Differences in Blood Pressure Measurements Obtained Using an Automatic Oscillometric Sphygmomanometer Depending on Clothes-Wearing Status

Original
Article

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Background: According to the current guidelines for blood pressure monitoring, clinicians are recommended to measure blood pressure by completely exposing the upper arm. However, it is a common practice that blood pressure is measured with the cuff placed over the sleeve or with the sleeve rolled up. We therefore conducted this study to examine whether there are any differences in blood pressure measurements among the three different settings: the sleeve group, the rolled sleeve group, and the bare arm group.

Methods: We conducted the current study in 141 male and female adult patients who visited our clinical department. In these patients, we took repeatedly blood pressure measurements using the same automatic oscillometric device on three different settings. Then, we analyzed the results with the use of randomized block design analysis of variance.

Results: The mean values of systolic blood pressure (SBP) between the first reading and those of the second reading were 128.5 ± 10.6 mm Hg in the sleeve group, 128.3 ± 10.8 mm Hg in the rolled sleeve group, and 128.3 ± 10.7 mm Hg in the bare arm group. These results indicate that there were no significant differences among the three groups ($P = 0.32$). In addition, the mean values of diastolic blood pressure (DBP) between the first reading and those of the second reading were 80.7 ± 6.1 mm Hg in the sleeve group, 80.7 ± 6.1 mm Hg in the rolled sleeve group, and 80.6 ± 5.9 mm Hg in the bare arm group. These results indicate that there were no significant differences among the three groups ($P = 0.77$). In addition, based on the age, sex, past or current history of hypertension or diabetes mellitus, the thickness of sleeve, weight, a drinking history, and a smoking history, there were no significant differences in SBP and DBP among the three groups.

Conclusion: There were no significant differences in blood pressure measurements between the three different settings (the sleeve group, the rolled sleeve group, and the bare arm group).

Keywords: Blood Pressure Determination; Clothing; Hypertension

INTRODUCTION

Hypertension is one of the chronic diseases that clinicians can encounter the most frequently in a primary care setting; its prevalence reaches up to 31.9% in patients aged 30 years or older, 55.6% in those in their 60s, and 69.5% in those in their 70s according to the fourth Korean National Health and Nutrition Examination Survey (2009).¹⁾ It would therefore be mandatory to make an accurate measurement of blood pressure, which is essential for making a correct diagnosis of hypertension and assessing the accuracy of current prescriptions. According to

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the current guidelines for blood pressure monitoring, clinicians are recommended to appropriately adjust factors that may affect blood pressure measurements, such as caffeine, cigarettes, position of the arm, and the size of cuff. Moreover, they are also recommended to measure blood pressure by completely exposing the upper arm. The sleeve should not be rolled up such that it has a tourniquet effect above the blood pressure cuff.²⁻⁷⁾ In a Korean clinical setting where clinicians cannot afford sufficient time to examine a single patient on a fixed-time basis, however, it is not easy to measure the blood pressure in patients who have taken off their top. In particular, elderly people account for a majority of ambulatory patients who feel it difficult to collaborate with their physicians for further evaluation of hypertension in an actual clinical setting. Therefore, clinicians encounter more challenging problems when they recommend the patients to take off their top in measuring blood pressure. It is therefore a common practice that blood pressure is measured with the cuff placed over the sleeve or with the sleeve rolled. As described here, there is an inconsistency between the guidelines for blood pressure monitoring and actual clinical practice. We have therefore questioned whether there would be any differences in blood pressure measurements depending on the status of patients' wearing their top.

Holleman et al.⁸⁾ conducted a study in 36 patients, and other several English reports have shown that there is no significant correlation between blood pressure measurements and the status of wearing the top. But this has not been described in Korean literature up to present. Given the above background, we conducted this study to examine whether there are any differences in blood pressure measurements among the three different settings: the sleeve group, the rolled-sleeve group, and the bare arm group.

METHODS

1. Study Patients

The current study was conducted in male and female adult patients aged 18 years or older who visited Gangneung Asan Hospital, Korea during a period ranging from January of 2010 to May of 2011. Exclusion criteria for the current study are as follows: 1) patients who drank a coffee or smoked cigarettes within 30

minutes; 2) patients who had bradycardia of 60 beats/min, atrial fibrillation or irregular arrhythmia on the electrocardiogram or those who had a past history of taking pharmacological treatments for arrhythmia, cardiac failure, or ischemic heart disease; 3) patients who wore only a short-sleeve top; and 4) patients who did not submit a written informed consent.

A total of 141 patients were evaluated for blood pressure. The current study was approved by the institutional review board of Gangneung Asan Hospital. In addition, we enrolled only those who were informed of the purposes and details of the current study and then submitted a written informed consent.

