Blood pressure and pulse measurement - a survey

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ABSTRACT
Monitoring the Blood pressure and pulse are the vital parameters for any human being and particularly for the cardiac patients. Worldwide there have been many research works have been carried out in measuring the blood pressure and pulse in the precise manner by using many measurable methods in order to diagnose the cardiac patient by the physician. The existing methods namely Non-invasive and invasive methods have been effectively used for measuring the blood pressure and pulse. The objective of this paper is to survey different methods like Mercury sphygmomanometer, aneroid sphygmomanometer, Oscillometric manometer and invasive method to measure the arterial blood pressure and pulse. The comparative analysis have also been done to analyze and conclude the merits and demerits of each measurement procedure. From the analysis, it is inferred that Oscillometric algorithm using least square analysis has got an edge over other methods in terms of accuracy and cost effectiveness.

KEYWORDS: Blood pressure, Non-invasive and invasive methods, Oscillometric manometer, pulse, sphygmomanometer.

INTRODUCTION
Biomedical Instrumentation is the branch of science developed by the joint effort of the engineer and the physician. It provides the tools to measure the physiological variables and parameters known as biometrics. It is a unique field of medicine with the adaptations of widely used physical measurements. Living Human being like complex black boxes with in that can be found hydraulic, pneumatic, thermal, acoustical, and electrical and many other types of systems, all are interacting with one another. To find the input-output relationship in the complex system is deterministic to an engineer. The most important thing is variables to be measured are not easily and readily accessible to measuring devices. Clinical instrumentation is devoted to the diagnosis, care and treatment of patient where as research instrumentation is the new knowledge pertaining to various systems related to human being. Biomedical instrumentation employed can be divided in two categories namely in vivo and in vitro. In vivo method, one that made on or within the living organism itself. In vitro method, observations performed outside the body of living organism, it relates to the function of body.
II. Literature survey:

<table>
<thead>
<tr>
<th>Publication</th>
<th>Author</th>
<th>Year</th>
<th>Title</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>NIH Public Access Author Manuscript Crit Care Med</td>
<td>La-wei H. Lehman, Mohammed Saeed, Daniel Talmon, Roger Mark, and Atul Malhotra</td>
<td>2013</td>
<td>Methods of Blood Pressure Measurement in the ICU</td>
<td>The author suggested that clinically significant discrepancies were observed between invasive and noninvasive oscillometric methods in measuring systolic blood pressure during hypotension.</td>
</tr>
<tr>
<td>The journal of clinical Hypertension, vol.15, iss.11</td>
<td>Sigdurdur R. Elíasdóttir, Sandra D. Steinthorsdóttir, Olafur S. Indridason, Runolfur Palsson, Vidar O. Edwardsson,</td>
<td>2013</td>
<td>Comparison of Aneroid and Oscillometric Blood Pressure Measurements in Children</td>
<td>The author proposed some ideas behind the BP levels of children and the backbone of critical illness</td>
</tr>
<tr>
<td>Arch Pediatr Adolesc Med</td>
<td>Park MK, Menard SW, Yuan C.</td>
<td>2001</td>
<td>Comparison of auscultatory and oscillometric blood pressures.</td>
<td>The author concludes oscillometric method is preferred for home BP measurement</td>
</tr>
<tr>
<td>SunTech Medical Publications/online ebook</td>
<td>Kenneth Andersen</td>
<td>2013</td>
<td>10 STEPS TO ACCURATE MANUAL BLOOD PRESSURE MEASUREMENT</td>
<td>The author proposed 10 steps for measuring Blood Pressure</td>
</tr>
</tbody>
</table>

III. Motivation for measuring blood pressure:

As part of this survey, measured pulse and blood pressure manually and automatically. Although these tests appear simple, accurate measurements depend on many factors. This section of the paper has been devised to help understand how to obtain these measurements accurately and the sources of error that can occur. The accurate measurement and control of blood pressure are key elements in the prevention of cardiovascular disease and stroke. Pulse is the rhythmic expansion and contraction of an artery caused by the impact of blood pumped by the heart. The pulse can be felt with the fingers at different pulse pressure points throughout the body and heard through a listening device called a stethoscope. Arterial blood pressure is the force exerted by the blood on the wall of a blood vessel as the heart pumps. Systolic blood pressure is the degree of force when the heart is pumping. The diastolic blood pressure is the degree of force when the hearts relaxed[1,2]. Risk of illness and death are related to changes in blood pressure. The following table: 1 shows the standardized readings of blood pressure for the adults.

