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Research Article

Comparative Analysis and Range of Variation of BP Measurements at Different Tiers of Expertise of medical and paramedical staff: Reliability for decision making

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Abstract: Blood pressure (BP) forms an important constituent of the triumvirate of vital signs i.e. pulse, BP and respiration. Measurement and treatment of blood pressure (BP) is one of the most common and important reasons for visiting a physician. The range of variance and level of reliability of the blood pressure (BP) measurements that should be used for clinical decision making and quality reporting are uncertain. The objective of this study was to compare the BP measurements and ascertain their range of variation between different tiers of healthcare workers. Comparative analysis of the BP measurements by Nursing staff, Interns/Junior residents and Senior Resident/Consultant performed. We found that nursing staff recordings fit poorly compared to Jr. Residents /Interns and Sr. residents/Consultants, showing high variance and low reliability. We concretely recommend to cross verifying the reliability and validity of the recordings made by the nursing staff by the clinicians themselves before clinical decision making and quality reporting. This study was performed at Department of Medicine, Adesh Institute of Medical Sciences and Research Bathinda, Punjab, India.
Keywords: Blood Pressure, Measurements, Expertise, Tiers, Decision

INTRODUCTION

Blood pressure (BP) forms an important constituent of the triumvirate of vital signs i.e. pulse, BP and respiration. Measurement and treatment of blood pressure (BP) is one of the most common and important reasons for visiting a physician [1, 2] . BP measurements play a very crucial role in the management of patients especially in the acute intensive care settings. Diagnosis and management of Hypertension as a disease entity depends entirely upon measurement of BP. Hence it is mandatory that accurate measurement of blood pressure is essential to classify individuals; to ascertain blood pressure- related risk and to guide management protocols. The aim of this study was to assess the knowledge of hospital staff comprising Consultants, Senior residents (SRs), junior doctors and nurses on the basic principles of BP measurement and the variability in recording BP between these groups [1] .

Recent medical advances leading to improvements in anti-hypertensive therapy to effectively treat high BP have reduced cardiovascular, cerebrovascular, and renal events significantly [3, 4]. The harmful effects of elevated BP are mainly attributable to a person's average daily (or true) BP [5, 6] with specific emphasis given to systolic BP (SBP) [7, 8]. However, a person's BP in the clinical set-up is measured by the healthcare workers with varying level of expertise and training, and the clinician must infer the true value on the basis of a small number of these measurements. Therefore any error in the measurement of BP either due to faulty measurement technique or observer effects can affect the clinical decision making and patient care may get affected [9, 10]. Furthermore, varying level of expertise

and training may result in measurement variability [11, 12]. This short-term variability has been recognized as an important threat to both clinical decision making and hypertension research [13]. In this study, we compare BP measurement by Nursing staff; Interns /Junior Residents (JR) and Senior Residents (SR)/ Consultants in primary care patients with hypertension and estimate the range of variability with which a patient's BP can be determined by different healthcare professionals. Gold standard for clinical blood pressure measurement continues to be the readings taken by a physician using a mercury sphygmomanometer. Oscillometric technique, which primarily detects mean arterial pressure, is used in electronic devices. Other methods include ultrasound (used mainly to detect systolic pressure) and the finger cuff method of Penaz, which records pressure noninvasively from the finger beat-to-beat. The upper arm is the preferred location, but changes in the position of the arm may lead to errors. Other errors include inappropriate cuff size and too rapid deflation of the cuff [14].

Aims and Objectives

The aim of this study was to examine the BP measurements and ascertain their range of variation between different tiers of healthcare workers.

MATERIALS AND METHODS

The study protocol complied with the Helsinki declaration for human experimentation. Subjects were fully informed about the institution and details of the study. Subjects signed an informed consent form, which was approved by institutional ethics committee. The study was conducted at Adesh Institute of Medical Sciences & Research, Bathinda, Punjab. The study was mostly conducted on inpatients of ICU and medical wards. To give a measures of health care providers in other departments and wards, patients from other disciplines were also included. The major aim was to study the differences in BP records of patients in ICU as immediate and urgent measures may be required in such patients.