2. Study Methods

A single investigator measured blood pressure using an automatic oscillometric sphygmomanometer with a cuff of 107 × 63 mm in size, Omron MX-3 blood pressure monitor (Omron, Tokyo, Japan). The accuracy of an oscillometric blood pressure monitor has been well described in several Korean or English literatures.⁹⁻¹¹⁾ Blood pressure was measured in accordance with the Korean Society of Hypertension guidelines for blood pressure monitoring²⁾ and the American Heart Association recommendations.³⁾ Patients were instructed to refrain from drinking coffee or smoking cigarettes for at least 30 minutes. In addition, they were also instructed to lean back in their chair and to place their foot on the ground with legs uncrossed. Moreover, they were also instructed to place their arm on the desk at the height of the heart. Thus, following a more than 5-minute stabilization, their blood pressure was measured. Prior to the measurement of blood pressure, they were instructed to urinate. But they were not permitted to speak during measurement of blood pressure.

Blood pressure was measured in the following three settings: 1) with the cuff placed over the sleeve on the patients' upper arm (the sleeve group); 2) with the patients' sleeve rolled above the upper border of the blood pressure cuff (the rolled sleeve group); and 3) with the cuff placed on the patients' bare and unclothed arm (the bare arm group).

In rolling up the sleeve, we made a 2-cm space between the sleeve and the upper arm. Three measurement orders were randomly applied to the patients, where there was a minimum interval of more than two minutes between each measurement. Following the first measurement reading, there was a time gap

of more than ten minutes. Then, blood pressure was measured again in three different settings for the second reading of the measurement. Thus, blood pressure was measured a total of six times using the same sphygmomanometer for the same arm of the patients placed in the same posture in the same place.

In our patients, we measured the thickness of the clothes using a skinfold caliper. We also recorded such data as the height, weight, current drug history, smoking history, frequency of drinking, and mean daily amount of drinking. Moreover, we also evaluated such underlying diseases as hypertension, diabetes mellitus, chronic renal disease, peripheral arterial diseases, and ischemic heart disease.

3. Statistical Analysis

Firstly, we performed a paired t-test to compare measurements from the first reading and those from the second reading. Then, measurements were averaged. This was followed by an analysis of three measurements obtained from three different settings with the use of randomized block design analysis of variance (ANOVA). Statistical analysis was performed using SPSS ver. 18.0 (SPSS Inc., Chicago, IL, USA). A P-value of < 0.05 was considered statistically significant.

RESULTS

Baseline characteristics of the patients are summarized in Table 1. The mean age of the patients was 53.7 ± 11.8 years. Our

Table 1. Baseline characteristics of the patients

Factor	Value
Age (y)	53.7 ± 11.8
Sex	
Male	117 (83.0)
Female	24 (17.0)
Body mass index (kg/m ²)	
<23	30 (21.3)
23–25	50 (35.5)
≥25	58 (41.1)
Hypertension	59 (41.8)
Diabetes mellitus	28 (19.9)
Smoking	
Non-smoker	42 (29.8)
Current smoker	52 (36.9)
Ex-smoker	47 (33.3)
Alcohol (times/wk)	
Never	43 (30.5)
<3	75 (53.2)
≥3	23 (16.3)
Thickness of clothes (mm)	
<2	118 (83.7)
≥2	23 (16.3)
Total	141 (100)

Values are presented as mean ± SD or number (%).

Table 2. Comparison between blood pressure measurements of the first reading and those of the second reading in three different settings

Variable	The first reading	The second reading	P-value*
Systolic blood pressure (mm Hg)			
Sleeve group	128.5 ± 10.6	128.5 ± 10.8	0.94
Rolled sleeve group	128.3 ± 11.1	128.4 ± 10.6	0.58
Bare arm group	128.4 ± 10.8	128.3 ± 10.7	0.51
Diastolic blood pressure (mm Hg)			
Sleeve group	80.7 ± 6.3	80.7 ± 6.2	0.89
Rolled sleeve group	80.9 ± 6.3	80.7 ± 6.0	0.07
Bare arm group	80.8 ± 6.0	80.6 ± 6.0	0.16

Values are presented as mean ± SD.

*By paired t-test.

Table 3. Comparison of blood pressure measurements between the three groups

Variable	Sleeve group	Rolled sleeve group	Bare arm group	P-value*
Systolic blood pressure (mm Hg)	128.5 ± 10.6	128.3 ± 10.8	128.3 ± 10.7	0.32
Diastolic blood pressure (mm Hg)	80.7 ± 6.1	80.7 ± 6.1	80.6 ± 5.9	0.77

Values are presented as mean ± SD.

*By randomized block design analysis of variance.

