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Original Research Article

Automated versus manual blood pressure measurement in the emergency- A comparative cross-sectional study

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Abstract

Introduction: Manual BP measurement is associated with white-coat anxiety which may lead to overestimation of BP. Use of ABP device may alleviate the problem and allow emergency physicians and nurses to focus on other resuscitative procedures. ABP also alleviates inter-operator variability. Hence this study was conducted to compare the difference between the blood pressure readings measured by automated method and manual method and to compare the measured blood pressure readings and correlate them with respect to gender and mid arm circumference.

Materials and Methods: Conducted in a tertiary care hospital, involved 684 patients. A trained Emergency physician operated the Automated device. The blood pressure was taken in the left arm. Average of these readings was taken as the BP. Bland-Altman plots were used to assess the limits of agreement. The data was analyzed using SPSS version 21.

Results: 89 patients were detected hypotensive by MBP while ABP could detect hypotension in only 71.9% (64) of these patients. 75 (100%) patients diagnosed as hypertensive by the MBP were detected as hypertensive by ABP. 38 patients were hypotensive on MBP, ABP detected 84.2 % (32) of the patients. Bland and Altman analysis showed that the limits of agreement are 21.19 to -5.89 for SBP and 19.78 to -4.55 for DBP. Our device obtained a BHS grading of C for both SBP and DBP. As per the AAMI criteria, the standard deviation between ASBP and MSBP was 6.91 with a mean of 7.65. The standard deviation between ADBP and MDBP was 6.21 with a mean of 7.15.

Conclusion: We conclude that the ABP can be used with some degree of confidence to assess the blood pressure of walk in-patients with normotension and hypertension but care should be taken when taking BP readings for patients with hypotension and prehypertension.

Keywords: Automated blood pressure, Manual blood pressure, Emergency department, triaging.

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1. Introduction

BP monitoring is consistently performed in the Emergency as a routine investigation and is often done using different methods and devices making the readings often incomparable between different settings [1,2]. It is very important to measure the blood pressure correctly since wrong measurements can lead to under or over treatment of the patient [3].

Blood pressure monitoring can be done using Automated Blood Pressure (ABP) device or the conventional manual device [4]. For clinical use, the acceptable limit of the difference between ABP and manual monitoring is 5mmHg (Advancement of Medical Instrumentation (AAMI) validation protocol) [5].

The gold standard for measuring arterial blood pressure is a direct intra-arterial measurement but this technique is not practical for repeated measurements. Thus, the indirect method of measuring is commonly used where the BP is determined by the use of a sphygmomanometer [6,7].

In a few studies, automated readings averaged higher than the manual method. It is also seen that the prevalence of masked hypertension is lower with ABP rather than manual BP monitoring as the direct interaction between the doctor and the patient is bypassed [7,8]. Contrary to this, ABP readings have been more reliable in few studies which have shown manual readings to have higher values, especially in patients above the age of 65.

Under-treatment of hypertension has been a great concern in recent years [9].

Aneroid devices are less likely to remain calibrated. Automated blood pressure devices for both in-office (AOBP) and ambulatory (ABPM) measurement help to eliminate these pitfalls and support more accurate hypertension diagnoses [10]. ABP resolves the problem of observer bias and observer skill and also alleviates the problem of white coat anxiety

Use of Automated BP device may allow emergency physicians and nurses to focus on other resuscitative procedures and has the potential to alleviate inter-operator variability. To the best of our knowledge, there are no studies in Indian population to compare the two methods of blood pressure measurement in Emergency. Hence this study was undertaken to compare the accuracy of ABP and manual monitoring of blood pressures in the Emergency Department.

2. Materials and methods

This cross-sectional study was conducted in the Emergency Department of a tertiary care super specialty hospital in New Delhi. A total of 684 patients were selected by random sampling. The study was carried out for 3 months from January to March 2020. Institutional Scientific and Ethics Committee approval was obtained. Informed consent was obtained from the patients.

