EXPLORATORY PROJECT

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Low cost blood pressure monitor device for developing countries

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Introduction:

One of the biggest disputes in the government right now concerns the astronomical deficit generated primarily by health care. The United States spent more than $2.3 trillion on health care in 2008 according to the Kaiser Family Foundation, and it does not appear to be slowing down anytime soon . In addition to tightening the reins on wasteful spending and changing health insurance policies, it is necessary to find innovative new solutions to these very expensive problems. Luckily, the investigation for low cost solutions can be greatly beneficial for people in developing nations who face similar problems with excessive spending. Mortality for countries at different income levels by cause Global health care needs vary largely with the income level of the country so it is difficult to generalize what the biggest problems are worldwide. Consistently, countries with lower incomes have higher mortality rates; however the most fatal disorders differ with income level. For developing countries, high blood pressure is the leading cause of death . While it may be challenging to combat the causes of death directly, identifying the risks appropriately and dealing with those problems will have a large impact on preventable. Healthcare costs due to blood pressure problems have been estimated to be upwards of $370 billion or 10% of the world's healthcare expenditures in 2001. Over a 10-year period, suboptimal blood pressure has been predicted to cost nearly $1 trillion globally with indirect costs reaching $3.6 trillion annually . High blood pressure incurs costs far beyond that of the medication used to combat it. Hypertension often leads to more complicated conditions such as heart disease which may demand expensive treatment or surgery. In developing countries, very few people are even screened for suboptimal blood pressure. This is due to the downfalls in the design of the devices currently available, and the amount of training that is often required to operate them. One example of a disorder that is receiving a lot of press and funding recently is preeclampsia. Preeclampsia occurs during pregnancy and the postpartum period, and can have negative effects on both the mother and the unborn child. It is the second largest killer of pregnant women; characterized by proteinuria, and hypertension. After onset, there is typically damage to the mother's liver, kidneys, and endothelium in addition to vasoconstrictive factors being released which account for the increase in blood pressure. Preeclampsia refers to a set of symptoms rather than an underlying cause, which makes it relatively easy to screen for with the appropriate tools. Preeclampsia is very treatable through the injection of magnesium sulfate, which is both cheap and effective. But this relies on an accurate and early recognition of the disorder . Extremely few mothers die from preeclampsia in developed countries where prenatal care is very common. Unfortunately, very few women in developing countries receive the appropriate prenatal care required for diagnosis.

Problem Statement :

Taking the Blood Pressure (BP) with a traditional sphygmomanometer requires a trained user. In developed countries, patients who need to monitor their BP at home usually acquire an electronic BP device with an automatic inflate/deflate cycle that determines the BP through the oscillometric method. For patients in resource constrained regions automated BP measurement devices are scarce because supply channels are limited and relative costs are high. Consequently, routine screening for and monitoring of hypertension is not common place. In this project we aim to offer an alternative strategy to measure BP and Heart Rate (HR) in developing countries. Given that mobile phones are becoming increasingly available and affordable in these regions, we designed a system that comprises low-cost peripherals with minimal electronics, offloading the main processing to the phone. A simple pressure sensor passes information to the mobile phone and the oscillometric method is used to determine BP and HR. Data are then transmitted to a central medical record to reduce errors in time stamping and information loss.

