Elder Health Care: Blood Pressure Measurement

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***Abstract*-Home-bound aged elders and elderly patients face many problems regarding their critical health parameter variations and timely assistance in case of emergencies. Monitoring of critical health parameters is very much needed when they suffer from severe heath issues related to heart, blood pressure (BP), pulse rate etc. A constant and reliable assistive technology is essential while taking care of home-bound patients. Of many parameters to be monitored, this study paper mainly deals with the BP monitoring of elderly and various existing methods to measure the BP. The paper points out how each technology is dominated over its past technology. In this paper we focus on comparing all existing technologies and conclude on the technology which can be most useful in elderly to monitor their blood Pressure.**

I. INTRODUCTION

Providing quality and timely heath care for the elderly has always been area of concern for the younger generation. Employment, Work stress and other family issues has always convoluted this problem. Though old age homes and elder care centres has emerged as a possible solution to this problem they are rather business minded and quiet expensive. Moreover elderly people, who are particularly home-bound patients do not prefer custodial care and want to be at home where they are not detached from their family, friends and society.

When we analyse the diseases of the elderly we can see that many of the diseases that haunt them are chronic in nature. In many a case the detection and cure of these diseases require continuous monitoring of the physical parameters due to their special nature of occurrence. Other major issues affecting elders are bed-sore in case of bed-ridden elders and unintentional fall. Though there are many products available in the market today for monitoring patients we can see that many of them only measure individual parameters like heart rate, body temperature etc. and many of them do not address the problem of tilt or fall and are not specific for elders.

Blood pressure (BP) is a major concern for any human being. Maintaining the normal value of BP is possible only through good diet and continuous exercises. In most of the cases, elders find it difficult to continue with the daily exercises considering their physical constraint. As a result, BP is one of the major health concerns in elders compared to middle aged or young people. So, it highly requires having a continuous monitoring of BP. Different technologies have been developed for the measurement of blood pressure, today. Each Technology has its own advantages and disadvantages. There are certain measurement techniques that really suits elderly people. This paper will be comparing all different technologies available in the world and tries to find the most suitable method that would be comfortable for elderly.

For most adults, a BP reading of 120/80 is considered to be the normal. According to an expert panel convened by the American College of Cardiology (ACC) and the American Heart Association (AHA), the recommended BP readings for the elders are, 140/90 or less for the age group from 65 to 79 and 140/90 to 145/90 for the age group of 80+ [7].

II. PROBLEM DEFINITION

Projected increase in both the absolute and relative size of the elderly population in countries all over the world is a subject of growing concern. Along with the rise in the population of the aged there arises a need for better technology in monitoring their health. The proportion of elderly persons in the population of India rose from 7.5% in 2001 to 8.5% in 2010. The Indian aged population is currently the second largest in the world. As population ages, more demand is placed on caring for the elderly. The absolute number of the elderly (above 60 years old) population in India is projected to increase from 77 million in 2001 to 137 million by 2021.

Many of the elderly have various degrees of disabilities. They are often dependent on others for their activities of daily living. Some of them remain bedridden due to various causes. A person who is bedridden usually needs full-time care and attention. This means that a 'Care Team' (including family, friends, nurses and other professionals) will likely be working together. Because of this, it is important to make sure that every care team member keeps a written record of the elder's health parameters. The healthcare provider may also be interested in a record of body temperature, BP, pulse and respiration and they have to make sure that the position of the elder is changed periodically so as to reduce the

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possibility of bed sore. Clearly, in view of such a demographic trend, medical assistance to the rising number of dependent elderly is a major problem that many countries are facing now. In this scenario, a constant and reliable

