COMPARATIVE STUDY OF DENSITY DISTRIBUTION OF MICROBUBBLES BETWEEN FRAMES END-SYSTOLE AND END-DIASTOLE INSIDE CAVITY LEFT VENTRICLE

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Abstract: Echocardiography analysis technique has played an important role in correctly establishing the diagnosis. Moreover, microbubbles (MB) or contrast agent was designed to cross the pulmonary capillary beds into the left ventricle so as to allow the left ventricular contrast enhancement and to study its microcirculation. In this study we computed density distribution MB in the left ventricle (LV) between the frames end-systole and end-diastole for two diagnoses, pulmonary hypertension and one that attest a healthy LV. The process of evaluating the MB was computed inside the LV cavity using density distribution in function by radius of MB experimented in pixels.

Keywords: echocardiography, microbubbles, density distribution, pulmonary hypertension

1. INTRODUCTION

Echocardiography is an imaging modality that takes advantages of the physical properties of sound. In echocardiography, sound pulses generated by a transducer travel through the thoracic cavity, reflect off structures around and in the heart, and return to the transducer to be processed into images [1].

Contrast echocardiography was first described in 1968 by Edward *et al*. [1]. However the first reference to the notion of "bubble" was made in 1917, when the researchers have developed a variety of theoretical models to study gas bubble and nowadays the microbubbles are used as contrast agents to estimate the local microvascular flow rate [2].

Modonesi *et al*. in their studies on the myocardial contrast echocardiography method concluded that the MB produces strong backscattered acoustic signal based on its compressibility, which depends on the viscoelastic and pressure properties of both shell and gas [3]. MB encapsulation is required to increase stability and persistence, which depends on rigidity and provides persistence and good resistance to blood pressure changes and US pressure waves.

The diameter of the MB was computed by F.S. Villanueva *et al.*, in the paper "*Myocardial Ischemic Memory Imaging With Molecular Echocardiography*" [4] as being equals with $3.3 \pm 1.7 \mu m$.

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Density distribution of the microbubbles from the ROIs (Regions of Interest) of the normal left ventricle and one affected by pulmonary hypertension was computed with the first derivative:

$$f^{'}(a) = \lim_{x \to 0} \frac{f(a+h) - f(a)}{h} \tag{1}$$

It was applied on surface array represented by each ROI. In this case the first derivative calculates differences between adjacent elements of the each ROI as follow:

$$\left[X(2) - X(1); X(3) - X(2);...; X(n) - X(n-1)\right] \tag{2}$$

The density distribution was used in molecular dynamics simulations for the hard sphere fluid when the equilibrium condition of densities is accomplished [5]. The same applicability of this method is presented in the paper [6].

2. EXPERIMENTAL AND RESULTS

In this study, the hardware experiment environment was Intel (R) Core (TM) 2 Duo CPU T 5900, 2.20 with 3G RAM, and the programming environment is the MATLAB R2009a. The images used for the analysis are acquired from scanning systems, VIVID E9 and GE HORTEN MOK WAY using curvilinear probe with transducer frequency of 3.5 MHz. The echocardiography images of the heart used in this research were all captured from the same machine and then digitized with 512 x 524 pixels and 256 grey-level resolutions.

The microbubble from echocardiography illustrated in Figures 1 and Figures 2 was obtained following the specifications presented in [7]. The contrast agent has the encapsulating shell because it is designed to be stable for the use of intravenous injection. The analysis of the density distribution of the microbubbles can be optimally used for all cavities of the heart [8].

It allows defining the borders of the left ventricular cavity and improves the viewer's ability to assess ventricular chamber dimensions and both global and regional systolic function. Figures 3 present the cropped cavities of the left ventricle.

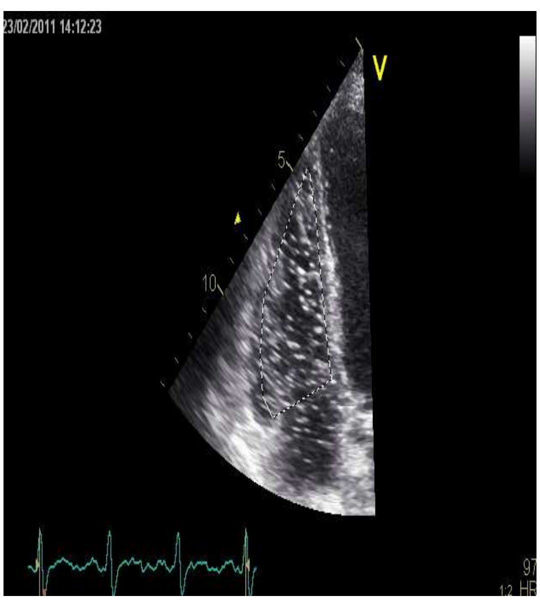

Fig. 1.a. The normal left ventricle have been manually traced with dashed line in frame end-systole.

