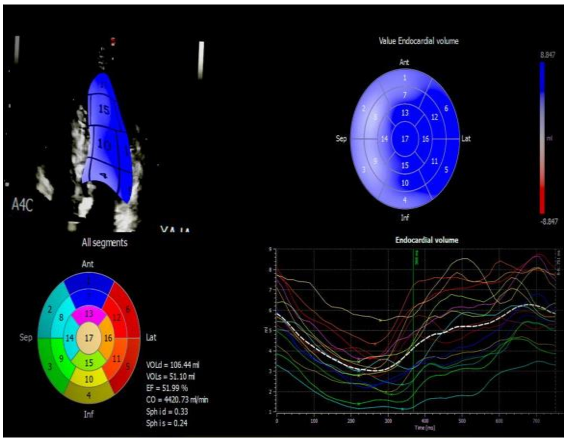
b) 

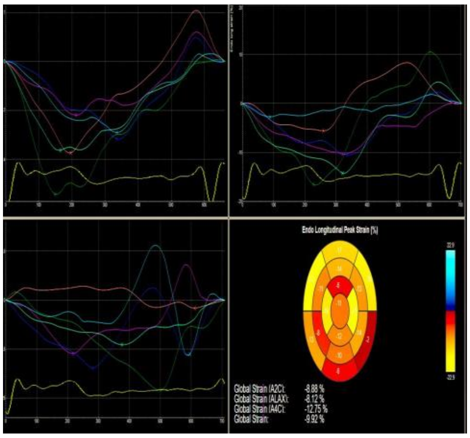

**Figure 9:** Contrast Tuned Imaging Echocardiography distinctly portrayed the LV apical thrombus in (a), on the left panel in diastole and (b), on the right panel in systole

**4Dimensional XStrain Speckle Tracking Echocardiography**

The striking features of 4Dimensional XStrain speckle tracking echocardiography are summarised below (Figure 10):

1. Cardiac output and sphericity index were normal. 4D LVEF was 51.99%.
2. "Bulls" eye mapping of LV strain - global LV strain, 2CH strain, LAX strain and 4CH strain were - 9.92%, - 8.88% - 8·12% and -12.75% respectively. The values are consistent with severe depression of strain in all the views.
3. Individual polar mapping of the strain values in different views similarly reflected a marked decline, particularly in the apical segments.
4. Furthermore, conspicuously, there was substantial decrease in LV strain values, ranging from - 0.54 to - 1.94 % in the apical segments.

a) 

b) 

