Is it reliable to measure the forearm blood pressure in children?

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ABSTRACT

Background: When the upper arm (UA) is inaccessible or a standard-sized blood pressure (BP) cuff is unavailable, some healthcare workers use the forearm (FA) to measure BP with a mercury sphygmomanometer. **Objective:** The objective was to determine the accuracy of BP measurement in the arm and FA. **Design:** Prospective, randomized study. **Setting:** Department of Pediatrics, JNMC, Sawangi (Meghe) **Participants:** A total of 72 children aged 5–15 years. **Measurements:** Mercury and Automatic (OMRON Tokyo, 108-0075 Japan) BP measurements were recorded from the arm and FA at 2 min intervals. **Results:** In our study, 72 children of both sexes were enrolled. The mean age of the children was 10.13 ± 2.82 years, and 48% were females. Pearson's correlation coefficient between FA and UA systolic BP (SBP) measured by mercury was 0.782, and for diastolic BP (DBP) it was 0.824. Similarly, Pearson's correlation coefficient between FA and UA SBP measured with an automated device (OMRON) was 0.843, and for DBP it was 0.846. The average readings for the SBP and DBP were higher in the FA than in the UA by approximately 3 mmHg. There was a statistically significant difference in both SBP and DBP. **Conclusions:** The FA is an acceptable method of BP monitoring when the UA cannot be accessed. The pressure from FA is probably higher than it would be from UA.

Key words: Blood pressure, forearm, OMRON, upper arm

INTRODUCTION

Blood pressure (BP) is seen as one of the vital signs of life. Accurate measurements of BP should be part of the routine annual physical examination of all children 3 years old or older. BP measurement can be taken both invasively and noninvasively, but it requires careful attention and is dependent on the proper use of the equipment. Since hypertension is the most common risk factor for cardiovascular disease, an accurate BP measurement is essential for the provision of healthcare to decrease the risks of cardiovascular morbidity and mortality.[1] The use of automatic, noninvasive BP (NIBP) monitors to obtain routine and emergent vital signs is common.[2] The upper arm (UA) is the primary site used for BP measurement, and UA NIBP measurement is the most commonly accepted method of BP monitoring. Measuring BPs in the forearm (FA) rather than UA site is prompted when it is difficult to physically access the UA.[3] With the increasing numbers of overweight and obese children, a larger cuff may not be available during routine screening. However, when it is not possible to use the UA, FA is commonly used as alternative site.[4] Healthcare providers are increasingly obtaining BP in FA in place of UA, but clear parameters are not known for BP taken in this location. This study was done to assess the difference between BP measurements of UA and FA using the mercury sphygmomanometer (M) and automated devices (A) in children.

Access this article online	
Quick Response Code:	Website: www.jfcmonline.com
	DOI: 10.4103/2230-8229.155376

MATERIALS AND METHODS

This cross-sectional study was done in Pediatric Department at Acharya Vinoba Bhave Rural Hospital, Datta Meghe Institute of Medical Sciences, Sawangi (Meghe), Wardha. We included children aged 5–15 years without any known history of serious illness like chronic respiratory or neurological problem. We excluded the children, who had upper limb amputation, cuts or bruising of the skin at measurement sites, hypertension, arrhythmia, aortic coarctation, aortic dissection, peripheral vascular disease, congenital heart disease, and vacuities. A Diamond mercury sphygmomanometer, India (M) and an OMRON HEM-7112 series: Tokyo 108-0075 Japan, Automatic (A) BP apparatus were used to obtain data on all children during the study. A pilot study was done to determine the accuracy and reliability of readings. Inter-rater reliability of the readings of the researchers was established, which did not vary by >2–4 mmHg.