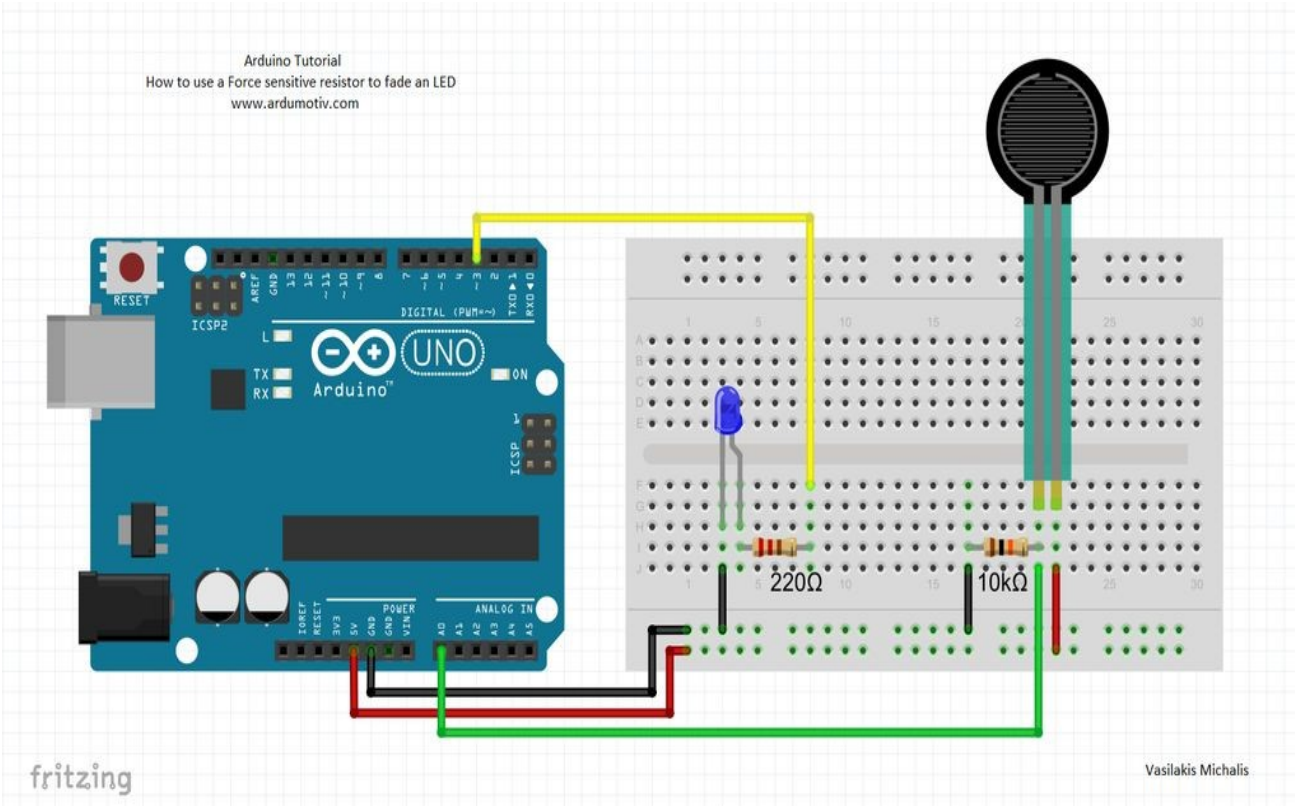
Objective of project:

The objective of this project is to design and make a low cost blood pressure device for developing countries.

Scope of work:

New innovations are made in the field of digital Blood Pressure measuring machines, cuffless Blood Pressure are a new field of research. Lot of scope is there in digital Blood Pressure machine there I are researches going on in order to improve the Blood Pressure device and the internal hardware is made more compact . In this era of semiconductor technology new compact circuits can be made for digital Blood Pressure's and regular Blood Pressure checkup can be done and the data can be stored in the computer database in digital form. Further the collected data can be used for diagnosis. Blood Pressure related diseases can be easily diagnosed by using the data in the computer and now a days new software are also developed which read different Blood Pressure graphs and give us the proper treatment.

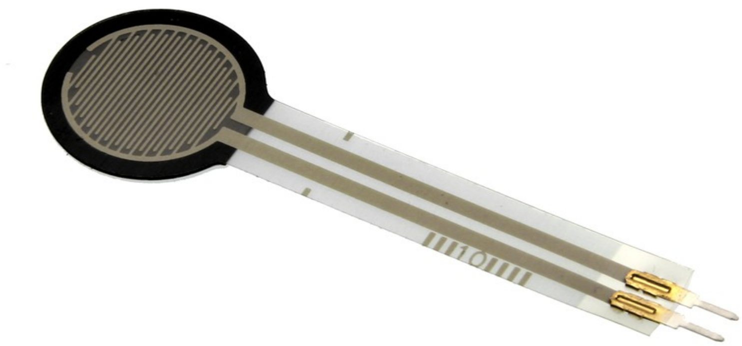
Circuit Description:



Materials required:

- Arduino uno
- Breadboard
- Force sensitive resistor
- LED
- 10KOhm & 220 Ohm resistors
- BP cuff

FSR(Force Sensitive Resistor):



Force sensitive resistor definition

A force sensitive resistor is a type of variable resistor whose resistance decreases when the applied force increases. Force sensitive resistors are also known as force sensing resistors, FSR, force sensor, or pressure sensor.

