

Serial blood pressure measurements

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Abstract

The objective of the present investigation was to study the effects of a 60-s interval of venous congestion between two noninvasive measurements of arterial blood pressure (ABP) on the fluctuation of ABP, assessed by the standard deviation of the differences between two readings. ABP was measured in 345 successive patients, at rest, four times each. For 269 participants, one pair of readings was obtained with a 60-s interval and the other pair without an interval. For 76 patients, the first pair was read at the same interval, and the second pair had venous congestion interposed and there was no waiting interval. There was no increased ABP oscillation, either when there was no interval between ABP readings, or when venous congestion was interposed compared to pairs of ABP measurements performed with a 60-s interval. There was no increase in ABP oscillations when successive ABP readings were taken without an interval or even with venous congestion interposed. Contrary to the present belief, there seems to be no loss of reliability when blood pressure recordings are taken immediately one after another, in the clinical setting.

Key words

- Blood pressure
- Arterial blood pressure oscillations
- Venous congestion
- Arterial blood pressure measurement technique
- Arterial blood pressure fluctuations in the short term

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Introduction

Hypertension is a leading risk factor for coronary artery disease, congestive heart failure, renal disease and stroke. Cost, invasiveness and technical limitations restrict the use of the most accurate devices available for measuring arterial blood pressure (ABP). Therefore, ABP cuff measurement remains the most appropriate screening test for hypertension. This method of ABP measurement is prone to errors resulting from instrument, observer and patient factors. Among other standards, guidelines on ABP measurement recommend that two or more readings separated by at least 30-60 s should be averaged. The recommendation of having an interval of 30 to 60 s between two consecutive ABP measurements is present in textbooks and even in the guidelines prepared by societies or committees involved in blood

pressure and high blood pressure investigation (1-8). However, we are not aware of documentation in the literature describing experimental studies supporting this recommendation.

There are reports that venous congestion following the first ABP measurement could be responsible for a possible alteration of the next reading (9). Foot blood flow is reduced under venous occlusion when the leg is positioned below the level of the heart. The increased response of precapillary resistance (by a local myogenic or sympathetic reflex) can act as a protective mechanism against edema formation (10). Although the existence of a peripheral circulation regulatory reflex in humans (the venoarterial cutaneous vasoconstrictor reflex) is known, an effect of venous congestion on ABP measurement is speculative.

When venous congestion is produced,

hydrostatic overload develops, triggering the venoarterial cutaneous vasoconstrictor reflex, a physiological reaction that produces a reduction in local flow of about 50% through an increase in vascular resistance caused by vasoconstriction. This reflex consists of constriction of small arteries or arterioles in response to venous distension, probably corresponding to a local axonal reflex situated between a distension vein receptor and a constrictor arterial effector. Sympathetic alterations can affect the performance of this reflex (10).

Therefore, we decided to compare the oscillation of ABP assessed in pairs of measurements separated by the conventional 60-s interval with the variation observed without this delay between records. We also investigated the effect of venous congestion upon the second reading by comparing two measurements following the recommended time interval with pairs of readings with venous congestion interposed without an additional time interval.

Patients and Methods

A total of 345 consecutive patients had their ABP measured four times at rest, in the right arm, by the conventional noninvasive method. In group A (N = 92), aged 21-86 years, blood pressure was measured in the sitting position using a mercury sphygmomanometer. In group B (N = 158), aged 17-80 years, blood pressure was measured with the patients in the supine position using a mercury sphygmomanometer. In group C (N = 19), aged 27-82 years, blood pressure was measured in the sitting position using an automatic Datascope device, model 2NEL (Datascope Corporation, Paramus, NJ, USA). In group D (N = 44), aged 17-82 years, blood pressure was measured in the supine position using a mercury sphygmomanometer. In group E (N = 32), aged 18-75 years, blood pressure was measured using a Nihon Seimitsu Sokk (Nissei, Japan) digital elec-

tronic device, model DS-91, with the subjects in the supine position.

All measurements were made by the first author. The first pair of readings was obtained at the beginning of the consultation, and the second one at the end. In groups A and B this sequence was inverted in one third of the subjects. The patients did not smoke or drink coffee during the last 15 min. They were relaxed, the arm examined was at heart level and they did not cross their legs or talk during the examination. There was no randomization of the patients at admission to the study.

In the last two groups (D and E), the first pair of readings was obtained with an interval of 60 s, while in the second pair of readings venous congestion of the right arm was caused immediately after the first reading, with no delay before the second reading.

The patients attended either the private clinic of one of the authors (groups B, C, D and E) or a cardiology outpatient clinic of the public health system (Sistema Unificado de Saúde, SUS). Systolic blood pressure was measured at Korotkoff phase I and diastolic blood pressure at Korotkoff phase V.

The noninvasive automatic and non-automatic blood pressure devices used were not checked for previous validation because the variable under study was blood pressure fluctuation or oscillation and not the accuracy of measurements. Both mercury sphygmomanometers used had meniscus at zero level, column in vertical position and were free of dust and air bubbles.

Venous congestion was obtained by using the same cuff as used for blood pressure measurements. The pressure exerted was the mean of the systolic and diastolic pressures over a period of 10 to 15 s, causing venous dilatation and cyanosis of the right upper limb.

