

Echocardiography in Clinical Decision Making for Acute Coronary Syndromes

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Case report

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Abstract

Background Acute coronary syndromes encompass an array of complex symptoms and presentations. The role of echocardiography in acute coronary syndrome has recently assumed a distinguished role in detecting early and late mechanical complications of acute coronary syndrome paving way for emergent clinical decision-making. **Case Presentation** Three clinical cases are discussed where emergent use of echocardiography identified mechanical complications of acute coronary syndromes including free wall rupture, ventricular septal defect, and papillary muscle rupture allowing for early decision making. **Conclusion** Due to its non-invasiveness and accessibility, its utility in rapid assessment of acute coronary syndromes and its complications is promising and may lead to improved outcomes.

Background

There have been prior studies investigating the utility of echocardiography as a preliminary diagnostic modality in evaluating patients with acute chest pain and suspected acute coronary syndrome (ACS). The results have been promising and its implementation in emergent ACS assessment seems beneficial. These studies will be discussed in detail within the “literature review” section in the manuscript. This case series aims to validate the use of echocardiography as a preliminary imaging modality in ACS. Its use in identifying early and late mechanical complications of ACS can help in rapid clinical decision making to improve outcomes.

Case Presentations

Case 1

An 85-year-old female with a past medical history of coronary artery disease, status post drug-eluting stent placement presented to the emergency department after having acute onset chest pain and dyspnea on exertion. The patient was diaphoretic and hemodynamically unstable with hypotension and tachycardia. Physical examination revealed jugular venous distension, tachycardia, and clammy extremities. An initial electrocardiogram showed ST-segment elevations in leads II, III, and aVF with T-wave inversions noted in leads V2-V6 with anterolateral T-wave inversions.

Given the patient’s clinical presentation and EKG changes, emergent cardiac catheterization was recommended. Coronary angiography demonstrated a 90% calcific stenosis of the left main coronary artery extending distally to the ostium of the left anterior descending artery and left circumflex artery. The left anterior descending artery showed a 70-80% mid-vessel stenosis with TIMI 2 flow distally and the right coronary artery appeared to be the dominant vessel with 60% stenosis proximally and 70% stenosis distally with probable distal occlusion of the posterolateral branches. There was a patent stent in the mid-portion of the vessel with mild in-stent stenosis.

While severe, three-vessel disease was demonstrated, it was felt that the coronary anatomy could not fully explain the patient’s hemodynamic instability nor the acute changes on the EKG. Therefore, a stat

bedside transthoracic echocardiogram was performed with the patient on the cath lab table. This revealed a large pericardial effusion with significant thrombus, suggesting free wall rupture (Figure 1-3).

An intra-aortic balloon pump was placed, and inotropic therapy was initiated for concurrent cardiogenic shock. Cardiothoracic surgery was consulted. The patient refused surgical intervention. Per her request, her code status was changed to a DNR-CC arrest. She was transferred to the CCU where she continued to deteriorate and expired shortly thereafter.

Clinical analysis:

Free wall rupture is a known complication of myocardial infarction that occurs typically within the first five days after MI in about one-half of cases and within two weeks in over 90 percent of cases. It leads to rapid accumulation of blood within the pericardium and resultant tamponade. It results from severe myocardial tissue necrosis with perforation. In most cases, the left anterior descending artery is involved but the phenomenon can occur with any coronary vessel.

Survival depends primarily upon the rapid recognition of myocardial rupture and provision of immediate therapy.

Echocardiography can quickly identify mechanical complications of myocardial infarction in hemodynamically unstable patients. Although, many acute cases of free wall rupture cause death, some cases may be subacute allowing time for intervention. Utilizing echocardiography in a patient with hemodynamic instability and presumed cardiogenic shock can accurately recognize the severity of myocardial infarction and catch early mechanical complications that allow for more rapid intervention.

In our patient's presentation, the presence of the pericardial fluid and thrombus increased the concern for an acute/subacute free wall rupture. Percutaneous revascularization of the coronary artery disease would likely not have changed the outcome.