The research was approved by an Institutional Ethics Committee and informed consent was obtained from the parents. Detail history, anthropometry, and examination of the children were recorded. Appropriate-sized cuffs were chosen according to the circumferences measured at the midpoint of the UA and FA. All BP measurements were taken in the supine position after 5 min of rest. The UA and FA were kept at heart level. There were 2 min minimum resting periods between each BP measurement to assure reliable readings. In first phase, BP measurements were taken in the UA and from the FA by mercury sphygmomanometer (M). In second go, BP measurements were taken in the UA and from the FA by automatic BP machine (A). The order of taking the measurements was randomly assigned and alternated so that half of the participants had first measurements from the UA followed by the FA readings and half had FA measurements first followed by UA measurements. Two readings were taken each for UA and FA at a gap of 2 min each. Heart rate was also obtained from the BP monitor. SPSS 14.0.1 statistical software (SPSS Inc., Chicago, IL, USA) was used for the statistical analysis. Means and standard deviations were calculated for UA and FA BP measured by M and A appartus. Paired *t*-tests were used to determine the differences between UA and FA BPs. Pearson's correlation coefficient was used to determine the relationship between UA and FA BPs.

RESULTS

In our study, 72 children of either sex were enrolled. The mean age of children was 10.13 with a standard deviation of 2.82 years and 47.2% were females [Table 1]. The anthropometric characteristics of the children are shown in Table 2. The mean FA and UA systolic BP (SBP) (M) were 117.06 mmHg and 114.63 mmHg, respectively, whereas the mean FA and UA SBP measured by OMRON (A) were 112.87 mmHg and 109.02 mmHg, respectively. The mean FA and UA diastolic BP (DBP) (M) were 79.6 mmHg and 77.76 mmHg, respectively, whereas the mean FA and UA DBP measured by OMRON (A) were 77.40 mmHg and 75.36 mmHg, respectively. Pearson's correlation coefficient between FA and UA SBP measured by mercury sphygmomanometer (M) was 0.782 and for DBP was 0.824 as shown in Tables 3 and 4. Similarly, Pearson's correlation coefficient between FA and UA SBP measured by automated device (OMRON) was 0.843 and for DBP was 0.846 as shown in Tables 5 and 6. The average readings for the SBP and DBP were higher in FA than in UA by approximately 3 mmHg. Statistically significant difference existed in both SBP and DBP.

Table 1: Number of children according to sex and age included in the study

Sex	Number of children	Percentage	Age mean (range)
Male	38	52.8	10.45 (5-15) years
Female	34	47.2	10.12 (5-13) years

Table 2: Anthropometric characteristics of the children

Children (*n*=72)	Minimum	Maximum	Mean	SD
Weight	13.00	47.00	27.2157	8.72319
Height	96.00	162.00	130.1667	16.24396
BMI	10.40	20.82	15.6419	2.54157
MFAC	13.00	18.00	15.1667	1.33216
MAC	15.00	22.00	18.0583	1.48341

SD: Standard deviation; BMI: Body mass index; MFAC: Middle fossa arachnoid cysts; MAC: Mid-arm circumference

DISCUSSION

There are less number of studies looking at differences in BP between UA and FA in children. In adults, large numbers of studies have shown a significant difference between UA and FA measurements. FA BP tends to be higher because of vessel size and location of the vessels. The vessels in the FA have a smaller diameter and are placed more superficial than the vessels in the UA.[5] In earlier research, FA BPs were higher than UA BPs, but statistical significance varied among systolic, diastolic, and mean arterial pressure (MAP) readings. Watson *et al.*[6] revealed that significantly higher FA systolic ($P < 0.0001$) and diastolic ($P < 0.0002$) BP measurements compared with BP obtained in the UA with the reference standard BP cuff. Leblanc *et al.*[7] found that the correlation between the intra-arterial and the FA measures was 0.90 ($P < 0.001$) for the 2570 data (systolic and diastolic). Compared to intra-arterial, the FA method overestimated systolic (6 ± 16 mmHg, $P < 0.001$) and underestimated DBP (2 ± 11 mmHg, *P* 5 0.03). Compared to intra-arterial, UA underestimated systolic (8 6 16 mmHg, $P < 0.01$) and overestimated DBP (9 ± 7 mmHg, $P < 0.001$). Keidan *et al.*[8] found that the SBP difference between the arm-FA or the arm-ankle was within the ± 10% range in 63% and 29% of measurements, and within the ±20% range in 85% and 67% of measurements, respectively. The DBP difference between the arm-FA or the arm-ankle was within the ±10% range in 42% and 44% and within the ±20% range in 67% and 74% of measurements, respectively. Schimanski *et al.*[9] mentioned that the FA measure overestimated systolic (mean difference