Table 4. Comparison of systolic blood pressure measurements depending on other variables between the three groups (mm Hg)

Variable	Number	Sleeve group	Rolled sleeve group	Bare arm group	P-value*
Age (y)					
<65	118	128.1 ± 10.6	127.8 ± 10.7	127.9 ± 10.6	0.15
≥65	23	130.5 ± 10.8	130.7 ± 11.0	130.6 ± 10.8	0.71
Sex					
Male	117	128.9 ± 10.3	128.7 ± 10.5	128.8 ± 10.4	0.67
Female	24	126.6 ± 12.2	126.0 ± 12.0	126.0 ± 11.8	0.14
Hypertension					
Yes	59	134.3 ± 8.7	134.3 ± 8.8	134.2 ± 8.9	0.94
No	82	124.3 ± 9.9	124.0 ± 10.0	124.0 ± 9.8	0.17
Diabetes mellitus					
Yes	28	134.4 ± 8.3	134.4 ± 8.5	134.1 ± 8.3	0.40
No	113	127.0 ± 10.7	126.8 ± 10.8	126.9 ± 10.7	0.21
Thickness of clothes (mm)					
<2	118	128.2 ± 10.5	127.9 ± 10.6	127.9 ± 10.5	0.16
≥2	23	130.0 ± 11.5	130.0 ± 11.7	130.1 ± 11.4	0.95
Body mass index (kg/m ²)					
<23	30	129.2 ± 9.1	128.7 ± 9.3	128.5 ± 8.8	0.07
23–25	50	126.2 ± 11.5	126.5 ± 11.5	126.5 ± 11.6	0.58
≥25	61	129.9 ± 10.5	129.6 ± 10.8	129.6 ± 10.6	0.08
Smoking					
Never	42	126.6 ± 10.2	126.2 ± 10.6	126.3 ± 10.5	0.11
Ex-smoker	47	129.1 ± 10.0	129.3 ± 9.9	129.2 ± 10.3	0.82
Current	52	130.1 ± 11.7	129.8 ± 11.8	129.8 ± 11.2	0.37
Alcohol (times/wk)					
Never	43	129.2 ± 9.1	128.6 ± 9.3	128.5 ± 8.8	0.07
<3	75	129.6 ± 10.1	129.6 ± 10.1	129.5 ± 10.2	0.96
≥3	23	130.0 ± 9.8	130.2 ± 9.9	130.0 ± 9.8	0.55

Values are presented as mean ± SD.

*By randomized block design analysis of variance.

clinical series of patients ($n = 141$) consisted of 117 men (83%) and 24 women (17%). There were 59 hypertensive patients (41.8%) and 28 diabetic patients (19.9%). Moreover, there were 118 patients (83.7%) where the thickness of the sleeve was smaller than 2 mm.

Following a comparison between blood pressure measurements of the first reading and those of the second reading in three different settings, it was found that there were no significant

differences between the two readings (Table 2). The mean values of systolic blood pressure (SBP) were 128.5 ± 10.6 mm Hg in the sleeved group, 128.3 ± 10.8 mm Hg in the rolled sleeve group, and 128.3 ± 10.7 mm Hg in the bare arm group. These results indicate that there were no significant differences among the three groups ($P = 0.32$). In addition, the mean values of diastolic blood pressure (DBP) between measurements of the first reading and those of the second one were 80.7 ± 6.1 mm Hg in the sleeve

Table 5. Comparison of diastolic blood pressure measurements depending on other variables between the three groups (mm Hg)

Variable	Number	Sleeve group	Rolled sleeve group	Bare arm group	P-value*
Age (y)					
<65	118	80.4 ± 6.1	80.5 ± 6.1	80.5 ± 5.8	0.67
≥ 65	23	82.0 ± 6.2	81.9 ± 6.4	81.5 ± 6.2	0.15
Sex					
Male	117	81.3 ± 5.5	81.4 ± 5.6	81.3 ± 5.3	0.51
Female	24	77.3 ± 7.8	77.4 ± 7.4	77.6 ± 7.4	0.63
Hypertension					
Yes	59	82.9 ± 6.2	82.9 ± 6.1	82.7 ± 5.9	0.27
No	82	79.0 ± 5.6	79.2 ± 5.7	79.2 ± 5.5	0.51
Diabetes mellitus					
Yes	28	82.4 ± 4.8	82.5 ± 4.5	82.2 ± 4.4	0.43
No	113	80.2 ± 6.4	80.3 ± 6.4	80.3 ± 6.1	0.94
Thickness of clothes (mm)					
<2	118	80.5 ± 6.1	80.6 ± 6.1	80.5 ± 5.8	0.86
≥ 2	23	81.3 ± 2.3	81.3 ± 2.3	81.2 ± 6.2	0.86
Body mass index (kg/m^2)					
<23	30	79.9 ± 6.2	79.8 ± 6.2	79.8 ± 5.8	0.81
23–25	50	79.3 ± 6.4	79.8 ± 6.4	79.5 ± 6.3	0.09
≥ 25	61	82.2 ± 5.7	81.9 ± 5.7	82.0 ± 5.4	0.25
Smoking					
Never	42	80.6 ± 7.1	80.7 ± 6.9	80.5 ± 6.7	0.62
Ex-smoker	47	81.1 ± 6.2	81.0 ± 6.3	81.1 ± 5.9	0.80
Current	52	80.3 ± 5.3	80.5 ± 5.4	80.3 ± 5.2	0.56
Alcohol (times/wk)					
Never	43	81.2 ± 5.4	81.4 ± 5.4	81.2 ± 5.2	0.68
<3	75	80.1 ± 6.4	80.0 ± 6.4	80.2 ± 6.2	0.71
≥ 3	23	81.5 ± 6.5	81.8 ± 6.3	81.1 ± 6.1	0.13

