Eleven patients with deformed papillary muscles and downward movement were misdiagnosed as cardiomyocyte ischemia due to giant negative T wave

Mingyan Ding[1], Lijuan Guo[1], Zhongxin Deng[1], Ying Li[1], Wei Ji[1], and Fang Zhu[1]

[1]Affiliation not available

July 7, 2020

Abstract

Objective: To analyze the clinical manifestations of a huge inverted T wave and to summarize the causes of misdiagnosis of deformed papillary muscle as myocardial ischemia. Cases and Results: A retrospective analysis of the clinical data of 215 patients with 12-lead ECG T wave inverted myocardial ischemia from 2006 to 2018 in our hospital. Combined with multi-factor logistic regression analysis of echocardiography and electrocardiogram, we evaluated 11 cases of unique clinical malformed papillary muscles with lowered position. The electrocardiogram showed sinus rhythm, the electrocardiogram axis was normal, and the T wave inversion was 6-10 mm. The angiography showed no abnormalities. The echocardiogram showed that the left ventricular wall structure, motion, and left ventricular ejection fraction were within the normal range. Echocardiography showed that the anterolateral papillary muscle base of 11 patients originated from the apex 1/3. A 12-lead ECG with deformed papillary muscles shows that a huge inverted T wave is not a feature of myocardial ischemia. In this case, the 12-lead ECG feature is insufficient to identify the cause of myocardial ischemia. Therefore, we must exclude these myocardial ischemia in order to diagnose and treat correctly. Conclusion: Conventional 12-lead electrocardiogram shows that the giant inverted T wave of the deformed papillary muscles is diagnosed as myocardial ischemia, which is a misdiagnosis.

1.Introduction

A large amount of evidence indicates that more than one third of patients with coronary heart disease have myocardial ischemia. It is a worldwide clinical and public health problem. It is a risk factor for cardiovascular and cerebrovascular diseases and gradually becomes the cause of morbidity and death.

At present, early detection and disease monitoring of patients with CD, PET/CT scan, MRI, and cardiac magnetic resonance (CMR),The use of contrast agents[1] increases the burden on the patient's heart, and even leads to an increase in patient mortality. Due to the high cost of MRI, Cardiac magnetic resonance (CMR) has many advantages in the structure of the heart, and it is sometimes used as the gold standard. Traditional electrocardiogram and ultrasound examination are not sensitive to the diagnosis of mankind. it is necessary to improve ultrasound as a routine early examination method for heart disease.

A 12-lead electrocardiogram (ECG) with a wave Giant Negative T Wave (GNT) on the anterior lead usually represents myocardial ischemia. GNT is defined as the T-wave depth of any lead [?]10mm, but it is not a myocardial ischemia There are various factors that lead to GNT, such as ADPM and malformation, due to the specific performance of blood. Sometimes clinical diagnosis will be misdiagnosed. Therefore, it is of great significance to find the cause of GNT in time. The characteristics of ECG in patients with apical hypertrophic cardiomyopathy (Ap HCM) also have T wave inversion, and HCM without coronary artery disease often shows symmetric T wave inversion on ECG. For several patients in this study, serum lipids, blood glucose levels, TET [2], and dynamic electrocardiogram were normal, and coronary angiography showed no obvious

lumen stenosis. Therefore, we can rule out myocardial ischemia, combined with medical history, and coronary artery spasm. Possible; based on normal heart size, left ventricular wall motion and left ventricular ejection fraction, dilated cardiomyopathy (DCM) can also be excluded.

Under normal circumstances, myocardial cell repolarization is from the epicardium to the endocardium. The obvious T wave inversion may represent physiological changes during rapid ventricular repolarization. On the other hand, the T wave inversion may be due to hereditary heart muscle disease or it may be normal variation [3]. American scholars have pointed out that GNT is not a specific manifestation of apical hypertrophic cardiomyopathy. For example, in this study, the abnormal manifestation of papillary muscles is position shift to the apex (ADPM). ADPM is defined as the papillary muscle originating from the apical four-chamber view of the left ventricle near the apical segment of the third, regardless of whether it is associated with hypertrophy of the apical segment. We found that the number, shape, shape, and position of the papillary muscles vary considerably. According to Victor and Nayak's research, in the anterior-lateral group of papillary muscles, only 1.5% of the papillary muscles originate from the middle and lower third [4].

This study confirmed for the first time the relationship between papillary muscle deformity and a downward shift with a huge inverted T wave and myocardial ischemia. However, the significance of 12-lead ECG and ultrasound imaging methods in the early detection of myocardial ischemia needs further study.

