Original Research Paper

Volume - 15 | Issue - 08 | August - 2025 | PRINT ISSN No. 2249 - 555X | DOI : 10.36106/ijar

Community Medicine

# COMPARISON BETWEEN MANUAL AND ELECTRONIC BLOOD PRESSURE RECORDINGS IN ICU PATIENTS AT A TERTIARY CARE CENTRE

| | |
|---|---|
| **Dr Ruchika Sharma*** | Assistant Professor. *Corresponding Author |
| **Dr Aanchal Bijlwan** | Assistant Professor. |
| **Dr ShriKrishna Singh** | PG-2nd Year. |

**ABSTRACT** This cross-sectional observational study aimed to evaluate the difference between manual and electronic blood pressure (BP) recordings among 112 adult ICU patients in a tertiary care hospital. Systolic and diastolic BP readings were taken using both manual auscultatory and electronic oscillometric methods during morning and evening hours. Results revealed that manual readings consistently overestimated BP, with a mean difference of 7.90 mm Hg for systolic and 7.77 mm Hg for diastolic values compared to electronic measurements. Over 97% of patients had a ≥5 mm Hg difference, and nearly 74% had a ≥10 mm Hg difference. The overestimation was uniform across gender and age groups, though slightly more pronounced in older adults. Minimal diurnal variation was observed. Cross-classification analysis showed that 44% of patients were misclassified into higher BP categories by manual readings, potentially impacting clinical decision-making. Despite strong correlation coefficients between the two methods, the consistent bias suggests that electronic monitoring offers more reliable data in critical care. These findings highlight the need to reevaluate the reliance on manual methods in ICU settings, especially in cases requiring precise BP control for medication titration and risk stratification.

**KEYWORDS :** Blood pressure, ICU, Manual vs electronic measurement, Oscillometric monitoring, Hypertension classification

## INTRODUCTION

Blood pressure (BP) measurement is a cornerstone of bedside assessment because it offers immediate insight into cardiovascular status and tissue perfusion [1]. In intensive-care units (ICUs), where haemodynamic instability may develop within minutes, clinicians rely on accurate BP readings to titrate vasoactive drugs, optimise fluid therapy, and decide on invasive procedures [1,2]. Even a 5-10 mm Hg error can translate into under- or over-treatment, with potential consequences for organ perfusion and patient survival.

The auscultatory technique with a mercury sphygmomanometer has long been considered the reference standard owing to its reproducibility and low cost when performed by trained personnel [1]. However, this method is operator-dependent susceptible to digit bias, rapid cuff deflation, and misinterpretation of Korotkoff sounds and it requires a quiet setting that is seldom achievable in busy critical-care environments [3]. Environmental concerns regarding mercury disposal and the global push to eliminate hazardous substances have further accelerated the move away from mercury devices [3].

Automated oscillometric monitors promise several advantages in such settings. They provide rapid, non-invasive, and repeatable BP estimates, minimise observer error, store trend data, and reduce staff workload, all of which are attractive in high-acuity units where continuous vigilance is essential [2,4]. Moreover, automated office and ward devices have been shown to attenuate the white-coat effect by taking multiple readings in the absence of an observer, potentially offering values closer to true resting BP [4].

Despite these benefits, concerns persist regarding the accuracy of oscillometric technology in critically ill patients. Factors such as arrhythmias, poor peripheral perfusion, altered vascular compliance, and frequent patient movement can interfere with algorithm-derived readings, leading to clinically meaningful discrepancies [5]. Small hospital-based studies report that manual methods may record higher systolic and diastolic pressures than electronic devices, particularly in neurosurgical, overweight, or critically ill subgroups [6,7]. These inconsistencies raise the question of whether automated monitors can safely replace manual measurement or whether manual confirmation remains indispensable when therapeutic thresholds are narrow.

Data addressing this issue in Indian ICUs are scarce, and most published comparisons originate from outpatient clinics or general wards, limiting their applicability to critically ill populations. Furthermore, few investigations have quantified average absolute differences between techniques information that could guide bedside policies on cross-checking and alarm limits.

To address these gaps, the present study compares manual auscultatory and electronic oscillometric readings of systolic and diastolic BP among adult patients admitted to the ICU of a tertiary-care centre. By estimating the magnitude of disagreement and considering its clinical relevance, we aim to determine whether routine manual verification should continue alongside electronic monitoring in high-dependency care.