Case 2

A 59-year-old male with a past medical history of type 2 diabetes mellitus presented with acute onset chest pain and hemodynamic instability with a heart rate of 127 beats per minute and a systemic blood pressure of 51/29 mmHg. Initial EKG revealed ST-segment elevations in the anterolateral leads. The patient was in cardiogenic shock and immediately intubated and started on vasopressors.

Emergent coronary angiography revealed complete thrombotic occlusion of the left anterior descending artery. Hemodynamics on right heart catheterization demonstrated a severely elevated pulmonary artery oxygen saturation of 95% consistent with a ventricular septal rupture. An intra-aortic balloon pump as well as a Swan-Ganz catheter were placed.

Urgent echocardiography showed severely reduced right ventricular systolic function with an extensive apical ventricular septal defect (VSD) and a large left to right shunt (Figure 4,5). The following day, the

patient went to VSD closure using an Amplatzer septal occluder. A TEE was conducted and identified the VSD closure device to be in stable position with significant improvement of the left to right shunt.

Unfortunately, the patient's stay was further complicated by a number of comorbid conditions. He continued to deteriorate clinically and ultimately after extensive discussion with the involved family, further care was withdrawn. The patient was extubated and died shortly thereafter.

Clinical Analysis:

Development of VSD due to myocardial ischemia requires extensive tissue deterioration and perforation leading to open communication between the left and right ventricles. It leads to massive left to right shunting of oxygenated blood, reduces cardiac output ultimately resulting in cardiogenic shock. Similar to free wall rupture as previously discussed, use of echocardiography in a hemodynamically unstable patient can quickly identify mechanical complications of myocardial infarction. In addition, a VSD is difficult to distinguish from severe mitral regurgitation clinically. The rapid use of echocardiography can identify shunting through the necrotic myocardium providing rapid confirmation of the diagnosis as well as assessment of size and severity.

Case 3

An 82-year-old female presented for an elective left hip revision after multiple prior procedures complicated by infection. During her hospital stay she developed severe left-sided chest pain. EKG revealed atrial fibrillation with rapid ventricular response and troponin was elevated at 3.6 ng/ml.

A stat echocardiographic assessment was performed showing a mobile linear echogenic structure attached to the atrial side of the mitral valve annulus with mild mitral regurgitation. Follow up blood cultures confirmed MSSA bacteremia and subsequent transesophageal echocardiogram revealed an anterior mitral leaflet abscess with chordal rupture and leaflet perforation. There was a large annular vegetation with echolucencies consistent with abscess formation. (Figure 6,7)

The patient was deemed to be of unacceptably high risk for valve replacement. She was treated with intravenous antibiotics and discharged home with strict follow up.

Clinical Analysis:

Acute papillary muscle rupture is a frequently lethal complication of endocarditis as well as acute myocardial infarction. Echocardiography in the setting of acute hemodynamic decompensation in a patient who may have either of these diagnoses, can rapidly identify valvular pathologies and aid in the differentiation of these clinical entities. In a patient who presents with sudden onset chest pain and an elevated troponin, and in the appropriate clinical scenario, the rapid use of an echocardiography can distinguish the cause of the decompensation and is invaluable in avoiding unnecessary procedures (e.g coronary angiography).

Discussion

Advantages

The rapid use of echocardiography as a clinical decision-making tool in the setting of acute coronary syndrome carries a number of potential advantages. These include early detection of regional wall motion abnormalities confirming a likely ischemic etiology and potentially for anatomical localization, a rapid estimation of left ventricular function, early recognition of mechanical complications, and perhaps most importantly recognition of alternate etiologies with the potential to decrease unnecessary invasive procedures. We will discuss each of these components in further detail.

Diagnostic utility and clarification

Echocardiography stands as a fairly rapid, noninvasive, and accurate test to detect early myocardial dysfunction. [1] Given that wall motion abnormalities may manifest prior to the development of EKG changes or a troponin elevation, it also has the potential for ruling in ischemia early on. [2] Perhaps one of the best uses of echocardiography is in the setting of mixed or atypical presentations of chest discomfort. In this setting, it plays a crucial role in ruling out other known culprits such as tamponade, endocarditis, or pericarditis where cardiac catheterization would commit the patient to additional risks without the potential for benefit.