Construction and working of force sensitive resistor

The force sensitive resistor consists of conductive polymer whose resistance changes when the force is applied. It is normally supplied as polymer sheet or ink that can be applied by a technique called screen-printing. Screen-printing is a technique used to transfer ink into a substrate.

The sensing film consists of both electrically non-conducting and conducting particles suspended in matrix. When the force is applied, the sensing film causesparticles to touch the conducting electrodes. As a result, the resistance of the film decreases.

The resistance of the force sensitive resistor is depends on the amount of force applied. If large amount of force is applied, the resistance of the force sensitive resistor decreases and provides low resistance to the electric current. On the other hand, if little force or no force is applied to the force sensitive resistor, the resistance remains same and provides high resistance to the electric current.

History of force sensitive resistor

In 1972, Franklin Eventoff started developing a series of musical instrument controllers. Five years later (1977), he invented the force-sensing resistor or force sensitive resistor.

In 1985, Franklin Eventoff founded Interlink Electronics, a company based on his invention, force-sensing resistor.

Advantages and disadvantages of force sensitive resistor

Advantages of force sensitive resistor

- Low cost
- Small size
- Highly sensitive to force

Disadvantages of force sensitive resistor

- Low accuracy

Applications of force sensitive resistor

- Musical instruments: In musical instruments, the force sensitive resistors are used to translate the emotions of a person into musical expressions through his touch.
- Computer input devices: Force sensitive resistors are used to control the force and speed of the cursor movement.
- Industrial applications: Force sensitive resistors are used in brakes, seat occupancy detection, motor speed control and mirror adjustor.
- Robotics fingertips
- Medical applications
- Sports

Arduino uno:

Arduino is an open-source electronics platform based on easy-to-use hardware and software. Arduino boards are able to read inputs - light on a sensor, a finger on a button, or a Twitter message - and turn it into an output - activating a motor, turning on an LED, publishing something online. You can tell your board what to do by sending a set of instructions to the microcontroller on the board. To do so you use the Arduino programming language (based on Wiring), and the Arduino

Software (IDE), based on Processing.Over the years Arduino has been the brain of thousands of projects, from everyday objects to complex scientific instruments. A worldwide community of makers - students, hobbyists, artists, programmers, and professionals - has gathered around this open-source platform, their contributions have added up to an incredible amount of accessible knowledge that can be of great help to novices and experts alike.

Arduino Pin Diagram

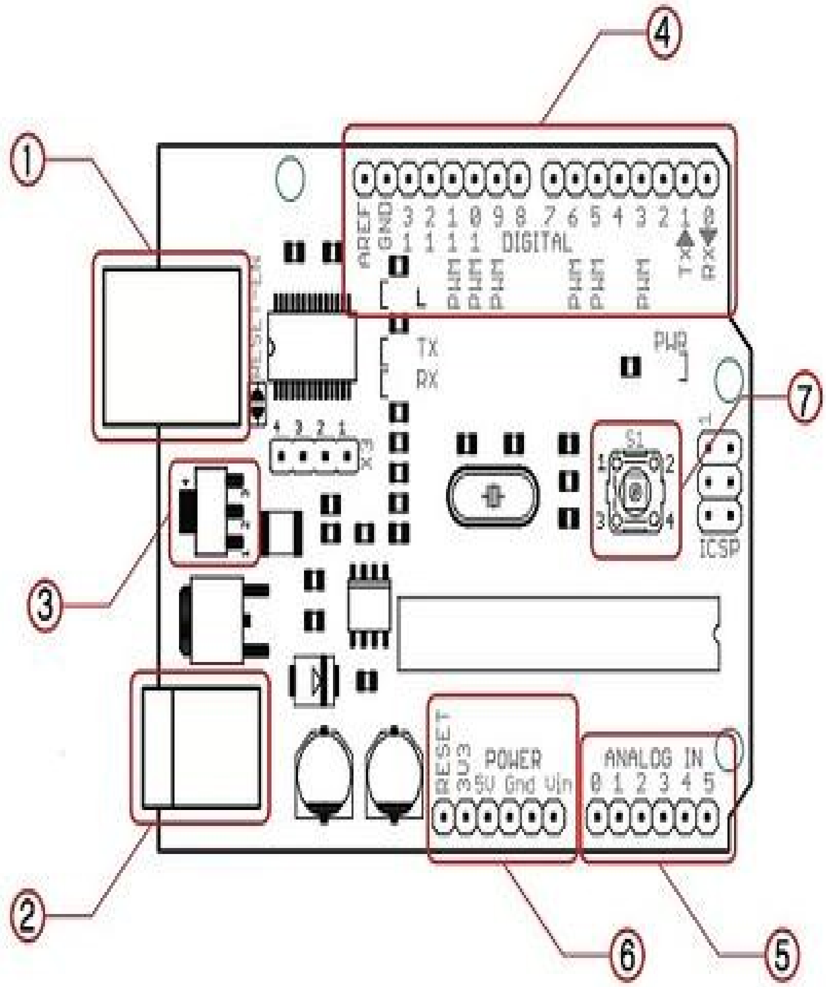
A typical example of Arduino board is Arduino Uno. It consists of ATmega328- a 28 pin microcontroller.Arduino Uno consists of 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button.

