

# Blood Pressure Variation on Each Measuring Site in the Right Lateral Position

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**Background.** Blood pressure measurement are used by medical purposes. Most clinical staffs assume that its values are accurate and reliable irrespective of the measured position. In order to measure blood pressure exactly the cuffed upper arm and the heart should be kept at the same level. However, sometimes the blood pressure must be taken with the patient lying on his/her side. In this lateral position it is difficult to set the cuff at the heart's level.

**Purpose.** This study aims at applying exact measurements of blood pressure to practical use. Blood pressure measurements taken from the four extremities (right arm, left arm, right leg and left leg) in the lateral position are compared to those taken in the right arm in the supine position.

**Methods.** Thirty-one female and Thirty-two male subjects were sampled among fit students and the data were collected from May 7th, 2001 through June 7th, 2001. To begin with, the blood pressure of right arm in the supine position was measured. Then the blood pressure was measured again after 3 minutes in the subject's right lateral position.

**Results.** The blood pressure in the left arm in the right lateral position was lower than the right arm's blood pressure in the supine position (systolic difference=15.57 mmHg, diastolic difference=10.86 mmHg).

**Discussion.** Hydrostatic effects are the most likely cause of the drop in blood pressure of left arm in right lateral position. When blood pressure is measured in the left arm in the right lateral position, the position and site should be noted as well as the pressure may be 10mmHg or more lower than the precise blood pressure.

**Key Words:** Blood Pressure; Right Lateral Position

## INTRODUCTION

Blood pressure is an important indicator in diagnosis and in assessing treatment of a patient. Numerous factors influence an individual's blood pressure measurement, one of which body position (Kozier & Erb, 1987; Fitzpatrick, Ortiz, Sibilano, Marcantonio & Braun, 1999). To measure blood pressure exactly, the cuffed upper arm and the heart should be kept at the same level whether the patient is reclining, sitting or standing

(Potter & Perry, 1995). Measurements made with the arm dangling by the hip have been on an average 11 to 12 mmHg higher than those made with the arm supported and the cuff at heart level (Londe & Gollub, 1979; Webster, 1984). In studies using normal blood pressure measurements in intensive care units where the transducer was placed at the same level as the right atrium, it was observed that significant statistical differences ( $p=0.677$ ) did not occur between the supine position and various reclining position, (i.e. 30°, 45°) (Song, Mun & Park, 2000).

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Due to medical necessity blood pressure must be occasionally taken in the lateral position. Some examples of such situations might be severe decubitus in the sacral region due to spinal injury or unconsciousness (Kim, 1985); labor with insufficient uterus circulation due to supine position; reduced cardiac output due to reduced venous return (Goodlin, 1971); a wound or a burn in the back, and those in recovery room after general anesthesia who are in danger of asphyxia or respiratory obstruction in these situations (Foley, 1971). Precise blood pressure measurement is very important to them.

The findings of Webster's (1984) study seem to be related with the effect of gravity.

The effect of gravity on blood pressure is influenced by the density of the blood, the acceleration of gravity, and the vertical length between the heart and the measured site. In normal blood density there are pressure variations per vertical length between heart and the measured site, which are 0.77 mmHg/cm. For example, if the average pressure at the heart level is 100 mmHg the pressure of the cerebral artery which is 50 cm higher than heart should be 62 mmHg ( $=100 - [0.77 \times 50]$ ) and the pressure at the foot 105cm lower than heart should be 180 mmHg ( $=100 + [0.77 \times 105]$ ) (Ganong, 1973). Frohlich (1988) deduced that there is 0.8mmHg difference per 1cm between the heart and the measured site. Du Toit (1976) also reported that blood pressure measured in the right arm in the left lateral position is much lower than in the supine position.

