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The Smart Blood Pressure Measuring System with the Help of Ultrasound (BP.P)

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ABSTRACT

Hypertension is a common disease. In order to treat and prevent its complications there is a need to control blood pressure precisely. Nowadays, so many mercury, gnomon, and digital measuring devices are being used to measure blood pressure, which, in a way. All of them may possess the possibility of imperfection. In this research, we will study the measurement of blood pressure into artery by Ultrasound (Ultrasound pressure system). By using these devices, we will be able to control blood pressure of patients, through expending lower expenditure. In additions, we will be able to prevent dangerous complications of non-precise control of blood pressure. And also we can minimize the extend of current measuring imperfection.

KEYWORDS: High blood pressure, Ultrasound, Transducer, BP.P.

INTRODUCTION

The researchers have indicated that cardiovascular disease in causes more than 50% of mortalities in the western countries[1]. There are one billion persons patients in the world who are affected by high blood pressure. And four million persons are being died each year due to direct blood pressure cause. Furthermore, blood pressure is one of the important causes of heart attacks and cerebral apoplexies. There are about 62% brain blood vessels disease and 49% heart Isckimic related to blood pressure (systole blood pressure is more than 115 mm mercury).

Everyday too many people are dying due to increasing epidemical blood pressure disease. And it indicates a serious alert concerning this silent disease. During recent years statistics have indicated that blood pressure is the first cause of mortality among non-epidemic diseases until 2025 there will be about 1.2 billion persons affected to blood pressure diseases [2].It is worth noting that the number of patients affected to blood pressure diseases in the developed counties in more than those of developing countries. (37.3 % in developed countries, 29.4% in developing countries).

The reason for this is that because of absolute number of people affected by blood pressure in the developing countries, the extent of blood pressure diseases in the developing countries is more than those of the developed countries. This reason not only contributes to increase the number of people affected to the disease, but also it contribute to affecting people of those countries to cardiovascular and heart disease in lower ages.

In addition Hypertension or blood pressure, equal or higher than 140/40 is one of the most common epidemic vascular and heart diseases, especially in oldery people [3].

Inappropriate treatment or non-treatment of the diseases led to increase in vascular and heart diseases. As a result extent of heart attack, brain stroke, congestive heart disease and chronic lung diseases have dramatically increased, which all of those would lead to increase in mortalities [4,5].

Furthermore, due to higher epidemical aspect of the disease (30% in people higher than 20 years old, 66% in people older than 65 years and 90% for people more than 80 years old) it coasted high treatment price in different societies [6,7].Blood pressure is one of the important vital signs measurement of blood pressure gives us an important information about one's health.

Blood pressure has two minimum or maximum levels. During heart contraction blood enters into artery, as a result, blood pressure level reaches to its maximum capacity, which is called systole blood pressure.

However during resting or sleeping it does not happen. As blood evicts from arteries gradually and enters into capillaries blood pressure reduces and reaches to minimum level which is called blood pressure systole.

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In only case blood pressure is measured off two systole and diastole levels. The measurement number of these two levels is shown as mmHg. Extent of systole blood pressure or bigger number is on the numerator and the extent of diastole blood pressure in on denominator of a fraction as 138/86 mmHg. According to 7th Joint national committee report for prevention, recognition, analysis and treatment of higher blood pressure (JNC7).

In new classification for people aged 18 or higher indicates that natural blood pressure lower than 120/80 mmHg, pre higher blood pressure 120-139/80-89, higher first degree blood pressure 140-90/159-99and higher second degree blood pressure 100/160 mmHg.(table 1).

In this table, the extent of blood pressure is considered without any other dangerous elements and diseases.

Table1. Classification of blood pressure according to JNC7

Blood pressure	Nature blood pressure	Pre higher blood pressure	Higher degree blood pressure (1)	Higher degree blood pressure (2)
Systole b-p according to mmHg	Less than 120	120-139	140-159	160 and higher
Diastole b-p according to mmHg	Less than 80	80-89	90-99	100 and higher

Measurement of blood pressure is carried out by pressure measurement devices. The available blood pressure devices are in different types, as follows: all out manually (which includes cuff inflation and listening to sound pulse done by patient) the other one is automatic (which is carried out by pushing on a button that shows the number of blood pressure to patient.)

This last type in usually used in arm, wrist and finger. Popularity of usage of this method is due to simplicity and low cast of that. In this respect, some studies, carried out by so many patients, indicates that 24% to 60% of patient preferred this method. However, this method has its own failure, including lack of patient's access to medical doctors and his or hers instructions during measurement of blood pressure and non-ability of patients in emergency conditions [8,9,10].As a result different devices were designed to overcome those disadvantages. In Ultrasound technique, the possibility for carrying out non harmful and direct method to measure diameter of peripheral arteries, such as carotid artery has been provided. In recent year as a result of teqnogical progress, achieved in manufacturing Ultrasound b.p.m devices and designation of all kinds of wave radiators and, usage of these devices for diagnostic and therapeutic purposes has been dramatically raised[11].Waves, radiated by this device are in fact a sort of Ultrasound wave, which reaches to tissues [12]. Taking into account that accurate measuring of arteries, lead to possibilities of appropriate pathology in initial phases of patient's disease. Some researchers have suggested different mathematical and automatically methods to determine measure of arty diameter so that it indicates the tightness of walls of arties in pathological condition [13,14].