2.

Cases and methods

2.1 Finalist criteria

This study is a retrospective observational study. To analyze the clinical data of 215 cases of myocardial ischemia diagnosed in our hospital from 2006 to 2018 due to the presence of GNT on the electrocardiogram. After careful observation, combined with angiography and echocardiography, 11 cases of clinical data with the characteristics of Papillary muscle deformity downward movement(Male: female = 9: 2, age 46-73 years old), the average age is (59.5 ± 13.5) years old(Table 1).

Inclusion criteria: (1) According to the 2014 ESC "Diagnostic and Treatment Guidelines for Hypertrophic Cardiomyopathy". ECG examination: T wave asymmetry, of which 9 cases are: anterior myocardial ischemia, and the patient has a 6-14 mm T wave inversion in leads V4-V6 (Figure 1-a/b). There are 2 cases of inferior wall ischemia. ECG tips: sinus rhythm, normal ECG axis, 6-10mm T wave inversion (Figure 1-c/d), no abnormal angiography, echocardiography shows left ventricular wall structure, exercise, and left ventricular ejection fraction Within normal range. (2) Coronary angiography results were normal. (3) Result of left ventriculography: the left ventricle nipple is grossly deformed, and its position is down. Echocardiography showed that the base of the anterolateral papillary muscles(Figure 2)originated from the top third of the left ventricle. At the same time, the combined medial papillary deformity and downward movement showed a huge negative T wave, corresponding to leads II, III, and Arterial vessel fistula. Eleven patients had different degrees of discomfort in the precardiac area, normal exercise tolerance, and left ventricular wall motion and left ventricle ejection fraction were within normal ranges. The patient's age ranged from 1-73 years, with an average age of (59.5 +- 13.5) years. The patient had no risk factors for coronary artery disease such as hypertension, diabetes, and obesity, nor had a history of other cardiovascular diseases, and was not given medication. Eleven patients had normal physical examination, blood pressure remained within the normal range of 70-90 / 110-125 mmHg, and the chest was not deformed.**The exclusion criteria are:** (1) There are other heart diseases; (2) The spectrum of the heart cannot be accurately detected; (3) In multiple examinations, the highest values of ECG, echocardiography, coronary angiography and cardiac CT / MRI values are The difference of the lowest value is greater than 3.

This study was approved by the Medical Ethics Committee of Liaoning Provincial People's Hospital of China Medical University.