Power Jack: Arduino can be power either from the pc through a USB or through external source like adaptor or a battery. It can operate on a external supply of 7 to 12V. Power can be applied externally through the pin Vin or by giving voltage reference through the IORef pin.

Digital Inputs: It consists of 14 digital inputs/output pins, each of which provide or take up 40mA current. Some of them have special functions like pins 0 and 1, which act as Rx and Tx respectively , for serial communication, pins 2 and 3- which are external interrupts, pins 3,5,6,9,11 which provides pwm output and pin 13 where LED is connected.

Analog inputs: It has 6 analog input/output pins, each providing a resolution of 10 bits.

ARef: It provides reference to the analog inputs
Reset: It resets the microcontroller when low.



The most important parts on the Arduino board high lighted in red:

1: USB connector
2: Power connector
3: Automatic power switch
4: Digital pins
5: Analog pins
6: Power pins
7: Reset switch

Blood Pressure:

Blood pressure (**BP**) is the pressure of circulating blood on the walls of blood vessels. Used without further specification, "blood pressure" usually refers to the pressure in large arteries of the systemic circulation. Blood pressure is usually expressed in terms of the systolic pressure (maximum during one heart beat) over diastolic pressure (minimum in between two heart beats) and is measured in millimeters of mercury (mmHg), above the surrounding atmospheric pressure.

Blood pressure is one of the vital signs, along with respiratory rate, heart rate, oxygen saturation, and body temperature. Normal resting blood pressure in an adult is approximately 120 millimetres of mercury (16 kPa) systolic, and 80 millimetres of mercury (11 kPa) diastolic, abbreviated "120/80 mmHg".

Traditionally, blood pressure was measured non-invasively using a mercury-tube sphygmomanometer, or an aneroid gauge, which is still generally considered to be the gold standard of accuracy for auscultatory readings.[1] More recently other semi-automated methods have become common, largely due to concerns about potential mercury toxicity,[2] although cost and ease of use have also influenced this trend.[1] Early automated alternatives to mercury-tube sphygmomanometers were often seriously inaccurate, but validated devices allow for an average difference between two standardized reading methods of 5 mm Hg or less and a standard deviation of less than 8 mm Hg.

Blood pressure is influenced by cardiac output, total peripheral resistance and arterial stiffness and varies depending on situation, emotional state, activity, and relative health/disease states. In the short term, blood pressure is regulated by baroreceptors which act via the brain to influence nervous and endocrine systems.Blood pressure that is low is called hypotension, and pressure that is consistently high is hypertension. Both have many causes and may be of sudden onset or oflong duration. Long-term hypertension is a risk factor for many diseases, including heart disease, stroke and kidney failure. Long-term hypertension is more common thanlong-term hypotension, which often goes undetected because of infrequentmonitoring and the absence of symptoms.