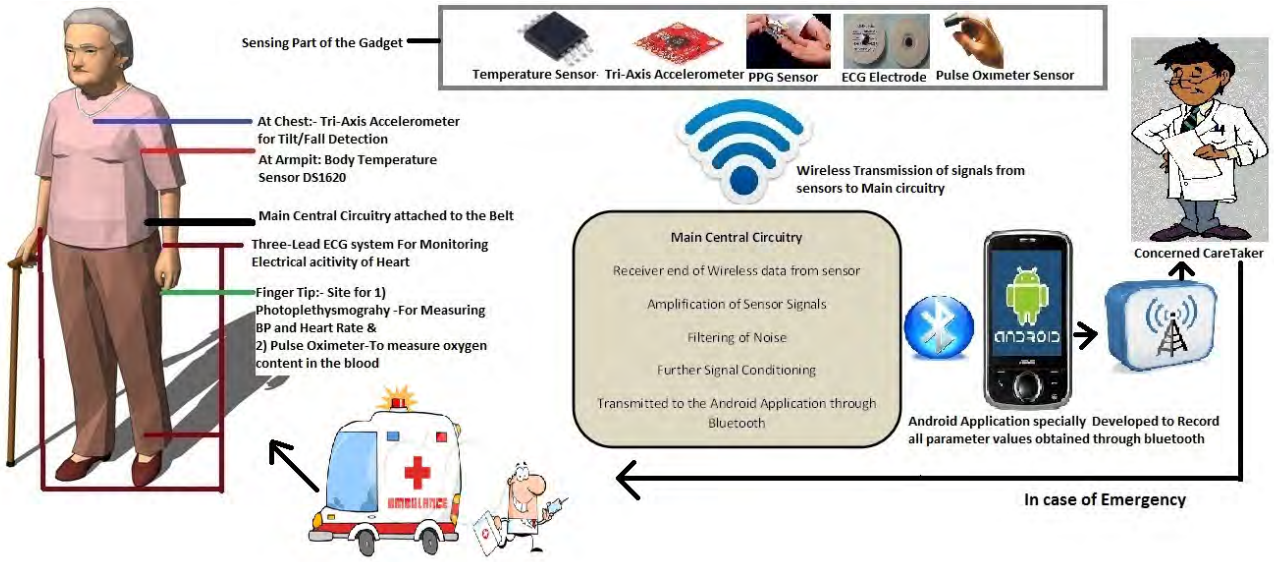

Figure I. System Architecture

assistive technology which can cater the needs of these home bound elders is the need of the hour.

As mentioned earlier this paper we are particularly concentrating various methods of measuring BP, both invasive and non-invasive, the effects of BP on elders, and how much of them are assistive in nature for elderly population.

III. RELATED WORKS

The paper on a real time, wearable ECG and BP Monitoring System [1], discusses about a simple way of measuring and storing the data of ECG and BP. All the sensors are placed in wearable textile and measured data is stored in data logging unit which is also attached to body. This data is transmitted to computer/ mobile using wireless interface. This research paper [2] proposes a cuff-less blood pressure monitoring using Wireless Sensor Networks. Here BP is measured as a combination of ECG derived from waist and PPG measured at the ear. ZigBee wireless nodes by Philips were used to realize wireless Body Sensor Network. Here the authors were checking the interference of other wireless interfaces like 802.15.1 (Bluetooth) and 802.11b/g (Wi-Fi) and found the latter is more harmful in interfering with Zigbee signals. Remote BP and heart rate monitoring using Telemedicine is discussed in paper [3] only measures heart rate and BP using devices from market. The system uses a PDA to collect data from sensors which are always attached to the body and serves as patient personal server. PDA data is transferred to central medical server using Wi-Fi or GSM/GPRS. The BP monitor and the PDA are connected via SimpliciTi wireless protocol. The PDA is connected to internet via Wi-Fi / GPRS/ GSM. A continuous BP monitoring utilizing a CMOS tactile sensor is elaborated in this paper work [4]. In the research work presented in the paper [5] a portable continuous blood pressure monitoring kit design is discussed. This paper concentrates on the method to measure BP using ECG using neural network model. As we see that most of the BP methods of measuring and monitoring are for any person or patients and are not particularly focussed or designed for elder health care.