Using Ganong's system of calculation, the variations in blood pressure measurement when taken in the lateral position can be determined. Suppose the vertical length from the aortic reference level to the upper measured site in the lateral position is 20cm, and the vertical length from the aortic reference level to the lower measured site in the same position is 10cm. If the average pressure at the heart level (aortic reference level) is 100 mmHg the pressure in the upper arm, which is 20cm higher than heart, should be 85 mmHg ( $=100 - [0.77 \times 20]$ ) and the pressure in the lower arm, which is 10 cm lower than heart level, should be 107 mmHg ( $=100 + [0.77 \times 10]$ ).

In the past there were several studies that had researched arterial blood pressure differences by position, standing, sitting and various degrees of reclining (Kirchhoff, Rebenson-Piano & Patel, 1984; Puisieux et al., 1999; Song et al., 2000; Yoo, 1987). Those studies only stressed the upper arm as the measured site in spite

of practical necessity. Unfortunately, there is a scarcity of concrete studies on the variations of blood pressure in the lateral position. Moreover, it is rare that a nurse records the posture and the site of blood pressure measurement in the chart (Kim & Kim, 2000). Nurses do not think this information is not pertinent due to the lack of literature and research that comments specifically on how blood pressure measurements differ depending on site and posture.

In reality, clinical staff put blood pressure measurements to medical use on the assumption that the values are accurate and reliable irrespective of the measurement position (Cho, Hwang, Kim, Oh & Kim, 1996). However, in the lateral position the measured site is not at the same level with patient's heart level. This is why it is important and necessary to conduct research into the precise blood pressure measurement in the lateral position.

Hereupon, this research took steps to establish some criteria to decide how much blood pressure measurements vary when taken in the lateral position by comparing four measurement sites -right arm, left arm, right leg and left leg- in lateral positions with that taken in the right upper arm in the supine position.

The purpose of this study is to determine how widely blood pressure measurements differ in both supine and lateral positions; to demonstrate the need of recording both the position and site of the measurement; and to provide information about more precise blood pressure measurements for those involved in medical services.

## METHODS

### 1. Research design

This is a comparative study designed to examine the blood pressure variations according to the sites of blood pressure measurements.

### 2. Sample

The college of natural science was selected as a source of convenient subjects. A volunteer sample of 106 was selected from there at D University.

It was determined that a sample size of 64 subjects was needed to fulfill the aim of this study. This was accomplished by considering the degree of freedom ( $u = \text{number of groups} - 1 = 1$ ), size of effect ( $f = 0.25$ ), and power of test ( $1 - \beta = 0.8$ ) at the significance level  $\alpha = .05$ . This is calculated through the figure presented by Cohen assuming more than two average differences (Lee, Lim &

Park, 1998). In this study, 63 candidates from the college were selected among 106 because some would not match the study criteria.

Thirty-one female and thirty-two male students aged 19 to 29 years from D University in Busan City participated in the study. Data were collected from May 7, 2001 to June 7, 2001. Inclusion criteria for the subjects were as follows;

- 1) Body Mass Index(BMI) is 19.2 - 25.9 kg/m<sup>2</sup> in female subjects and 20.8 - 26.5 kg/m<sup>2</sup> in male subjects (Kim, 1996).
- 2) Circumference of upper arm is between 23 and 33 cm (Kim et al., 2001).
- 3) Circumference of leg is between 23 and 33 cm (Kim et al., 2001).
- 4) Vital signs are in the normal range.
- 5) The differences in blood pressures measured from the right arm and the left arm are less than 10 mmHg (Lee, 1998).
- 6) Not taking any medication on a regular basis (Lee, 1998).
- 7) Agreed to participate in the study.

### 3. Blood Pressure Measurement

#### 1) Instrument

##### (1) Preparing researcher and Instrument

Blood pressure measurements were monitored and recorded by one researcher, who followed a written protocol to ensure identical technique. Blood pressure was measured with electric sphygmomanometer (HG 160 COMFORT, HARTMAN CO., GERMANY), which is a oscillometric sphygmomanometer. The measurement error of electric sphygmomanometer is  $\pm 3$  mmHg. A adapter instead of a battery was used to ensure a stable supply of electricity.