Patients with hemodynamic instability, cardiac arrhythmias, pregnant women, patients with weak Korotkoff sounds and patients younger than 15 years were not included in the study.

Short-term variation in the arterial pressure at rest (seconds to minutes) was reported as the mean of the standard deviations of the differences in arterial pressure between the pairs of measurement separated by a 60-s interval or by no interval or with venous congestion interposed.

The paired *t*-test was used to compare the fluctuation between paired samples, with the level of significance set at $P < 0.05$.

Results

The clinical and demographic characterization of the patients are displayed in Table 1. As observed in Table 2, in groups B, C, D and E the fluctuation of ABP in the pairs of measurement without an interval or with venous congestion interposed was not significantly greater than that observed in the ABP measurement pairs with a 60-s interval

Table 1. Clinical and demographic characterization of the patients.

Groups	N	Age (mean \pm SD) Range (min-max)	Men	Women	White	Non-white	Normotensive	Hypertensive
A	92	57 \pm 12 21-86	16	76	71	21	23	69
B	158	47 \pm 16 17-80	65	93	138	20	83	75
C	19	56 \pm 16 27-82	5	14	18	1	11	8
D	44	49 \pm 18 17-82	18	36	37	7	28	16
E	32	57 \pm 13 18-75	9	23	22	10	5	27
Total	345	53 \pm 14	113	232	286	59	150	195

Table 2. Analysis of the difference in mean fluctuation between two pairs of blood pressure measurements (systolic and diastolic) with and without a 60-s interval between them.

Group	N	Interval (s)	Systolic variation	P	Diastolic (mmHg)	P
A	92	60	5.47 \pm 0.53	0.019*	3.41 \pm 0.29	0.249
		0	4.14 \pm 0.41		2.94 \pm 0.29	
B	158	60	3.60 \pm 0.27	0.141	2.91 \pm 0.23	0.054
		0	3.11 \pm 0.24		2.26 \pm 0.17	
C	19	60	3.46 \pm 0.69	0.080	2.20 \pm 0.46	0.304
		0	5.32 \pm 0.73		3.24 \pm 0.66	
D	44	60	3.25 \pm 0.41	0.462	2.69 \pm 0.33	0.687
		0 + VC	2.80 \pm 0.41		2.96 \pm 0.32	
E	32	60	5.70 \pm 1.11	0.090	5.75 \pm 1.14	0.611
		0 + VC	8.29 \pm 1.22		6.45 \pm 0.97	

The other comparison was among mean changes in pairs of blood pressure measurements with a 60-s interval versus no interval and venous congestion interposed. Variation is reported as the mean of standard deviation (mmHg) \pm mean error. The readings were obtained from the right arm. VC: venous congestion interposed.

* $P < 0.05$ comparing groups with and without interval (bilateral *t*-test for paired samples).

and no venous congestion between assessments. For group A the fluctuation in systolic ABP was significant and was greater for pairs of measurement obtained with a 60-s interval. Analysis of smaller strata in groups A and B (women vs men, white vs non-white, adults vs aged) did show significant differences in the oscillation of ABP with a 60-s interval vs no interval, with the variation being greater in ABP measurement pairs with a 60-s interval than in ABP pairs measured without such interval (data not shown).

Discussion

The data did not demonstrate a significantly greater variation in ABP between pairs of measurement without an interval and with interposed venous congestion when compared with the oscillation in pairs of measurement with a 60-s interval. Only one sample stratum (A) showed a significantly greater oscillation in systolic ABP in the pairs of measurements with a 60-s interval.

The present results do not support the established guidelines for blood pressure measurement techniques. Neither elimination of a time interval nor the occurrence of venous congestion between measurements increased ABP variation in the sample studied. The absence of randomization of the subjects upon admission to the study was a real limitation of the present study.

There is evidence of a strong correlation between venous and arterial blood flow at least under certain conditions. The skin circulation not only provides the skin with nutrients, but is also an important factor in thermoregulation: in the presence of thermal changes, human beings regulate the tonus of skin vessels through many reflexes which modulate the heat exchanges with the environment. Extremities such as the plantar ar-

reas of toes, palmar areas of finger extremities, nose and ears present a plethora of arterial-venous anastomoses with a rich innervation, as well as nutrient capillary loops, venous plexuses and subpapillary arteries (8). The human subcutaneous blood flow is reduced by approximately 50% when the transmural vascular pressure rises by 25 mmHg or more. This phenomenon also occurs in the skin and skeletal muscle. Precapillary resistance increases while postcapillary resistance is reduced during venous stasis (9).

With venous congestion in the extremities, a reflex response of probably peripheral origin occurs, causing arterial constriction and blood flow reduction to these tissues (10). This phenomenon was investigated in cirrhotic patients with or without palmar erythema and compared with controls (11). In the control subjects blood flow reductions were observed after venous occlusion, with a rise in vascular resistance. However, arterial pressure in the corresponding area was not estimated. In cirrhotic patients with palmar erythema, the venoarterial cutaneous vasoconstrictor reflex was not affected in the dorsum of the hand, but was depressed in the palmar region. Nevertheless, the authors did not report that venous congestion affected ABP.

Our main finding was that overall results do not support the hypothesis that absence of the time interval or presence of venous congestion that may occur in clinical practice significantly affects the ABP oscillation that occurs naturally.

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