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# Accuracy Assessment of Measured Blood Pressures in Three Departments of one Tertiary Hospital

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**Abstract**

**Background:** Auscultatory methods with a mercury sphygmomanometer had been approved as BP measurement method. Decline in accuracy of BP measurement might lead to pitfalls in diagnosis and management of patients. Present study was performed for assessment differences between standard and routine measurement of blood pressure in study wards.

**Methods:** Present clinical survey was performed for assessment quality and accuracy of sphygmomanometers which had been used in three main wards of a tertiary educational hospital. Blood pressure of patients which measured by trained clinical resident with new calibrated sphygmomanometers was considered as standard values of systolic and diastolic blood pressures and compared with recorded blood pressures in the check list of patients hospital beds.

**Results:** In the clinical survey 86 patients were included into the study. Correlation coefficient between two measurements was 0.82 and 0.59 in systolic and diastolic blood pressure (P = 0.00). Mean and standard deviation of differences between standard and routine systolic and diastolic blood pressures had significant differences (7.62 ± 12.69 and 6.39 ± 11.55 mmhg; P = 0.00).

**Conclusion:** one of the possible causes of difference between routine and standard measured blood pressures in the present study was lack of calibration in a sphygmomanometer and this defect was also the easier problem to correct by change of dam-

aged portions. Findings of our study showed that physicians did not reliance only to routine blood pressure measurements for clinical decision making about patients due to several confounding variables that had impact on measurements.

**Keywords:** Accuracy; Blood pressure; Sphygmomanometer

## Introduction

Accurate measurement of blood pressure (BP) is one of the essential parts of management of hypertensive patients and research. Auscultatory methods with a mercury sphygmomanometer had been approved as BP measurement method (1-3). Some problems might occur in this measurement method and known as confounding parameters. Firstly training of health care workers was complex and time consuming. Secondly we had few studies for accuracy comparison between health care centers and personnel. Tertiary, we had potential for environment contamination due to mercury spills (4).

World health organization reported hypertension as first in women and second cause of mortality in men (5). Other epidemiological studies on general population reviled that blood pressure abnormalities is related to cardiovascular disorders (6)

In health care, BP is measured using devices that classified as manual of automatic. Human judgment had main role in manual devices in determination of systolic and diastolic pressure (7). In recent guideline of National Institute of Health and Clinical excellence (NICE) produced guideline for management of hypertension in adult and this management focused on accurate BP measurement (8). Although accurate BP measurement is essential for BP management, measurement of this vital sign is challengeable and has low accuracy in some clinical settings (9). Decline in accuracy of BP measurement might lead to pitfalls in diagnosis and management of patients (10). Accurate devices with are suggested for better diagnosis and control of blood pressure in clinical setting specially in hospitalized patients (11). Indirect measurement of blood pressure with standard silver sphygmomanometers was common method in clinical care and management of hypertensive patients (12). Present study was performed for assessment differences between standard and routine measurement of blood pressure in three wards of one educational hospitals of Shahid Beheshti University of medical sciences. Within the study consistency

rate of two measurements methods was assessed.

**Patients and Methods**

Present clinical survey was performed for assessment quality and accuracy of sphygmomanometers which had been used in three main wards (surgery, internal medicine and nephrology) of a tertiary educational hospital (Shohadaye Tajrish) of Shahid Beheshti University of medical sciences and health services. All of adult (more than 18 years old) hospitalized patients had eligibility for including into the study and among them, 86 patients (38 male patients) were randomly selected. Present study was approved in ethical committee of Shahid Beheshti University of medical sciences.

In the present study measured blood pressure of patients which were written in the check list of their hospital beds were compare with standard values. In standard measurements, one clinical resident were selected and educated in two one hour sessions according to American Heart Association (AHA) recommendation for measuring blood pressure. For practical test, blood pressures of some volunteers were measured by clinical resident and his teacher. Measuring method of clinical resident were improved until four mmhg difference between himself measurements and his teachers. Blood pressure of patients which measured by trained clinical resident with new calibrated sphygmomanometers was considered as standard values of systolic and diastolic blood pressures and compared with recorded blood pressures in the check list of patients hospital beds. For selecting calibrated devices, we fill sphygmomanometers until 250 mmhg and observed them in the next 10 seconds. Decline same or more than 10 mmhg in the pressure was considered as air leakage. Similar assessments were repeated for 50 and 150 mmhg.

**Statistical analysis**

Mean, standard deviation and difference between mean and absolute difference were measured in two measuring methods. Paired t-test was used for comparing recorded blood pressure with blood pressure that measured with standard method. Inter class Correlation Coefficient (ICC) was used for correlation analysis between two measuring blood pressures. We determined frequency of measured blood pressure near to patients' hospital bed with more than five and ten millimeter of mercury (mmhg) from standard blood pressure. We Considered 140 mmhg and 90 mmhg as standard values for systolic and diastolic blood pressure measurement. Kappa index

calculated for measuring inter-rate agreement between high measured blood pressures with two methods.