IV. SYSTEM ARCHITECTURE

The System architecture of a continuous health monitoring device is shown in figure I. As specified in the figure, various health parameters like body temperature, heart rate, blood pressure, oxygen content in the blood can be continuously monitored. Also, wireless Electrocardiogram can also be implemented to record the electrical activity of heart. Any tilt/fall of the body can also be identified using this continuous monitoring device. All the measurements are non-invasively done so that it is a perfect option for 24*7 monitoring. Wireless transmission of data from sensors to the main circuitry adds more convenience for the patient. All processed data are passed into an android application developed through Bluetooth. Periodically, notifications are given to the concerned caretaker through message alert system. Blood pressure is

an important parameter which should be monitored in elderly. This paper deals with different methods of blood pressure measurement and the best method which suits for this continuous monitoring device will be identified.

V. Causes of tension in elders

There are many major reasons that causes hypotension or hypertension especially in elders

A. Stiffness of Arteries

As people get older, the flexibility of the muscles and nerves weakens. As a result, the ability of the arteries to bend gets reduced. This increases the resistance offered by the blood vessel against the blood flow which automatically results in the gradual increase of pressure inside it.

B. Medications for multiple disorder

Elders experience multiple disorders in their body. Several organs inside the body get weaker. So, they are forced to take multiple medicines for their diseases. Some medicines like anti-depression, anti-anxiety may cause low Blood Pressure [8].

C. Dehydration

Water content inside the body plays an important role in smoothening the interior walls of the arteries so that blood vessels don't exert high resistance against the blood flow. Dehydration occurs in the case of elders due to several factors like lack of hunger, dental problems, reduction of the sense of smell or taste, depression, poverty or inadequate access to food [8].

D. Heart Failure

Heart failure is more common in elderly. A poorly pumping heart may not have the ability to pump the blood through the arteries at the adequate level resulting in the lower BP. It often begins after a heart attack [8].

E. Prolonged Rest

Elders spend a long time in the bed or chair due to several reasons like injury and illness. They are forced to take rest for a long time considering their health issues. A sudden change in the posture from the rest results in a rapid fall in the BP which results in the Postural Hypotension [6].

F. Micturition syncope

This is a condition brought about by urinating, in elders. Because of this there will be temporary drop in BP. This is typical condition in elders and may be due to the release of autonomic nerves of hormones that reduce BP [6].

VI. Complications caused due to the abnormal values of BP

A. Low Blood Pressure

Also known as hypotension is caused when the pressure in the arterial vessels is decreased beyond a certain limit. In the beginning, it causes headache, dizziness and fainting. Low BP can reduce the oxygen content in blood resulting in the failure of heart and brain. It causes lack of blood flow to the organs thus leading to their failure [6]. Various complications are stroke, heart attack, kidney failure, decreased blood supply to the intestines. Prolonged cases low BP may eventually lead to shock and death.

B. High Blood Pressure

Also called Hypertension, the higher blood pressure increases heart workload. This gradually leads to thickening of heart muscles and weakening. Smaller complications are confusion, headache and convulsion. High BP is one of the major causes of stroke and heart attack. It can damage the blood vessels in the retina and cause a condition known as Hypertensive retinopathy. It can lead to elevated sugar levels. It can cause slow progressive decline of kidney function known as chronic renal failure [9].

VII. Evolution of BP Measuremts

In the course of years there are various methods and technology used for measuring BP. There are direct methods, also known as invasive and indirect methods which are non-invasive. Palpatory, Ascultatory, Oscillometric, volume compensation and Tonometry methods measure BP non-invasively. The extravascular sensor and intravascular sensors are used for invasive measurements.

A. Palpatory method of Blood Pressure Measurement

This is one of the most frequently used methods for the measurements for Blood Pressure. A simple inflatable cuff and a sphygmomanometer are the only required items for the Measurement of BP by this technique. The cuff has to be inflated rapidly to 70 mm Hg and increments it by 10 mm Hg while palpating the radial pulse. The pressure at which pulse disappears during increment is called systolic Blood Pressure. The main disadvantage of the system is that the diastolic Blood pressure cannot be determined. Also, the system cannot be applied on severe obese persons as their fat prevents the sensing of pulse [11].Also, shivering and tremor can cause mechanical errors in the system. Elderly Persons have very thin subcutaneous fat which can lead to continuous palpations and caretakers find it difficult to identify the thrill in pulse. Even though these limitations exist, they are still used frequently in wards considering the ease of measurement [10].

