ORIGINAL ARTICLE

INACCURACY OF NONINVASIVE BLOOD PRESSURE MONITOR DEVICES, DO WE HAVE AN ALTERNATIVE?

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ABSTRACT

Background: Blood pressure (BP) is obligatorily measured each time a patient visits Emergency room (ER) or is admitted in ICU/CCU. Accuracy of blood pressure measurement in clinical settings is the key to appropriate diagnosis of hypertension in a patient. It remains elusive, however, whether oscillatory automated BP measurement yields lower values than auscultatory manual methods. It has been witnessed that both the devices give different readings of the same patient at one point in time. This study helped to determine the accurate or more reliable of the two devices.

Methods: A double-blind randomized clinical cross over trial was carried out at Ziauddin University Hospital from February 2018 to June 2018. Sample of 100 was taken through random sampling. The device used in this study was the Dinamap Procare 100. SPSS 20 was used for data entry and analysis.

Results: The mean of difference in systolic manual Blood Pressure (sMBP) and systolic automated Blood Pressure (sABP) was estimated to be 15.62 with a standard deviation of ± 8.57, while the mean of difference in diastolic MBP and ABP was 12.6 with a standard deviation of ± 24.7. Both systolic and diastolic readings were far low by automated devices in comparison to Manual devices.

Conclusion: The results of this study suggested that automated method in measurement of BP frequently shows lower BP. This can influence diagnosis of hypertension and management of certain medical conditions.

KEYWORDS: Blood Pressure Calibration; Hypertension; Intensive care Unit; Emergency room.

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INTRODUCTION

Hypertension is known as a silent killer and affects more than 1 billion people worldwide.1

It has a negative impact on various body organs. It speeds up the process of arterial stiffness and atherosclerosis resulting in cerebrovascular disease, myocardial infarction, congestive heart failure, stroke, ischemic cardiac and end-stage renal disease as well as dementia.2

Antihypertensive drugs seem to be one of the most frequently prescribed medications worldwide.

Hypertension can rupture tiny and delicate blood vessels of the kidneys and eyes. In order to avoid these complications, caused independently by hypertension, it is mandatory to monitor blood pressure continuously so that early diagnosis is made and prompt treatment is initiated.

The high prevalence of hypertension in both developed and developing countries makes it a signifi-
The findings of present study suggested that home intervention in arm volume after decongestive therapy showed improved quality of life in relation to reduced arm and forearm after home based intervention. The results are in support with the previous literature of lymphatic drainage is still under debate and gestive lymphatic therapy for patients with arm oedema following treatment for breast cancer: radiotherapy and chemotherapy (CMF or AC) in patients with breast cancer: a matched pair case-control study. Lymphology 2002;35(2):59-71.


ER and ICU both are the most crucial places in a hospital where swift and accurate working techniques have to be adopted so that prompt diagnosis can be grafted. These tactics become the basis of low mortality affiliated to a hospital.

Patients with the complaints of altered mental status and chest pain were excluded because it was not appropriate to subject them to double BP calibrations due to either critical condition or non-cooperation. In addition to this patients who had a history of smoking were not included in the study because they have a good chance of variability in the readings.

Data was analyzed by version 20 of SPSS. Test of significance was T test and p value <0.05 was taken as significant.

The Performa that was filled by staff nurses comprised of questions like, name of the device, presenting complaint, history of smoking or any co morbid. Randomization was done by sealing patients envelop with filled performas. The crossover was performed by taking manual then automated or automated and then manual measurements.

RESULTS

Mean age of participants was 44.17 with a standard deviation of ±13.6. There were 53 male subjects and 47 female. 31 samples were obtained from ER where as 69 from the ICU. Thorough history and examination was carried out. 22 patients out of the total 100 had diagnosed hypertension. Majority of the patients (41%) had cardiac issues followed by other diseases (36%), surgical (14%) and lastly obstetric/gynaecological (9%). This is further elaborated in Figure 1.

![Figure 1: Presenting complaints in ER and ICU/CCU](image)

Sixty-two patients had normal GCS (14), 11 were found to have a minor drop in GCS level (≤13), 20 had a moderate GCS (9-12) where as 7 had severe-

![Figure 2: GCS level of patients received in the emergency room and ICU/CCU](image)

68% had normal BMI, 20% were overweight, 8% were obese however only a small percentage were underweight (4%) as illustrated in Figure 3.

