

Digital processing of ultrasound images on dilated blood vessels from diabetic patients

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Abstract. Introduction Peripheral arterial disease (PAD) is a fairly common degenerative vascular condition in diabetic patients that leads to inadequate blood flow (BF), this disease is mainly due to atherosclerosis that causes chronic narrowing of arteries, which can precipitate acute thrombotic events. In patients with diabetes, atherosclerosis is the main reason for reducing life expectancy, as long as diabetic nephropathy and retinopathy are the largest contributors to end-stage renal disease and blindness, respectively. Objective This was an assessment of dilatation of the blood vessels on diabetic patients vs. healthy volunteers by using digital processing of imaging's. Materials and Methods The study subject was ultrasound imaging processing of blood vessels dilation on low extremities of diabetic patients, the results were compared with ultrasound images of healthy subjects. Results The digital images processing suggests that there is a significant difference among images experimental of the diabetic group and healthy volunteers' images, the control group. Discussion The digital imaging processing performed in the Matlab platform is an adequate procedure for blood vessels dilation analysis of the ultrasound images taken from the lower extremities in diabetic patients.

Keywords: Lower extremity, diabetic patients, images processing, magnetic field, patch

1. Introduction

Blood vessel dilation in humans is helpful in treating various medical conditions, including hypertension, preeclampsia and heart failure. Can blood vessels be dilated by using an external stimulus? It is known that, the walls of arteries impede the muscles from constricting and the walls from thinning, such blood to flow more easily throughout your arteries, reducing how hard your heart must work to pump, which in turn lowers your blood pressure.

Peripheral arterial disease (PAD) is a fairly common degenerative vascular condition in diabetic

patients that leads to inadequate blood flow (BF), PAD is due to atherosclerosis that causes chronic narrowing of arteries, which can precipitate acute thrombotic events. It is known that, this atherosclerotic condition often affects a large primary conduit artery and it can also be multilevel and diffuse, causing complex and generally more severe complications [1]. In patients with diabetes, atherosclerosis is the main reason for impaired life expectancy, and diabetic nephropathy and retinopathy are the largest contributors to end-stage renal disease and blindness, respectively [2]. One of the physiological consequences affecting up to half of diabetic patients is the progressive deterioration of the peripheral nervous system, resulting in spontaneous pain and eventually loss of sensory function, motor weakness, and organ dysfunctions [3]. Wang X et al., and Bek T showed

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that theretinal artery diameter decreases in diabetic patients [4–6].

On the other hand, circulating blood generates frictional forces, also known as shear stress, on the walls of blood vessels. These frictional forces critically regulate vascular function. The endothelium senses these frictional forces and, in response, releases various vasodilators that relax smooth muscle cells in a process termed flow-mediated dilatation. There is a study aimed to define the mechanisms of mechanical force or the shear stress transduction in the endothelium of intact arteries exposed to flow, and to address whether local cholinergic mechanisms provide a mechanochemical transduction pathway responsible for promoting flow-mediated dilatation [5].

There are several works that report great positive effects in cells behaviors that were undergone a sinusoidal magnetic field in their growth, then the aim of this study is to assess the dilatation of the peripheral vessels of the anterior and posterior tibial artery by using signal processing analysis performed in Matlab platform.

A digital imaging processing based on thresholding was performed; This is due to the fact that

thresholding methods can be made from a certain intensity in a pixel and thus segment the image into light and dark areas, which help to identify in a simpler way the way some regions of interest. (Sunil 2015, reviewing otsu's method for image thresholding).

The Canny detection method was used to determine the edges corresponding to the internal walls of the artery because it allowed detecting discontinuities in certain regions of the image, this method is the most efficient even in images that present noise. (Alang 2017, Global Canny algorithm based on Canny edge detector framework in magnetic resonance imaging).

2. Materials and methods

Test were conducted in two study groups: a) 30 diabetic patients with peripheral arterial disease in a range of age from 60 to 80 years and b) 30 healthy volunteers without any circulatory problems in a range of age from 18 to 30 years. Before individually study the patient artery, an ultrasound is performed on each blood vessel to measure the initial values of diameter and resistance of the tibial artery, anterior and posterior respectively. To make the measurement, the lower extremity of the patient is placed in the system of the Helmholtz coils, this one induces a magnetic field in a frequency range from 200 Hz to 400 Hz and magnetic field induction from 30 mT to 50 mT, the process is carried out for 60 minutes and the temperature is monitored each 15 minutes with a Fluke Ti400[®] thermal camera. When the stimulation therapy is ended on the lower extremity of the patient, a second ultrasound is performed in order to know the final values of the diameter and resistance of the artery, (see Fig. 1).