##### (2) Validating the instrument

To validate the instrument, the correlation between blood pressure values measured by electric sphygmomanometer and the mercury sphygmomanometer (Ninghai, Goode CO., JAPAN) was obtained from 20 subjects. The correlation between the two measures were .95 for systolic blood pressure and .92 for diastolic blood pressure.

#### 2) Procedure

##### (1) Measuring circumferences of both extremities

Circumferences of both extremities were measured, af-

ter the subjects were asked to relax their upper arms in the upright position. The circumference of the upper arm was estimated by measuring the middle circumference between the olecranon and the acromion (Kim et al., 2001).

The circumference of the leg was estimated by measuring middle circumference between the thickest portion of gastrocnemius muscle and lateral malleolus part of the fibula (Elkin, Perry & Potter, 2000; Kim et al., 2001)

##### (2) Preparing the subject

The subjects were taken to a room with a temperature of 21 - 22 away from any noise. Consumption of alcohol or cigarettes during in the test day was not allowed. All subjects were instructed to wear light clothes. The procedure was performed between meals. The subjects were instructed to refrain from talking or moving during the procedure and asked to lie on their backs and to relax for 10 minutes (Lee, 1998).

##### (3) Measuring blood pressure

Blood pressure was measured in the right upper arm in the supine position and at 4 sites (right arm, right leg, left arm, left leg) in the right lateral position.

##### Positioning the subject

The subjects were asked to lie the right side down with subject's head on a small pillow, while bending the upper leg forward easily, pulling the lower leg forward easily and stretching both arms comfortably and naturally.

##### Detailed description each measuring site

- i) *right arm*: Lying with the right palm upward, and the arm stretched naturally, the cuff was wound uniformly over the brachial artery its lower border 2-3cm higher than the bending portion of the elbow.
- ii) *left arm*: Stretching naturally and the sphygmomanometer was applied the same as the right arm.
- iii) *right and left leg*: Putting the lower border of the cuff at the lateral malleolus of the fibula right above the ankle, the tube was connected with the cuff parallel to the posterior tibial artery (Elkin et al., 2000).

(4) Blood pressure was measured two times at each site with the sphygmomanometer with an interval of 12 minutes to examine test-retest reliability. The correlation coefficient was higher than 0.90 which indicates high test-retest reliability (Table 1).

### (5) Each measurement's interval

The blood pressure in the right arm in the supine position was measured first. After 3 minutes, the blood pressure was measured again in the right lateral position, in this order: right arm, left arm, right leg and left leg each at an interval of 2 minutes. After 3 minutes, the previous process was repeated once again (Lee, 1998; Hill & Grim, 1991).

### 3) Data Analysis

Only the first measurement of blood pressures were used for the final analysis. The mean, the standard deviation, and the minimum and the maximum values were obtained to describe the measurements from the various different sites and the discrepancies between the blood pressure values in right lateral position. The blood pressure value in supine positions was obtained to indicate the differences in blood pressure values at the different sites and positions. The differences were analyzed by paired t-tests with a significant level of 0.05. SPSS/WIN 10.0 program was utilized.

## RESULTS

Down arm refers to the right arm when in the right lateral position, and up arm refers to the left arm when in the right lateral position.

In analyzing systolic pressure, setting the right arm pressure in the supine position as the standard pressure, there was no significant difference between standard pressure and right arm pressure ( $t=1.985$ ,  $p=.052$ ) in the right lateral position. But right leg ( $t=-3.922$ ,  $p=.000$ ), left arm ( $t=19.560$ ,  $p=.000$ ) and left leg ( $t=-4.034$ ,  $p=.000$ ) in the right lateral position subtracted from standard pressure resulted in significant differences. The difference between the systolic pressure in the right arm

(down arm) in the right lateral position and the standard systolic pressure was 1.10 mmHg. This most closely approximated the standard among the systolic pressures in the four extremities in the right lateral position. On the contrary, the difference between the systolic pressure at the left arm (up arm) in the right lateral position and the standard systolic pressure was 15.57 mmHg. This most widely different from the standard among the systolic pressures in the four extremities in the right lateral position (Table 2).

