Kufa Medical Journal | Vol. 21, No. 1, 2025

Original article DOI: https://doi.org/10.36330/kmj.v21i1.18997

p-ISSN: 1993-517X
e-ISSN: 2709-4464

Comparative Accuracy of Automated Upper Arm and Wrist Blood Pressure Devices: A Comparison with Intra-arterial line

Ahmed B. Abdulwahid

Department of Physiology, Al-Zahraa College of Medicine, University of Basrah, Iraq.

E-mail: ahmed.bader@uobasrah.edu.iq

ABSTRACT

Background: *Accurate measurement of blood pressure is crucial for the diagnosis and treatment of cardiovascular diseases. Automatic non-invasive blood pressure devices are now widely used for the measurement of blood pressure of patients at home and even by the doctors in emergency room in Iraq due to their ease of use. However, the accuracy of these devices had been a matter of debate.* ***Aim of the study:*** *Our study aimed to evaluate the accuracy of the automated wrist and upper arm devices in blood pressure measurement.* ***Methods****: The study was a cross sectional study involved 75 patients who were undergoing cardiac catheterization. Blood pressure was measured using two types of automated devices, Rossmax upper arm and wrist devices. Their readings were compared simultaneously with the readings of an intra-arterial catheter to assess their accuracy.* ***Results****: The automated upper arm device measured a significantly higher value (p<0.05) of diastolic and mean arterial pressures than those measured by intra-arterial catheter with means of differences of 6.79 mmHg and 6.57 mmHg respectively. While the systolic blood pressure was not significantly different (p>0.05) from those measured by intra-arterial catheter. The automated wrist device measured a significantly higher value (p<0.05) of systolic, diastolic and mean arterial pressures than those measured by intra-arterial catheter with means of differences of 11.32 mmHg, 18.30 mmHg and 15.98 mmHg, respectively. Both devices exhibited good reproducibility.* **Conclusion:** *Rossmax upper arm and wrist devices overestimate blood pressure. They are inaccurate and should not be relied upon for critically ill patients and in the emergency room.*

Keywords: Blood pressure, Rossmax, Automated Blood Pressure Devices, Upper Arm, Wrist.

Article Information

Received: March 7, 2025; Revised: May 16, 2025; Online June, 2025

INTRUDUCTION

Accurate measurement of blood pressure is crucial for the diagnosis and treatment of cardiovascular diseases, which are a leading cause of mortality worldwide (1). The invasive intra-arterial measurement of blood pressure is considered the gold standard method because it provides accurate and real time data (2,3). However, it is not practical because of it is risky, expensive, painful, time consuming and must done by skilled personnel (4). Mercury sphygmomanometry has been considered the gold standard non-invasive method for the measurement of blood pressure for long time due to its accuracy in comparison with invasive intra-arterial measurement (5) but it may be affected by patients related factors such as anxiety that leads to white coat hypertension (6). Other disadvantages of this method are the requirement of trained personnel as auscultation with stethoscope is needed for accurate reading and the toxicity and environmental hazards of mercury [7]. So, Mercury sphygmomanometer was replaced by the automated noninvasive blood pressure devices which measure blood pressure by inflating a cuff around the arm or the wrist and detect pressure changes induced by the arterial pulsation during deflation. The devices analyze pressure waveforms and use an algorithm to estimate blood pressure [8]. These devices are now widely used by the patients at home and even by the doctors in emergency room in Iraq due to their ease of use. However, the accuracy of these devices especially in critically ill patients had been a matter of debate between researchers [9-11]. This study aims to evaluate the accuracy of the Rossmax upper arm and wrist devices in the measurement of blood pressure as they are widely used in Iraq.