Complementing the measurements, a magnetic susceptibility patch similar to that of magnetite was

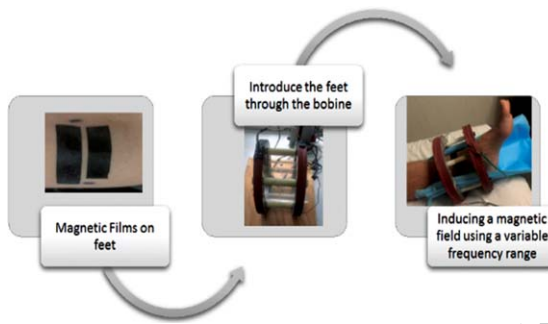


Fig. 1. Setup of the magnetic patch, Helmholtz coils system and the human low extremity in the stimulation system.



Fig. 2. Steps schematization in the imaging processing.

also used in this study. Once it is verified that the developed composite does not have a degree of cytotoxicity below 80%, it is possible to use them for

the intended medical application (arterial dilation in extremities of the human body).

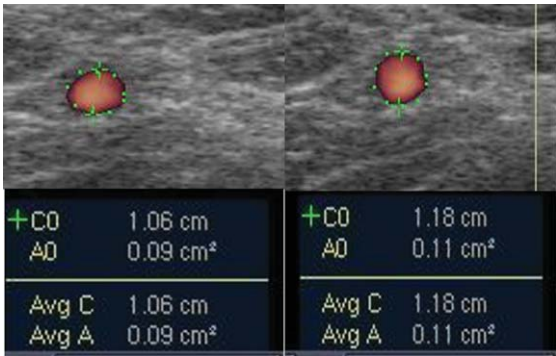


Fig. 3. The red area is of the left frame is smaller than the red section on the right size, this is due to one of the was made after magnetic stimulation and the other was acquired previous the evoked process.

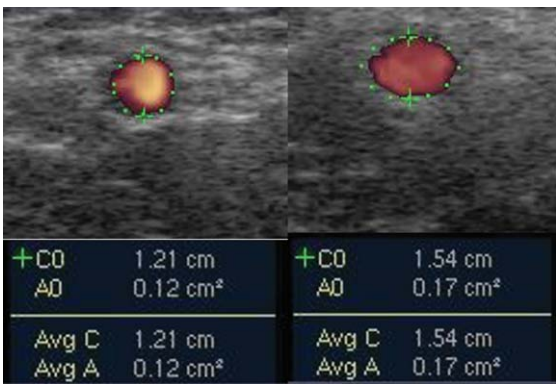


Fig. 4. The area in red, on left size, was acquired previous to magnetic stimulations therapy, as long as, on right size is the artery vessel in coronal cut after the treatment.