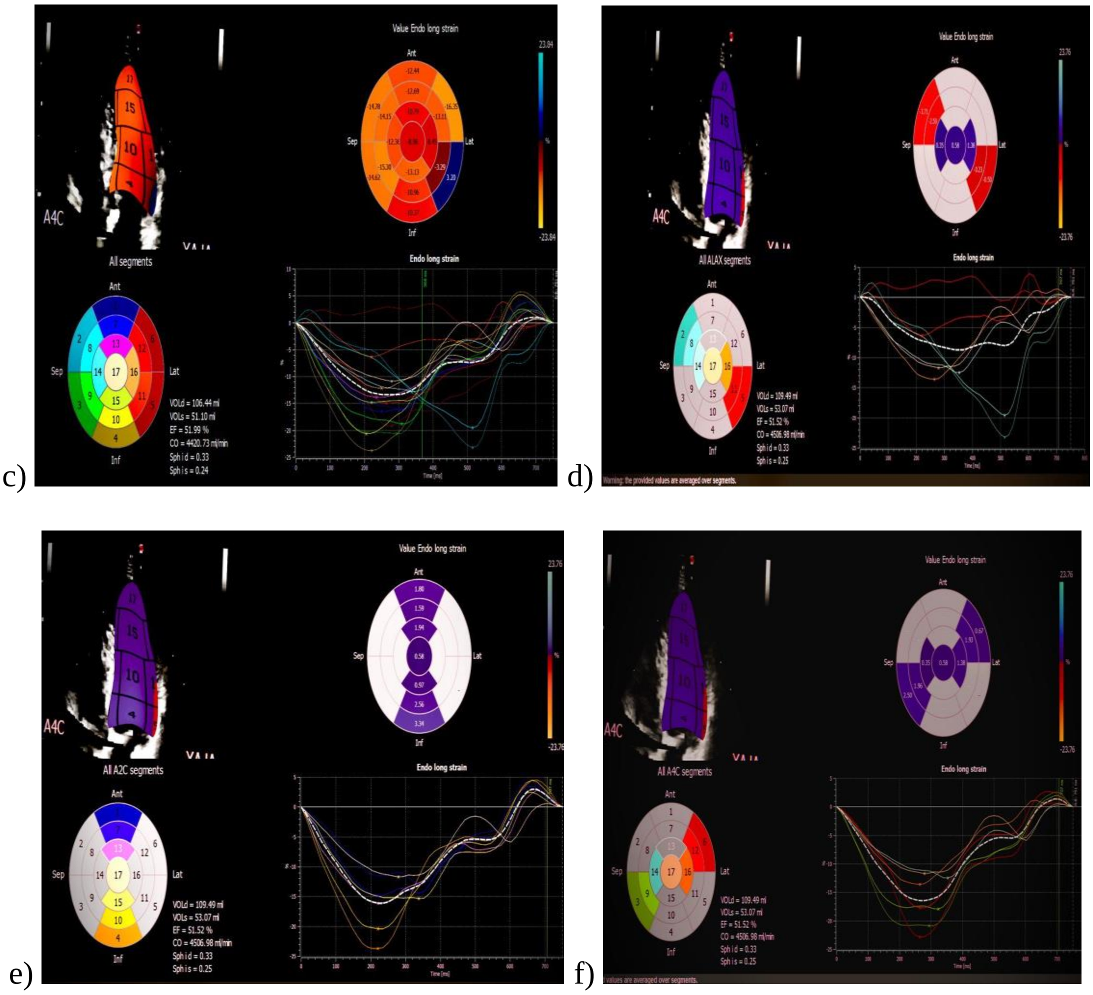



**Figure 10:** 4Dimensional XStrain speckle tracking echocardiography-a) LV volumes, cardiac output, sphericity index and ejection fraction were normal- LVEF 51.99 %, b) "Bulls" eye representation of polar mapping of LV strain identified severely depressed values of LV strain - global LV strain, 2CH strain, LAX strain and 4CH strain were -9.92 %, -8.88 %, -8.12 % and -12.75 % respectively, c) polar mapping of strain of all the LV segments recognized marked depression of strain values in all the segments, particularly in the apical region , d- f) polar mapping of LV strain in LAX, 2 CH and 4CH view conspicuously revealed LV strain values ranging from - 0.54 to - 1.94 % in the apical segments.

## Discussion

In the contemporary era of routine early revascularization and more aggressive anticoagulation, the incidence of LVT complicating an anterior myocardial AMI (acute myocardial infarction) is likely reduced and is currently estimated at 5% - 15% [2 - 4].

Thrombi are typically amorphous echogenic structures with varying shape and are adherent to the endocardium. Thrombi may be multiple, mobile and may protrude into the left ventricular cavity. In most cases, they have a texture and appearance that are distinct from the adjacent myocardium. Thrombi generally involve the apex of the left ventricle, most often in the presence of akinesis or dyskinesis. Predisposing factors include recent myocardial infarction, left ventricular aneurysm and dilated cardiomyopathy and thrombi can develop in any situation in which low flow and blood stasis occurs [7].

Sometimes the thrombi may be flat lying along the left ventricular wall even in some cases, it may be very difficult to differentiate thrombus from myocardium [1].

TTE remains the imaging modality most widely used to screen for LV thrombi, as it is cost effective, accessible, and non-invasive. A LVT appears as an echo-dense mass distinct from the LV wall, but adjacent to an area of abnormal wall motion [16]. Despite the widespread use of TTE, diagnostic performance is suboptimal with a sensitivity of only 33% and specificity of 91% [11]. TTE can be technically challenging as a result of an indistinguishable myocardial-thrombus interface, foreshortening of the LV apex or poor visualization of small protuberant thrombi or mural thrombi of any size [6].

Echocardiographic appearance of intracardiac thrombus is heterogenous, they can vary from a small, immobile mural thrombus to a large protruding mobile thrombi. Echodensity and shape of the thrombi depend on age and degree of thrombus organization. They may be homogenously echogenic or may have heterogenous texture with lucent areas. An echolucent center suggest that the thrombus is relatively new and actively growing. Very fresh thrombi tend to protrude into the center of the cavity and are highly mobile. Older thrombi generally have smooth cavitary surfaces and they are less likely to change or embolize. In some cases vascularization and layer formation can be found [1].