2.2 Detection method:

Careful analysis of the medical history, laboratory data, electrocardiogram, echocardiography, coronary angiography and cardiac CT / MRI of 11 patients. After further examination, blood lipids, blood sugar, treadmill exercise test (spring games), 24-hour dynamic electrocardiogram, coronary angiography were not abnormal, echocardiography showed that the papillary muscles were close to the apex (Figure 3). Echocardiographic evaluation: In this study, GE Vivid E9 line echocardiography was used for general ultrasound and Sonove sonography. Observe the levels of the apical four-chamber heart, apical three-chamber heart, left ventricle and short-axis apical segment, and at the same time try to avoid the short contraction of the left ventricle in the horizontal section of the apical four-chamber. Echocardiography showed that the base of the anterolateral papillary muscles originated from the top third of the left ventricle(figure4). At the same time, the medial papillary deformity and downward movement after the merger showed a GNT, corresponding to leads II, III, and Arterial vessel fistula. All 11 patients had varying degrees of precordial discomfort, normal exercise tolerance, and left ventricular wall motion and left ventricle ejection fraction were within the normal range. For the papillary muscles of healthy subjects, the left ventricular papillary muscle is a tapered meat column that extends from the left ventricular wall into the chamber. It is the muscle part of the mitral valve device, which is always thick and paired, divided into The two groups are located in the middle of the left ventricular cavity, in which the anterolateral papillary muscles are located at the junction of the anterior wall and the lateral wall of the left ventricle, and the posterior medial papillary muscles are located in the posterior wall of the left ventricle. The papillary muscles form a parallel arrangement and no hypertrophy. We found that the number, shape, shape, and position of the papillary muscles vary considerably. The position of the papillary muscles has moved down. American studies have pointed out that GNT is not a specific manifestation of apical hypertrophic cardiomyopathy. In this study, the abnormal manifestation of papillary muscles is position shift to the apex. Apically displaced papillary muscle is defined as the papillary muscle originating from the apical four-chamber view of the left ventricle near the apical segment of the third, regardless of whether it is associated with hypertrophy of the apical segment. Under normal circumstances, myocardial cell repolarization is from the epicardium to the endocardium. The obvious T-wave inversion may represent physiological changes during rapid ventricular repolarization. On the other hand, the T-wave inversion may be due to hereditary heart muscle disease or it may be normal variation[2]. According to Victor and Nayak's research, in the anterior-lateral group of papillary muscles, only 1.5% of the papillary muscles originate from the middle and lower third. In the papillary muscles of healthy subjects, there are usually two sets of anterolateral and posteromedial muscles of equal size in the left ventricular cavity (Figure5). However, in this study, echocardiography showed that 11 cases of anterolateral papillary muscle base originated from 1/3 of the apex(Figure6), and 2 cases of posterior internal papillary muscle base originated from the posterior and medial apex of the left ventricle 1/3 (Figure 7) and some patients have morphological variations in the papillary muscles, divided into multiple groups (Figure8). The results showed that the position of the displaced, thick, and grouped papillary muscles was consistent with the corresponding lead changes of the conventional 12-lead ECG, and the corresponding rate was more than 90%. After 5 years of follow-up, the patient's ECG and echocardiogram showed no abnormal changes and no cardiovascular events occurred. The presence of GNT in the differential diagnosis of electrocardiogram GNT may indicate that the patient has apical hypertrophy, especially when GNT is difficult to interpret, it must be taken into account, and has certain predictive value. Apical hypertrophic cardiomyopathy is a subtype of hypertrophic cardiomyopathy, which is limited to the apex of the heart, and Japan accounts for about 24% [5,6]. Apical hypertrophy is defined as the thickest part of the apical part [?]15mm, and the ratio of the thickest part to the posterior wall [?]1.5. This is the characteristic [7] of echocardiography in clinically suspected apical hypertrophy [8]. Kobashi [9]and others believe that papillary muscle hypertrophy is an early form of hypertrophic cardiomyopathy. GNT can exist in single papillary muscle hypertrophy [10,11]. Papillary muscle hypertrophy is defined as at least one group of papillary muscles with a diameter [?] 1.1 cm. Echocardiography is the main method of diagnosing the disease, with a specificity of 90%, but in our study, we found that two-dimensional echocardiography did not show evidence of left ventricular hypertrophy. At the same time, we know that the clinical manifestations depend on the onset of emergency, mitral regurgitation, and primary disease. Mild papillary muscle insufficiency that occurs gradually can be asymptomatic due to its small effect on hemodynamics. In severe cases, palpitations, shortness of breath,

cough, fatigue, etc. may appear.

The purpose of this study was to compare the evaluation of myocardial ischemia with 12-lead ECG and the evaluation of early myocardial ischemia by combining multiple ultrasound imaging methods.

3.Discussion

This study aimed at the cases where GNT was diagnosed as myocardial ischemia. After careful examination and combined with electrocardiogram and echocardiography, it was found that the position of the papillary muscle deformity moved down, and the papillary muscles were found to be hypertrophic and branched. Most of the papillary muscles (95%) are attached to the middle third, and only a small portion (5%) is located in the middle and lower third. It was confirmed that the base of the papillary muscle originated in the lower third of the left ventricular cavity, regardless of whether it was complicated with apical hypertrophy. On two-dimensional ultrasound, we found that 2 of them had posterior medial papillary muscles moving down and 2-3 groups of branches appeared, and the corresponding ECG leads showed T wave inversion. Left ventricular angiography clearly shows that the 11 patients in this study not only had papillary muscle hypertrophy, but the position of the papillary muscles moved downward, and some patients had multiple sets of deformities that led to end-systolic occlusion of the left ventricular apex. Studies have shown that papillary muscles have different morphological functions in samples of different types of papillary muscles [12]. These different patterns can be traced back to embryonic development and are related to changes in morphological characteristics of papillary muscles with incompletely differentiated left ventricular trabeculae [13]. In these 11 patients, the four-chamber view clearly showed that the anterolateral papillary muscle hypertrophy was reduced under the left ventricular angiography. The basal base originated from the 1/3 of the left ventricular apex, which was inserted into the anterior mitral valve. There are several branches in science, including 2 cases with posterior medial papillary muscle downward and 2-3 groups of branches, and the corresponding ECG leads have T wave inversion. In this case, if an abnormal T wave inversion occurs on the electrocardiogram, the position and morphological variation of the papillary muscles should be considered. In fact, in the past, on conventional echocardiography, due to poor apical sound transmission, information such as the position of the left ventricular apex and papillary muscles was often ignored. Left ventricular acoustic contrast can help improve the sensitivity of diagnosis, which has good specificity and repeatability. When we find that GNT exists in the 12-lead ECG and consider myocardial ischemia, echocardiography combined with left heart sonography should be used to give a clear diagnosis. This is very important for comparing and differential diagnosis of GNT. In this study, it was shown that the positional displacement and deformed papillary muscles are consistent with the conventional 12-lead ECG T wave inversion site, and the coincidence rate is more than 90%. We believe that it actually causes the negative ventricular extension of the relevant part. Therefore, the origin of abnormal papillary muscle location and papillary muscle morphology can also lead to the occurrence of GNT [14]. Isolated papillary muscle hypertrophy does not belong to the category of hypertrophic cardiomyopathy. In many cases, the two overlap. In the study population, overlaps need to be excluded. Isolated papillary muscle hypertrophy can cause T wave inversion, and an abnormally located papillary muscle with abnormal origin can also cause GNT. Changes in the shape and position of the papillary muscle may cause certain diseases. Some scholars have studied the relationship between papillary muscle morphology and cardiac arrest [15]. Parapapillary muscle and papillary muscle hypertrophy are associated with unexplained sudden cardiac arrest. Therefore, when GNT appears on the ECG, further echocardiography Examination of the chart to confirm the diagnosis is of guiding significance to the clinic. Therefore, when there is unexplained GNT, we need to consider the position of the papillary muscles close to the apex of the heart. Further supportive diagnostic tools can also rely on laboratory data, echocardiography, left ventriculography, coronary angiography, and cardiac CT / MRI analysis Comprehensive analysis of cardiac arrest [16]. The identification of papillary muscles close to the apex and apical hypertrophic cardiomyopathy is also clinically significant. Papillary muscle hypertrophy is the single factor that causes these ECG abnormalities to cause left ventricular wall hypertrophy. Limitations of this study: (1) Selecting patients from the People's Hospital of China Medical University as the research object may have a certain selection bias due to the regional and economic nature of the disease. (2) This study is a single-center small sample study. But the heart is different from the thyroid or liver, and its