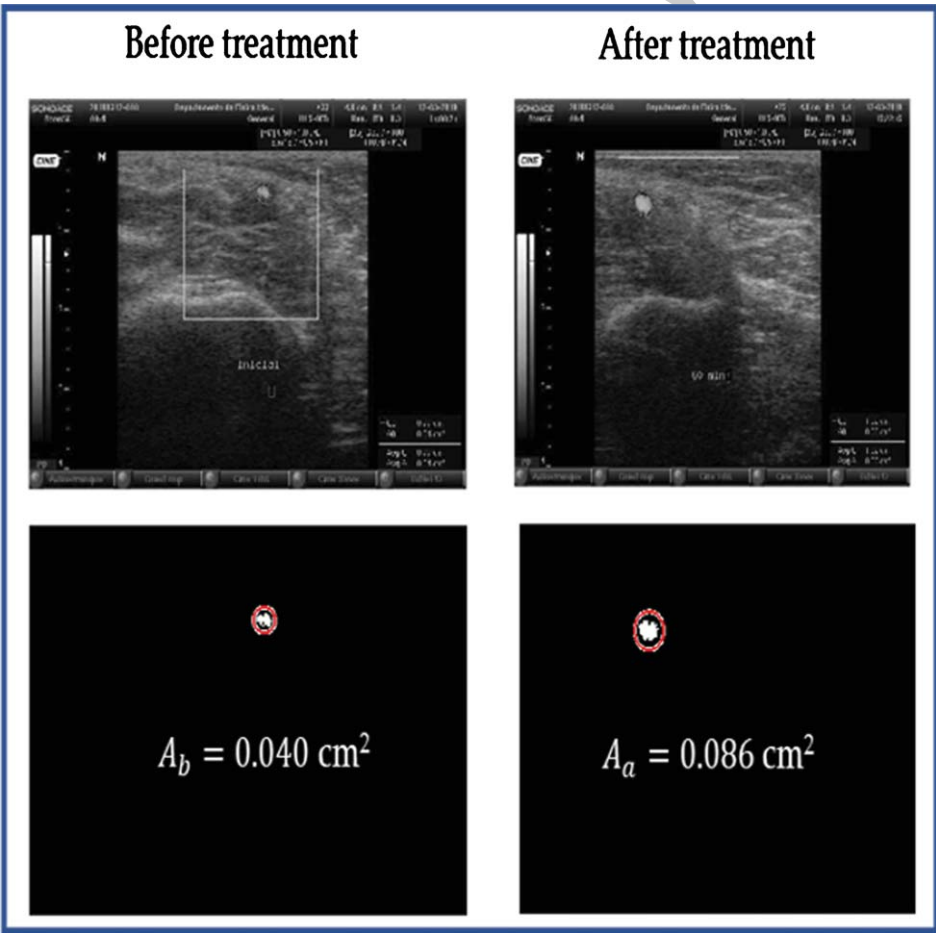


Fig. 5. It is shown the behavior of the transversal artery vessel before and after of the therapy in a female patient.

For the group of healthy volunteers, the same procedure was performed, however the measurements were performed by locating the brachial artery, in the upper limb, both groups undergo treatment in the same period of time and under the same conditions.

The realization of the image processing for comparing that was done before and after the treatment followed next methodology, see Fig. 2.

Each image obtained before and after the treatment undergo this methodology to obtain the distance between the internal walls of the artery (diameter) and compare its variation in the dimensions after the treatment.

3. Results

The volunteer subject tests were performed on 15 men and 15 women. Having as a result an arterial

dilation in men close to 72% and in women of 52%. The comparison of images obtained by means of a SONOACE 8000SE ultrasound before treatment and after treatment is shown below, see Fig. 3.

A female volunteer image is shown in Fig. 4, the dilation can be observed by using ultrasound images, a picture was acquired before and after a treatment, this is an evidence of the arterial dilation in the limb where the developed magnetic composite was placed and magnetic field was applied for an hour. The result is shown below in a male volunteer, who has a greater dilation.

These images taken from the ultrasound will apply the image processing on Matlab platform in order to obtain a more reliable result in terms of the area of the artery since with the ultrasound device the manual form is performed, so there is greater uncertainty about the arterial area.