**Results**

In the clinical survey 86 patients (25 patients in surgery, 48 patients in internal medicine and 13 patients in nephrology wards) were included into the study. Mean of age in study patients was 35 ± 4.03 years old and 38 patients were male. Mean of routine and standard systolic blood pressure in study patients were 115.47 ± 17.55 and 123.08 ± 22.07 mmhg respectively.

Mean of routine and standard diastolic blood pressure in study patients were 69.24 ± 11.21 and 75.64 ± 13.76 mmhg respectively. Correlation coefficient between two measurements was 0.82 and 0.59 in systolic and diastolic blood pressure (P = 0.00). Mean and standard deviation of differences between standard and routine systolic and diastolic blood pressures had significant differences (7.62 ± 12.69 and 6.39 ± 11.55 mmhg; P = 0.00).

In dividing patients into the normal and high blood pressure; routine blood pressure only showed eight patients with high blood pressure whereas standard measurement methods showed 21 patients with high blood pressure. Consistency analysis show significant differences between two measurements (Kappa = 0.40; P = 0.00). In diastolic blood pressure measurement, routine blood pressure detected only five patients with high diastolic blood pressure and in standard measurement; we had 16 patients with high diastolic blood pressure. In consistency analysis, two measurements were not consistent (Kappa = 0.11; P = 0.21).

In the present survey, we detected patients with more than five and ten mmhg differences between routine and standard measurements. Among 86 measurements of blood pressure, 31 (36%) measurements had more than 10 mmhg and 43 (50%) patients had more than five mmhg differences between routine and standard blood pressure.

**Blood pressure measurements in surgery ward**

Mean of routine and standard systolic blood pressure measurements were 116.15 ± 18.68 mmhg and 123.75 ± 24.55 mmhg respectively. In about diastolic blood pressure noted blood pressures were 71.77 ± 9.97 mmhg and 77.19 ± 14.36 mmhg respectively. Correlation analysis showed high and significant ICC between two measurements (systolic: ICC = 0.87, P = 0.00; diastolic: ICC = 0.67, P = 0.00). Findings of our analysis showed that difference between routine and standard blood pressure level in study patients

was significant in systolic (7.60 ± 12.24, P = 0.00) and diastolic blood pressures (5.42 ± 10.71, P = 0.001). In the other hand standard systolic blood pressure was significantly higher and standard diastolic blood pressure was significantly lower than same systolic and diastolic routine blood pressure measurements (P = 0.00). Routine measurements can detect five patients with high blood pressure among 10 patients (Kappa = 0.61, P = 0.00). In diastolic blood pressure, routine method determined only three patients with high diastolic blood pressure among 10 patients (kappa = 0.23, P = 0.04). In surgery ward, 18 (37.5%) patients had more than 10 mmhg and 23 (47.9%) had more than five mmhg difference between standard and routine blood pressure measurements. (Table 1)

**Blood pressure measurements in internal medicine ward**

Mean of routine and standard systolic blood pressure measurements were 114.80 ± 15.64 mmhg and 124.80 ± 19.49 mmhg respectively. In about diastolic blood pressure noted blood pressures were 66.40 ± 9.85 mmhg and 74.40 ± 12.85 mmhg respectively. Correlation analysis showed high and significant ICC between two measurements (systolic: ICC = 0.82, P = 0.00; diastolic: ICC = 0.69, P = 0.00). Findings of our analysis showed that difference between routine and standard blood pressure level in study patients was significant in systolic (10 ± 11.18, P = 0.00) and diastolic blood pressures (8 ± 9.35, P = 0.00). In the other hand standard systolic blood pressure was significantly higher and standard diastolic blood pressure was significantly lower than same systolic and diastolic routine blood pressure measurements (P = 0.00). (P = 0.00). Routine measurements can detect one patient with high blood pressure among 9 patients (Kappa = 0.14, P = 0.17). In diastolic blood pressure, routine method did not determine any patients with high diastolic blood pressure among four patients. In internal medicine ward, 10 (40%) patients had more than 10 mmhg and 11 (44%) had more than five mmhg difference between standard and routine blood pressure measurements. (Table 1)