## Methodology

The present study was conducted with the aim of evaluating the difference between manual and electronic recordings of systolic and diastolic blood pressure among patients admitted to the ICU of a tertiary care hospital, with specific objectives to compare the readings obtained by both methods and assess the extent of variation.

### Study Setting And Participants:

A cross-sectional observational study was conducted in the intensive care unit (ICU) of a tertiary care centre. Data collection was carried out on alternate days over a two-month period, from 1st June to 30th July 2019. On each data collection day, a list of newly admitted ICU patients was generated. Patients who met the study requirements and were willing to participate were enrolled after obtaining informed verbal consent. The study protocol was approved by the Institutional Ethics Committee of the tertiary care centre.

### Sample Size And Sampling Technique:

A total of 112 patients were included in the study. The sample size was determined based on feasibility and the average ICU admission rate observed during the study period. On each alternate day, patients were selected from the list of new ICU admissions using simple random sampling through a computer-generated random number table, ensuring unbiased and representative sampling.

### Details Of Data Collection:

For each participant, blood pressure was measured using both manual and electronic methods. Manual readings of systolic and diastolic blood pressure were taken using a mercury sphygmomanometer and stethoscope by trained healthcare personnel following standard auscultatory procedures. Immediately afterward, the corresponding systolic and diastolic values were recorded from the electronic oscillometric monitor already attached to the patient. To reduce variability, patients were allowed to rest before readings were taken and asked to remain quiet and still during measurement. Cuff sizes were adjusted appropriately based on the arm circumference of each patient. BP measurements were recorded twice once in the morning and once in the evening for both manual and electronic methods. The average of the two readings for each method was calculated and used for analysis. Variables collected included systolic blood pressure (SBP), diastolic blood pressure (DBP), age, and gender.

**Data Analysis:**

Data were entered in Excel and analysed using SPSS v20. Continuous variables were expressed as mean ± SD and range, while categorical variables were summarized as frequencies and percentages. For each patient, morning and evening BP readings were averaged for both manual and electronic methods. Paired t-tests compared systolic and diastolic values, with significance set at $p < 0.05$. Mean differences and proportions of patients with ≥5 mm Hg and ≥10 mm Hg gaps were calculated. Diurnal variation was assessed separately. BP categories were assigned using JNC-8 guidelines and cross-tabulated to evaluate classification agreement.

## RESULTS:

The study included 112 adult ICU patients with a mean age of 43.30 ± 13.19 years, ranging from 18 to 72 years, indicating broad age diversity. Males comprised the majority (64.3%, n=72), while females accounted for 35.7% (n=40). Most participants were middle-aged, with the highest representation in the 40-49 (26.8%) and 50–59 (23.2%) age groups, followed by 30-39 years (21.4%). Younger adults (18-29 years) made up 17.0% of the sample, and those aged 60 and above constituted 11.6%, suggesting a predominantly working-age population. The average body temperature was 99.01 ± 1.07 °F, ranging from 97.6 to 101.2 °F. Morning and evening pulse rates were 78.18 ± 9.53 bpm and 77.24 ± 9.34 bpm, respectively, with all vital signs falling within clinically stable ranges, reflecting a relatively stable patient population at the time of observation.

**Table:1 Comparison Of Manual And Electronic Blood Pressure Measurements**

| Measurement Type | Morning Mean ± SD (mm Hg) | Evening Mean ± SD (mm Hg) | Overall Average Mean ± SD (mm Hg) |
|---|---|---|---|
| **Manual SBP** | 125.12 ± 12.77 | 126.38 ± 13.01 | 125.75 ± 12.82 |
| **Electronic SBP** | 118.15 ± 12.35 | 117.54 ± 11.94 | 117.85 ± 12.15 |
| **Manual DBP** | 81.41 ± 8.53 | 81.24 ± 8.90 | 81.32 ± 8.72 |
| **Electronic DBP** | 73.45 ± 8.18 | 73.66 ± 8.07 | 73.55 ± 8.12 |

Table 1 compares systolic and diastolic blood pressure readings recorded using manual and electronic methods during morning and evening shifts. Manual readings were consistently higher than electronic ones across all time points. The overall average systolic BP was 125.75 ± 12.82 mm Hg (manual) vs. 117.85 ± 12.15 mm Hg (electronic), and diastolic BP was 81.32 ± 8.72 mm Hg vs. 73.55 ± 8.12 mm Hg, respectively. Minimal diurnal variation (<1.3 mm Hg) suggests that the measurement gap is method-related rather than time-dependent.