Echocardiographic criteria for LV Thrombus include:

- A distinct echogenic mass within the LV cavity (may be sessile/layered or protruding/mobile) that is contiguous with, but acoustically distinct from the underlying endocardial surface. It is seen throughout the cardiac cycle and visualized on at least two orthogonal views.
- An associated underlying region of severe wall motion abnormality, usually severe hypokinesis, akinesis, dyskinesis or aneurysmal dilatation.

Given the propensity for thrombi to form at the apex of the left ventricle, the best imaging planes to visualize LV thrombus are apical views, where the transducer is closest to the region of interest. The characteristics of the thrombus, including intracavitary motion, shape (protruding vs flat), echodensity, heterogeneity and central lucency as defined by Haugland, et al.[8] have been described. The shape of thrombus may be protruding or flat. Thrombi that projected into the ventricular cavity were classified as protruding and thrombi that did not were classified as flat. A thrombus has usually an echodensity similar to the myocardium while pannus appears more hyperechoic [17].

**Contrast tuned imaging echocardiography**

CTI is sophisticated technology for Contrast Enhanced Ultrasound (CEUS) imaging [18]. Based on low mechanical index and real-time scanning, CTI is an immaculate way to utilize second-generation contrast media. CTI is delineated by:

- High Sensitivity - detection of the lowest intensity signals.
- High Homogeneity same representation for signals - whether emanating from same vessels or same tissues.
- High Spatial Resolution - recognition of very small structures (both hyperechoic and hypoechoic).
- High Temporal Resolution - real-time detailed analysis of arterial and venous phase.

**Contrast Enhanced Ultrasound**

Ultrasound contrast agents are liquid suspensions of biocompatible gas-filled microspheres. When injected into a patient's vein, they circulate in the cardiovascular system, producing augmented ultrasound reflectivity. CEUS uses special biocompatible ultrasound contrast agents to improve the quality and reliability of ultrasound scans, thereby accurately diagnose medical conditions and monitor therapy. In our index patient the LVT was a hazy structure at the LV apex on 2Dimensional echocardiography. With utilization of CTI technology the LVT was strikingly delineated, despite non employment of intravenous contrast agents.

**Decorrelated Contrast Tuned Imaging**

An exceptional, CTI offers decorrelated contrast tuned imaging (DCTI) function [18], which spontaneously captures the breaking frame and decorrelates the signal, thus eradicating all artifacts by increasing sensitivity in the late phase. DCTI is designed to boost the contrast information. By using specific decorrelation software and combining the technique with a low and high mechanical index, DCTI is able to detect even the feeble information from low concentrations of contrast agent circulating even after five minutes of the bolus injection. DCTI technology is depicted by

- High-Power transmission to destroy the microbubbles and saving the first frame after their demolition.
- Maximising the diagnostic information by applying a decorrelation algorithm and integrating low and high mechanical index technologies.
- Heightened ability to distinguish between a signal coming from static tissue and contrast agent bubbles inside the vessels.

**4Dimensional XStrain Speckle Tracking Echocardiography**

Ali-Barman et al.[19], we investigated the prognostic value of apical longitudinal strain (ALS) in patients with LV apical thrombus after AWMI. It was a cross-sectional study including 211 patients who were followed up after primary percutaneous coronary intervention performance for anterior myocardial infarction and had a reduced LVEF $\leq$ 40 %. The study subjects were divided into two groups based on the presence or absence of LVT detected by 2Dimensional echocardiography. There were three principal findings of their study. First, apical strain (AS) and EF were significantly lower in patients with LV apical thrombus compared to those without LV apical thrombus. Second, univariate and multivariate analyses revealed that apical analysis (AA) and AS were independent predictors of LV apical thrombus. Finally, non-parametric receiver operating characteristic (ROC) analysis revealed a cutoff value of - 6.5 for AS, which was found to be a predictor of LV apical thrombus with a sensitivity of 83% and a specificity of 73%. According to this cutoff value, patients with a strain value of - 6.5 and higher had a 12.7-fold increase in thrombus risk. In our patient there was substantial decrease in strain values, ranging from - 0.54 % to -1.94 % in the apical segments.

