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COMPARATIVE STUDY ON BP VARIATION IN UPPER AND LOWER LIMB IN DIFFERENT POSTURES USING ARM CUFF

Physiology

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ABSTRACT

Measurement of blood pressure is an important part of clinical examination as it provides valuable information about cardiovascular system under normal and diseased condition. The upper arm is the preferred site because in the sitting posture when the cuff is tied around the upper arm it comes to the level of the heart. However alternate sites for BP recording may be helpful in instances like patients with intravenous devices on both arms or in trauma or with lymph edema and in patients with arteriovenous fistula access on the upper limbs .Hence the need for an alternate site for measuring BP arises. We undertook this study to find out whether calf muscle BP recording taken in supine posture will correlate with upper limb BP recording. In our study the study participants were grouped on the basis of age, gender and BMI. We found that the systolic BP recordings varied as much as by 20mm of Hg in the above fifty age group whereas the diastolic BP variation was limited to 2mm of Hg in the aforementioned age group. The mean difference of the systolic BP measurements recorded from upper limb and lower limb was found to be 20mm of Hg among those who were obese compared to the difference of 18mm of Hg in the normal sub-group. The mean difference in the upper limb and lower limb systolic BP readings taken in the supine posture was 22 mm of Hg for males and 17 mm of Hg for females, however it was not statistically significant. The mean difference in systolic BP measurements between the upper and lower limb in all the subgroups that were analysed were statistically insignificant but clinically beyond an acceptable range. There was no significant variation in the values of the diastolic BP and mean arterial pressure recordings. It was consistently noted that among all the subgroup BP recordings analyzed, the systolic BP in the lower limb was on an average 20mm of Hg higher than that those measured from the upper limb. We could not find any consistent variation among the subgroups so a definitive formula also cannot be derived. Bland Altmann analysis showed that there was poor agreement between the Systolic BP readings measured from upper and lower limb which makes calf a poor alternative site for measuring Systolic BP.

KEYWORDS

Systolic BP, Diastolic BP

INTRODUCTION

Blood pressure is the lateral pressure exerted by the circulating blood on the walls of the blood vessels and is one of the principal vital signs. BP usually refers to the arterial pressure of systemic circulation measured at a person's upper arm. BP values of an individual shows physiological variation depending on posture, time of the day and degree of mental and physical activity (1). Measurement of blood pressure is an important part of clinical examination as it provides valuable information about cardiovascular system under normal and diseased conditions. BP reading is usually taken from upper arm, recording the brachial artery pressure. BP measurements can be taken from other sites as well like fore arm, thigh and calf muscles using BP cuffs of suitable width and length. The upper arm is the preferred site because in the sitting posture when the cuff is tied around the upper arm it comes to the level of the heart (2). The pressure in any vessel below the heart level is increased and that in any vessel above heart level is decreased by effect of gravity at the rate of .77mmHg/cm (2). However alternate sites for BP recording may be helpful in instances like patients with intravenous devices on both arms or in trauma or with lymph edema. Measuring BP at upper arm is also contraindicated in patients with arteriovenous fistula access on the upper limbs (3). Hence the need for an alternate site for measuring BP arises. BP can be measured at the level of thigh or calf muscles. American Heart Association recommends use of progressively larger cuffs with larger arm circumference. Measurement of BP at thigh level requires thigh cuff which is not available freely. This also requires the patient to be placed in prone position which is uncomfortable. So calf muscle B P monitoring was chosen for our study. We undertook this study to find out whether calf muscle BP recording taken in supine posture will correlate with upper limb BP recording.

Zahn et al had studied the BP measurements in arm and calf in pregnant women during caesarian section (4). This study revealed a higher Systolic BP(SBP) in the arm and lower Diastolic BP(DBP) in the calf. Parul Sareen had conducted a similar study and got poor agreement between the sites with respect to SBP and DBP and agreement was better for Mean Arterial BP(MBP) (3). A study by Jason Wilkes on patients undergoing colonoscopy also found ankle SBP and MBP higher than brachial measurements (5)

So far we could not find any study done on normal subjects in India to compare upper limb and lower limb blood pressure. We are here by trying to find out whether BP recording in the calf can be taken as an alternative to upper limb BP recording for subjects in whom upper limb BP measurement is not feasible.