![Figure 3: BMI of the participants](image)

Fig 1 and Fig 2 show graphically the combined sensitivity of all Gm +ve organisms and all Gm –ve organisms against applied antimicrobials. Higher sensitivity of gram +ve organisms against Linezolid (100%), Vancomycin (92%) and Teicoplanin (91%) can be observed. While gram-ve organisms has shown a superior sensitivity against Amikacin (82%), Meropenem (73%) and Cefazidime/Sulbactum (67%).
Previous literatures have identified that the provision consistent with a previous study which concluded axillary lymph node dissection had significant based decongestive lymphatic therapy following.

In the current study the patient’s cooperation, reduced significantly as compared to pre decon. The focus on the home based management of lymphedema almost 2 years post surgery.

- Emotions, tobacco, alcohol, temperature, pain, disease as well as dementia.
- 

There are two non invasive methods; Auscultatory fort, needs an expert supervision and second that it can be done and continuous monitoring. This has certain disadvantages.

Emergency Department and ICU/CCU are the most vital departments in a hospital. Diagnosis made in the ED design the rest of management for the patient and the treatment carried out in critical care units help save lives. These two departments all over the world receive a diverse array of ill patients with a variety of deteriorating clinical conditions.

Accurate blood pressure measurements lay the basis for management of a patient. Care must be taken in using automated or manual BP readings in important clinical scenarios. Heinemann et al. compared the mean values of the two methods and mentioned that automated device underestimated SBP and DBP.

Skirton et al suggested that replacing automated oscillometric machines with auscultatory devices could cause negative affects in many ways; for instance cases of trauma or an unstable patient, hypertensive patients or patients with arrhythmias should be monitored with manual meters as opposed to automated.

Suokhrle et al revealed that automated readings averaged 3.9 points higher that is a significant difference between manual and automatic SBP readings.

Automated Oscillometric devices are gaining fame and are gradually replacing auscultatory (mercury or aneroid) devices because they are less time consuming, do not require a skilled or trained person and overcome white collar hypertension bias. They are perfect for BP recording at home. Myers et al demonstrated that ABP measurement significantly reduces the white coat hypertension in comparison with its counterparts.

The British Hypertension Society (BHS) and the US Association for the Advancement of Medical Instrumentation (AAMI) have compiled a list of devices that are approved for home as well as clinical use.

**Table 1a: MEANS, SD, SE obtained by Dinamap Procare 100 and manual mercury**

<table>
<thead>
<tr>
<th>Blood Pressure Reading</th>
<th>Mean</th>
<th>Standard deviation (SD)</th>
<th>Standard error (SE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Systolic MBP</td>
<td>138.12</td>
<td>26.96</td>
<td>2.69</td>
</tr>
<tr>
<td>Systolic ABP</td>
<td>122.5</td>
<td>27.57</td>
<td>2.75</td>
</tr>
<tr>
<td>Diastolic MBP</td>
<td>86</td>
<td>16.83</td>
<td>1.66</td>
</tr>
<tr>
<td>Diastolic ABP</td>
<td>73.4</td>
<td>18.13</td>
<td>1.81</td>
</tr>
</tbody>
</table>

SD: standard deviation, SE: standard error

**DISCUSSION**

**Figure 4: Antihypertensives given to patients with abnormal blood pressure**

The mean of difference in systolic MBP and ABP was estimated to be 15.62 with a standard deviation of ± 8.57, while the mean of difference in diastolic MBP and ABP was 12.6 with a standard deviation of ± 24.7. The values for individual means, standard error and significance can be seen in Table 1a and 1b. The range of difference between systolic taken by the two methods was 90 to 100, while that of diastolic blood pressure was 70 to 80. The 95% CI for systolic blood pressure lies in the range of 13.9 to 17.3. The 95% CI for diastolic blood pressure lies in between 7.68 to 17.5.