B. Auscultatory Method [12]

Auscultation is the term used for listening to the internal sounds of the body. The Blood Pressure value is estimated by listening to the sounds produced during the auscultation. The sounds heard over an artery during this method of BP measurement called Korotkoff sounds. Observation of the variation of korotkoff sounds produced during the measurement is the important part in the method. These sounds are measured with the help of a stethoscope or even with the help of a microscope in the case of automatic measurement technique. It is possible to measure both systolic and diastolic BP using this technique. Systolic blood pressure is the pressure experienced by the artery walls when the heart is pumping blood and diastolic blood pressure is the pressure experienced by the artery walls when the heart is expanding in each cycle.

In this conventional method, a cuff is tied on the right upper arm in parallel with the heart. The size of cuff varies with age. Initially, a pressure is applied in the cuff manually which is of the value more than the expected systolic BP value. As a result, the blood vessels at the spot experience a compression. A Stethoscope is placed to listen to the pulse rate at various instants of the measurement. The cuff pressure is slightly released linearly or stepwise. A stage will be reached where the korotkoff sound is audible to the listener through auscultation. The value of cuff pressure at this point is called systolic blood pressure. Further release of cuff pressure will make the pulse rate more audible and also decrease in the korotkoff sounds. The value of cuff pressure at which the korotkoff sounds disappear is called diastolic pressure [12].

C. Oscillometric method:

The term "oscillometric" refers to any measurement of the oscillations caused by the arterial pressure pulse. It was introduced in 1876. These devices do not use microphones. It uses a sphygmomanometer cuff, like the auscultatory method, but with an electronic pressure sensor to observe cuff pressure oscillations. Unlike auscultatory techniques, which measure systolic and diastolic through korotkoff sounds, it estimate mean arterial pressure. Oscillometric devices measure the mean but estimate systolic and diastolic [13]. A cuff is wrapped around the patient's upper arm and it was inflated to occlude the brachial artery. As the cuff is allowed to deflate above the systolic pressure, all of sudden there will be a rise in amplitude as the pulse breaks through the occlusion in the brachial artery. The pressure at which this occurs is very close to systolic pressure. As the pressure in the cuff is reduced further, the pulsations increase in amplitude, reach the maximal (which approximates to the mean pressure), and then abate rapidly. The index of diastolic pressure is acquired from where this rapid transition begins. This pressure data is recorded by the device. The pressure data looks like a waveform.

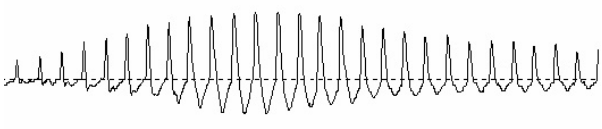

Figure II. A typical oscillometric waveform [13]

Oscillometric measurement requires less skill than the auscultatory technique and may be suitable for use by untrained staff and for automated patient home monitoring. Oscillometric monitors may produce inaccurate readings in patients with heart and circulation problems, which include arterial sclerosis, arrhythmia, preeclampsia, pulsus alternans, andpulsus paradoxus[13].

Auscultatory methods have many disadvantages compared to Oscillometric methods. Auscultatory method is prone to noise of surrounding environment. The auscultatory measurement observation varies from person to person. The Auscultatory measurement does not always correspond to intra-arterial pressure (clear from the figure 2).Auscultatory method need not give accurate value hypotension. The only main advantage of Auscultatory measurement is that it can be used with patients with fluctuating heart beat rate. Unlike auscultatory method, oscillometric method is not prone to outside environment noise. Also, the hypotension value is also correctly given by the oscillometric method. The oscillometry works on a definite predefined algorithm unlike Auscultatory method. Many devices use different algorithms leading to the variation in the values [14].