<table>
<thead>
<tr>
<th>Blood Pressure category</th>
<th>Systolic Blood Pressure (mmHg)</th>
<th>Diastolic Blood Pressure (mmHg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypotension (low pressure)</td>
<td>&lt;90</td>
<td>&lt;60</td>
</tr>
<tr>
<td>Normal</td>
<td>90-119</td>
<td>And 60-79</td>
</tr>
<tr>
<td>Pre hypertension</td>
<td>120-139</td>
<td>Or 80-89</td>
</tr>
<tr>
<td>Hypertension (stage 1)</td>
<td>140-159</td>
<td>Or 90-99</td>
</tr>
<tr>
<td>Hypertension (stage 2)</td>
<td>160-179</td>
<td>100-109</td>
</tr>
<tr>
<td>Hypertension (stage 3)</td>
<td>180-199</td>
<td>110-119</td>
</tr>
<tr>
<td>Hypertension (stage 4)</td>
<td>&gt;200</td>
<td>&gt;120</td>
</tr>
</tbody>
</table>

Blood pressure is measured by auscultation of Korotkoff’s sound in the manual method. In automated blood pressure measurement, the Korotkoff’s sound is recorded by using a microphone directly or by using oscillometric analysis of pressure pulses in the cuff indirectly. The measurement accuracy depends on the characteristics of different measuring devices used, patient condition and the environmental situations. Blood pressure monitoring in the ICU, in a clinical purpose or general practice mainly depends the measuring devices operated manually. Automated tools are useful for patient self monitoring purpose.

IV. Measuring arterial blood pressure:

In the measurement procedure a cuff is wrapped around a person's upper arm or wrist with an inflatable rubber bag inside the cuff. Enough air pressure is pumped into the cuff to close the artery. Air pressure is then released by opening the thumb valve. When the pressure in the cuff is equal to the pressure on the artery, the artery opens and the blood begins to return to the part of the artery that was closed. As the blood returns to the artery, pulse sounds begin. These sounds can be heard through a stethoscope placed over the brachial pulse point. The sounds continue for a time while the cuff is deflated slowly, eventually becoming too faint to hear.
The cuff is connected by tubing to a manometer, which shows the amount of pressure on the artery. When the first pulse sounds are heard, the reading on the manometer measures the systolic blood pressure. The last sound heard is the diastolic blood pressure.

V. Analysis of various measuring methods:

Among the widespread conditions in the world facing the healthcare system globally is Hypertension (High Blood Pressure). Two different methods used by the physicians to diagnose hypertension.

5.1. Invasive Blood pressure measurement:

Invasive blood pressure (IBP) measurement, intra-arterial catheter is used to measure the blood pressure[1]. This technique is applicable only in the hospital with the trained physicians[3].

![Blood pressure measurement](image)

Fig. 1: Classification of various methods for measuring hypertension

5.2. Non-invasive Blood pressure measurement:

Non-invasive blood pressure measurement, based on cuff occlusion. The automated Blood pressure measurement devices based on NIBP measurement. The auscultatory and oscillometric devices estimate blood pressure with the mathematical algorithms constructed using statistical data of the patients physiological parameters[3]. Blood pressure is measured by occluding a major artery in the upper arm with an external pneumatic cuff. When the pressure in the cuff is higher than the blood pressure inside the artery, the artery collapses. As the pressure in the external cuff is slowly decreased by venting through a bleed valve, cuff pressure drops below systolic blood pressure, and blood will begin to spurt through the artery. These spurts cause the artery in the cuffed region to expand with each pulse and also cause the famous characteristic sounds called Korotkoff sounds. The pressure in the cuff when blood first passes through the cuffed region of the artery is an estimate of systolic pressure. The pressure in the cuff when blood first starts to flow continuously is an estimate of diastolic pressure. There are several ways to detect pulsatile blood flow as the cuff is deflated: palpation, auscultation over the artery with a stethoscope to hear the Korotkoff sounds, and recording cuff pressure oscillations. These correspond to the three main techniques for measuring blood pressure using a cuff.

5.1.1. Mercury sphygmomanometer:

- The mercury sphygmomanometer is the device which has seen the longest use for indirect measurement of blood pressure. The mercury sphygmomanometer has been the first choice for blood pressure measurement for many decades, a fact symbolized by the use of millimeters of mercury (mmHg). The mercury sphygmomanometer is gradually disappearing from clinical use. Mercury-free blood pressure measuring devices (when clinically validated) are generally reliable substitutes for mercury-containing sphygmomanometer in routine clinical practice. Other mercury column as the universal units for recording blood pressure, whatever the device.

- The mercury manometer is calibrated when it is manufactured and, once calibrated, recalibration is unnecessary. However, regular inspection is necessary to eliminate conditions that could cause the blood pressure measurement to be read as erroneously high or low. The level of mercury in the calibrated glass tube should always be at the zero line when the manometer is on a level surface with the inflation system disconnected. If the level of mercury is above or below the zero line, the cause may be too much mercury in the reservoir, mercury leak, or dirt in the mercury or in the calibrated glass tube. Tip the manometer gently to the right and then back to the erect position. If the top of the mercury column does not return to zero, replace the...
equipment. If the shape of the mercury meniscus (top of the column of mercury) is not a smooth, well-defined curve, replace the equipment. This is also caused by dirt in the mercury or the glass tube. If the mercury does not rise easily in the tube, or if the mercury column bounces noticeably as the valve is closed, replace the equipment. The atmospheric pressure within the tube has been altered.

