Original Article

Does Errors Made during Indirect Blood Pressure Measurement affect the Results?

Ülkü Yapucu Güneş, PhD
Associated Professor, Ege University Faculty of Nursing, Bornova, Izmir, Turkey

Elçin Ülker Efteli, MSc
Research Assistant, Ege University Faculty of Nursing, Bornova, Izmir, Turkey

Correspondence: Ülkü Yapucu Güneş, Associated Professor, Ege University Faculty of Nursing, Bornova, Izmir, Turkey E-mail: ulku.gunes@ege.edu.tr

Abstract

Aim: The aim of this study is to determine the extent to which errors such as not supporting the arm during blood pressure (BP) measurement, deflation of the cuff at a rate faster than 2-3 mmHg/sec and placement of the stethoscope's diaphragm beneath the cuff affect blood pressure measurement.

Methods: This study used repeated measures design with 116 nursing students. A single investigator was measured the BP in the direction of the guidelines of Turkish Cardiology Association, with the cuff deflated as a rate of 6-7 mmHg/sec., by holding the arm at the level of heart without support and placing of the stethoscope's diaphragm beneath the cuff using a sphygmomanometer in 116 healthy subjects.

Results: While the mean systolic BP was higher in measurements performed without providing any support beneath the arm, it was lower when the cuff was deflated at a rate of 6-7 mmHg/sec. If the cuff was deflated at a rate of 6-7 mmHg/sec., diastolic BP increased significantly.

Conclusion: This study has shown that arm support and deflating the sphygmomanometer cuff faster than the recommended rate have effects on BP measurements.

Keywords: Vital signs, blood pressure measurement, error

Introduction

Blood pressure measurement is one of the routine procedures performed by nurses during clinical care. The diagnosis and treatment of hypertension is made according to the BP measured by the nurse or the physician (Carter, 2004, p. 19). BP measurement is an important criterion in determining the pharmacological or non-pharmacological treatment of a patient (Beevers, Lip & O'Brien, 2001, p. 982; Drevenhorn, Håkansson & Petersson, 2001, p. 189). During important therapeutic decisions, measurements obtained are generally considered correct. Since most BP measurements are done using the indirect method, false results or faults due to standardization or calibration are usually encountered (Armstrong, 2000, p. 119). Therefore, measuring BP according to appropriate standards is extremely important. The BP measurements that are not compatible with the set standards result in mismeasurements or administration of unnecessary or improper treatments. In the study of Turner, Baker and Kam (2004, p. 252) investigating systemic faults in BP measurements, it was reported that measurement of systolic BP 3 - 5 mmHg higher than the actual value increases the rate of patients classified as hypertensive by 24% and 43%. In case of systolic BP measurement 3-5 mmHg lower than the actual value, 19-30% of the patients were not mistakenly diagnosed as hypertensive. In another study, it was reported that 97% of the physicians did not follow the recommendations of American Heart Association during BP measurement and base on this inaccurate measurements important decisions were made concerning patients' therapies (McKay, Campbell, Parab, Chockalingam & Fodor, 1990, p. 639).

The factors that affect the true measurement of BP are; choosing the correct arm from which to measure from, the correct cuff, period of rest before or between measurements, position of the arm, underarm support correct placement of the stethoscope's diaphragm, and the rate of inflation and deflation of the cuff (Barclay, 2005; Turner, Baker & Kam, 2004, p. 252; Williams, Brown & Conlin, 2009). However, in the literature there are limited numbers of studies concerning the extent to which these factors affect BP measurement. Other than that, these factors that have important influence on BP measurements are neglected in the daily practice and even in the investigations due to time scantiness and being more practical (Bailey & Bauer, 1993, p. 2742).

Methods

Aim

The aim of this study is to determine the extent to which errors such as not supporting the arm during BP measurement, deflation of the cuff at a rate faster than 2-3 mmHg/sec and placement of the stethoscope's diaphragm beneath the cuff affect BP measurement.

Research design

A descriptive design was used for the study

Setting

This study was conducted at a nursing faculty in İzmir with nursing students as participants between January and December 2013.

Sample

Participants included 116 randomly selected students whose body mass index are within the normal range, who accepted to participate in the study, did not have any chronic or acute disease or physical obstacle that may impair with the measurement on the arm and nonsmokers.

Procedure

BP measurements were performed by a single investigator using a new mercury sphygmomanometer (ERKAmeter 3000; ERKA, Bad Tölz, Germany) and stethoscope. Before the data collection, 10 BP measurements were taken with the investigator and an experienced and trained observer, who determined the auscultation readings simultaneously in a blinded manner with a dual-earpiece teaching stethoscope.