**Table 2: Difference Between Manual And Electronic Blood Pressure Readings And Clinical Thresholds**

| Parameter | Mean Difference (mm Hg) | ≥5 mm Hg Higher (%) | ≥10 mm Hg Higher (%) | Paired *t* (t, *p*) |
|---|---|---|---|---|
| Systolic BP (SBP) | 7.90 | 97.3% | 74.1% | 29.76, $p < 0.001$ |
| Diastolic BP (DBP) | 7.77 | 96.4% | 74.1% | 29.88, $p < 0.001$ |

This table presents the mean differences between manual and electronic blood pressure measurements, along with the proportion of patients whose manual readings were at least 5 mm Hg and 10 mm Hg higher than their corresponding electronic values. On average, manual systolic and diastolic pressures were 7.90 mm Hg and 7.77 mm Hg higher than electronic readings, respectively. Notably, more than 96% of patients showed a difference of ≥5 mm Hg, and approximately 74% had a difference of ≥10 mm Hg. The differences were highly statistically significant as confirmed by paired *t*-tests ($p < 0.001$), reinforcing the presence of a consistent and clinically meaningful discrepancy between the two methods.

**Table:3 Comparison of Manual and Electronic BP by Sex and Age Group (Mean ± SD, mm Hg)**

| Group | Manual SBP | Elec SBP | Δ SBP | Manual DBP | Elec DBP | Δ DBP |
|---|---|---|---|---|---|---|
| Gender | | | | | | |
| Male | 126.4 ± 12.9 | 118.4 ± 12.2 | 8.0 | 82.0 ± 8.7 | 74.0 ± 8.2 | 8.0 |
| Female | 124.9 ± 12.6 | 116.9 ± 12.0 | 8.0 | 80.4 ± 8.6 | 72.3 ± 8.0 | 8.1 |
| Age Group | | | | | | |
| 18–29 years | 122.9 | 115.2 | 7.7 | 78.6 | 71.7 | 7.0 |
| 30–39 years | 132.3 | 124.2 | 8.1 | 84.5 | 77.3 | 7.2 |
| 40–49 years | 121.6 | 114.0 | 7.6 | 78.6 | 71.3 | 7.2 |
| 50–59 years | 126.9 | 119.3 | 7.6 | 83.5 | 74.4 | 9.2 |
| ≥60 years | 125.3 | 116.1 | 9.2 | 81.2 | 72.9 | 8.4 |

Table 3 illustrates the consistency of manual overestimation of blood pressure across both gender and all age groups. Males and females showed nearly identical mean differences (~8 mm Hg) between manual and electronic readings for both SBP and DBP. Similarly, across age groups, manual values remained higher by 7.6 to 9.2 mm Hg for systolic and 7.0 to 9.2 mm Hg for diastolic BP. The discrepancy was slightly more pronounced in older adults (≥60 years).

**Table 4: Cross-classification Of BP Categories**

| Manual \ Electronic | Normal | Elevated | Stage 1 HTN | Stage 2 HTN |
|---|---|---|---|---|
| Normal | 21 | 0 | 0 | 0 |
| Elevated | 20 | 0 | 0 | 0 |
| Stage 1 HTN | 29 | 15 | 11 | 2 |
| Stage 2 HTN | 2 | 0 | 11 | 1 |

Table 4 highlights the discrepancy between manual and electronic blood pressure classifications using standard criteria. While all patients categorized as Normal by manual BP were similarly classified by electronic BP, many patients labelled as Elevated or Stage 1 Hypertension by manual readings were downgraded by the electronic method. Notably, 29 patients marked as Stage 1 by manual BP were reclassified as Normal by electronic BP. This indicates a consistent tendency of manual readings to classify patients into higher BP categories compared to electronic monitors, which may have clinical implications for diagnosis and treatment decisions.

## DISCUSSION

In the present study, a total of 112 ICU patients were assessed for differences between manual and electronic blood pressure recordings. The average systolic and diastolic blood pressure measured manually was significantly higher than that recorded electronically. The mean difference was 7.90 mm Hg for SBP and 7.77 mm Hg for DBP, with over 97% of patients showing a ≥5 mm Hg difference and nearly three-fourths (74%) exhibiting a ≥10 mm Hg difference. These findings highlight a consistent and clinically significant overestimation of blood pressure by manual readings when compared to electronic monitors.

