ABSTRACT

Valvular Regurgitation (VR) is acknowledged as the fundamental reason for morbidity and mortality among cardiac patients. Although mere physical examination is enough for a clinician to find out the existence of regurgitation, diagnostic methods are necessary to estimate the seriousness of VR and the changes in cardiac chambers as a consequence of the volume overload. Recently echocardiography with Doppler proved to be the most useful to have the non-invasive recognition and assessment of severity besides etiology of the regurgitation of the valves. The measurements of the regurgitation help in evaluating the exact advancement of the disease which is crucial in deciding the opportune time for surgical treatment or any specific treatment. Doppler echocardiography plays the vital role in giving valuable information on the severity of VR. Today in clinical cardiology a very high quantification precision is needed for medical application which is provided by the Color Doppler Echocardiographic images. Comprehensive methods are presented herein to estimate and quantify Mitral Regurgitation (MR) and Aortic Regurgitation (AR) through the two dimensional color Doppler echocardiographic images which is the outcome of Proximal Flow Convergence (PFC) method. Experiments show better MR and AR quantification accuracy compared to the American Heart Association (AHA) values due to its flexibility in the selection of features and parameters.

The process commences with the quantification of MR, using an image processing and Proximal Flow Convergence method in the first part of the thesis. In the preprocessing stage the color Doppler echocardiographic MR images which are in RGB color space are converted into Y C_b C_r color space. Followed by preprocessing, in the second stage, the converted image is segmented using non-linear anisotropic diffusion method for flow field measurements. The percentage of backward flow of blood is calculated from the segmented image. The Proximal
Isovelocity Surface Area (PISA) method is used for the quantification of the Mitral Regurgitation. Quantitative left ventriculography has the capacity to compute regurgitant flow rate, Regurgitant Orifice Area (ROA) and Regurgitant Volume (R vol). Simple measurements of obvious jet size do not correlate closely with regurgitant flow rate and Regurgitant Fraction (RF) when color flow Doppler mapping is used. Presently converging flow field proximal to a regurgitant lesion is analysed by exploiting the Proximal Flow Convergence method to quantify Valvular Regurgitation. The proposed research provides a significant evaluation by applying the echocardiographic and Doppler methods for assessing the Mitral Regurgitation in the patients. In addition to that based on the scientific literature and opinion of a panel of experts, mild, moderate and severe i.e. various stages of the Mitral Regurgitation are estimated.

Quantitative evaluation of Aortic Regurgitation is dealt with in the second part of the thesis. The PISA method is proposed to calculate the severity of Aortic Regurgitation as a quantitative method. It is an image processing based effective approach, to precisely quantify the Effective Regurgitant Orifice Area (EROA) in AR that uses the Doppler Echocardiographic image. In preprocessing stage, the color Doppler echocardiographic AR image with RGB color space has been subjected to Wiener filtering. Accordingly it has been quantized with the help of color quantization by using National Bureau of Standards/Inter-Society Color Council (NBS/ISCC) color space that made the quantification of Aortic Regurgitation from color Doppler echocardiographic image more precise. The parameters such as EROA, Rvol and RF are evaluated by using the PISA method. By exploiting the Proximal Flow Convergence method, the mildness, severity and eccentricity of an aortic regurgitant lesion is estimated with the analysis of flow field convergence to measure the Valvular Regurgitation.
The final part of the thesis proposes a modification of the existing quantification of AR. Here an effective approach using Doppler echocardiography assisted by clustering based image segmentation and PISA methods is presented for the quantification of EROA in AR. At first, the signal to noise ratio of the image is improved in the preprocessing step by Gaussian filtering the color Doppler echocardiographic image. After that, image contrast improvement method employing Contrast-Limiting Adaptive Histogram Equalization (CLAHE) is used to enhance the image. More accurate quantification of the Aortic Regurgitation is facilitated by segmenting the enhanced image using Fuzzy K- means clustering. Furthermore the quantitative parameters such as EROA, R vol and RF etc., are calculated using the PISA method. By exploiting the Proximal Flow Convergence method, the mildness, severity and eccentricity of an Aortic Regurgitation lesion is estimated.

The improvement in performance is proved with the proposed approaches in the quantification of MR and AR by the experimental assessment on the commonly available data set of fifty color Doppler images (both MR and AR) collected from available free web sources and Nizam’s Institute of Medical Sciences (NIMS), Hyderbad. Moreover the performance comparison process in severity of MR and AR techniques has shown that proposed techniques have classified the input color Doppler images into mild, moderate, and severe based on quantitative parameters with high accuracy more than the existing techniques.