All patients who presented to the emergency, aged more than 18 years and willing to give consent were included in the study. Patients not willing to give consent, pregnant females, patients having an AV fistula in the left hand and patients who left the Emergency due to discharge, transfer or death within 30 minutes of the 1st BP reading were excluded from the study. Measurement of BP was done using the following devices-ABP (Mindray Umec 10; SN-KN93039193), Aneroid sphygmomanometer (Welch Allyn Flexiport BP cuff- Adult 11) for arm circumference 25 to 33cm and Aneroid sphygmomanometer (Welch Allyn Flexiport BP cuff- Adult 12) for arm circumference 33-43.

A single Emergency physician was trained on how to use the automated device according to the user manual. The BP monitor screens were faced away from the patient during the measurements. The aneroid sphygmomanometer and the ABP were used alternately to take three BP measurements, first by manual method and then by automated. Patients were examined in supine position. The blood pressure was taken in the left arm. An interval of 10 minutes was kept between all 3 readings. Average of these three readings was taken as the BP.

The patients were categorized as per the Joint National committee 8 classifications [13] in hypotensive, normotensive, prehypertensive and hypertensive. They were also categorized based on the Mid arm Circumference [14] as underweight, normal, overweight, obese and morbidly obese.

The data was analyzed using SPSS version 21. Results were expressed in proportions and standard derivations. Chi-square test, kappa test and T test were used to test statistical significance. P value of <0.05 was considered significant.

3. Results

A total of 684 patients were included in the study, out of which 397 (58%) were males and 287 (42%) were females. The age of the study population ranged from 18 to 97 years with a mean age of 52.9 years. Mean MAC was 25.9 cm. Mean manual systolic BP was 114.9/76.3 mmHg and mean automated BP was 122.6/84 mmHg. A total of 178 (26%) patients were more than 65 years, 266 (38%) patients were between 45 and 65; remaining 240 (35%) patients were between 18-65 years.

A total of 89 patients were detected hypotensive by MBP while ABP could detect hypotension in only 71.9% (64) of these patients. 251 patients were detected normotensive by MBP whereas ABP could detect normotension in 91.6% (230) patients. Out of 227 patients, who were detected pre-hypertensive by MBP while ABP could detect only 77.1% (175) patients as pre-hypertensive. A total of 117 patients were detected hypertensive by MBP. ABP detected all hypertensive patients. (Table 1)

Table 1: Association between Manual and Automated BP Measurement

Automated SBP	Manual SBP				Total
	Hypotensive	Normotensive	Pre-Hypertensive	Hypertensive	
Hypotensive	64 71.9%	0 0.0%	0 0.0%	0 0.0%	64 9.4%
Normotensive	25 28.1%	230 91.6%	0 0.0%	0 0.0%	255 37.3%
Pre-Hypertensive	0 0.0%	21 8.4%	175 77.1%	0 0.0%	196 28.7%
Hypertensive	0 0.0%	0 0.0%	52 22.9%	117 100.0%	169 24.7%
Total	89 100.0%	251 100.0%	227 100.0%	117 100.0%	684 100.0%
Measure of agreement (Kappa Value)	0.712	0.856	0.721	0.772	

Out of total 51 male patients detected as hypotensive by MBP, 32(62,.7%) were found to be having similar BP range by ABP method while19 (37.3%) male patients were labelled as normotensive by ABP. Out of 138 normotensive males in MBP category, 11 (8%) were found to have pre-hypertension with automated BP recording. Total 133 males were pre-hypertensive with MBP recording and out of those 32 (24.1%) males were hypertensive in automated recording. All 75 (100%) patients diagnosed as hypertensive by the MBP were detected as hypertensive by ABP.