METHODS

Study design:

This study was a cross sectional study which involved 75 patients (41 males and 34 females) with an average of age of 48±8.1 years and 57±6.23 years respectively, who were undergoing cardiac catheterization in AL-Sader teaching hospital in Basrah

Blood pressure measurement:

Blood pressure was measured using two types of automated devices, wrist and upper arm devices, manifactured by Rossmax, Switzerland. Their readings were compared simultaneously with the readings of an intra-arterial catheter to assess their accuracy using a wide still catheter. Additional measures were taken to avoid incorrect readings including proper placement of the cuff of the automated devices, avoid talking or excessive movement, and maintain one minute gap between readings to avoid venous congestion[12] .

Statistical analysis

We used SPSS program version 26. Data were tabulated as mean ± standard deviation. To estimate the accuracy of the devices, we assess them for systemic error and random error. Systemic error: We made a comparison between the value of blood pressure obtained by the tested devices and those measured by the invasive intra-arterial line . Random error: We made a comparison between two consecutive measurement of blood pressure for each device in order to evaluate the reproducibility of the devices.

RESULTS

The evaluation of the upper arm device

a. Systemic error

The automated upper arm device measured a higher value of systolic, diastolic and mean arterial pressures than those measured by intra-arterial catheter. However, statistical analysis revealed significant difference ($p<0.05$) between the values of diastolic and mean arterial pressures but no significant difference ($p>0.05$) regarding systolic blood pressure as shown in tab.1.

b. Random error

Regarding the upper arm device, there was significant difference ($p<0.05$) between the two measured values for diastolic and mean arterial pressure but no significant difference ($p>0.05$) between the two measured values for systolic blood pressure as shown in tab.2.

The evaluation of the wrist device

a. Systemic error

The automated upper arm device measured a higher value of systolic, diastolic and mean arterial pressures ($p<0.05$) than those measured by intra-arterial catheter as shown in tab.3.

b. Random error

There was no significant difference ($p>0.05$) between the two consecutive measures of blood pressure by the wrist device as shown in Tab.4.

Table (1): The values of blood pressures measured by Rossmax upper arm device in comparison with those measured by intra-arterial line.

Parameters (n=75)	Invasive method (mean ± SD)	Upper arm device (mean ± SD)	Mean of difference ± SD	P value
SBP (mmHg)	142.67 ± 28.26	148.78 ± 24.78	6.11 ± 5.36	P > 0.05
DBP (mmHg)	77.56 ± 11.99	84.35 ± 10.57	6.79 ± 2.41	P < 0.05
MABP (mmHg)	99.26 ± 14.26	105.83 ± 12.31	6.57 ± 2.87	P < 0.05

BP: blood pressure, SBP: systolic blood pressure, DBP: diastolic blood pressure, MABP: mean arterial blood pressure.

Table (2): Assessment of blood pressure measurement reproducibility with Rossmax upper arm device.

Parameters (n=75)	First reading of BP (mean ± SD)	Second reading of BP (mean ± SD)	Mean of difference ± SD	P value
SBP (mmHg)	125.32±23.64	124.76±25.30	0.56±4.47	P > 0.05
DBP (mmHg)	78.53±14.62	75.99±13.01	2.54±6.45	P < 0.05
MABP (mmHg)	94.13±15.92	92.45±16.42	1.68±5.11	P < 0.05

BP: blood pressure, SBP: systolic blood pressure, DBP: diastolic blood pressure, MABP: mean arterial blood pressure.

Table (3): The values of blood pressures measured by Rossmax wrist device in comparison with those measured by intra-arterial line.

Parameters (n=75)	Invasive method (mean ± SD)	wrist device (mean ± SD)	Mean of difference ± SD	P value
SBP (mmHg)	144.24±28.11	155.56±16.77	11.32±4.56	P < 0.05
DBP (mmHg)	77.63±12.82	95.93±13.61	18.30±2.54	P < 0.05
MABP (mmHg)	99.83±16.12	115.81±13.33	15.98±3.19	P < 0.05

BP: blood pressure, SBP: systolic blood pressure, DBP: diastolic blood pressure, MABP: mean arterial blood pressure.