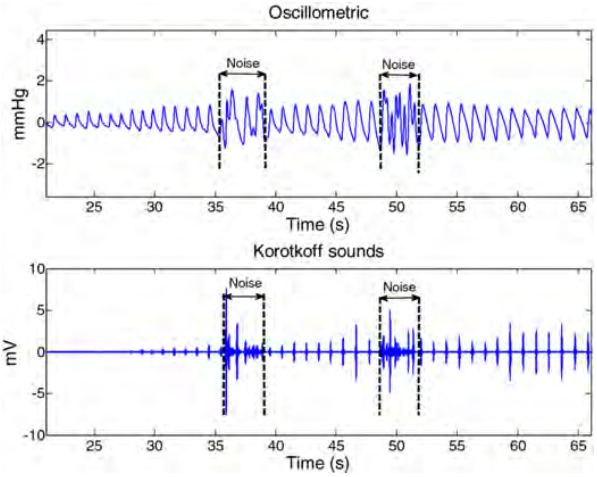

Figure III. A comparison between waveforms of oscillatory auscultatory methods [15]

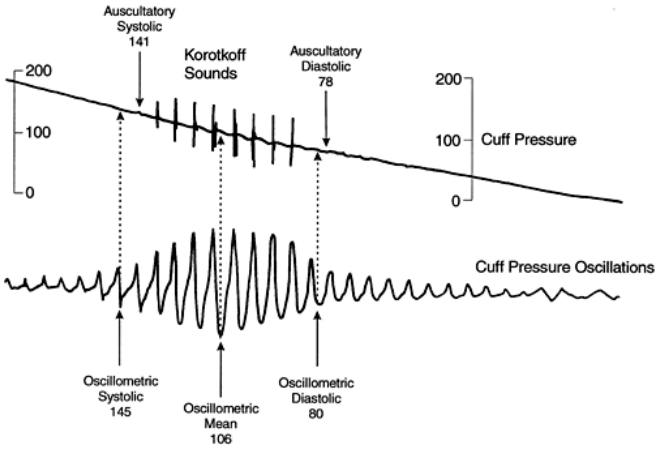

Figure IV. Comparison between waveforms [16]

D. Volume Compensation Method for the determination of Blood Pressure[17]

Considering the relation between volume and pressure, this is yet another method for the measurement of arterial blood pressure. Both systolic and diastolic blood pressures in the artery are measured for each heartbeat. The vascular volume in the artery changes in each cycle as a result of which a change in the intra-arterial pressure is also observed. Photoplethysmography is used for the detection of change in the vascular volume. The photoplethysmographic DC signal and the AC signal obtained when the vessel is in unloaded state and loaded state respectively is clamped and a servo controlled cuff pressure compensating for the change in blood volume is automatically applied. So the cuff pressure automatically controlled follows the intra-arterial pressure thereby the blood pressure measurements are made.

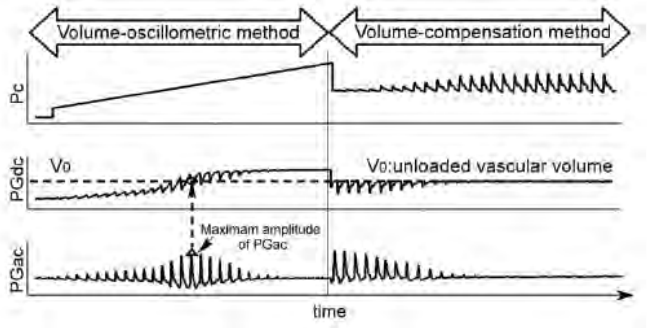

Figure V. Waveform obtained from volume-Compensation Method [17]

D. Ultrasound Image-based system for Blood Pressure measurement

BP is seen more in people at older age. This is because as people get older, the strength and elongation of their blood vessels decreases. On drawing the stress-strain relationship of the artery, the curves, for both younger and older adults, exhibit non-linear relationships due to the viscoelastic nature of blood vessels. Arteriosclerosis is a disease that can cause increase in blood pressure. So it is important to detect arteriosclerosis in early diagnosis in order to stop the progression of this condition. Ultrasound can be used as a tool to estimate the level of arteriosclerosis [18].