A total of 38 female patients were hypotensive on MBP, ABP detected 84.2 % (32) of the patients. Out of 113 normotensive females in MBP category, 10 (8.8%) were found to have pre-hypertension with automated BP recording. Total 94 females were pre-hypertensive with MBP recording and out of which 20 (21.3%) females were hypertensives in automated recording. (Table 2)

Table 2: Association between Automated and Manual Measurement in Males and Females

Automated SBP	Manual SBP							
	Hypotensive		Normotensive		Pre-Hypertensive		Hypertensive	
Gender	Male	Female	Male	Female	Male	Female	Male	Female
Hypo-tensive	32 62.7%	32 84.2%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%
Normo-tensive	19 37.3%	6 15.8%	127 92.0%	103 91.2%	0 0.0%	0 0.0%	0 0.0%	0 0.0%
Pre-Hypertensive	0 0.0%	0 0.0%	11 8.0%	10 8.8%	101 75.9%	74 78.7%	0 0.0%	0 0.0%
Hyper-tensive	0 0.0%	0 0.0%	0 0.0%	0 0.0%	32 24.1%	20 21.3%	75 100.0%	42 100.0%
Total	51 100.0%	38 100.0%	138 100.0%	113 100.0%	133 100.0%	94 100.0%	75 100.0%	42 100.0%
MEASURE OF AGREEMENT								
Males	FISHER'S EXACT TEST= 0.001				KAPPA VALUE= 0.610			
Females	FISHER'S EXACT TEST= 0.001				KAPPA VALUE= 0.563			

A total of 61 patients were underweight. Out of which 48 were found to be hypotensive, 7 were pre-hypertensive and 6 were hypertensive on MBP. 31 were found to be hypotensive, 6 were pre-hypertensive and 7 were hypertensive on ABP. Out of the 257 patients were within normal MAC range,41 were found to be hypotensive, 22 were pre hypertensive and 29 were hypertensive on MBP. 33 were found to be hypotensive, 35 were pre-hypertensive and 29 were hypertensive on ABP. A total of 366 patients were over the normal MAC range. None of the patients were hypotensive, 86 patients were found to be normotensive, 198 were pre hypertensive and 82 were hypertensive on MBP. However, none of the patients were hypotensive. Out of the same, 78 patients were found to be normotensive, 155 were pre hypertensive and 133 were hypertensive on ABP. (Table 3)

Table 3: Association between MAC categories and Manual BP measurement

MAC Category	Blood Pressure Categories								Total	Measure of Agreement
	Hypotensive		Normotensive		Pre Hypertensive		Hypertensive			
	MBP	ABP	MBP	ABP	MBP	ABP	MBP	ABP	MBP ABP	Kappa Value
Underweight	48 78.7%	31 50.8%	0 0.0%	17 27.9%	7 11.5%	6 9.8%	6 9.8%	7 11.5%	61 100.0%	0.489
Normal	41 16.0%	33 12.8%	165 64.2%	160 62.3%	22 8.6%	35 13.6%	29 11.3%	29 11.3%	257 100.0%	0.853
Over-weight	0 0.0%	0 0.0%	86 38.9%	78 35.3%	86 38.9%	77 34.8%	49 22.2%	66 29.9%	221 100.0%	0.829
Obese	0 0.0%	0 0.0%	0 0.0%	0 0.0%	89 73.0%	68 55.7%	33 27.0%	54 44.3%	122 100.0%	0.637
Morbidly-Obese	0 0.0%	0 0.0%	0 0.0%	0 0.0%	23 100.0%	10 43.5%	0 0.0%	13 56.5%	23 100.0%	Cannot be computed.
Total	89 13.0%	64 9.4%	251 36.7%	255 37.3%	227 33.2%	196 28.7%	117 17.1%	169 24.7%	684 100.0%	

The Bland and Altman analysis showed that the limits of agreement are 21.19 to -5.89. The graph (Figure 1) shows that the difference is mostly within the acceptable limits. The reading by automated method is mostly greater than reading by manual method. On average, the difference of SBP between the two methods is 7.65.