Materials and Methods

This was a cross sectional study conducted on normal individuals between the age group of 20-60 years of both genders. After getting approval from the institutional ethics committee, the subjects were selected randomly from among the staff working in AIMS, Kochi. A total of 125 subjects were included in the study after getting informed consent from the subjects. Subjects who were on treatment for hypertension, cardiac diseases, hypercholesterolemia, Diabetes Mellitus, pregnant women, were excluded from the study. Demographic data was collected from the enrolled subjects. Weight was measured using a standardized weighing machine and height was determined by stadiometer BP was recorded using Omron automated apparatus. A standard adult sized cuff was used, the bladder of the cuff being at least 40% of the circumference of the limb being measured. The same sized cuffs were used to record the pressure from both the limbs. Two apparatuses were used to record BP from upper limb and calf simultaneously. For measurement of BP in the upper arm the cuff was tied in the upper arm 1inch above the cubital fossa. For the calf, the cuff was placed over the most prominent aspect of the posterior calf. At first BP was recorded from the arm in the sitting posture. The subjects were allowed to rest for 5minutes before the reading was taken. Initially BP was measured from the left upper limb in sitting posture. Two readings were taken within a gap of one minute and the average of the two readings was calculated. Next the subject was asked to lie down in supine position. One cuff was tied in the left upper arm and the other cuff was tied in the left calf according to standards prescribed. The readings were taken simultaneously from upper and lower limb. Here also two readings were taken within one-minute interval from the previous recording and average calculated. SBP, DBP and heart rate were recorded in each case. The results were recorded manually and then entered into excel sheet and analyzed by SPSS.

RESULTS

One hundred and twenty-five adult patients were enrolled into the

study. Subjects were grouped into three categories-based on their gender, age and BMI

There were 26 males (20.8%) and 99 females (79.2%). Majority of the subjects were in the 36-50 years' age group. Subjects were also grouped on the basis of their BMI and 52% came under the normal category. The upper limb and lower limb(calf) Systolic and diastolic BP were recorded in sitting and supine posture.

Results were analysed using Systolic and Diastolic BP recordings from the two sites using Bland Altmann analysis (6). As shown in Table 1 the mean difference between Upper limb and lower limb Systolic BP in supine posture varies as high as 21 mm of Hg (in the above 50yrs subgroup) with the lower limb reading being higher. The other subgroups also showed similar pattern. The diastolic BP difference was only 2mm of Hg (reading in the upper limb higher)

Table-1 Mean- Difference between Upper limb and lower limb Systolic and Diastolic BP in supine posture

Age group (in years)	Mean Difference between Upper limb and lower limb Systolic BP in supine posture(mm of Hg)	p value	Mean Difference between Upper limb and lower limb Diastolic BP in supine posture(mm of Hg)	p value
20-35	-15.514(±9.621)	0.037	.583(±4.798)	0.290
36-50	-19.017(±10.099)		2.095(±5.299)	
>50	-21.516(±8.278)		2.387(±5.579)	

The mean difference in upper limb and lower limb Systolic and Diastolic BP in supine posture based on BMI was calculated(Table-2). All the three sub groups showed lower limb systolic BP to be higher than upper limb in supine posture with the obese group having a difference of 20mm of Hg. The difference in diastolic BP was only 2mm of Hg in the obese category. But these differences were not statistically significant

Table 2- Mean Difference in Upper limb and lower limb Systolic and Diastolic BP in supine posture

BMI	Mean Difference in Upper limb and lower limb Systolic BP in supine posture (in mm of Hg)	p value	Mean Difference in Upper limb and lower limb Diastolic BP in supine posture (in mm of Hg)	p value
uw(<18.5)	-11.750(±7.60)	.094	2.000(±2.91)	.534
n(18.5-25)	-18.000(±9.17)		1.188(±4.96)	
ob (>=25)	-20.279(±10.42)		2.288(±5.84)	

(uw-underweight, n-normal, ob-obese)