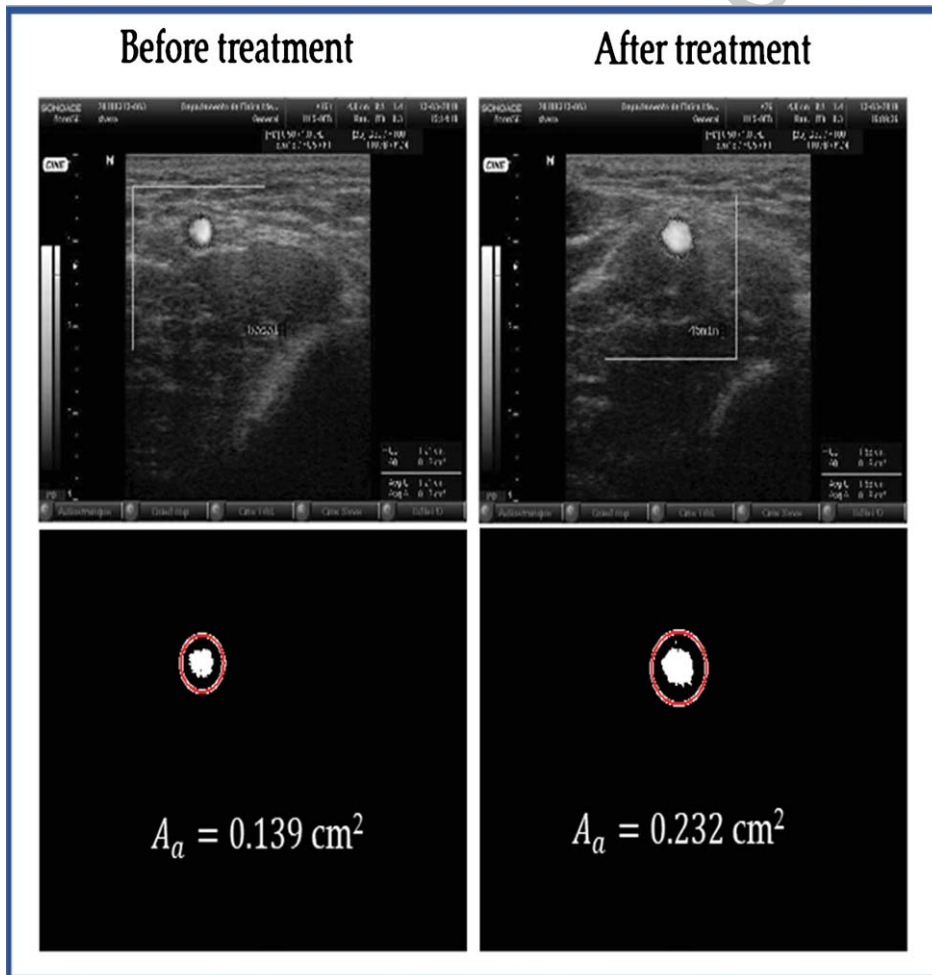


Fig. 6. It is shown the behavior of the transversal artery vessel before and after of the therapy for a male patient.

For the treatment of the original images extracted by ultrasound, the color red was isolated, because of it is the color of the blood. A thresholding method was applied to highlight the area of interest. After a mask was created to eliminate the elements that are not of interest, the area will finally be calculated from the characteristics of the image. There procedure and results are shown in Figs. 5 and 6.

Below is a table with the results before and after the applied treatment to diabetic people with peripheral arterial disease in Table 1.

An increase in the diameter of the blood vessel was observed in each of the patients, the effect of dilation was independent of gender, that is, there was an increase in the diameter of the stimulated artery of about 15%.

4. Discussion

The magnetic fields have side effects in the human system that still are not understand at all, there is controversial opinions about these effects, some of the is said that a positive result is found as long as other studies suggest that there is a not positive conclusion. This degenerative vascular disease is distributed more proximally than in the non-diabetic and is commonly associated with calcification of the vessel wall. The concept has thus grown up that the blood supply to the diabetic leg is impaired mainly because of oblit-

erative degenerative arterial disease (Ward JD). Bek T. et al, [7] showed that how diameter changes of retinal vessels contribute to the development of diabetic retinopathy and may be a marker of the prognosis of the disease.

Another microvascular abnormality has also been suggested—an increased flow through the arteriovenous shunts resulting in a reduced capillary flow (8–13). Ingemar Fredriksson et al, investigated the skin blood flow response to local heating (44 °C for 20 min) was assessed in 28 diabetic patients and 29 control subjects, the heat provocation increases the blood flow for velocities over 1 mm/s, whereas blood flow at lower velocities is unchanged, 2) the reduced perfusion increase after local heating that is observed in diabetic patients compared with control subjects is found for velocities 10 mm/s, and 3) a reduced low-velocity flow (1 mm/s) and increased mid-velocity flow (1–10 mm/s) are related to diabetes duration at baseline conditions.

This study is focused in the signal processing of ultrasound digital images and through this procedure is found that artery vessels has a drastic change when it is compared among ultrasound frames of a videos taken before and after a magnetic therapy where oscillate magnetic fields were applied on the lower limb of a diabetic patient where a magnetic patch was fixed in order to increase the effect.

5. Conclusions

The dilatation due magnetic stimulations were evident in the sixty subjects that undergone the magnetic stimulation, this was independent if they were or not diabetic patients. To date, there is no evidence of the side effects similar to the ionization radiation, so this study suggest that this therapy can be implemented in diabetic patients in order to restore the blood flow and in this way to save their body extremities and the tracking can be done through the digital processing of ultrasound images.

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Table 1

It is shown the diameter measurement previous and posterior the applied treatment

Patient	Before treatment	After treatment
1	1.5	1.97
2	1.7	1.85
3	1.49	1.98
4	2.06	2.18
5	1.86	1.92
6	2.21	2.53
7	2	2.23
8	1.23	1.25
9	2.2	2.8
10	2.1	2.4
11	1.64	2.03
12	1.42	1.69
13	1.96	2.28
14	1.95	2.15
15	1.75	1.97
16	2.66	3.26
17	2.24	2.4
18	1.25	1.39
19	1.69	1.89
20	1.08	1.33
21	1.85	1.94
22	1.57	1.73

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