TEXTURE ANALYSIS OF PLAQUE IN CAROTID ARTERY

[1]D.SASIKALA, [2]R.ROSHINIYA, [3]SARISHNARATNAKARAN, [4]TAPATI DEB

[1]Research Scholar Anna University, Chennai, India
[2, 3, 4] Research scholar Vivekanandha college of engineering for women, Tiruchengode, India
[1]sasivas@rediff.com, [2] roshiniya27@gmail.com, [3]sarishnaratnakaran6847@gmail.com, [4]debtapati@gmail.com

ABSTRACT: Our blood circulation is very complex in nature the easy flow of blood through the vessels is important for the proper supply of blood and thus obtaining the required amount of oxygen to the tissues. Any lag in the supply may cause problem to the organs and its malfunction. Usually the blood supply is interrupted by the clot that is deposited in the circulating path. Stroke is caused by the interrupted blood supply to the carotid artery. The early detection of clot affected area and its texture analysis will help to understand the stage of the disease and thus we can provide the proper treatment before the disease reaches its vulnerable stage.

1. INTRODUCTION

Cardiovascular disease is one of the main causes of death and causes disability in the world. This further causes atherosclerosis in the wall of the common carotid artery. This is the one the major causes behind the stroke. It's a serious cerebrovascular disease and it is the main disease which causes death in developed countries. It is an acute manifestation of atherosclerosis and in brain tissue damage due to interrupted blood supply to the brain. Almost 18 million people suffering from stoke yearly, 9 million are left permanently disabled and becoming a burden to all. Reports show that 8% in subject aged less than 70 years to 15% or more in subjects aged more than 80 years in Europe and are about 6% in the USA. Although the incidence of stoke is declining the high-income countries, it is increasing in middle-income countries and low –income countries due to the life style and awareness to the disease; furthermore, the absolute number of stokes continues to increase because of the aging population. Carotid atherosclerosis (CA) is the main cause of majority of strokes. In its asymptomatic status in particular, it is increasingly encountered in the general clinical practice, as a result of advances in medical imaging. CA is a manifestation of the systemic atherosclerotic disease, in which fatty deposits, inflammation and scar tissue build up within the walls of arteries. The presence of steno-tic plaques, causing luminal narrowing of more than 50% or more in internal carotid arteries, Ultrasound imaging holds a prominent position in the diagnosis of CA. This is a diagnostic medical procedure that uses sound waves to produce images on a screen, which allows medical providers to view internal structures of the body. Ultrasound is a sound wave with frequencies higher than the upper audible limit of human hearing. Ultrasound is no different from 'normal' (audible) sound in its physical properties, except in that humans cannot hear it. Compared to other imaging modalities, namely magnetic resonance imaging, computed tomography

2. CHALLENGES: VALIDDIAGNOSIS OF CAROTID ATHEROSCLEROSIS AND RISK STRATIFICATION

People may experience carotid artery problems by various symptoms, those at high stoke risk have athermanous plaque known as "vulnerable plaques". A normal definition of this term is still lacking, that may be active inflammation, a thin cap with large lipid core, endothelial denudation, fissured cap, severe stenosis or combinations of these findings. Diagnosis of this kind of problems is biased on degree of stenosis that is the percentage of lumen area occupied by athermanous material. Here we are going to find the degree of stenosis, ultra sonograpically. Early and valid discrimination between vulnerable and stable carotid plaque is critical for optimal management of the disease. But the symptoms of disease may be asymptomatic or symptomatic. Currently asymptomatic subjects with stenosis degrees higher than 70% are offered an invasive revascularization procedure (endarterectomy or stenting), whereas subjects with lower stenosis degrees are not; both groups are offered medical treatment, namely statin theraphy. Patients with asymptomatic carotid stenosis is greater that are equal to 50% have an overall risk of stoke 2% per year and within this patient group higher stenosis degrees are associated with higher risk. Symptoms of stenosis larger