The difference in upper limb and lower limb systolic and diastolic BP in supine posture based on gender is given in Table3. As can be seen both males and females had a higher systolic BP in the lower limb with a difference of 17mm of Hg for females and 22mmof Hg for males. Males showed lesser difference in the Diastolic BP reading (0.192) when compared to females (2.13)

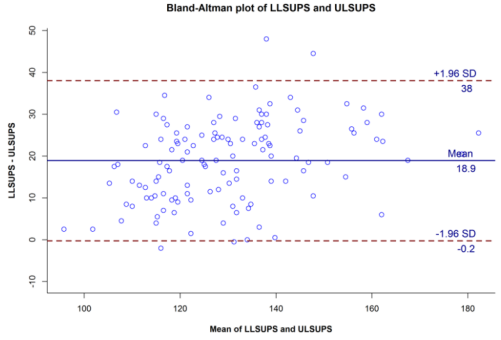
Table 3- Difference in Upper limb and lower limb Systolic and Diastolic BP in supine posture

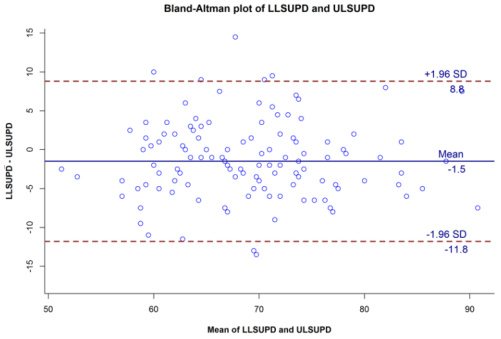
Gender	Difference in Upper limb and lower limb Systolic BP in supine posture (in mm of Hg)	p value	Difference in Upper limb and lower limb Diastolic BP in supine posture (in mm of Hg)	p value
Female	-17.672	.022	2.136(5.1219)	.146
Male	-22.269		.192(5.1219)	

Mean Difference in Mean Arterial Pressure between upper and lower limb in supine posture among the three categories are given in Table 4. Mean Arterial BP did not show a large difference in the three sub groups. Males showed a difference of 7mm of Hg while the above 50yrs category showed a difference of 5.5mm of Hg

Table 4- Mean Difference in Mean Arterial Pressure between upper and lower limb in supine posture

Difference in Mean Arterial Pressure between upper and lower limb in supine posture(mm of Hg)	Age(years)	Difference (mm of Hg)	p value	Gender	Difference (mm of Hg)	p value	BMI	Difference (mm of Hg)	p value
	20-35	4.7824(±5.14)	.714	F	4.4663(±4.96)	.017	uw(<18.5)	2.5833(±1.68)	.320
	36-50	4.9425(±5.44)		M	7.2949(±5.43)		N (18.5-25)	5.2083(±4.97)	
	>50	5.5806(±4.79)					ob(>=25)	5.2340(±5.66)	





The Bland Altman analysis gives only a moderate agreement for systolic BP recordings from upper and lower limb (ICC (95% CI) :0.553) while Diastolic BP gives a good agreement (ICC (95% CI) :0.881)

DISCUSSION:

A very well-known and standard practice during a clinical evaluation, is to measure the non-invasive blood pressure (NIBP) using the oscillometric equipment. The most common site of blood pressure measurement is the upper arm. However, there are times when it is either not ideal or not possible to use the upper limb for blood pressure measurement.

In this study, the participants were grouped based on their age, sex and BMI.

Majority of the participants ,46% were in the age group between 36-50yrs. The systolic and diastolic BP in both upper and lower limbs were found to be higher among the participants in the above 50 years age group in both sitting and supine postures. The mean difference between upper and lower limb pressure recordings were also greater for the above fifty age group. The systolic BP recordings varied as much as by 20mm of Hg in this age group whereas the diastolic BP variation was limited to 2mm of Hg in the aforementioned age group. The BP variations in the rest two age groups also showed a similar pattern with the difference being pronounced in their systolic BP recordings.