Table 3: SBP (mercury) of UA and FA

SBP (mercury)	Mean (mmHg)	SD	Range	Correlation coefficient	Significance
UA	114.6389	9.51101	96-132	0.782	$P<0.0001$
FA	117.0694	8.07941	100-134		

SD: Standard deviation; SBP: Systolic blood pressure; UA: Upper arm; FA: Forearm

Table 4: DBP (mercury) of UA and FA

DBP (mercury)	Mean (mmHg)	SD	Range	Correlation coefficient	Significance
UA	77.7639	9.82737	58-98	0.824	$P<0.0001$
FA	79.6111	6.71252	66-96		

DBP: Diastolic blood pressure; SD: Standard deviation; UA: Upper arm; FA: Forearm

Table 5: SBP (OMRON) of UA and FA

SBP (OMRON)	Mean (mmHg)	SD	Range	Correlation coefficient	Significance
UA	109.0278	11.86185	85-131	0.843	$P<0.0001$
FA	112.8750	9.13581	91-131		

SBP: Systolic blood pressure; SD: Standard deviation; UA: Upper arm; FA: Forearm

Table 6: DBP (OMRON) of UA and FA

DBP (OMRON)	Mean (mmHg)	SD	Range	Correlation coefficient	Significance
UA	75.3611	11.98274	53-108	0.846	$P<0.0001$
FA	77.4028	8.44311	55-99		

DBP: Diastolic blood pressure; SD: Standard deviation; UA: Upper arm; FA: Forearm

2.2 mmHg, 95% limits of agreement ±19 mmHg), diastolic (mean difference 3.4 mmHg, 95% limits of agreement ±14.4 mmHg), and MAPs (mean difference 4.1 mmHg, 95% limits of agreement ±13.7 mmHg). In this study, FA BPs were also statistically significantly greater than UA BPs measured by both mercury and automatic devices.

Singer *et al.*[3] compared FA and UA NIBPs in seated stable patients in an ambulatory emergency department. They found the correlation between FA and UA SBPs was 0.75 and for DBPs was 0.72 ($P < 0.001$). They also reported that FA BP was an acceptable predictor of the standard UA BP when measurement of UA BP was not possible. In another study done by Schell *et al.*[4] study revealed significant differences ($t = 2.07$, $P = 0.04$) between mean UA and FA SBPs. A 14–20 mmHg difference was found between systolic, diastolic, and mean FA and UA BPs as determined by Bland–Altman analyzes. Pierin *et al.*[10] studied in the obese population and revealed that UA systolic and DBPs were significantly lower ($P < 0.05$) than FA BPs. They also concluded that FA BP measurements could inappropriately inflate the prevalence of hypertension diagnoses in the obese. Milmaniene *et al.*[11] reported systolic and DBPs was higher in the FA than the UA in over 90% of participants. The mean differences between the two sites were 9.7 ± 10 mmHg for SBP and 9.9 ± 7 mmHg for DBP. Emerick[12] compared BP readings of wrist and UA in hospitalized patients and reported that the degree of difference between the two readings was so significant that the location of the readings should be indicated. The study also reported both the diastolic and systolic measurements were significantly higher in the FA when compared to the UA in the sampled health young adults. Same finding was also found in our study also.

CONCLUSIONS

The pressure from FA is probably higher than it would be from UA. The correlations between UA and FA systolic and DBP measurements were significant. FA is an acceptable method of BP monitoring in case UA is not available for the same.

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How to cite this article: Taksande AM, Jadhav A, Nair J. Is it reliable to measure the forearm blood pressure in children?. J Fam Community Med 2015;22:85-7.

Source of Support: Nil, **Conflict of Interest:** None declared.