The study was started from the month of March 2012 and concluded in February 2013. This wide period was intended to have more and more number of health care providers involved due to some rotational duties of the Para- medical staff and also to study any effects of climatic conditions varying from extremely high summer temperatures to very low wintry temperatures. The study comprised recording of BP of a total number of 170 patients comprising of 105 males and 65 female patients in different wards. The BP was recorded with a mercury sphygmomanometer, which was repeatedly standardized with other instruments. The BP of the same patient, as recorded by various personnel in the health care system like Nurse, Intern, Junior Residents and Consultants was noted and recorded in a separate file for further analysis. As BP fluctuations are commonly encountered in the seriously sick patients in ICU, the Senior Residents (SRs) /Consultants were requested to personally record BP of the critically sick patients in ICU at least twice a day. Most of the patients were in the medical stream. However 19 patients were of Gynecology wards and 13 patients belonged to the surgical stream. This was done to extend the spectrum of variability of patients as well as different staff personnel working in various medical streams. A large number of healthcare workers were engaged for wider coverage of differences. Also it was stipulated that the BP record by the nurse and JR will be either preceded or followed by recording done done by SR/Consulant with a gap of about minimum ten minutes. Minimum four recordings were mandated in a day. In critical cases at least hourly BP records were conducted.

Data analysis

BP data collected was analysed by principal investigator and statistical Analysis was performed and script written by Satwant Kumar. Descriptive and inferential statistical methods are used for analysis and obtaining results. Substantial use of R statistical environment [15] a freely available open source advanced statistical analysis language is used for automated descriptive analysis of the data. We wrote R script to generate the graphics and result tables. Standard R psychometric library module (Psych) is used to perform descriptive analysis. Gclus R package is utilized for Pearson's product-moment correlation analysis. Linear regression learning utilizing gradient descent algorithm is implemented to generate prediction model from the data using freely available Octave software (http://www.gnu.org/software/octave/).

RESULTS

After performing data analysis we observed abrupt skew of 0.17 directed negatively(-ve) in the Systolic recording made by the Nursing staff (Figure 1), also these recordings have standard deviation(s.d) of 23.84, mean absolute deviation (m.a.d) of 20.76 and standard error (S.E) of 1.83. Whereas the recordings made by the Senior Residents (SR's)/Consultants follow normal distribution (Gaussian distribution), Figure 3. Figure-2 shows systolic recordings made by Junior Residents/ Interns. On performing the Pearson's product-moment correlation analysis it was observed that the recordings by the nursing staff are less correlated with Consultants recordings as compared to Junior Residents and Interns recordings, which showed very high correlation of 0.96 as compared to 0.82. Detailed Pearson's product-moment correlation analysis of systolic B.P. recordings made by junior residents and senior residents/consultants provides, t = 44.831, df (degree of freedom) = 168, p-value ¡ 2.2e-16 whereas alternative hypothesis resulted that true correlation is not equal to 0.95 percent confidence interval resulted in 0.947, 0.970 with sample estimates correlation equals to 0.960. Similar analysis between systolic B.P. recordings made by nursing staff and senior residents/consultants provides, t = 19.0662, df (degree of freedom) = 168, p-

value ¡ 2.2e-16 and alternative hypothesis for true correlation is not equal to 0. 95 percent confidence interval resulted in 0.772 and 0.869 with sample estimates for correlation equals to 0.826. This result establishes that recordings made by junior and senior residents are more coherent with each other, while the recordings made by nursing staff are more skewed and less correlated with the former. To further analyze and verify our inference we generated scatter plots for data visualization (Figures 4, 5 and 6). Figure-4 clearly reinforces our results by showing that the nursing recordings are less correlated with the recordings made by the Junior/Senior residents. We implemented the linear regression parameters to our data set using gradient descent. Figures 6 and 5 show scatter-plot of training data with linear regression fit models. The linear regression fit models shows that the nursing staff recordings fit poorly compared to linear fit between Jr. residents/Interns and Sr. residents/Consultants showing high variance and low reliability.

Table1: Descriptive Analysis

	n	mean	SD	Median	mad	skew	kurtosis	SE
Age	170	53.99	20.56	53.5	24.46	0.11	-1.10	1.58
Sys(N)	170	132.71	23.84	130.0	20.76	0.17	0.49	1.83
Dias(N)	170	79.32	12.59	80.0	14.83	0.13	1.51	0.97
Sys(J)	170	130.64	19.56	130.0	14.83	0.34	1.15	1.50
Dias(J)	170	79.06	9.99	80.0	5.93	0.40	4.80	0.77
Sys(S)	170	131.60	19.44	130.0	14.83	0.39	0.87	1.49
Dias(S)	170	79.53	9.63	80.0	5.93	0.44	3.90	0.74

Table 2: Correlation (BP-all)