Ultrasound reflections, originated from body's tissues which are seen as a B-mode picture would from a tissue model which characterized photographic tissue which was examined [15].Measurement of blood pressure by Ultrasound waves, using transducer, would transfer material, existed in air, into the body. When Doppler beams target a designated blood artery, Doppler is able to illustrate and analyze movement of blood cells inside vessel. In addition, it shows their frequency and speed.

MATERIALS AND PROCEDURES

There are so many different blood pressure measuring devices in markets. These are in forms of mercury, gnomon, digital wrist and arm blood pressure measuring devices. The best kind of blood pressure measuring devices are mercury and gnomon ones which are less available for ordinary people. These are usually used by medicine doctors and specialists. Using these devices needs special qualification. On the other hand digital blood pressure measuring devices are more available in markets, at reasonable prices and with simple usage.

Kinds of blood pressure measuring devices

1. Mercuryblood pressure measuring device:

In this device blood pressure monitor is made by mercury. It has a metallic compartment, vertical graded platform which is graded according to mercury mm (10 mercury mm).There is a glass compartment at the pipe which is filled by mercury. The extent of blood pressure can be determined by the number of mercury level in graded platform. These kinds of blood pressure measuring devices are made in accordance with guidelines and standards of British Hypertension.

2. Gnomon blood pressure measuring device:

In these kinds of b.p.m device instead of mercury compartment and glass pipe, a sort of gnomon b.p.m is used. This device works, using a spring and the reaming parts of is like mercury one.

The utility of this model is light, small and simply potable. Whoever it should be periodically regulated and calebrized. It has standard certification of CE and U.S.A food and drug organization.

3. Digital BP.M device:

Digital BPM device operate in accordance with oscillator meter method. Oscillator metric methods are being used in long-term measurement and occasionally in cynical cases. Blood pressure measurement used in this method is like those of audited methods. But it has pressure sensors (transducer) which recognize blood circulation and it operates in audited methods instead of medical stethoscope. Pressure sensor (transducer) in fact is an organized electronical device which shows blood pressure figure. This kind of blood pressure measuring device possess WHO standard certification.

The diagnostic Ultrasound Doppler effect is used to illustrate non-harmful flow of blood and body's structure. When bath sonication of a moving body is reflecting, frequency of reflected beam will be different from the initial one [16,17].Doppler effect provides unique to measure blood flow by Ultrasound [18,19]. Accordingly using an Ultrasound beam, reflected signal of blood possesses information about speed and direction of blood flow. Nowadays, blood flow measurement is used to assess location of blood vessels and function of specific tissues. In addition Doppler Ultrasonic devices would provide instant blood pressure flow velocity measurement. It is worth nothing that by combining of these instruments (Plused-Refexive ones).

We are able to measure instant flow rate of blood vessel as a function of time and heart by using Ultrasound non-harmfully. We assume that an Ultrasound beam is hopped with a blood vessel and makes a relative angle$\theta$of blood flow. Dissemination direction of an Ultrasound with frequency f with a blood vessel makes an angle θ along with relative speed of V . Accordingly blood flow in blood vessel has same speed. Reflective signals have Doppler shifting. It is worth nothing that Doppler frequency shifting is fd frequency of Ultrasound beam f and it could be obtained from following relation:

$$f\mathrm{d}=\frac{2\,v\cos\theta}{c}\quad[1,1]$$

In this relation speed c is the Ultrasound speed in blood and it is usually equal f 1540 m/s.

Doppler shifting frequency for blood flow speed in human being vessels and Ultrasound frequency is 1 – 15 KHz, which within auditory range [20,21,22].Doppler device can analyze movement of globules inside blood vessel and illustrate their frequency and speed. Number of Doppler frequency changes, existing in signal, depends on velocity scatterer dissemination of blood vessels, which in fact is up to heart itself. Due to the fact that heart is a pump long with two parts of systolic and diastolic, the maximum rate of blood flow occurs during systole the minimum one happens during diastole.

In this connection, in larger blood vessels, movement of red globules may accurses close to vessels wall hardly, while movement of globules encounters any resistance near central part of vessel. In fact narrowed areas in arteries create strong spray of blood flow rate which would cause big changes in Doppler frequency. Behind of stricture of blood vessels, there some eddy currents that are confused and inverted. Natural flow provides narrow range of speeds, using a layer, which the most of blood globules are with a velocity inside it. So they have smaller bar area. Increasing flow of blood tracks in a narrow place creates a larger range of speeds, which as a result, it widens spectrum.

In Doppler sample which located immediately after the stricture, a vast range of frequencies will be illustrated. In order to obtain blood we can use Doppler effect. Red blood globules operate as Ultrasound scattered place. To obtain a useful Doppler signal, from diagnostic point of view, transducer should be located in the angle 60-30 degree toward direction of flow. In this connection it is worth nothing that an angle greater than 60 degree would cause changing of frequency very little, while an angle smaller than 30 degree, due to more length of way, would cause decreasing of a group of beams.