In analyzing diastolic pressure, setting the right arm pressure in the supine position as the standard pressure, there was no significant difference between standard pressure and right arm ( $t=-.726$ ,  $p=.470$ ), or left leg ( $t=1.936$ ,  $p=.057$ ) pressures in the right lateral position. But right leg ( $t=-2.236$ ,  $p=.029$ ), and left arm ( $t=15.069$ ,  $p=.000$ ) pressures in the right lateral position subtracted from standard pressure resulted in significant differences.

The difference between the diastolic pressure at the right arm (down arm) and the standard was 0.38 mmHg and this most closely approximated the standard among the diastolic pressures of the four extremities in the right lateral position. On the contrary, the difference between the diastolic pressure at the left arm (up arm) in the right lateral position and the standard diastolic pressure was 10.86 mmHg and this most widely different from the standard among the diastolic pressure at four extremities in the right lateral position (Table 3).

**Table 1.** Pearson correlation coefficient ( $r$ ) between two measurements of blood pressure at the same site

blood pressure	supine position	right lateral position			
	right arm	right arm	right leg	left arm	left leg
systolic	.932	.950	.922	.943	.928
diastolic	.947	.953	.942	.904	.947

**Table 2.** Differences between systolic pressures at the right arm in the supine position and at the four extremities in the right lateral position

Division	M $\pm$ SD (mmHg)	Minimum (mmHg)	Maximum (mmHg)	t	p
the right arm in the supine position (a)	115.49 $\pm$ 9.94	96	139		
the right arm in the right lateral position (b)	114.40 $\pm$ 9.72	91	135		
the right leg in the right lateral position (c)	120.94 $\pm$ 12.34	95	153		
the left arm in the right lateral position (d)	99.92 $\pm$ 8.83	80	118		
the left leg in the right lateral position (e)	120.05 $\pm$ 13.01	80	146		
(a) - (b)	1.10 $\pm$ 4.38	- 9.00	9.00	1.985	.052
(a) - (c)	- 5.44 $\pm$ 11.02	- 31.00	29.00	- 3.922	.000
(a) - (d)	15.57 $\pm$ 6.32	.00	26.00	19.560	.000
(a) - (e)	- 4.56 $\pm$ 8.96	- 22.00	26.00	- 4.034	.000

## DISCUSSION

Setting the blood pressure in the supine position as the standard, both systolic and diastolic pressures were closed to its value in the right arm (down arm) in the right lateral position when subtracted from standard pressure (systolic difference: 1.10 mmHg, diastolic difference: -.38 mmHg).

Both systolic and diastolic pressures showed the most difference in the left arm (upper arm) in the right lateral position when subtracted from standard pressure (systolic difference: 15.57 mmHg, diastolic difference: 10.86 mmHg).

Hydrostatic effects are the most likely cause of this result. In other words, the pressure in any vessel below heart level tends to be high and that in any vessel above heart level tends to be low by the effect of gravity (Kang, 1988; Kim, Sung, Kim & Eum., 1986; Sung & Kim, 1997; Ganong, 1973). The decreased pressure in the left arm when in the right lateral position is probably caused by the hydrostatic effect and is consistent with the Foley's findings (1971). In Foley's study, all upper arm systolic and diastolic pressures were significantly lower than the corresponding supine pressures.

However, the findings for right arm (down arm) pressure in the right lateral position were inconsistent in this study. Down arm pressure did not rise as much as could be accounted for by hydrostatic effects. This could be because pressures may be affected by changes in flow as a result of compression of the arteries. So, if blood pressure were to be measured in right lateral position, taking it in the right arm should be avoided.

