Comparison of manual versus automated blood pressure measurement in intensive care unit, coronary care unit, and emergency room

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Original Article

Abstract

BACKGROUND: Accuracy of blood pressure (BP) measurement in clinical settings is one of the most concerns despite of promotion in techniques for the measurement of BP. Our aim was to compare automated versus manual BP measurement in intensive care unit (ICU), coronary care unit (CCU), and emergency room patients.

METHODS: Totally, 117 patients in ICU, CCU, and emergency department were registered in the study. Demographic information was recorded. The cardioset heart monitoring device was used for measuring BP and mercury sphygmomanometer with appropriate cuffs was used for manual method. Then, the mean BP of two methods was compared based on different age, sex, weight, and disease findings.

RESULTS: The mean systolic blood pressure (SBP) was 124.526 mmHg, with minimum and maximum of 123.111 and 125.940 mmHg, respectively (Cronbach's alpha = 0.893); furthermore, mean diastolic blood pressure (DBP) was 73.496 mmHg, with minimum and maximum of 72.718 and 74.247 mmHg, respectively (Cronbach's alpha = 0.852). SBP was significantly different between the two methods, and especially in patients below 60 years, hospitalized in ICU ward, overweight, mid-upper arm circumference below 27 cm, and with neurosurgery problems, it was higher by manual method ($P < 0.050$). Moreover, DBP was more in manual method in patients with female sex, below 60 years, hospitalized in ICU ward and with neurosurgery problems ($P < 0.050$).

CONCLUSION: The results of this study suggested that manual method in measurement of BP frequently shows higher BP, especially in patients admitted to hospitals-affecting up to 15 mmHg higher, and this discrepancy is more in critical situations.

Keywords: Intensive Care Unit, Coronary Care Unit, Automated, Manual, Blood Pressure

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Introduction

Accuracy of blood pressure (BP) measurement in clinical settings is one of the most concerns despite of considerable promotion in measurement techniques.[1,2] Manual BP measurement can be so accurate when using a device such as the mercury manometer which is similar to the mean awake ambulatory blood pressure (AABP).[2]

Recent studies demonstrate that an accurate BP measurement requires at least 14 minutes, including a period of rest and a conversation between physician and patient to reduce the white coat anxiety[3,4] which had low likelihood in routine clinics. This may lead to overestimate BP in healthy individuals.[5-7]

In recognizing the concerns about manual office blood pressure (MOBP) measurement, new techniques have been recommended. Proposals for improve assessment of BP status include greater reliance on home and 24 hours ambulatory BP monitoring.[8,9] This protocol eliminates white coat anxiety and receiving unnecessary drug treatment for hypertension in healthy individuals.[10] Advances in automated office blood pressure (AOBP) measurement provide a third option for accurate measurement of BP status which eliminates many factors influencing imprecise BP.[11-13]

Suokhrie et al.[14] showed that automated readings were averaged 3.9 points higher than manual method; and, based on these findings, a protocol was recommended in an acute care psychiatry unit that BP must be measured manually for each patient. In another study performed by Myers et al.[15] showed that the prevalence of masked hypertension was lower with AOBP compared with MOBP.

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Table 1. Mean difference of systolic blood pressure (SBP) and diastolic blood pressure (DBP) based on two methods and age group

BP	Age	Mean difference	Standard error mean	P
SBP	Below 60 years (n = 55)	3.20	1.28	0.016
	Over 60 years (n = 62)	3.70	1.32	0.090
DBP	Below 60 years (n = 55)	2.18	1.32	0.004
	Over 60 years (n = 62)	1.00	1.29	0.463

DBP: Diastolic blood pressure; SBP: Systolic blood pressure; BP: Blood pressure

We sought to evaluate the difference between automated and manual BP measurement in various clinical conditions among our patients over a 1-year period.

Materials and Methods

This cross-sectional study was conducted in Shariati Hospital of Isfahan, center of Iran, from August to December 2014. Patients hospitalized in intensive care unit (ICU) and coronary care unit (CCU) and emergency department were enrolled to study. Exclusion criteria were lack of patients' consent to participate to study.

Totally, 125 patients in ICU, CCU, and emergency department who had been hospitalized for different chief complaint had considered for the study. Eight patients refused consent for entering the study, so the study accomplished with 117 patients.

Demographic information for each patient was recorded, as well as height, weight, BP and mid-upper arm circumference (MUAC), and body mass index (BMI). Standardized questionnaire was used to obtain the information of alcohol consumption, smoking, and medications status.

The cardioset heart monitoring device was used for measuring BP with noninvasive BP cuff. Meanwhile, BPs were measured manually, by an adult size cuff and standard sphygmomanometer. BP of patients was measured based on American Heart Association (AHA) recommendation, and after 5-minute rest, BP was measured by automated machine. In manual method of measurement, appropriate cuff was chosen. In adults with MUAC < 28 cm, a cuff with size of 23 cm × 12 cm was chosen and with MUAC more than 28 cm, a cuff with size of 28 × 36 was chosen to record systolic BP (SBP) and diastolic BP (DBP).