The Focused Cardiac Ultrasound (FoCUS) exam has been described in the literature as an adjunct to physical examination to emergently recognize structural causes of cardiac dysfunction. This exam focuses on the systolic function, chamber sizes, valvular abnormalities, the presence of pericardial effusion or tamponade, and likelihood of volume responsiveness. [3] The use of echocardiography in this application can both guide and expedite treatment. For cardiogenic shock patients, the FoCUS exam may help to guide mechanical circulatory device therapy.

One recent study investigating the use of echocardiography in the evaluation of ACS in the pre-hospital setting demonstrated the sensitivity and specificity of pre-hospital transthoracic echocardiography for non-ST segment elevation myocardial infarction at 90.9% and 100% respectively. [5] This demonstrates clear potential for the use of echo as a standardized initial evaluation strategy.

In addition, the FoCUS exam can detect contraindications to certain cardiac mechanical support devices that may have resulted from ACS. Several examples include the Impella that has a contraindication in patients with LV thrombus, the Intra-aortic balloon pump that has an absolute contraindication to moderate to severe aortic regurgitation, and the Tandem Heart Devices that are contraindicated with left atrial thrombus. Any suspicion of these findings before or during cardiac catheterization by physical examination or by catheterization findings should lead to further evaluation by FoCUS exam before proceeding with mechanical circulatory support.

Early identification of mechanical complications of myocardial infarction

Echocardiography remains the most accessible and reliable initial imaging modality to evaluate for structural cardiac disease. The management of life-threatening complications of ACS including ventricular free wall rupture, ventricular septal defect, acute papillary muscle rupture, ventricular aneurysm, cardiac tamponade, and ventricular thrombus formation all benefit from early recognition. While a thorough physical exam can frequently raise suspicion for one of these complications, it invariably requires imaging confirmation.

A patient presenting with cardiogenic shock and a newly auscultated murmur raises suspicion for a mechanical complication of an MI. An urgent, focused echocardiogram offers the possibility of immediate visualization of the VSD, imaging and quantification of new valvular regurgitation and also allows the rapid identification of a pericardial effusion associated with free wall rupture. [6] Mechanical complications of myocardial infarction carry a poor prognosis without immediate surgical intervention; coronary angiography in such situations may delay such life-saving surgery.

It is also important to mention that such complications can also present as late complications of ACS, where the door to balloon time will not be considered or in patient with STEMI who have been treated with thrombolytics and transferred to PCI capable facilities. The use of echocardiography may be prudent and a rapid assessment by an experienced ultrasonographer can help evaluate for these complications before proceeding with cardiac catheterization.

Reduction in unnecessary cardiac catheterizations

Prompt echocardiography in ACS has the potential to reduce unnecessary cardiac catheterizations as well as associated morbidity and mortality. Emergent coronary angiography is indicated when a thrombotic or embolic cause of ACS is suspected. In the absence of a strong indication, it may delay other more appropriate therapies and expose the patient to an invasive procedure with its concomitant risks

In cases such as left ventricular thrombus, echocardiography may both confirm the need for catheterization (i.e. LV thrombus with associated wall motion abnormality) and decrease complication rates by identifying the need to avoid left ventricular catheterization.

Potential disadvantages

The additional step of performing echocardiography in cases of suspected acute coronary syndrome also carries potential drawbacks. In many institutions, the ability to obtain an echocardiogram may be limited. If the etiology of ischemia is otherwise clear, any additional imaging reduces time to potential revascularization. Therefore, such utilization of echocardiography relies upon a rapidly available, appropriately trained technician and physician.

Delaying time to the catheterization lab

Current guidelines for the treatment of ST-segment elevation myocardial infarction recommend a 90-minute door-to-balloon time at a catheterization capable facility. Any delay for additional imaging should be avoided unless mechanical complications are suspected. A delay in care has to be carefully balanced relative to its potential benefit. Patients to be targeted are those with troponin elevation without an obvious type 1 MI and patients in whom the diagnosis of a mechanical complication will significantly affect their outcomes.

