Influence of arm position on measurement of blood pressure

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Abstract

A series of measurements of blood pressure in normotensive and hypertensive subjects showed that measurements made with a sphygmomanometer with the arm dependent by the side were consistently higher than those made with the arm horizontal at heart level. The mean difference in a group of 90 hypertensive outpatients was 11/12 mm Hg. Failure to appreciate the importance of arm position may lead to erroneous measurements of blood pressure. This has important implications for clinical practice and research.

Introduction

Many factors influence the measurement of blood pressure by sphygmomanometer. Much attention has been paid to the importance of the choice of instrument,¹ defects of the instrument,^{2,3} size of the cuff,⁴ and diastolic end point.⁵ The influence of changes in arm position on blood pressure measured by sphygmomanometer was first reported 75 years ago.^{6,7} Our experience led us to believe that this factor has been overlooked by many observers. We undertook a series of investigations to evaluate this aspect of measuring blood pressure. The aim of this study was to estimate the effect on measurement of blood pressure by sphygmomanometer of changes in arm position; we studied this in normotensive subjects, untreated patients with hypertension, and patients with hypertension receiving various antihypertensive drugs.

Subjects and methods

First study—Twenty normotensive subjects and 20 patients with untreated, uncomplicated mild essential hypertension were studied in a student elective project. Blood pressure was measured with the Remler recording system.⁸ Dimensions of the cuff were either 22 × 12 cm or 32 × 15 cm. Phase V diastolic pressure was recorded. Duplicate measurements were made after the patient had been supine for five minutes, standing for two minutes, and sitting for two minutes. In the standing and sitting positions blood pressure was measured with the arm dependent by the patient's side and with it supported in a roughly horizontal position at heart level. Whether the first measurement was made with the arm dependent or horizontal was determined at random. In some of the subjects additional measurements were made with the horizontal arm unsupported and with the arm overhead. **Second study**—Because of the striking differences observed in the first series of measurements we proceeded to a more formal study to validate our observations. Ninety consecutive outpatients with hypertension attending the blood pressure clinic were seen by two

observers (JW and JCP). They included patients with a wide range of blood pressures, of whom some were untreated and others taking various antihypertensive drugs. Blood pressures were measured in duplicate using Hawksley random zero sphygmomanometers. The size of the cuff was either 23 × 12 cm or 38 × 15 cm depending on arm circumference. Phase V diastolic pressure was recorded. Measurements were made after the patient had been supine for 10 minutes and seated for two minutes. In the sitting position measurements were made with the arm dependent by the patient's side and with it supported on a bench horizontally at heart level. Whether the first measurement was made with the arm horizontal or dependent was determined by a strict randomisation table stratified for sex, observer, and treatment group. **Statistical analysis**—The data from the second study were initially analysed by ANOVA. Thereafter, paired *t* tests were used to compare the amounts by which blood pressure measured with arm dependent exceeded those with the arm horizontal within subgroups according to drug treatment, age, and observers. A binomial test was used to compare the proportions of patients in whom blood pressure when the arm was dependent exceeded that when the arm was horizontal and vice versa. Correlation coefficients were computed for the differences in blood pressures with the arm dependent and the arm horizontal according to age, weight, height, and sex.

Results

First study—Table I shows the effects on the recorded blood pressure of changing the position of the arm. In both normotensive and hypertensive patients measurements made with the arm dependent were consistently higher than those made with the arm supported horizontally at heart level. In the sitting position this difference

TABLE I—Mean (SD) blood pressures (mm Hg) in untreated normotensive and hypertensive subjects

Posture and arm position	Normotensive subjects			Hypertensive subjects		
	No	Systolic	Diastolic	No	Systolic	Diastolic
Supine	20	125 (13)	64 (10)	20	159 (24)	98 (9)
Standing:						
Dependent	20	129 (14)	73 (11)	20	160 (25)	108 (10)
Horizontal supported	20	102 (14)	60 (9)	20	138 (24)	90 (13)
Horizontal unsupported	20	108 (11)	61 (10)	13	148 (26)	96 (12)
Sitting: Dependent	20	128 (10)	69 (12)	20	158 (27)	104 (14)
Horizontal, unsupported	20	105 (8)	62 (10)	13	140 (22)	87 (14)
Horizontal, supported	20	108 (12)	64 (10)	20	140 (21)	90 (14)
Overhead	16	86 (9)	52 (6)	11	123 (21)	71 (15)

