Step-by-Step Approach for Guiding Endomyocardial Biopsy by Real-Time Three-Dimensional Transthoracic Echocardiography

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INTRODUCTION

An endomyocardial biopsy (EMB) is a common procedure used to obtain samples from the myocardium for histological examination. Although it is generally a safe procedure, there are some serious risks associated with the procedure. Imprudent sampling of the right ventricle (RV) free wall increases the risk of perforation and cardiac tamponade. To minimize the risk, sampling is most commonly performed from the interventricular septal wall. Therefore, EMB is most commonly performed in the catheterization laboratory using conventional techniques by an experienced team.[1,2]

To demonstrate a step-by-step approach, we performed a routine EMB with real-time three-dimensional (3D) transthoracic echocardiography (RT3DE) guidance in the catheterization laboratory on a patient who was presumptively diagnosed with cardiac amyloidosis.

CASE PRESENTATION

A 60-year-old man was admitted with the chief complaints of fatigue, weakness, and dizziness for the last 2 months. The patient's blood pressure was 90/60 mm Hg, heart rate was 95 beats per minute, and oxygen saturation was 97% on room air. Based on clinical presentation, a number of tests were planned to confirm the diagnosis of cardiac amyloidosis. A 12-lead electrocardiogram was abnormal with low voltage, right-axis deviation, and ischemic ST-segment changes in the lateral leads. A transthoracic echocardiogram (TTE) was performed and demonstrated increased wall thickness (septum = 14 mm; posterior wall = 20 mm) and left ventricular (LV) mass index (179.27 g/m^2), reduced LV systolic function (biplane LV ejection fraction = 43%) with hypokinesis in the basal wall segments, biatrial enlargement with left atrial volume index of 68 mL/m^2, severely reduced longitudinal tissue velocity (tissue Doppler imaging e' basal < 5 m/sec), and "cherry on top" appearance on two-dimensional (2D) speckle-tracking echocardiography with a maximal systolic global longitudinal strain of −6.7% (Figure 1). All these data were suggestive of cardiac amyloidosis. An EMB procedure was justified to confirm cardiac amyloidosis.

The EMB procedure was performed under fluoroscopic guidance and further confirmed using RT3DE. A bioptome, which is a 7-Fr biopsy forceps, was used to obtain samples. The bioptome was inserted into the long sheath and advanced using fluoroscopic imaging with the aim of positioning the tip of the bioptome against the mid-to-distal interventricular septum of the RV. Real-time 3D TTE was introduced after the bioptome was already in the RV with fluoroscopy confirmation. Initially, RT3DE was performed using an apical 4-chamber (A4C) view (Figure 2, Video 1). We used the A4C 3D view to see the tip of the bioptome right at the distal interventricular septum and then used the 3D image display (2D tomographic slicing) mode to get 12 slices in the short-axis RV view from mid to apex so that the position of the bioptome tip could be ascertained to be right at the precise distal interventricular septum (Figure 3, Video 2). In this case, the interventionist must adjust the bioptome's position after positioning it under fluoroscopic guidance and confirming it via RT3DE guidance. We propose a step-by-step approach for guiding EMB by RT3DE (Table 1). The bioptome tip was located, and the biopsy was performed successfully without complication. Histopathological examination of our sample confirmed cardiac amyloidosis.

The patient passed away soon after the diagnosis of amyloid light-chain cardiac amyloidosis and prior to the initiation of chemotherapy.

VIDEO HIGHLIGHTS

Video 1: Three-dimensional TTE, A4C view (*top left*), orthogonal long-axis (*bottom left*), and volume-rendered (*right*) displays during placement of the bioptome.

Video 2: Three-dimensional TTE, A4C view with 3 orthogonally selected long-axis displays (*left panel*) and 9 short-axis slices from the apex to the level of the tricuspid valve, demonstrates the precise location of the bioptome positioning at the septal wall within the RV.

