Comparing the accuracy of different blood pressure determination methods: a cross-sectional study of adolescents in Isfahan, Iran

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Abstract

Introduction: Hypotension and hypertension have the potential ability to injure the vital organs. Controlling blood pressure is necessary to stabilize the patient's hemodynamic situation. There are different blood pressure measurement methods such as invasive blood pressure measurement (IBP), noninvasive blood pressure measurement (NIBP) and auscultatory method.

Methods: This cross-sectional study was conducted on 20 inpatients of angiography ward of Sina hospital, Isfahan, Iran. The measurement accuracy of IBP, NIBP and auscultatory method compared and the effective parameters in each technique discussed.

Results: The mean error and standard deviation of IBP and oscillometric in all patients was -4.06±8.9 for MAP, -3.64±10.3 for systolic and -4.22±4.9 for diastolic. The mean error and standard deviation of oscillometric and auscultatory for all patients was -1.73±6.5 in systolic pressure and 0.42±4 in diastolic pressure. Based on gender, systolic pressure error in men was -3.3±4.2 and -0.78±3.6 in women; diastolic pressure error in men was -4.37±9.5 and -4.37±8.9 in women and MAP error reported -4.2±8.57 and -1.2±8.17 in men and women respectively.

Conclusion: Findings showed that in the range of normal pressure and prehypertension, the accuracy of IBP, NIBP and auscultatory method was nearly the same but for hypertension grade 1 and 2, only the mean error and standard deviation of MAP is acceptable. Considering the effect of gender on blood pressure manifest that the error of systolic pressure, diastolic pressure and MAP for women is less than men.

Introduction:

Blood pressure is one of the vital signs that plays an undeniable role in determining clinical procedure and controlling the patient's condition. Previous studies demonstrate that hypertension is one of the main risk factors of coronary artery disease, stroke, sudden cardiac death (SCD), heart failure (HF) chronic renal insufficiency and eye problems (1, 2).

In the other hand, low blood pressure can lead to faintness, glaucoma and dizziness. It is essential to manage the blood pressure especially in some situations like brain damage or patients

undergoing cardiac surgery (3, 4).

There are 2 different methods for measuring the blood pressure include invasive blood pressure (IBP) and noninvasive blood pressure (NIBP). Invasive blood pressure measurement directly records the mean arterial pressure (MAP) moment-to-moment by placing a cannula in an appropriate artery. This technique is suitable for patients who are in danger of sudden blood pressure changes. Another advantage of this method is the ability to read the very low pressures; that is useful for shocked patients. For measuring the blood pressure noninvasively different techniques are available like oscillometric and auscultatory (5). In oscillometric technique, blood pressure is measured by using a cuff that is inflated over the arm. Despite the comfortable using, reliability of this method is less than other methods. In the auscultatory method, blood pressure is measured by using a sphygmomanometer and a stethoscope. The mercury sphygmomanometer is known as the gold standard method (6).

Previous studies compared the accuracy and reliability of these methods. This study considers the accuracy of all of these 3 methods in different grades of blood pressure, effect of gender in blood pressure determination and evaluates the efficiency of Iranian's measurement devices of Pooyandegane rahe salamat company .

Patients and methods:

This cross-sectional study has been accomplished during 2015, in Sina hospital, Isfahan, Iran. This study organized base on declaration of Helsinki and all patient's information secured. All patients admitted to angiography ward who required radial catheterization considered. Written consent was obtained from all eligible and volunteer participants before entering the study and agitated patients who had excessive movement were excluded. For twenty radial catetherized patients IBP, NIBP and auscultatory pressure four times at intervals of five minutes measured. If the range of changing was wider than 20mmHg in systolic pressure or 12mmHg in diastolic pressure the measurement deleted.

For recording IBP and NIBP the B9 monitor of Pooyandegane rahe salamat, an Iranian company, was used. This monitor connected to the laptop to save the data for next statistical analysis. In IBP method data changes every moment, so the average number of the time that monitoring started to the end of recording has been considered.

The mean systolic error, standard deviation of systolic pressure error, mean diastolic error, standard deviation of diastolic pressure error, mean MAP error and standard deviation of MAP error for all patients calculated. Then separately in the groups of normal blood pressure, prehypertension,

hypertension grade I and II the mean error and standard deviation of IBP and NIBP compared.

Then the accuracy of auditory method and NIBP compared by measuring the mean systolic and diastolic error and standard deviation of systolic and diastolic error; first for all patients and then for each group of blood pressure. To consider the effect of gender in blood pressure measurement first the range of systolic pressure, diastolic pressure, MAP and average pressure for each gender determined. Then systolic, diastolic and MAP error separately for men and women evaluated.

By using MATLAB R2015b (MathWorks Company) program from MathWorks company of USA, the IBP and corresponding NIBP has been matched. For each patient a txt format file has been created that includes patient's information (patient's number, age, arm circumference size, location of NIBP and IBP and gender) and their IBP and NIBP number (the changing range of systolic and diastolic pressure and the MAP for IBP).

Results:

Over all 200 measurements of 20 patients done that 15% were done in diabetic patients the age range of patients were 30-80 years with the average of 62.06 years old. Among participants, 79.78% were male and 20.21% were female. Their arm circumference sizes were 26-34cm with average of 29.38 cm. The adult' blood pressure category is written in table 1.