An excellent agreement was found among the two readers (intraclass correlation coefficient, 0.9940 [95% confidence interval: 0. 9890, 0.9990)

The participants were each rested for 10 minutes prior to the commencement of measurement, all measurements were taken from the right arm in the sitting position, in accordance with the protocol (Table 1) described by the Turkish Cardiology Association (Turkish Cardiology Association, TCA, Hypertension Working Group, 2000, p. 360). A 16x30 cm sized cuff was used for the all participants. BPs were obtained via 4 protocols one of which was the standard protocol defined by TCA and the remaining three were faulty methods. In the faulty methods, certain standard procedures were followed alongside deliberate errors. Each method was performed twice and the mean BP value was calculated. The participants were rested for a minimum of 1 minute between the two measurements of one method and a minimum of 5 minutes between methods. They were also asked to empty their bladders prior to the measurement. Additionally, they were asked not to talk, move or put one leg on the other, or lean during the measurement. The methods A, B and C were randomized by drawing, and the BPs of each individual were finally measured using the standard protocol.

Standard method: BP was measured in accordance with the standards defined in Table 1.

Method A: The arm of the individual was held to the level of the heart, but no support was placed beneath.

Method B:In this method, BP was measured by being placed the diaphragm of the stethoscope beneath the cuff.

Method C: Measurement was obtained with the cuff deflated as a rate of 6-7 mmHg/sec.

Statistical analysis

Statistical analysis was done on SPSS, 16.0 version (SPSS Inc., Chicago IL, USA). Interobserver agreement was assessed by using an intraclass correlation coefficient. A one-way repeated measures ANOVA was used to compare the mean BP for different methods. Adjustment for multiple comparisons was done using Bonferroni correction. The significance level was set at $p<0.05$.

Ethical perspective

Ethical committee approval was obtained prior to the study. The participants were informed about the study and oral informed consents were obtained.

Results

The mean age of the participants was 20.47±15.49, 73.8% were female, 26.2% male. Table 2 demonstrates the mean BP value (SBP: Systolic blood pressure, DBP: Diastolic blood pressure) measured using the four different methods. The mean systolic BPs tends to increase in measurements performed without providing any support beneath the arm, whereas it tends to decrease when the cuff was deflated at a rate of 6-7mmHg/sec., and the difference between the methods of systolic BPs measurement was found to be significant($p<0.001$). Although there was no statistically significant difference between the methods in diastolic BP ($p>0.05$), it was shown to increase when the cuff was deflate data rate of 6-7 mmHg/sec.

The changes in systolic BPs were statistically significant except for Method B (placement of the stethoscope diaphragm beneath the cuff) (all $p<0.001$).

Discussion

In this study, we investigated the effects of common errors done during BP measurement on indirect BP measurement results. It has been emphasized that errors related to inadequate measurement technique are frequently made during BP measurement (La Batide-Alanore, Chatellier, Bobrie, Fofol & Plouin, 2000, p. 391; Myers, Oh, Reeves & Joyner, 1995, p. 592). One of the most frequent errors made, is measurement without providing any support to the arm. It has been demonstrated in observational studies that nurses most of the time, disregarded this principle as well (Armstrong, 2000, p.123; Uysal & Enç, 2005, p. 54; Zaybak & Güneş, 2007, p.25). Systolic BP was significantly higher in the measurements performed without arm support than those performed in accordance with the standards. As of the time of this study, only one paper concerning the subject was available in the literature and the results of this study was found to be in accordance with the results of our study (Webster, Newnham, Petrie & Lovell, 1984, p. 1574). During BP measurement, the arm should be held to the level of the heart and supported beneath (O'Brien et al, European Society of Hypertension -ESH- Working Group on Blood Pressure Monitoring, 2003, p. ; Mourad et al., 2003, p. 390; Netea, Lenders, Smits & Thien, 2003, p. 459; Pickering et al., 2005, p. 705). It has been reported in various literatures that when the arm is not adequately supported during measurement, higher BP measurements may be obtained due to isometric muscle exercise (Beevers, Lip & O'Brien, 2001, p.983; Silverberg, Shemesh & Iaina, 1997, p. 1331). This change observed in BP following isometric exercise may be explained by reduced vagal stimulation, increased alpha-adrenergic stimulation and peripheral resistance (Guyton & Hall 1996, p. 164).