5.1.2. Aneroid sphygmomanometer:
- A variety of auscultatory devices use other means of measuring the pressure inside the cuff. Aneroid manometers, which contain no fluid, work by a system of bellows and/or levers which move a pointer on a dial. Electronic devices measure the pressure in the cuff with an electrical transducer. They display the pressure in a readout, which can simulate a mercury column, an aneroid gauge, or simply display a number.
- A similar range of devices automate detection of the Korotkoff sounds, so that the operator does not need to listen. These automated auscultatory devices can, in principle, use any of the pressure sensing methods, but all have a microphone, electronic circuitry, and a display to indicate when the sounds are registering. Most commonly, the operator has to record the indicated pressure when a light begins flashing (for systolic pressure) and then again when it stops flashing (for diastolic). These devices are mainly used at present for patients with an irregular heartbeat, for whom other modern methods are unsuitable, and for measuring blood pressure during exercise.

5.1.3. Oscillometric measurement:
The oscillometric method relies on finding of variations in pressure oscillations due to arterial wall movement beneath an occluding cuff. Empirically derived algorithms are employed, which calculate systolic, mean arterial and diastolic blood pressure.
- The main alternative is the oscillometric technique, so-called because it detects changes or oscillations in the pulsation of the artery as the cuff is pressurized and depressurized. This method also appears in many automated devices, including ones which feature automated inflation and deflation of the cuff, and are especially suitable for home use and for 24-hour ambulatory monitoring. Some devices operate from the wrist or even the finger instead of the arm[4].
- The oscillometric technique does not yield systolic and diastolic pressures directly. The oscillations or vibrations of the artery which happen as the cuff pressure is increased or decreased reach a maximum at the mean arterial pressure. The incorporated electronics convert this recording of pressure waves into a readout of systolic and diastolic pressures, according to a computation which is specific to each model of the device.[5,6].
- Oscillometric measurement requires less skill than the auscultatory technique and may be suitable for use by untrained staff and for automated patient home monitoring. As for the auscultatory technique it is important that the cuff size is appropriate for the arm.
- The cuff is inflated to a pressure initially in excess of the systolic arterial pressure and then reduced to below diastolic pressure over a period of about 30 seconds. When blood flow is nil (cuff pressure exceeding systolic pressure) or unimpeded (cuff pressure below diastolic pressure), cuff pressure will be essentially constant.[7,8]. When blood flow is present, but restricted, the cuff pressure, which is monitored by the pressure sensor, will vary periodically in synchrony with the cyclic expansion and contraction of the brachial artery.[9,10]
- Over the deflation period, the recorded pressure waveform forms a signal known as the cuff deflation curve. A band pass filter is utilized to extract the oscillometric pulses from the cuff deflation curve. Over the deflation period, the extracted oscillometric pulses form a signal known as the oscillometric waveform (OMW)[11,12]. The amplitude of the oscillometric pulses increases to a maximum and then decreases with further deflation. A variety of analysis algorithms can be employed in order to estimate the systolic, diastolic, and mean arterial pressure. The following Table :2 shows the various methods of oscillometric blood pressure measurement and their advantages and disadvantages[13,14].
Oscillometric measurement devices use an electronic pressure sensor with a numerical readout of blood pressure. Oscillometric method records and evaluates the oscillations of the arteries. Those oscillations have a very typical curve. The oscillations occur when the blood flow first is interrupted and then starts flowing again. They become stronger, than diminish until they disappear when the blood starts flowing normally.

**VI. Novelty:**

BP must be measured in a consistent approach using a appropriately validate, well maintain and recently calibrated screen. Use the average BP from several visits when estimate cardiovascular risk in mild hypertension. Semi automatic and automatic oscillometric devices are now the commonest method for BP measurement and are suitable for home BP measurement[10]. Indirect methods of blood pressure measurement usually requires the patient not to be physically active during measurement procedure, otherwise it brings a significant errors into measurements. Besides indirect measurements could not be done continuously for a long time. It only could be repeated at certain time intervals,[11]. The amalgamation of the latest suitable telecommunication means (GPRS ) with new algorithms and solutions for automatic real-time, cost-effective diagnosis and ease of use can make the oscillometric measurement is useful for remote monitoring for BP.

**Conclusions:**

Nevertheless, specifying a valid method for extracting systolic and diastolic pressures from the envelope of cuff pressure oscillations remains an open problem. Here is projected a mathematical model incorporating anatomy, physiology, and biomechanics of arteries that predicts cuff pressure oscillations produced during noninvasive measurements of blood pressure using the oscillometric method using least square analysis. Accepting the primary mechanisms leads to a model-based algorithm for deducing systolic and diastolic pressures accurately from cuff pressure oscillations in the presence of varying arterial stiffness or varying pulse pressure.

**REFERENCES**