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DISCUSSION

Fluoroscopy guidance is the primary imaging modality for determining bioptome placement and has good safety reports. When fluoroscopy guidance was used, the bioptome was guided through the tricuspid valve

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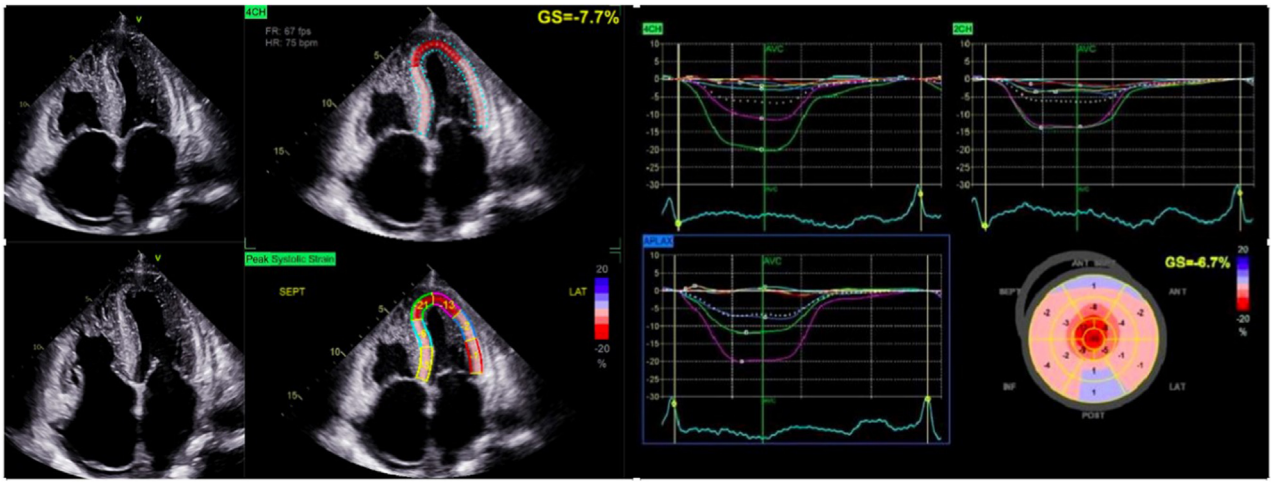

Figure 1 Two-dimensional TTE, A4C view, systolic and diastolic phase (*left panel*), demonstrating the thick LV myocardial wall segments and biatrial enlargement. Automated functional imaging analysis (*middle panel*) demonstrates that the regional longitudinal strain measurements are reduced with relative normal apical values, creating a ''cherry on top'' finding on the bull's-eye display (*right panel*), which is commonly seen in cardiac amyloidosis.

