A STUDY OF COMMON CAROTID ARTERY BEHAVIOR FROM B-MODE ULTRASOUND IMAGE FOR DIFFERENT GENDER AND BMI CATEGORIES

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Abstract- The increment thickness of intima-media thickness (IMT) which involves the changes of diameter of the carotid artery is one of the early symptoms of the atherosclerosis lesion. The manual measurement of arterial diameter is time consuming and lack of reproducibility. Thus, this study reports the automatic approach to find the arterial diameter behavior for different gender, and body mass index (BMI) categories, focus on tracked region. BMI category is divided into underweight, normal, and overweight categories. Canny edge detection is employed to the B-mode image to extract the important information to be deal as the carotid wall boundary. The result shows the significant difference of arterial diameter between male and female groups which is 2.5% difference. In addition, the significant result of differences of arterial diameter for BMI category is the decreasing of arterial diameter proportional to the BMI.

Index Terms- B-mode Ultrasound Image, carotid artery diameter, canny edge detection, body mass index.

I. INTRODUCTION

Atherosclerosis is considered to be the main cause of cardiovascular disease. Atherosclerosis is defined as the accumulation of lipids in the inner surface of the arterial wall [1].

When the cholesterol level (LDL) in blood is abnormally high, the endothelium cell lining on the luminal surface of arterial wall is in dysfunction [2]. This phenomenon will trigger the inflammatory response that stimulates the migration of the monocytes in lumen as macrophages into the intima layer [1].

Continued inflammation results the thickening of arterial wall and thus decrease the arterial diameter. Numbers of works have reported the essential of arterial diameter measurements for assessing cardiovascular risk [3]-[5].

The diameter needs to be accurately measured. In current practice, sequence of images in seconds of length is used in manual measurement by controlling the electronic calipers setting at ultrasound equipment [6]. This method is time consuming, depends on the operator, and lack of reproducibility. Therefore, in this study, an automated measurement of common carotid arterial (CCA) diameter is proposed by employing Canny edge detection to extract the important information of arterial wall, and focused on tracked region. This research will focus on different gender and body mass index (BMI) categories to assess the relation of arterial diameter in each category. The BMI category is divided into three groups: underweight, normal, and overweight. Male and female are two groups in gender category. The next subsection in methodology will explain the method used in this study to measure the common carotid arterial diameter automatically. The result subsection will show the analysis obtained.

II. METHODOLOGY

A. Data Collection

B-mode ultrasound image of carotid artery was obtained with a linear-array transducer at 7.5 MHz, which is connected to ultrasonic diagnosis equipment (SSA-580A, TOSHIBA NEMIO XG). The 18 subjects are selected with no histological background of cardiovascular disease. 9 subjects are male and the other half are female. Within each groups, 3 subjects are underweight (BMI<18.5), normal (BMI 18.5 – 24.9), and overweight (BMI>25) groups, respectively. Fig. 1 shows the B-mode image of CCA in transverse and longitudinal sections, for a normal subject.

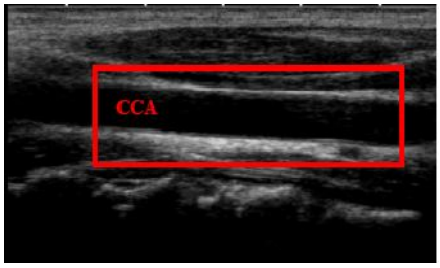


Figure 1 B-mode image of CCA normal subject in longitudinal section

B. Canny Detection

Canny edge detection uses a multi-stage algorithm to detect a wide range of edges in images and video which is the main advantage by using this operator of edge detection [7]. Four steps are operated in canny edge detection:

(a) Smooth the B-mode image whose edges are to be found out using 2D Gaussian Function.
(b) Find the gradient of the image
(c) Suppress all points that not at maximum value
(d) Thresholding the high and low value. If the value of the pixel is above the high threshold, it is set as an

edge pixel. If value of pixel is above the low threshold and is neighbour of an edge pixel, it is also set as an edge pixel. If a pixel has a value above the low threshold but is not the neighbour of an edge pixel, it is not set as an edge pixel.

III. RESULTS

C. CCA Diameter Calculated from Pixel Image

To study the behavior of the CCA, the changes of arterial diameter are the important parameter need to be considered. In this research, the video of CCA within one second, which consists of 30 images, was extracted. This video is obtained with the frame rate of 31 frames per second (fps). By using the image sequence from the video, the diameter changes of the blood vessel could be analyzed. Fig. 2 shows the original B-mode image of CCA and the enlarge one. It seems that even in the enlarge image, it is difficult and unclear to detect the boundary of arterial wall.

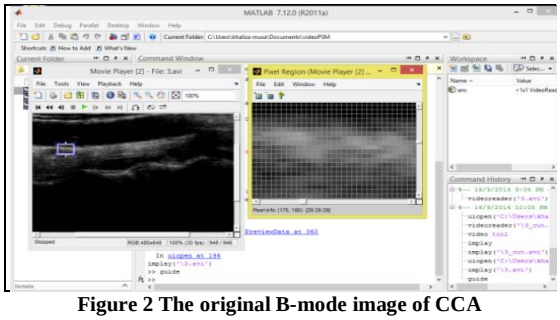
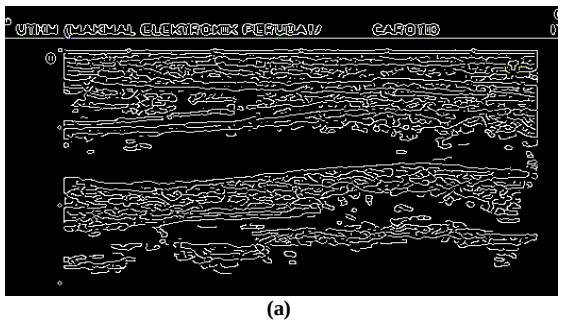