individual differences are quite large. Although this study believes that the clinical manifestations of gross deformity of the papillary muscles and lowering of the position show that GNT is not an effective factor for myocardial ischemia, these results require the verification of large multicenter samples. Due to the small sample size, this study did not classify by different pathological types, and whether there are differences in myocardial ischemia of different pathological types during ultrasound examination remains unresolved. (3) In addition, due to the limitations of medical ethics, cardiac examinations cannot perform large sample testing at multiple centers.

This study first confirmed the relationship between the papillary muscle deformity and the inversion t wave and cardiac ischemia. However, in early detection of myocardial ischemia, the significance of applying 12-lead ECG and ultrasound imaging requires further research.

Abbreviations and acronyms:

electrocardiograms(ECGs)

giant negative T-wave(GNT)

left ventricular ejection fraction (LVEF)

apically displaced papillary muscle (ADPM)

apical hypertrophic cardiomyopathy (Ap HCM)

hypertrophic cardiomyopathy (HCM)

dilated cardiomyopathy (DCM)

cardiac magnetic resonance (CMR)

computerized tomography (CT)

magnetic resonance imaging (MRI)

Acknowledgements:

The author acknowledges: "All authors read and approved the final manuscript and agreed to publish it", in terms of funds, it was funded by the key project of "Liaoning Provincial Natural Fund", project number: 20180530109.

References:

1. Lee SP, Park K and Kim HK, et al. Apically displaced papillary muscles mimicking apical hypertrophic cardiomyopathy. *Eur Heart J Cardiovasc Imaging* 2013; 14: 128-134. Comparative Study; Journal Article; Research Support, Non-U.S. Gov't. DOI: 10.1093/ehjci/jes113.

2. Noyes AM and Schulman P. Normal Variant T-Wave Changes in an Athlete with Structurally Normal Cardiac Anatomy and Function. *Ann Noninvasive Electrocardiol* 2016; 21: 102-106. Case Reports; Journal Article. DOI: 10.1111/anec.12293.

3. Victor S and Nayak VM. Variations in the papillary muscles of the normal mitral valve and their surgical relevance. *J Card Surg* 1995; 10: 597-607. Journal Article. DOI: 10.1111/j.1540-8191.1995.tb00642.x.

4. Sakabe K, Fukuda N and Wakayama K, et al. Spontaneous pneumomediastium: a cause of T-wave inversion in electrocardiogram. *Int. J. Cardiol.* 2004; 94: 123-126. Case Reports; Letter. DOI: 10.1016/j.ijcard.2003.09.001.