The purpose of the previously established FoCUS exam is to perform a more limited, high-yield examination by a skilled provider. Loss of time remains an unavoidable drawback of adding additional diagnostic testing. A useful test must be incorporated into a system of implementation that allows for timely performance and interpretation. This will allow for meaningful clinical impact.

Literature review

There have been prior studies investigating the utility of echocardiography as a preliminary diagnostic modality in evaluating patient with acute chest pain and suspected acute coronary syndrome (ACS). The results of these studies have been promising and its implementation in emergent ACS assessment seems beneficial. [9-17]

Table 1 reviews nine studies that measured the accuracy of echocardiography as a predictor of cardiac events by assessing the presence and absence of wall motion abnormality. The primary endpoints for these studies range from major endpoints such as myocardial infarction, to revascularization, angiographic findings of coronary artery disease, and abnormal study findings. [11,17]

The positive predictive value (PPV) of the various studies is variable ranging from 31-100 % but it is important to note that the PPV correlates with low-risk and high-risk patients. Conducting echocardiography for assessment of ACS in the high-risk population, such as the study by Mohler and colleagues [17], reveals a high PPV in high-risk patients. This study identified all patients with new wall motion abnormality; of those, myocardial infarction was identified in 43% giving a PPV of 100% and a negative predictive value (NPV) of 57%.

However, in the low-risk population, echocardiogram seems to be less predictive. In the study with Sabha and colleagues [11], who had a lower-risk population, the overall prevalence of a cardiac events was 17 % giving echocardiography a PPV of 31% and NPV of 98%. In addition, Krontos and colleagues [9] found that the PPV and NPV between echocardiography and electrocardiography in the low-risk population were similar with a PPV of 44% and 60% and a NPV of 98% and 44% respectively.

Overall, echocardiogram is more useful in evaluating for acute coronary syndrome in moderate to high risk populations. Its value in low-risk populations is non-superior to a standard electrocardiogram.

Prior case series regarding the use of echocardiography in ACS

A case series investigating the use of echocardiography by ER physicians to identify clinically significant acute occlusive coronary artery lesions concluded that ultrasound-trained Emergency Physicians can identify significant wall motion abnormalities. These cases involved high-risk patients in whom echocardiography would not have changed management. The strengths of this study included real-life cardiac function assessment and quicker assessment than laboratory data could allow. Some of the drawbacks include body habitus which may make it difficult to obtain certain views, interpretation of images that varied from provider to provider, and the ability to identify new versus old wall motion abnormalities. [19]

Another more recent study investigated the use of echocardiography in the evaluation of ACS in the pre-hospital setting. The study demonstrated very high sensitivity (90%) and specificity (100) for the early detection of NSTEMI. [5]

Suggested implementation strategy

Wall motional abnormalities in acute coronary syndrome may occur before electrocardiographic changes and before chest pain. [18] Suggested implementation of echocardiography in acute coronary syndromes, is in a moderate-to-high risk patient presenting with chest pain in the emergency department after an initial electrocardiogram is negative for STEMI. . This may aid in identifying new wall motion abnormalities for early identification of a probable ischemic etiology while blood work is pending.

A moderate-to-high risk patient who presents with an ST elevation myocardial infarction (STEMI), may benefit from emergent echocardiography just prior to cardiac catheterization if this does not delay door-to-balloon time. This may be especially useful in patients with hemodynamic compromise to identify possible mechanical complications of the MI in whom further interventions prior to coronary angiography (e.g circulatory support, surgical consultation) may be critical. The assessment should be performed by a trained ultrasonographer in the emergency department or on the cath table immediately preceding the procedure. (Table 2)

Conclusion

The use of echocardiography in the acute setting is a valuable tool in the early assessment of a hemodynamically unstable patient. It can provide a rapid assessment of the likelihood of ischemic myocardial disease, the degree of global and wall motion abnormality, and it can identify mechanical and valvular complications that allows for early recognition of life-threatening processes. The utilization of echocardiography in the acute setting may allow more rapid and appropriate intervention thereby reducing morbidity and improving outcomes.

Declarations

Ethics approval and consent to participate

Informed consent obtained

Consent for publication

Consent was obtained by all authors

Availability of data and materials

Data sharing is not applicable to this article as no datasets were generated or analysed during the current study.