than 50% are all offered a revascularization procedure. It is pointed out that a subject is considered asymptomatic if they have not experienced a cerebrovascular symptom within a specific time period, usually not longer than six months, prior to the time of the examination. Even if the degree of stenosis has traditionally been approved as a key point laboratory measurement for the therapeutic decision making of CA, several studies have indicated that most cerebrovascular events are associated with less severe stenosis and plaque composition appear to be a critical determinant of the risk for future ischemic events. In order to overcome from all these problems we go for texture analysis and nuclear imaging, which allow accurate identification and evaluation of vessels, ultrasound has a number advantages, short examination times, lack of radiation exposure and low cost. Such advantages have established it as a validated method for visualizing and quantifying atherosclerotic lesions using a repeatable procedure that has proved to be a strong indicator of cardiovascular disease. Here in this project by analyzing the texture of the plaque we are going to find the vulnerability of the plaque and finding its properties will make us to understand which kind of stage the disease is spreaded and what type of treatment can prevent it.

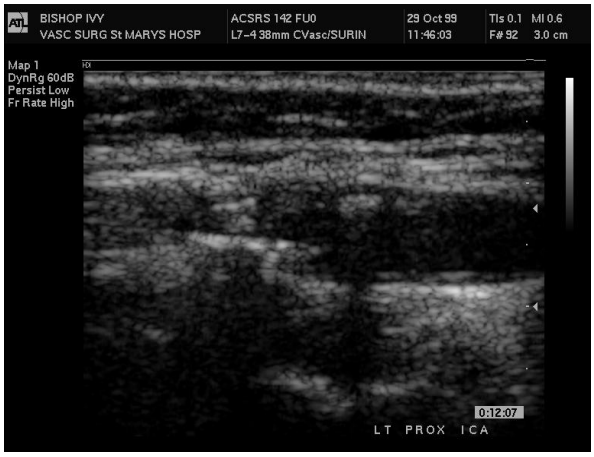
3. MATERIALS AND METHODS

3.1 Recording of ultrasound CCA plaque images

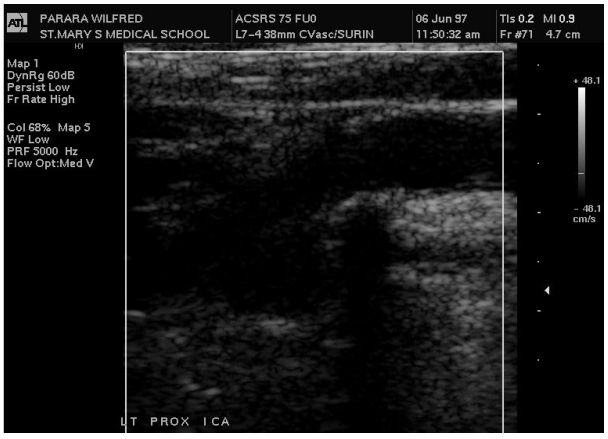
A total of 10 images of carotid artery is taken consisting of 5 asymptomatic and 5 symptomatic. Which are of B-mode longitudinal ultrasound images of the CCA bifurcation, taken by ATL HDI-3000 ultrasound scanner? These RGB images are converted
in to respective gray level in order to undergo further processing and analysis. These images were recorded digitally on a magneto optical drive with resolution of 768*576 pixels with 256 gray levels. As in our technique we are considering both asymptomatic and symptomatic patients, symptomatic images were recorded from patients at risks of atherosclerosis, or plaque in artery wall and asymptomatic images were taken from the patients at risk of atherosclerosis at absence of clinical symptoms. The digitalized images were resolution normalizedat 16.66 pixels/mm. This is done for maintaining the uniformity in the images and carried out due to the small variations in the number of pixels per mm of image depth (for certain plaques which are situated deep in the walls of the artery).

3.1.1 Original asymptomatic plaque in ultrasound images:

1.



2.



