

A REVIEW ON DIFFERENT BLOOD PRESSURE MEASURING METHODS

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Abstract: Blood pressure is the process which involves circulation of blood through the walls of arteries and veins. The process of measuring the blood pressure includes many techniques such as invasive and non-invasive. Current trends in research are towards many non-invasive methods for measuring blood pressure that includes wearable watch. The present wearable device supports in measuring the blood pressure and pulse rate without using the cuff. In this paper we made a review on different types of blood pressure measuring or monitoring techniques. This includes invasive and non-invasive methods for blood pressure measurement. Non-invasive blood pressure measurement includes cuff and cuff-less measurement. While invasive method is used for continues monitoring of blood pressure in Intensive Care Unit and other operating theatres.

Keywords— *Blood pressure, cuff and cuff-less, invasive, non-invasive, wearable device*

1. INTRODUCTION

Human blood is the mixture of liquid and solid whereas the liquid consists of plasma made of water, salts, protein and solid contains red blood cells (RBC) and white blood cells (WBC) along with platelets. Blood flow is the metabolic function that happens due to the transfer of carbon dioxide, oxygen and glucose to and from body tissues. This is expressed in terms of volume of blood per unit time. Hence the blood pressure is termed as the force of blood that flows through artery walls. Systolic phase and diastolic phase are the two parameters of blood pressure. The rate of pressure during contraction of muscles is systolic pressure and the rate of pressure during relaxation of muscles is diastolic pressure. The two methods measuring the blood pressure (BP) is by invasive and non-invasive methods. In invasive method the pressure of the arterial is directly measured by inserting a cannula needle on to the artery [1]. Non-invasive methods include the cuff wrapped around the upper arm for the intermittent

monitoring and the values are obtained by hearing to the Korotkoff sound [2]. During BP measurement using cuff, patient may feel uncomfortable and this type of measurement is not suitable for continues BP monitoring, cuff-less BP monitoring instruments are introduced in which BP is measured by calculating PTT (Pulse Transit Time) using sensors. For a normal reading, the BP readings are between 80 and 120 for systolic pressure and between 60 and 80 for diastolic pressure. The readings are taken in unit of mmHg. Normally we consider blood pressure to be within the normal range when both systolic and diastolic numbers are in these ranges [3]. The abnormal condition of BP results in Hypertension (BP>180/120mmHg) and Hypotension (BP<90/60mmHg)

The calculation part on blood circulatory system and relation between heart and pulse rate of animals was introduced by William Harvey in early 1600. Horse was the first animal on which the blood pressure is calculated in the year 1773 by Reverend Stephen Hales. He made a long inserting glass tube that could measure BP and was placed upright into artery of horse. In 1881 the standard BP measuring device Sphygmomanometer was invented by Samuel Siegfried Karl Ritter von Basch. In 1896 the device was further upgraded by Scipione Riva-Rocci. This device included a cuff that was wrapped or affixed around the arm for providing the pressure to limb. Till 1905, no modern devices were introduced. Later the difference between systolic and diastolic pressure was given by Dr. Nikolai Korotkoff, the first sound observed is known as Korotkoff sound which is named after scientist.

2. METHODS

2.1 INTRA-ARTERIAL BLOOD PRESSURE MONITORING

A commonly used technique to continuously monitor BP in health care sectors is invasive blood pressure or intra-arterial BP (IBP) monitoring. Invasive BP measurement is the method in which BP is directly

measured from artery. This can be measured by placing a cannula needle in a suitable artery. One of the advantages in using Invasive BP monitoring in hospitals is to measure continuously without any discomfort to the patient. This measured BP is displayed on the patient care unit display. Invasive blood pressure measurement can be used in the ICU and monitoring unit.

The main components in this measurement are a measuring apparatus, a transducer and a monitor. The measuring apparatus consists of a cannula connected to tubing containing column of saline which conducts the pressure wave to the transducer. A transducer with flexible diaphragm is used in intra-arterial monitoring which is connected to piezoelectric sensor. As more pressure is applied to the diaphragm, it deforms and stretches the electro-mechanical element present in diaphragm; electrical output of the system will be altered as the resistance changes. Monitors are used to display the results of BP measurement in digital form.

2.2 AUSCULTATORY METHOD

Auscultatory method of BP measuring uses Sphygmomanometer to measure systolic and diastolic pressure. The Sphygmomanometer can be classified as three types [4]. First is the mercury sphygmomanometer in which the liquid element used for measurement is mercury. Second is the Aneroid sphygmomanometer, also a type of mercury sphygmomanometer. Thirdly, the Digital Sphygmomanometer which measures the BP in a digital manner which is easy to observe. The subject must be in seated position, the arm must be in relaxed state and the subject must not move while measuring BP. For more accurate readings subject's arm should be at his heart level.