Basic techniques of blood pressure measurement

Location of measurement

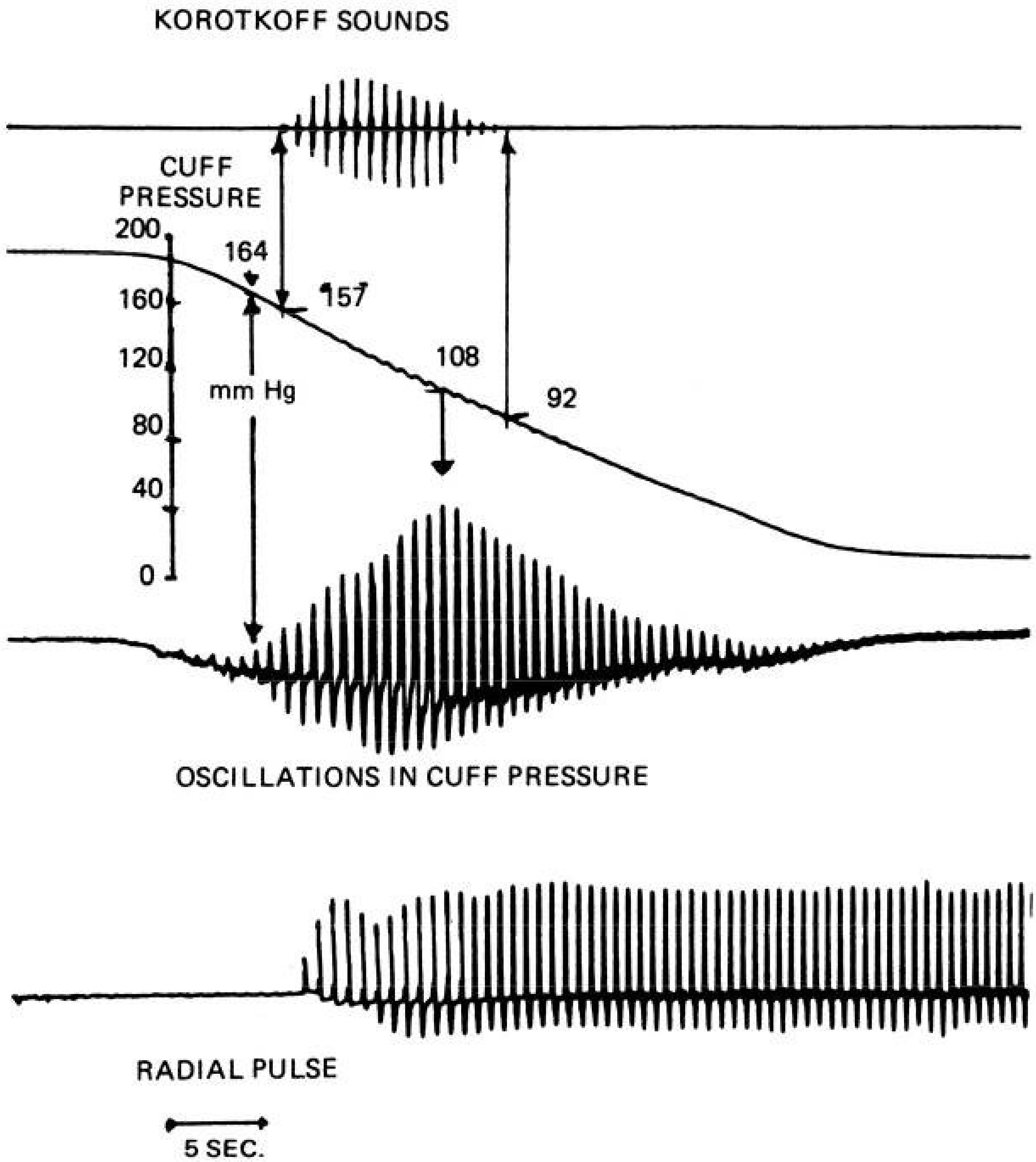
The standard location for blood pressure measurement is the brachial artery. Monitors that measure pressure at the wrist and fingers have become popular, but it is important to realize that systolic and diastolic pressures vary substantially in different parts of the arterial tree with systolic pressure increasing in more distal arteries, and diastolic pressure decreasing.