When a group of Doppler beams are targeted against a specific blood vessel. Passing red would scatter Ultrasound beam. After this phase a part of scattered signal would return to transducer, which will be a vast range of frequencies. The reason for this phenomenon is due to the fact that red globules are morning in vessels with different speeds [16,17]. In this method transducer would dispatch waves with frequency, approximately 10 MHz, without using tissue. And on the other hand diastolic beams would decrease in their return movement.

Ultrasound waves transducer

Transducer is a signal-element in which Doppler method is combined with an array of multi-element. Ultrasound transducer converts electrical energy in to mechanical energy (Ultrasound) and vice versa [16,17]. In

addition transducer operates on the basis of piezoelectric, principle, i.e electric pressure [23]. It produces a voltage by being pressurized. Piezoelectric crystals have positive and negative charge that are called two poles. When piezoelectric is stimulated electrically, crystal would expand toward its short axis. On the other hand, if electric current is revised, crystal will contract. If electric current fluctuates, having high frequency, crystal will contract and expand periodically, bearing the same frequency. In such a procedure, crystal acts exactly like an accurate proboscis loud speaker. And such an Ultrasound mechanical movement would be produced, bearing the same electrical current frequency.

In fact an Ultrasound transducer would return an electrical message into mechanical movement. In a way that it causes Ultrasound and the revise is also possible. Collision of Ultrasound with a suitable crystalic materials, transforms energy compaction and elongation into expansion and contraction of crystal. In return it would create an oscillating electrical message. Transducer pole is made of piezoelectric crystal or transducer element. Too many crystalline materials such as Quartz, Nyvabat, Lithium, Sulphate and Ceramic materials such as Zirconate, Titanate (PZT), Barium Titanate, Lead Mtanyuabat are used. It is worth nothing that these crystals are not piezoelectric naturally. They have bearing grown in very accurate condition. In addition they would be ready by a strong electric filed, having high temperature, in a way which crystal texture is perpendicular to major crystal axis. As a result it would produce a wafer-like object that behind of it electrodes are placed on bolt surfaces. Some of crystals produce an electrical pulse when they are pressurized mechanically. Furthermore, they give a periodical voltage to piezoelectric crystal in a way that it would fluctuate and make them to produce high frequency waves (supersonic) [15,16].

RESULTS

In this research the samples are chosen at random. In order to study those samples 93 patients (69 women i.e 75% and 23 men i.e 25%) aged 13-52 years old, were examined during morning (7-10 a.m). These patients were affected with systolic blood pressure and diastolic blood pressure disease in sit-down manner. The test was done in a clinical center by mercury, gnomon, wrist, arm and digital blood pressure measuring devices which all of them has German Riester mercury b.p.m device, German Presisa N b.p.m and German arm wrist, arm digital b.p.m standard certification. The time of test for mercury and pointer b.p.m devices was 2 minutes, that of wrist, arm digital b.p.m device was 5 minutes for each test.

Table2. Comparative study of failure percentage of b.p.m devices

All kinds of blood pressure measuring devices	69 women (75%) systole and diastole (mmHg) pressure failure	23 men (25%) systole and diastole (mmHg) pressure
Mercury b.p.m	± 3 mmHg	± 3 mmHg
Pointer b.p.m	± 3 mmHg	± 3 mmHg
Wrist digital b.p.m device	± 9 mmHg	± 9 mmHg
Arm digital b.p.m device	± 8 mmHg	± 8 mmHg

According to the above mentioned research, illustrated in the table 2, it has been indicate that mercury b.p.m device has the minimum failure percentage. It should be noted that those test was done by Ultrasound b.p.m.d. In this connection, average failure of systole pressure, using mercury b.p.m device was 1.1 ± 11.3 and average failure of diastole b.p was 1.1 ± 7.5.

Table3. Comparative study of failure percentage of mercury and Ultrasound b.p.m.d.

All kinds of b.p.m.d	69 women (75%) systole and diastole (mmHg) failure percentage	23 men (25%) systole and diastole b.p.m.d failure percentage
Mercury b.p.m.d.	± 3 mmHg	± 3 mmHg
Ultrasound b.p.m.d.	± 1 mmHg	± 1 mmHg

According to the research, shown in the above table, Ultrasound b.p.m.d. had the minimum failure percentage among all kinds of b.p.m. devices.

CONCLUSION

Nowadays, too different blood pressure measurement devices (mercury, gnomon and digital) are being used, all of which have their own fault. For example due to some peripheral elements (talking, voice, movement of

objects, etc.) it is possible that Korotkoff voice cannot be heard from stethoscope very well or medical doctors or nurses evict weather very fast as a result of which the result would be mistake. Stethoscope analyzes movement of globules inside vessel. Reflection scattered signal frequencies to transducer are red, due to different movement of globules. Ultrasound waves are sent to body through setting. Transducer, in order to evict weather between head's skin and transducer, by using material such as jell, water and oil.

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