Based on the BMI of the participants 52% were classified as normal. Among those who were noted to be obese, systolic and diastolic BP recordings irrespective of the limb or posture were higher, however not statistically significant (p value 0.005). The mean difference of the systolic BP measurements recorded from upper limb and lower limb was found to be 20mm of Hg among those who were obese compared to the difference of 18mm of Hg in the normal sub-group. In contrast, the diastolic BP recordings from the lower limb showed a difference of only 2mm of Hg compared to the values recorded from the upper limb among those who were obese and 1.18 mm of Hg in the normal sub-category. In the study by LN.Goldstein relationship between upper limb lower limb BP based on BMI showed similar pattern (7)

The mean difference in the upper limb and lower limb systolic BP readings taken in the supine posture was 22(±10.18) mm of Hg for males and 17(±9.42) mm of Hg for females, however it was not statistically significant (p- 0.022). The variation in the diastolic BP recordings was 0.192(±5.51) mm of Hg for males and 2(±5.12) mm of Hg for females, indicating that there was definitely no significant difference among the diastolic values for either gender. In a study by L N Goldstein the mean SBP measured in the ankle was 13 mmHg higher than that measured in the arm. They also found that there was a larger difference between arm and ankle SBP in males than in females (which we did not get in our study) There were statistically significant differences in BP measurements between the male and female patients, although further subgroup analysis showed no change in the relationship between arm and ankle BPs. There was a statistically and clinically significant difference between arm and ankle SBP in both males and females. There was a statistically but not clinically significant difference between arm and ankle DBP and MAP in males and females.

The mean difference in systolic BP measurements between the upper and lower limb in all the subgroups that were analysed were statistically insignificant but clinically beyond an acceptable range. There was no significant variation in the values of the diastolic BP and mean arterial pressure recordings. It was consistently noted that among all the subgroup BP recordings analyzed, the systolic BP in the lower limb was on an average 20mm of Hg higher than that those measured from the upper limb.

In another study by Drake (8) in pregnant ladies, mean differences between ankle -arm readings were11.2 mmHg for Systolic BP, 0.5 mmHg for MAP and3.8 mmHg for Diastolic BP, using cuffs of different sizes.

The study by Parul Sareen compared arm and calf BP measurements in patients who were to be operated upon just prior to anesthesia. In their study they found that with respect to Systolic BP the calf measurement is on an average 15.25 mmHg higher than the arm measurement. The mean DBP of the upper limb was 5 mmHg more than in the lower limb. The MBP was on an average 2 mmHg higher than the arm.

Zahn et al did their study in pregnant ladies, their findings were also consistent with our study in that the systolic BP in lower limb was much higher than in the upper limb.

Moore *et al*. in a study compared BP in the arm, calf and ankle (9). They concluded that there was a poor agreement between the different sites with respect to SBP. The agreement was closer for DBP and MBP measurements. The MBP calf measurement was on average 4 mmHg higher than the arm. Moore *et al*. in their study used the same sized cuff for measurement of arm and calf BP. Similarly, in our study, we used the same cuff to measure BP in the calf and upper arm as their diameter is similar.

Wilkes and DiPalma (5) suggested that the ankle can be used as an alternative to the arm should the arm not be available, keeping in mind that the readings will be higher than the corresponding brachial pressures.

Although there have been quite a number of studies conducted to ascertain whether lower limb can be used as an alternative site for BP recording, most of them were conducted in patients undergoing surgery, colonoscopy and caesarean delivery under spinal anesthesia. Our study was aimed at normal subjects and also to find out whether age, sex and BMI had an impact on the variation between upper limb and lower limb BP recordings. Our findings were also in par with the earlier studies showing that Systolic BP showed greater variation than diastolic and MAP. We could not find any consistent variation among the subgroups so a definitive formula also cannot be derived. Bland Altmann analysis showed that there was poor agreement between the Systolic BP readings measured from upper and lower limb which makes calf a poor alternative site for measuring Systolic BP

CONCLUSION

Our study results showed that there was poor agreement in systolic BP recordings from upper and lower limb irrespective of age, gender and BMI. The difference in the readings were also not consistent making it difficult to derive a common formula. Diastolic BP and MAP showed better agreement between upper and lower limb readings. But since Systolic BP values are more significant in clinical practice calf cannot be taken as an alternative site for measurement of BP. Small sample size and a single centre study are the limitations of our study

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