	Age	Sys(N)	Dias(N)	Sys(J)	Dias(J)	Sys(S)	Dias(S)
Age	1.000	0.382	0.292	0.340	0.163	0.307	0.161
Sys(N)	0.382	1.000	0.614	0.874	0.402	0.826	0.441
Dias(N)	0.292	0.614	1.000	0.531	0.663	0.541	0.688
Sys(J)	0.340	0.874	0.531	1.000	0.557	0.960	0.548
Dias(J)	0.163	0.402	0.663	0.557	1.000	0.574	0.888
Sys(S)	0.307	0.826	0.541	0.960	0.574	1.000	0.572
Dias(S)	0.161	0.441	0.688	0.548	0.888	0.572	1.000

Sys(N)= Systolic B.P recorded by Nursing staff; Dias(N)= Diastolic B.P recorded by Nursing staff; Sys(J)= Systolic B.P recorded by Junior residents/Interns; Dias(J)= Diastolic B.P recorded by Junior residents/Interns; Sys(S)= Systolic B.P recorded by Senior residents/Consultants.; Dias(S)= Diastolic B.P recorded by Senior residents/Consultants

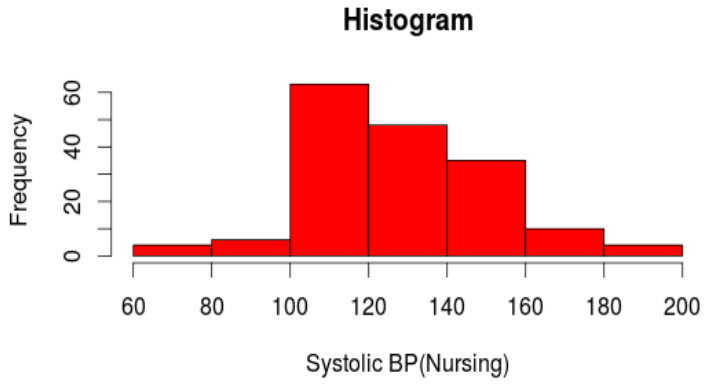
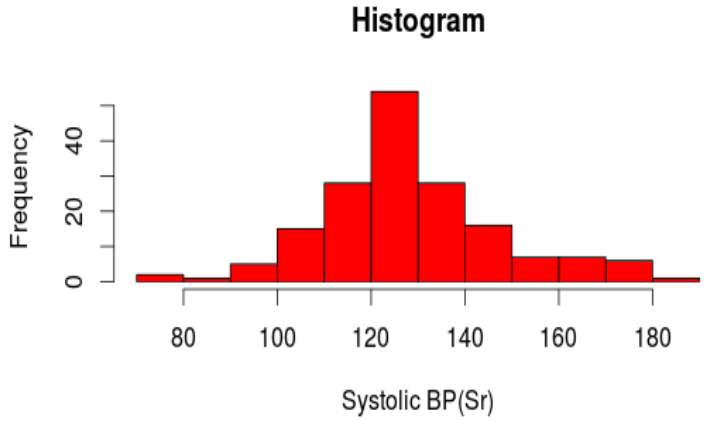


Fig. 1: Systolic BP record: Histogram showing Systolic BP recorded by the nursing staff, distribution is not normal and negatively skewed



Fi. 2: Histogram showing Systolic BP recorded by the Senior residents/Consultants, distribution is normal (Gaussian)

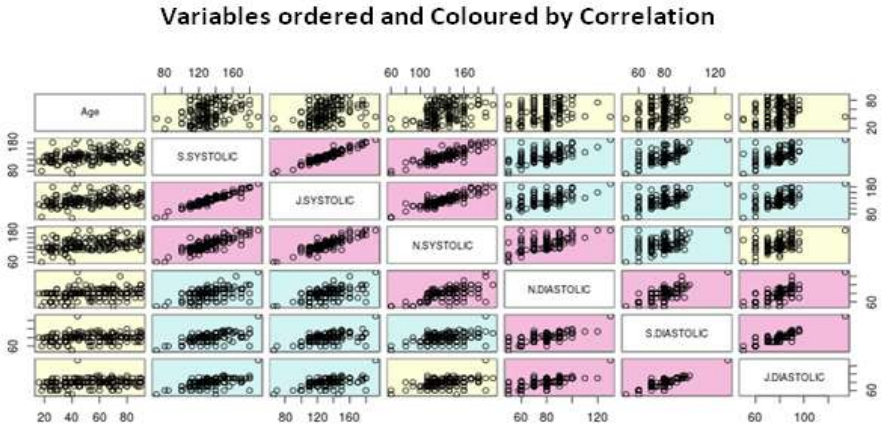


Fig. 3: Matrix scatter-plot showing variables ordered and colored on the basis of the correlation. Systolic BP recorded by Sr/Consultants is more correlated with the recordings made by JRs/Interns as compared to nursing staff