Figure 2 The original B-mode image of CCA

Figs. 3(a) and (b) are the CCA processed images using Canny at 33 ms and 990 ms, respectively. Significantly, at one point, the position of nearwall and farwall was changes in lateral and axial directions. The displacement of the point is focused to measure the artery diameter. As shown in Fig.4, the value between the nearwall and farwall was 53. The value obtained in pixel unit was converted to centimeter value. However, the conversion from pixel unit to centimeter unit depends on image visualized setting on ultrasound equipment. By increasing the value of depth, it allows deeper structures of CCA to be viewed, thus reduces the scale and frame rate. In this study, 1 cm is set to 77.5 pixel. Therefore, the calculation of the CCA diameter could be followed as in (1).

$$\text{CCA diameter (cm)} = \frac{53.00}{77.50}(1\,\text{cm}) \qquad (1)$$



(a)



(b)

Figure 3 The image of CCA after Canny process at (a) 33 ms and (b) 990 ms

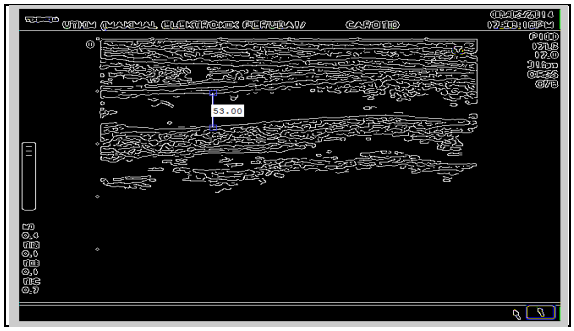
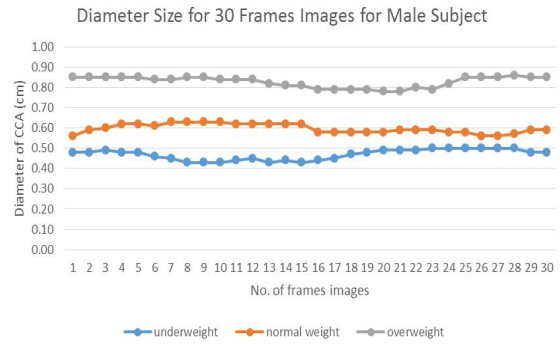


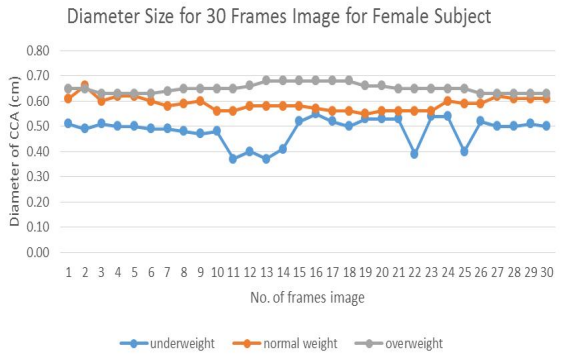
Figure 4 The measurement of artery diameter

D. CCA Diameter for Different Gender and BMI Categories

Figs. 5(a) and (b) show the result ofCCA diameter for male and female subjects, respectively. The analysis was divided into three categories which are underweight, normal, and overweight categories. The diameter size was analyzed for each frame within one second (30 frames). From both of the graphs, the diameter size of CCA showed the changes within one second image sequence which representing of one cycle heart pulsating. Here, 1 s is assumed as one cycle heart pulse. The underweight categories have a larger difference of diameter change during the one cycle, which is 0.06 cm for male and female. Thus, the stiffness of arteries for underweight category is less compared to normal weight cetegory which is 0.05 cm for male and 0.04 cm for female, and 0.04 cm for male and 0.03 cm for female in overweight category. In addition, the average of CCA diameter for 9 male and female subjects was calculated and the tabulated data are shown in Figs. 9 and 10. The three categories of BMI were grouped for clearly distinguised the changes of CCA diameter. From the result obtained, the diameter of CCAshows the significant difference between those BMI categories. The overweight category has the highest range of CCA diameter size compared to the underweight and the normal weight categories. For the underweight category, it shows the lowest range of size measurement for the CCA diameter compared to the normal and the overweight categories of subjects. As for the normal weight category, it could be summarized into the median range of the CCA diameter size between the underweight and normal weight categories.



(a)



(b)

Figure 5 Diameter Size for 30 Frames Image for (a) Male and (b) Female Subjects

DISCUSSION AND CONCLUSIONS

The thickening of arterial wall due to the accumulation of fatty streak inside the arterial wall is one of the factors the cardiovascular disease occurs. The early diagnosis of the condition or atherosclerosis is essential to prevent the condition become worse. Thus, the objective of this study was to assess the relation between common carotid artery diameter and heart pulse during one cycle heart rate in different gender and weight. The result shown the larger size of diameter for male and overweight category compared to female and other categories. Moreover, the underweight category had less stiffness at 0.06 cm, both for male and female. In the future, we recommend the measurement of those parameters for atherosclerosis patient to compare and evaluate the condition and possibility risk for atherosclerosis.

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