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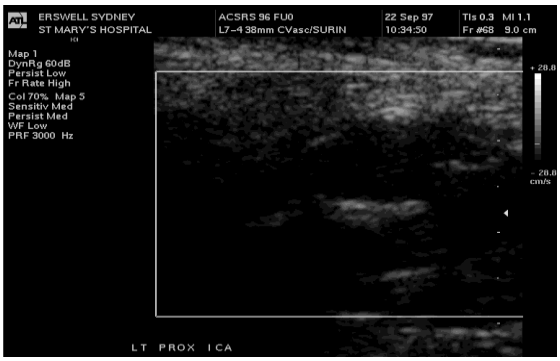
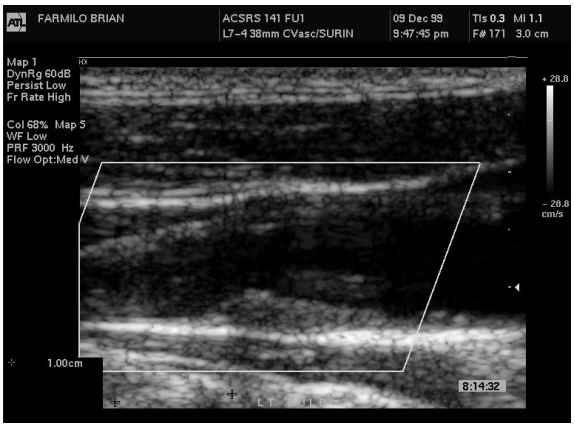


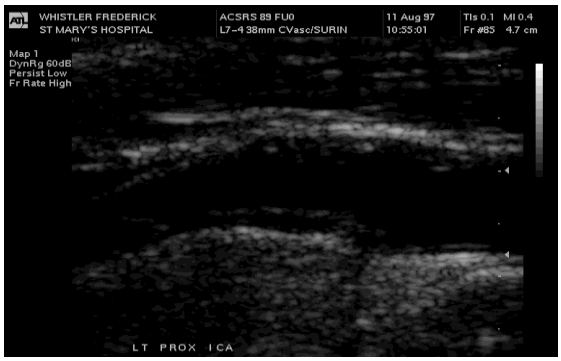
4.



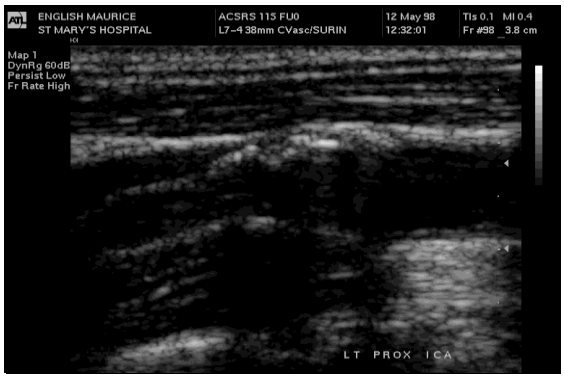
3.1.2 Original symptomatic plaques in ultrasound images:

1.

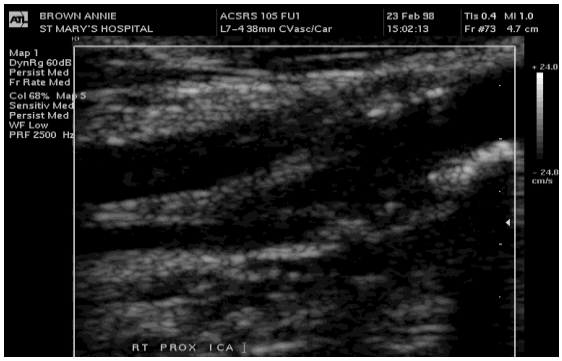
2.



3.



4.



3.2. Ultrasound image normalization

In these study brightness adjustments of the given ultrasound images were carried out. which improves the image compatibility by reducing the variability introduced by the different gain settings , different equipments and different operators and facilitates ultrasound tissue comparability. Linear adjustment of the images gives the algebraic scaling of the image manually. So that the median gray level value of the blood will be 0-5 and the median gray level value of the artery wall(adventitia) will be 180-190. The gray level

of images ranges from 0-255, i.e. a total of 266.thus the brightness of all pixels in the image was readjusted according to the linear scale defined by selecting the two reference regions. Further details about normalization will be discussed in the subsequent steps.