Table 1. Blood Pressure Categories		
Category of blood pressure	Systolic(mmHg)	Diastolic(mmHg)
Normal	90-119	60-79
Pre hypertension	120-139	80-89
Hypertension (Grade I)	140-159	90-99
Hypertension (Grade II)	$\geq$160	$\geq$100

Comparison between IBP and oscillometric

The mean error and standard deviation of IBP and oscillometric in all patients was -4.06±8.9 for MAP, -3.64±10.3for systolic and -4.22±4.9 for diastolic.

Patients were classified to four groups; Normal blood pressure, Prehypertension, Hypertension grade I and Hypertension grade II and analysis done. As a result, comparison of IBP and oscillometric in normal blood pressure group suggested mean error of -2.3±3.2 for MAP, -4.1±6.2 for systolic pressure and -1.99±4.1 for diastolic pressure. These findings in prehypertension group were 4.2±6.58 for MAP, 4.06±7.8 for systolic pressure and 3.5±7.9 for diastolic pressure. In the group of hypertension grade I, mean error for MAP was 2.9±6.78, for systolic pressure was -5.6±7.9 and for diastolic pressure was 6.33±8.4 while in hypertension grade II group, these were-1.98±7.3, -9.2±10.8 and 0.61±7.9 respectively.

Comparison between Auscultatory and Oscillometric

The mean error and standard deviation of oscillometric and auscultatory for all patients was -1.73±6.5 in systolic pressure and 0.42±4 in diastolic   pressure.

Regarding the classification of patients in four

groups of Normal blood pressure, Prehypertension, Hypertension grade I and Hypertension grade II, analysis repeated. In normal blood pressure range mean error for systolic pressure was 4.3±5.2 and 0.46±4.29 for diastolic pressure. In prehypertension group mean error was -0.56±7.36 for systolic and 2.95±5.2 for diastolic pressure. These findings in hypertension grade I were -6.35±4.15 for systolic and -3.78±7.96 for diastolic and in hypertension grade II reported -9.06±8.9 and -4±9.3 for systolic and diastolic pressure respectively.

Effect of gender in blood pressure measurement

Based on gender, systolic pressure error in men was -3.3±4.2 and -0.78±3.6 in women; diastolic pressure error in men was -4.37±9.5 and -4.37±8.9 in women and MAP error reported -4.2±8.57 and -1.2±8.17 in men and women respectively.

Effect of diabetes on blood pressure measurement

Out of all, 30 measurements (15%) were done in diabetic patients. The errors were -2.4±7.8 for systolic, 1.2±3.6 for diastolic and -3.4±5.3 for MAP.

Discussion:

In this cross sectional study blood pressure of 20 patients in 3 ways including invasive blood

pressure (IBP), oscillometric and auscultatory has been recorded. In the range of normal blood pressure and prehypertension, the accuracy of these methods was near. However, in the range of hypertension only the mean error and standard deviation of MAP was acceptable. Furthermore, the errors of IBP and NIBP for the women was less than for the men.

 A study conducted by Lehman LW during 2001-2007 showed that for hypotensive patients, invasive blood pressure (IBP) is more accurate also in ICU (Intensive Care Unit) the elected method was IBP (7). Krishna BV et al. compared accuracy of different blood pressure measurement methods in critically ill children and manifest that the less-error method for children is IBP (8). A study conducted by Lakhal K in intensive care unit patients confirmed that continuous non invasive arterial pressure is not as reliable as invasive method (9); but in the study of Langwieser N in 30 patients treated in the CICU of a German university hospital the new non invasive techniques (radial artery applanation tonometry with T-line 200 pro device) showed reasonable accuracy versus invasive method (10)[a],.

For monitoring blood pressure noninvasively in different situations, some techniques are available. In this study, the oscilometric and auscultatory techniques were compared which were in the same level of accuracy. As the systematic review

and meta-analysis study conducted by Duncombe SL showed there are no significant differences in blood pressure measured in both techniquesin the pediatric population (11). In the other hand a study conducted by Alfano G in Forty hemodynamically stable hemodialysis patients expressed that auscultatory method is significantly more reliable than oscillometric method, especially in patients with a high prevalence of vasculopathy (12). An other systematic review and meta-analysis study conducted by Park SH in 2019 showed a very high heterogeneity between the studies. The oscillometric devices showed different result in blood pressure determination according to the product type (13).

 present study showed that systolic and diastolic blood pressure in women was less than men, also the mean error of both IBP and NIBP methods for women was less. Based on Briant LJB's study hemodynamic variables are different between men and women. Mechanisms that control blood pressure are affected by the sex and age; Young women are at the less risk of hypertension compared with the men in the same age. By aging the risk of hypertension, increase for both sex but for women after menopause this increasing is more perceptible (14).

The agreement between present study and previous studies in different location confirmed the reliability and subtillity of Iranian device made by

Pooyandegane rahe salamat company. In addition, based on results the preferable blood pressure determination method for unstable hemodynamic and critically ill patients is invasive blood pressure, but for stable hemodynamic patients, non invasive methods are nearly as acceptable as invasive methods by less side effects.

Conclusion:

The most reliable method for blood pressure measurement is IBP. The accuracy of all methods is affected by different conditions. It is offered for next studies to investigate different methods in people with different BMI.

Authors' Contributions:

All the listed authors were equally involved in preparation of manuscript. All authors have approved the final version of manuscript.

Conflict of Interest Disclosures:

There are no conflicts of interest in terms of the present manuscript.

Ethical approval/Consideration:

This study was registered at ethics committee of Islamic Azad University of Najafabad, Isfahan, Iran. A written informed consent was taken from patients for participating in this study. All the personal information remained anonymous.

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