AWMI with apical dysfunction is associated with an increased risk of LV thrombus formation and systemic embolism [20, 21]. The incidence of LV thrombus has recently decreased due to the use of primary percutaneous coronary intervention (PPCI), earlier reperfusion, shorter door-to-balloon times, and intensive antiplatelet and antithrombin therapy. However, thrombus remains a serious risk, particularly in patients with AWMI affecting high-risk regions like the LV apex.

Although the structure and function of LV are commonly assessed by echocardiography in post-MI patients, the poor image quality and advanced LV remodeling can limit its power in detecting LV thrombus[10,11]. In addition to standard views for a thorough and careful examination, the use of apical views with angulation and the use of transducers with a short focus and higher frequency are required for better near-field resolution. STE is an objective and reproducible method used for quantifying myocardial deformation globally and regionally, regardless of the insonation angle or cardiac translational movements [11,22,23]. Direct strain measurement from 2D grayscale images makes STE a better tool for the evaluation of cardiac mechanics.

**Conclusions**

The diagnosis and management of LV thrombus after AMI is a clinical conundrum despite significant progress in medical and device-based therapies. Early diagnosis of LV thrombus is critical to avoid thromboembolism, and the choice of imaging modality and timing in relation to the incident myocardial infarction are important. Standard echocardiography is often inconclusive or falsely negative regarding the detection of apical thrombus. There are many studies and guidelines support the use of contrast to improve diagnostic accuracy, especially in patients with suboptimal definition in routine echocardiography. Global longitudinal strain, particularly of the apical segments is an independent risk factor for LVT formation in the apical region after AWMI. An early accurate thrombus evaluation may prevent embolic complications, particularly cerebrovascular events. Assessment of ALS by 2Dimensional speckle tracking echocardiography is likely to become an a salient procedure in clinical practice. The role of newer oral anticoagulants (NOACs) remains poorly defined, and vitamin K antagonists (VKA) remains the mainstay of anticoagulation therapy until higher-quality evidence at least demonstrates noninferiority for the prevention of thromboembolic events. Strategies that target Virchow's triad by mitigating myocardial injury and preventing LV remodeling (stasis) and inflammation are likely to form the basis of the prevention and management of LV thrombus well into the future.

**References**


1. Muthiah R, Left Ventricular "Horseshoe-Thrombus"- A Case Report. Case Report in Clinical Medicine, 2016; 5:140-146.
2. Kalra, A. and Jang, I.K. Prevalence of Early Left Ventricular Thrombus after Primary Coronary Intervention for Acute Myocardial Infarction. Journal of Thrombosis and Thrombolysis, 2000; 10:133-136.
3. Greaves, S.C., Zhi, G., Lee, R.T., et al. Incidence and Natural History of Left Ventricular Thrombus Following Anterior Wall Acute Myocardial Infarction. American Journal of Cardiology, 1997; 80:442-448.
4. Nayak, D., Aronow, W.S., Sukhija, R., McClung, J.A., Monsen, C.E. and Belkin, R.N. Comparison of Frequency of Left Ventricular Thromb I in Patients with Anterior Wall versus Non-Anterior Wall Acute Myocardial Infarction Treated with Antithrombotic and Antiplatelet Therapy with or without Coronary Revascularization. American Journal of Cardiology, 2004; 93:1529-1530.
5. Cacciapuoti, F., Varrichio, M., D'Avino, M., Gentile, S., Lama, D. and Cotrufo, M. Post Necrotic Endoventricular Thrombosis, Comparative Evaluation of the Diagnostic Reliability of 2-Dimensional Echocardiography and Cineventriculography. Gionale Italiano di Cardiologia, 1986; 16:344-349.
6. Srichai, M.B., Junor, C., Rodriguez, L.L., et al. Clinical, Imaging, and Pathological Characteristics of Left Ventricular Thrombus; a Comparison of Contrast-Enhanced Magnetic Resonance Imaging, Transthoracic Echocardiography and Transesophagial Echocardiography with Surgical or Pathological Validation. American Heart Journal, 2006; 152:75-84.
7. Asinger, R.W., Mikell, F.L., Sharma, B. and Hodges, M. Observations on Detecting Left Ventricular Thrombus with Two-Dimensional Echocardiography, Emphasis on Avoidance of False Positive Diagnoses. American Journal of Cardiology, 1981; 47:145-156.
8. Haugland, J.M., Asinger, R.W., Mikell, F.L., Elsperger, J. and Hodges, M. Embolic Potential of Left Ventricular Thrombi Detected by Two-Dimensional Echocardiography. Circulation, 1984; 70:588-598.
9. Olszewski R, Timperley J, Szmigielski C, Monaghan M, Nihoyannopoulos P, Senior R, Becher H. The clinical applications of contrast echocardiography. Eur J Echocardiography 2007; 8: S13-S23.
10. Weinsaft JW, Kim RJ, Ross M, Krauser D, Manoushagian S, LaBounty TM, et al. Contrast-enhanced anatomic imaging as