Competing interests

There are no financial and non-financial competing interests for this manuscript

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Authors' contributions

PH assisted in conceptualization, data curation, analysis, investigation, methodology, writing, revision, and editing

ZN assisted in conceptualization, data curation, analysis, investigation, methodology, writing, revision, and editing

SM assisted in data curation, writing, editing, revisions, and supporting

RS assisted in revisions, analysis, investigating and supporting

EE assisted in conceptualization, data curation, analysis, investigation, methodology, writing, revision, editing, and supervision

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Tables

Table 1: Prior studies investigating the correlation between wall motion abnormality and cardiac events using echocardiography. [19]

Author	Year Published	Sample Size (N)	Wall motional abnormality (WMA)	Acute cardiac event, present (+)/absent (-)	Positive Predictive Value (%)	Negative Predictive value (%)
Krontos, et al. [10]	1998	260	WMA present	41+ / 53 -	44	-
			WMA absent	4 + / 162 -	-	98
Krontos, et al. [11]	1998	130	WMA present	15 + / 29 -	34	-
			WMA absent	6 + / 80 -	-	93
Sabia, et al. [12]	1991	169	WMA present	27 + / 60 -	31	-
			WMA absent	2 + / 80 -	-	98
Korosoglou, et al. [13]	2004	98	WMA present	19 + / 2 -	90	-
			WMA absent	18 + / 59 -	-	77
Saeian, et al. [14]	1994	60	WMA present	22 + / 3 -	88	-
			WMA absent	2 + / 33 -	-	94
Sasaki, et al. [15]	1986	46	WMA present	17 + / 1 -	94	-
			WMA absent	6+ / 22 -	-	79
Horowitz,	1982	65	WMA	34 + / 2 -	94	-

et al. [16]			present			
			WMA absent	2 + / 27 -	-	93
Peels, et al. [17]	1990	35	WMA present	22+ / 4 -	85	-
			WMA absent	3 + / 14 -	-	82
Mohler, et al. [18]	1998	92	WMA present	27 + / 0 -	100	
			WMA absent	28 + / 37 -		57

Table 2:

ACUTE ECHO TEAM IMPLEMENTATION

- Assignment of one acute echo sonographer and one acute echo reader
- Goal of acute ECHO performed and interpreted within 45-minute window