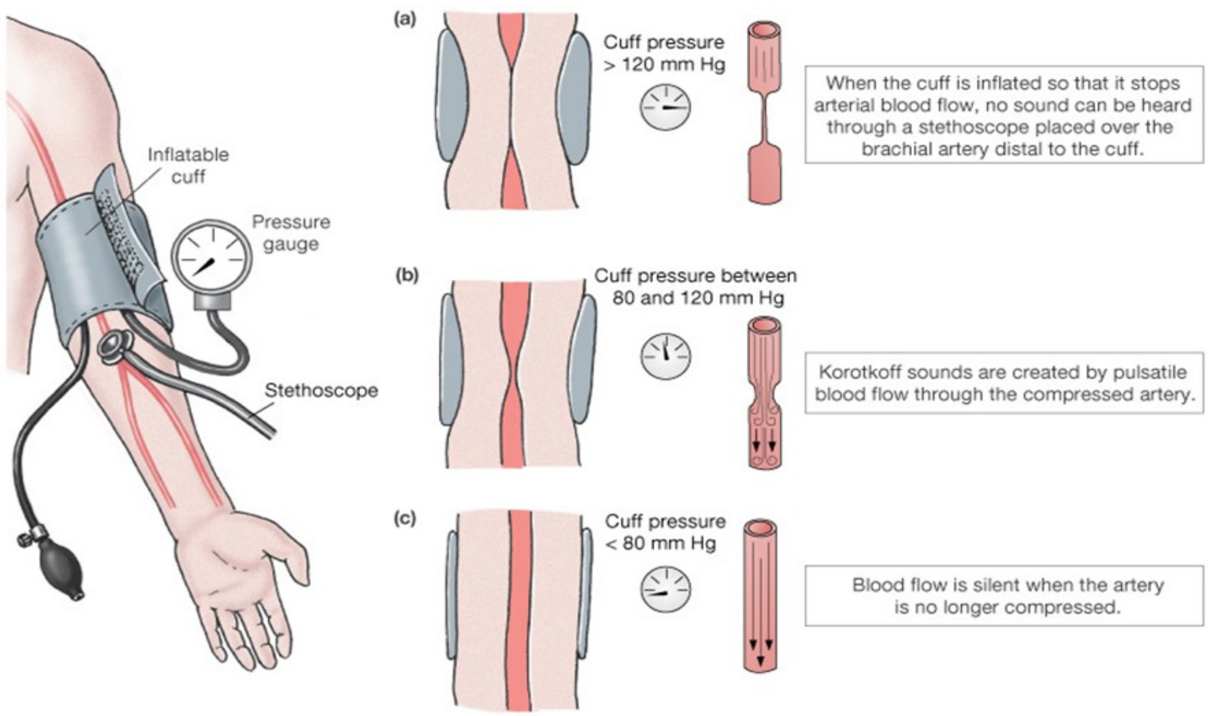
The auscultatory method

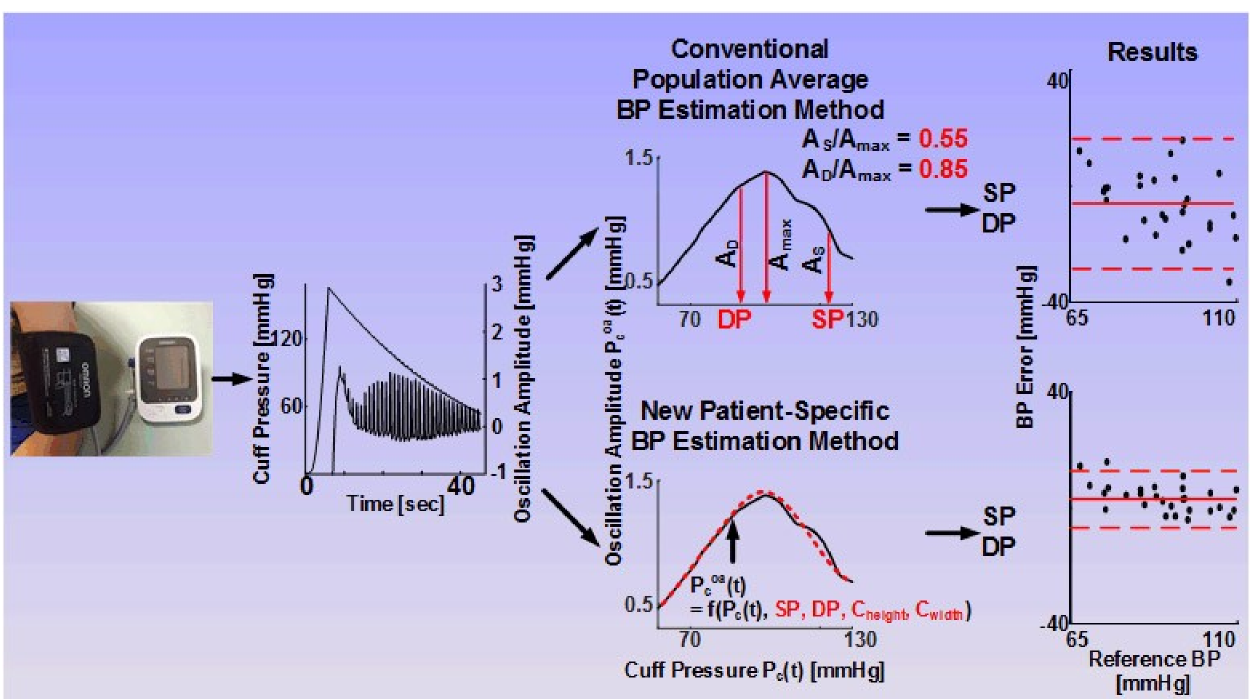
Although the auscultatory method using mercury sphygmomanometer is regarded as the ‘gold standard’ for office blood pressure measurement, widespread implementation of the ban in use of mercury sphygmomanometers continues to diminish the role of this technique.The situation is made worse by the fact that existing aneroid manometers, which use this technique, are less accurate and often need frequent calibration.New devices known, as “hybrid” sphygmomanometers, have been developed as replacement for mercury devices. Basically, these devices combine the features of both electronic and auscultatory devices such that the mercury column is replaced by an electronic pressure gauge, similar to oscillometric devices, but the blood pressure is taken in the same manner as a mercury or aneroid device, by an observer using a stethoscope and listening for the Korotkoff sounds.