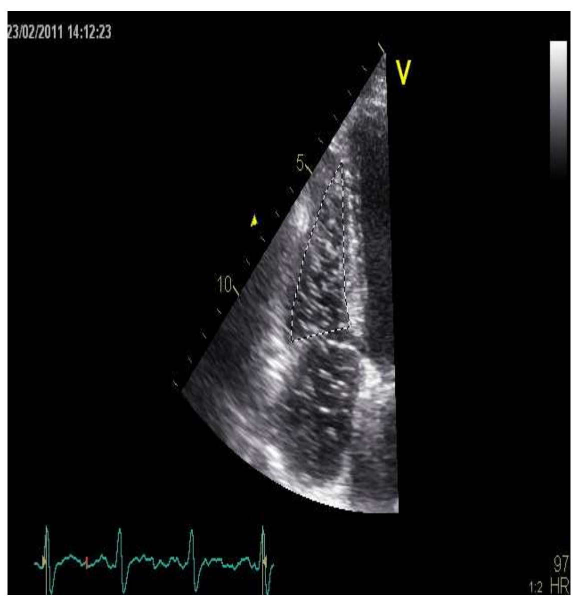

Fig. 1.b. The normal left ventricle have been manually traced with dashed line in frame. end-diastole

The region of interest (ROI) for each left ventricle was delimitated manually by specialist physician and cropped with interactive functions from application Matlab R2009a.

Density distribution of the microbubbles is shown in graphs of the Figures 4. The method of calculation is the following: the microbubbles radius measured in pixel is plotted versus sum in pixels of values bubbles as function by radius.

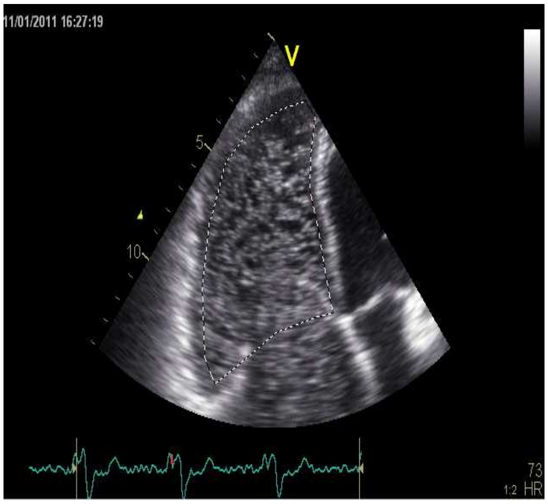

Fig. 2.a. The left ventricle of a patient diagnosed with pulmonary hypertension the contour have been manually traced with dashed line in frame end-systole.

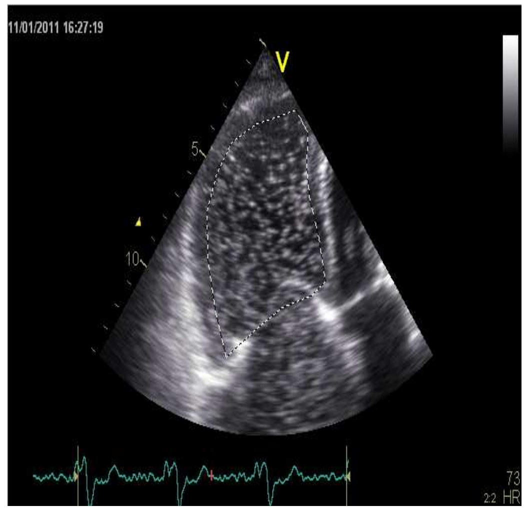

Fig. 2.b. The left ventricle of a patient diagnosed with pulmonary hypertension the contour have been manually traced with dashed line in frame end-diastole.

Fig. 3.a. ROI from normal left ventricle cropped in frame end-systole.

Fig. 3.b. ROI from normal left ventricle cropped in frame end-diastole.

Fig. 3.c. ROI from left ventricle of the patient affected by pulmonary hypertension cropped in frame end-systole.

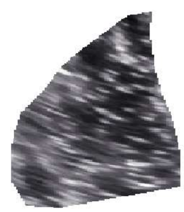

Fig. 3.d. ROI from left ventricle of the patient affected by pulmonary hypertension cropped in frame end-diastole.

