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Detection of Blood Flow Obstruction through Piezoelectric Method in Healthy and Obsessed Subjects

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Abstract

Objectives: This study involves the measurement of obstructions in the blood flow of an arterial system. An attempt is made to find the correlation between the pressure and flow of the blood. **Methods:** The obstructed area produces vascular sounds which are acquired through disturbed blood flow patterns. The measurements are carried over by audio frequency analysis of the sound observed during arterial stenosis. These sounds can be measured using piezoelectric film sensor by placing it in the wrist and mid arm in the blood flow path. **Results:**The sounds that initiate in the narrowed arteries is measured by non-invasive, sensitive piezoelectric film sensor that captures the vibration caused by the flow of blood inside arteries and generate appropriate waveform for different flow conditions. **Conclusion:** The waveforms are analyzed in spectrum analyzer and compared with the normal flow patterns and if the values deviate from normal it is concluded for occlusion or clot that happened in the blood flow passage.

Keywords: Arterial Stenosis, Blood Flow, Occlusion, Piezoelectric Film Sensor

1. Introduction

A complete obstruction to blood flow (no flow) is called artesia. A narrowing that causes an obstruction to blood flow is called stenosis[1]. There are two ways to detect the blood flow obstruction in the body namely invasive and non-invasive methods. Blood is pumped out from the heart during each cardiac cycle via arteries at considerably high pressure. The blood vessels occlude by the turbulence caused at pressure fluctuation. This disturbance produces a measurable sound known as ejection murmurs. These murmurs are generally high-frequency sounds that can be heard and measured along the body surface covering a frequency range of 250-1000 Hz. The sounds can be heard over the brachial artery occurred due to coronary occlusions. This pathological condition exists when the narrowing of arteries exceeds 75% of the normal area. Such cases involving obstruction with the blood flow can be diagnosed using spectral analysis. Recent researches show that detection of blood turbulence associated with the measured acoustics can differentiate patients with the normal subjects thus aiming at improving the performance of the patient's clinically[2,3].

There are two different methods to measure the turbulence produced in the blood vessel. The first method involves the nonlinear analysis of third-order auto covariance and time reversal which are calculated to identify blood flow turbulences. This method was found less complex on comparing the values obtained against a substituted data having similar power spectra. The analysis depicted that the values obtained by third-order auto covariance were significantly different from the proxy data of the subjects, but only when the artery was partially narrowed and turbulent blood flow was present but this

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method is not so sensitive when subsequently used and when occlusion is minimum[4]. Several methods like ultrasonic Doppler, flowmetry, optical methods etc. have been used to find the obstruction in the blood vessels[5–14].

PPG-based methods for non invasive and continuous blood pressure measurement for monitoring of hypertensive patients to timely prevent cardiovascular problems and precisely regulate anti-hypertension cures. Blood pressure can be only measured through either cuff-based or invasive instruments that cannot be continuously used due to their characteristics[15].

To overcome the above said disadvantages the sensor-based systems are developed[16] and integrated with computer-based health care systems which aim at supporting continuous and remote monitoring of assisted livings. The main objective is to develop a non-invasive, low cost method to find the blood flow obstruction by acquiring the mechanical vibration by placing a piezoelectric sensor in wrist arm and mid arm.

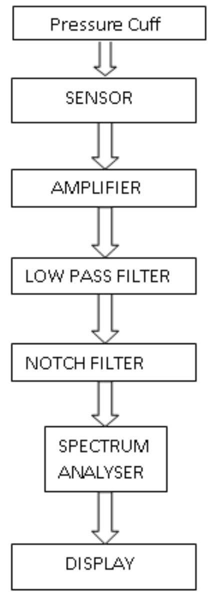

Figure 1. Work flow process of the proposed blood flow obstruction system.

2. Proposed System

In this paper, the authors intended to measure the acoustical vibration caused by the flow of blood in human arterial system through major blood vessels such as brachial artery which is close to the heart. As a first step, the piezoelectric film sensor is used to pick up the vibration along the blood vessel by placing the sensor and wrapping it around the wrist tightly. Its response is too sensitive to the low level mechanical actions and it has an electrostatic shield placed on both sides of the element to reduce power line interferences (50/60 Hz), response in the low frequency range from 0.7 to 12 Hz. A multipurpose sensor is used for the detection of physical parameters like vibration which is the required phenomena for the non invasive method. The piezo electric film sensor is laminated into sheets that convert force into electrical signal. The obtained signal is processed further connecting to a circuit or a monitoring device. The output voltage is analyzed to detect whether the arterial blood vessel has normal flow patterns or has certain stenosis.