Data are expressed as mean ± standard error for continuous variables. One sample t-test was used to detect differences between SBP and DBP from two methods. Intraclass correlation coefficient evaluated agreement between automated and manual BP measurements.

$P < 0.050$ was considered statistically significant. Data analysis was done using SPSS software (version 15, SPSS Inc., Chicago, IL, USA).

Results

During the enrollment period, 117 adults were seen in the CCU, ICU, and emergency department, and agreed to participate in our study. The mean age of patients was 60.9 ± 16.84. A total of 66.7% (n = 78) of patients were male.

The mean difference between SBP was 3.47 ± 0.89 mmHg (Cronbach's alpha = 0.893), furthermore, mean difference between DBP was 1.55 ± 0.93 mmHg, (Cronbach's alpha = 0.852). As obtained, SBP in patients below 60 years was significantly more in manual method compared to automatic method (P = 0.016), but not for cases over 60 years (P = 0.090), and DBP shows a significant difference between two methods in patients below 60 years too (P = 0.004), but not for cases over 60 years (P = 0.463) (Table 1).

Mean difference of DBP in female was 4.58 (P = 0.035); this difference is existed on the subject of systole too (P = 0.028) (Table 2).

Table 2. Mean difference of systolic blood pressure (SBP) and diastolic blood pressure (DBP) based on two methods and sex

BP	Gender	Mean difference	Standard error mean	P
SBP	Male (n = 78)	3.21	1.02	0.002
	Female (n = 39)	3.97	1.74	0.028
DBP	Male (n = 78)	0.04	0.88	0.965
	Female (n = 39)	4.58	2.09	0.035

DBP: Diastolic blood pressure; SBP: Systolic blood pressure; BP: Blood pressure

Table 3. Mean difference of systolic blood pressure (SBP) and diastolic blood pressure (DBP) based on two methods and ward

BP	Ward	Mean difference	Standard error mean	P
SBP	Emergency (n = 8)	−4.24	2.74	0.164
	CCU (n = 60)	0.02	0.98	0.968
	ICU (n = 39)	8.95	1.36	< 0.001
DBP	Emergency (n = 8)	−3.00	1.68	0.117
	CCU (n = 60)	−0.45	1.30	0.731
	ICU (n = 39)	4.75	1.40	0.001

DBP: Diastolic blood pressure; SBP: Systolic blood pressure; BP: Blood pressure; CCU: Coronary care unit; ICU: Intensive care unit

Moreover, both SBP and DBP were more in ICU patients by manual method. Mean difference of SBP was 8.95 (P < 0.001). Mean difference of DBP was 4.75 (P = 0.001) (Table 3).

As shown in table 4, mean difference of SBP was 4.40 in overweight patients (P = 0.002). Moreover, mean difference of SBP in patients with MUAC below 27 cm was 4.08 (P = 0.001) (Table 5).

Both SBP and DBP were more in neurosurgery patients in manual method. Mean difference of SBP was 10.9 (P < 0.001). Mean difference of DBP was 5.86 (P = 0.002) (Table 6).

On the strength of table of ranking base on differences between the two methods of measurement, automated SBP was higher mostly in obese patient, patients admitted in CCU and ones with cardiac complaint; on the other hand, manual SBP was higher mostly in overweight patients, patients admitted in ICU and ones with neurosurgery complaints. In this manner, automated DBP was higher in cases with multiple trauma, while, manual DBP was higher in neurosurgery cases, that almost all of them were ICU admitted.

Discussion

Based on our knowledge, this is the first independent, prospective, observational study on the potential association between BP measurement method and BP levels in Iran. The mean SBP was 124.526 mmHg, with minimum and maximum of 123.111 mmHg and 125.940 mmHg, respectively (Cronbach's alpha = 0.893). SBP was significantly different between the two methods, especially in patients below 60 years, hospitalized in ICU ward, overweight, MUAC below 27 cm, and with neurosurgery problems. Moreover, DBPs were more in manual method in patients with female gender, hospitalized in ICU ward, and with neurosurgery problems. In addition, on the basis of result of ranking table, more disagreement between two method was in critical cases.

Suokhrie et al.[14] revealed a significant difference between manual and automatic SBP readings (P < 0.050) so that automated readings averaged 3.9 points higher. No remarkable differences in diastolic readings (P = 0.720) were found. Care must be taken in using automated or manual BP readings in important clinical scenarios. According to these findings, a protocol was recommended in an acute care psychiatry unit that BP must be measured manually for all patients.

Myers et al.[16] showed that AOBP reduced office-induced hypertension. The decrease in MOBP was seen in participation in a research study, and it was not related to any specific intervention.