One of the frequent errors encounter during BP measurement is the placement of the stethoscope's diaphragm beneath the cuff (Method B). It has been reported in some literatures that error as a result of the stethoscope touching the cuff, thus the pulse sounds cannot be heard clearly (O'Brien et al., European Society of Hypertension -ESH- Working Group on Blood Pressure Monitoring, 2003; Frese, Fick & Sadowsky, 2011, p. 7). However, no statistically significant difference was observed between systolic and diastolic BP measurements performed using this method and the standard method. Although this principle is noted in the guidelines, only one study supporting our findings was found in the literature (Pan, Zheng & Murray, 2013, p. 897).

It has been reported in the literature that the deflation rate of the cuff during BP measurement should be 2-3 mm Hg/sec. (O'Brien et al., European Society of Hypertension -ESH- Working Group on Blood Pressure Monitoring, 2003; Pickering et al., 2005, p. 706; TCA, Hypertension Working Group, 2000). In our study, the deflation rate of the cuff was set as 6-7 mmHg/sec., and the systolic BP was found to be significantly lower compared to the standard method. When the cuff is deflated at a rate 3 times faster than the recommended rate, systolic BP measurement was found to be 7 mmHg lower, and diastolic BP was 1 mmHg higher when compared with the standard deflation rate. Our results are in accordance with the two other studies (King, 1963, p. 304; Zheng, Amoore, Mieke & Murray 2011, p. 2588).

Since the BPs are measured by a single investigator during this study, compliance between investigators was not evaluated. Furthermore, inclusion of only normotensive individuals is another limitation of this study. However, the methods used for measurement was randomly selected and more than one measurement performed for each method are the advantages of the study.

Table 1. Blood pressure measurement protocol

1. Patient should be seated comfortably, with back supported, legs uncrossed, and upper arm bared.

2. Patient's arm should be supported at heart level and supported on a table

3. The cuff should be placed on neatly with the centre of the bladder over the brachial artery. The bladder should encircle at least 80% of the arm (but not more than 100%)

4. Estimate the systolic beforehand:

- **a) Palpate the brachial artery**
- **b) Inflate cuff until pulsation disappears**
- **c) Deflate cuff**
- **d) Estimate systolic pressure**

5. Then inflate to 30 mmHg above the estimated systolic level needed to occlude the pulse

6. The stethoscope diaphragm should be placed over the brachial artery without touching blood pressure cuff and deflate at a rate of 2-3mm/sec until you hear regular tapping sounds

7. Measure systolic (first sound) and diastolic (disappearance) to nearest 2 mmHg

Table 2. The mean blood pressure recordings for 4 different methods

Methods	Mean SBP, mmHg (SD)	Mean DBP, mmHg (SD)
Standart	110.7 (3.6)	67.5 (8.9)
Method A	113.7 (15.8)	68 (9.3)
Method B	108.5 (16.2)	65.9 (10.3)
Method C	103.9 (14.4)	68.3 (11.2)
Wilks' Lambda	0.42	0.91
F	50.8	3.61
p	<0.001	>0.05

Conclusion

This study has shown that arm support and deflating the sphygmomanometer cuff faster than the recommended rate have effects on BP measurements. Increasing the awareness of nurses on the importance of the arm support and cuff deflation rate during BP measurement as well as the importance of the subject should be emphasized in nursing education.

BP differences in this study may lead to important outcomes. A 3-5 mmHg false measurement of the BP may result in the misdiagnosis, unnecessary or improper treatment, or an altered life style of the patient. Bringing the arm to the level of the heart is commonly emphasized in the guidelines of BP measurement, whereas there inconsistencies concerning simultaneous arm support. It is critically important to provide support beneath the arm during BP measurement by the nurses, and also obey the deflation rate of the cuff as mentioned in the manuals. Furthermore, although placing the stethoscope diaphragm over the brachial artery is mentioned in the manuals, no significant difference was observed in this study. Placing the stethoscope's diaphragm beneath the cuff may be a more practical method for nurses, however, it complicates generalizing the subject in practice due to the limited number of studies. Therefore, studies should be performed on different samples.

References

Armstrong, R. S. (2002). Nurses' knowledge of error in blood pressure measurement technique. International Journal of Nursing Practice, 8(3), 118-126.

Bailey, R.H. & Bauer, J.H. (1993). A review of common errors in the indirect measurement of blood pressure: sphygmomanometry, *Archives of Internal Medicine*, 153(24), 2741-2748.

Barclay, L. (2005). American heart association updates recommendations for blood pressure measurements, *Hypertension,* 45, 2-21.

Beevers, G., Lip, G.Y. & O'Brien, E. (2001). ABC of hypertension: Blood pressure measurement: Part I—Sphygmomanometry: factor common to all techniques. *British Medical Journal* , 322, 981-985.