Table (4): Assessment of blood pressure measurement reproducibility with Rossmax wrist device

Parameters (n=75)	First reading of BP (mean ± SD)	Second reading of BP (mean ± SD)	Mean of difference ± SD	P value
SBP (mmHg)	124.10 ± 18.87	125.61±18.25	1.51±4.39	P > 0.05
DBP (mmHg)	76.99±15.79	77.17±12.02	0.18±12.82	P > 0.05
MABP (mmHg)	92.69±16.11	93.32±14.17	0.63±13.01	P > 0.05

BP: blood pressure, SBP: systolic blood pressure, DBP: diastolic blood pressure, MABP: mean arterial blood pressure.

DISCUSSION

The evaluation of the accuracy of the Rossmax upper arm device for measurement of blood pressure compared to intra-arterial line indicated that it overestimates blood pressure values particularly for diastolic and mean arterial pressure where the differences were statistically significant ($p<0.05$). The means of the differences between the values of the Rossmax upper arm device and the intra-arterial line in measuring systolic, diastolic and mean arterial pressures were 6.11 mmHg, 6.79 mmHg, 6.57 mmHg respectively, which indicated that the device is slightly inaccurate according to the British hypertension society protocol for validation of devices that measure blood pressure which considers a difference more than 5 and up to10 mmHg as slightly inaccurate [13,14].

The assessment of the reproducibility of the upper arm device demonstrated no significant difference between two consecutive systolic blood pressure measurements. However significant difference was observed between the duplicate measurements of diastolic and mean arterial pressure but the means of differences were very low (2.54 mmHg and 1.68 mmHg) which may indicate the sensitivity of the device to minute-to-minute small blood pressure fluctuations. The evaluation of the accuracy of the Rossmax wrist device revealed that it also overestimates blood pressure values. The means of the differences between the values of the Rossmax wrist device and the intra-arterial line in measuring systolic and mean arterial pressures were 11.32 mmHg and 15.98 mmHg respectively, which indicated that the device is moderately inaccurate while the differences between the values of diastolic blood pressures was 18.30 mmHg which indicated that the device is very inaccurate in measuring diastolic blood pressures according to the British hypertension society protocol for validation of devices that measure blood pressure which considers a difference more than 15 mmHg as very inaccurate [13,14]. The assessment of the reproducibility of the wrist device demonstrated no significant difference between two consecutive measurements of systolic, diastolic and mean arterial pressures, which indicates a good reproducibility of the wrist device. However, the systematic overestimation of this device raises concerns about its clinical reliability. The inaccuracy of the oscillometric blood pressure devices could be duo to several factors. First factor is their dependence on empirical algorithms derived from population studies to interpret arterial wall oscillation. These algorithms may not accommodate with the unique arterial properties of each patient [15,16].

Second factor is that individual variations in vascular compliance and arterial stiffness may affect the algorithm. In elderly, hypertensive and diabetic patients increased arterial stiffness causes overestimated blood pressure readings by oscillometric method [17,18]. Third, arrhythmias affect the readings of oscillometric devices. Algorithms assume regular oscillation but in arrhythmias such as atrial fibrillation irregular beats cause fluctuations in the oscillation leading to miscalculation of blood pressure [9,19,20]. Fourth, globally a minority of automated blood pressure measuring devices undergo validation for accuracy [21]. The inaccurate blood pressure measurement can have serious consequences. The overestimation of blood pressure causing inappropriate diagnosis of hypertension and exposing the patient to unnecessary medication with unnecessary side effects [22,23]. Our study is in agreement with several studies that reported automatic blood pressure devices tend to overestimate blood pressure [24-27]. However, some studies reported good agreement of manual and automatic blood pressure measurement by oscillometric technique [10,28].

CONCLUSION

Although Rossmax upper arm and wrist devices had good reproducibility but they overestimate blood pressure. The systemic error was higher in wrist device than upper armdevice. These devices are inaccurate and should not be relied upon for critically ill patients and in the emergency room.

