Study of the Blood Flow average for Atherosclerosis using Ultrasound Doppler shift

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Abstract. Atherosclerosis is a condition that affects the walls of arteries repeatedly; blood vessel blockage caused by atherosclerosis is a frequent cause of heart attack and stroke. The use of Doppler change, a recent advancement in ultrasound technology, would improve its function by improving accuracy. Blood flow measurement is crucial because it can aid in the early detection of many diseases. One of these diseases is atherosclerosis, which has been researched using the ultrasound Doppler scattering method to measure blood flow average velocity in the dorsal artery of the foot. The study's findings revealed that age and diabetes had a greater impact than other factors such as medical history, high blood pressure, and triglycerides.

Key word: Blood flow average, Doppler shift, ultrasound techniques, Factors of atherosclerosis, Piezoelectric (transduce probe), Variance.

1. Introduction

Arteriosclerosis is a general term for a number of conditions in which the artery wall thickens and becomes less elastic. Doppler ultrasound is a non-invasive way of measuring blood flow. The Doppler shift [2] is used to determine the technique. A Doppler ultrasound supply is a device that is used to measure blood flow. It's also used in studies and clinical trials to measure the scope and impact of arterial disease [3]. Another technique named laser Doppler flow-me try (LDF) is a technique for determining microvascular blood perfusion. The term "Doppler" describes the frequency change that occurs as light is dispersed by moving red blood cells. The fundamentals of LDF theory are based on this fundamental principle [4]. Dr. Dussik at the University of Vienna wrote the first paper on medical imaging ultrasound in 1942. This article detailed the transmission ultrasound of the brain as well as a number of studies in the field of medical ultrasound [5]. In Doppler image scanning, a linear probe with a frequency of more than 5 MHz is needed for research and development [6, 9]. Many of the first breakthroughs were made at Japan's Osaka University and the United States' University of Washington. Doppler ultrasound technology has supported clinical applications of blood-flow sensing, waveform analysis, blood-flow localization, and two-dimensional (2-D) mapping of blood flow through a series of steps. [10] The aims in this work to Study of the effect on blood flow by Doppler shift in Ibn Al-Nafees Hospital for Heart Patients and taking samples from patients with atherosclerosis.
aged between 35-90 years and taking ultrasound examination for them and using statistical analysis to analyses the data for blood flow average

2. Blood flow techniques

There are a variety of techniques for visualizing and quantifying blood flow average rate, as well as measuring blood flow and volume. Blood flow measurement is crucial because it can aid in the early detection of a variety of diseases. Blood flow can be measured in a variety of ways and classified into different categories. By combining the Doppler-shifted wave with an original frequency reference wave, a beat frequency that is much lower than either of the two constituent waves is produced, making it much easier to calculate. This beat frequency is exactly equal to the frequency change caused by the Doppler Effect since it equals the difference between the two frequencies. The relationship between frequency change and relative velocity of source and detector is given by [11].

\[
\Delta f' - f = \frac{v}{c-v} f
\]

(1)

Where \( f \) represents the transmitted frequency, \( f' \) represents the received shifted frequency, \( v \) represents the relative velocity between the source and the detector, and \( c \) represents the wave's velocity. In the case of light waves, \( c \) is the speed of light, which is normally much higher than the speeds being measured, so (1) can be approximated as [12]

\[
\Delta f' - f = \frac{v}{c} \Delta \nu
\]

(2)

As a result, when the Doppler shifted light is mixed with a reference beam of the original frequency, the frequency shift, and thus the frequency when the Doppler shifted light is mixed with a reference beam of the original frequency, is proportional to the velocity being measured in research and clinical investigations. Doppler ultrasound is used to assess blood average velocity and flow, as well as to quantify the range and effect of arterial disease [13]. Doppler ultrasound is a non-invasive test that produces photographs of blood vessels, tissues, and organs using high-frequency sound waves. [14].

\[
\Delta F_D = 2 \nu (\cos \theta) \frac{f_{o}}{c}
\]

(3)

Where, \( \Delta F_D \) = the difference in received and transmitted ultrasound is called change Doppler frequency or frequency.

\( f_o \): Ultrasound probe frequency (Hz); transmitted signal frequency.

\( v \): The blood flow velocity of the target.

3. Statistical analyses

The statistical test that determined not a single value is representative the entire distribution. Its goal is to give a complete picture of the data. It usually refers to the arithmetic mean when used without an adjective (as mean).

\[
Mean = \frac{\sum x}{n}
\]

(4)

Where \( \sum x \) is the number of observations in the sample (sample size), is the summation, is the individual value, and \( n \) is the number of observations in the sample (sample size) [15].

The Normal distribution is a set of curves described by two parameters: the population's mean and standard deviation. The standard deviation is a summary measure of the deviations between each observation and the mean.
The following formula calculates the variance:

\[
\text{Variance} = \frac{\sum (x - \overline{x})^2}{n-1}
\]  

(5)

Finally, the standard deviation is calculated using the square root of the variance [16]:

\[
\text{SD} = \sqrt{\frac{\sum (x - \overline{x})^2}{n-1}}
\]  

(6)

4. Materials and Methods

When an electric current passes through the probe ingredient, it has the potential to generate ultrasound signal waves. Piezoelectric (PE) influence is the name for this process. Figure 1 shows the basic components of an ultrasound probe, which are made of crystal, rubber, and lead zirconate titanate, which is the most commonly used ingredient.