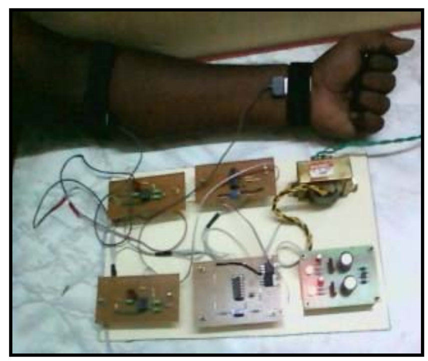

Figure 2. Experimental setup of the blood flow obstruction system before applying the pressure.

3. Methodology

The procedure followed is depicted in Figure 1. Pressure cuff is used here to apply pressure in the upper arm to cause inflation and deflation to create occlusion by reducing the blood flow. The photograph of the proposed

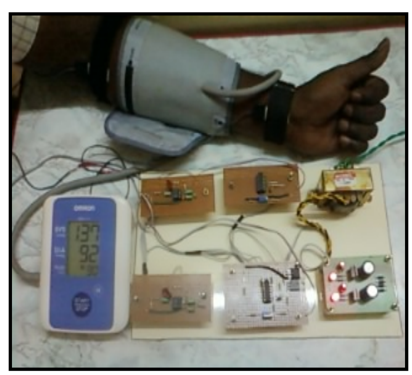

Figure 3. Experimental setup of the blood flow obstruction system after applying the pressure.

system before and after applying pressure is shown in Figure 2 and Figure 3. Piezoelectric sensor is used to pick up vibration caused by the blood flow due to difference in pressure applied. The output voltage obtained from the sensor is in the milli volt range therefore an amplifier part is required to get desired output. Low pass filter of 0.5-100 Hz frequency is designed according to the blood flow range. Notch filter is designed to remove power line interference from the mains. The obtained signal is given to spectrum analyzer to measure the difference between normal and abnormal blood flow patterns and is analyzed and the results are displayed.

4. Results

In this work there are two types of observation has been made:

- Before applying the cuff pressure between the two sensor.
- After applying the cuff pressure between the two sensor.

5. Signals from Sensor

The signals obtained in oscilloscope as picked up from the peizo sensor placed at wrist and mid-arm respectively as shown in Figure 4 and Figure 5. From the Figure 6 it is inferred that there is a difference in the waveform observed from the signals obtained from the sensor due to the pressure applied in the cuff. By applying the pressure, the cuff is inflated so the blood flow passage is narrowed which causes a change in frequency. Two sensors placed at the mid-arm and wrist pick up the vibrations caused

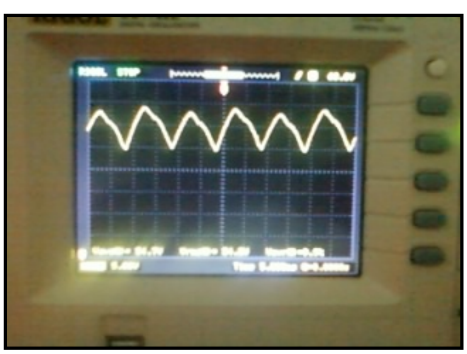

Figure 4. Plethysmogrphic signal captured from the wrist position before applying the pressure of the blood flow obstruction system.

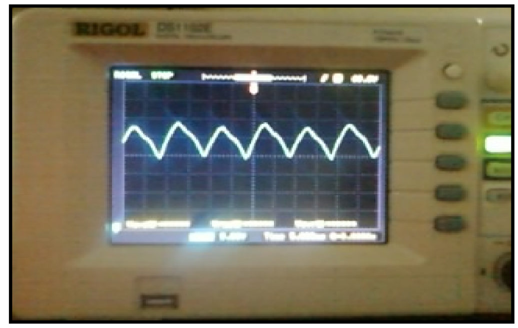

Figure 5. Plethysmogrphic signal captured from the mid arm position before applying the pressure of the blood flow obstruction system.