Myers et al.[17] demonstrated that using AOBP measurement in routine primary care significantly reduced the white coat response in comparison with MOBP assessment. AOBP measurement was more accurate than MOBP measurement regarding to AABP assessment.

Table 4. Mean difference of systolic blood pressure (SBP) and diastolic blood pressure (DBP) based on two methods and body mass index (BMI)

BP	BMI	Mean difference	Standard error mean	P
SBP	Normal (n = 40)	3.17	1.47	0.038
	Over weight (n = 58)	4.40	1.36	0.002
	Obese (n = 19)	1.26	1.83	0.501
DBP	Normal (n = 40)	0.55	1.63	0.738
	Over weight (n = 58)	1.18	1.07	0.272
	Obese (n = 19)	4.78	3.20	0.152

BP: Blood pressure; BMI: Body mass index; DBP: Diastolic blood pressure; SBP: Systolic blood pressure

Table 5. Mean difference of systolic blood pressure (SBP) and diastolic blood pressure (DBP) based on method and mid-upper arm circumference (MUAC)

BP	MUAC (cm)	Mean difference	Standard error mean	P
SBP	Below 27 cm (n = 58)	4.08	1.15	0.001
	Above 27 cm (n = 59)	2.86	1.36	0.040
DBP	Below 27 cm (n = 58)	0.51	1.15	0.626
	Above 27 cm (n = 59)	2.57	1.51	0.095

DBP: Diastolic blood pressure; SBP: Systolic blood pressure; BP: Blood pressure; MUAC: Mid-upper arm circumference

Heinemann et al.[18] showed agreement between automated and manual readings on one set of criteria for SBP and DBP. It was mentioned automated machine underestimated SBP and DBP by comparing of mean values of two methods.

They concluded that the Dinamap 8100 machine can be used with some degree of confidence to measure SBP in a general population, but its DBP measurements should be considered accurate cautiously.[18]

The manual BP measurement, especially with mercury sphygmomanometer has been used for more than 100 years. Regarding to advances in BP recording methods, mercury method seemed to be removed from the clinics, but, mercury sphygmomanometer remains available as a reference standard until an alternative device will be recognized as much.[19,20]

Studies comparing manual with automated BP measurement have shown that manual method has more levels. This difference can be decreased if some rules for automated method are followed: patients rest in a quiet room, and multiple readings considered to make a decision.[2] The presence of a white coat hypertension is likely, if marked decreases in automated method are seen by leaving the patient alone in the room.[21]

Physicians in practice can use several examining rooms for performing physical exam for patients. This measure is suitable for automated and manual method, even when the manual way is used by considering 5 minutes of rest before the BP recording. An important point for automated method is that patients should be seated in a quiet room for some minutes while readings are being taken. If only one or two readings are considered without adequate rest, a white coat effect would interfere with recordings, as seen with the first two readings taken by BpTRU device.[21] Adequate patients' rest, in addition, to use validated automated device with multiple recordings lead to accurate BP measurement.

Manual BP recording is highly dependent to environment condition. BP will be detected higher when taken by physicians instead of nurses, in treatment settings in comparison to non-treatment settings and at office instead of home.[22,23] Manual method may be 15-18 mmHg higher than the AABP if recorded in routine clinics.[8] Automated and AABP measuring methods was disagreed less than 3 mmHg in research and clinical settings.[2] Manual BP recording also decreases if a non-treatment setting such as an ambulatory BP monitoring unit be used instead of physician's office.[23] It is not true for AOBP measuring.[24]

Table 6. Mean difference of systolic blood pressure (SBP) and diastolic blood pressure (DBP) based on method and disease

BP	Disease	Mean difference	Standard error mean	P
SBP	Heart disease (n = 56)	0.32	0.99	0.748
	Internal and orthopedic disease (n = 18)	2.38	2.29	0.312
	General surgery (n = 9)	4.44	2.79	0.150
	Neurosurgery (n = 22)	10.9	2.24	< 0.001
	Multiple trauma (n = 8)	6.62	4.93	0.222
	Other diseases (n = 4)	3.00	1.77	0.190
DBP	Heart disease (n = 56)	−0.46	1.35	0.734
	Internal and orthopedic disease (n = 18)	4.61	2.60	0.095
	General surgery (n = 9)	0.88	2.25	0.703
	Neurosurgery (n = 22)	5.86	7.84	0.002
	Multiple trauma (n = 8)	−1.00	4.84	0.824
	Other diseases (n = 4)	−1.00	2.85	0.750

BP: Blood pressure; DBP: Diastolic blood pressure; SBP: Systolic blood pressure

Conclusion

The results of this study suggested that manual method in measurement of BP frequently show higher BP, especially in patients admitted to hospitals - affecting up to 15 mmHg higher - and is strongly associated with age, sex, different disease, and obesity.

Based on this study, we cannot completely trust to automatic findings in measurement of BP in hospital setting and especially in critical conditions, and manual method should be considered as a reference standard.

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Conflict of Interests

Authors have no conflict of interests.

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