The oscillometric technique

This was first demonstrated by Marey in 1876,and it was subsequently shown that when the oscillations of pressure in a sphygmomanometer cuff are recorded during gradual deflation, the point of maximal oscillation corresponds to the mean intra-arterial pressure. The oscillations begin at approximately systolic pressure and continue below diastolic , so that systolic and diastolic pressure can only be estimated indirectly according to some empirically derived algorithm. This method is advantageous in that no transducer need be placed over the brachial artery, and it is less susceptible to external noise (but not to low frequency mechanical vibration), and that the cuff can be removed and replaced by the patient during ambulatory monitoring, for example, to take a shower. The main disadvantage is that such recorders do not work well during physical activity when there may be considerable movement artifact. The oscillometric technique has been used successfully in ambulatory blood pressure monitors and home monitors. It should be pointed out that different brands of oscillometric recorders use different algorithms, and there is no generic oscillometric technique. Comparisons of several different commercial models with intra-arterial and Korotkoff sound measurements, however, have shown generally good agreement.[6,79]




Inflatable cuff
Pressure gauge
Stethoscope
(a)
Cuff pressure > 120 mm Hg
When the cuff is inflated so that it stops arterial blood flow, no sound can be heard through a stethoscope placed over the brachial artery distal to the cuff.
(b)
Cuff pressure between 80 and 120 mm Hg
Korotkoff sounds are created by pulsatile blood flow through the compressed artery.
(c)
Cuff pressure < 80 mm Hg
Blood flow is silent when the artery is no longer compressed.


Cuff Pressure [mmHg]
Time [sec]
Oscillation Amplitude [mmHg]
Conventional Population Average BP Estimation Method
As/Amax = 0.55
AD/Amax = 0.85
AD
Amax
AS
DP
SP
SP
DP
New Patient-Specific BP Estimation Method
Pc^os(t) = f(Pc(t), SP, DP, Cheight, Cwidth)
Cuff Pressure Pc(t) [mmHg]
Oscillation Amplitude Pc^os(t) [mmHg]
SP
DP
Results
BP Error [mmHg]
Reference BP [mmHg]

References:

Blood Pressure:

https://tbme.embs.org/2016/05/25/patient-specific-oscillometric-blood-pressure-measurement/

Arduino:

https://www.elprocus.com/arduino-basics-and-design/

FSR:

https://www.physics-and-radio-electronics.com/electronic-devices-and-circuits/passive-components/resistors/forcesensitiveresistor.html

Graph Analyis of BP:

http://faculty.pasadena.edu/dkwon/chapter%2015/chapter%2015_files/textmostly/slide14.html