5. Palaniswamy C, Aronow WS and Agrawal N, et al. Syncope: Approaches to Diagnosis and Management. *Am. J. Ther.* 2016; 23: e208-e217. Journal Article; Review. DOI: 10.1097/MJT.0b013e318256ed0f.

6. Yamaguchi H, Ishimura T and Nishiyama S, et al. Hypertrophic nonobstructive cardiomyopathy with giant negative T waves (apical hypertrophy): ventriculographic and echocardiographic features in 30 patients. *Am. J. Cardiol.* 1979; 44: 401-412. Journal Article. DOI: 10.1016/0002-9149(79)90388-6.

7. Park SY, Park TH and Kim JH, et al. Relationship between giant negative T-wave and severity of apical hypertrophy in patients with apical hypertrophic cardiomyopathy. *Echocardiography* 2010; 27: 770-776. Journal Article; Research Support, Non-U.S. Gov't. DOI: 10.1111/j.1540-8175.2010.01152.x.

8. Shim CY, Ha JW and Hong SJ, et al. Uncommon variation in the papillary muscles presenting with ST elevation and T-wave inversion. *Eur. Heart J.* 2008; 29: 2633. Case Reports; Journal Article. DOI: 10.1093/eurheartj/ehn199.

9. Kobashi A, Suwa M and Ito T, et al. Solitary papillary muscle hypertrophy as a possible form of hypertrophic cardiomyopathy. *Jpn Circ J* 1998; 62: 811-816. Case Reports; Journal Article. DOI: 10.1253/jcj.62.811.

10. Ker J. Solitary papillary muscle hypertrophy: a new echo-electrocardiographic syndrome? A case report. *Angiology* 2007; 58: 502-503. Case Reports; Journal Article. DOI: 10.1177/0003319706291159.

11. de Gregorio C, Speranza G and Zagari D, et al. Solitary papillary muscle hypertrophy in young athletes: a rationale for inverted T-waves on ECG?*J Cardiovasc Med (Hagerstown)* 2017; 18: 702-703. Case Reports; Journal Article. DOI: 10.2459/JCM.0b013e328360943e.

12. Gumusalan Y, Ozbag D and Ozden H, et al. The comparative investigation of left ventricle papillary muscle arteries in different species. *Saudi Med. J.* 2006; 27: 826-832. Comparative Study; Journal Article.

13. Oosthoek PW, Wenink AC and Wisse LJ, et al. Development of the papillary muscles of the mitral valve: morphogenetic background of parachute-like asymmetric mitral valves and other mitral valve anomalies. *J Thorac Cardiovasc Surg* 1998; 116: 36-46. Comparative Study; Journal Article; Research Support, Non-U.S. Gov't. DOI: 10.1016/S0022-5223(98)70240-5.

14. Sutton MG, Dubrey S and Oldershaw PJ. Muscular false tendons, aberrant left ventricular papillary musculature, and severe electrocardiographic repolarisation abnormalities: a new syndrome. *Br Heart J* 1994; 71: 187-190. Case Reports; Journal Article. DOI: 10.1136/hrt.71.2.187.

15. Uhm JS, Youn JC and Lee HJ, et al. Accessory papillary muscles and papillary muscle hypertrophy are associated with sudden cardiac arrest of unknown cause. *Int. J. Cardiol.* 2015; 197: 285-291. Journal Article. DOI: 10.1016/j.ijcard.2015.06.097.

16. Shim CY, Ha JW and Hong SJ, et al. Uncommon variation in the papillary muscles presenting with ST elevation and T-wave inversion. *Eur. Heart J.* 2008; 29: 2633. Case Reports; Journal Article. DOI: 10.1093/eurheartj/ehn199.