For Diastolic Blood Pressure, the limits of agreement are 19.78 to -4.55. The graph (Figure 2) shows that the difference is within the limits, implying the agreement between the readings by automated method and manual method. On average, the difference of DBP between the two methods is 7.61, ABP measuring higher DBP compared to the manual method.

Our device obtained a British Hypertension Society (BHS) grading of C for both SBP and DBP. As per the AAMI criteria, the standard deviation between ASBP and MSBP was +/-6.91 with a mean of 7.65. The standard deviation between ADBP and MDBP was +/-6.21 with a mean of 7.15 with a p value <0.001.

Figure 1: Bland-Altman Plots for SBP

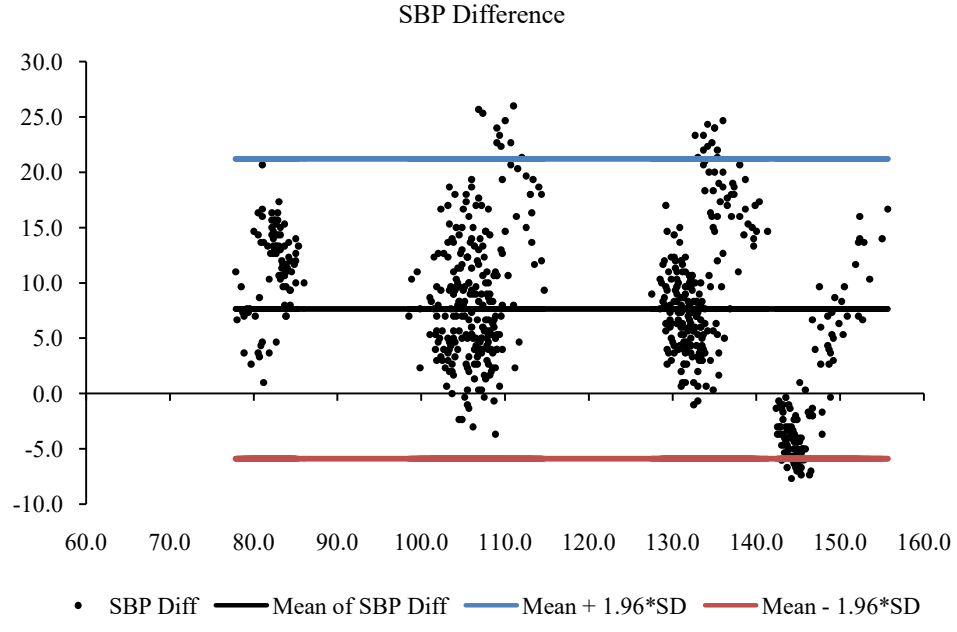
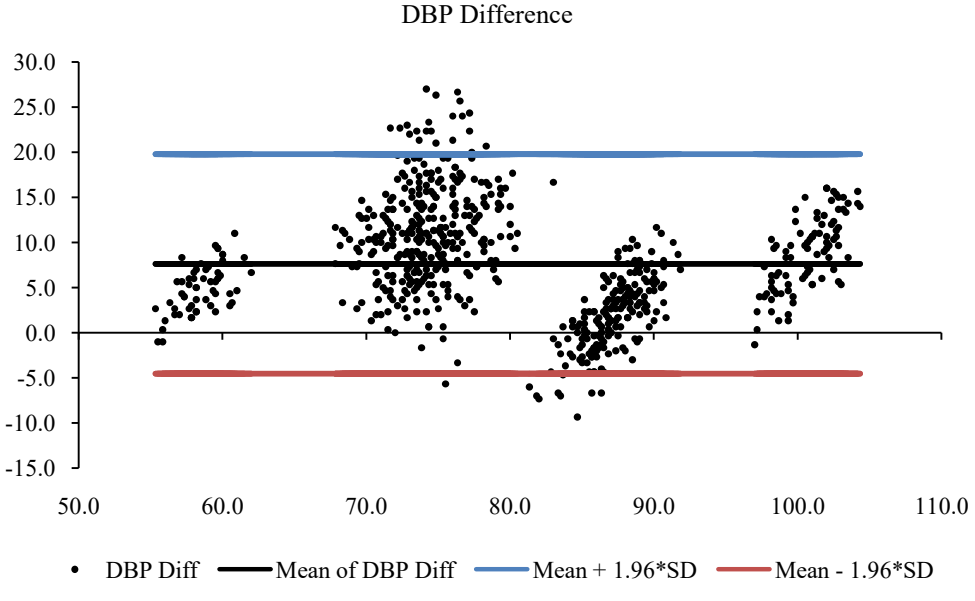