3. CONCLUSIONS

Analyzing the graph of density distribution presented in Figures 4 we concluded that in the case of normal left ventricle in frame end-systole the most microbubbles have the radius are between 2 and 4 values. For the same ventricle in frame end-diastole the radius microbubbles have the values between 2 and 4 or 14 and 16. In case of the left ventricle of the patient affected by pulmonary hypertension the density distribution is maximum in many domains: for frame end-systole the most microbubbles values are in intervals 2 and 4, 10 and 12 or 14 and 18. For frame end-diastole the most microbubbles values are between 2 and 4 or 17 and 19. Finally, we conclude that the left ventricle affected by pulmonary hypertension contains microbubbles with higher radius. This new evaluation tool of the density distribution of microbubbles for various heart diseases can be used by physician to differentiate between normality and pathology, or to analysis density distribution of the microbubbles between end-systole and end-diastole for the same diagnostic.

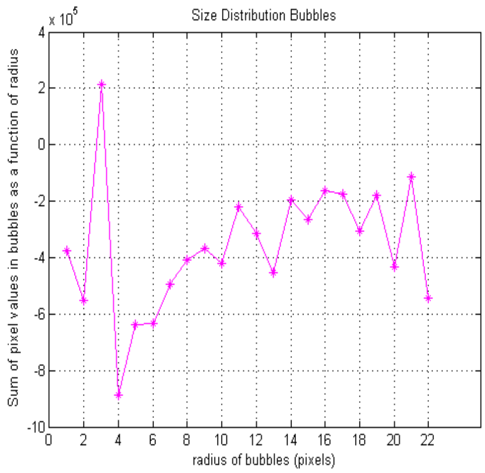

Fig. 4.a. Density distribution of the microbubbles from the ROI of figure 2(a) which represent a normal left ventricle, cropped in frame end-systole.

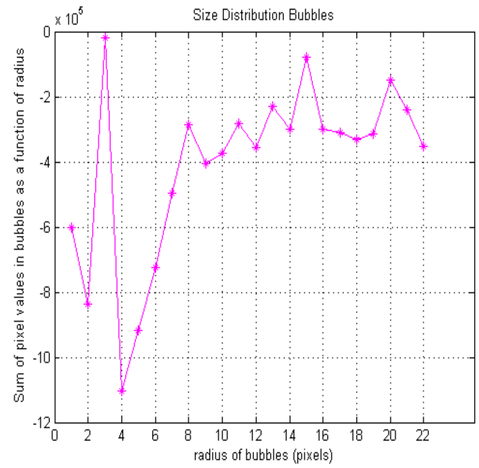

Fig. 4.b. Density distribution of the microbubbles from the ROI of figure 2(b) which represent a normal left ventricle, cropped in frame end-diastole.

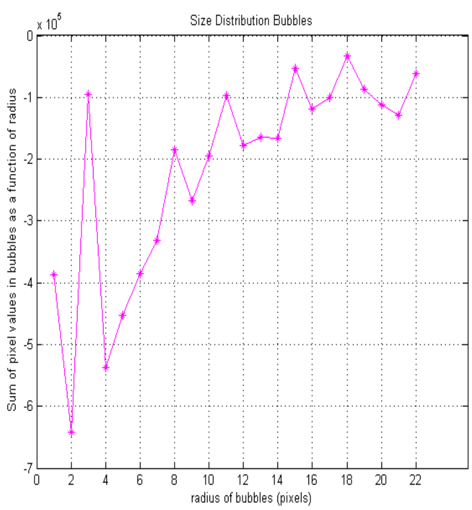

Fig. 4.c. Density distribution of the microbubbles from the ROI of figure 2(c) which represent a left ventricle of the patient affected by pulmonary hypertension, cropped in frame end-systole.

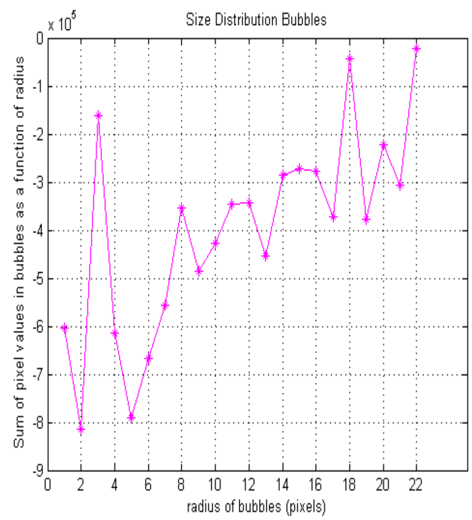

Fig. 4.d. Density distribution of the microbubbles from the ROI of figure 2(b) which represent a left ventricle of the patient affected by pulmonary hypertension, cropped in frame end-diastole.

ACKNOWLEDGEMENTS

The authors would like to thank the Project SOP HRD-EFICIENT 61445/2009 and the Project TOP ACADEMIC - 107/1.5/S id 76822 of “Dunarea de Jos” University of Galati, Romania.

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