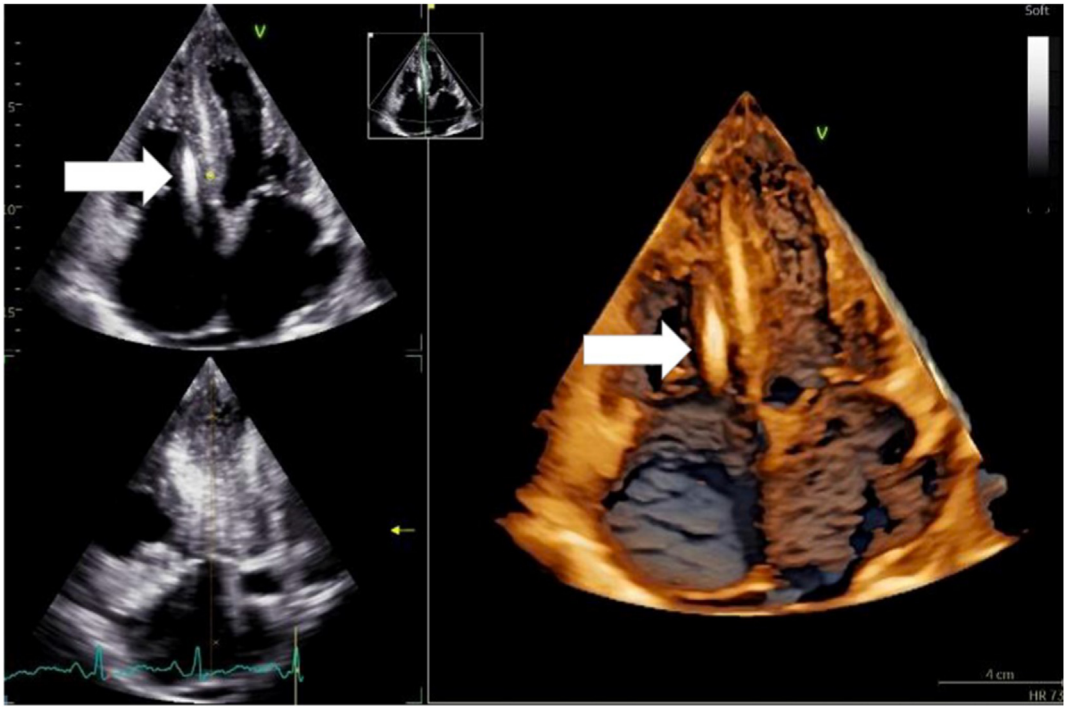

Figure 2 RT3DE, end-diastolic phase, A4C view (*top left*), orthogonal long-axis (*bottom left*), and volume-rendered (*right*) displays during placement of the bioptome (*white arrows*).

and put on the intraventricular septum of the RV. The position was confirmed using both anteroposterior and left anterior oblique angles (approximately 45°) such that the operator was confident of the sampling site. Previous research suggested that 5 bioptome placements that were thought to be against the septum by biplane fluoroscopic imaging were actually placed against the free wall of the RV. Therefore, the ability to precisely place a bioptome using fluoroscopy imaging is limited, even under optimal conditions, and this imprudently increases the risk of cardiac perforation and/or tamponade.[3,4]

Fluoroscopic guidance cannot directly visualize the anatomical location of the tip of the bioptome within the RV. To address this limitation, RT3DE has been used as an alternative or complementary form of imaging to guide the tip of the bioptome. Using RT3DE, it is possible to adequately visualize the right heart structures, sheath tip location, and orientation within the RV. During an EMB procedure, after appropriate fluoroscopic placement of the long sheath, RT3DE imaging can be used to assess whether the sheath tip is correctly placed or if repositioning of the sheath is necessary.[1,2,5,6]