Ethical approval

The present study Which is conducted by Ahmed Badr Abdulwahid was approved by the local department of physiology committee.

Statement of Permission and Conflict of Interests

The author declares that there is no conflict of interests.

REFERENCES

1. Stergiou GS, Palatini P, Parati G, O'Brien E, Januszewicz A, Lurbe E, et al. European Society of Hypertension Council and the European Society of Hypertension Working Group on Blood Pressure Monitoring and Cardiovascular Variability. 2021 European Society of Hypertension practice guidelines for office and out-of-office blood pressure measurement. J Hypertens. 2021 Jul 1;39(7):1293-1302. .
2. Lam S, Liu H, Jian Z, Settels J, Bohringer C. Intraoperative Invasive Blood Pressure Monitoring and the Potential Pitfalls of Invasively Measured Systolic Blood Pressure. Cureus. 2021 Aug 31;13(8):e17610.
3. Meidert AS, Briegel J, Saugel B. Principles and pitfalls of arterial blood pressure measurement. Anaesthesist. 2019 Sep;68(9):637-650.
4. Nuttall G, Burckhardt J, Hadley A, Kane S, Kor D, Marienau MS et al. Surgical and Patient Risk Factors for Severe Arterial Line Complications in Adults. Anesthesiology. 2016.Mar;124(3):590-7.
5. Schutte AE, Kollias A, Stergiou GS. Blood pressure and its variability: classic and novel measurement techniques. Nat Rev Cardiol. 2022 Oct;19(10):643-654. Verdecchia P, Staessen JA, White WB, Imai Y, O'Brien ET. Properly defining white coat hypertension. Eur Heart J. 2002 Jan;23(2):106-9.
6. John O, Campbell NRC, Brady TM, Farrell M, Varghese C, Velazquez Berumen A, et al. The 2020 "WHO Technical Specifications for Automated Non-Invasive Blood Pressure Measuring Devices With Cuff". Hypertension. 2021 Mar 3;77(3):806-812.
7. Sharman JE, Tan I, Stergiou GS, Lombardi C, Saladini F, Butlin M, et al. Automated 'oscillometric' blood pressure measuring devices: how they work and what they measure. J Hum Hypertens. 2023 Feb;37(2):93-100. Kumar S, Yadav S, Kumar A. Accuracy of oscillometric-based blood pressure monitoring devices: impact of pulse volume, arrhythmia, and respiratory artifact. J Hum Hypertens. 2024 Jan;38(1):45-51.
8. Hou G, Wu Y, Wang J, Zhi J. Validation of the DBP-1333b upper-arm blood pressure monitor according to the AAMI/ESH/ISO universal standard (ISO 81060-2:2018+Amd.1:2020). Blood Press Monit. 2024 Jun 1;29(3):149-155.
9. Glenning JP, Sheeran F, Cuthbert J, Harris W, Quinlan C, Mynard JP. Validation of the Uscom BP+ automated oscillometric blood pressure monitor for professional office use in children and adolescents according to the AAMI/ESH/ISO Universal

Standard (ISO 81060-2:2018). Hypertens Res. 2024 Dec 24.