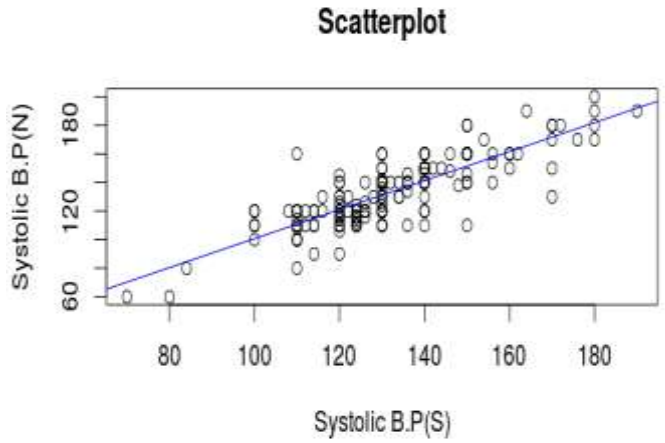


Fig. 4: Scatter-plot showing implementation of the linear regression parameters to our dataset using gradient descent. Linear regression model fit line (Blue color) is passing through the dataset of Systolic BP recorded by SRs /Consultants and Nursing staff

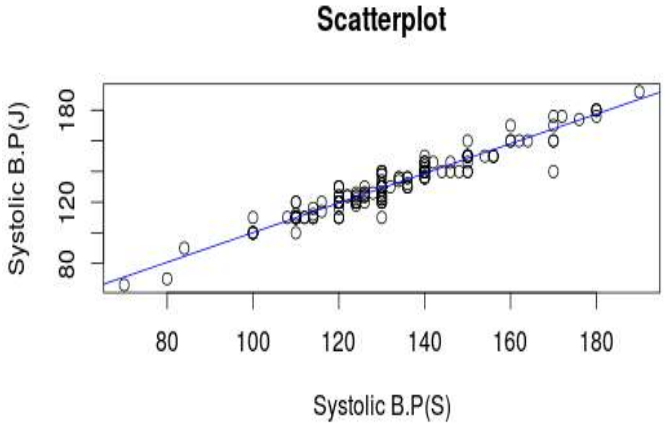


Fig. 5: Scatter-plot showing implementation of the linear regression parameters to our dataset using gradient descent. Linear regression model fit line (Blue color) is passing through the dataset of Systolic BP recorded by SRs /Consultants and JRs /Interns

DISCUSSION

It is evident from the results that there is a significant variability in the BP measurement by different levels of health workers. The correct methodologies have been amply stressed in various studies [16, 17]. The recording of BP also becomes variable depending upon arm size, position of the arm as well as of body position and the proper size and tying of the sphygmomanometer cuff, which has been amply stressed upon by various workers. Also significantly higher SBP (by 4.6 +/− 6.1 mmHg) and DBP (by3.9 +/− 2.8 mmHg) were obtained when the arm of the patient was placed on the bed (below the right atrium level), than when the arm was placed at the level of the right atrium [18–20]. Arm cuff not adhering to the recommended 40 % of upper arm circumference also cause discrepancies [21] . The use of cuffs containing inappropriate invariably leads to incorrect diagnosis in clinical settings and erroneous conclusions. It has been unequivocally proved that either too narrow or too short a bladder (under cuffing) causes overestimation of BP or too wide or too long a bladder (over cuffing) leads to underestimation of BP. Under cuffing causes over diagnosis of hypertension and over cuffing may label hypertensives as normotensive [21]. No single cuff, when used in accordance with current recommendations, yields accurate systolic as well as diastolic BP. The selection of a right size arm cuff for an accurate measurement of BP remains unresolved and aptly mentioned as a century of confusion. The use of bell / diaphragm does make a slight difference in the recordings [22, 23]. In a latest study to demonstrate the use of a large number of BP recordings to come to a more qualitative and authentic level of measurement, it has been recommended that Physicians who want to have 80% or more certainty that they are correctly classifying patients' BP control should use the average of several measurements. Decisions based on a single measurement are potentially misleading [24].