averaged 20/5 mm Hg (normotensive subjects) and 18/14 mm Hg (patients with hypertension); in the standing position these mean differences were 27/13 mm Hg (normotensive subjects) and 22/19 mm Hg (patients with hypertension). Supporting the raised arm had a relatively minor effect on the recorded blood pressure. The blood pressures recorded in the sitting and standing positions were similar and were lower than the supine pressure provided that the arm was at heart level. **Second study**—The blood pressure recorded in the sitting position was significantly lower when the arm was supported roughly horizontally at heart level than when it was dependent by the patient's side. The overall difference in sitting blood pressure between the two arm positions averaged 11/12 mm Hg (*p* < 0.001, table II). The mean blood pressures in the subjects studied were 156/95 mm Hg supine, 145/90 mm Hg when seated with the arm horizontal, and 156/102 mm Hg when seated with the arm dependent. The same pattern emerged regardless of treatment group, age group, observer, sex, or whether the first measurement was with the arm dependent or horizontal. In the overwhelming majority of patients the recorded blood pressure was higher when the arm was dependent (table III).

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TABLE 11—Amounts (mm Hg) by which blood pressure measured with arm dependent exceeded that measured with arm horizontal, according to drug treatment*

Treatment category	No of subjects	Mean blood pressure (mm Hg)	
		Systolic	Diastolic
Normotensive subjects	3	11.2	16.3
Patients with hypertension:			
Untreated	22	9.4	11.9
Thiazide alone	14	13.5	13.1
β blocker alone	12	9.8	10.6
Thiazide + β blocker	10	8.6	8.4
Triple treatment†	14	10.5	12.6
Prazosin or methyldopa	6	10.8	13.8
Captopril or enalapril	12	15.7	12.3
All subjects	93	11.1	12.0

*A detailed statistical analysis is available on request.

†Combination of a diuretic, a β blocker, and a vasodilator (hydralazine or nifedipine).

TABLE 111—Results of binomial test comparing differences in observed blood pressure produced by changing position of arm while subject sitting (figures are numbers of subjects (n=93))

	Systolic	Diastolic
Blood pressure when arm dependent:		
< Pressure when arm horizontal	10	5
> Pressure when arm horizontal	83	88
Probability (two sided) of such an extreme occurrence	9×10^{-16}	1×10^{-20}

Occasionally, little difference was seen when the position of the arm was changed; exceptionally, the recorded blood pressure was slightly higher when the arm was supported at heart level. Further detailed statistical analysis (available on request) showed no correlation between the size of the difference in recorded blood pressure and age, sex, weight, or height.

Discussion

Our results confirm that changing the position of the arm has a substantial influence on the blood pressure recorded in that arm by a sphygmomanometer. We believe that the magnitude of this difference, first reported in 1909,⁶ has been overlooked and underestimated. Our studies indicate that the technique of measuring blood pressure, in terms of both the posture of the patient and the position of the arm, may be just as important a factor as selection of phase IV or V as the diastolic end point.^{5, 6} Our experience shows that both systolic and diastolic blood pressures may be changed by 20 mm Hg simply by moving the arm through 90°. These differences in blood pressure with arm position are probably due to hydrostatic factors.⁹

Variations in recorded blood pressure are particularly important when a decision has to be made on whether to treat patients with so called mild or borderline hypertension or to modify treatment regimens in patients with poorly controlled hypertension. Treatment is often started when diastolic blood pressure is within the range 90-100 mm Hg. In our first series of measurements in untreated patients with hypertension the mean supine and sitting blood pressures when the arm was

dependent were 159/98 and 158/104 mm Hg respectively. Many clinicians would consider such blood pressures as an indication to start drug treatment. In those same patients the mean sitting blood pressure when the arm was supported at heart level was 140/90 mm Hg, at which level the need for treatment is not substantiated. Within this range of blood pressures the decision whether to treat affects millions of patients, especially if the benefits of treating even mild hypertension are confirmed.^{10, 11}

There seems to be a clear need for approved guidelines to standardise the method of measuring blood pressure by sphygmomanometer to take these factors into account. In a separate study we established that most doctors measure blood pressure with the patient sitting. This position has also been used in the major trials in hypertension that have reported recently. O'Brien and O'Malley reviewed various aspects of measurement of blood pressure that should be standardised¹²; we suggest that, in addition, attention should be directed to standardising the posture of the patient and the position of the arm. On the basis of our findings we recommend that the patient should usually be sitting, with the arm in a roughly horizontal position at heart level supported on a desk. If measurements of blood pressure are required when the patient is standing the observer must recognise the effect of the dependency of the arm on the resultant reading.

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