Figure 1: Twelve-lead electrocardiogram（a, b, c, d）

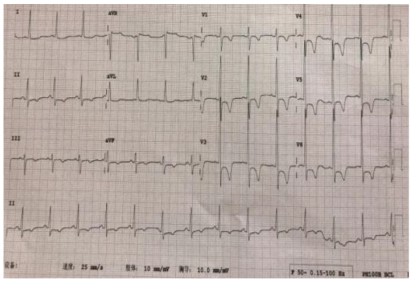


Figure 1-a

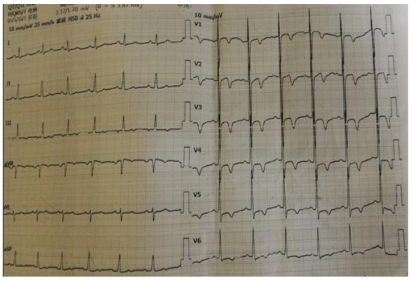


Figure 1-b

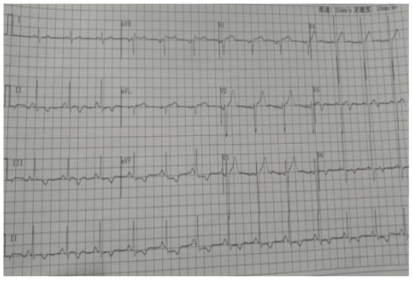


Figure 1-c

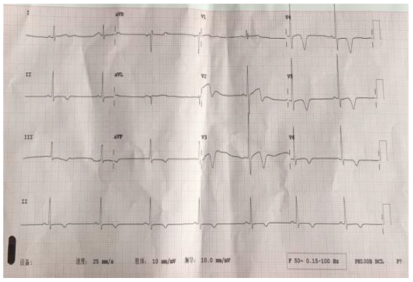


Figure 1-d

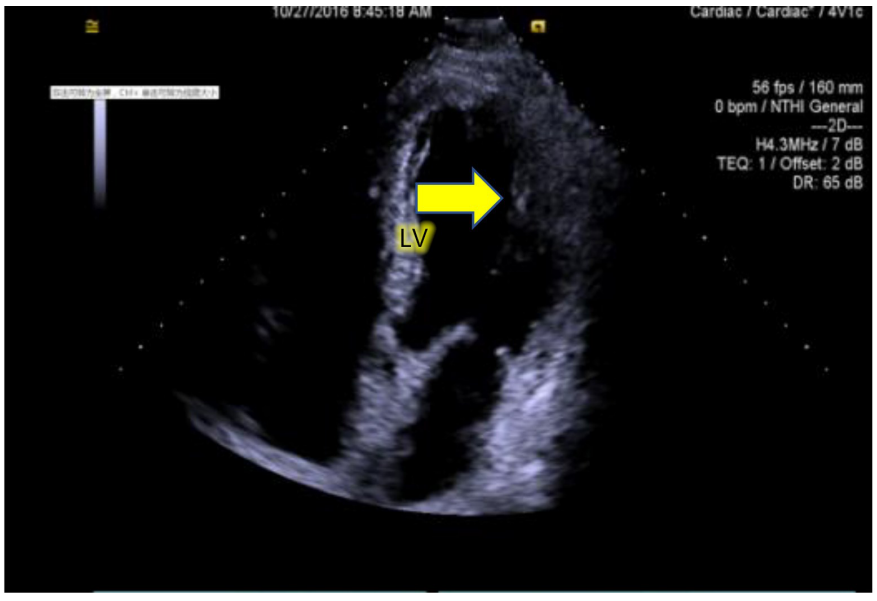


Figure 2 The papillary muscles are in normal position.