In a study in a large teaching hospital in southern Saudi Arabia involving consultants, junior doctors and nurses; a poor knowledge of some of the basic techniques of BP measurement regarding the knowledge of cuff size, recording of diastolic BP, position of the arm and rate for deflating the cuff has been demonstrated [25]. Similar observations were made in a study conducted at a teaching medical college and hospital in Chandigarh where sitting position BP apparatus was kept below the level of heart and one - fifth did not have their arm supported. They also observed that a large majority was found to be not using palpatory method for SBP and about three-forth did not inflate cuff to raise pressure 30-40 mm Hg above the systolic level before checking the BP by auscultation. Also majority of personnel lowered the BP at a rate of more than 2 mm/s also rounded off the BP to nearest 5-10 mm Hg. Re-inflation of the cuff without completely deflating was done. Non observance of these small norms leads to avoidable errors [26]. Variation occurred between doctors & nurses in the measurement of both SBP and DBP but less variation was found in the measurement of systolic than for diastolic blood pressure. On an average, doctors reading do demonstrate higher than those by nurses (white coat hypertension) [14]. Of course 24 hour ambulatory monitoring has been found to a better predictor of cardiovascular risk in the individual patient and is the only technique that can describe the diurnal rhythm of blood pressure accurately [5], But in the hospitalized patients especially for acute/ ICU cases it is not practicable. Though for domicil- iary control of hypertension in a patient's daily life the automatic monitoring of blood pressure help the health professionals to get average BP values [27]. However to get the most accurate BP measurements, it is recommended that the the Finapres technology (Finger Arterial Pressure), which gives a continuous finger arterial pressure waveform, may be considered [28].

CONCLUSION

We conclude that B.P recordings, especially systolic B.P. made by nursing staff are more prone to error as compared to the observations made by clinicians with different tier of experience. Recording made by Senior residents/ consultants are more coherent. Also the correct way of tying the cuff as well as the incorrect position of the arm leads to wrong recordings. Many a times the health care professionals were was found to be erring in recording PB over fully clothed arms especially in winter months; which is to be deprecated. We can also infer that the recordings by the nursing staff are more prone to bias as they are centered mostly around round figure values, showing non-normal (negatively skewed) distributions. Therefore we concretely recommend to cross- verify the reliability and validity of the recordings made by the nursing staff by the clinicians themselves before clinical decision making and quality reporting. Incorrect measurement can result either in unnecessary investigations, treatment, and follow-up for the mistaken diagnosis of hypertension, or no treatment for hypertension in individuals mistakenly thought to have normal BP.