Figures

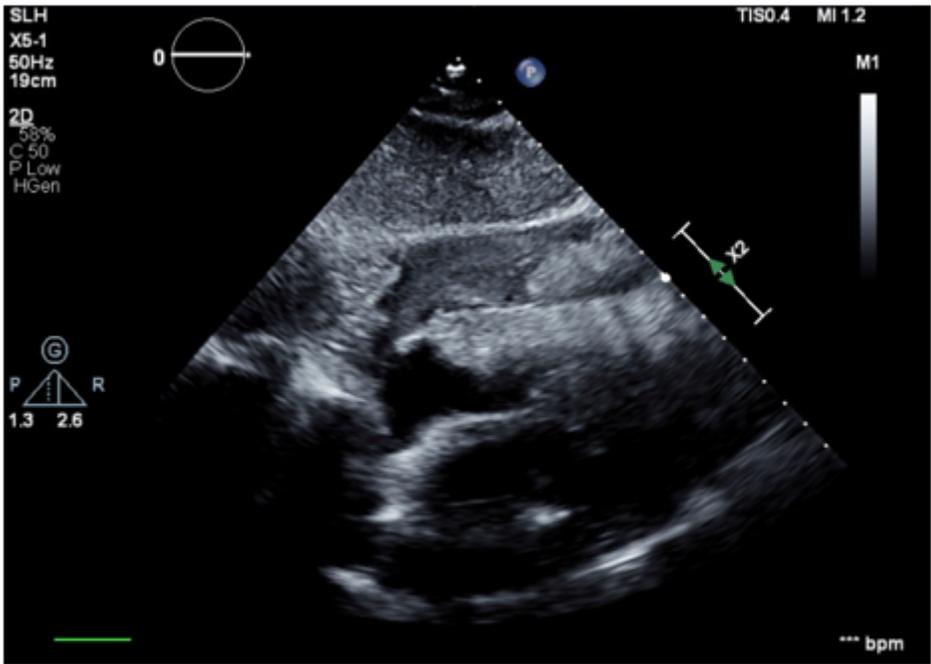


Figure 2

Echocardiography showing large anterior free space thrombus

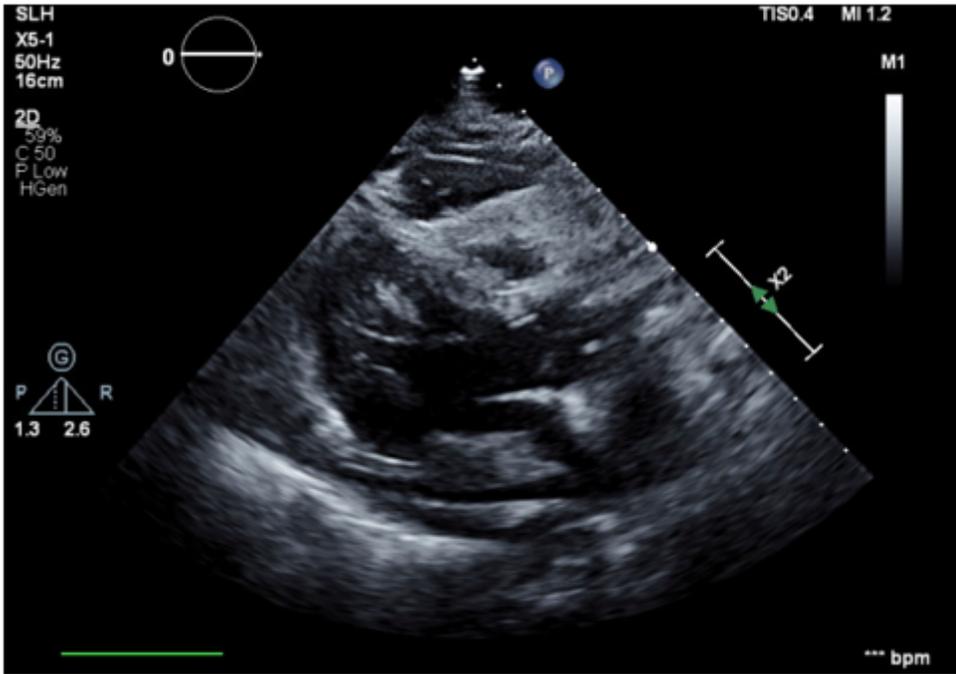


Figure 4

Echocardiography showing anterior free space with free wall rupture

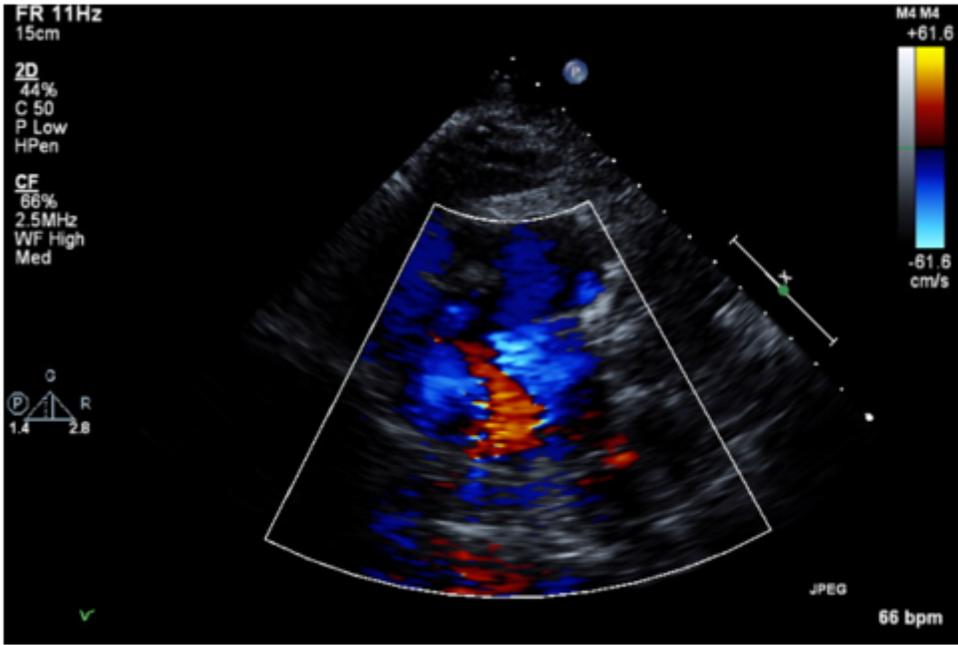


Figure 5

Echocardiographic dopplers showing anterior jet flow into the anterior free space consistent with free wall rupture