**Blood pressure measurements in nephrology ward**

Mean of routine and standard systolic blood pressure measurements were 114.23 ± 17.89 mmhg and 117.31 ± 16.91 mmhg respectively. In about diastolic blood pressure noted blood pressures were 66.40 ± 9.85 mmhg and 72.31 ± 13.33 mmhg respectively. Cor-

relation analysis showed high and significant ICC between two measurements in systolic (ICC = 0.56, P = 0.04) and non-significant in diastolic pressure (ICC = 0.27, P = 0.36). Findings of our analysis showed that difference between routine and standard blood pressure level in study patients was significant in systolic (13.08 ± 9.69, P = 0.00) and diastolic blood pressures (15.77 ± 10.18, P = 0.00). Routine measurements can detect all of patient with high blood pressure as the same with standard method (Kappa = 0.41, P = 0.14). In diastolic blood pressure, routine method detect all of two patients with high diastolic blood pressure as the same as with standard method. In nephrology ward, three (23.1%) patients had more than 10 mmhg and 9 (69.2%) had more than five mmhg difference between standard and routine blood pressure measurements. (Table 1)

**Table 1.** Mean and Standard Deviation of Standard and Routine Blood Pressure Measurements among Study Patients

| | | |
|---|---|---|
| **Surgery ward** | | |
| Systolic blood pressure | Standard | 123.75 ± 24.55 |
| | Routine | 116.15 ± 18.68 |
| | ICC | 0.87 |
| | P-value | 0.00 |
| Diastolic blood pressure | Standard | 71.77 ± 9.97 |
| | Routine | 77.19 ± 14.36 |
| | ICC | 0.67 |
| | P-value | 0.00 |
| Internal Medicine ward | | |
| Systolic blood pressure | Standard | 124.80 ± 19.49 |
| | Routine | 114.80 ± 15.64 |
| | ICC | 0.82 |
| | P-value | 0.00 |
| Diastolic blood pressure | Standard | 66.40 ± 9.84 |
| | Routine | 74.40 ± 12.86 |
| | ICC | 0.69 |
| | P-value | 0.00 |
| Nephrology ward | | |
| Systolic blood pressure | Standard | 117.31 ± 16.90 |
| | Routine | 114.23 ± 17.89 |
| | ICC | 0.56 |
| | P-value | 0.04 |
| Diastolic blood pressure | Standard | 65.38 ± 15.74 |
| | Routine | 72.31 ± 13.32 |
| | ICC | 0.27 |
| | P-value | 0.36 |

**Discussion**

In our study correlation between measured blood pressure with routine and standard methods were suitable for systolic and weak for diastolic blood pressure. Findings of our study showed that health care workers in study hospital wards had underestimation for BP measurement using routine method. It seems that diastolic blood pressure had lower correlation coefficient in compare with systolic blood pressure due to narrow changing range. In detecting patients with high blood pressure, standard method had more patients than routine method and their consistency in systolic blood pressure was intermediate to weak and in diastolic blood pressure was not significant due to lower patients with high diastolic blood pressure. There were some peoples with more than five or ten difference between blood pressure measurement with routine and standard methods.

Previous reports believed that stethoscope pressure (9) incorrect selecting of Korotkoff sounds (9, 13), tendency to select non digit number and conversation within the measurements. In measurement of diastolic blood pressure might be due to auscultator gap, preferring non digit numbers (14) and bad position without arm support (9, 13). In our study, clinical resident was trained and occurrence probability of these defects was low. In our study some confounding variables such as cardiovascular disorders especially in obese patients might have difficulty in blood pressure measuring, time period between standard and routine blood pressure measurements, blood pressure measuring in same arm with standard position of patients, blindness of clinical resident and health care workers about recorded blood pressure of patients.

This study showed that approximately one-third of sphygmomanometers were inaccurate. This amount didn't include those instruments with physical problems such as air leak. It means that totally three out of four blood pressure measurements may be false and inaccurate.

Oscillometric or automated devices for BP measurement operate via detection of the variation in pressure oscillations caused by arterial wall movement under the cuff, which enables a systolic, mean arterial and diastolic BP to be measured (15). The perceived benefits of the electronic (oscillometric) devices are that they are more accurate, less time-consuming and labour intensive and require less concentration for use (15). In addition, they can be used

in noisy surroundings and provide a reading when sounds are faint, such as with obese patients (16). Another advantage relates to their use in clinical settings, where use of oscillometric devices may result in greater 'within-subject' reliability than conventional readings, because of the absence of digit preference, observer bias and compared white coat effect (17).

## Conclusion

One of the possible causes of difference between routine and standard measured blood pressures in the present study was lack of calibration in a sphygmomanometer and this defect was also the easier problem to correct by change of damaged portions. Despite these correctable features of the matter, the inaccurate sphygmomanometers are still an important problem in practice. Findings of our study showed that physicians did not reliance only to routine blood pressure measurements for clinical decision making about patients due to several confounding variables that had impact on measurements. Calibration of sphygmomanometers and teaching proper method of measuring blood pressure to health care workers can decrease difference between routine and standard measurements. Repeat blood pressure measuring in borderline or suspected patients,

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