3.3. Manual segmentation and separation of plaque

An expert of neurovascular area manually delineated the 230 CCA plaque ultrasound images (5 symptomatic and 5 asymptomatic). The analyzed plaques were used for normalization, speckle reduction filtering , and texture feature extraction. The manual delineations were done by using the Mat lab software(Math Work, Natick, MA) from our group. the delineations were done between 1 and 2 cm proximal to the bifurcation of the CCA at the far wall over a distance of 1.5 cm starting at a point .5 cm and ending at a point 1.5 cm proximal to the carotid bifurcation. This bifurcation of CCA acts as a guide and stands as a reference for all the measurements and all measurements were taken from that region. Among this the plaque contours were taken for the texture analysis. The 230 CCA plaque were then automatically separated in three different equidistant components. The horizontal major axis of the segmented plaque were estimated and perpendicular lines (which starts from the left component of the plaque) were selected, at the 33% and 66% of the plaque horizontal major axis and thus separating the CCA plaque into three different components of equal major axis length of particular sizes. Among the three sections the middle component is used for the future texture analysis.

3.4. Texture Analysis

Texture analysis is a very useful method in image processing field. Especially in medical image processing were the naked eyes can't reach its vision is possible by taking images of the interior areas like blood vessels and view through the images taken by ultrasound scanning method and processed which will provide the required information regarding that area and analyzing the texture of the images will provide the sufficient data required for our studies or analysis. The texture provides the use full information of the characterization of plaque images in the CCA. In order to identify the texture properties extracted from the different plaque components, we go for a few properties through which we can identify the characteristics of the plaque present. Even though there are many properties are present to analyze such as (i) first order statistics,(ii) spatial gray level dependence matrices (SGLDM),(iii) gray level difference statistics (GLDS), (iv) neighborhood Gray tone Difference Matrix(NGTDM), (v)statistical Feature Matrix (SFM), (vi) Laws Texture Energy Measures (LTEM) (vii)Fractal Dimension method etc., we go only for the first method that is FIRST ORDER STATISTICS, in first order statistical method itself many features we can analyze. such as (a)mean, (b) variance, (c)median, (d)skewness, (e) kurtosis, (f) energy, (g) entropy etc. But we are concentrating only on Mean, variance, median, skewness, and kurtosis. Where,

3.4.1. Skewness and kurtosis

Kurtosis is a statistical measure that is used to describe the distribution, or skewness, of observed data around the mean, sometimes referred to as volatility of volatility. Kurtosis is used generally in the statistical field to describe trends in charts. Kurtosis can be present in the chart with fat tails and a low, even distribution, as well as be present in a chart with skinny tails and distribution concentrated toward the mean.
The skewness of a distribution is defined as

$$Y = [E(x-\mu)^3] / \sigma^3$$

The kurtosis of a distribution is defined as

$$Y = [E(x-\mu)^4] / \sigma^4$$

4. RESULTS

Figures illustrates a manually segmented asymptomatic and a symptomatic plaque from an ultrasound image of the CCA. The selected texture features (mean±IQR) extracted from the middle component of the plaques, that showed significant differences between the asymptomatic and symptomatic CCA plaques for the original and despeckledimages(- / -). The IQR values for each feature are given in parentheses (±IQR). The nonparametric Wilcoxon rank-sum test was performed between the asymptomatic and symptomatic despeckled CCA plaques and the p-values are given in the last column, showing statistical significant differences between the two different groups.

5. DISCUSSIONS AND CONCLUSIONS

In this the manual segmentations from carotid artery expert to perform texture analysis of the middle

component of the atherosclerotic carotid plaque in ultrasound Images in CCA . our objective in this study was to estimate the values of mean, median, standard deviation, variance, kurtosis, skewness i.e., first order statistics. The study showed that there are some texture features that might be used to classify the two different groups of subjectsaswell as to follow up the progression of the atherosclerosis disease. The investigation of this helps in decreasing the risk of stroke in symptomatic and asymptomatic subjects at risk of atherosclerosis. **5.**

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