**Table 1b: MEANS, SD, SE and significance level obtained by Dinamap Procare 100 and manual mercury**

<table>
<thead>
<tr>
<th>Blood Pressure Reading</th>
<th>Mean</th>
<th>Standard deviation (SD)</th>
<th>Standard error (SE)</th>
<th>pValue</th>
</tr>
</thead>
<tbody>
<tr>
<td>Difference between Systolic ABP and MBP</td>
<td>15.62</td>
<td>8.57</td>
<td>0.85</td>
<td>0.000</td>
</tr>
<tr>
<td>Difference between Diastolic ABP and MBP</td>
<td>12.6</td>
<td>24.7</td>
<td>2.47</td>
<td>0.000</td>
</tr>
</tbody>
</table>

SD: standard deviation, SE: standard error
They have devised protocols for validating BP monitors sadly; these two protocols are not followed strictly. Different types of oscillometric devices are available in the market without validation. 16

Oscillometric devices can be influenced by Diabetes, pregnancy, arrhythmias and age of patients. Multiple readings should be taken at regular intervals to ensure accuracy. Many studies have suggested that Oscillometric devices overstate blood pressure and at times underestimate blood pressure this can influence management. 17 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. 18

On the other hand the manual BP measurement, especially with mercury sphygmonanometer has been used for more than 100 years and considered as a gold standard for BP calibration. They require a skilled staff, a good stethoscope and also dependent upon environmental conditions. BP is detected higher when taken by physicians instead of staff nurses, in treatment settings in comparison to non-treatment settings and at office instead of home. 15

Mercury can act as a potent neurotoxin and cause serious harm even at very low levels. The WHO considers Mercury sphygmonanometers a major occupational hazard, as it may result in dangerous exposures to patients and health care staff and is working towards the removal of Mercury from hospitals and other health care settings. Many countries have already eradicated mercury sphygmanometers and have adopted other alternative devices. Mercury sphygmanometer remains available as a reference standard until an alternative device will be recognized as much. 21

While some studies suggest that auscultatory measurements are comparatively more accurate others clearly favour oscillometric devices. 22 23 Accurate BP measurements can be attained if patients are asked to rest for a few minutes before BP calibration along with selection of a validated automated device and multiple recordings are taken. In routine clinics ABP may be 15-18 mmHg lower than the manual method. 14 An automated device is only recommended if AAMI criteria are fulfilled; that is both systolic and diastolic measurements should not have a mean difference > 5 mmHg or a standard deviation > 8 mmHg. The British Hypertensive Society denotes a grade of A or B if a device is approved. 24

In the current study, out of the sample of 100 patients, 22 had diagnosed hypertension. Diuretics were widely prescribed antihypertensive drugs followed by beta blockers, ACE inhibitors, ARBs, Calcium channel blockers. Combined therapy was also used in such patients with blood pressure anomalies. Mean age of participants was 44.17; majority was males. Most of the samples were obtained from the ICU. Thorough history and examination was carried out. GCS levels were assessed and BMI was calculated for each patient. 62% patients had normal GCS however only 7% were assessed to have severely low GCS levels (≤8). In addition to this, majority had a healthy BMI whereas almost 30% had abnormal levels.

The mean of difference of systolic blood pressure was 15.62 with a standard deviation of ± 8.57 (p-value 0.000), while the mean of difference of diastolic blood pressure was 12.6 with a standard deviation of ± 24.7 (p-value 0.000). Both systolic and diastolic readings were understated by automated devices majority of the times in comparison to Manual devices.

The device used in this study was the Dinamap Procare 100, which has been validated and approved by the British Hypertension Society. Figure 5 shows the photographs of automated and manual devices used in the ICU and ER. BHS has labeled 28 devices to be reliable.

![BP Devices Used at Ziauddin Hospital](image)

Figure 5: Automated and manual devices used in the ICU and ER

The average price is PKR 201,973/. The cost is significantly high for developing countries like Pakistan. Cheaper and accurate alternatives of mercury sphygmanometers are a requirement of a poverty stricken country, in order to diagnose hypertension.

**CONCLUSION**

Manual blood pressure measuring devices that is aneroid and mercury sphygmanometer are the
most accurate and reliable but depend on trained staff and environment. Automated blood pressure monitors are safe, faster and easier to use but are expensive and also underestimate the readings. More efforts need to be put in for the development of accurate ABP devices so that mercury sphygmomanometers can be smoothly banned.

REFERENCES