An ultrasound gel is applied to the skin surface of the subject's neck and a linear-type ultrasound transducer (7.5 MHz) is used. B-mode images of the patients' common carotid artery are displayed on the ultrasound equipment monitor. Because sclerosis of the artery proceeds in localized areas, we measure the stiffness distribution with regular intervals of 3~5 mm for nine positions [18].

E.Photoplethysmography

Plethysmography is a technique used to graphically obtain the changes in volume in a region. As it can tell us the changes in volume in an area, it can be used to find the heart beats per minute, oxygen saturation and even blood pressure by monitoring the changes in the blood flow through a thin region of the body. In Photoplethysmography, an IR LED and a phototransistor are kept on each side of a finger. A portion of the light from the IR LED after undergoing absorption and reflection inside the body reach the phototransistor on the other side. The amount of light received at each instant varies depending on the volume of blood inside the finger at that time. BP measurement using PPG is based on the principle that if externally applied pressure in the cuff is equal to the arterial pressure instantaneously, the arterial walls will be unloaded and the arteries will not change in size. In this condition the blood volume will not change. BP can be measured in two ways using PPG - with cuff and without cuff. In both methods, Pulse Transit Time is the basically used technology [19] [20].

1) Measurement of BP using Electrocardiogram and Photoplethysmography by calculating Pulse Transit Time

Pulse Transit Time is the amount of time a particular volume of blood inside the artery takes to shift from one arterial site to another. Photoplethysmography and ECG are the two main technologies used for measuring Pulse Transit time. In this method, PTT is calculated by an ECG-PPG combination. The PQRS waveform obtained by the ECG is compared with the Photoplethysmography waveform which is obtained by the apparatus fixed at the fore-fingertip. The time interval between the R-peak of the ECG waveform and the peak of photoplethysmography waveform gives the pulse transit time. The blood pressure and pulse transit time are highly related. An increase in blood Pressure makes an increase in blood velocity as a result of which blood takes very less time to move from one arterial location to another. A low blood pressure gives a high PTT value. An algorithm

is developed to find the systolic and diastolic blood pressure from the PTT [21].

2) Measurement of BP using PPG and a cuff-method of calculating amplitude difference

The PPG sensor was placed at the tip of the finger and the pressure is applied at proximal phalanx of the finger using cuff. The blood volume changes will be detected and corresponding data will transmitted to the system by Bluetooth transmitter. In this method, the signals obtained from pressure cuff and PPG sensor was observed. The amplitude differences after systolic pressure is the highest systolic pressure and the amplitude differences obtained after the diastolic pressure is the lowest pressure [19].

F. Tonometry

Tonometry is yet another method used for the measurement of arterial Blood Pressure. A tonometer actually scans the blood vessels in the arm and record the pressure of radial artery. The basic principle behind tonometry is compressing and partial flattening of blood vessels. A transducer which acts as tonometric pressure sensor is placed on the wrist over radial artery. The sensor exerts a sufficient pressure on the skin to partially flatten the radial artery. An array of piezoelectric sensors is used for applying pressure so that at least one sensor will be properly oriented relative to artery. The signal waveform from the properly oriented sensor is taken and given to the tonometer where further processing is done so that the tonometric waveform obtained will be similar to the arterial waveform. A tonometric pressure sensor gives only a waveform similar to arterial pressure but not its absolute value. As a result, exact value of blood pressure is not obtained with this technique [22].

VIII. CONCLUSION

An intelligent health care system for elder health care is proposed for monitoring the vital parameters and take decisions at critical times. As part of the system, a detailed study of various methods of measuring blood pressure in elders is listed in the paper. Of all the technologies specified above, blood pressure measurement using the combination of photoplethysmography and electrocardiogram is considered as the best method which can be implemented in a continuous health monitoring device. This technology is purely cuffless and provides accurate value of both systolic and diastolic blood pressure by calculating pulse transit time. Exclusion of cuff during measurement provides more comfort for the elders. No external pressure application is required which makes this technology more suitable for continuous health monitoring. Also, this method of blood pressure measurement has a major advantage in continuous health monitoring since it is possible to estimate both heart rate and electrical activity of heart using PPG and ECG respectively. This is purely a study paper and the work is still in progress.

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