Values are presented as mean $\pm$ SD.

*By randomized block design analysis of variance.

group, 80.7 ± 6.1 mm Hg in the rolled sleeve group, and 80.6 ± 5.9 mm Hg in the bare arm group. These results indicate that there were no significant differences among the three groups ($P = 0.77$) (Table 3).

In addition, we divided the patients into subgroups based on age, sex, past or current history of hypertension or diabetes mellitus, thickness of the sleeve, weight, a drinking history, and a smoking history. There were no significant differences in SBP and DBP among the three groups among the subgroups (Tables 4, 5).

DISCUSSION

In this study, we compared blood pressure measurements obtained from three different settings in a total of 141 patients: the sleeve group, the rolled-sleeve group, and the bare arm group. As a result, there were no significant differences among the three settings. Holleman et al.⁸⁾ compared blood pressure measurements obtained using an automatic sphygmomanometer between the sleeve group and the bare arm group in 36 patients, thus reporting that there were no significant differences in SBP and DBP between the two settings. Kahan et al.¹²⁾ conducted a study using an automatic sphygmomanometer in 201 patients, who were assigned to three different groups: the sleeve group, rolled sleeve group, and the bare arm group. Then, following a comparison of blood pressure measurements using a repeated-measure ANOVA, it was found that there were no significant differences among the three groups. However, the authors also noted that some patients with a SBP of ≥ 140 mm Hg had a maximum difference of 32 mm Hg in the mean blood pressure measurements between the sleeve group and other groups. Thus, they proposed that blood pressure should be measured for the bare arm in hypertensive patients. In this study, we found that there were no significant differences even in hypertensive patients. We strictly followed the guidelines for blood pressure monitoring. We found no patients with a great discrepancy in blood pressure measurements, which is not in agreement with previous reports.

Liebl et al.¹³⁾ measured blood pressure using both a mercury sphygmomanometer and an automatic sphygmomanometer in 201 patients. Considering that most clothes have sleeves with a thickness of < 1 mm, the above authors enrolled only patients who wore clothed with sleeve with a thickness of < 2 mm. They

measured SBP and DBP using both devices and then compared the results between the sleeve group and the bare arm group using Pearson's correlation analysis. As a result, there were no significant differences between the two different settings. Ma et al.¹⁴⁾ reported that sleeve thickness had no correlation with the difference between bare- and sleeved-arm readings. In this study, we did not restrict the clothes the patients wore when visiting Gangneung Asan Hospital. We therefore enrolled patients who wore clothes with sleeves with a thickness of > 2 mm. We found that thickness of the clothes did not affect measurement of blood pressure if a 2-cm space between the sleeve and the upper arm was made.

According to several studies, if clinicians use a cuff with an inappropriate size for the measurement of blood pressure, this will cause measurement errors.¹⁵⁻¹⁹⁾ Considering that 41.1% of patients in this study were obese, there was a limitation in that we used a cuff with consistently the same size with no respect to diameter of the arm. Moreover, was is another limitation that we did not enroll pediatric patients and failed to obtain sufficient data from younger patients. Additionally, we used an automatic sphygmomanometer rather than a classic mercury sphygmomanometer in measuring the blood pressure in the current study. This is because we attempted to minimize measurement errors because we had to measure blood pressure a total of six times in each patient. Kahan et al.¹²⁾ and Ma et al.¹⁴⁾ measured blood pressure using a commercially automatic oscillometric device. There was also a report that oscillometric blood pressure measurements showed no difference from a classic mercury sphygmomanometer.¹³⁾ We therefore presumed that the use of a classic mercury sphygmomanometer was not one of the limitations of the current study.

To summarize, our results showed that there were no significant differences in blood pressure measurements among the three different settings (the sleeve group, the rolled sleeve group, and the bare arm group). It can therefore be concluded that clothes-wearing status does not have a clinically important effect on blood pressure measurements.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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