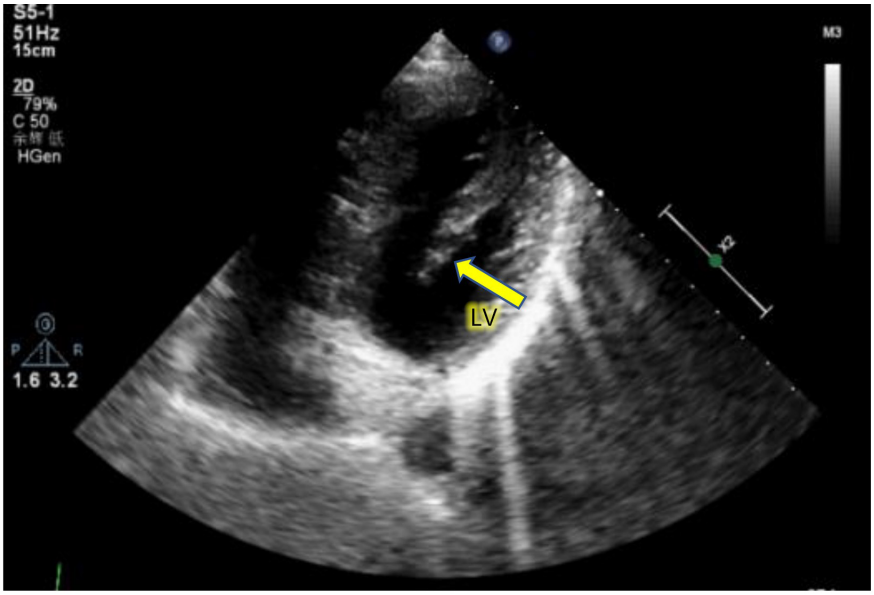


Figure 3 **The anterolateral papillary muscle is close to the apex and thick.**

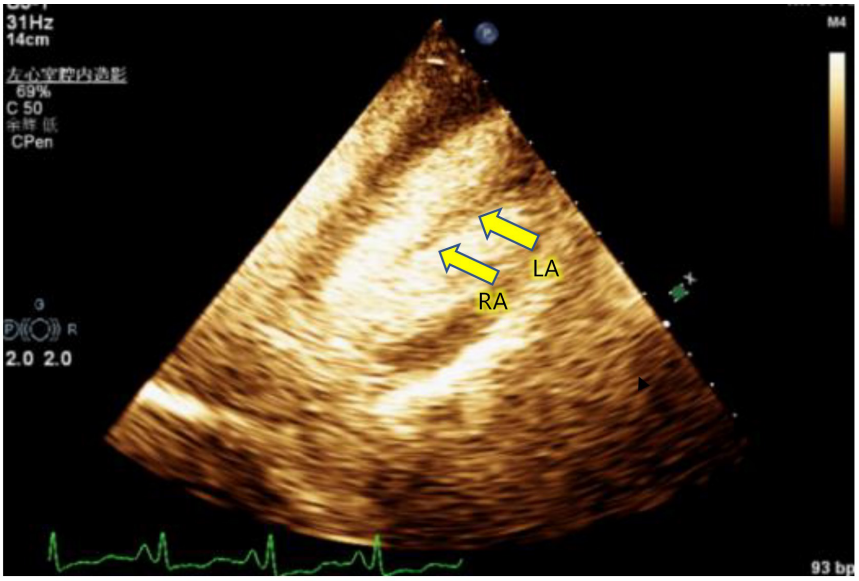


Figure 4 **LVO of the same patient shows that the anterolateral papillary muscles are close to the apex, thick and divided into two groups.**

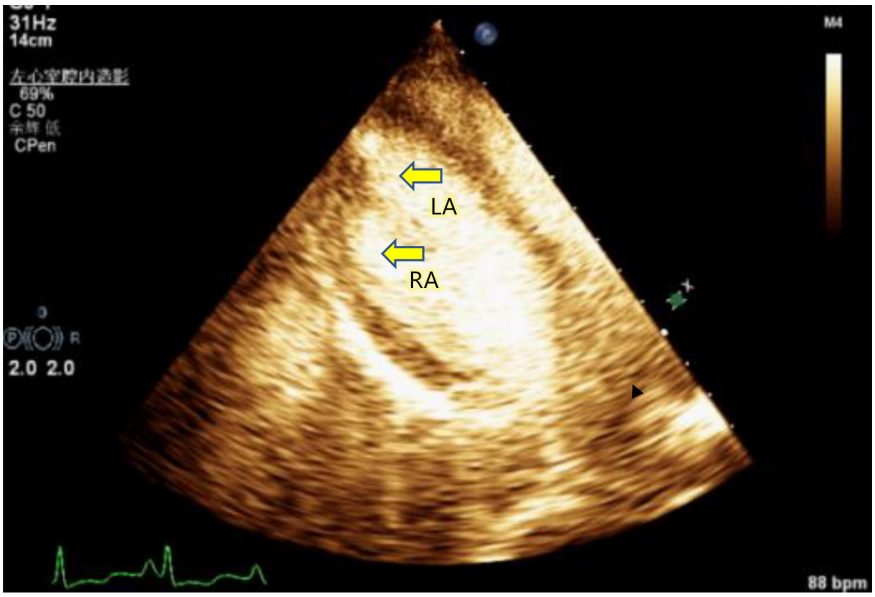


Figure 5 **LVO of the same patient shows that the posterior medial papillary muscle is close to the apex, thick and divided into two groups.**