Carter, B. L. (2004). Implementing the new guidelines for hypertension: JNC 7, ADA, WHO-ISH, *Journal of Managed Care Pharmacy*, 10, 18-25.

Drevenhorn, E., Håkansson A. & Petersson, K. (2001). Blood pressure measurement–an observational study of 21 public health nurses, *Journal of Clinical Nursing*, 10(2), 189-194.

Frese, E.M., Fick, A. & Sadowsky, H.S. (2011). Blood pressure measurement guidelines for physical therapists, *Cardiopulmonary Physical Therapy Journal,* 22(2), 5.

Guyton, A.C. & Hall J.E. (1996). Textbook of medical physiology. W.B. Saunders Company, 9th Edition, 164

King, G.E. (1963). Influence of rate of cuff inflation and deflation on observed *blood pressure* by sphygmomanometry, *American Heart Journal,* 65, 303-306.

La Batide-Alanore, A., Chatellier, G., Bobrie, G., Fofol, I. & Plouin P.F. (2000). Comparison of nurse-and physician-determined clinic blood pressure levels in patients referred to a hypertension clinic: implications for subsequent management, *Journal of Hypertension*, 18(4), 391-398.

McKay, D.W., Campbell, N.R., Parab, L.S., Chockalingam, A. & Fodor, J.G. (1990).Clinical assessment of blood pressure, *Journal of Human Hypertension*, 4(6), 639-645.

Mourad, A., Carney, S. Gillies, A., Jones, B., Nanra, R., & Trevillian, P. (2003). Arm position and blood pressure: a risk factor for hypertension?, *Journal of Human Hypertension*, 17(6), 389-395.

Myers, M.G., Oh, P.I., Reeves, R.A. & Joyner, C.D. (1995). Prevalence of white coat effect in treated hypertensive patients in the community, *American Journal of Hypertension*, 8(6), 591-597.

Netea, R.T., Lenders, J.W.M., Smits, P. & Thien, T. (2003). Both body and arm position significantly influence blood pressure measurement, *Journal of Human Hypertension*, 17(7), 459-462.

O'Brien, E., Asmar, R., Beilin, L., Imai, Y., Mallion, J. M., Mancia, G. et al. European Society of Hypertension Working Group on Blood Pressure Monitoring. (2003). European Society of Hypertension recommendations for conventional, ambulatory and home blood pressure measurement. *Journal of hypertension*, 21(5), 821-848.

Pan, F., Zheng, D. & Murray, A. (2013). Effect of stethoscope position on auscultatory blood pressure measurement, *In Computing in Cardiology Conference (CinC),* IEEE, 895-898.

Pickering, T.G., Hall, J.E., Appel, L.J., Falkner, B. E., Graves, J., Hill, M. N. et al. (2005). Subcommittee of Professional & Public Education of the American Heart Association Council in High Blood Pressure Research, AHA Scientific Statement: recommendations for blood pressure measurement in human 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, *Hypertension,* 45(1), 142–161.

Silverberg, D.S., Shemesh, E. & Iaina, A. (1997). The unsupported arm: a cause of falsely raised blood pressure readings, *British Medical Journal,* 2(6098), 1331.

Turkish Cardiology Association, Hypertension Working Group. (2000). A guide for national hypertension treatment and follow-up, *Archives of the Turkish Society of Cardiology,* 28, 335–397.

Turner, M.J., Baker, A.B. & Kam, P.C. (2004). Effects of systematic errors in blood pressure measurements on the diagnosis of hypertension, *Blood Pressure Monitoring*, 9 (5): 249-253.

Uysal, H. & Enç, N. (2005). Evaluation of Nurses About Oriented Towards; Theoretical and Application Knowledges, *Journal of Ege University School of Nursing,* 21:47-61

Webster, J., Newnham, D., Petrie, J.C. & Lovell, H.G. (1984). Influence of arm position on measurement of blood pressure, *British Medical Journal (Clinical Research ed.)*, 288(6430), 1574.

Williams, J.S., Brown, S.M. & Conlin PR. (2009). Blood-pressure measurement, *New England Journal of Medicine*, 360(5), 5

Zaybak, A. & Güneş, U. (2007). An Observational Study of Indirect Arterial Blood Pressure Measurement Methods of Nurses, *Journal of Cumhuriyet University School of Nursing,* 11(3), 23-28.

Zheng, D., Amoore, J.N., Mieke, S. & Murray A. (2011). How important is there commended slow cuff pressure deflation rate for blood pressure measurement?, *Annals of Biomedical Engineering,* 39(10), 2584-2591.