Previous studies have shown corresponding results of the hydrostatic effect of blood pressure measurement in the lateral position (du Toit, 1976; Frohlich, 1988;

Ganong, 1973; Newton, 1981) as the present study. In application of the result, Newton (1981) recommended that blood pressure measurements taken in the lateral position be made in the upper arm by calculating as follows: an aortic reference point is marked on the anterior chest, and then the distances from this aortic reference point to the left or right brachial pressure measurement site is measured and recorded in both lateral position for each subject. For every centimeter above or below this reference point the brachial pressure measurement site is located, 0.77 mmHg is added to (if located above) or subtracted from (if located below) the measured pressure.

To avoid the artifacts created by hydrostatic effects, blood pressure should be taken with the cuff at heart level whenever possible in supine or sitting position. When necessity requires that have his blood pressure measured in right lateral position in the left arm, the nurse must recognize that the systolic and diastolic pressures measured in that arm may be more than 10 mmHg lower than those measured in the supine. The pressure should be recorded with the measured site and the patient's position.

The present study shows that measuring the blood pressure in the leg should be, if possible, avoided because the ranges of different values between blood pressure measurement in the leg in the lateral position and brachial pressure in the supine are so wide.

However, in this study, as the samples were limited to only right lateral position, it is difficult to generalize to left lateral position.

## CONCLUSION AND RECOMMENDATION

Setting the blood pressure in the supine position as the standard, in the systolic blood pressure the difference

**Table 3.** Differences between diastolic pressures at the right arm in the supine position and at the four extremities in the right lateral position

Division	M $\pm$ SD (mmHg)	Min (mmHg)	Max (mmHg)	t	p
the right arm in the supine position (a)	69.54 $\pm$ 6.79	60	89		
the right arm in the right lateral position (b)	69.92 $\pm$ 7.46	54	87		
the right leg in the right lateral position (c)	67.37 $\pm$ 9.26	48	89		
the left arm in the right lateral position (d)	58.68 $\pm$ 7.11	46	80		
the left leg in the right lateral position (e)	67.67 $\pm$ 9.38	51	88		
(a) - (b)	-.38 $\pm$ 4.16	- 10.00	8.00	- 7.26	.470
(a) - (c)	2.17 $\pm$ 7.72	- 16.00	18.00	- 2.236	.029
(a) - (d)	10.86 $\pm$ 5.72	- 3.00	24.00	15.069	.000
(a) - (e)	1.87 $\pm$ 7.68	- 16.00	20.00	1.936	.057

was 15.57 mmHg less than the standard and in the diastolic blood pressure the difference was 10.86 mmHg less than the standard. Hydrostatic effects are the most likely cause of left arm (upper arm) pressure change in the right lateral position. For the other side, right arm (down arm) pressure change in the right lateral position may be affected by hydrostatic effects and changes in flow as a result of compression of the arteries supplying the arm.

There is room to argue about compression of arteries, though. For practical need, it is thought necessary to verify whether consistent differences show up within significant range or not through repeated studies in the lateral position.

In reality, it is considered necessary to measure body temperature variations from each site such as axilla, oral cavity and rectum. It is little different with blood pressure. It may also become necessary to measure blood pressure variations at each site and position through repeated studies.

Indirect blood pressure measurement should be taken with the cuff at heart level whenever possible in the supine or sitting position. If blood pressure must be measured in the right lateral position, to have a more accurate understanding of the measurement the site and patient's position should be reflected in the assessment and treatment. In addition, repeated blood pressure measurement should be tried in the same site and position.

Further studies to assess a subject's blood pressure measurements in different postures are still needed and efforts to standardize accurately the blood pressure measurement in lateral position should be done.