compared to contrast- enhanced tissue characterization for detection of left ventricular thrombus. JACC Cardiovasc Imaging. 2009; 2:969-79.

11. Weinsaft JW, Kim HW, Crowley AL, et al. LV thrombus detection by routine echocardiography: insights into performance characteristics using delayed enhancement CMR. J Am Coll Cardiol Img. 2011; 4:702-12.
12. Stratton JR, Resnick AD. Increased embolic risk in patients with left ventricular thrombi. Circulation, 1987; 75:1004-1011.
13. Lehman EP, Cowper PA, Randolph TC, Kosinski AS, Lopes RD, Douglas PS. Usefulness and Cost-Effectiveness of Universal Echocardiographic Contrast to Detect Left Ventricular Thrombus in Patients with Heart Failure and Reduced Ejection Fraction. Am J Cardiol. 2018; 122:121-128.
14. Contrat Tuned Imaging: Esoate, S.P.A, Genova, Italy: White Paper.
15. Porter TR, Abdelmoneim S, Belcik JT, McCulloch ML, Mulvagh SL, Olson JJ, Porcelli C, Tsutsui JM, Wei K. Guidelines for the Cardiac Sonographer in the Performance of Contrast Echocardiography: A focus Update from the American Society of Echocardiography, J Am Soc Echocardiogr. 2014; 27:797-810.
16. Porter A, Kandalker H, lakobishvili Z, Sagie A, Imbar S, Battler A, et al. Left ventricular mural thrombus after anterior ST-segment-elevation acute myocardial infarction in the era of aggressive reperfusion therapy - still a frequent complication. Coron Artery Dis. 2005; 6:275-9.
17. Mehra, S., Movahed, A., Espinoza, C. and Marcu, C.B. Horseshoe Thrombus in a Patient with Mechanical Prosthetic Mitral Valve. A Case Report and Review of Literature. World Journal of Clinical Cases, 2015; 3:838-842.
18. Mendichovszky IA, Marks SD, Simcock CM, Olsen OE. Gadolinium and nephrogenic systemic fibrosis: time to tighten practice. Pediatr Radiol. 2008; 38:489- 96.
19. Ali-Barman H, Atici A, Erturk E, Faruk-Baycan O, Rasih-Sonsoz M, Betul-Medik Y, And Sahins I. Apical longitudinal strain can help predict the development of left ventricular thrombus after anterior myocardial infarction. Rev Invest Clin. 2020, 726:353-62.
20. Garber AM, Mentz RJ, Al-Khalidi HR, Shaw LK, Fiuzat M, O'Connor CM, et al. Clinical predictors and outcomes of patients with left ventricular thrombus following ST-segment elevation myocardial infarction. J Thromb Thrombolysis. 2016; 41:365-73.
21. Gianstefani S, Douiri A, Delithanasis I, Rogers T, Sen A, Kalra S, et al. Incidence and predictors of early left ventricular thrombus after ST-elevation myocardial infarction in the contemporary era of primary percutaneous coronary intervention. Am J Cardiol. 2014; 113:1111-6.
22. Blessberger H, Binder T. Non-invasive imaging: two dimensional speckle tracking echocardiography: basic principles. Heart. 2010; 96:716-22.
23. Mor-Avi V, Lang RM, Badano LP, Belohlavek M, Cardim NM, Derumeaux G, et al. Current and evolving echocardiographic techniques for the quantitative evaluation of cardiac mechanics: ASE/EAE consensus statement on methodology and indications endorsed by the Japanese society of echocardiography. J Am Soc Echocardiogr. 2011; 24:277-313