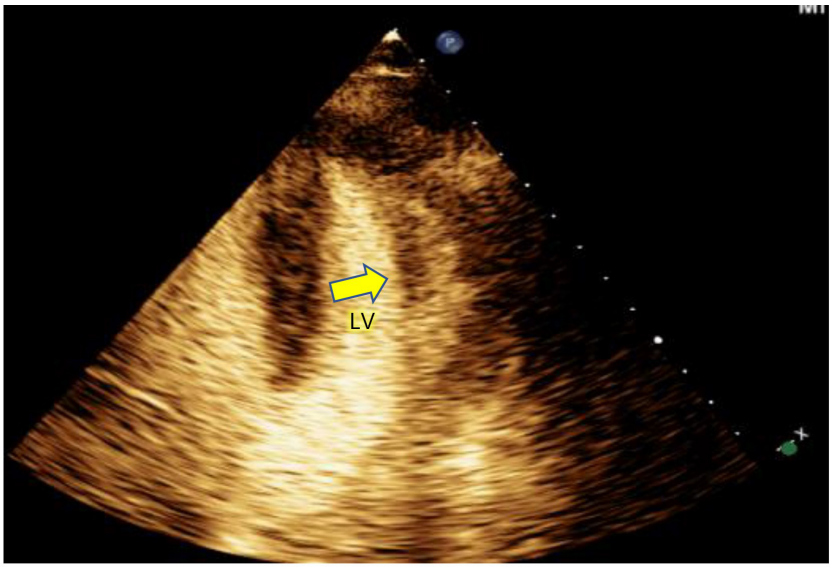


Figure 6 The same patient's apical four-chamber heart LVO shows that the anterolateral papillary muscles are close to the apex and thick.

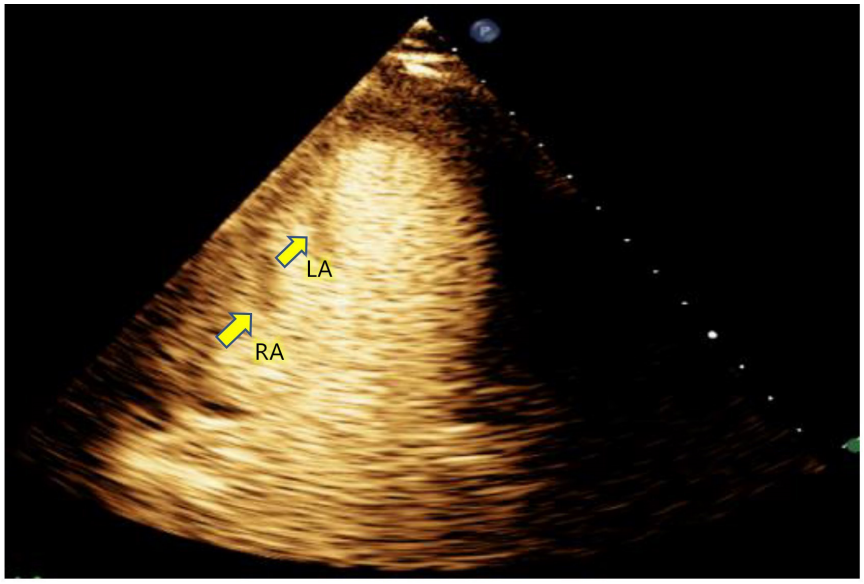
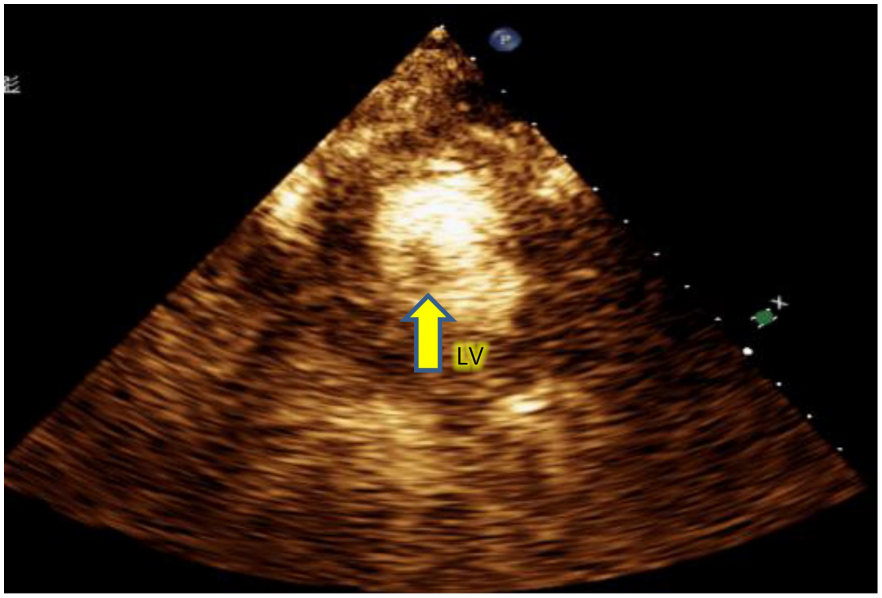


Figure 7 Apical three-chamber LVO showed that the posterior medial papillary muscle was close to the apex and was divided into 2 groups.



Hosted file

Table 1.docx available at https://authorea.com/users/313719/articles/467608-eleven-patients-with-deformed-papillary-muscles-and-downward-movement-were-misdiagnosed-as-cardiomyocyte-ischemia-due-to-giant-negative-t-wave