This pattern of higher manual readings aligns with previous studies conducted in hospital and primary care settings. Mirdamadi et al. reported that manual readings exceeded automated values by 3–5 mm Hg, with even larger gaps in neurosurgical ICU patients [7]. Similarly, Myers et al. in the CAMBO trial found that routine manual systolic BP values were on average 10 mm Hg higher than automated ones, suggesting a prominent white-coat or observer effect in manual measurements [8]. Fodor et al. also observed a consistent bias where manual readings were higher than automated devices in population surveys [9]. However, some studies, particularly among younger populations such as medical students, showed either negligible differences or even slightly higher digital readings for SBP, as reported by Shekhar et al. and Jasani et al. [10,5].

The diurnal variation observed in our study was minimal, with morning and evening readings differing by less than 1.3 mm Hg for both SBP and DBP, within each method. This suggests that time-of-day did not significantly influence the measurement gap. Kusum et al. similarly noted that repeated measurements at different times of the day did not alter the bias between manual and digital methods [11]. This strengthens the observation that the discrepancy between manual and electronic BP is likely method-based rather than time-dependent. When assessing the level of agreement between the two methods, we observed strong correlations for both systolic and diastolic pressures (r = 0.976 and 0.949, respectively). These findings are consistent with those of Singh et al., who reported excellent concordance between automated and manual measurements using Lin's concordance correlation coefficient (CCC > 0.85) [12], and Fodor et al., who found a correlation of r = 0.93 in their large community study [9]. Moore et al., in their study during exercise testing, observed excellent correlation for SBP (ICC = 0.96), although the agreement for DBP was more moderate (ICC = 0.78), likely due to increased cardiovascular dynamics during physical activity [13].

A crucial finding in our study was the substantial misclassification of patients into higher BP categories by manual methods. Nearly 44% of patients classified as Stage 1 or Stage 2 hypertension based on manual readings were reclassified as normal or elevated when using electronic measurements. This diagnostic discordance echoes the findings of Myers et al., who emphasized that automated office BP more closely matched ambulatory BP readings, thereby reducing overtreatment risks [8]. Curi-Curi et al., in a Mexican hospital-based validation study, demonstrated that semi-automated upper-arm devices had high specificity (97%) for hypertension detection, supporting their clinical reliability [14].

Stratified analyses by age and sex in our study revealed that the manual-electronic gap was consistent across all groups, with slightly greater systolic differences observed in those aged 60 years and above which may reflect increased arterial stiffness interfering with oscillometric accuracy. Overall, these findings support that the measurement gap is independent of gender and relatively stable across age, with a mild increase in older populations. Mirdamadi et al. found a greater bias in younger patients and females [7], while Jasani et al. and Shekhar et al. found no significant influence of age or gender on the measurement differences [5,10]. Overall findings suggest that the observed bias is predominantly device-related and not significantly modified by patient demographics.

Lastly, logistic regression in our study failed to identify strong independent predictors for a ≥10 mm Hg gap, though increasing age showed borderline significance for systolic BP. Similar predictive analyses were not reported in most prior studies, limiting direct comparison. Nonetheless, the lack of effect modification in our model reinforces the consistent nature of the measurement bias across population subgroups.

## CONCLUSION

This study provides compelling evidence of a systematic and clinically significant discrepancy between manual and electronic blood pressure measurements in adult ICU patients. Manual readings were consistently higher by approximately 8 mm Hg for both systolic and diastolic pressures, regardless of the time of day, age group, or sex. This overestimation led to a substantial proportion of patients being classified into higher hypertension categories when assessed manually, with nearly three-fourths showing a ≥10 mm Hg gap. Despite a strong correlation between the two methods, the observed differences have direct clinical relevance, especially in critical care settings where precise BP control influences medication titration, fluid management, and outcome monitoring. The findings reinforce the importance of considering the measurement modality when diagnosing and managing hypertension and call for increased awareness among clinicians regarding potential biases associated with manual techniques.

### Limitations

This study was limited to a single tertiary care centre, which may affect the generalizability of its findings. Additionally, the clinical impact of BP misclassification on treatment decisions and outcomes was not assessed.

### Recommendations

Electronic BP monitoring should be preferred in ICU settings to reduce observer bias and improve accuracy. Clinicians should recognize the tendency of manual methods to overestimate BP, especially in borderline cases. Regular device calibration, cross-validation with digital monitors, and staff training on standardized measurement techniques are essential. Future studies should explore broader populations and assess the clinical consequences of measurement discrepancies.