2.3 PALPATORY METHOD

Palpatory method of BP measurement measures only systolic pressure. This method is similar to auscultatory method of BP measurement, in which a standard cuff is applied on upper arm about 4cm above the elbow joint, and then the cuff is inflated until the radial pulse cannot be heard or felt. As in auscultatory method here also the cuff pressure is released slowly and note down the point at which radial pulse can be felt again. This point is known as systolic pressure [5].

2.4 RHEOGRAPHIC METHOD

Rheography is a method used to detect the filling of blood in particular body part, and this method can graphically record the resistance changes or fluctuations in that part of body.

In this method four electrodes are used to measure the fluctuations in resistance for blood flow in arteries. The impedance of blood flow is calculated by rheographic method, from which one can evaluate the pulse rate. Once the pulse rate is calculated systolic and diastolic pressure can be evaluated.

2.5 PHOTO-ELECTRIC PLETHYSMOGRAPH

This method uses photo-detector to measure the BP non-invasively and is similar to the rheographic method. Plethysmography is commonly used to calculate cutaneous blood flow in the veins, which can be used to calculate BP of the subject. The rate of change in blood volume in area of earlobe or fingertip and other peripheral area can be used for indication of magnitude of systolic pressure in artery. This quantity will be measured in each cardiac cycle to make the readings more accurate [6].

2.6 ULTRASOUND SCANNING METHOD

Ultrasound method needs to apply a small amount of gel to make good contact with human skin. This method is able to visualize the blood flow and blood vessel wall motion, which can be used to derive blood pressure by means of mathematical modeling. This can also visualize the variation in blood pressure results of heart beat. The motion of the blood vessel walls or change in pressure on walls of blood vessels is detected using a Doppler sensor at different parts of occlusion. Once the signal hits wall and rebounded, the signal will be captured by a receiving crystal and processed. The frequency distribution between 40Hz-500Hz and the velocity of the blood vessel walls are proportional to each other.

2.7 MAGNETOPLETHYSMOGRAM PULSIMETER

This is a cuff-less method for measuring blood pressure in which a wearable wrist Magnetoplethysmogram (MPG) pulsimeter is used which involves a Hall sensor to sense the magnetic field fluctuations due to rate of flow of blood in artery. This pulsimeter consist of a permanent magnet

attached to silicon covering at the center of a radial artery. This technique is currently under development in which the accuracy of the MPG is still being measured [7].

2.8 A CHEST BASED CONTINUOUS CUFF-LESS BLOOD PRESSURE METHOD

BP can be measured based on Pulse Arrival Time (PAT). This PAT measurement requires two measurements, one is to time reference and another is to obtain time delay. PAT can be obtained using multiple sensors placed on the body. Electrocardiogram and Photoplethysmogram are commonly used signals recorded from a patient's body. This includes 5 different PAT readings using bio-impedance at shoulder. Sensor is placed on the patient's chest which is more suitable for ambulatory measurement systems [8].

3 DISCUSSION

Currently the blood pressure is measured by smartwatch-based measurement tool accurately. This technique involves capturing of light reflected by hemoglobin in blood under the skin. This method predicted systolic, diastolic, pulse pressure with 95% of accuracy compare to standard BP measuring device.

Blood Pressure Tele-monitoring (BPT) is introduced recently which is a telemedicine strategy to send the BP of self-measured patient's information to health care sectors. This method results in improved BP control compare to usual care without tele-monitoring.

Invasive blood pressure monitoring gives an accurate blood pressure reading. This method is used for close BP measuring for a long period of time, like in intensive care unit or other operation units. This method is not suitable for daily BP measurement or for homebased monitoring. Sphygmomanometer is the standard for BP measurement. It is durable, easy to use, doesn't requires readjustments. But it also has some disadvantages, it may be bulky to carry, the mercury filled in sphygmomanometer may be hazardous, the readings must be taken at eye level. Also, it may feel uneasy to patients while measuring. On the other hand, the cuff-less BP measurement techniques introduced recently are more convenient, easy to carry and can be measured repeatedly. On the basis of these references we came up with a new idea to calculate the BP using piezoelectric sensor. A wearable band is wrapped around the wrist to place

the sensor near radial artery, in which the systolic and diastolic pressure is calculated and displayed.

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