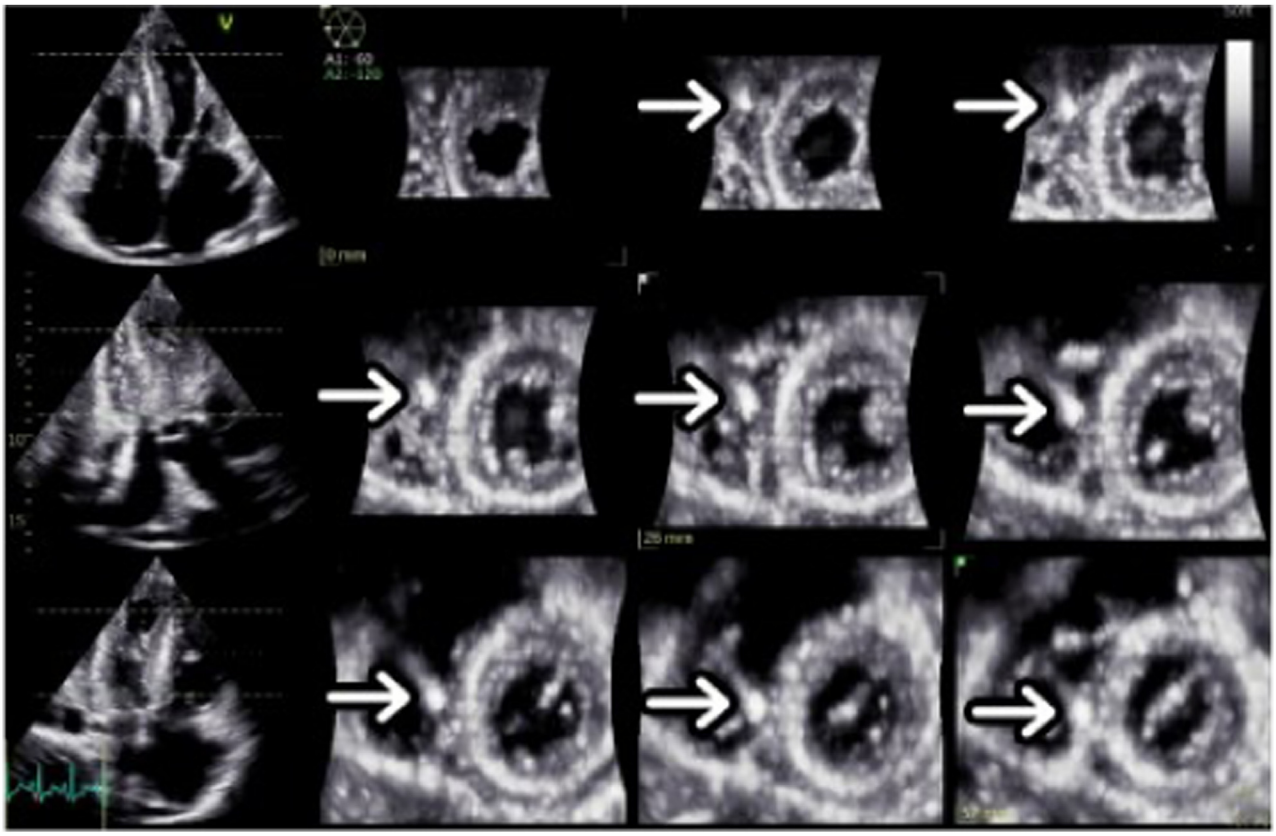

Figure 3 RT3DE, end-diastolic phase, A4C view with 3 orthogonally selected long-axis displays (*left panel*) and 9 short-axis slices from the apex to the level of the tricuspid valve, demonstrates the precise location of the bioptome (*arrows*) positioning at the septal wall within the RV.

Table 1 Step-by-step approach for guiding EMB by RT3DE

Step 1	RT3DE imaging from an A4C view with volume rendering technique when bioptome is in the RV.
Step 2	Use 2D tomographic slicing technique to visualize the tip of the bioptome, adjust the slice thickness for optimal cropping of the RV focusing on the bioptome tip.
Step 3	Confirm the bioptome's placement on the RV's septal wall, and then perform biopsy.

The addition of RT3DE during the EMB procedure will optimize the visualization of the right atrium, RV, and bioptome tip. In RT3DE, C-plane visualization can be used to view the RV; thus, this view is comparatively better than the 4-chamber view to direct the biopsy tip to the septal region. C-plane visualization can be moved in either direction from the apex region along the RV's long axis to provide the clinician with better identification of the bioptome tip. This might help the clinician in identifying the bioptome tip location in the RV, thereby improving the precision with which the biopsy site is located. We consider the use of RT3DE to be valuable, and we believe it allows us to increase the effectiveness of our sample collection. With this technique and its increased precision with respect to the specific sampling location, we also believe it allows us to reduce the total number of samples necessary for an accurate specimen; it may lower the chance of unintended RV free wall biopsy and may lower the complication rate. Further prospective comparison with conventional approaches would be necessary to confirm our beliefs. The bioptome placement can already be viewed normally using the A4C view, but adding the 2D tomographic slicing mode from RT3DE allows better visualization of the short axis from the RV view. The translation can be set to produce thinner slices to ensure the tip of the bioptome is precisely located on the RV septal wall. Compared to 2D echocardiography, RT3DE is an advanced imaging technique that provides a more comprehensive and realistic view of the heart. Advanced computer and transducer technology enables RT3DE acquisition and presentation of cardiac structure from any spatial perspective. Volume rendering, surface rendering, wireframe, and 2D tomographic slicing are the 4 broad categories used to display 3D images. Visualization of the bioptome in RT3DE allows accurate localization of the bioptome tip and biopsy site and may translate into improved efficacy of the procedure. Furthermore, using RT3DE to place the bioptome could result in a reduced incidence of fibrosis-containing samples during a procedure of similar duration.[5,7-10]

CONCLUSIONS

Endomyocardial biopsy is the standard procedure for the diagnosis of cardiac amyloidosis. Our case report demonstrates the step-by-step approach for using RT3DE to guide bioptome placement during

EMB. Our report adds to the published literature that suggests that RT3DE guidance may increase the precision of bioptome forceps positioning and may lead to improved procedural efficacy.

ETHICS STATEMENT

The authors declare that the work described has been carried out in accordance with the following guidelines: Ethical clearance was obtained from The Committee on Institutional Review Board/Health Research Ethics of Haji Adam Malik General Hospital.

CONSENT STATEMENT

Complete written informed consent was obtained from the patient (or appropriate parent, guardian, or power of attorney) for the publication of this study and accompanying images.

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DISCLOSURE STATEMENT

The authors report no conflict of interest.

SUPPLEMENTARY DATA

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