Figure 2: Bland-Altman Plots for DBP



4. Discussion

Automated blood pressure was developed to standardize blood pressure measurement in the clinical setting. However, the problem with automated devices is the cost of machine, the reliability of the device and difference in reliability of different devices [5]. The inaccuracy of automated over manual monitoring has been reported with regards to the failure of automated monitoring to reliably detect orthostatic hypotension in patients at the ER in triage [15]. Automated devices have the potential to provide false readings, especially on the first inflation, patient discomfort, and the need to regularly calibrate the machine. Automated and AABP measuring methods was disagreed less than 3 mmHg in research and clinical settings [16-17].

In our study, we found that the manual and automated BP measurements could be used interchangeably (kappa value >0.5 and p value <0.05). However, we also inferred that the automated BP devices exaggerate the readings and it can be a concern when a hypotensive individual is considered as a normotensive or a pre-hypertensive individual is considered as a hypertensive individual, which may affect therapeutic decisions. This was also noticeable in underweight and obese patients. It can have serious implications and affects the prognosis of the patients in an adverse manner. The standard deviation was 6.91mmHg for SBP and 6.21mmHg for DBP which was within the AAMI criteria but failed to comply with the mean difference criteria. (SBP 7.65mmHg and DBP 7.15mmHg)

Previously, study by Clenki JJ, Deluca LA and Daniel N failed to evaluate ABP devices against accepted reference standards or demonstrate triage readings as accurate reflections of blood pressure. They evaluated ED triage measurements made using an ABP device and assessed agreement between triage BP and BP taken under recommended conditions. The ABP device was assessed using Association for the AAMI and BHS criteria. The ABP device failed to meet AAMI criteria and received a BHS rating of "D." Poor operator technique and extraneous patient and operator movement appeared to hamper accuracy. [4]

The results of our study suggested that automated method in measurement of BP frequently show higher BP, especially in patients admitted to ER (Emergency) - affecting up to 6 mmHg higher - and is strongly associated with age, sex and obesity. Based on this study, we cannot completely trust the automated BP findings in measurement of BP in ER setting and especially in critical conditions, and manual method should be considered as a reference standard.

We recommend that automated and manual devices can be used interchangeably for walk in patients in Emergency Room. An experienced nursing staff should take the BP in critical patients. The first measurement for red or yellow triage category patient in the Emergency should be taken by the manual method and automated method can be utilized for further follow up. Similarly, it should be done for underweight and obese patients. Care should be taken when labelling a patient hypertensive or hypotensive. The hypotensive patients should be monitored meticulously in conjunction with clinical presentation. ABP should not be used during resuscitation in critical patients. IABP should be considered wherever possible.

However, our study did have few limitations. Manual blood pressure measurement is subjected to intra-observer variation. An experienced staff was always needed to check BP with precision. Automated BP device was calibrated multiple times to maintain adequate functionality. Pregnant females and patients with AV fistula were excluded and only 1 device was used during the study due to lack of availability.

From this study, we conclude that the ABP machine can be used with some degree of confidence to assess the blood pressure of general Emergency walk in-patients with normotension and hypertension but care should be taken when taking BP readings for patients with hypotension and prehypertension.

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