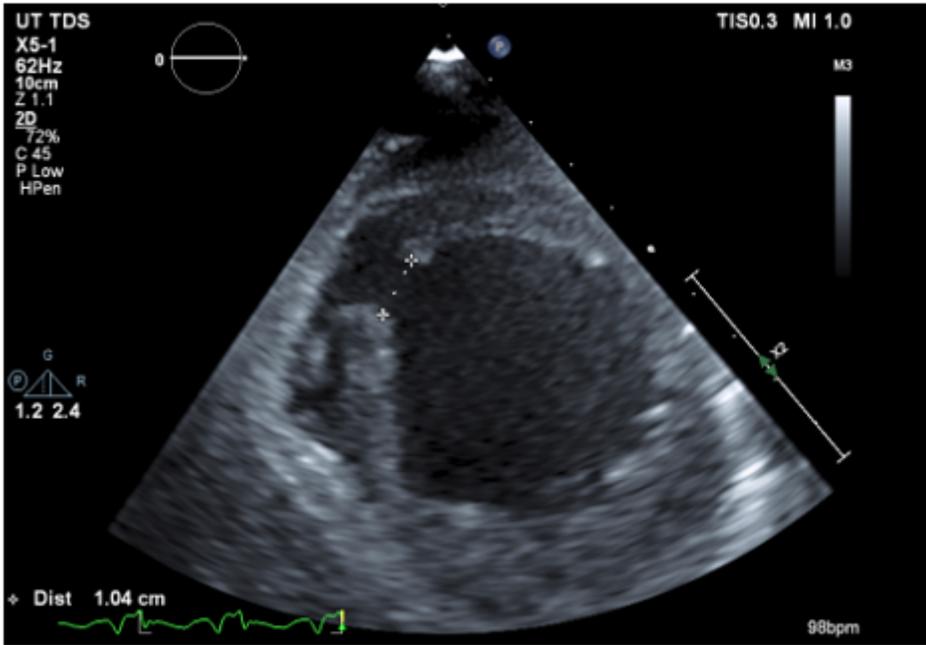


Figure 7

Parasternal short view showing large ventricular septal defect

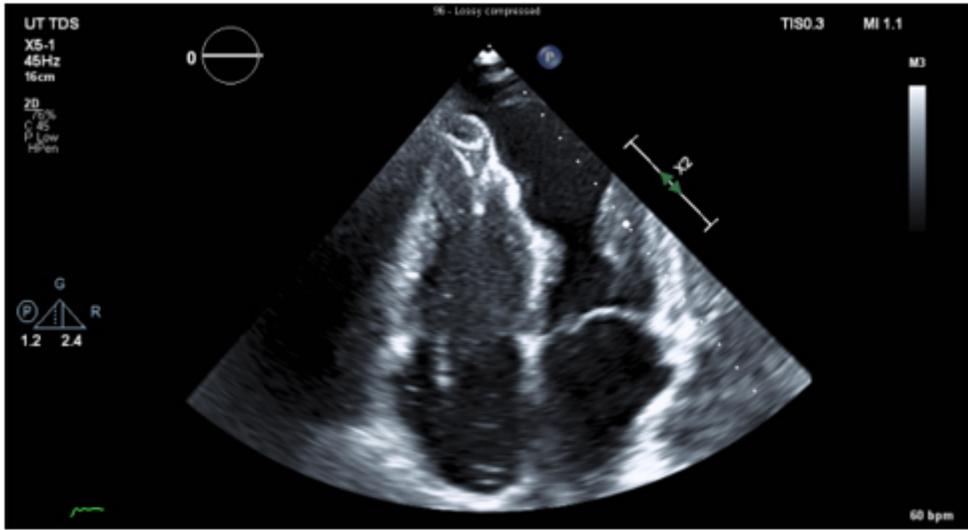


Figure 9

Parasternal long view showing closure of the VSD using an ASD occluder

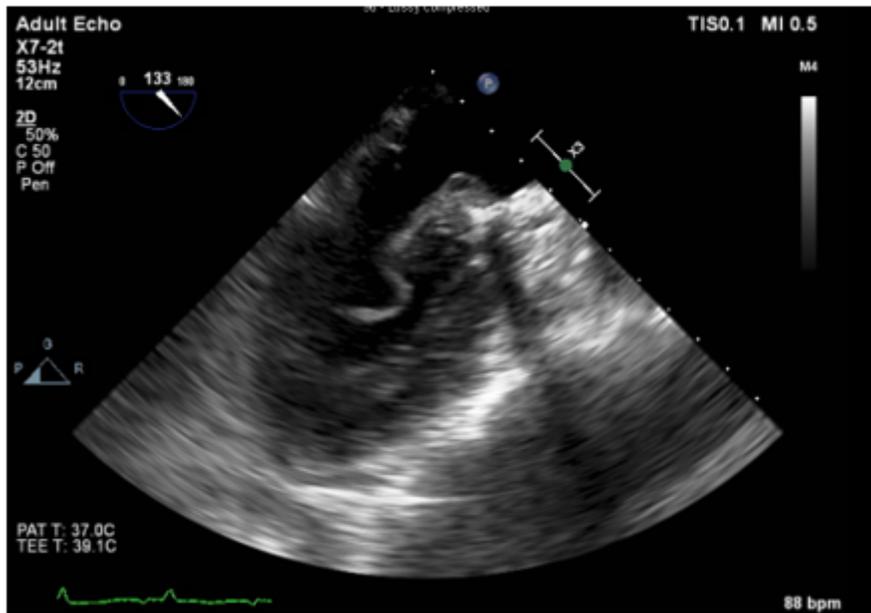