## References

- Cho, S. H., Hwang J. H., Kim, E. K., Oh, B. H. & Kim, C. Y. (1996). Evaluation for accuracy of blood pressure measurement. *J Korean Aca Med QA*, 3(1), 94-103.
- Du Toit, J. M. (1976). Left lateral blood pressure reading. *South African Medical Journal* 50. 1427.
- Elkin M. K., Perry A. G. & Potter P. (2000). *Nursing interventions & clinical skills (2nd)*. Mosby. USA.
- Fitzpatrick, L. F., Ortiz, A., Sibilano, H., Marcantonio, R. & Braun, L.T. (1999) The Effects of Crossed Leg on Blood Pressure Measurement. *Nurs Res*, 48(2), 105-108.
- Foley, M. F. (1971). Variations in blood pressure in the lateral recumbent position. *Nurs Res*, 20(1), 64-69.
- Frohlich, E. D. (1988). Recommendation for human blood pressure determination by sphygmomanometer. Report of a Special task Force appointed by the Steering Committee, American Heart Association. *Circulation*, 77, 501A-514A Feb.
- Ganong, W. F. (1973). *Review of medical physiology (6th edition)*. California: Lange. 425-426.
- Goodlin, R. C. (1971). Importance of the lateral position during labor. *Obstet Gynecol*, 37(58), 698-701.
- Hill, M. N., & Grim, C. M. (1991). How to take a precise blood pressure. *Am J Nurs*, 91(2), 38-42.
- Kang, D. H. (1988). *Physiology*. Seoul: Shin Kwang. 8.72-8.73.
- Kim, J. S. & Kim, S. S. (2000). Evaluation of accuracy for blood pressure measurement of nurse in a polyclinic. *Journal of the Korean Academy of Fundamental Nursing*, 7(1). 7-15.
- Kim, M. J., Kim, K. S., Kim, J. I., Kim, J. S., Park, H. S., Song, K. A. & Choi, S. H. (2001). *Fundmental of nursing*. Seoul: Hyun Moon. 319-338. 798-806. 931.
- Kim, S. K. (1996). *Exercise and health*. Seoul: 21th Century Education. 247-249.
- Kim, W. K., Sung, H. K., Kim, K. H. & Eum, Y. E. (1986). *Physiology*. Seoul: Seo Young. 190-192.
- Kim, Y. S. (1985). A study on character for occurrence of decubitus. *A Master of Thesis at Yeon-Sei university*.
- Kirchhoff, K. T., Rebenson-Piano, M. & Patel, M. K. (1984). Mean arterial pressure reading: Variations with positions and transducer level, *Nurs Res*, 33(6), 343-345.
- Kozier, B., & Erb, G. (1987). *Fundamentals of nursing*, Addison wesley. 788-796.
- Lee, H. O., Lim, N. Y., Park, H. A. (1998). *Nursing medical research and a statistical analysis*. Seoul: Su Moon Sa.
- Lee, W. L. (1998). *Clinical cardiology*. Seoul: Korea Medical. 127-129. 471-487.
- Londe, S. & Gollub, S. W. (1979). Arm position and blood pressure. *J Pediatr*, 94, 617-618.
- Newton, K. M. (1981). Comparison of aortic and brachial cuff pressure in flat supine and lateral recumbent positions. *Heart Lung*, 10, 821-825.
- Potter, P. A. & Perry, A. G. (1995). *Basic nursing, Theory and Practical*. Mosby. USA. 292.
- Puisieux, F., Boumbar, Y., Bulckaen, H., Bonnin, E., Houssin, F., & Dewailly, P. (1999). Intraindividual variability in orthostatic blood pressure changes among older adults: the influence of meals. *J Am Geriatrics Society*. Nov. 47(11), 1332-6(25 ref).
- Song, H. S., Mun, J. R. & Park, H. J. (2000). Comparative study on accuracy of blood pressure measurement depending on the posture and the kind of sphygmomanometer. *Clinical Nursing Research. In Sam-Sung Medical Center (4th)*. 73-86.
- Sung, H. K. & Kim, K. H. (1997). *Physiology*. Seoul: Medical Culture. 201-211.
- Webster, J. (1984). Influence of arm position on measurement of blood pressure. *Br Med J*, 288, 1574-1575.
- Yoo, T. S. (1987). The Influence of the posture on the blood pressure measurement. *A Master of Thesis at Sung Gyun Gwan University*.