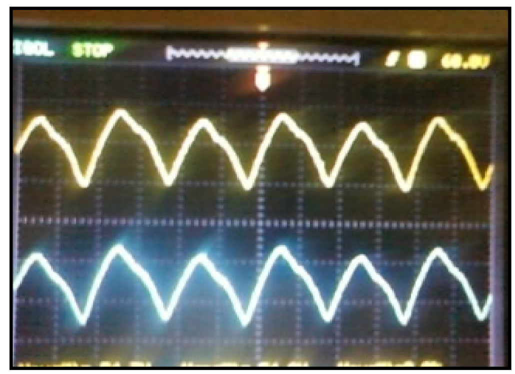

Figure 6 . Plethysmogrphic signals captured from the wrist and mid arm position before applying the pressure of the blood flow obstruction system.

by the blood flow at their respective places and further difference between both the signals are computed from that it can be concluded that there is a block in blood flow passage.

6. Before Applying Pressure in the Cuff

There is significant variation in the blood flow in wrist and mid-arm for each subject by observing the Tables 1 and 2. The changes were seen in voltage and frequency while taking the readings and by measuring the blood pressure using BP monitor both frequency and velocity were high in mid arm when compared to wrist position, Since blood flowing to the wrist area is less. With the frequency and voltage information at wrist and the mid-arm we can predict whether there is obstruction in the blood vessel.

Table 1. Before applying pressure in the cuff

Parameters	Subject 1		Subject 2		Subject 3	
	Wrist	Mid-Arm	Wrist	Mid-Arm	Wrist	Mid-Arm
Vmax(v)	6.04	6.16	5.76	5.80	6.40	6.44
Vmin(v)	5.04	5.12	4.80	4.92	5.32	5.44
Risetime(ms)	3.00	3.80	3.00	3.20	3.40	3.80
Fall time(ms)	4.20	4.60	3.8	3.80	2.80	3.00
Vavg(v)	5.58	5.72	5.35	5.42	5.97	6.04
Vrms(v)	5.59	5.73	5.36	5.43	5.97	6.04
Vamp(mv)	767	932	738	868	869	947
Freq(Hz)	100	104.2	102	104	100	104.2

Parameters	Subject 4		Subject 5		Subject 6	
	Wrist	Mid-Arm	Wrist	Mid-Arm	Wrist	Mid-Arm
Vmax(v)	5.72	5.80	6.28	6.36	5.92	6.00
Vmin(v)	4.80	4.84	5.24	5.36	4.92	5.00
Risetime(ms)	3.00	3.80	2.20	3.00	2.40	2.40
Fall time(ms)	4.60	4.60	3.60	5.40	3.40	3.60
Vavg(v)	5.29	5.38	5.84	5.93	5.49	5.56
Vrms(v)	5.30	5.39	5.85	5.93	5.49	5.56
Vamp(mv)	793	851	758	872	760	763
Freq(Hz)	96.15	100	94.34	96.15	96.15	96.15

Table 2. After applying pressure in the cuff

Parameters	Subject 1		Subject 2		Subject 3	
	Wrist	Mid-Arm	Wrist	Mid-Arm	Wrist	Mid-Arm
Vmax(v)	6.28	6.36	5.72	5.80	6.28	6.36
Vmin(v)	5.36	5.36	4.76	4.86	5.36	5.36
Risetime(ms)	2.200	3.000	2.600	3.000	2.200	3.000
Fall time(ms)	3.600	5.400	4.200	4.800	3.600	5.400
Vavg(v)	5.84	5.93	5.33	5.38	5.84	5.93
Vrms(v)	5.85	5.93	5.33	5.38	5.85	5.93
Vamp(mv)	758	872	754	825	758	872
Freq(Hz)	94.34	96.15	96.15	100.4	94.34	96.15

Parameters	Subject 4		Subject 5		Subject 6	
	Wrist	Mid-Arm	Wrist	Mid-Arm	Wrist	Mid-Arm
Vmax(v)	5.44	5.48	5.82	5.90	6.00	6.08
Vmin(v)	3.41	3.56	4.78	4.82	5.08	5.14
Risetime(ms)	1.80	2.60	2.80	3.00	3.80	3.8
Fall time(ms)	2.20	3.00	3.60	5.20	4.2	5.0
Vavg(v)	4.80	4.89	5.64	5.73	5.65	5.72
Vrms(v)	4.82	4.91	5.55	5.73	5.66	5.73
Vamp(mv)	562	776	724	738	886	956
Freq(Hz)	91.3	95.12	96.15	97.96	100	104.2

7. Conclusion

A non-invasive and a low cost method for finding the blood flow obstruction in the arm by the piezo electric sensor produced satisfactory results by measuring frequency and voltage information for different subjects at wrist and the mid-arm. From the results it is found that the developed system is capable to predict the block in the blood vessel.

8. Acknowledgement

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