**Figure 1:** Shown the probe and component of ultrasound Doppler
The probe sends ultrasound energy into the foot, specifically the Dorslis pedis tissue, or into samples, and then receives the reflected signal echoes, which can then be converted into images on a computer monitor using an ultrasound device.

Probing device selection
Because of the morphological features and position (depth) of the carotid artery, a high-frequency linear array probe is commonly used for artery ultrasonography. The probe must have a center frequency of at least 7 MHz.
In a Doppler ultrasound unit, choose probe linear L12-4 (Model Philips 2019).

4.1 Patients
This research was carried out at the Ibn Al-Naphed Hospital in Baghdad, Iraq. The experimental procedure complies with the concepts of medical and biological detection.
 Patients were also divided into two groups, with 9 females and 21 males ranging in age from 35 to 90.
By using a randomized approach, we were able to work with a total of 50 healthy and 30 Atherosclerosis patients, all of whom were clinically normal, 29 female and 21 male, and ranged in age from 20 to 69 years old.
The patient is asked to have a comprehensive medical history, the length of the US technique test, and any family history of disease. Patients' biomedical factors, such as diabetes, total cholesterol, and blood pressure, are assessed as part of their diagnostic workup.
While atherosclerosis can strike anyone at any age, it is more prevalent in people over 45. The exact cause of the disease is unknown.
Atherosclerosis has two forms of risk factors: those that can be monitored or modified and those that cannot.
The following are some of the changeable risk factors for this disease:
- Tobacco use and secondhand smoke are also harmful to your health.
- Blood pressure that is too high (hypertension)
- Cholesterol and fat levels in the blood are abnormal.
- Diabetes is a medical condition that affects
- Heart disease is a serious condition.
- Obesity is a problem that affects many people.
- Daily exercise is lacking.

Other risk factors that cannot be adjusted include:
- Age is a factor.
- gender (male/female)
- stress

5. Results
According the producer of ultrasound techniques (US) and Doppler shift Measurements in hospital. Though our study, cases were taken of 92 people, 50 cases are normal and patients were determining the blood flow average about 42 cases. As shown in table (1) the blood flow of velocity from normal range (30-118) (cm/s), the statistically was calculated in eq.(4) and (6) with variance using Doppler scattering shift in Ultrasound techniques by the value as shown in table (1) the mean of blood flow was different between the two study subgroups.
The mean of blood flow of average velocity for healthy or normal was 57.596 cm/s but Atherosclerosis patients 41.49667 cm/s.
Table (1) explain the clinically normal or healthy were ages from (12-69) years old and the disease (35-90).

| subgroup | age(years)   | Blood flow average velocity(cm/s) | fo(HZ) |
|----------|--------------|-----------------------------------|--------|
| healthy  | 12-69        | 50.06                             | 57.626 |
| range    |              | 17.12                             |        |
| Mean     |              | 13.12922                          | 2.30339|
| SD       |              |                                   |        |

| subgroup | age(years)   | Blood flow average velocity(cm/s) | fo(HZ) |
|----------|--------------|-----------------------------------|--------|
| patient  | 35-90        | 61.21951                          | 17.60976|
| range    | (-149) to (+118) | 35.53415  |        |
| Mean     |              | 11.40285                          | 45.67128|
| SD       |              | 1.145043                          |        |

The effect of others risk on Atherosclerosis wasn’t appeared in US technique using Doppler shift with range source sound 14-27Hz see fig.2.
Figure 2: Explain the factors and the stronger effect is Diabetes in Atherosclerosis

The effect of age and diabetes is stronger to Atherosclerosis patient has age 90 years at blood flow -149 cm/s and notes some persons were negative sign average velocity when received the signal from transducer prob.

Compare the other factors such medical history, LPL and high pressure were weak effect. The effect of diabetes, as shown in fig.2, was more powerful than the other effects.

Figure 3: Explain the effect of age on the average blood flow for patients

Figure 4: The effect of diabetics on the blood flow for disease
6. Conclusions

Ultrasound methods were used to measure average blood flow with the Doppler shift in this article. The benefit of the instrument is that it is non-invasive and can detect and easy by using Doppler shift to diagnosis Atherosclerosis early in the medical diagnosis process in dorsalis pedis artery. Calculated Doppler shift has a benefit, and some details can be as follows:

1) The average blood flow is used to measure the factors of for atherosclerosis
2) The effect of factors on Atherosclerosis is distinguished for various distributions between healthy and sick people.
3) Statistical data analysis was a mathematical tool for separating various variables in the early detection of atherosclerosis.
4) the advantage of US technique was distinguish of the effect of age and diabetes together on atherosclerosis and the values of blood flow were negative indicated the backscattering accorded with growing age and duration of Diabetes
5) Blood flow is inadequate in the affected arterioles. Because The walls thicken, narrowing the arterioles especially in the capillary of arteries is blocked. This condition is more common in diabetics.
6) the technique couldn’t distinguish the influence of other biomedical factors on atherosclerosis such as medical history , ,LPL, and high pressure hypertension(stress/strain)

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