## REFERENCES:


1. Pickering, T. G., Hall, J. E., Appel, L. J., Falkner, B. E., Graves, J., Hill, M. N., et al. (2005). Recommendations for blood pressure measurement in humans and experimental animals: Part 1. *Hypertension, 45*(1), 142–161. https://doi.org/10.1161/01.HYP.0000150859.47929.8e
2. Parati, G., Stergiou, G. S., Bilo, G., Kollias, A., Pinna, G. D., Ochoa, J. E., et al. (2021). Home blood pressure monitoring: Methodology, clinical relevance and practical application. *Journal of Hypertension, 39*(9), 1742–1767. https://doi.org/10.1097/HJH.0000000000002926
3. O'Brien, E., Atkins, N., Stergiou, G., Karpettas, N., Parati, G., Asmar, R., et al. (2010). European Society of Hypertension International Protocol revision 2010 for the validation of blood pressure measuring devices in adults. *Blood Pressure Monitoring, 15*(1), 23–38. https://doi.org/10.1097/MBP.0b013e3283360e98
4. Myers, M. G., & Godwin, M. (2006). Automated blood pressure measurement in routine clinical practice. *Blood Pressure Monitoring, 11*(2), 59–62. https://doi.org/10.1097/01.mbp.0000209070.09832.bf
5. Jasani, K., Patel, N., Harkhani, J., Rana, D. A., & Malhotra, S. D. (2020). Variability in blood pressure measurement methods. *National Journal of Physiology, Pharmacy and Pharmacology, 10*(2), 159–164. https://doi.org/10.5455/njppp.2020.10.1133323102019
6. Chandrasekar, K. A., Raj, G., Reddy, P. S., & Ambareesha, K. (2022). Automated versus manual measurement of blood pressure in a tertiary-care hospital. *National Journal of Physiology, Pharmacy and Pharmacology, 12*(3), 307–312. https://doi.org/10.5455/njppp.2022.12.11279202108122021
7. Mirdamadi, A., & Etebari, M. (2017). Comparison of manual versus automated blood pressure measurement in intensive-care and emergency settings. *ARYA Atherosclerosis, 13*(1), 29–35.
8. Myers, M. G., Godwin, M., Dawes, M., Kiss, A., Tobe, S. W., & Kaczorowski, J. (2011). Conventional versus automated measurement of blood pressure in primary care patients with systolic hypertension: Randomised controlled trial. *BMJ, 342*, d286. https://doi.org/10.1136/bmj.d286
9. Fodor, G. J., Leenen, F. H. H., Tobe, S. W., McDonald, P. W., Petrella, R. J., & Kaczorowski, J. (2008). Comparison of an automated and manual sphygmomanometer in a population survey. *American Journal of Hypertension, 21*(3), 280–286. https://doi.org/10.1038/ajh.2007.51
10. Shekhar, A., Begum, S., & Majgi, S. M. (2020). A comparative study of blood pressure recording from mercury, aneroid and digital devices in healthy volunteers. *Indian Journal of Physiology and Allied Sciences, 72*(1), 1–5.
11. Kusum, K., Shruti, C., Ravikant, R., Kalyani, V., & Singh, A. (2019). Comparison of BP measurements taken by one-stage, two-stage approach and digital apparatus. *Journal of Biological Medicine, 3*(1), 37–39.
12. Singh, S. B., Kumar, D., Kashyap, V., & Singh, S. (2020). Concordance of automated BP device with mercury-free LED device using Lin's CCC. *Journal of Family Medicine and Primary Care, 9*(3), 1464–1469. https://doi.org/10.4103/jfmpc.jfmpc_1120_19
13. Moore, M. N., Picone, D. S., Callisaya, M. L., Schultz, M. G., Ahuja, K. D., Arnolda, L., et al. (2019). Comparison of manual and automated auscultatory blood pressure during graded exercise among people with type 2 diabetes. *Journal of Clinical Hypertension, 21*(12), 1872–1878. https://doi.org/10.1111/jch.13708
14. Curi-Curi, P. J., Morales-Sánchez, E. F., González-Ramírez, A. R., Romero-Millán, E. J., Hernández-Mendoza, G. A., Guevara-Cruz, M., et al. (2025). Diagnostic accuracy comparison between automatic and conventional BP devices in adults with hypertension. *Open Nursing Journal, 19*, 1–8. https://doi.org/10.2174/1874434602519010001