Figure 12

Large mobile mitral valve vegetation seen during diastole

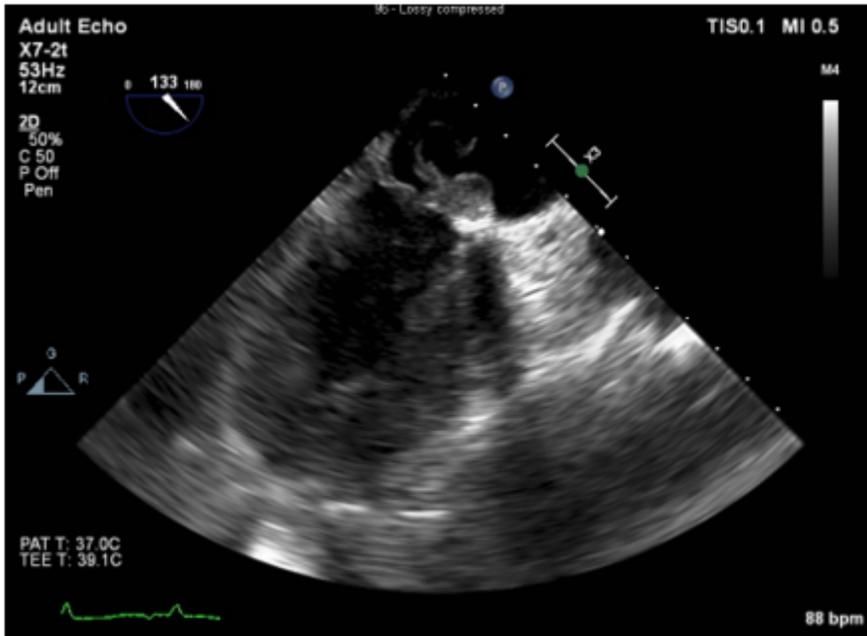


Figure 14

Large mobile mitral valve vegetation seen during systole

Supplementary Files

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