10. Mousavi SS, Reyna MA, Clifford GD, Sameni R. A Survey on Blood Pressure Measurement Technologies: Addressing Potential Sources of Bias. Sensors (Basel). 2024 Mar 7;24(6):1730.
11. O'Brien E, Petrie J, Littler W, de Swiet M, Padfield PL, Altman DG, et al. An outline of the revised British Hypertension Society protocol for the evaluation of blood pressure measuring devices. J Hypertens. 1993-Jun;11(6):677-9.
12. O'Brien E, Pickering T, Asmar R, Myers M, Parati G, Staessen J, et al. Working Group on Blood Pressure Monitoring of the European Society of Hypertension. Working Group on Blood Pressure Monitoring of the European Society of Hypertension International Protocol for validation of blood pressure measuring devices in adults. Blood Press Monit. 2002 Feb;7(1):3-17.
13. Braam RL, Thien T. Is the accuracy of blood pressure measuring devices underestimated at increasing blood pressure levels? Blood Press Monit. 2005 Oct;10(5):283-9.
14. Jones DW, Appel LJ, Sheps SG, Roccella EJ, Lenfant C. Measuring blood pressure accurately: new and persistent challenges. JAMA. 2003 Feb 26;289(8):1027-30.
15. Van Ittersum FJ, Wijering RM, Lambert J, Donker AJ, Stehouwer CD. Determinants of the limits of agreement between the sphygmomanometer and the SpaceLabs 90207 device for blood pressure measurement in health volunteers and insulin-dependent diabetic patients. J Hypertens. 1998 Aug;16(8):1125-30.
16. Van Popele NM, Bos WJ, de Beer NA, van Der Kuip DA, Hofman A, Grobbee DE, et al. Arterial stiffness as underlying mechanism of disagreement between an oscillometric blood pressure monitor and a sphygmomanometer. Hypertension. 2000 Oct;36(4):484-8.
17. Šelmytė-Besusparė A, Barysienė J, Petrikonytė D, Aidietis A, Marinskis G, Laucevičius A. Auscultatory versus oscillometric blood pressure measurement in patients with atrial fibrillation and arterial hypertension. BMC Cardiovasc Disord. 2017 Mar 23;17(1):87.
18. Clark CE, McDonagh STJ, McManus RJ; Blood Pressure Measurement Working Party of the British and Irish Hypertension Society. Measurement of blood pressure in people with atrial fibrillation. J Hum Hypertens. 2019 Nov;33(11):763-765.
19. Picone DS, Campbell NRC, Schutte AE, Olsen MH, Ordunez P, Whelton PK, et al. Validation Status of Blood Pressure Measuring Devices Sold Globally. JAMA. 2022 Feb 15;327(7):680-681.
20. S, Jaeger BC, Akinyelure OP, Bress AP, Shimbo D, Schwartz JE, Hardy ST, Howard G, Dra
21. Sakhuja S, Jaeger BC, Akinyelure OP, Bress AP, Shimbo D, Schwartz JE, et al. Potential impact of systematic and random errors in blood pressure measurement on the prevalence of high office blood pressure in the United States. J Clin Hypertens (Greenwich). 2022 Mar;24(3):263-270.
22. Gulati M, Peterson LA, Mihailidou A. Assessment of blood pressure skills and belief in clinical readings. Am J Prev Cardiol. 2021 Oct 13;8:100280.
23. Davis JW, Davis IC, Bennink LD, Bilello JF, Kaups KL, Parks SN. Are automated blood pressure measurements accurate in trauma patients? J Trauma. 2003 Nov;55(5):860-3.
24. Palatini P, Longo D, Toffanin G, Bertolo O, Zaetta V, Pessina AC. Wrist blood pressure overestimates blood pressure

measured at the upper arm. Blood Press Monit. 2004 Apr;9(2):77-81.

25. Zweiker R, Schumacher M, Fruhwald FM, Watzinger N, Klein W. Comparison of wrist blood pressure measurement with conventional sphygmomanometry at a cardiology outpatient clinic. J Hypertens. 2000 Aug;18(8):1013-8.
26. Evripidou K, Chainoglou A, Kotsis V, Stabouli S. Challenges in blood pressure measurement in children with obesity: focus on the cuff. Pediatr Nephrol. 2025 Feb 5.
27. Botta B, Bramlage C, Hachaturyan V, Jost L, Bramlage P. Validation of the Microlife BP3T01-1B blood pressure monitoring device in adults and adolescents according to the ISO 81060-2:2018 protocol. Blood Press Monit. 2025 Apr 1;30(2):86-92.
28. Huang JF, Li Y, Wang JG. Validation of the Rossmax AC1000f upper-arm blood pressure monitor in adults according to the British Hypertension Society Protocol. Blood Press Monit. 2020 Aug;25(4):231-235.