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REFERENCES

1. Hing E, Hall MJ, Ashman JJ, Xu J; National Hospital Ambulatory Medical Care Survey: 2007 outpatient department summary. National Health Statistics Reports. 2010; 28:1–32.
2. Ogden LG, He J, Lydick E, Whelton PK; Long-term absolute benefit of lowering blood pres- sure in hypertensive patients according to the JNC VI risk stratification. Hypertension. 2000; 35(2): 539–543.
3. Collins R, Peto R, MacMahon S, Hebert P, Fiebach NH, Eberlein KA *et al.*; Blood pressure, stroke, and coronary heart disease. Part 2, Short-term reductions in blood pressure: overview of randomised drug trials in their epidemiological context. Lancet. 1990; 335(8693): 827–838.
4. Casas JP, Chua W, Loukogeorgakis S, Vallance P, Smeeth L, Hingorani AD *et al.*; Effect of inhibitors of the renin-angiotensin system and other antihypertensive drugs on renal outcomes: systematic review and meta-analysis. Lancet, 2005; 366(9502): 2026–2033.
5. Pickering TG; Principles and techniques of blood pressure measurement. Cardiology cClinics. 2002; 20(2): 207–223.
6. MacMahon S, Peto R, Cutler J, Collins R, Sorlie P, Neaton J *et al.*; Blood pressure, stroke, and coronary heart disease. Part 1, Prolonged differences in blood pressure: prospective observational studies corrected for the regression dilution bias. Lancet, 1990; 335(8692):765–774.
7. Williams B, Lindholm LH, Sever P; Systolic pressure is all that matters. Lancet, 2008; 371(9631): 2219–2221.
8. Chobanian AV, Bakris GL, Black HR, Cushman WC, Green LA, Izzo J Joseph L *et al.*; The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure: the JNC 7 report. JAMA: The Journal of the American Medical Association. 2003; 289(19): 2560–2572.
9. Kim JW, Bosworth HB, Voils CI, Olsen M, Dudley T, Gribbin M *et al.*; How well do clinic-based blood pressure measurements agree with the mercury standard? Journal of General Internal Medicine, 2005; 20(7): 647–649.
10. Jones DW, Appel LJ, Sheps SG, Roccella EJ, Lenfant C; Measuring blood pressure accurately: new and persistent challenges. JAMA: the journal of the American Medical Association. 2003; 289(8): 1027–1030.
11. Keenan K, Hayen A, Neal BC, Irwig L; Long term monitoring in patients receiving treatment to lower blood pressure: analysis of data from placebo controlled randomised controlled trial. BMJ (Clinical Research ed)., 2009; 338: b1492.
12. Marshall T; Misleading measurements: modeling the effects of blood pressure misclassification in a United States population. Medical Decision Making: An International Journal of the Society for Medical Decision Making, 2006; 26(6): 624–632.
13. Martnez MA, Aguirre A, Snchez M, Nevado A, Laguna I, Torre A *et al.*; The determination of arterial pressure by the physician or the nurse: its relation to ambulatory pressure and left ventricular mass. The MAPA-Madrid Group. Monitorizacin Ambulatoria de la Presin Arterial (Ambulatory Monitoring of Arterial Pressure)]. Medicina Clnica., 1999; 113(20): 770–774.
14. Richardson JF, Robinson D; Variations in the measurement of blood pressure between doctors and nurses. An observational study. The Journal of the Royal College of General Practitioners, 1971; 21(113): 698–704.
15. R Core Team. R: A Language and Environment for Statistical Computing. Vienna, Austria; 2012. Available from: http://www.R-project.org/.
16. Clark EG Glock CY, Schweitzer MD, Vought RL; Studies in hypertension. II. Vari- ability of daily blood pressure measurements in the same individuals over a three-week period. Journal of Chronic Diseases, 1956; 4(5): 469–476.
17. Pickering TG, Hall JE, Appel LJ, Falkner BE, Graves J, Hill MN *et al.*; Recommendations for blood pressure measurement in humans and experimental animals: part 1: blood pressure measurement in humans: a statement for

professionals from the Subcommittee of Professional and Public Education of the American Heart Association Council on High Blood Pressure Research. Circulation, 2005; 111(5):697–716.
18. Netea RT, Bijlstra PJ, Lenders JW, Smits P, Thien T; Influence of the arm position on intra- arterial blood pressure measurement. Journal of Human Hypertension, 1998; 12(3): 157–160.
19. Mattoo TK; Arm cuff in the measurement of blood pressure. American Journal of Hypertension. 2002; 15(2 Pt 2): 67S–68S.
20. Netea RT, Lenders JWM, Smits P, Thien T; Both body and arm position significantly influence blood pressure measurement. Journal of Human Hypertension, 2003; 17(7): 459–462.
21. Clark JA, Lieh-Lai MW, Sarnaik A, Mattoo TK; Discrepancies between direct and indirect blood pressure measurements using various recommendations for arm cuff selection. Pediatrics, 2002; 110(5): 920–923.
22. Kantola I, Vesalainen R, Kangassalo K, Kariluoto A; Bell or diaphragm in the measurement of blood pressure? Journal of Hypertension, 2005; 23(3): 499–503.
23. O'Brien E; Review: a century of confusion; which bladder for accurate blood pressure measure- ment? Journal of Human Hypertension, 1996; 10(9): 565–572.
24. Powers BJ, Olsen MK, Smith VA, Woolson RF, Bosworth HB, Oddone EZ; Measuring blood pressure for decision making and quality reporting: where and how many measures? Annals of Internal Medicine, 2011; 154(12): 781–788, W–289–290.
25. Ahmed ME; Knowledge of blood pressure measurement among a teaching hospital staff in a developing nation. Journal of Human Hypertension, 1997; 11(8): 495–499.
26. Bhalla A, Singh R, D'cruz S, Lehl SS, Sachdev A; Accurate blood pressure recording: is it difficult? Indian Journal of Medical Sciences, 2005; 59(11): 480–487.
27. Vilaplana JMG; Blood pressure measurement. Journal of renal care. 2006; 32(4): 210–213.
28. Imholz BP, Wieling W, van Montfrans GA, Wesseling KH; Fifteen years experience with finger arterial pressure monitoring: assessment of the technology. Cardiovascular Research, 1998; 38(3): 605–616.